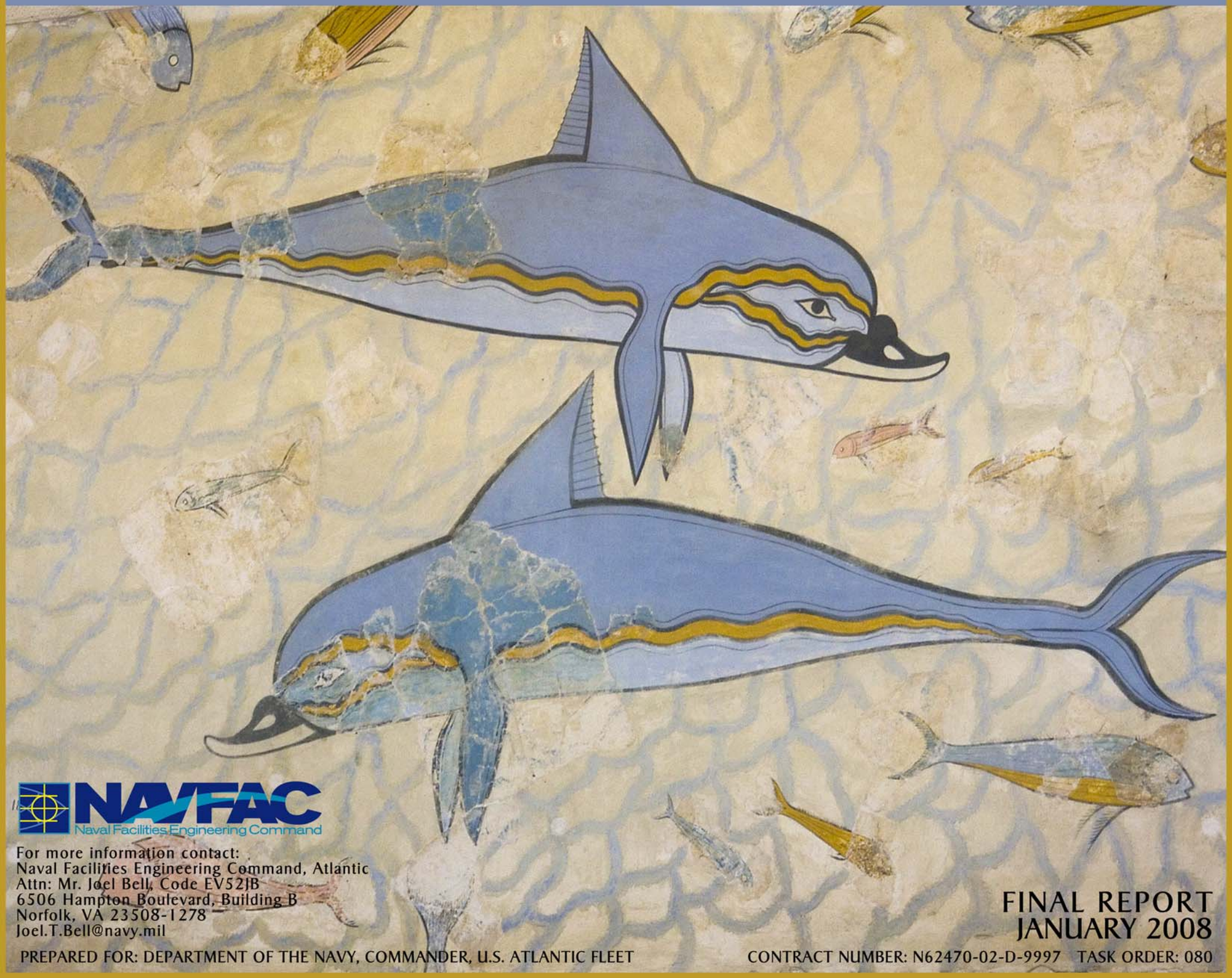
Marine Resources Assessment for the Eastern Mediterranean Sea



NAVFAC
Naval Facilities Engineering Command

For more information contact:
Naval Facilities Engineering Command, Atlantic
Attn: Mr. Joel Bell, Code EV52JB
6506 Hampton Boulevard, Building B
Norfolk, VA 23508-1278
Joel.T.Bell@navy.mil

FINAL REPORT
JANUARY 2008

PREPARED FOR: DEPARTMENT OF THE NAVY, COMMANDER, U.S. ATLANTIC FLEET

CONTRACT NUMBER: N62470-02-D-9997 TASK ORDER: 080

MARINE RESOURCES ASSESSMENT FOR THE EASTERN MEDITERRANEAN SEA

FINAL REPORT

Prepared for:
Department of the Navy
Commander, U.S. Atlantic Fleet

Naval Facilities Engineering Command

Contract Number: N62470-02-D-9997
Task Order Number: 0080

JANUARY 2008

Naval Facilities Engineering Command, Atlantic
Attn: Mr. Joel Bell, Code EV52JB
6506 Hampton Boulevard, Buildiing B
Norfolk. VA 23508-1278
Joel.T.Bell@navy.mil

Prepared by:
Geo-Marine, Inc.
2201 K Avenue, Suite A2
Plano, TX 75074

STATEMENT OF PURPOSE

The Navy Commander, United States (U.S.) Atlantic Fleet (COMLANTFLT) implemented the Marine Resources Assessment (MRA) Program to establish a comprehensive source of information (which could include published information and consultations with regional and/or subject matter experts) concerning the protected and managed resources found in the Study Area. The information found within a MRA is vital for environmental planning and for use in environmental compliance documentation. A MRA is not intended to be used in the place of a National Environmental Policy Act (NEPA) document. Marine Resources Assessments are reviewed by subject matter experts familiar with the region.

This page intentionally left blank

EXECUTIVE SUMMARY

The Department of the Navy (DoN) is committed to demonstrating environmental stewardship while executing its national defense mission. The United States (U.S.) Navy is responsible for compliance with a suite of federal environmental and natural resources laws and regulations that apply to the marine environment, including the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), the Marine Plastic Pollution Research and Control Act (MPPRCA), Executive Order (EO) 12114 on Environmental Effects Abroad of Major Federal Actions and EO 13089 on Coral Reef Protection. The Navy Commander in Chief, U.S. Atlantic Fleet (COMLANTFLT) implemented the marine resources assessment (MRA) program to develop a comprehensive compilation of data and literature concerning the protected and managed marine resources found in its various operating areas (OPAREAs) and Study Areas. The information in this MRA is vital for planning purposes and for various types of environmental documentation such as biological and environmental assessments that must be prepared in accordance with the NEPA, MMPA, and ESA.

This MRA documents and describes the marine resources that occur in the eastern Mediterranean Study Area (**Figure ES-1**). An overview of the marine environment in the Strait of Sicily and the Ionian and Levantine basins within the eastern Mediterranean Study Area illustrates the important physical parameters that may affect the occurrence and distribution of protected and managed marine species. Detailed information is included on the characteristics and life history of protected marine mammals and sea turtles that may occur in the eastern Mediterranean Study Area. Seasonal variations in protected species occurrence patterns have been identified, mapped, and described along with the likely associated factors (behavioral, climatic, or oceanographic).

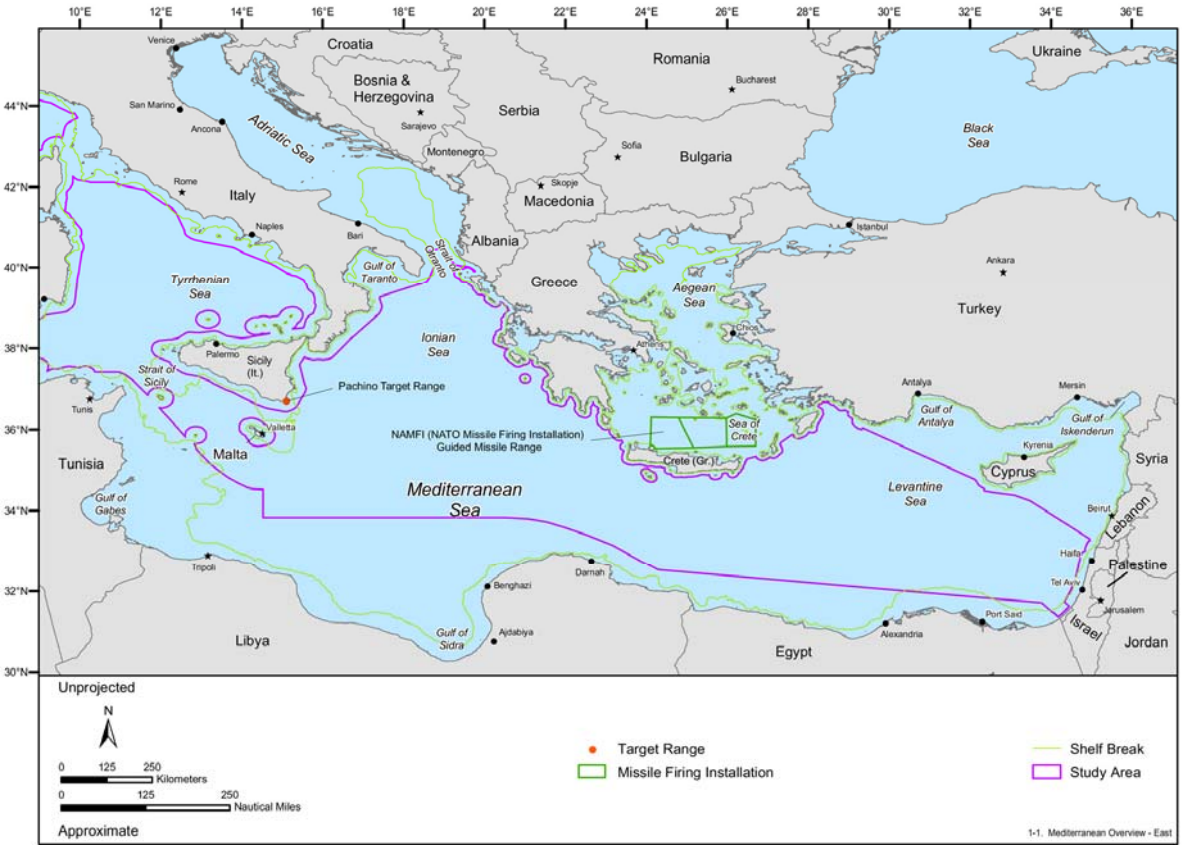


Figure ES-1. The eastern Mediterranean Study Area is located in the eastern Mediterranean Sea including the Strait of Sicily and the Ionian and Levantine Seas. The Study Area includes NATO Missile Firing Installation (NAMFI) and Pachino Target Range. Source data: DoN (1998).

The probable distributions of marine communities such as seagrasses, rocky reefs, and maërl beds have been assessed and mapped. Oceanic habitats including artificial structures, deep-sea corals, and chemosynthetic communities are also described and mapped. An overview of the fish assemblages associated with the waters of the eastern Mediterranean Study Area along with the commercial fishing activities are reviewed, their occurrences noted, and highly migratory fish species spawning and fishing grounds mapped. The International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of threatened marine mammals, turtles, highly migratory fish (i.e., bluefin tuna, swordfish), and shark species are briefly discussed in terms of location and prevalence in the Study Area. Finally, information and mapping is provided on additional considerations that may potentially impact Navy activities in the Study Area. These include maritime boundaries, major trade routes/seaports, navigable waterways, marine protected areas (MPAs), and oil and gas structures within the Eastern Mediterranean Study Area.

Thorough and systematic literature and data searches were conducted to provide as much relevant information as possible for this assessment. Sighting, stranding, and incidental fisheries bycatch data for marine mammals and sea turtles were compiled and interpreted to predict the occurrence patterns in the eastern Mediterranean Study Area for these protected and managed species. Nesting data for sea turtles were also collected for interpretation of occurrence patterns. Predictions of the areas of occurrence for marine mammals and sea turtles are based on available occurrence data (e.g., sighting, stranding, and bycatch records) as well as scientific literature and expert opinion.

The geographical representation of marine resources in the eastern Mediterranean Study Area is a major constituent of this MRA. A geographic information system (GIS) was used to store, manipulate, analyze, and display the spatial data and information accumulated for the eastern Mediterranean Study Area. Over 50 GIS-generated map figures are included in this assessment; data layers associated with these maps comprise bathymetry, sea surface temperature (SST), protected and managed species' occurrences, and maritime boundaries in addition to many others. Metadata (documentation of the GIS data) were also prepared for each GIS file associated with this MRA report. The MRA report for the eastern Mediterranean Study Area is provided in both paper and electronic form.

REPORT ORGANIZATION

This report consists of nine chapters and three appendices:

Chapter 1 Introduction—provides background information on this project, an explanation of its purpose and need, a review of relevant environmental legislation, and a description of the methodology used in the assessment;

Chapter 2 Physical Environment—describes the natural environment of the eastern Mediterranean Study Area including the climate/weather, marine geology (physiography, bathymetry, and bottom sediments), chemical oceanography (surface temperature and salinity), physical oceanography (hydrography, circulation, currents, thermocline, upwelling, and tides), and biological oceanography (plankton: primary and secondary productivity);

Chapter 3 Species of Concern—covers protected marine mammals and sea turtles found in the eastern Mediterranean Study Area, with detailed narratives of their morphology, status, habitat preferences, distribution, behavior, life history, acoustics, and hearing;

Chapter 4 Habitat—discusses habitat complexity: benthic (e.g., seagrass beds, maërl beds, rocky reefs, shallow-water and deep-sea corals, and chemosynthetic communities) and artificial (e.g., artificial reefs, fish aggregating devices (FADs), buoys and moorings, offshore platforms, sea-cage farms, and shipwrecks);

Chapter 5 Fish and Fisheries—investigates fish assemblages (distribution, spawning, and habitats) and commercial fishing activities for managed species that occur within the eastern Mediterranean Study Area;

Chapter 6 Additional Considerations—provides information on maritime boundaries, major trade routes/seaports, navigable waterways, marine protected areas (MPAs), and oil and gas structures;

Chapter 7 Recommendations—suggests future avenues of research that are necessary to fill the data gaps identified in this project and prioritizes research needs within a cost/benefit approach;

Chapter 8 List of Preparers—lists all individuals who helped prepare the eastern Mediterranean Study Area MRA report;

Chapter 9 Glossary—includes definitions of the terms used in the MRA report;

Appendix A—contains source information for marine mammal and sea turtle data, data confidence levels, and map projection information used in this MRA;

Appendix B—contains marine mammal occurrence maps discussed in Chapter 3.1; and

Appendix C—contains sea turtle occurrence maps discussed in Chapter 3.2.

LITERATURE CITED

DoN (Department of the Navy). 1998. Fleet training area/range directory. Naval Warfare Assessment Station.

This page intentionally left blank

ACKNOWLEDGMENTS

We are grateful to the many people who provided scientific data, literature, and information needed for this assessment.

Thanks to Mr. Kelly Smith (IHS Energy) for providing oil platform data, Dr. Helmut Zibrowius for coral reef data, and Dr. Chris Jenkins for bottom substrate data for the Mediterranean Sea.

We are especially grateful to the personnel with the NATO Undersea Research Centre (NURC) for providing recent shipboard survey data in the Mediterranean Sea. In particular, we'd like to acknowledge the efforts of Ms. Angela D'Amico, Dr. Colin MacLeod, Mr. Iain Kerr, Mr. Marc Webber, Dr. Carlos Carreras, Dr. Brandon Southall, Dr. Ron Kastelein, Dr. Dimitris Margaritoulis, Dr. Giovanni Bearzi, Dr. Paolo Casale, Dr. Robert Kenney, Mr. Renaud de Stephanis, Dr. Moira Brown, Dr. Randall Reeves, Dr. Jonas Teilmann, Dr. Stefania Gaspari, Dr. Bruce Mate, Ms. Barbara Lagerquist, Mr. Greg Donovan, Dr. Amy Knowlton, Dr. Michela Podesta, Dr. Nils Øien, Dr. Brian Hutchinson, Dr. Scott Eckert, Mr. Jesus Tomás, Ms. Lorna Patrick, Dr. Oz Goffman, Dr. Jaume Forcada, the United Kingdom Hydrographic Office, Oceanus, Centro Studi Cetacei, Ms. Sonja Kromann (NMFS-NMML), Ms. Debra Losey (NMFS-SWFSC), Dr. Mike James, and Dr. Robin Baird.

Finally, we would like to thank Dr. Giuseppe Notarbartolo di Sciara, Dr. Thomas Jefferson, Ms. Giulia Mo, and Dr. Ertan Taskavak for their technical review of and assistance with the protected species chapter of this MRA.

This page intentionally left blank

TABLE OF CONTENTS

Page

STATEMENT OF PURPOSE

EXECUTIVE SUMMARY ES-1

ACKNOWLEDGMENTS

LIST OF FIGURES vii

LIST OF TABLES ix

LIST OF ACRONYMS AND ABBREVIATIONS xi

1.0 INTRODUCTION 1-1

1.1 PURPOSE AND NEED 1-1
1.2 LOCATION OF THE EASTERN MEDITERRANEAN SEA 1-1
1.3 APPLICABLE LEGISLATION 1-3
1.3.1 Federal Resource Laws 1-3
1.3.2 Executive Orders and Presidential Proclamations 1-6
1.3.3 International Environmental Protection 1-6
1.3.4 Navy Compliance 1-7
1.4 METHODOLOGY 1-8
1.4.1 Literature and Data Search 1-8
1.4.2 Spatial Data Representation—Geographic Information System 1-9
1.4.2.1 Maps of the Physical Environment—Oceanography 1-10
1.4.2.2 Biological Resource Maps—Species of Concern 1-12
1.4.2.3 Habitat Maps 1-13
1.4.2.4 Biological Resource Maps—Fish and Fisheries 1-13
1.4.2.5 Maps of Additional Considerations 1-13
1.4.2.6 Metadata 1-13
1.4.3 Limitations of Marine Survey Sighting Data 1-13
1.4.4 Limitations of Stranding Data 1-14
1.5 REPORT ORGANIZATION 1-15
1.6 WEBSITES ACCESSED 1-15
1.7 LITERATURE CITED 1-16

2.0 PHYSICAL ENVIRONMENT OF THE EASTERN MEDITERRANEAN STUDY AREA 2-1

2.1 INTRODUCTION 2-1
2.2 CLIMATE/WEATHER 2-1
2.2.1 Seasons 2-3
2.2.2 Air Temperature 2-3
2.2.3 Atmospheric Circulation 2-4
2.2.4 Precipitation 2-5
2.2.5 Storms 2-7
2.2.6 Large-Scale Climactic Influences 2-7
2.2.6.1 North Atlantic Oscillation 2-7
2.2.6.2 Climate Change 2-8
2.3 MARINE GEOLOGY 2-9
2.3.1 Geologic Setting 2-9
2.3.2 Physiography and Bathymetry 2-9
2.3.2.1 Strait of Sicily 2-11
2.3.2.2 Ionian Basin 2-11
2.3.2.3 Levantine Basin 2-13
2.3.2.4 Adriatic Basin 2-13
2.3.2.5 Aegean Basin 2-13

TABLE OF CONTENTS
(continued)

Page

2.3.3 Bottom Substrate 2-14
2.4 CHEMICAL OCEANOGRAPHY 2-14
2.4.1 Hydrography 2-14
2.4.1.1 Sea Surface Temperature 2-14
2.4.1.2 Salinity 2-14
2.5 PHYSICAL OCEANOGRAPHY 2-17
2.5.1 General Circulation 2-17
2.5.1.1 Strait of Sicily 2-17
2.5.1.2 Ionian Sea 2-17
2.5.1.3 Levantine Sea 2-19
2.5.1.4 Adriatic Sea 2-19
2.5.1.5 Aegean Sea 2-20
2.5.2 Thermocline 2-20
2.5.3 Upwelling Centers 2-20
2.5.3.1 Ionian Sea 2-20
2.5.3.2 Aegean Sea 2-20
2.5.3.3 Levantine Sea 2-21
2.5.4 Tides 2-21
2.6 BIOLOGICAL OCEANOGRAPHY 2-21
2.6.1 Primary Production 2-21
2.6.1.1 Phytoplankton 2-22
2.6.1.2 Phytoplankton of the Eastern Mediterranean Sea 2-22
2.6.1.3 Chemosynthesis 2-24
2.6.2 Secondary Production 2-25
2.6.2.1 Zooplankton 2-25
2.6.2.2 Zooplankton of the Eastern Mediterranean Sea 2-25
2.7 WEBSITES ACCESSED 2-26
2.8 LITERATURE CITED 2-26

3.0 SPECIES OF CONCERN 3-1

3.1 MARINE MAMMALS 3-3
3.1.1 Introduction 3-3
3.1.1.1 Adaptations to the Marine Environment: Sound Production and Reception 3-3
3.1.1.2 Marine Mammal Distribution and Habitat Associations 3-4
3.1.2 Marine Mammals of the Eastern Mediterranean Study Area 3-7
3.1.2.1 Threatened and Endangered Marine Mammals of the Eastern Mediterranean Study Area 3-9
- North Atlantic Right Whale (*Eubalaena glacialis*) 3-10
- Humpback Whale (*Megaptera novaeangliae*) 3-16
- Sei Whale (*Balaenoptera borealis*) 3-20
- Fin Whale (*Balaenoptera physalus*) 3-22
- Sperm Whale (*Physeter macrocephalus*) 3-26
- Mediterranean Monk Seal (*Monachus monachus*) 3-32

3.1.2.2 Non-Threatened and Non-Endangered Marine Mammal Species of the Eastern Mediterranean Sea Operating Area (OPAREA) 3-36
- Common Minke Whale (*Balaenoptera acutorostrata*) 3-36
- Dwarf Sperm Whale (*Kogia sima*) 3-38
- Cuvier's Beaked Whale (*Ziphius cavirostris*) 3-40
- Northern Bottlenose Whale (*Hyperoodon ampullatus*) 3-45
- Rough-toothed Dolphin (*Steno bredanensis*) 3-46

TABLE OF CONTENTS
(continued)

Page

- Common Bottlenose Dolphin (*Tursiops truncatus*) 3-48
- Striped Dolphin (*Stenella coeruleoalba*) 3-53
- Short-beaked Common Dolphin (*Delphinus delphis*) 3-55
- Indo-Pacific Humpback Dolphin (*Sousa chinensis*) 3-58
- Risso's Dolphin (*Grampus griseus*) 3-59
- False Killer Whale (*Pseudorca crassidens*) 3-61
- Killer Whale (*Orcinus orca*) 3-63
- Long-finned Pilot Whale (*Globicephala melas*) 3-65
- Harbor Porpoise (*Phocoena phocoena*) 3-67

3.1.3 Websites Accessed 3-70
3.1.4 Literature Cited 3-70
3.2 SEA TURTLES 3-119
3.2.1 Introduction 3-119
3.2.2 Sea Turtle Life History 3-119
3.2.3 Sea Turtle Distribution and Behavior 3-120
3.2.4 Sea Turtle Sensory Adaptations 3-121
3.2.5 Sea Turtles of the Mediterranean Sea 3-122
- Leatherback Turtle (*Dermochelys coriacea*) 3-123
- Loggerhead Turtle (*Caretta caretta*) 3-126
- Green Turtle (*Chelonia mydas*) 3-136
- Hawksbill Turtle (*Eretmochelys imbricata*) 3-141
- Kemp's Ridley Turtle (Lepidochelys kempii) 3-144

3.2.6 Website Accessed 3-147
3.2.7 Literature Cited 3-147

4.0 HABITATS OF THE EASTERN MEDITERRANEAN STUDY AREA 4-1

4.1 INTRODUCTION 4-1
4.2 HABITAT REGIONS 4-3
4.2.1 Continental Shelf 4-3
4.2.2 Continental Slope 4-4
4.2.3 Continental Rise and Abyssal Plain 4-5
4.3 BENTHIC BIOLOGICAL RESOURCES 4-7
4.3.1 Seagrass Beds 4-7
4.3.2 Maërl Beds 4-13
4.3.3 Rocky Reefs 4-14
4.3.4 Shallow-Water Corals 4-19
4.3.5 Deep-Sea Corals 4-20
4.3.6 Chemosynthetic Communities 4-24
4.3.6.1 Hydrothermal Vents 4-24
4.3.6.2 Cold Seeps 4-26
4.3.6.3 Gas Hydrates 4-27
4.3.6.4 Whale Falls 4-27
4.3.6.5 Mud Volcanoes 4-27
4.3.6.6 Deep Hypersaline Anoxic Basins 4-28
4.4 ARTIFICIAL HABITATS 4-29
4.4.1 Artificial Reefs 4-30
4.4.2 Fish Aggregating Devices 4-32
4.4.3 Buoys and Moorings 4-32
4.4.4 Offshore Platforms 4-33
4.4.5 Sea-Cage Farms 4-33
4.4.6 Shipwrecks 4-34

TABLE OF CONTENTS
(continued)

Page

4.5 WEBSITES ACCESSED 4-34
4.6 LITERATURE CITED 4-34

5.0 FISH AND FISHERIES 5-1

5.1 FISH/INVERTEBRATES 5-1
5.1.1 Distribution 5-1
5.1.2 Spawning 5-3
5.1.3 Fisheries 5-7
5.2 HABITATS 5-8
5.3 FISHERIES RESOURCES 5-10
5.3.1 Introduction 5-10
5.3.1.1 Fisheries Management 5-11
5.3.1.2 Subsidiary Measures 5-14
5.3.1.3 Fishing Gears 5-17
5.3.1.4 Fishing Fleets 5-18
5.3.2 Commercial Fisheries 5-18
5.3.2.1 Italy 5-19
5.3.2.2 Malta (GSA 16) 5-21
5.3.2.3 Greece 5-21
5.3.2.4 North Levant (GSA 24) and Cyprus (GSA 25) 5-22
5.3.2.5 Gulf of Hammamet (GSA 13), Gulf of Gabes (GSA 14), Tripoli (GSA 14bis), Gulf of Sirt (GSA 21), Gabel Akhdar (GSA 21bis), South Levant (GSA 26), and Levant (GSA 27) 5-23
5.3.3 Recreational Fisheries 5-23
5.4 WEBSITES ACCESSED 5-24
5.5 LITERATURE CITED 5-24

6.0 ADDITIONAL CONSIDERATIONS 6-1

6.1 MARITIME BOUNDARIES 6-1
6.1.1 Territorial Seas 6-5
6.1.2 Exclusive Economic Zone 6-5
6.1.3 Exclusive Fishing Zone 6-5
6.1.4 Continental Shelves 6-5
6.2 MAJOR TRADE ROUTES AND SEAPORTS 6-6
6.2.1 Ports 6-6
6.2.2 Oil-traffic 6-9
6.3 MARINE PROTECTED AREAS 6-9
6.3.1 Marine Protected Area Designations 6-10
6.3.2 International and Regional Initiatives relating to Marine Protected Areas 6-10
6.3.3 Marine Protected Areas in the Eastern Mediterranean Study Area 6-12
6.4 OIL AND GAS STRUCTURES 6-26
6.5 WEBSITES ACCESSED 6-33
6.6 LITERATURE CITED 6-33

7.0 RECOMMENDATIONS 7-1

7.1 MARINE RESOURCES ASSESSMENTS 7-1
7.2 ENVIRONMENTAL DOCUMENTATION 7-3
7.3 LITERATURE CITED 7-6

8.0 LIST OF PREPARERS 8-1

9.0 GLOSSARY 9-1

TABLE OF CONTENTS
(continued)

Page

APPENDICES

APPENDIX A INTRODUCTION

APPENDIX B MARINE MAMMALS

APPENDIX C SEA TURTLES

This page intentionally left blank

LIST OF FIGURES

No.		Page
1-1	The eastern Mediterranean Study Area is located in the eastern Mediterranean Sea eastward of the Strait of Sicily	1-2
2-1	3D bathymetry of the eastern Mediterranean Sea	2-2
2-2	2D bathymetry of the eastern Mediterranean Sea	2-10
2-3	Geologic features of the eastern Mediterranean Sea	2-12
2-4	Distribution of bottom substrates in the eastern Mediterranean Sea	2-15
2-5	SST of the eastern Mediterranean Sea during the summer (29 May through 15 November) and winter (16 November through 28 May)	2-16
2-6	Regional surface circulation of the eastern Mediterranean Sea	2-18
2-7	Seasonal distribution of chlorophyll throughout the eastern Mediterranean Sea during the summer (29 May through 15 November) and winter (16 November through 28 May)	2-23
3-1	Current knowledge of the migration pathways of North Atlantic right whales	3-14
3-2	Current knowledge of the migration pathways of humpback whales in the North Atlantic Ocean	3-18
3-3	Known major and minor nesting areas for the loggerhead turtle in the Mediterranean Study Area	3-131
3-4	Known major and minor nesting areas for the green turtle in the Mediterranean Study Area	3-138
4-1	The benthic habitat regions of the eastern Mediterranean Sea including abyssal plain, continental rise, continental slope, and continental shelf	4-2
4-2	Seagrass and maërl bed habitat locations in the eastern Mediterranean Sea.	4-8
4-3	Distribution of rocky reefs and deep-water corals in the eastern Mediterranean Sea	4-9
4-4	Chemosynthetic habitats of the eastern Mediterranean Sea including the locations of mud volcanoes, deep hyper saline anoxic basins, gas hydrates, cold seeps, and hydrothermal vents.	4-11
4-5	Artificial substrates located in the eastern Mediterranean Sea, including artificial reefs, shipwrecks, fish aggregating devices, moored buoys, drifting buoys, and offshore platforms	4-31
5-1	Major spawning and juvenile areas of the bluefin tuna in the eastern Mediterranean Study Area.	5-4
5-2	Major spawning and juvenile areas of the albacore tuna in the eastern Mediterranean Study Area.	5-5
5-3	Major spawning and juvenile areas of the swordfish in the eastern Mediterranean Study Area.	5-6
5-4	New Mediterranean bluefin tuna fishing grounds and routes of live transferred bluefin tuna to offshore tuna ranches.	5-12
5-5	Geographical Sub-areas (GSAs) within the Food and Agriculture Organization (FAO) Area 37.	5-15
6-1	A generalized 3D depiction of maritime boundaries, including territorial sea, contiguous zone, exclusive fishing zone, EEZ, and continental shelf	6-1
6-2	Maritime boundaries in the eastern Mediterranean Study Area and vicinity	6-3
6-3	Ferry routes of the eastern Mediterranean Study Area and vicinity	6-7
6-4	Commercially navigable waterways of European oil maritime transport and amount transported as of 2004 in the eastern Mediterranean Study Area and vicinity	6-8
6-5	Marine protected areas in the eastern Mediterranean Study Area and vicinity	6-23
6-6	Proposed marine protected areas in the eastern Mediterranean Study Area and vicinity	6-25

LIST OF FIGURES
(continued)

No. **Page**

7-1 Areas in which there have been no dedicated cetacean research efforts within the eastern Mediterranean Sea 7-5

LIST OF TABLES

No. **Page**

1-1 The federally protected marine mammal and sea turtle species with known or potential occurrence in the Mediterranean Study Area and surrounding region 1-5

2-1 Monthly mean and extreme air temperatures from 1995 through May 2005 at five sites located near the study area in the eastern Mediterranean basin 2-4
2-2 Monthly mean and extreme precipitation totals from 1995 through May 2005 at five sites located near the study area in the eastern Mediterranean basin 2-6

3-1 Marine mammal species with known or potential occurrence in the Mediterranean Study Area 3-11
3-2 Sea turtle species of the Mediterranean Study Area 3-123
3-3 Nesting status of the loggerhead turtle in the Mediterranean Study Area 3-133
3-4 Nesting status of the green turtle in the Mediterranean Study Area 3-139

4-1 Common flora and fauna on rocky reefs in the Mediterranean Sea (Cocito et al. 2000; Cebrián and Ballesteros 2004) 4-16
4-2 Common fish species associated with rocky reefs high in algal cover in the Mediterranean Sea 4-17
4-3 Percentage distribution of sparid juveniles per microhabitat (0 to 15 m water depth) in the Mediterranean Sea 4-18
4-4 Invertebrates and fishes (recorded in the Ionian Sea) that can be found associated with the 3D habitat formed by *Lophelia pertusa*, *Madrepora oculata*, and *Desmophyllum dianthus* 4-22

5-1 Sharks incidentally taken as bycatch in swordfish and tuna fisheries operating in the Mediterranean Sea 5-8
5-2 Fish and invertebrate species found in the continental shelf/slop and bathyal/abyssal habitats within the Mediterranean Sea 5-9
5-3 Prioritized commercial fish and invertebrate species in the Mediterranean Sea 5-16
5-4 Fisheries in the Strait of Sicily (GSA 16) 5-20

6-1 The maritime boundaries of the Mediterranean Sea and their seaward and jurisdictional extents 6-2
6-2 Claims to maritime jurisdiction by the states bordering the eastern Mediterranean Sea 6-4
6-3 Marine protected areas in the eastern Mediterranean Study Area 6-12
6-4 Oil platforms in the eastern Mediterranean Sea 6-26

7-1 Suggested expert reviewers for the eastern Mediterranean MRA 7-2

This page intentionally left blank

LIST OF ACRONYMS AND ABBREVIATIONS

%	Percent
°	Degree(s)
°C	Degree(s) Celsius
µm	Micron(s)
µsec	Microsecond(s)
2D	Two-dimensional
3D	Three-dimensional
ABR	Auditory Brainstem Response
ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area
AD	Anno Domini
ADRIAMED	Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea
AEP	Auditory Evoked Potential
AIS	Atlantic Ionian Stream
APPS	Act to Prevent Pollution from Ships
ARION	Cetacean Rescue and Rehabilitation Research Society
ASCI	Area of Special Conservation Interest
ASSI	Area of Special Scientific Interest
ATC	Atlantic Tunisian Current
AVHRR	Advanced Very High-resolution Radiometer
bbl/d	Barrels Per Day
BLM	Bureau of Land Management
blow(s)/min	Blow(s) Per Minute
BR	Biosphere Reserves
ca.	Circa
CAD	Computer-aided Design
CBA	Capture-Based Aquaculture
CCC	Caribbean Conservation Corporation
CCL	Curved Carapace Length
CEBC-CNRS	Le Centre d'Études Biologiques de Chizé-Centre National de la Recherche Scientifique
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	Methane
chl *a*	Chlorophyll *a*
CIESM	International Commission for Scientific Exploration of the Mediterranean Sea
CIHEAM	Centre International de Hautes Etudes Agronomiques Mediterranneenes
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
click(s)/sec	Click(s) Per Second
cm	Centimeter(s)
CNO	Chief of Naval Operations
CO_2	Carbon Dioxide
COM	Commission of the European Communities
COMLANTFLT	Commander, Atlantic Fleet
COPEMED	Cooperacion Pesca Mediterraneo
CPUE	Catch Per Unit Effort
CR	Critically Endangered
CRMM	Centre de Recherche sur les Mammifères Marins, La Rochelle
CSC	Centro Studi Cetacei
CT	Computerized Tomography
CZCS	Coastal Zone Color Scanner

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

dB	Decibel(s)
dB re: 1 µPa	Decibels at the Reference Level of One Micropascal
dB re: 1 µ Pa-m	Decibels at the Reference Level of One Micropascal at One Meter
dB re: 1 $\mu Pa^2 s$	Decibels at the Reference Level of One Micropascal-Squared Second
DCM	Deep Chlorophyll Maximum
DD	Data Deficient
DHAB	Deep Hypersaline Anoxic Basin
DNA	Deoxyribonucleic Acid
DoD	Department of Defense
DoE	Department of Energy
DoI	Department of the Interior
DoN	Department of the Navy
DSL	Deep Scattering Layer
dyn/cm^2	Dynes per Square Centimeter
E	East
EA	Environmental Assessment
EAWR	Eastern Atlantic Western Russia
EC	European Commission or European Community
EEA	European Environmental Agency
EEB	European Environmental Bureau
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFZ	Exclusive Fishing Zone
EIS	Environmental Impact Statement
EMDW	Eastern Mediterranean Deep Water
EMT	Eastern Mediterranean Transient
EN	Endangered
EO	Executive Order
EPM	European Program of the Mediterranean
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute, Inc.
ETP	Eastern Tropical Pacific
EU	European Union
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization
FM	Frequency-modulated
FoC	Flag of Convenience
FR	Federal Register
gC/yr	Gram(s) of Carbon Per Year
g dry $wt/m^2/yr$	Gram(s) of Dry Weight Per Square Meter Per Year
GFCM	General Fisheries Commission for the Mediterranean
GIS	Geographic Information System
GMI	Geo-Marine, Inc.
GPS	Global Positioning System(s)
GREC	Groupe de Recherche sur les Cétacés
GRT	Gross Registered Ton
GRUMM	Grupo de Estudio y Conservacion de Mamiferos Marinos
GRUND	Gruppo Nazionale Risorse Demersali
GSA	Geographic Sub-areas
ha	Hectare(s)
HEMR	Hellenic Centre for Marine Research
hr(s)	Hour(s)
H_2S	Hydrogen Sulfide

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

HTML	Hyper Text Markup Language
Hz	Hertz
ICBIBE	University of Valencia's Cavanilles Biodiversity Institute
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICCAT-SCRS	International Commission for the Conservation of Atlantic Tunas-Standing Committee on Research and Statistics
ICES	International Council for the Conservation of the Sea
ICRAM	Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare
IFAW	International Fund for Animal Welfare
IMBC	Institute of Marine Biology of Crete
IMO	International Maritime Organization
IUCN	International Union for Conservation of Nature and Natural Resources
IUCN-SSC	International Union for Conservation of Nature and Natural Resources-Species Survival Commission
IUU	Illegal, Unreported, and Unregulated
IWC	International Whaling Commission
kg	Kilogram(s)
kHz	Kilohertz
km	Kilometer(s)
km^2	Square Kilometer(s)
km^3	Cubic Kilometer(s)
km/hr	Kilometer(s) Per Hour
LIW	Levantine Intermediate Water
LR/NT	Lower Risk/Near Threatened
m	Meter(s)
m^2	Square Meter(s)
m^3	Cubic Meter(s)
m/day	Meter(s) Per Day
m/sec	Meter(s) Per Second
m/yr	Meter(s) Per Year
MAB	Man and the Biosphere Program
MAP	Mediterranean Action Plan
MARPOL	International Convention for the Prevention of Pollution from Ships
MBRC	Marine Biology Research Centre Tajura, Libya
MEDACES	Mediterranean Database of Cetacean Strandings
MEDASSET	Mediterranean Association to Save the Sea Turtles
MEDITS	Mediterranean Trawl Survey
MedPAN	Mediterranean Marine Protect Area
MEDSAP	Special Action Program for the Mediterranean
MEDSUDMED	Assessment and Monitoring of Fishery Resources and Ecosystems in the Strait of Sicily
METAP	Mediterranean Environmental Technical Assistance Program
mg	Milligram(s)
mg/m^3	Milligram(s) Per Cubic Meter(s)
$mgC/m^2/d$	Milligram(s) of Carbon Per Square Meter(s) Per Day
mi	mile(s)
min	Minute(s)
ML	Maximum Likelihood
mm	Millimeter(s)
mm/day	Millimeter(s) Per Day
mm/yr	Millimeter(s) Per Year
MMA	Ministerio de Medio Ambiente (Spanish Ministry of Environment)
MMC	Marine Mammal Commission

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MOm	Hellenic Society for the Study and Protection of the Monk Seal
MPA	Marine Protected Area
MPPRCA	Marine Plastic Pollution Research and Control Act
MR	Marine Reserve
MRA	Marine Resources Assessment
msec	Millisecond(s)
mt	Metric Ton(s)
MTSG	Marine Turtle Specialist Group
MVP	Multi-Purpose Vessel
n	Number (sample size)
N	North
NAMFI	North Atlantic Treat Organization Missile Firing Installation
NAO	North Atlantic Oscillation
NASA	National Aeronautic and Space Administration
NASS	North Atlantic Sightings Survey
NATO	North Atlantic Treaty Organization
NCDC	National Climate Data Center
NEMO	Neutrino Mediterranean Observatory
NEPA	National Environmental Policy Act
nest(s)/yr	Nest(s) Per Year
NGO	Nongovernmental Organization
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
NMFS-NMML	National Marine Fisheries Service-National Marine Mammal Laboratory
NMFS-PR	National Marine Fisheries Service-Protected Resources
NOAA	National Oceanic and Atmospheric Administration
NT/LC	Near Threatened/Least Concern
NURC	North Atlantic Treaty Organization Undersea Research Centre
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
ODA	Ocean Dumping Act
OPAREA	Operating Area
OPNAVINST	Office of the Chief of Naval Operations Instruction
PDF	Portable Document Format
PI	Principal Investigator
PINS	Padre Island National Seashore
POM	Particulate Organic Matter
PSSA	Particularly Sensitive Sea Area
psu	Practical Salinity Unit(s)
RAC/SPA	Regional Activity Centre for Specially Protected Areas
RFMO	Regional Fisheries Management Organization
REMPEC	Regional Marine Pollution Emergency Response Centre
rms	Root Mean Square
S	South
SAC	Scientific Advisory Committee or Special Area of Conservation
SACLANT	Supreme Allied Commander, Atlantic
SAD-AFAG	Underwater Research Society-Mediterranean Seal Research Group
SAR	Stock Assessment Report
SCL	Straight Carapace Length
SCUBA	Self Contained Underwater Breathing Apparatus
S.D.	Standard Deviation

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

sec	Second(s)
SECNAVINST	Secretary of the Navy Instruction
SEL	Sound Exposure Level
SH	Sensitive Habitats
SOSUS	Sound Surveillance System
sp.	Species
SPA	Special Protection Area
SPAMI	Specially Protected Area of Mediterranean Importance
SPAWAR	Space and Naval Warfare Systems Command
spp.	Species (plural)
SSSI	Site of Special Scientific Interest
SST	Sea Surface Temperature
STPS	Sea Turtle Protection Society of Greece
STECF	Scientific Technical and Economic Committee for Fisheries
SWOT	State of the World's Sea Turtles
t/yr	Ton(s) Per Year
TAC	Total Allowable Catch
TEU	Twenty-foot Equivalent Unit
TEWG	Turtle Expert Working Group
TIN	Triangular Irregular Network
TL	Total Length
TTS	Temporary Threshold Shift
U.K.	United Kingdom
U.N.	United Nations
U.S.	United States
U.S.C.	United States Code
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNEP-CBD	United Nations Environment Programme-Convention on Biological Diversity
UNEP-MAP	United Nations Environment Programme-Mediterranean Action Plan
UNEP-WCMC	United Nations Environment Programme-World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USD	United States Dollars
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USSR	Union of the Soviet Socialist Republic
USVI	United States Virgin Islands
UV	Ultraviolet
VU	Vulnerable
W	West
WIDECAST	Wider Caribbean Sea Turtle Conservation Network
WWF	World Wildlife Fund
XML	Extensible Markup Language
YOY	Young-of-the-Year
yr(s)	Year(s)
ZTA	Zevenbergen and Thorne Algorithm

This page intentionally left blank

1.0 INTRODUCTION

The United States (U.S.) Navy Commander, Atlantic Fleet (Fleet) (COMLANTFLT) contracted this Marine Resources Assessment (MRA) to initiate collection of data and information concerning the protected and commercial marine resources found in the eastern Mediterranean Sea. For the purposes of this MRA, the eastern Mediterranean Sea and surrounding region may also be referred to as the "Study Area" or "Study Region." Unless otherwise stated in this report, the extent of coverage lies from the outer boundaries of the Study Area to within 12 nautical miles (NM) of any coastline, except in Greece where the Study Area extends to within 6 NM of the coastline.

1.1 PURPOSE AND NEED

The goal of this MRA is to provide a compilation of the most recent data and information on the occurrence of marine resources in the eastern Mediterranean Study Area. This MRA includes a discussion of the physical environment, oceanic habitats, and species that are found in the Study Area and protected by U.S. federal law. This assessment also addresses fish, fisheries, and other areas and activities of interest that occur in the ocean waters of the eastern Mediterranean Study Area. The identification of data gaps and the prioritization of recommendations for future research in the Study Area are additional components of this report.

The information assembled in this MRA will serve as a baseline from which the U.S. Navy may evaluate its operations and their potential impacts on the marine environment while balancing the requirement to provide trained and ready forces with the obligations of sound resource stewardship. Section 4.1.1 of Department of Defense (DoD) Instruction 4715.3, "Environmental Conservation Program" states that "All DoD conservation programs shall work to guarantee continued access to our land, air, and water resources for realistic military training and testing while ensuring that natural and cultural resources are sustained in a healthy condition for scientific research, education, and other compatible uses by future generations" (DoD 1996). This assessment will contribute to the Fleet's integrated long-range planning process and represents an important component in the Fleet's ongoing compliance with U.S. federal mandates that aim to protect and manage resources in the marine environment. All species and habitats potentially affected by the Navy's maritime exercises and protected by U.S. federal resource laws or Executive Orders (EO) are considered in this assessment.

A search and review of relevant literature and consultations with regional experts were conducted to provide information on important features of the marine environment, the occurrence patterns of protected species, and other Navy concerns in the eastern Mediterranean Study Area. To describe the physical environment and habitats of the Study Area, physiographic, bathymetric, geologic, hydrographic, and oceanographic data were compiled.

Occurrence maps were created for all marine mammal and sea turtle species potentially occurring in the Study Area. The maps were developed from available sighting and habitat data as well as known distributional information (e.g., foraging/breeding ranges). Biological characteristics such as habitat preferences, behaviors, and life history patterns were researched for all federally protected species potentially occurring in the eastern Mediterranean Study Area. Also reviewed were fish species' distribution, spawning, and habitats, commercial and recreational fishing resources, maritime boundaries, major trade routes/seaports, navigable waterways, Marine Protected Areas (MPA), and oil and gas structures.

1.2 LOCATION OF THE EASTERN MEDITERRANEAN SEA

The Mediterranean Sea is bordered by Europe, Asia, and Africa and lies between 45.8 degrees (°) North (N) and 30.2°N latitude and 5.6° West (W) and 36.3° East (E) longitude. Although nearly entirely enclosed, the Mediterranean Sea is linked to the Atlantic Ocean by the Strait of Gibraltar, to the Red Sea via the Suez Canal, and to the Black Sea via the Dardanelles and the Bosporus Strait. The Mediterranean Sea has an average depth of 1,500 meters (m) and is composed of an eastern and a western sub-basin connected by the Strait of Sicily. The Strait of Sicily is located between Sicily, Italy, and Tunisia in

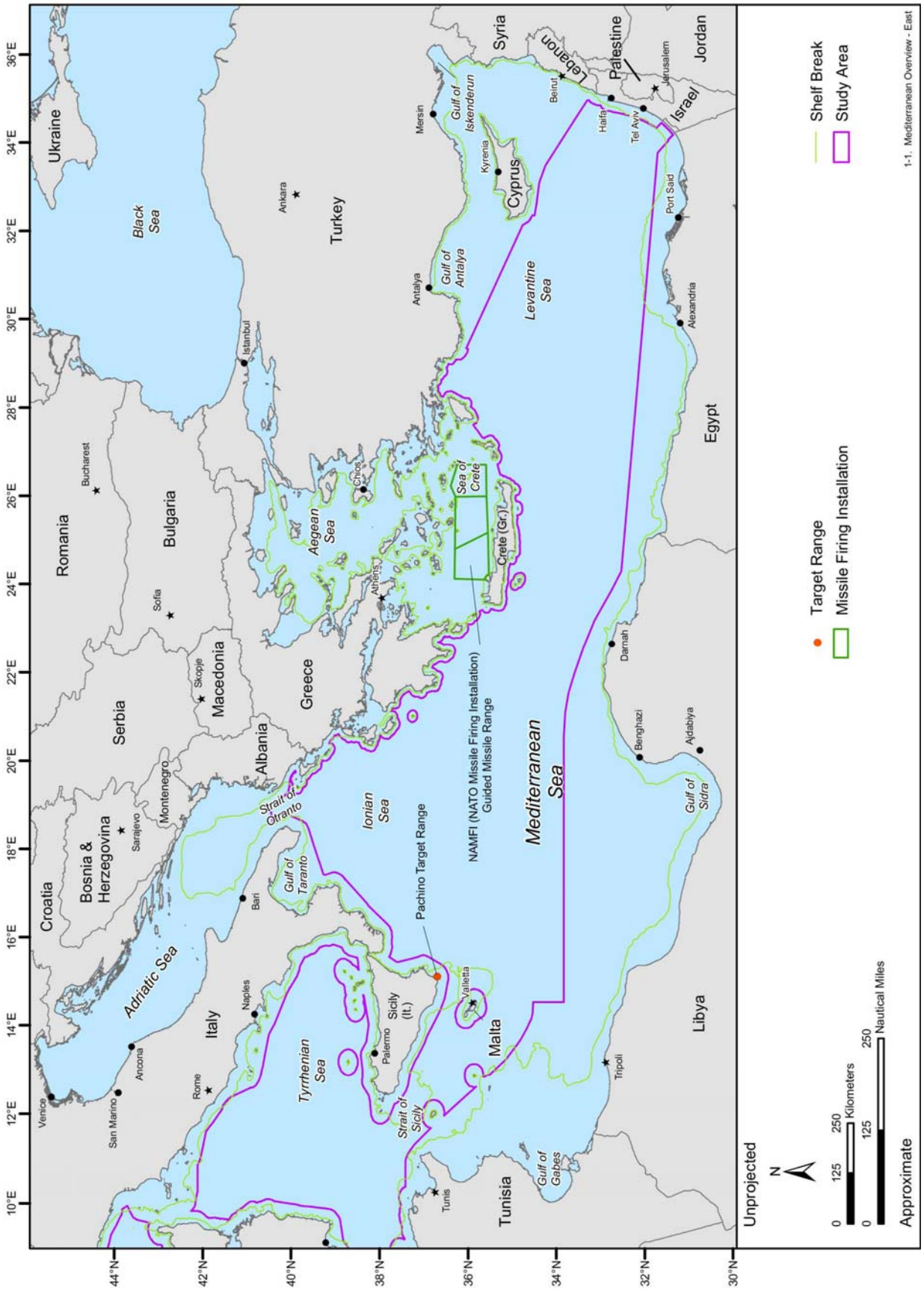


Figure 1-1. The eastern Mediterranean Study Area is located in the eastern Mediterranean Sea eastward of the Strait of Sicily. The Study Area includes NATO Missile Firing Installation (NAMFI) and Pachino Target Range. Source data: DoN (1998).

northern Africa and serves as the demarcation between the western Mediterranean Study Area and the eastern Mediterranean Study Area. The Study Area for the eastern Mediterranean Sea extends eastward from the Strait of Sicily (**Figure 1-1**). Fifteen countries abut the eastern Mediterranean Sea: Tunisia, Italy, Malta, Croatia, Bosnia and Herzegovina, Serbia and Montenegro, Albania, Greece, Turkey, Cyprus, Syria, Lebanon, Israel, Egypt, and Libya. Covering approximately 1.65 million square kilometers (km^2) of ocean area, the eastern Mediterranean Study Area includes habitats ranging from 10 m to over 5,400 m in depth. The habitats of the Mediterranean Sea can be defined by three important regions (continental shelf, continental slope, and abyssal plain) that support benthic biological resources such as seagrass beds, maërl beds, rocky reefs, corals, submarine canyons, seamounts, and chemosynthetic communities (hydrothermal vents, mud volcanoes, cold seeps, and deep hyper-saline anoxic basins) as well as several artificial habitats (Fish Aggregation Devices [FADs], artificial reefs, buoys, ship and plane wrecks, offshore platforms, and fish sea cages).

Two important areas for U.S. training operations in the vicinity of the eastern Mediterranean Study Area are the North Atlantic Treaty Organization (NATO) Missile Firing Installation (NAMFI) and the Pachino Target Range (**Figure 1-1)**. The NAMFI is located along the north coast of Crete, Greece near the town of Chania. This training area was established in 1968 as a training facility for Air Defense Systems.[1] The Pachino Target Range is located in Pachino, Italy along the south coast of Sicily, Italy. This training area is a U.S. operated aerial bomb scoring target range and is used by U.S. and NATO forces.[1]

1.3 APPLICABLE LEGISLATION

The primary environmental laws governing Naval activities in the international marine environment are the National Environmental Policy Act (NEPA), Marine Mammal Protection Act (MMPA), and Endangered Species Act (ESA). There are also other federal mandates that govern resource conservation and management in U.S. waters, as well as govern the actions of persons under federal jurisdiction operating outside U.S. waters. U.S. Navy activities abroad may also be impacted by international agreements to which the U.S. is a party or by provisions of international agreements to which the U.S. adheres. The following is a list of the many laws and regulations that the Navy must consider when conducting maritime activities in the eastern Mediterranean Sea.

1.3.1 Federal Resource Laws

- The **National Environmental Policy Act** (NEPA) of 1969 (42 U.S. Code [U.S.C.] §§ 4321 et seq.) established national policies and goals for the protection of the environment. The NEPA aims to encourage harmony between people and the environment, to promote efforts to prevent or eliminate damage to the environment and the biosphere, and to enrich the understanding of ecological systems and natural resources important to the U.S. Thus, environmental factors must be given appropriate consideration in all decisions made by federal agencies.

  The NEPA is divided into two sections: Title I outlines a basic national charter for protection of the environment, while Title II establishes the Council on Environmental Quality (CEQ), which monitors the progress made towards achieving the goals set forth in Section 101 of the NEPA. Other duties of the CEQ include advising the President on environmental issues and providing guidance to other federal agencies on compliance with the NEPA.

  Section 102(2) of the NEPA contains action-forcing provisions that ensure that federal agencies act according to the letter and the spirit of the law. These procedural requirements direct all federal agencies to give appropriate consideration to the environmental effects of their decision-making and to prepare detailed environmental statements on recommendations or reports on proposals for legislation and other major federal actions significantly affecting the quality of the environment.

  Future studies and/or actions requiring federal compliance which may utilize the data contained in this MRA should be prepared in accordance with Section 102(2)(c) of the NEPA, the CEQ regulations on implementing NEPA procedures (40 Code of Federal Regulations [CFR] 1500-1508), and the Department of the Navy (DoN) regulations on implementing NEPA procedures (32 CFR 775).

- The **Marine Mammal Protection Act** (MMPA) of 1972 (16 U.S.C. §§ 1361 et seq.) established a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. Marine mammals as defined by the MMPA are cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees and dugongs), sea otters, and polar bears. The MMPA defines taking as "harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. §§ 1362[13]). It also prohibits the importation into the U.S. of any marine mammal or parts or products thereof, unless it is for the purpose of scientific research or public display, as permitted by the Secretary of the Interior or the Secretary of Commerce. In the 1994 amendments to the MMPA, two levels of "harassment" were defined. Harassment is defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A), or any act that has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B). In 2003, the National Defense Authorization Act for Fiscal Year 2004 altered the MMPA's definition of Level A and B harassment in regards to military readiness and scientific research activities conducted by or on behalf of the federal government. Under these changes, Level A harassment was redefined as any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment was redefined as any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered.

  Section 101(a)(5)(A) of the MMPA directs the Secretary of Commerce, upon request, to authorize the unintentional taking of small numbers of marine mammals incidental to activities (other than commercial fishing) when, after notice and opportunity for public comment, the Secretary: (1) determines that total takes during a 5-year (yr) (or less) period have a negligible impact on the affected species or stock, and (2) prescribes necessary regulations that detail methods of taking and monitoring and requirements for reporting. The MMPA provides that the moratorium on takes may be waived when the affected species or population stock is at its optimum sustainable population and will not be disadvantaged by the authorized takes (i.e., be reduced below its maximum net productivity level). Section 101(a)(5)(A) also specifies that the Secretary has the right to deny permission to take marine mammals if, after notice and opportunity for public comment, the Secretary finds: (1) that applicable regulations regarding taking, monitoring, and reporting are not being followed, or (2) that takes are, or may be, having more than a negligible impact on the affected species or stock.

- The **Endangered Species Act** (ESA) of 1973 (16 U.S.C. §§ 1531 et seq.) established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. Under the ESA, an "endangered" species is a species that is in danger of extinction throughout all or a significant portion of its range, while a "threatened" species is one that is likely to become endangered within the foreseeable future throughout all or in a significant portion of its range. All federal agencies are required to implement protection programs for threatened and endangered species and to use their authority to further the purposes of the ESA. The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) jointly administer the ESA and are also responsible for the listing (i.e., the labeling of a species as either threatened or endangered) of all "candidate" species and "species of concern". A "candidate" species is one that is the subject of either a petition to list or status review, and for which the NMFS or USFWS has determined that listing may be or is warranted (NMFS 2004; NMFS 2006). The NMFS is further charged with the listing of all "species of concern" that fall under its jurisdiction. A "species of concern" is one about which the NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA (NMFS 2004). Species can qualify as both species of concern and candidate species (NMFS 2006).

  A species may be a candidate for listing as a threatened or endangered species due to any of the following five factors: (1) current/imminent destruction, modification, or curtailment of its habitat or range; (2) overuse of the species for commercial, recreational, scientific, or educational purposes; (3)

high levels of disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or human-induced factors affecting its continued existence.

The major responsibilities of the NMFS and USFWS under the ESA include: (1) the identification of threatened and endangered species; (2) the identification of critical habitats for these species; (3) the implementation of research programs and recovery plans for these species; and (4) the consultation with other federal agencies concerning measures to avoid, minimize, or mitigate the impacts of their activities on these species (Section 7 of the ESA). Further duties of the NMFS and USFWS include regulating "takes" of listed species on public or private land (Section 9) and granting incidental take permits to agencies that may unintentionally "take" listed species during their activities (Section 10a).

The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. The physical and biological features essential to the conservation of a threatened or endangered species are included in the habitat designation. Designation of critical habitat affects only federal agency actions and federally funded or permitted activities and can only be designated on lands or in waters under U.S. jurisdiction..

There are 24 marine mammals (21 cetaceans and 3 pinnipeds) and 5 sea turtles with known or potential occurrence in the Mediterranean Study Area. Of these, six marine mammals and five sea turtles are listed as either an endangered or threatened species (**Table 1-1**). Jurisdiction over cetaceans and pinnipeds is vested in the NMFS, as is jurisdiction over sea turtles in the water. The USFWS has jurisdiction over sea turtles while they are on land (including eggs, hatchlings on the beach, and nesting or hauled-out individuals). Outside of U.S. waters, this jurisdiction extends only to the behavior of those persons or agencies subject to U.S. federal law or on territory under U.S. jurisdiction.

Table 1-1. The federally protected marine mammal and sea turtle species with known or potential occurrence in the Mediterranean Study Area and surrounding region.

Taxon Group	Scientific Name	ESA Status
Marine Mammals		
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Mediterranean monk seal	*Monachus monachus*	Endangered
Sea Turtles		
Green turtle	*Chelonia mydas*	Threatened[1]
Hawksbill turtle	*Eretmochelys imbricata*	Endangered
Loggerhead turtle	*Caretta caretta*	Threatened
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered
Leatherback turtle	*Dermochelys coriacea*	Endangered

[1] Although this species as a whole is listed as threatened, the eastern Pacific Ocean nesting stock of the green turtle is listed as endangered.

- The **Marine Plastic Pollution Research and Control Act** (MPPRCA) of 1987 (33 U.S.C. §§ 1901 et seq.) implements the provisions set forth in Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL). The MPPRCA regulates the discharge of contaminants into the ocean by U.S. flag vessels. Under this federal statute, the discharge of any plastic materials (including synthetic ropes, fishing nets, plastic bags, and biodegradable plastics) into the ocean is prohibited. The discharge of other materials, such as floating dunnage, food waste, paper, rags, glass, metal, and crockery, is also regulated by this act. Ships are permitted to discharge

these types of refuse into the water, but they may only do so when beyond a set distance from shore, as prescribed by the MPPRCA. An additional component of this act requires that all ocean-going, U.S. flag vessels greater than 12.2 m in length, as well as all manned, fixed, or floating platforms subject to U.S. jurisdiction, keep records of garbage discharges and disposals.[2]

1.3.2 Executive Orders and Presidential Proclamations

- **EO 12114 on Environmental Effects Abroad of Major Federal Actions** (32 CFR 187) was issued in 1979 to further environmental objectives consistent with U.S. foreign and national security policies by extending the principles of the NEPA to the international stage. Under EO 12114, federal agencies that engage in major actions with the potential to significantly affect the environment outside of U.S. jurisdiction must prepare or consult appropriate documents to determine the effect such actions may have on the environment. These documents may include environmental impact statements (EIS), overseas EISs, relevant bilateral or multilateral environmental studies in which the U.S. is a participant, environmental assessments (EAs), summary environmental analyses, or any other document relevant to the issue at hand. The type of document that must be consulted or prepared is dependent upon where the major federal action is set to take place. Certain actions, such as intelligence activities, disaster and emergency relief actions, and actions that occur in the course of an armed conflict, are exempt from this order. Such exemptions do not apply to major federal actions that significantly affect an environment that is not within any nation's jurisdiction, unless permitted by law. The purpose of the order is to force federal agencies to consider the effects their actions have on international environments.

- **EO 13089 on Coral Reef Protection** (63 Federal Register [FR] 32701) was issued in 1998 "to preserve and protect the biodiversity, health, heritage, and social and economic value of U.S. coral reef ecosystems and the marine environment." This EO directs all federal agencies to protect coral reef ecosystems to the extent feasible and instructs particular agencies to develop coordinated science-based plans to restore damaged reefs as well as mitigate current and future impacts on reefs, both in the U.S. and around the globe (Agardy 2000). This order also establishes the interagency U.S. Coral Reef Task Force, which is co-chaired by the Secretary of the Interior and the Secretary of Commerce through the Administrator of the National Oceanic and Atmospheric Administration (NOAA).

1.3.3 International Environmental Protection

There are a number of international agreements, treaties, conventions and organizations that seek to protect the natural resources and environmental quality of the marine environment outside the jurisdiction of any one nation. The U.S. is a party to many of these agreements and a member of several international organizations, and thus U.S. Navy vessels operating abroad should be aware of their provisions. The following is a limited review of those agreements most relevant to the Mediterranean Study Area.

The United Nations (U.N.) has several groups that deal with environmental resource protection and management on the high seas. The U.N. Environment Programme (UNEP) has a number of secondary groups and programs in various areas of environmental stewardship, all of which strive to protect global natural resources and enable member nations to protect their own natural resources. In the second half of the twentieth century, the U.N. also led a worldwide effort to provide a governance structure for maritime operations, boundary disputes and natural resource protection on the global commons which resulted in the U.N. Convention on the Law of the Sea (UNCLOS). The U.S. has abided by all of the provisions of the UNCLOS since 1994, and many of these provisions have been adopted by the federal government and codified into U.S. federal law. The U.S. is not an official signatory to the UNCLOS, however, as the convention has not been ratified by the Senate.

The International Union for the Conservation of Nature and Natural Resources (IUCN) is an organization of nations, federal agencies and non-governmental organizations that seeks to protect natural resources on a global scale. Two programs developed under the aegis of the IUCN are especially relevant to the

marine environment and international operations. The IUCN created and periodically updates its Red List of Threatened Species, which is a database of taxonomic, conservation, and distribution information of species. The IUCN Red List determines the relative risk of extinction and documents those species that face an increased risk of extinction as well as the factors most commonly thought to promote the risk of extinction for that species. Red List categories are Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened/Least Concern (NT/LC), and Data Deficient (DD).[2] The function of the Red List is much the same as the U.S. ESA, but species not found on the ESA may be identified as at risk for extinction by the Red List. Therefore it is important for U.S. vessels operating abroad to be aware of these designations. The IUCN is also responsible for the development of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The CITES is an agreement between governments to restrict the trade in certain species of wild animals and plants for the purpose of aiding in their conservation. Species listed under the CITES may be traded in a limited manner or not at all across international borders. The U.S. is a party to the CITES.

There are also international bodies that have formed conventions or treaties for the purpose of protecting a specific taxon. The International Whaling Commission (IWC) is made up of member nations who adhere to a global moratorium on taking marine mammals for commercial exploitation. This agreement is codified at the federal level in the MMPA. The International Convention for the Conservation of Atlantic Tunas (ICCAT) is a multi-governmental fishery management organization (under the aegis of the U.N.) that promotes the sustainable use of tunas and related species in the Atlantic Ocean, including the two major spawning grounds of tunas in the North Atlantic Ocean, the Gulf of Mexico, and the Mediterranean Sea. ICCAT member nations are subject to quotas and time-area closures designed to promote conservation of tuna and tuna-like species stocks throughout the Atlantic Ocean. The U.S. is a party to both the IWC and ICCAT.

1.3.4 Navy Compliance

Chapter 22–Environmental Compliance Afloat—of the U.S. Navy's *Environmental and Natural Resources Program Manual* (Office of the Chief of Naval Operations Instruction [OPNAVINST] 5090.1C) applies to U.S. Navy ships and floating drydocks worldwide and, as appropriate, to the boats and other craft carried by these ships (DoN 2007). Chapter 22 lays out Navy policy for environmental stewardship and compliance for its vessels operating both within U.S. waters and abroad. The discharge of waste, including blackwater, graywater, hazardous and medical wastes, plastics and other trash, as well as procedures for oil spill response and ballast water control are included in this chapter along with relevant regulatory drivers. The U.S. Navy is required to comply with U.S. federal policy when operating within U.S. waters or on the high seas. This includes abiding by relevant international agreements to which the U.S. is a signatory or conforming to international agreements if it is the practice of the U.S regardless of whether the U.S. has officially ratified the agreement (e.g., recognition of MARPOL "special areas" or conformity to the provisions of UNCLOS despite the fact that the U.S. is not an official signatory). When operating within foreign territorial waters, Navy vessels are required to conform to the environmental provisions set forth by prior agreement between the U.S. federal government and the government of the foreign nation. Absent such an agreement, U.S. Navy vessels are to conform to the extent practicable to the standards outlined in Chapter 22; where this is not possible, U.S. Navy vessels should follow the example of the foreign nation's warships.

The Navy is required to assess the impacts of its actions both within U.S. waters and abroad per the mandates of the NEPA and EO 12114. The Secretary of the Navy Instruction (SECNAVINST) 5090.6 lays out Navy policy for compliance with this legislation. It is the policy of the Navy to provide for the national defense in a manner consistent with federal environmental policy and to utilize the systematic approach of the NEPA as an effective decision-making tool. To this end, NEPA processes are integrated with U.S. Navy and U.S. Marine Corps actions as early as possible to protect, enhance, and restore environmental quality within a framework consistent with the mission of the Navy, stated national policy and security requirements.

Due to the protection afforded marine mammals by the MMPA, Navy vessels are prohibited from deliberately harassing a marine mammal. Per Navy policy, vessels must report all instances of shipstrikes

(i.e., the collision between a vessel and a marine mammal for any reason) to the Chief of Naval Operations (CNO). Navy policy also mandates that those in authority plan and act to protect marine mammals during operations (OPNAVINST 5090.1C).

1.4 METHODOLOGY

1.4.1 Literature and Data Search

Prior to the production of this report, a thorough and systematic search for relevant scientific literature and data was conducted. Information, data, and literature that were deemed vital to the production of this MRA were identified, obtained, reviewed, and then catalogued. Of the available scientific literature (both published and unpublished), the following types of documents were utilized in the assessment: journals, periodicals, bulletins, monographs of scientific and professional societies, theses and dissertations, symposium/conference/workshop proceedings, project reports, threatened and endangered species recovery plans, stock assessment reports, and other technical reports published by government agencies. A multitude of individuals, agencies, and databases were consulted during the search for data and information on the occurrence of marine resources in the eastern Mediterranean Sea (all of which are mentioned below).

To investigate the physical environment and habitats of the Study Area; to summarize the occurrence patterns of federally protected species; to describe the region's commercial and recreational fisheries; and to ascertain the distribution of U.S. maritime boundaries, major trade routes/seaports, navigable waterways, oil and gas structures, and MPAs, data and information were either received or requested from the following sources:

- Academic and educational/research institutions/organizations (Scripps Institution of Oceanography; Texas A&M University; Texas A&M University at Galveston; University of Colorado; Tethys Research Institute; Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare [ICRAM]; International Sea Turtle Society/Archelon; the Sea Turtle Protection Society of Greece; Accademia Albertina; Alnitak; United Kingdom (U.K. Parliament) Hydrographic Office; National Centre for Marine Research-Greece; University of Exeter; University of Barcelona; Accademia del Leviatano, Groupe de Recherche sur les Cétacés [GREC]-France; Cavanilles Institute of Biodiversity and Evolutionary Biology, Spain; Centre National de la Recherche Scientifique–France; International Council for the Conservation of the Sea [ICES]; Ocean Alliance; Hellenic Society for the Study and Protection of the Monk Seal [MOm]; Hellenic Centre for Marine Research; Regional Activity Centre for Specially Protected Areas [RAC/SPA]; International Fund for Animal Welfare [IFAW]; World Wildlife Fund [WWF]; Gruppo Nazionale Risorse Demersali [GRUND] Project; Grupo de Estudio y Conservacion de Mamiferos Marinos [GRUMM]; PELAGOS; Mediterranean Association to Save the Sea Turtles [MEDASSET}; Mediterranean Trawl Survey [MEDITS] Project; Oceanus; Sea Watch Foundation; University of Valencia; Gatty Marine Lab at the University of St. Andrews; Centre.de Recherche sur les Mammifere Marins; Inst de la Mer et du Littora, Ministerio de Educacion y de Ciencia–Spain; IHS Energy; Wider Caribbean Sea Turtle Conservation Network [WIDECAST]; WiLDCOAST; Museo di Sotria Naturale di Milano; University of Aberdeen; University of Rhode Island; New England Aquarium; Woods Hole Oceanographic Institution; Natural History Museum of Los Angeles County; Ocean Alliance; Laboratoire d'Oceanographie et de Biogeochimie, France; Centre d'Océanologie de Marseille; Hellenic Centre for Marine Research [HEMR]; Station Marine d'Endoume; Università di Genova, Dipartimento Territorio e Risorse);

- The Internet, including various databases and related websites (Allen Press; IngentaConnect; Blackwell-Science; CRC Press; Kluwer Academic; Elsevier Science; Taylor & Francis Group; Pergamon; Springer-Verlag Heidelberg; National Climate Data Center [NCDC]; FR; Europa; Oceana; European Commission [EC]; Food and Agriculture Organization [FAO]; Google; NMFS; NOAA; Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations [OBIS-SEAMAP]; Science Direct; European Commission; seaturtle.org; University of Florida Sea Turtle Bibliography; and U.S. Geological Survey [USGS]);

- Grey literature (technical reports; conference proceedings; theses; dissertations; and newsletters);
- U.S. federal agencies and commissions (DoD; DoN; Department of Energy [DoE]; Department of the Interior [DoI]; Bureau of Land Management [BLM]-Minerals Management Service [MMS]; USFWS; Marine Mammal Commission [MMC]; National Aeronautic and Space Administration [NASA]; NMFS Office of Protected Resources [NMFS-PR]; and NMFS Office of National Marine Mammal Laboratory [NMFS-NMML]);
- International agencies and commissions (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area [ACCOBAMS]; Cooperacion Pesca Mediterraneo [COPEMED]; Commission of the European Communities [COM]; UNEP–Convention on Biological Diversity [CBD]; UNEP–World Conservation Monitoring Centre [WCMC]; Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea [ARIAMED]; Assessment and Monitoring of Fishery Resources and Ecosystems in the Strait of Sicily [MEDSUDMED]; ICCAT; IWC; UNEP–Mediterranean Action Plan [MAP]; Greenpeace International; European Environment Agency [EEA}; Centre International de Hautes Etudes Agronomiques Mediterranneenes [CIHEAM]; Scientific Technical and Economic Committee for Fisheries [STECF]; General Fisheries Commission for the Mediterranean [GFCM]; International Commission for Scientific Exploration of the Mediterranean Sea [CIESM]; U.N.; Atlas of the Environment; IUCN, IUCN-Species Survival Commission [SSC] Cetacean Specialist Group; and IUCN-SSC Marine Turtle Specialist Group [MTSG]).

1.4.2 Spatial Data Representation—Geographic Information System

The geographical representation of marine resource occurrences in the eastern Mediterranean Study Area and vicinity was a major constituent of this MRA report. The marine resources geospatial data accumulated for this project were accessed from a wide variety of sources, were in disparate formats, covered a broad range of time periods, and represented differing levels of accuracy, as well as quality assurance.

A Geographic Information System (GIS) was used to store, manipulate, analyze, and display the spatial data and information accumulated for the eastern Mediterranean Study Area. For this project, Environmental Systems Research Institute, Inc.'s (ESRI®) ArcGIS® version 9.2 GIS software was used to create the majority of the map figures and metadata. ArcGIS® was chosen for this project due to its widespread use, use by the Navy, flexibility, and ability to integrate disparate data types.

The geographic locations of important marine resources in the eastern Mediterranean Study Area and vicinity were derived from four types of sources (in order of reliability): source data, scanned source maps, source information, and information adapted from published maps. The “source data,” containing geographic coordinates or GIS shapefiles were scrutinized to ascertain their data quality. If the data were in coordinate form, they were then converted to decimal degrees if necessary and text fields were renamed or added for ease of manipulation. Once standardized, the source data were imported into the GIS software. Some of the data were only available as graphical representations or “source maps.” These data were scanned, imported into ArcView™, and geo-referenced, after which significant information was digitized into a shapefile format. Materials acquired as Adobe® portable document format (PDF) files were also treated as scanned source maps (i.e., they were geo-referenced and pertinent information was digitized), since they were already in a digital form. A third type of source, “source information,” encompasses information that was neither taken from a scanned map nor was available in coordinate form. For example, maps displaying non-coordinate data, information given via personal communication, or information extracted from a literature description are referenced as source information. In certain cases, source maps and/or information had to be interpreted to be usable in the GIS environment. Maps displaying geographic information that was interpreted or altered from the original source map/information are noted in the figure caption as being “adapted from” with a corresponding source name.

The source type and associated references for all marine resource data presented in the map figures are listed in each figure’s caption. The full reference citations for map source data or information may be found in the Literature Cited sections of the MRA. The two primary types of spatial information used in the

eastern Mediterranean Study Area were coordinate data and scanned maps. These two source types are associated with differing levels of data reliability or confidence (**Appendix A-1** contains a further explanation of data confidence). Numerical or authentic data are associated with the highest level of reliability while data obtained by scanning source maps is less reliable.

Source data were not always in a standard format, there was often no standard naming convention for species names, and some data sets included missing or unlabeled data fields. To mitigate these difficulties, many steps were taken to standardize and ensure the quality of the numerical data, especially for the marine mammal and sea turtle data. Therefore, prior to using the data, a master database was created in Microsoft® Access where the data format was standardized so that the data could be merged and later used in GIS. To accomplish this, data were manipulated so that records were matched with a set of standard field names. In some cases, the latitude and longitude had to be converted to decimal degrees with accuracy to the fourth decimal place. Species' common names were added to the database to replace the multiple species codes that accompanied the original data. The codes or names used to identify species were not always consistent from one data set to the next. Compiling a comprehensive list of species names increased the chances of plotting all sightings for a given species on the map figures. To maintain integrity of the original data, all fields and records were kept without alteration. When necessary, fields were created to store supplemental information or data that was altered from the original source. No original data fields were deleted and all added fields are signified by the "GMI_" prefix (GMI: Geo-Marine, Inc.). For example, the field that was added to the main dataset to indicate the origin (source) of the data is indicated by the field name "GMI_source."

GIS data are displayed as layers for which scale, extent, and display characteristics can be specified. Multiple themes are represented on an individual map figure. Although ArcGIS® can project data "on the fly" into the projection defined in the map view, all geospatial data for the MRA projects is produced and delivered in the unprojected geographic coordinate system, which uses decimal-degree latitude and longitude coordinates (**Appendix A-2** contains more information on map projections). The printed maps and geospatial data for this MRA report are unprojected and are, therefore, not as spatially precise (in terms of distance, area, and shape) as a projected map. Consequently, the maps should not be used for measurement or analysis, and an appropriate projection, such as Mercator, should be selected when analyzing areas with the GIS data.

Once the marine resource data were imported and stored in the GIS, maps were created representing multiple layers of either individual or combined data. The maps in this MRA report are presented in kilometers and nautical miles. The majority of maps in this report are presented in either of two forms: a display that includes two seasonal maps per page and a display that includes one full-page map. Maps of each display type are often presented at the same approximate scale. Dividing the calendar year into two seasons, a warm and a cool season, was accomplished by analyzing sea surface temperature (SST) data for the entire Mediterranean Sea. SST values spanning 20 yrs (1985 through 2004) were averaged to calculate an overall mean SST of 18.24 degrees Celsius (°C).[4] The time period during the calendar year when the average daily SST exceeded the overall mean SST was defined as the summer (29 May through 15 November), and the time period when the average daily SST was less than the overall mean SST was defined as the winter (16 November through 28 May).

The ability to display and analyze multiple geospatially correct data themes or layers simultaneously is one of the advantages to using a GIS rather than computer-aided design (CAD) or other graphic software. Customizations were made to the software in ESRI®'s ArcObjects™ proprietary language to automate the more repetitive map-making tasks as well as the processing and analysis of large volumes of data.

1.4.2.1 Maps of the Physical Environment—Oceanography

Bathymetry— Bathymetric data from Scripps Institution of Oceanography[5] were sampled and extracted at 2 minute (min) resolution. Highly detailed vector bathymetry or depth contours (isobaths) were prepared with contour intervals of 10 m for depths shallower than 100 m while depths deeper than 100 m were contoured at 100-m intervals. Selected isobaths from the resulting two-dimensional (2D) contours are shown on the bathymetry figures and on various maps throughout the MRA report.

To illustrate the three-dimensional (3D) bathymetry of the Mediterranean Sea, triangular irregular networks (TIN), which interpolate intermediate data values between surveyed data points, were created using the available bathymetry data and processing those data in the ArcGIS® 3D Analyst™ extension. The 2 min bathymetric sounding data sampled from Scripps Institution of Oceanography[5] were used to create the TIN, which depicts the 3D bathymetry of the Mediterranean Sea Study Area (see **Figure 2-1**). The TINs were viewed in the ArcGIS® 8.3 ArcScene™ extension to model the 3D display. ArcScene™ allows the 3D display to be manipulated (i.e., rotated, tilted, zoomed, classified, and overlaid with data). The most authentic display was exported directly from an ArcScene™ view as a graphic file (.tif), which was then imported into ArcView™ for the final map layout.

The true or natural continental shelf break for the Mediterranean Sea was derived using the detailed vector bathymetry contours that were adapted from the Scripps Institution of Oceanography[5] raster datasets. The bathymetric contours were transformed into a 0.004-decimal degree grid of water depths. This grid was created using the Zevenbergen and Thorne (1987) algorithm (ZTA), which is a complex series of equations used to model elevation data. The ZTA analysis is based on a rectangular grid of evenly spaced depths that covers the Study Area. An analytical unit composed of three grid cells by three grid cells was repetitively analyzed throughout the rectangular depth grid to derive a digital depth model. ArcView 3.3™ was then employed to evaluate the gridded digital depth-model against the quartic formula (the ultimate of the ZTA equations). The resulting grid of depth gradient values was visualized as 50 continental shelf break classes (50 was an arbitrary value and represented neither too large nor too small a set of depth classes). The true continental shelf break was identified from within the 50 classes of grid cell values. The shelf-break class representing the grid cell value of 100 was determined to be the location of the true continental shelf break. The value of 100 best matched the gradient change associated with the continental shelf break as defined by (Kennett 1982) where the depth changes from the gradient of 1:1000 on the continental shelf to 1:30 on the continental slope. The grid cells for the associated depth model were reclassified into two values: 1 (original depth values ≤100 m) and 0 (original depth values >100 m) to isolate the continental shelf break. The grid model was converted into polygons, which were then converted to line topology, removing all extraneous lines. The isolated shelf break line was then splined to smooth the 90° angles characteristic of grid cells. The model of the continental shelf break was then evaluated in conjunction with the detailed isobaths to determine positional accuracy. The resulting line feature represents the model of the "true" continental shelf break and is not representative of one depth but varies in depth.

Satellite Data—Seasonal averages of SST were compiled from weekly averaged Advanced Very High-resolution Radiometer (AVHRR) satellite data, which contain multi-channel SST pixel data.[6] Seasons were defined with the same monthly derivations used throughout the MRA report (summer: 29 May through 15 November, winter: 16 November through 28 May). Data for the Study Area were collected from 1981 to 2001; these data were extracted from the global dataset and the pixel values were converted to SST using MATLAB® with the following function:

$$\text{SST (°C)} = 0.15 * \text{DN} - 2.1$$

where DN is the pixel value.

Day and night SST values were averaged and the data were parsed into seasons. The seasonal data were then converted to a grid with cell sizes of 0.12 kilometers (km) by 1.09 km and interpolated to produce a smoother image. In the GIS environment, the range of SST values for the eastern Mediterranean Study Area (presented in °C) are associated with a color spectrum grading from red (warmest) to blue (coldest).

Seasonal averages of chlorophyll *a* (chl *a*) concentrations were compiled from monthly averaged Coastal Zone Color Scanner (CZCS) satellite data to provide a proxy for primary productivity in the eastern Mediterranean Study Area.[7] Pixel data for the eastern Mediterranean Study Area extent from 1978 to 1986 were extracted and converted to chl *a* values using MATLAB® and the provided function:

$$\text{chl } a \text{ (mg/m}^3\text{)} = 10^{(DN * 0.012) - 1.4}$$

where DN is the pixel value.

The chlorophyll data were parsed into seasons, converted to grid cell sizes of 0.12 km by 1.09 km, and interpolated. On the MRA map figures, the seasonal range of chl *a* concentrations (in milligrams per cubic meter [mg/m^3]) is presented as a color spectrum with chl *a* concentrations increasing from blue to red.

1.4.2.2 Biological Resource Maps—Species of Concern

Marine mammal and sea turtle occurrence data were accumulated from every available source; however, it was impossible to obtain every data source in existence for the eastern Mediterranean Study Area. An overview of known marine mammal and sea turtle data sources for the Study Area is found in **Appendix A-3**. Marine mammal and sea turtle data that were provided for use in this MRA are listed in **Table A-1** and are displayed on the occurrence maps in **Appendices B** and **C**. The data described in **Table A-1** include occurrence data from aerial and shipboard (sighting) surveys, stranding records, incidental fisheries bycatch records, and other sources (e.g., opportunistic sighting programs and species occurrence databases). Sighting, stranding, and bycatch records available from the scientific literature or through personal communications with regional experts were also used in this MRA. The combined source data mentioned above were vital to the determination of areas of occurrence for marine mammals and sea turtles potentially occurring in the eastern Mediterranean Study Area.

Several assumptions were made regarding the marine mammal and sea turtle data collected for this MRA. First, it was assumed that the species identifications given in each dataset were correct. This assumption was necessary since the reliability of species identifications from one dataset to the next was not always known. Marine mammals and sea turtles are often difficult to distinguish to species when they are young (i.e., small size classes), during poor sighting conditions, and when those who observe them do not have a high level of identification experience. Correct species identification is highly dependent on the skill level of the observer. Sighting data presented in this MRA range from those collected by experienced professionals during dedicated surveys to those collected opportunistically and/or by less experienced observers. For the sake of consistency, reliability of species identification was not considered in the plotting of any marine mammal or sea turtle records.

Although it was assumed that the species identifications provided in each dataset were correct, it could not always be assumed that the locations of the occurrence records, when provided, were also correct. Problems were often encountered when original geographic coordinates were plotted and animals were shown to occur in unexpected locations or in areas far from the dedicated survey coverage. Occurrence records that were obviously erroneous were omitted if they could not be corrected through consultation with the data provider. It should be noted that some of the marine mammal and sea turtle datasets lacked geographic coordinates entirely. As a result, determination of the locations where the records occurred required educated predictions based upon physical descriptions of the locales.

In conjunction with regional experts and hired subcontractors, marine mammal and sea turtle areas of occurrence were defined and then drawn for each species known to occur in the eastern Mediterranean Study Area. The areas of occurrence are based upon expert opinion (i.e., many years of survey experience in the area), known habitat preferences and distribution patterns of the animals, and the available sighting, stranding, and bycatch. Three types of occurrence information may be displayed on each marine mammal or sea turtle species map: areas of **primary occurrence** (areas and habitats where a species or group of species is likely to be encountered), areas of **secondary occurrence** (areas and habitats where a species or group of species may be found, especially during unusual environmental conditions or seasonal migrations), and areas of **rare occurrence** (areas and habitats where a species or group of species is not expected to be found with any regularity. An underlying premise used during the map creation process was that a conservative approach to delineating the areas of occurrence for marine mammals and sea turtles was necessary since all five sea turtle species and several of the marine mammal species are listed as either threatened or endangered under the ESA.

As a supplement to the seasonal occurrence maps and species-specific discussions, **Section 3.1** of this MRA includes migration maps for the humpback and North Atlantic right whales, which are summaries of the vast amount of data and information that have been collected on migration patterns of these whale species in the North Atlantic Ocean. **Section 3.2** of this MRA includes maps of the nesting areas in the Mediterranean region for green and loggerhead sea turtles, as well as rough approximations of known neritic and oceanic habitats for these species here.

1.4.2.3 Habitat Maps

Habitat Data—Multiple sources of data and information were used in the creation of maps for the habitats of the eastern Mediterranean Study Area and vicinity. These maps were created using images, coordinate data, GIS shapefiles, and other information available from the scientific literature, technical reports, GIS databases, and federal agency websites.

1.4.2.4 Biological Resource Maps–-Fish and Fisheries

Fishery maps displaying the major spawning and juvenile areas of the bluefin tuna (*Thunnus thynnus*), albacore tuna (*T. alalunga*), and swordfish, (*Xiphias gladius*), new bluefin tuna fishing grounds and routes to offshore tuna ranches, and the Scientific Advisory Committee (SAC)/GFCM geographical sub-areas (GSAs) of the Mediterranean Study Area were adapted from information taken from the following sources: (FAO-GFCM 2006); (STECF 2006); and (WWF 2006). Since these data sources were not available in a usable electronic format, the physical maps for each of the large pelagic species, fishing grounds/routes, and GSAs were scanned, imported into ArcView™, and geo-referenced using the image analysis extension, with the significant information being digitized into a shapefile format.

1.4.2.5 Maps of Additional Considerations

Information regarding the locations of maritime boundaries, navigable waters, MPAs, and oil and gas structures in the western Mediterranean Study Area was gathered from a wide array of sources. Maps displaying the maritime boundaries, major trade routes/seaports, navigable waterways, MPAs, and oil and gas structures were created using data available for downloading from U.S. and European websites. Some information on the maritime boundaries and MPAs were derived from literature sources; these data were scanned, digitized, and geo-referenced. The information regarding the location of oil and gas structures was received in the form of data points from IHS Energy.

1.4.2.6 Metadata

The creation of metadata (or information about the GIS data) documentation files was a large component of the GIS work completed for this assessment. Every GIS file used in the creation of the map figures within this MRA has a metadata file associated with it. When possible, metadata were obtained along with GIS data used in this MRA; those data are included in the metadata documentation. Often documentation information, especially on the accuracy or reliability of the associated data, was not available.

Metadata for geographical data should include the data source, creation date, format, projection, scale, resolution, accuracy, and reliability with regard to some standard. Metadata also consists of properties and process documentation. Properties are derived from the data source, while documentation is entered manually. ESRI® ArcCatalog™ creates metadata in extensible markup language (XML) format, so the same metadata can be viewed in many different ways using different styles. Metadata created to accompany this MRA report are provided in both XML and hyper text markup language (HTML) formats so that the metadata can be viewed in many types of viewers and are accessible within the GIS environment by other users.

1.4.3 Limitations of Marine Survey Sighting Data

When attempting to use sighting data from aerial and shipboard surveys as a major indicator of a species' occurrence, it is necessary to first recognize the inherent biases associated with each survey type. One of

the main drawbacks of surveys in the marine environment is that shipboard and aerial surveys count only the number of animals at the water's surface, where species such as marine mammals and sea turtles spend relatively little time. Sea turtles often spend over 90 percent (%) of their time underwater (e.g., Byles 1988; Renaud and Carpenter 1994; Mansfield and Musick 2003). As a result, it has been postulated that marine surveys undersample (underestimate) the total number of sea turtles in a given area by as much as an order of magnitude (Shoop and Kenney 1992). While scientists have devised mathematical formulas to account for animals not seen at the surface, the diving behavior of one animal may be different from that of other members of the same species. Even though marine mammals and sea turtles are obligated to come to the surface to breathe, many individuals will not surface within an observer's field of view. This is of particular concern when attempting to sight species that dive for extended periods of time; do not possess a dorsal fin; and are known to exhibit cryptic behavior, such as beaked whales (*Mesoplodon* spp.), pygmy and dwarf sperm whales (*Kogia* spp.), and sperm whales (e.g., Würsig et al. 1998; Barlow 1999). Beaked whales are often solitary individuals, which makes their sightability much different from a species that regularly occurs in large groups, such as dolphins in the genus *Stenella* (e.g., Scott and Gilbert 1982).

Sighting conditions also affect the sightability of marine mammals and sea turtles. Sighting frequencies vary due to the amount of sun glare on the water's surface, sea state, weather, and water clarity. Both sea state and glare have statistically significant effects on sighting frequency (e.g., Scott and Gilbert 1982; Thompson 1984). When water clarity is poor, animals are difficult to sight below the water's surface, and only those animals at the water's surface that are extremely close to the observer are usually identifiable.

Problems also arise when attempting to select an optimal and efficient survey method for sampling marine mammals and sea turtles. Since most sighting surveys target multiple species, the sampling designs, although likely cost- and labor-efficient, cannot be considered optimal for each species (Scott and Gilbert 1982). The altitude at which marine mammal aerial surveys are flown is much higher than is desirable to sight sea turtles (which are typically much smaller than cetaceans). Shipboard surveys designed for sighting marine mammals are adequate for detecting large sea turtles but usually not the smaller-sized turtles. Their size, diving behavior, and startle responses to vessels make smaller sea turtles difficult to sight or visually observe from a ship. The youngest age-classes of sea turtles, which often inhabit waters far from land, are extremely difficult to spot. There have been no shipboard surveys in the Atlantic or Pacific oceans designed to specifically address information needs relative to sea turtles. Other difficulties with marine surveys include weather, time, and logistical constraints. For example, the operating cost for a research vessel is approximately 10,000 U.S. Dollars (USD) per day (Forney 2002).

In addition, seasonal occurrence of marine mammals and sea turtles in extremely large areas, such as the North Pacific Ocean, is unknown since no seasonal surveys have been conducted. The occurrence of marine mammals and sea turtles in an area often changes on a seasonal basis in response to changes in water temperature, movement and availability of prey, or an individual's life history requirements, such as reproduction. Therefore, the number of sightings on a specific date over a specific trackline may not be representative of the number of individuals occurring in the entire area over the course of an entire season. As a result, sighting frequency is often a direct result of the level of survey effort expended in a given area.

1.4.4 Limitations of Stranding Data

How closely the distribution of marine mammal and sea turtle stranding records mirrors the actual occurrence of a species in a given region is often not known. Sick animals may strand well beyond their normal range and carcasses may travel long distances before being noticed by observers. Stranding frequency in a given area is as much a function of nearshore and offshore current regimes and coastal zone patrol efforts as it is a function of the stranded species' actual pattern of occurrence in that area. Since coastal species will strand more frequently than oceanic species, due to their closer proximity to shore, stranding frequencies should not be used when attempting to compare the occurrence of a coastal versus an oceanic stock in a certain area. Comparisons cannot be made between species of differing sizes and social structures, as strandings of large-bodied species and groups of individuals are much

more likely to be reported than strandings of small-bodied species or single individuals. An additional problem with the use of stranding data involves the inability of reporters to identify carcasses as a certain species. For example, only the most experienced marine mammal scientists are able to differentiate between the several species of beaked whales in the genus *Mesoplodon*.

1.5 REPORT ORGANIZATION

This report consists of seven major chapters and three associated appendices. Chapter 1—Introduction provides background information on this project, an explanation of its purpose and need, a review of relevant environmental legislation, and a description of the methodology used in the assessment. Chapter 2—Physical Environment describes the natural environment of the eastern Mediterranean Study Area including the climate/weather, marine geology (physiography, bathymetry, and bottom sediments), chemical oceanography (surface temperature and salinity), physical oceanography (hydrography, circulation, currents thermocline, upwelling, and tides), and biological oceanography (plankton: primary and secondary productivity). Chapter 3—Species of Concern covers protected marine mammals and sea turtles found in the eastern Mediterranean Study Area , with detailed narratives of their morphology, status, habitat preferences, distribution, behavior, life history, acoustics, and hearing (if known). Chapter 4—Habitat discusses habitat complexity: benthic (e.g., seagrass beds, maërl beds, rocky reefs, shallow-water and deep-sea corals, and chemosynthetic communities) and artificial (e.g., artificial reefs, FADs), buoys and moorings, offshore platforms, sea-cage farms, and shipwrecks). Chapter 5—Fish and Fisheries investigates fish assemblages (distribution, spawning, and habitats) and fishing activities (commercial) for managed species that occur within the eastern Mediterranean Study Area. Chapter 6—Additional Considerations provides information on maritime boundaries, major trade routes/seaports, navigable waterways, MPAs, and oil and gas structures. Chapter 7—Recommendations suggests future avenues of research that are necessary to fill the data gaps identified in this project and prioritizes research needs from a cost-benefit approach. Chapter 8—List of Preparers lists all individuals who helped prepare the eastern Mediterranean Study Area MRA report. Chapter 9—Glossary includes definitions of the terms used in the MRA report. Appendix A contains supplementary information for marine mammal and sea turtle data used in this MRA while Appendix B contains marine mammal occurrence maps that are described or referenced in Section 3.1 and Appendix C contains sea turtle occurrence maps that are described or referenced in Section 3.2.

This report is written in a format and reference style similar to that found in *The Chicago Manual of Style*, 14th Edition. Citations for all peer-reviewed literature and a list of websites accessed appear at the end of each chapter except in Chapter 3, Species of Concern, where they appear at the end of each section.

1.6 WEBSITES ACCESSED

[1] Global Security. 2006. Accessed 2 October 2006. http://www.globalsecurity.org.
[2] Marine Plastic Pollution Research and Control Act (33 U.S.C. §§ 1901 et seq.). Accessed 14 December 2005. http://www.csc.noaa.gov/opis/html/summary/mpprca.htm.
[3] The 2006 IUCN Red List of Threatened Species. Accessed 13 December 2006. http://www.redlist.org.
[4] NASA (National Atmospheric and Space Administration). 2000. AVHRR Oceans Pathfinder Global Equal-angle Best weekly SST averages (NOAA/NASA). Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. Accessed 4 May 2004. ftp://daac.gsfc.nasa.gov/data/avhrr/tile_8km/.
[5] Global topography: Measured and estimated seafloor topography. Accessed 9 February 2006. http://topex.ucsd.edu/marine_topo/mar_topo.html.
[6] Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. Pathfinder AVHRR SST data. Accessed 12 October 2005. ftp://disc1.gsfc.nasa.gov/data/avhrr/tile_8km/.
[7] Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. CZCS chlorophyll a data. Accessed 12 October 2005. ftp://disc1.gsfc.nasa.gov/data/czcs/level_3/monthly_data/subsets/Chlor/.

1.7 LITERATURE CITED

Agardy, T. 2000. Key steps taken to preserve the U.S.'s marine heritage. Issues in Science and Technology 17(1):26.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209-221 in Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, eds. Marine mammal survey and assessment methods. Rotterdam, Netherlands: A.A. Balkema.

Byles, R.A. 1988. Behavior and ecology of sea turtles from Chesapeake Bay, Virginia. Ph.D. diss., College of William and Mary in Virginia.

DoD (Department of Defense). 1996. DOD Instruction 4715.3, Environmental Conservation Program. Washington, D.C.: Secretary of Defense.

DoN (Department of the Navy). 1998. Fleet training area/range directory. Naval Warfare Assessment Station.

DoN (Department of the Navy). 1999. Environmental and natural resource program manual (OPNAVINST 5090.1B). Washington, D.C.: Department of the Navy.

FAO-GFCM (Food and Agriculture Organization-General Fisheries Commission for the Mediterranean). 2006. Report of the ninth session of the Scientific Advisory Committee. Rome, 24-27 October 2006. FAO Fisheries Report No. 814. Rome, Italy: Food and Agriculture Organization.

Forney, K.A. 2002. Surveys. Pages 1203-1205 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Kennett, J.P. 1982. Marine geology. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Mansfield, K.L. and J.A. Musick. 2003. Loggerhead sea turtle diving behavior. Prepared for the U.S. Army Corps of Engineers, Norfolk, Virginia by the Virginia Institute of Marine Science, Gloucester Point, Virginia.

NMFS (National Marine Fisheries Service). 2004. Endangered and threatened species; establishment of species of concern list, addition of species to species of concern list, description of factors for identifying species of concern, and revision of candidate species list under the Endangered Species Act. Federal Register 69(73):19975-19979.

NMFS (National Marine Fisheries Service). 2006. Endangered and threatened species; Revision of species of concern list, candidate species definition, and candidate species list. Federal Register 71(200):61022-61025.

Renaud, M.L. and J.A. Carpenter. 1994. Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. Bulletin of Marine Science 55:1-15.

Scott, G.P. and J.R. Gilbert. 1982. Problems and progress in the US BLM-sponsored CETAP surveys. Reports of the International Whaling Commission 32:587-600.

Shoop, C.R. and R.D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

STECF (Scientific Technical and Economic Committee for Fisheries). 2006. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01.

Thompson, N.B. 1984. Progress report on estimating density and abundance of marine turtles: Results of first year pelagic surveys in the southeast U.S. Miami, Florida: National Marine Fisheries Service, Southeast Fisheries Science Center.

Road Traffic: The road vehicles (construction and use) regulations 1986. 1986 No. 1078. 25 June 1986.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24(1):41-50.

WWF (World Wildlife Fund). 2006. The plunder of bluefin tuna in the Mediterranean and East Atlantic in 2004 and 2005: Uncovering the real story. Rome, Italy: WWF.

Zevenbergen, L.W. and C.R. Thorne. 1987. Quantitative analysis of land surface topography. Earth Surface Processes and Landforms 12:47-56.

2.0 PHYSICAL ENVIRONMENT OF THE EASTERN MEDITERRANEAN STUDY AREA

2.1 INTRODUCTION

The Mediterranean Sea is an elongated semi-enclosed basin with significant water exchange occurring only at the Strait of Gibraltar. The Mediterranean Sea spans approximately 3,800 km from the Strait of Gibraltar in the west to Syria in the east; the greatest distance from north to south (900 km) is found from France to Algeria yet no spot in the Mediterranean Sea is farther than 370 km from land. Half of the area of the Mediterranean Sea lies within 100 km of the coast (UNEP 1989; 1996). In strictly geographical terms, the Mediterranean Sea is considered a regional basin. The Mediterranean Sea is surrounded by the three continents of Europe, Africa, and Asia. It has a mean depth of about 1,500 m and represents just 0.7% of the surface of the world's oceans (approximately 2.5 million km^2) and 0.3% of the volume (3.7 million cubic kilometers [km^3]; UNEP 1989; 1996; Bethoux et al. 1999; Sardà et al. 2004); the Mediterranean Sea is of sufficient size to be controlled by large-scale ocean dynamics (Marullo et al. 1999b). Almost all of the important physical oceanographic process that occur within large ocean basins are also present in the Mediterranean Sea (Drakopoulos and Lascaratos 1999).

The Mediterranean Sea can be divided into two similarly sized sub-basins which are connected by the Strait of Sicily (**Figure 2-1**). A shallow sill at the strait helps to decouple the hydrological and ecological conditions of the two sub-basins. External exchanges occur with the Atlantic Ocean via the Gibraltar Strait in the western Mediterranean Sea and with the Black Sea via the Dardanelles and Bosphorus straits in the eastern Mediterranean Sea (Crise et al. 1999).

The eastern Mediterranean Sea is itself an enclosed basin with multiple forcings and processes of global interest (The POEM group 1992; Golnaraghi 1993; Marullo et al. 1999b). This region is a unique environment whose structure and function is poorly understood. The eastern Mediterranean Sea is considered to be one of the most oligotrophic regions in the world (Tselepides et al. 2000).

2.2 CLIMATE/WEATHER

The climate of the eastern Mediterranean Basin is influenced by several factors including prevailing winds, oscillating atmospheric pressure systems, transient storm systems, and the geography of the region. Anthropogenic influences may also be significantly affecting the climate of the region on both seasonal and decadal timescales (Duarte et al. 1999; Sala et al. 2000; Molinero et al. 2005). Increasing desertification of the entire Mediterranean Basin has been linked to local anthropogenic as well as global atmospheric phenomena, (e.g., the North Atlantic Oscillation [NAO]) and is a concern because of the important socio-economic impacts (Turley 1999).

Oceanographic and atmospheric phenomena are interrelated and combine to create the long-term climate and short-term weather patterns that characterize the eastern Mediterranean Basin. When viewed over appropriate time scales any atmospheric event can be coupled in some way with an associated oceanographic occurrence; together the two components combine to form a larger ocean-atmosphere system (Gill 1982; Molinero et al. 2005; Orfila et al. 2005). For example, the Gulf Stream Current transports warm, tropical waters northward ultimately affecting the climate of the eastern North Atlantic Ocean and much of western Europe. Seasonal and decadal variations in the total transport of the Gulf Stream as well as its northward penetration have been linked directly to subsequent variations in weather and climate (Open University 1995).

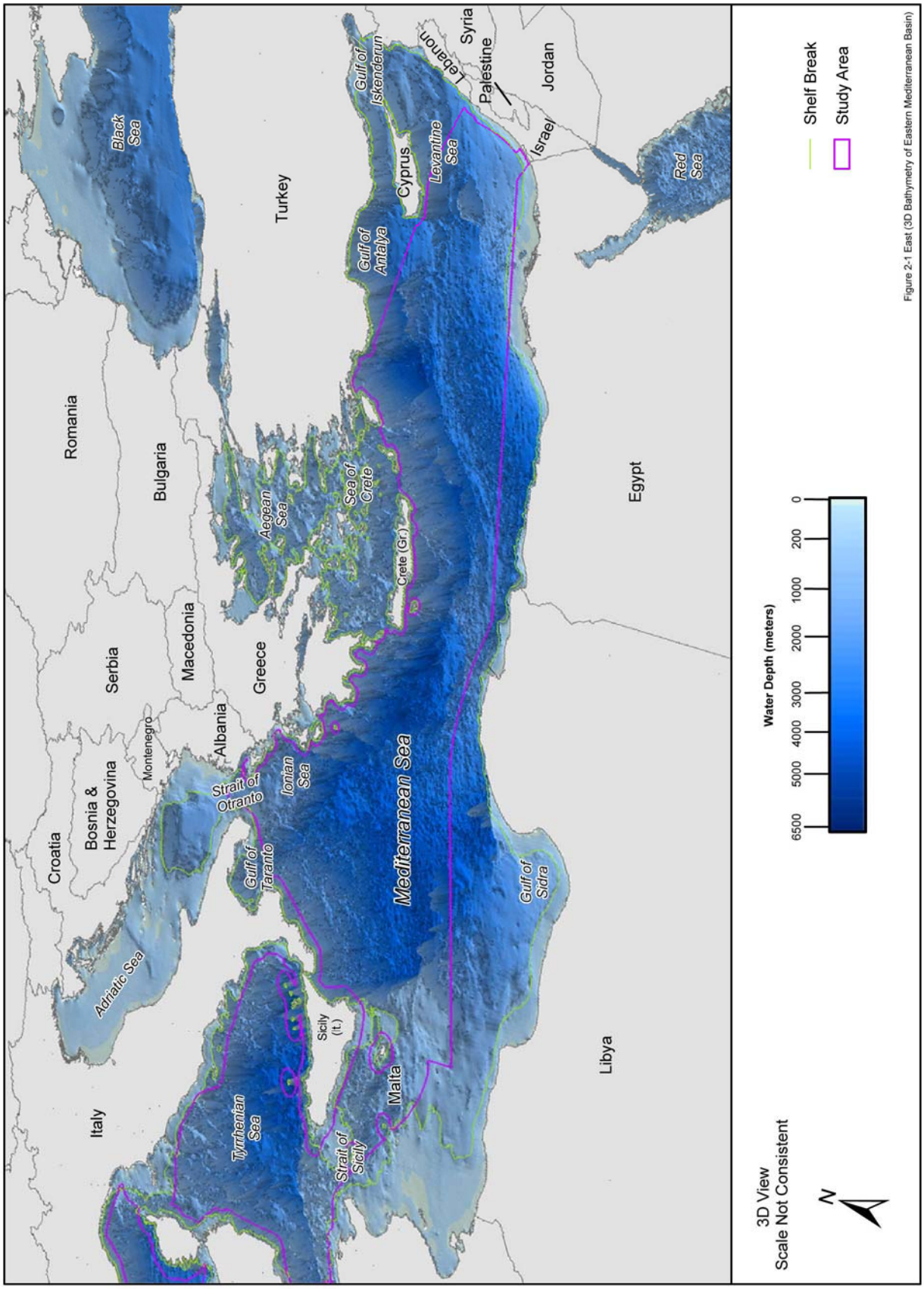


Figure 2-1. 3D bathymetry of the eastern Mediterranean Sea. Source data: Smith and Sandwell (1997).

The geography surrounding the Mediterranean Basin is a major factor influencing both weather and the climate of the region (UNEP 1996; Millán et al. 2005; Orfila et al. 2005). The steep, high-elevation (>4,000 m) mountain ranges that comprise the Pyrenees and the Alps dominate the terrain in many of the European countries to the north of the Mediterranean Sea, whereas flat, low-level, desert terrain makes up the landscape of the North African countries located to the south (UNEP 1996). Winds, storm systems, and precipitation are often blocked or diverted by the Alps resulting in milder conditions in Italy and Greece during the winter while generating late afternoon summer storms along the coast of Spain (Millán et al. 2005). The low-lying desert terrain south of the basin facilitates more persistent offshore winds and contributes to more widely ranging daily temperature cycles (UNEP 1996).

2.2.1 Seasons

The climate in the Mediterranean region can essentially be described by two seasons: a warm, dry summer season and a cool, wet winter season (Bakun and Agostini 2001; Fernández et al. 2005). For example, in their characterization of the climate around the Aegean Sea, Poulos et al. (1997) defined the summer season as May through September and the winter season as November through March. The months of April and October are described as intermediate months. This characteristic climate is so distinctive that subtropical regions around the world exhibiting a similar division of seasons, and in particular experiencing a well-defined cool, wet season (e.g., much of the coast of California), are often referred to as having a Mediterranean climate (Duarte et al. 1999).

Dividing the calendar year into two seasons, a warm and a cool season, can be accomplished by analyzing SST data for the entire Mediterranean Sea. Satellite-based SST measurements spanning 20 yrs (1985 through 2004) were averaged to calculate an overall mean SST of 18.24°C for the Sea. The time period during the calendar year when the average daily SST exceeded the overall mean SST is defined as summer (29 May through 15 November), and the time period when the average daily SST was less than the overall mean SST is defined as winter (16 November through 28 May).

2.2.2 Air Temperature

The NOAA's NCDC maintains an extensive database of climate related data for the U.S., and in cooperation with several international climate centers, provides access to worldwide climate data.[1] Air temperatures averaged over approximately 11 yrs (1995 through May 2005) from five sites along the perimeter of the eastern Mediterranean Sea indicate that, in general, mean air temperatures show little variance from east to west (**Table 2-1**). In fact, the two sites separated by the greatest latitudinal distance, Luqa, Malta and Lattakia, Syria, recorded the same mean monthly temperature of 19.2°C. The difference in mean monthly temperature is greatest between the northern-most (Kerkyra, Greece) and southern-most (Mersa Matruh, Egypt) sites surveyed. Kerkyra is located along the coast of the Ionian Sea and has the lowest mean temperature of any site (17.8°C), while Mersa Matruh averaged 2°C warmer over the 11 years surveyed (**Table 2-1**).

Little variability around the basin was observed in the temperature of the warmest month between 1995 and 2005. Four out of the five sites surveyed recorded a maximum monthly temperature of approximately 29°C; the fifth site, Mersa Matruh, recorded a maximum of 27.8°C, more than 1°C lower any other location despite being the southern-most site (**Table 2-1**). A larger span of 5°C occurred in the minimum monthly temperatures recorded around the eastern basin, with the coldest monthly mean (7.2°C) recorded in the Kerkyra, the northern most site.

Factors influencing long term temperature means and extremes include a combination of latitude, geography (e.g., proximity to mountains or desert), atmospheric circulation and precipitation (see below), and the moderating effects of the warm waters of Mediterranean Sea. Both Luqa and Souda are located on islands in the Sea, which may mitigate temperature extremes more so than at the coastal sites.

Table 2-1. Monthly mean and extreme air temperatures from 1995 through May 2005 at five sites located near the study area in the eastern Mediterranean Basin.[2,3,4,5,6]

City, COUNTRY	Latitude/Longitude	Mean Monthly Temperature (1995—2005) (°C)	Warmest Month (1995—2005) (°C)	Coldest Month (1995—2005) (°C)
Luqa, MALTA	35.85°N/14.48°E	19.2	29.3 (August 1999)	10.4 (February 2003)
Kerkyra, GREECE	39.62°N /19.92°E	17.8	29.0 (August 1998)	7.2 (January 2000)
Souda, GREECE	35.55°N/24.12°E	18.4	28.6 (July 2002)	8.6 (February 2003)
Lattakia, SYRIA	35.53°N/35.77°E	19.2	28.9 (August 1998)	10.6 (January 2002)
Mersa Matruh, EGYPT	31.33°N /27.22°E	19.8	27.8 (August 1998)	12.2 (January 2000)

Sorting the 11 yrs of data by month permitted an analysis of the coldest and warmest months throughout the region. January is traditionally the coldest month at Kerkyra, Lattakia, and Mersa Matruh while the two island sites, Luqa and Souda, usually do not experience their coldest temperatures until February. Average January and February temperatures ranged from 10°C in Kerkyra to 13.6°C in Mersa Matruh. Either July or August is the warmest month at the five sites in the eastern sub-basin, with average temperatures all within a degree of 27°C and with Souda and Kerkyra warming earlier than the other three sites.[2,3,4,5,6]

2.2.3 Atmospheric Circulation

Several large-scale, longer duration atmospheric pressure systems centered over Europe, Asia, and North Africa affect climate and weather in the Mediterranean region throughout the year. The dominant atmospheric phenomenon affecting the North Atlantic Ocean, including the Mediterranean region, is the NAO; a detailed description of the NAO is given in **Section 2.2.6.1** below.

The Bermuda-Azores High is a semi-permanent, high-pressure system centered over the island of Bermuda in summer and fall and over the Azores islands about 1,500 km east of Portugal in winter and spring (Open University 1995).[2] The anticyclonic (clockwise) circulation associated with the Bermuda-Azores High affects climate in the entire Mediterranean Basin, bringing fair weather and cloudless skies to the region that may persist from two weeks to a month (Poulos et al. 1997; Duarte et al. 1999). Reduced cloud cover enhances diurnal temperature gradients by increasing the amount of shortwave ultraviolet (UV) radiation that penetrates to ground level during the day and allowing more longwave (infrared) radiation to escape during the night, resulting in warmer days and cooler nights (Millán et al. 2005).

A prominent sea-level pressure anomaly know as the Eastern Atlantic Western Russia (EAWR) system (Krichak and Alpert 2005) affects the climate and weather patterns in Europe and the eastern Mediterranean Basin, but its influence can extend into the western basin as well. An anticyclonic, high pressure system cycles between centers over the Caspian Sea and western Europe to form the EAWR.

The relative strength of the EAWR is based on the atmospheric pressure difference measured at the two pressure centers during winter months (Krichak and Alpert 2005). When the index is positive, northerly winds blow primarily over the Baltic region east of the Mediterranean Sea and conditions are drier than normal throughout much of the Mediterranean region. When the EAWR index is negative the northerlies shift westward and winters in the region are wetter than normal (Krichak and Alpert 2005). The Asiatic Low is a cyclonic (counter clockwise) rotating pressure system that can extend as far west as the island of Cyprus and influence both the wind stress in the region as well as summer time precipitation (Poulos et al. 1997).

Winds entering the region from the north are channeled by the Alps and the Pyrenees mountain ranges, intensifying the movement of air masses moving south-southeastward, particularly in spring and summer. These high intensity, generally short duration winds are all examples of katabatic wind systems, which are generated when a high altitude air mass is cooled, increasing its density and causing it to descend rapidly down slope. The Tramontane or Cers wind system moves towards the southeast north of the Pyrenees and into the Languedoc region of southwestern France; the Mistral wind system enters the region from the north, following the Rhone River valley towards the Gulf of Lion; the Bora blows from the north or northeast down to the Adriatic Sea; and similarly, the Meltemi winds enter the region at the head of the Aegean Sea (UNEP 1996; Orfila et al. 2005).

Similarly intense wind systems are also generated south of the Mediterranean Sea. The Sirocco and Khamsin winds blow north across desert terrain and are more persistent than the katabatic winds from the north. Both southerly winds brings hot, dry air into the region, which is then humidified as it passes over the Mediterranean Sea, contributing to the high evaporation rate for which the Sea is known (UNEP 1996). The Sirocco winds are usually of short duration (~days) and can reach speeds of 100 km per hour (km/hr) at their most intense periods in March and November; they also advect a considerable amount of dust into the Mediterranean region.

Monthly mean wind stress measurements have been used to estimate the wind stress field over the Mediterranean Sea which ranges from approximately 3 dynes per square centimeter (dyn/cm^2) in the western basin to 0.8 dyn/cm^2 in the Levantine Sea (Malanotte-Rizzoli and Bergamasco 1991). A distinct seasonal pattern in the winds stress field across the eastern sub-basin emerges from an analysis of the monthly data, with strong zonal flow (west to east) characteristic of the winter season and well defined meridional flow (north to south) dominant in the summer season. Transitions between the two seasons are described as smooth and gradual (Malanotte-Rizzoli and Bergamasco 1991).

Over the Aegean Sea, winds are predominantly out of the north or northwest except in spring when south-southwesterly winds prevail. Cold, dry northerly winds peak during December through February and are usually associated with the movement of an arctic or polar air mass onto the continent. Mean monthly wind speeds range between 3 and greater than 7.5 meters per second (m/sec) in areas surrounding the Aegean Sea (Poulos et al. 1997). From May through September the Etesian wind dominates the wind field extending from the Aegean Sea into the Levantine Sea. This northerly wind, which can persist for extended periods and exceeds 8 m/sec, is generated by the interaction of several atmospheric pressure systems in the Mediterranean region including the Bermuda-Azores High, the Asiatic Low, the EAWR, and transient high pressure systems over northwestern Europe (Poulos et al. 1997).

2.2.4 Precipitation

Most precipitation in the Mediterranean region occurs during the winter season north of 40°N; in summer, terrestrial regions bordering the Sea south of 40°N are essentially dry (Martin and Milliman 1997; Struglia et al. 2004). Precipitation in the eastern basin is almost exclusively rainfall, except in areas of higher elevation, such as the Italian Alps and the mountainous regions of Turkey, which receive significant amounts of snowfall. Even the island of Crete, located in the middle of the eastern Mediterranean Sea, receives significant accumulations of snow at higher elevations (>2,000 m) while snow along the coastal plains is extremely rare. Annual rainfall in areas surrounding the Aegean Sea ranges between 350 and 700 millimeters per year (mm/yr); evaporation, which exceeds precipitation throughout the entire

Mediterranean Basin, ranges between 3.5 and 5.0 millimeters per day (mm/day) in the Aegean Sea (Malanotte-Rizzoli and Bergamasco 1991; Poulos et al. 1997).

The highest annual precipitation in the eastern basin occurs in western Greece; although, the frequency of heavy (>10 mm/day) rainfall events appears to be decreasing in direct contrast to worldwide trends (Kostopoulou and Jones 2005). Overall, the western half of the eastern Mediterranean Sea, including Italy and Greece, receives greater amounts of precipitation and more intense rainfall events than the most easterly regions. By contrast, coastal areas in the eastern half of the basin, such as Turkey and Cyprus, show an increasing trend in the number of consecutive dry days per year (Malanotte-Rizzoli and Bergamasco 1991; Kostopoulou and Jones 2005).

An analysis of the average monthly precipitation recorded over approximately 11 yrs at 5 sites located along the perimeter of the eastern Mediterranean Sea supports a distinct north-south gradient in average precipitation while showing no consistent trend across the basin in the latitudinal direction (**Table 2-2**). The highest mean monthly precipitation occurred in Kerkyra, Greece, the northern-most site, and the lowest occurred in Mersa Matruh, Egypt, the southern-most site. Souda, Greece, Lattakia, Syria, and Luqa, Malta all reside along approximately the same latitude, yet precipitation varies significantly between the three sites (**Table 2-2**). The mountainous terrain on the island of Crete where Souda is located likely contribute to greater amounts of precipitation received at that site through localized cyclogenesis.

Table 2-2. Monthly mean and extreme precipitation totals from 1995 through May 2005 at five sites located near the study area in the eastern Mediterranean Basin.[2,3,4,5,6]

City, COUNTRY	Latitude/Longitude	Mean Monthly Precipitation (1995—2005) (mm)	Highest Monthly Precipitation (1995—2005) (mm)	Lowest Monthly Precipitation (1995—2005) (mm)
Luqa, MALTA	35.85°N/14.48°E	44.8	391 (November 1999)	0 (20 months)
Kerkyra, GREECE	39.62°N /19.92°E	171.1	2,562 (December 1995)	0 (6 months)
Souda, GREECE	35.55°N/24.12°E	85.2	1,069 (January 1995)	0 (29 months)
Lattakia, SYRIA	35.53°N/35.77°E	63.0	316 (December 1998)	0 (19 months)
Mersa Matruh, EGYPT	31.33°N/27.22°E	7.0	101 (January 2000)	0 (47 months)

Warm, dry summers are characteristic of the Mediterranean climate, so it is not unexpected that much of the region along the eastern basin would experience several months without any precipitation (**Table 2-2**). The number of months out of the 11 yrs surveyed that each of the 5 sites received no precipitation is consistent with the geographic trend in total annual precipitation; that is, Kerkyra, which receives the most precipitation had the fewest months without precipitation and Mersa Matruh, which receives the least amount of precipitation experienced 47 out of 105 months (reporting) without measured rainfall (**Table 2-2**).

2.2.5 Storms

Storms and intense rainfall in the eastern Mediterranean region occur most often in winter (16 November to 28 May) when cold continental air masses are advected over the waters of the Mediterranean Sea and collide with the warm, moist air that resides over the Sea (Millán et al. 2005). The intensity of these storms is highly dependent on the SST, and where storms occur in the region is affected by the direction from which the air masses are advected. Higher SST results in more intense storms. Cold air masses blown into the region from the north or northwest generate storms primarily over Italy and parts of North Africa, whereas air masses entering the region from the southeast to northeast affect the coasts of western North Africa, eastern Spain, and the south of France (Millán et al. 2005).

Tropical and extratropical storms enter the Mediterranean region along loosely established tracks extending from the North Atlantic Ocean. There is evidence to suggest that these storm tracks may be shifting poleward, resulting in fewer storms from the Atlantic Ocean entering the region. Between 1961 and 1990 an average of four storms impacted the Mediterranean region from December through February. Modeled data predict that this number will decrease to three per season by the end of this century (Bengtsson et al. 2006). Changes in large-scale atmospheric phenomena, such as the frequency of occurrence of tropical storms, are invariably connected to fluctuations in the NAO. Nevertheless, any reduction in total annual precipitation will contribute to the increasing trend of desertification in the region (Bengtsson et al. 2006).

2.2.6 Large-Scale Climactic Influences

Interpreting the signs of climate change in a region requires collecting and analyzing meteorological data measured over large spatial and temporal scales in order to separate seasonal or even decadal cycles from true long-term trends. Over decadal time scales the climate in the Mediterranean region is influenced primarily by the NAO and to a lesser extent by a similar sea-level pressure anomaly known as the EAWR (Krichak and Alpert 2005; Orfila et al. 2005). Climate change is both fueled by and influences these large scale pressure systems.

In 1988/89 the normally stable conditions of the deep-sea zone in eastern basin were disturbed by an atmosphere-ocean phenomenon now referred to as the Eastern Mediterranean Transient (EMT). Abnormally cold winters coupled with reduced precipitation in summer caused high density surface waters from the Aegean Sea to sink and move into the Levantine Basin, bringing typically scarce nutrients into the deeper regions of the Levantine Sea and resulting in a mesopelagic plankton bloom (Koppelmann and Weikert 2003).

2.2.6.1 North Atlantic Oscillation

The NAO is regarded as the dominant mode of decadal-scale variability in weather and climate in the North Atlantic Ocean, including the Mediterranean region (Hurrell 1995; Hu and Huang 2006). The NAO is a continual oscillation in the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores and the subpolar low-pressure center over Iceland (Curry and McCartney 2001; Stenseth et al. 2003). When the atmospheric pressure at sea level increases in Iceland it decreases in the Azores and vice-versa (Open University 1995; Stenseth et al. 2003). The NAO has global significance as it affects sea surface temperatures, wind conditions, and ocean circulation of the North Atlantic Ocean which in turn have significant ecological impacts on marine ecosystems and the terrestrial environments of Europe and North America (Open University 1995; Stenseth et al. 2003; Menzel et al. 2005).

The variability of the NAO is measured by an index, which indicates the departure from the mean atmospheric pressure difference between the Azores High and the Iceland Low. However, there are different NAO indices available using different reference stations and/or base-line time periods. Since the known effects of the NAO are most pronounced in winter (Taylor and Stephens 1998), the NAO index most often used is the winter index, which is the average over four or five months—December through

March or April (Hurrell 1995). Typical conditions expected during the two phases (positive and negative) of the NAO index include:

- *Positive or Strong Phase*

  - Both the Iceland Low and Azores High intensify (i.e., there is a larger difference between the two pressure centers)
  - Westerly winds strengthen (by about 8 m/sec over Europe) resulting in a jet stream that flows primarily from west to east; meandering of the jet stream is reduced
  - Air temperatures in eastern and central North America are warmer than normal
  - Europe is warmer and wetter than normal
  - Greenland and the northern North Atlantic Ocean are colder than average
  - The Mediterranean Sea and surrounding area is colder and drier than average

- *Negative or Weak Phase*

  - Both the Iceland Low and Azores High are weaker than average (i.e., there is a smaller difference between the two pressure centers)
  - Meridional flow dominates; the jet stream meanders strongly
  - Eastern North America is colder and drier than normal
  - Europe is colder and drier than normal
  - Greenland and the northern North Atlantic Ocean are warmer than normal
  - The Mediterranean Sea and surrounding area is warmer and wetter than normal (Hurrell 1995; Open University 1995; Rîmbu et al. 2001; Visbeck 2002; Krichak and Alpert 2005)

The NAO tends to remain relatively stable for extended periods ranging from several years to decades. On average, the NAO was positive from 1900 to 1950, negative in the 1960s and 1970s, and has been positive since 1970 (Hurrell et al. 2001); although, recently the NAO index has declined rapidly resulting in a weak to nonexistent trend in the index when averaged over the past 30 yrs (Cohen and Barlow 2005).

Since ocean circulation is wind and density driven, it is not surprising to find that the NAO appears to have a direct effect on the position and strength of currents in the North Atlantic Ocean. The NAO influences the latitude of the Gulf Stream and accounts for a great deal of the interannual variability in the location of the current. In years following a positive NAO index, the latitude of the “north wall” of the Gulf Stream Current (i.e., the northern boundary of the current east of Cape Hatteras, North Carolina) is located farther north than usual (Open University 1995; Taylor and Stephens 1998). In addition, the NAO is capable of affecting the strength of the Gulf Stream and its end-member, the North Atlantic Current. During the predominantly negative NAO years of the 1960’s, the Gulf Stream shifted southward and weakened. During the subsequent 25-yr period when the NAO index was predominantly positive, the Gulf Stream intensified reaching a record peak in transport in the 1990s that was 25 to 33% above average (Curry and McCartney 2001). The location and strength of the Gulf Stream is critical, because the current is an essential part of the North Atlantic atmospheric-oceanographic system, moderating local climate and weather from the U.S. to the Mediterranean Sea (Hurrell 1995; Open University 1995).

2.2.6.2 Climate Change

Climate change in the Mediterranean Sea may be enhanced due to the semi-enclosed structure of the Sea and the long residence time (~100 yrs) of water cycling between the Mediterranean Sea and the North Atlantic Ocean (Martin and Milliman 1997).

Millan et al. (2005) hypothesize that an observed shift in the precipitation pattern in the Mediterranean Basin towards fewer summer storms and increased torrential rains in fall and winter is related to 1) changes in land-use that lead to accelerated surface heating and 2) increases in the amount of greenhouse gasses present in the troposphere above the Mediterranean Basin. Increases in these two

factors are likely to reinforce the trend, the effects of which will be felt in both sub-basins and extend onto the adjacent continents (Millán et al. 2005).

Other anthropogenic pressures on the Mediterranean Basin such as an increased demand for freshwater are forecast to intensify as both the tourist and resident populations of the region increase. Reducing freshwater input into the Sea is likely to result in increases in SST, particularly on a seasonal time scale, which in turn will affect evaporation and the development of storm systems (Duarte et al. 1999). Efforts to model the impacts of climate change in the Mediterranean region predict that an increase in greenhouse gases over the Mediterranean Sea will result in an overall warming and drying out of the region. Furthermore, predicted decreases in annual precipitation (despite an anticipated increase in winter precipitation) throughout the Mediterranean region will reduce soil moisture, creating additional ecological and socio-economic impacts for the region (Gibelin and Déqué 2003).

Measurement of trends in climate extremes is often used as an indicator of climate change. In the eastern Mediterranean Basin several indicators seem to be opposing global trends whereas others are consistent with them. For example, although the number of frost days is generally decreasing worldwide (an indicator of global warming), for many areas in the eastern sub-basin the number of frost days has increased significantly (Kostopoulou and Jones 2005). By contrast, increases in the minimum air temperature, another indicator of global warming, are consistent with worldwide trends; an index measuring the duration of heat waves in the region indicates that the number of very warm days and nights have been increasing throughout the region (Kostopoulou and Jones 2005).

2.3 MARINE GEOLOGY

2.3.1 Geologic Setting

The Mediterranean Sea is a relative newcomer to Earth's landscape and is remnant of the once extensive Tethys Ocean, a wedge-shaped, eastward-open equatorial water-body that indented Pangea during the Triassic Era (Bianchi and Morri 2000; Amblàs et al. 2004; Sardà et al. 2004). Over time, the convergence of the African, Eurasian, and Arabian tectonic plates closed off the eastern Mediterranean Sea from the global ocean. From this point (approximately 9 million years ago), the Mediterranean Sea began developing the physiography evident in the Mediterranean Sea today (Amblàs et al. 2004).

2.3.2 Physiography and Bathymetry

The Mediterranean Basin occupies an area of approximately 2.6 million km^2; average water depth of the Mediterranean Sea is 1,500 m (Amblàs et al. 2004). The bathymetry of the region is complex, resulting in the formation of a series of small basins (Tsimplis et al. 1995). Although these basins differ greatly in terms of dimension, physiography, and geologic evolution, they can be grouped into western and eastern basins (Amblàs et al. 2004). Excluding the Adriatic and Aegean seas, the eastern and western basins are roughly equal in size (Robinson et al. 2001).

Continental shelves comprise between 20 and 25% of the total area of the Mediterranean Basin (UNEP 1989; 1996; Sardà et al. 2004). In general, the continental shelves of the Mediterranean Sea are narrow and are related to the mountain chains surrounding the basin. These restricted shelf regions include nearly the entire continental margin of the Mediterranean Basin, except off of Tunisia and where river deltas are present (**Figures 2-1** and **2-2**; Sardà et al. 2004). Shelf breaks in the Mediterranean Sea are typically located between 100 and 150 m depth, but can reach as deep as 260 m in some locations (e.g., the Nile shelf; Sardà et al. 2004).

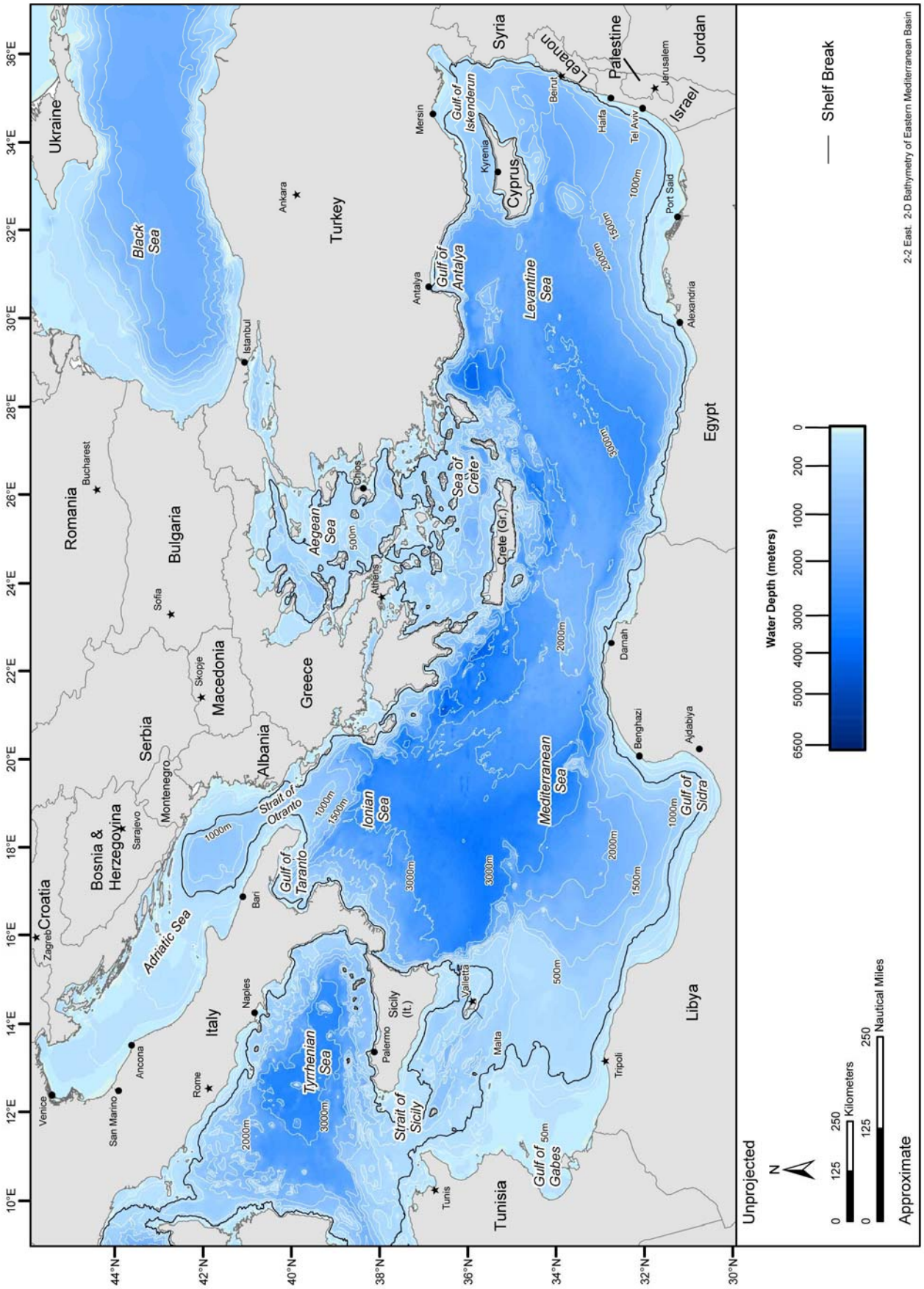


Figure 2-2. 2D bathymetry of the eastern Mediterranean Sea. Source data: Smith and Sandwell (1997).

Despite the overall significance of the continental shelf region in area, less than 1.5% of the total volume of water is found in this region (Menard and Smith 1966). Thirty percent of the surface area and 50% of the volume of the Mediterranean Sea occurs at depths greater than 2,000 m (Menard and Smith 1966; UNEP 1989; 1996). Apart from the submarine trenches that occur in the region, the abyssal plain is the deepest physiographic feature in the Mediterranean Sea (138,000 km^2, approximately 7% of the seafloor below the shelf break; Rothwell et al. 2000; Amblàs et al. 2004). The abyssal plains in the Mediterranean Sea are shallower than those that occur in large oceanic basins (4,200 m versus 6,200 m; Amblàs et al. 2004), and are typically defined as those areas that fall below the 2,700 m isobath (Rehault et al. 1985).

The eastern Mediterranean Sea lies to the east of the Strait of Sicily and has a highly varied physiographic character. The eastern Mediterranean Sea has been connected to the Red Sea via the Suez Canal since 1869.

The eastern Mediterranean Sea can be divided into two major sub-basins: the Ionian Basin and the Levantine Basin (**Figure 2-3**; Sardà et al. 2004; Alhammoud et al. 2005). The Ionian Basin lies between the southern coasts of Italy and Greece and the coast of Libya. A submarine ridge between western Crete and Libya separates the Ionian Basin from the Levantine Basin (Sardà et al. 2004). Often, the Adriatic Sea and Aegean Sea are included in discussions of the eastern Mediterranean Sea. Including these two seas, the eastern Mediterranean Sea encompasses an area of approximately 1.7 million km^2 (UNEP 1989; 1996; Amblàs et al. 2004). The northeastern limit of the Aegean Sea connects to the Black Sea through the narrow channel in the Dardanelles (sill depth is approximately 70 m). The eastern Mediterranean Sea region is often more difficult to describe in terms of physiography than the western basins; the main structures clearly visible in the bathymetry of the eastern Mediterranean Sea are the Hellenic Trench and the Mediterranean Ridge (**Figure 2-3**). Basin floors tend to be deeper, but smaller, than those found in the western Mediterranean Sea. Maximum depth approaches to 4,200 m in the Ionian Sea Abyssal Plain.

2.3.2.1 Strait of Sicily

The Strait of Sicily divides the Mediterranean Sea into western and eastern sub-basins. The Strait is a complex topographic region composed of two sill systems separated by an internal deep basin (**Figures 2-1** and **2-2**; Gasparini et al. 2005). The Strait is wide at the surface but rapidly narrows with depth due to the presence of shallow banks along both the Tunisian and Sicilian coastlines. Along these banks, depth ranges from 50 to 200 m. The bank on the Tunisian coast encroaches upon a substantial portion of the surface area of the Strait (Robinson et al. 1999).

The western boundary of the Strait is a topographically complex region (Gasparini et al. 2005). Two narrow passages connect the Strait to the western Mediterranean Sea; maximum depth in this region is approximately 530 m. A central basin, located between the isle of Sicily and Tunisia, occupies a significant portion of the Strait. This region has a mean depth of approximately 800 m, but in several trenches the depth can exceed 1,700 m. The eastern sill region has a maximum depth of approximately 540 m and connects the Strait with the Ionian Basin of the eastern Mediterranean Sea (Gasparini et al. 2005).

2.3.2.2 Ionian Basin

The Ionian Basin displays a sharp, broken topography that can be divided into three separate sub-basins or plains. In the northern areas of the Ionian Basin, the Messina Plain is delineated by the 3,600 m isobath and extends to a depth of 4,100 m. The Sirte Plain is located at the base of the Libyan continental slope to the west of the Mediterranean Ridge and the Herodotus Trough. The third sub-basin, the Hellenic Trench, is located between the Mediterranean Ridge and the continental margin of Greece (**Figure 2-3**; Sardà et al. 2004). The deepest recorded depth within the Mediterranean Sea (5,121 m) is located within the Hellenic Trench (Vanney and Gennesseaux 1985; Sardà et al. 2004).

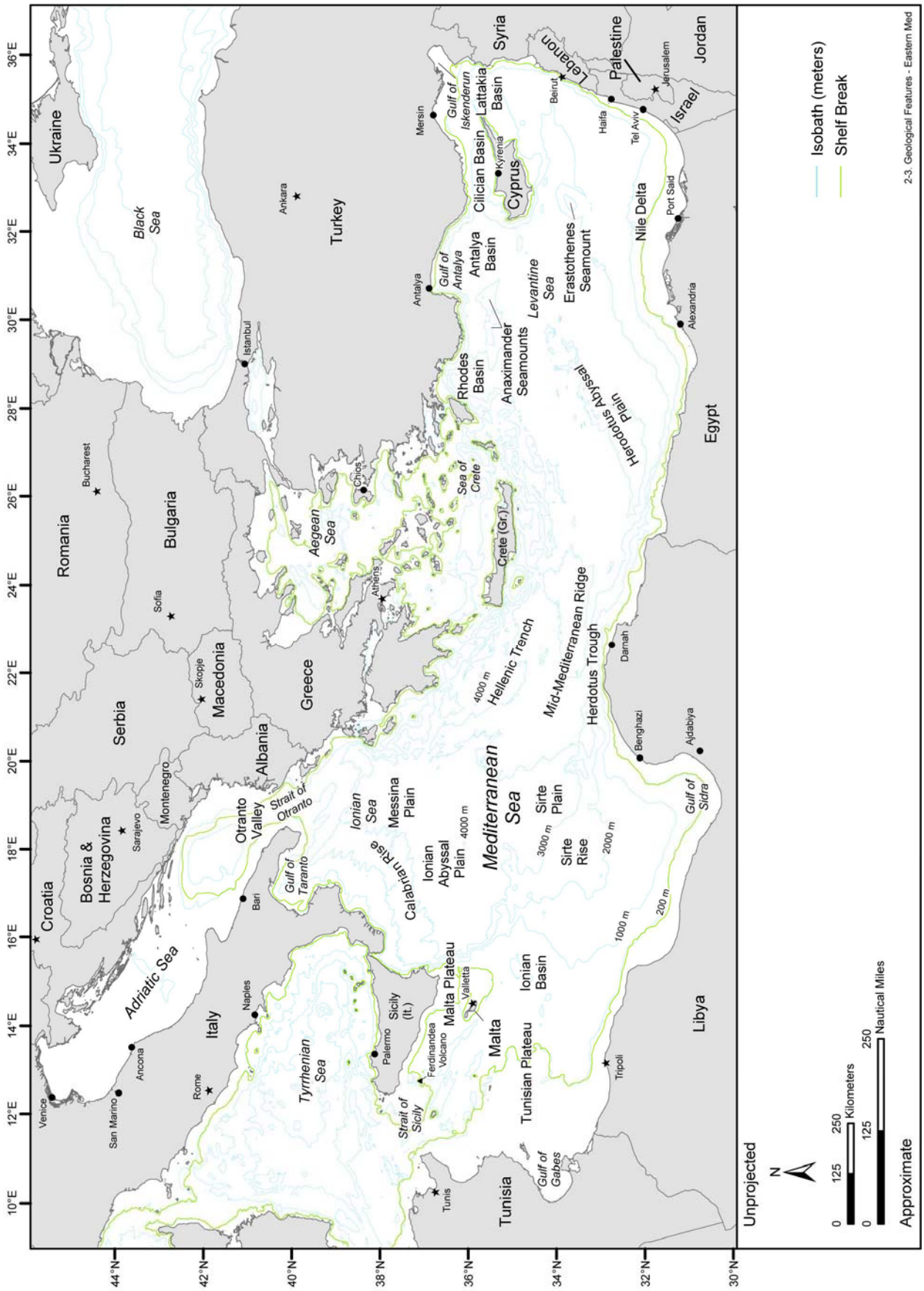


Figure 2-3. Geological Features of the eastern Mediterranean Sea. Map adapted from: Özsoy et al. (1993).

The central abyssal plain of the Ionian Basin is triangular in shape and encompasses an area of about 5,000 km^2. The exact bathymetry of the plain is difficult to determine (Hieke et al. 2003); it is bounded by the 3,000 to 4,000 m isobath and has a maximum depth of 4,140 m (Carter et al. 1972; Hieke et al. 2003; Sardà et al. 2004).

2.3.2.3 Levantine Basin

The Levantine Basin occupies the easternmost regions of the Mediterranean Sea. It is bounded by Crete and Asia Minor to the north, the Middle East to the east, and northeastern Africa to the south. The continental shelf throughout the basin is narrow, with the exception of the Gulf of Iskendrun northeast of Cyprus and the southeastern shelf at the Nile River delta (Özsoy et al. 1989; Alhammoud et al. 2005). The Levantine Basin is composed of four sub-basins: Lattakia, Cilician, Antalya, and Rhodes, and the Herodotus Abyssal Plain (**Figure 2-3**; Özsoy et al. 1993; Galil 2004; Alhammoud et al. 2005). The Herodotus Abyssal Plain is a northeast to southwest elongate depression bounded by the 2,800 to 3,000 m isobaths. It reaches a maximum depth of over 3,150 m, and encompasses an area of approximately 27,000 km^2, which makes the Herodotus Abyssal Plain the largest basin in the eastern Mediterranean Sea (Rothwell et al. 2000; Sardà et al. 2004).

The Mid-Mediterranean Ridge spans the region from the Ionian Basin to the center of the Levantine Basin, and provides relief from the otherwise flat surroundings in the Levantine Basin. Within the Levantine Basin, the Ridge extends northeast ultimately connecting with the insular margin surrounding the island of Cyprus (Alhammoud et al. 2005). Additional relief in the region is provided by the Anaximander and Eratosthenes Seamounts (**Figure 2-3**; Özsoy et al. 1993).

2.3.2.4 Adriatic Basin

The Adriatic Basin is a semi-enclosed rectangular basin oriented in a northwest-southeast direction. The Adriatic Sea has an overall length of approximately 800 km and is about 200 km wide (Artegiani et al. 1993; Manca et al. 2002). It can be divided in to three distinct regions. The northernmost region is shallow with a bottom topography that gently slopes south; maximum depth approaches 100 m. The second sub-basin of the Adriatic consists of three pits located off of Pescara, Italy with the maximum depth reaching 280 m. The most southern sub-basin is separated from the remainder of the Adriatic by the Palagruza Sill (120 to 170 m; Vucetic 1973; Manca et al. 2002).

The southern Adriatic is characterized by isobaths of nearly circular shape (**Figure 2-2**). Maximum depth (>1,200 m) occurs in the Adriatic Pit at the center of the southern Adriatic (Vucetic 1973; Faganeli et al. 1994; Tsimplis et al. 1995; Kovačević et al. 1999). South of the depression, the seafloor rises towards the Strait of Otranto. The Strait of Otranto connects the Adriatic Basin to the eastern Mediterranean Basin. The Strait is approximately 75 km wide and 800 m deep at the sill (Manca et al. 2002). The Strait of Otranto is capable of influencing the dynamics of water exchange throughout the Adriatic Sea and the eastern Mediterranean Sea (Kovačević et al. 1999).

2.3.2.5 Aegean Basin

The Aegean Basin has a volume of approximately 7.4×10^4 km^2, encompasses an area of 1.8×10^{11} square meters (m^2), and has a mean depth of 450 m. The Aegean Basin is approximately ten times smaller in volume than the Levantine Basin but larger and deeper than the Adriatic Basin (Theocharis et al. 1993; Poulos et al. 1997; Velaoras and Lascaratos 2005). The Aegean Basin is more complex than other regions of the eastern Mediterranean Basin with respect to geography and bottom topography. It is characterized by a very irregular coastline with over 2,000 islands scattered throughout the basin (**Figure 2-2**). Bottom topography is very irregular with large plateaus adjacent to steep slopes and deep basins or channels (Theocharis et al. 1993; Velaoras and Lascaratos 2005).

2.3.3 Bottom Substrate

The depositional pattern of sediments in the Mediterranean Basin is closely related to the topography, sediment input, and oceanographic conditions of the surrounding area (Sardà et al. 2004). Sediment deposition regions in the Mediterranean Sea can be subcategorized into five predominate regimes: 1) continental shelves located off of major river deltas and composed primarily of sands; 2) continental slopes that are dominated by the interaction between current flow and substrate settling; 3) submarine canyons that rapidly transport terrestrial sediments to deep basins; 4) submarine fans at the base of submarine canyons; and 5) bathyal or abyssal plains identified by their abundant muds (Sardà et al. 2004). Deep-sea muds are estimated to form 80% of the cover in the Mediterranean Sea (**Figure 2-4**; Stanley and Wezel 1985; Rothwell et al. 2000).

The widespread construction of dams on rivers that feed the Mediterranean Sea (e.g., the Nile River) has led to considerable reductions in sediment delivery (Duarte et al. 1999). Some locations have experienced as much as a 90% reduction in sediment delivery to the Sea (Martin and Milliman 1997; Skliris and Lascaratos 2004). Lack of sediment delivery further exacerbates the problem of coastal erosion in the region (e.g., Sestini 1989).

2.4 CHEMICAL OCEANOGRAPHY

2.4.1 Hydrography

Hydrography is the scientific study of the measurement and description of oceanic physical features. The following sections describe in detail the temperature of water at the sea surface and the distribution of the salinity in the eastern Mediterranean Sea.

2.4.1.1 Sea Surface Temperature

SST in the eastern Mediterranean Basin is strongly influenced by seasonality. SST oscillates between two main states corresponding to a cooler winter season and a warmer summer season in the region (Figure 2-5; Marullo et al. 1999b, 1999a). During winter, the average SST is 16.6ºC while in summer temperatures exceed 25°C (Hecht et al. 1988). A general gradient of increasing SST from north to south is evident in the region during both summer and winter, and the surface waters in the Adriatic and Aegean seas are noticeably cooler than the waters of the main eastern sub-basin (**Figure 2-5**). Since 1950, the surface waters of the entire Mediterranean Sea have undergone a sustained cooling (Painter and Tsimplis 2003).

<u>Aegean Sea</u>

SST in the Aegean Sea is heavily influenced by water exchange with the Black Sea through the Dardanelles. Surface waters in the Black Sea remain considerably cooler throughout the year than the waters of the Aegean Sea, resulting in a wide range in the annual SST of the Aegean (Marullo et al. 1999b, 1999a). In northern regions of the Sea, temperatures can dip to 8°C in winter, while at the southernmost extent of the Sea, where air temperature can have a dramatic effect on the SST, surface waters can reach 26°C (Poulos et al. 1997; Beşiktepe 2003).

2.4.1.2 Salinity

The Mediterranean Sea as a whole is a concentration basin in which evaporation exceeds precipitation and riverine runoff by 0.6 to 1.2 meters per year (m/yr; Bryden and Kinder 1991; Malanotte-Rizzoli and Bergamasco 1991; Drakopoulos and Lascaratos 1999; Manca et al. 2004). This imbalance results in salinities in the Mediterranean Sea that exceed the salinity of average seawater (Duarte et al. 1999). Salinity in the Mediterranean Sea increases steadily from west to east, with values of approximately 36 practical salinity units (psu) in the Strait of Gibraltar to 39 psu in the eastern sub-basin (Kallel et al. 1997; Brankart and Brasseur 1998; Theocharis et al. 1999). Lower salinities occur near the mouths of rivers (e.g., the Nile River) that discharge freshwater into the Mediterranean Sea (Poulos et al. 1997).

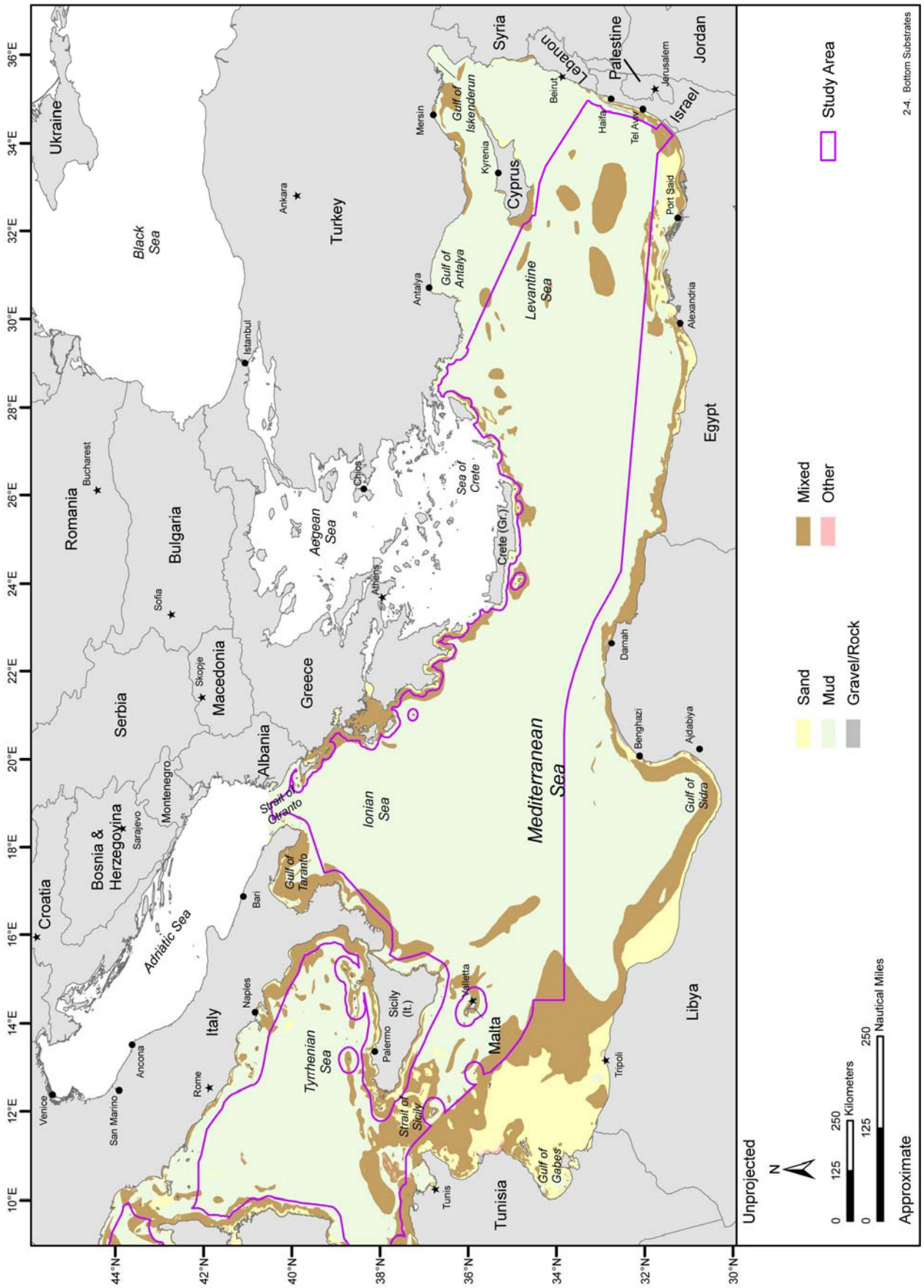


Figure 2-4. Distribution of bottom substrates in the eastern Mediterranean Sea. Source data: NAVO (2006).

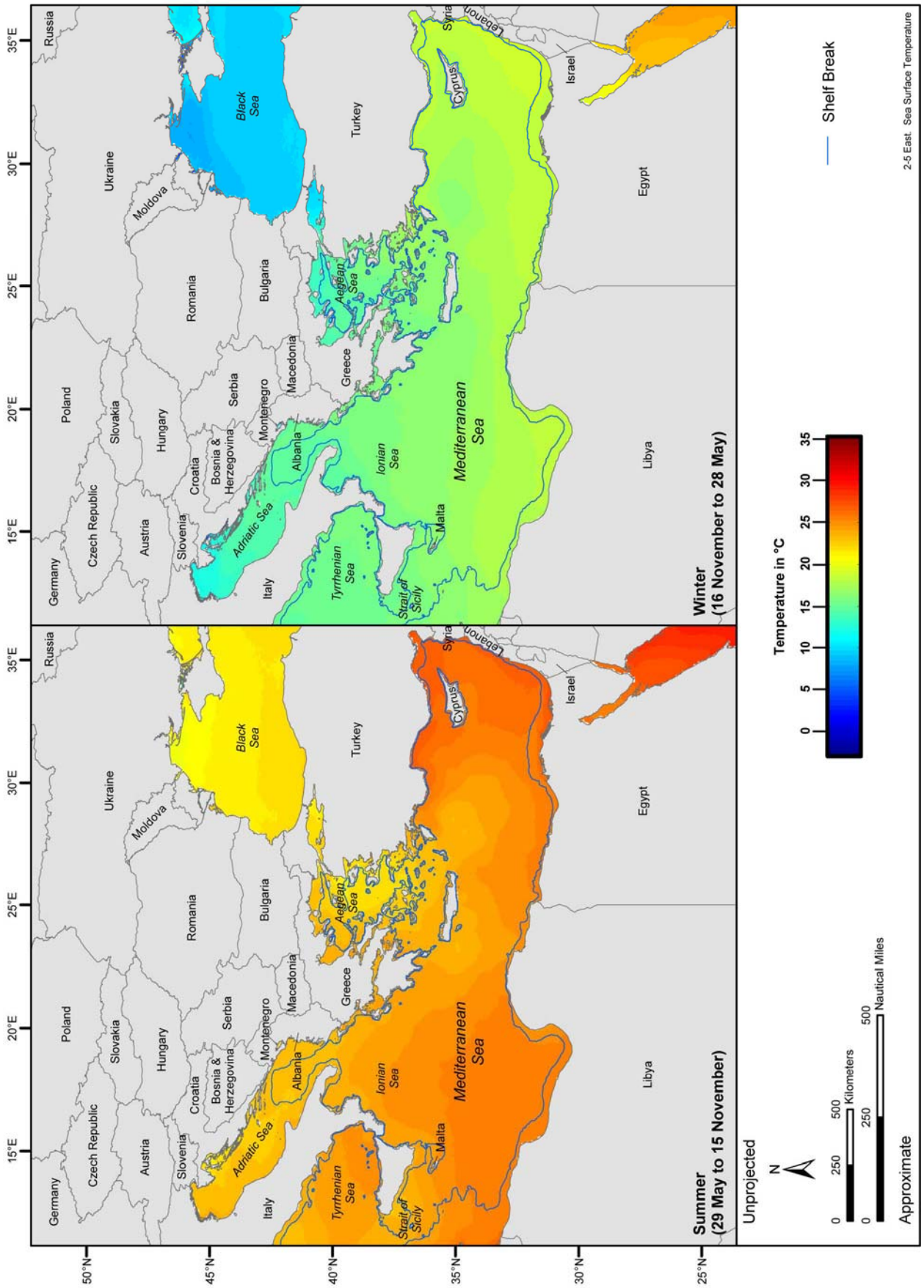


Figure 2-5. SST of the eastern Mediterranean Sea during the summer (29 May through 15 November) and winter (16 November through 28 May). Source data: NASA.[7]

Seasonality also plays a role in the salinity of the Mediterranean Sea. On average, salinity is at a minimum during winter and increases throughout summer (Hecht et al. 1988). In the Adriatic Sea, salinities can range from 31 psu in winter to 38 psu during summer (Vucetic 1973). The Aegean Sea is extremely saline with seasonal variability primarily affected by the entrainment of Black Sea water (Theocharis et al. 1993; Yüce 1995); mean salinity in the Aegean Sea does not drop below 39 psu (Beşiktepe 2003).

Over decadal time scales, the Mediterranean Sea is becoming saltier (Boscolo and Bryden 2001). Salinities in the upper waters of the Mediterranean Sea have been increasing since 1950 (Painter and Tsimplis 2003). In addition, deeper waters are also increasing in salinity; deepwater formed in the Gulf of Lion (western Mediterranean Sea) is increasing at 0.007 psu per decade (Lacombe et al. 1985; Leaman and Schott 1991; Rohling and Bryden 1992). Levantine Intermediate Water (LIW), formed in the eastern Levantine Basin, also began increasing in salinity following the diversion of the Nile and Russian rivers for use in crop irrigation (Rohling and Bryden 1992).

2.5 PHYSICAL OCEANOGRAPHY

2.5.1 General Circulation

Due to the sheer size of the Mediterranean Sea, many processes that are essential to the general circulation of the global ocean are also evident within the Sea (Robinson et al. 2001). The overall circulation of the Mediterranean Sea is dependent upon its sole connection to the open ocean at the Strait of Gibraltar (Sardà et al. 2004). The general circulation of the Sea is complex, and is composed of circulations occurring on three distinct spatial scales: basin, sub-basin, and mesoscale.

The structure of the water column in the eastern Mediterranean Sea can be described as a three-layer system. Surface waters are comprised primarily of Atlantic Ocean water modified during its passage through the western Mediterranean Sea. This layer is the most variable due to the presence of the thermocline, local freshwater runoff, and precipitation. Underlying the surface waters is the LIW which is formed in the Levantine Sea. Beneath the LIW is the eastern Mediterranean Deep Water (EMDW), which extends to the sea floor and is formed in the Aegean and Adriatic seas (The POEM group 1992; Theocharis et al. 1993; Balopoulos et al. 1999).

2.5.1.1 Strait of Sicily

The bifurcation of the Algerian Current entering the Strait of Sicily is composed of two major streams, the Atlantic Ionian Stream (AIS) and the Atlantic Tunisian Current (ATC; **Figure 2-6**). The ATC is more pronounced during winter; during summer the AIS is associated with several semi-permanent features including the Adventure Bank Vortex, Maltese Channel Crest, and Ionian Shelf Break Vortex (Robinson et al. 1999; Béranger et al. 2004). In addition to the general circulation, wind-driven currents generated from local and remote storm systems are common along the wide continental shelves of the region.

Through the water column, the circulation of the Strait of Sicily can be described as a two-layer exchange of Atlantic Ocean water (upper layer) and eastern Mediterranean Sea outflow water (lower layer; Béranger et al. 2004). At depth, the eastern Mediterrranean Sea outflow water flows to the west where it enters the Tyrrhenian Sea; this water is composed primarily of LIW formed in the Levantine Basin of the eastern Mediterranean Sea (Béranger et al. 2004; Béranger et al. 2005).

2.5.1.2 Ionian Sea

Relatively little is known about the general circulation of the Ionian Sea in comparison to the circulation of the western Mediterranean Sea to the west and the Levantine Sea to the east (Ayoub et al. 1998). The main characteristic of the Ionian region is the AIS which carries Atlantic Ocean water from the western Mediterranean Sea to the Levantine Basin. The AIS undergoes strong variability resulting in a path that is not well defined (Ayoub et al. 1998). Currents in the Ionian Sea are generally cyclonic in nature, forming large gyres (Hecht et al. 1988).

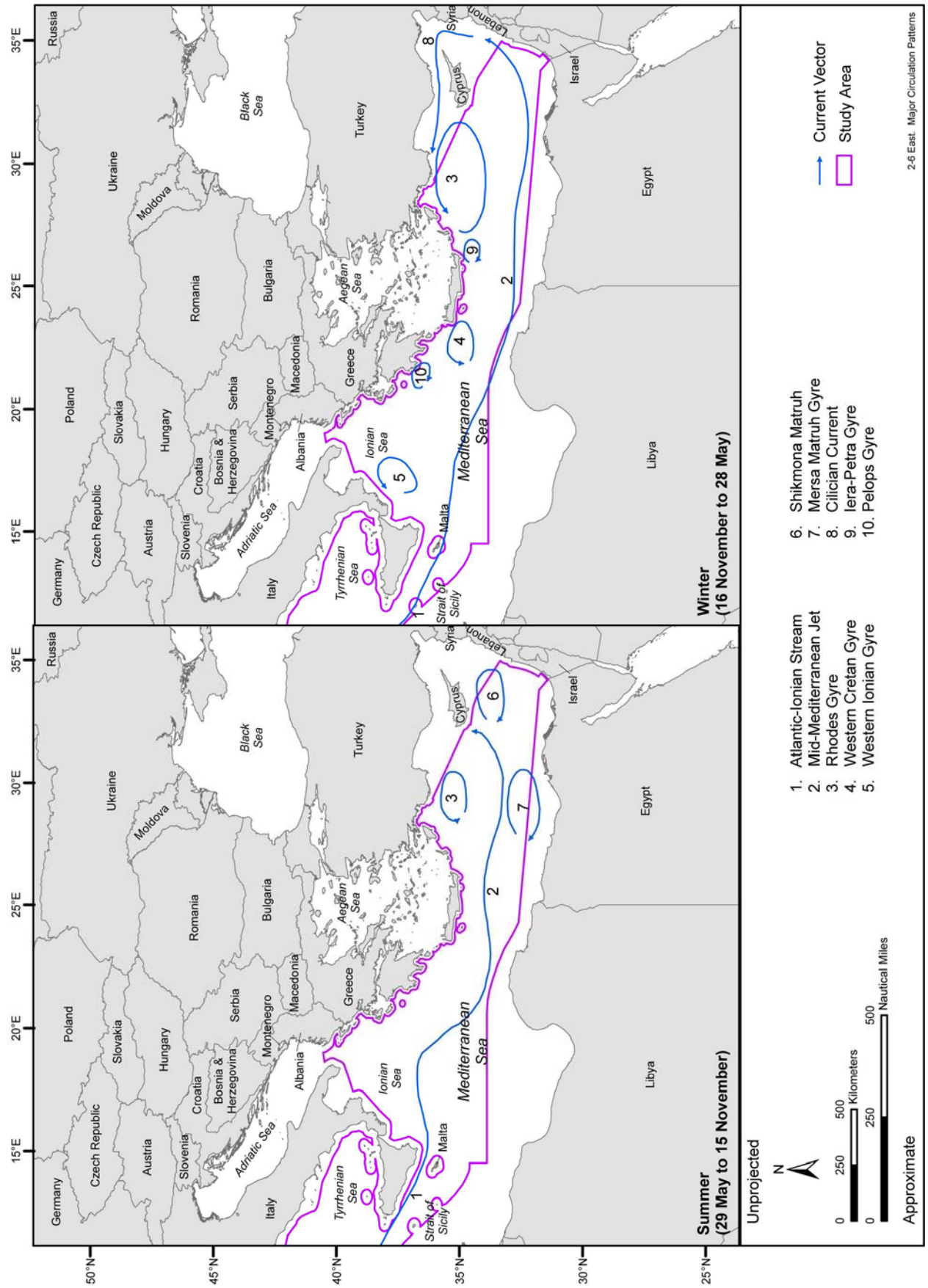


Figure 2-6. Regional surface circulation of the eastern Mediterranean Sea. Source maps (scanned): Ayoub et al. (1998) and Pinardi and Masetti (2000).

The eastern reaches of the Ionian Sea along the coast of Greece are dominated by two permanent gyres (The POEM group 1992; Theocharis et al. 1993). The Pelops Gyre has an anticyclonic rotation and is one of the most intense features in the eastern Mediterranean Sea (**Figure 2-6**; Theocharis et al. 1999). The Pelops varies in shape and dimension. Circulation from the gyre remains strong in intermediate layers and is detectable at depths up to 2,000 m. The Cretan cyclone dominates the northwestern regions of the Cretan Passage (**Figure 2-6**; Theocharis et al. 1999). Analytical models support the presence of a permanent cyclonic gyre in the northwestern region of the basin, and predict that the Cretan Gyre weakens during summer (Roussenov et al. 1995). The gyre is bordered to the south by the AIS which flows east across the central Ionian Basin (Ayoub et al. 1998). On average, cyclonic circulation has intensified in the Ionian Sea since 1997 (Larnicol et al. 2002).

2.5.1.3 Levantine Sea

The wintertime formation of LIW in the Levantine Sea is considered to be one of the primary drivers of the thermohaline circulation throughout the entire Mediterranean Sea (Roether et al. 1998; Lascaratos et al. 1999; Theocharis et al. 1999; Alhammoud et al. 2005). Water enters the Levantine Sea from the Ionian Sea as a jet or current often referred to as the Ionian Stream or the Mid-Mediterranean Jet (**Figure 2-6**). During winter, this strong current is clearly defined along the African coast, and is particularly stable between 23º and 25ºE. It flows at an approximate speed of 0.4 m/sec which drives the generally cyclonic circulation pattern present in the Levantine Sea (Ayoub et al. 1998; Alhammoud et al. 2005). During summer, it becomes more difficult to ascertain a clear basin-wide circulation; the strong cyclonic circulation pattern present during winter weakens, and the region is dominated by high mesoscale variability and numerous eddies (Ayoub et al. 1998; Alhammoud et al. 2005).

Numerous persistent gyres are also present within the Levantine Sea, both cyclonic and anticyclonic in rotation (**Figure 2-6**). The prominent anticyclonic gyres include the Mersa-Matruh Gyre in the southern Levantine off of the coast of Egypt, the Shikmona Matruh Gyre in the eastern Levantine south of Cyprus, the Pelops Gyre found off of Peloponnesus, and the Iera-Petra Gyre located south of Crete (Golnaraghi 1993; Drakopoulos and Lascaratos 1999; Larnicol et al. 2002). East of the Iera-Petra Gyre is the permanent, cyclonically rotating Rhodes Gyre (Theocharis et al. 1999). Although always present, the dimensions, position, and strength of the Rhodes Gyre are highly variable (Marullo et al. 1999b).

The water column in the Levantine Sea is composed of three distinct water masses. Surface waters make up the upper 100 to 200 m. Directly beneath the surface water layer is the LIW which extends to depths of 400 to 500 m. A bottom or deep water layer extends from the LIW to the sea floor and is referred to as the EMDW. The EMDW is formed in the Adriatic and Aegean Seas and resides at a depth greater than the sills at the Strait of Sicily, preventing it from flowing back into the western Mediterranean Sea (Zavatarelli and Mellor 1995; Alhammoud et al. 2005).

2.5.1.4 Adriatic Sea

The circulation of the Adriatic Sea is determined primarily by its geographic location, geologic morphology, the climate in the region, freshwater inflow, and water exchange with the Ionian Sea. While each of these factors influence the circulation independently, it is the interaction of factors that ultimately determines the overall circulation patterns of the Sea (Artegiani et al. 1993). In the north, the Adriatic Sea is relatively shallow and the local circulation is significantly influenced by fluctuations in the outflow from the Po and Adige rivers. Coupled with local wind stresses, the outflow from these two rivers modifies the local surface circulation patterns in addition to affecting vertical mixing of the water column (Aubry et al. 2004).

The Strait of Otranto is the region of exchange between the Adriatic Sea and the Ionian Sea to the south. In the upper layer of what is essentially a two-layer system, Adriatic surface waters flow southeast along the western edge of the Sea while Ionian surface water flows north west into the Adriatic along the eastern shore (Socal et al. 1999). At depth, Adriatic Sea deep water (which forms in the southern Adriatic Sea during winter) and LIW are exchanged, influencing the overall thermohaline circulation of the both the

Adriatic and Ionian seas (Haines and Wu 1998; Drakopoulos and Lascaratos 1999; Kovačević et al. 1999; Lascaratos et al. 1999; Manca et al. 2002).

2.5.1.5 Aegean Sea

The surface circulation of the Aegean Sea changes both seasonally and within shorter time scales. Strong sporadic meteorological events (e.g., local storms and gale force winds) can rapidly and dramatically alter local circulation patterns. The reasons for this complex circulation pattern are due to several factors including the geographical distribution of numerous island chains, exchange with the eastern Mediterranean Sea through straits to the east and west of Crete, the irregular physiography of the Aegean Basin, the inflow of cold, fresh waters from the Black Sea, riverine discharge, and the seasonal variability of persistent weather conditions (e.g., summer winds; Tsimplis et al. 1995; Poulos et al. 1997; Zeri and Voutsinou-Taliadouri 2003). Despite the overall geologic and physiographic complexity of the region, a generally cyclonic surface circulation can be detected in the Aegean (Yüce 1995; Lykousis et al. 2002); however, the most pronounced dynamic features of the Aegean Sea are transient cyclonic and anticyclonic eddies (Theocharis et al. 1999; Lykousis et al. 2002).

2.5.2 Thermocline

The thermocline is located between the surface and deepwater circulation zones; it is a transition region where water temperatures change rapidly from warmer surface waters to colder deep waters. A seasonal thermocline develops in the Mediterranean Sea during the months of May and June. This thermocline will persist throughout the Mediterranean Sea for four to five months prior to breaking down as a result of water column mixing by regional storms in September or October (Duarte et al. 1999). In addition to storms, winter cooling aids in eroding the thermocline (Pedrós-Alió et al. 1999). During winter, the water column is almost homogenous in temperature (Salat et al. 2002). Seasonal stratification is not as well defined in coastal waters (e.g., the Adriatic Sea) because advective processes create a more transient, unstable environment (Aubry et al. 2004).

2.5.3 Upwelling Centers

Upwelling is a wind-driven, dynamic process that brings nutrient-rich deep water to the surface and advects nutrient-poor surface waters offshore through the interaction of currents, density, or bathymetry (Mann and Lazier 1991). Coastal upwelling zones are among the most productive regions of the global ocean (Mote and Mantua 2002). The Mediterranean Sea is not well known for supporting upwelling dominated marine ecosystems; however, several upwelling zones in the Mediterranean Sea are substantial by world standards. These upwelling zones can reach intensities of approximately 50% the seasonal peak in the upwelling core of the California Current and 45% the intensity encountered off southern Peru two of the world's most prominent upwelling centers (Bakun and Agostini 2001).

2.5.3.1 Ionian Sea

During winter, high intensity katabatic winds out of the north result in the generation of an upwelling zone approximately 200 km south of the "heel" of the Italian "boot." To the west, the winds create a region of convergence along the southern coast of Calabria ("toe" of the boot). Upwelling decreases in late winter. During summer, strong upwelling events can occur off of the west coast of Greece. The offshore regions of the Ionian Sea are largely considered to be a downwelling zone (Bakun and Agostini 2001).

2.5.3.2 Aegean Sea

The surface waters of the Aegean Sea are subject to wind stress from strong katabatic winds out of the north and intense westward transport. Flow of water away from the eastern coasts results in intense upwelling along the Turkish coast, where, during summer upwelling velocities reach 0.5 to 1.5 meters per day (m/day). The strong transport also creates an intense downwelling zone off of the northern coast of Crete (Bakun and Agostini 2001).

2.5.3.3 Levantine Sea

The strong upwelling present along the eastern coastline of the Aegean Sea curves around Turkey to produce a region of upwelling in the northern Levantine Sea. Throughout the majority of the year, the region between Cyprus and mainland Turkey is an intense downwelling zone; however, upwelling occurs along the southern coast of Cyprus and reaches maximum intensity during summer. Isolated regions of upwelling and downwelling also occur along the eastern coastline of the Levantine Sea while the southern coastline is a continuous downwelling region. Upwelling favorable conditions have been observed along the east coast in the Gulf of Sidra (north of Libya) during summer (Bakun and Agostini 2001).

2.5.4 Tides

Tides are the most predictable oceanic motions; the gravitational pull of the moon (and to a lesser extent of the sun) creates "bulges" of water on opposite sides of the earth (Thurman 1997). Each region of the earth passes through these bulges twice a day, resulting in semi-diurnal (half daily) components to the tidal cycle. Furthermore, the moon and the sun do not generally lie over the equator; this displacement creates one tidal bulge larger than the other, thus leading to a diurnal (daily) component to the tides. Tides within the Mediterranean Sea are exceptionally small, exceeding 10 centimeters (cm) in the northern Adriatic, the Gulf of Gabes off Tunisia, and the north Aegean Sea (Tsimplis et al. 1995).

2.6 BIOLOGICAL OCEANOGRAPHY

Detailed descriptions of macrofauna found in the study area, such as marine mammals, sea turtles, fishes, and corals and other invertebrates, may be found in later chapters of this MRA (i.e., Chapters 3, 4, and 5). This section describes the plankton, which are particularly influenced by the physical environment and constitute a vital link in the global food web. Particular reference is given here to the physical mechanisms that affect the occurrence of plankton.

Plankton are organisms that float or drift and cannot maintain their direction against the movement of currents (Mann and Lazier 1991). Plankton include phytoplankton (plant-like organisms), zooplankton (animals), and bacterioplankton (bacteria). In general, planktonic organisms are very small or microscopic, although there are exceptions. Jellyfish and pelagic *Sargassum*, for example, are unable to move against the surrounding currents and therefore are considered plankton despite the fact that these organisms are macroscopic with some jellyfish reaching 3 m in diameter. Many zooplankton migrate hundreds of meters in the water column on a daily basis, which can place them under the influence of different currents than occur at the surface, allowing them to indirectly control their lateral movement; however, like all plankton, they cannot migrate against the prevailing current (Lalli and Parsons 2000).

2.6.1 Primary Production

Primary production refers to the amount of inorganic material (e.g., nitrate and phosphate) that is converted into organic compounds (e.g., proteins and lipids) primarily through the process of photosynthesis (Lalli and Parsons 2000). Phytoplankton are often referred to as primary producers, because, like terrestrial plants, they are able to use solar radiation and the pigment chlorophyll (mainly chlorophyll *a* [Chl *a*]) to fix carbon and create their own energy. Furthermore, phytoplankton form the base of the marine food chain making them essential to the overall productivity of the ocean.

Chlorophyll *a* (Chl *a*) is the principal pigment that enables phytoplankton to photosynthesize (Mann and Lazier 1991; Lalli and Parsons 2000; Schalles 2006). Measuring Chl *a* concentrations over large spatial scales is often accomplished using satellite-based detectors of ocean color. Translating the measurements of ocean color into estimates of primary production is a complex process involving multiple steps, each of which can contribute to error in the estimate. Sophisticated algorithms are developed to address these complexities, which include: uncertainty in the contribution of other pigmented compounds to the measured Chl *a* reflectance, particularly in turbid coastal regions; filtering atmospheric scatter from the water column response; and applying a single algorithm that must account for Chl *a* concentrations ranging over five orders of magnitude from low levels in the world's open oceans to much higher levels in

coastal waters and estuaries (Schalles 2006). Nevertheless, satellite-based measurements of ocean color provide an excellent, global-scale assessment of primary production in the world's oceans (Schalles 2006).

Analysis of global primary production reveals that 55.8% of the world's oceans (between 50° South [S] and 50°N) contain mean concentrations of less than 0.1 mg/m^3 Chl *a*, whereas 41.8% average between 0.1 mg/m^3 and 1.0 mg/m^3 Chl *a*, and only 2.4% exceed 1 mg/m^3 Chl *a*. These ranges have been used to define the terms oligotrophic, mesotrophic, and eutrophic, respectively, which describe the productivity of aquatic regions (Schalles 2006). The Mediterranean Sea is known for being one of the most oligotrophic marine environments in the world due in large part to its surface and deepwater circular patterns and low nutrient supply (Ignatiades et al. 2002; Koppelmann and Weikert 2003). Primary production in the predominantly oligotrophic eastern Mediterranean Basin is estimated at 19 to 60 milligrams of carbon per square meter per day (mgC/m^2/d), whereas in the considerably smaller western Mediterranean Basin primary production is estimated at 140 to 160 mgC/m^2/d (UNEP 1996; Sardà et al. 2004). By comparison, primary production in the North Atlantic Ocean is estimated at 400 to 800 mgC/m^2/d (Lalli and Parsons 2000).

The Mediterranean Sea is known for it's relatively warm (~18°C), high salinity (>36 psu) oligotrophic waters (Duarte et al. 1999). A narrow continental shelf and a relatively deep basin with an average water depth of 1,500 m further characterize the Sea. Oligotrophic conditions increase across the basin from west to east as measured by reductions in the biomass and productivity of bacteria, phytoplankton, and the abundance of ciliates (Ignatiades et al. 2002). Throughout the year, the vast majority of the Mediterranean Sea has concentrations of less than 1 mg/m^3 Chl *a*, and, with one exception, higher Chl *a* concentrations are observed in winter (16 November to 28 May) than in summer (29 May to 15 November); the exception being in the Gulf of Gabes to the east of Tunisia (south of the Strait of Sicily; **Figure 2-7**). In general, the concentration of Chl *a* decreases with increasing distance from shore. Regions in the eastern Mediterranean Sea where higher concentrations are observed include the northwestern Adriatic Sea along the Italian coast, the northern Aegean Sea along the Grecian coast, and in the southeastern corner of the basin along the Egyptian coast. In each of these regions concentrations exceed 4 mg/m^3 Chl *a* in winter and are only slightly reduced in summer (**Figure 2-7**).

2.6.1.1 Phytoplankton

Phytoplankton are single-celled organisms that are similar to plants because they photosynthesize using sunlight and chlorophyll to generate energy. Phytoplankton growth and distribution throughout the marine environment is influenced by several factors, the most important of which are temperature (Eppley 1972), light (Yentsch and Lee 1966), and nutrient concentration (Goldman et al. 1979). To a lesser degree, other factors such as pH, salinity, and iron concentration have also been shown to affect the growth of phytoplankton (Parsons et al. 1984). When one of these essential factors is in short supply, growth is said to be limited by that factor. In general, the concentration of phytoplankton will be higher in nearshore areas where nutrients are discharged from land sources, such as rivers and areas of urban runoff. The principal nutrients phytoplankton use for growth and photosynthetic processes are dissolved nitrogen (nitrate/nitrite/ammonia), phosphorous (phosphate), and silica (silicate). Phosphorous limitation is more typical of freshwater systems whereas marine systems are more likely to be nitrogen limited (Mann and Lazier 1991; Lalli and Parsons 2000); although it has been reported that phytoplankton growth in the eastern Mediterranean Sea is largely limited by phosphorus availability (Ignatiades et al. 2002).

2.6.1.2 Phytoplankton of the Eastern Mediterranean Sea

Diatoms (e.g., *Skeletonema costatum, Thalassiosira* spp*., Chaetoceros socialis,* and *Chaetoceros* spp.) dominated the species composition for the majority of the year, and dinoflagellates are significant contributors to phytoplankton abundance only in mid-summer, following the diatom spring bloom, when the nutrient supply was relatively low.

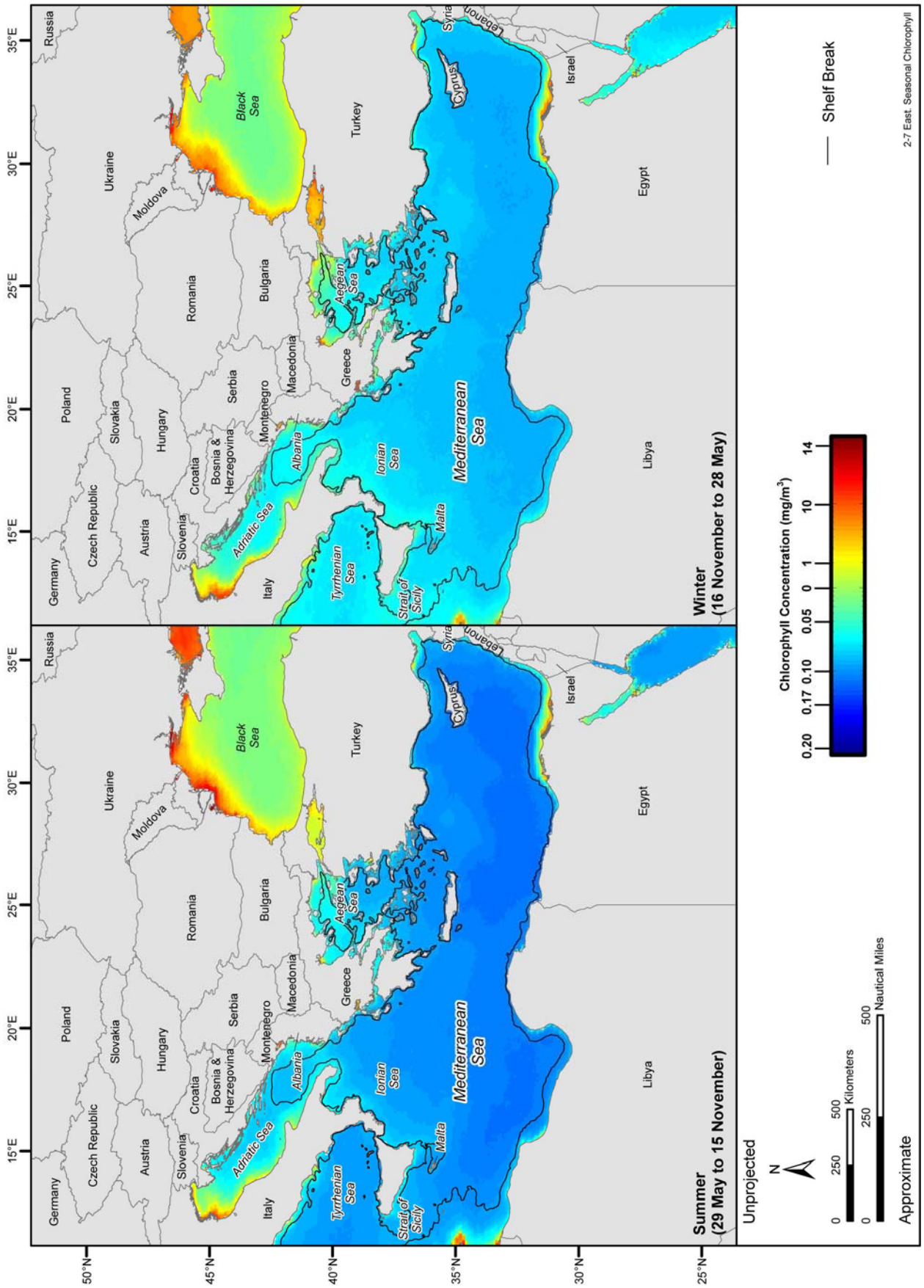


Figure 2-7. Seasonal distribution of chlorophyll throughout the eastern Mediterranean Sea during the summer (29 May through 15 November) and winter (16 November through 28 May). Source data: NASA.[8]

Over a 10-yr period (1990-1999), the greatest phytoplankton growth typically occurred during the months of February, April, and July and lowest abundance occurred in December and January (Aubry et al. 2004). Dinoflagellates present in the community structure during times of low diatom abundance include *Prorocentrum micans*, *P. minimum Gymnodinium* spp., and *Ceratium fusus*. Coccolithophores, mainly *Emiliania huxleyi*, are also present, with peak abundance occurring in February and a minimal contribution to the overall composition occurring from June through September (Aubry et al. 2004).

In the Aegean Sea, picophytoplankton (0.2 to 1.2 microns [μm]) dominate both species composition and primary productivity, comprising 56% of total chlorophyll and accounting for 51% of total primary productivity in the northern Aegean and 49% and 41%, respectively, in the southern Aegean (Ignatiades et al. 2002). The southern Aegean is homogenous in both temperature and salinity in fall, but develops a strong thermocline in spring that affects the distribution of phytoplankton within the water column (Ignatiades et al. 2002). Abundance of phytoplankton (cells per liter) varies both temporally and spatially with greater abundance occurring in the southern Aegean during the spring season. Species composition varies seasonally and interannually; at times coccolithophores dominate throughout the Aegean whereas on occasion diatoms and dinoflagellates dominate. During fall, dinoflagellates tend to be the most abundant taxa in both the north and south Aegean (Ignatiades et al. 2002).

The Nile River discharges into the southeastern Mediterranean Sea along the coast of Egypt and provides nutrient enriched waters to the predominantly oligotrophic waters of the eastern sub-basin (**Figure 2-7**). Annual concentrations of chlorophyll in coastal waters off of the Nile River delta average 0.86 mg/m^3 with the highest concentrations (1.89 mg/m^3 on average) occurring in winter. Peak concentrations occur at the sea surface, also in winter, and can exceed 6 mg/m^3 (Dowidar 1984). Summertime chlorophyll concentrations are significantly lower (~0.5 mg/m^3 on average) except within coastal waters immediately adjacent to inlets, which permit transport between offshore waters and several brackish lakes that border the Sea. Throughout the year a deep chlorophyll maximum (DCM) is present in offshore waters ranging in depth from 70 to 150 m and occurring at slightly shallower depths in winter than in summer (Dowidar 1984). A maximum chlorophyll concentration of 3 mg/m^3 at the DCM was observed in spring; DCM concentrations were mainly between 1 and 2 mg/m^3 in winter and spring, and less than 1 mg/m^3 during the rest of the year (Dowidar 1984).

Before construction of the Aswan High Dam (in 1965), which moderated the annual flooding of the Nile River, the influx of nutrient-rich flood waters onto the Mediterranean Sea coast fueled a massive phytoplankton bloom every fall. The bloom was dominated by diatoms (e.g., *Chaetoceros* spp. *Rhizosolenia* spp, and *Skeletonema costatum*) which comprised approximately 90% of all netphytoplankton (i.e., >180 μm; Dowidar 1984). Implementation of the dam reduced riverine discharge into coastal waters by a factor of 10, such that the coastal waters are now more oligotrophic, and wintertime resuspension, rather than river outflow, serves as the main source of nutrient enrichment fueling the fall bloom. Dinoflagellates, which tolerate nutrient-poor waters better than diatoms, are now nearly equally dominant in terms of species composition. Twenty years after the completion of the dam, increases in runoff associated with subsequent development have contributed to a resurgence in the importance of the Nile River discharge; however, species composition and distribution within the water column have not reverted to pre-dam conditions (Dowidar 1984).

2.6.1.3 Chemosynthesis

A second form of primary productivity, chemosynthesis, is performed by certain types of bacteria known as chemoautotrophs. Instead of using solar radiation to fix carbon and create energy these bacteria are able to oxidize inorganic compounds (e.g., nitrite, ammonia, methane) to derive energy (Lalli and Parsons 2000). Without the dependence on solar energy, chemosynthesis can, and does, take place well below the photic zone. Chemosynthetic communities were first discovered in 1977 around a hydrothermal vent located at a depth of 2,500 m off of the Galapagos Islands. Hydrogen sulfide (H_2S) is released in great quantities in hydrothermal fluid and is the essential compound fueling chemosynthesis by sulfide reducing bacteria (Lalli and Parsons 2000).

Chemosynthetic communities have also been discovered around shallow (as opposed to deepwater) hydrothermal vents, along the continental margins and subduction zones where cold-water seeps of dissolved methane occur, and in bottom locations where whale carcasses fall. In each of these cases the availability of H_2S is the common, essential factor supporting chemosynthesis.

Chemosynthetic communities in the Mediterranean Sea have been discovered in the eastern sub-basin at the Napoli Dome and Olimpi mud volcanoes located along the Mediterranean Ridge and at cold-water seeps off of southwestern Turkey at depths ranging from 1,700 to 2,000 m (Fiala-Médioni 2003). Evidence of additional communities (both live and dead) supported by cold seeps has been found off of Egypt and the Gaza Strip at depths between 500 and 800 m (Metaxas 2003). Despite these extreme conditions a diverse assemblage of sulfur reducing bacteria thrive in the thick brine mats found at the bottom of these deep-sea basins (Aloisi et al. 2001). The meiofaunal composition in each of the basins differs significantly from the surrounding non-brine sediments (Lampadariou et al. 2003). Nematodes dominate the non-brine bottom communities in all of the basins, whereas species composition in the brine mats varies from basin to basin.

2.6.2 Secondary Production

Secondary production refers to the increase in biomass of heterotrophic organisms through the consumption of primary producers. Zooplankton and bacteria within the water column feed on phytoplankton (as well as each other) and comprise the second link in the marine food web.

2.6.2.1 Zooplankton

Zooplankton are aquatic animals that, like all plankton, are unable to migrate against the prevailing current and therefore zooplankton distribution is essentially determined by the physical environment (Mann and Lazier 1991; Lalli and Parsons 2000). Cued by changes in ambient light, many zooplankton perform diel vertical migrations of hundreds of meters to feed and avoid predators. Despite demonstrating an ability to swim great distances through the water column on a daily basis, the large-scale horizontal distribution of zooplankton is primarily determined by both surface and deepwater currents (Wiebe et al. 1987; Mann and Lazier 1991). Seasonal changes in patters of vertical migration are also a characteristic of many zooplankton species. Changes are likely associated with bloom cycles of phytoplankton prey, zooplankton breeding cycles, and varying depth preferences of individual life stages of zooplankton species (Lalli and Parsons 2000).

Zooplankton can be further subdivided into two categories: holoplankton, which remain as part of the plankton for their entire life cycle, and meroplankton. Meroplankton describe those zooplankton species that spend only a portion of their life history as plankton. Certain lifestages of bivalves, fish, and arthropods are spent as plankton; however in each of these cases the adult lifestage is not (Lalli and Parsons 2000). Ichthyoplankton (a subset of the meroplankton) consist of the larvae and eggs of fish species.

The size of zooplankton found in the worlds oceans ranges widely from microscopic protozoans (<200 µm) to the largest jellyfish (~3 m in diameter; Lalli and Parsons 2000). Size also determines to some extent what different types of zooplankton consume. All zooplankton are heterotrophic, meaning that they must consume organic material in order to produce energy; however some zooplankton exclusively consume plants (herbivores), others eat only other animals (carnivores), and a third group consumes primarily detritus (detritivores). Many zooplankton, however, are omnivorous and are capable of feeding on the most available food source (Lalli and Parsons 2000).

2.6.2.2 Zooplankton of the Eastern Mediterranean Sea

Many species of zooplankton found in the Mediterranean Sea are also common throughout the world's oceans (e.g., *Globigerina bulloides*). A number of physical and biological factors control both species diversity and abundance of zooplankton in the eastern Mediterranean Sea including phytoplankton (prey)

abundance, temperature, the ocean current regime, river outflow, surface winds, and lifestage cycles of individual species (Bárcena et al. 2004).

In the central or deepwater regions of the Mediterranean Sea zooplankton abundance usually peaks once annually in summer, whereas in shallow, coastal, waters peak abundance may occur up to three times per year. In both coastal and deepwater regions the magnitude of the seasonal fluctuation in abundance is greatest in the northern part of the Sea and decreases to the south (Kovalev et al. 2003). Mirroring the decreasing gradient observed in primary production across the Mediterranean Basin, a decrease in zooplankton biomass has been observed from west to east throughout the water column (surface to abyssopelagic zone; Koppelmann and Weikert 2003).

Variations in the abundance of copepods, which at times have dominated the basin-wide zooplankton assemblage by comprising up to 90% of the individuals and biomass, are used as an indication of seasonal changes in zooplankton composition. Only during the warmer periods of the year is copepod abundance surpassed by the number of cladocerans (Kovalev et al. 2003).

Mesozooplankton (0.2 to 20 millimeters [mm]) biomass was sampled in the bathypelagic (deep-sea) zone at several sites in the eastern basin between 1987 and 2001, and is as much as 7 to 16 times lower than in the eastern North Atlantic Ocean and 3 to 5 times lower than in the Arabian Sea (Koppelmann and Weikert 2003). In June of 1993, following the onset of the EMT, an atmosphere-ocean phenomenon that resulted in abnormally high productivity in the deep waters (>1,000 m) of the eastern sub-basin, concentrations of mesozooplankton increased sharply (by more that 100 times) to 7,000 mg/1,000 m^3 to a depth of 4,000 m (Koppelmann and Weikert 2003). The increase in biomass was largely attributed to the increase in abundance of two copepod species, *Eucalanus monachus* and *Calanus helgolandicus*; however, surveys conducted in 1999 indicate that the original species composition observed in 1987 is reforming with the copepods *Haloptilus* spp. dominating the upper 250 m, *Eucalanus* spp. most abundant from 250 to 1,050 m, and *Lucicutia longiserrata* the predominant species below 1,050 m (Koppelmann and Weikert 2003).

2.7 WEBSITES ACCESSED

[1] NOAA (National Oceanic and Atmospheric Administration). 2006a. World data center for meteorology. Accessed 13 September 2006. http://www.ncdc.noaa.gov/oa/wmo/wdcamet.html.

[2] NOAA (National Oceanic and Atmospheric Administration). 2006b. Luqa, Malta temperature and precipitation data. Downloaded from: http://www.ncdc.noaa.gov/oa/mppsearch.html.

[3] NOAA (National Oceanic and Atmospheric Administration). 2006c. Kerkyra, Greece temperature and precipitation data. Downloaded from: http://www.ncdc.noaa.gov/oa/mppsearch.html.

[4] NOAA (National Oceanic and Atmospheric Administration). 2006d. Souda, Greece temperature and precipitation data. Downloaded from: http://www.ncdc.noaa.gov/oa/mppsearch.html.

[5] NOAA (National Oceanic and Atmospheric Administration). 2006e. Lattakia, Syria. temperature and precipitation data. Downloaded from: http://www.ncdc.noaa.gov/oa/mppsearch.html.

[6] NOAA (National Oceanic and Atmospheric Administration). 2006f. Mersa Matruh, Egypt. temperature and precipitation data. Downloaded from: http://www.ncdc.noaa.gov/oa/mppsearch.html.

[7] NASA. Accessed 4 May 2004. ftp://disc1.gsfc.nasa.gov/data/avhrr/tile_8km/.

[8] NASA. Accessed 30 June 2005. ftp://daac.gsfc.nasa.gov/data/czcs/level_3/monthly_data/subsets/Chlor/.

2.8 LITERATURE CITED

Alhammoud, B., K. Béranger, L. Mortier, M. Crépon, and I. Dekeyser. 2005. Surface circulation of the Levantine Basin: Comparison of model results with observations. Progress in Oceanography 66:299-320.

Aloisi, G., C. Pierre, B.D. Vedova, and C. Corselli. 2001. Carbon isotope measurements in the brines of the Urania and L'Atalante anoxic basins, eastern Mediterranean. Archo Oceanography Limnology 22:87-90.

Amblàs, D., M. Canals, G. Lastras, S. Berné, and B. Loubrieu. 2004. Imaging the seascapes of the Mediterranean. Oceanography 17(4):144-155.

Artegiani, A., M. Gacic, A. Michelato, V. Kovacevic, A. Russo, E. Paschini, P. Scarazzato, and A. Smircic. 1993. The Adriatic Sea by hydrography and circulation in spring and autumn (1985-1987). Deep-Sea Research II 40(6):1143-1180.

Aubry, F.B., A. Berton, M. Bastianini, G. Socal, and F. Acri. 2004. Phytoplankton succession in a coastal area of the NW Adriatic, over a 10-year sampling period (1990-1999). Continental Shelf Research 24:97-115.

Ayoub, N., P.-Y. Le Traon, and P. De Mey. 1998. A description of the Mediterranean surface variable circulation from combined ERS-1 and TOPEX/POSEIDON altimetric data. Journal of Marine Systems 18:3-40.

Bakun, A. and V.N. Agostini. 2001. Seasonal patterns of wind-induced upwelling/downwelling in the Mediterranean Sea. Scientia Marina 65(3):243-257.

Balopoulos, E.T., A. Theocharis, H. Kontoyiannis, S. Varnavas, F. Voutsinou-Taliadouri, A. Iona, A. Souvermezoglou, L. Ignatiades, O. Gotsis-Skretas, and A. Pavlidou. 1999. Major advances in the oceanography of the southern Aegean Sea-Cretan Straits system (eastern Mediterranean). Progress in Oceanography 44:109-130.

Bárcena, M.A., J.A. Flores, F.J. Sierro, M. Pérez-Folgado, J. Fabres, A. Calafat, and M. Canals. 2004. Planktonic response to main oceanographic changes in the Alboran Sea (Western Mediterranean) as documented in sediment traps and surface sediments. Marine Micropaleontology 53:423-445.

Bengtsson, L., K.I. Hodges, and E. Roeckner. 2006. Storm tracks and climate change. Journal of Climate 19:3518-3543.

Béranger, K., L. Mortier, and M. Crépon. 2005. Seasonal variability of water transport through the Straits of Gibraltar, Sicily and Corsica, derived from a high-resolution model of the Mediterranean circulation. Progress in Oceanography 66:341-364.

Béranger, K., L. Mortier, G.-P. Gasparini, L. Gervasio, M. Astraldi, and M. Crépon. 2004. The dynamics of the Sicily Strait: A comprehensive study from observations and models. Deep-Sea Research II 51:411-440.

Beşiktepe, S.T. 2003. Density currents in the two-layer flow: An example of Dardanelles outflow. Oceanologica Acta 26:243-253.

Bethoux, J.P., B. Gentili, P. Morin, E. Nicolas, C. Pierre, and D. Ruiz-Pino. 1999. The Mediterranean Sea: A miniature ocean for climatic and environmental studies and a key for the climatic functioning of the North Atlantic. Progress in Oceanography 44:131-146.

Bianchi, C.N. and C. Morri. 2000. Marine biodiversity of the Mediterranean Sea: Situation, problems and prospects for future research. Marine Pollution Bulletin 40(5):367-376.

Boscolo, R. and H. Bryden. 2001. Causes of long-term changes in Aegean sea deep water. Oceanologica Acta 24(6):519-527.

Brankart, J.M. and P. Brasseur. 1998. The general circulation in the Mediterranean Sea: A climatological approach. Journal of Marine Systems 18:41-70.

Bryden, H.L. and T.H. Kinder. 1991. Steady two-layer exchange through the Strait of Gibraltar. Deep-Sea Research 36(Supplement 1):S445-S463.

Carter, T.G., J.P. Flanagan, C.R. Jones, F.L. Marchant, R.R. Murchison, J.H. Rebman, J.C. Sylvester, and J.C. Whitney. 1972. A new bathymetric chart and physiography of the Mediterranean Sea. Pages 1-23 in Stanley, I. and J. Daniel, eds. Symposium on the Mediterranean Sea, Heidelberg, 1971. The Mediterranean Sea. Part 1. The geographic setting and hydrography. Stroudsburg, Pennsylvania: Dowden, Hutchinson & Ross, Inc.

Cohen, J. and M. Barlow. 2005. The NAO, the AO, and global warming: How closely related? Journal of Climate 18:4498-4513.

Crise, A., J.I. Allen, J. Baretta, G. Crispi, R. Mosetti, and C. Solidoro. 1999. The Mediterranean pelagic ecosystem response to physical forcing. Progress in Oceanography 44:219-243.

Curry, R.G. and M.S. McCartney. 2001. Ocean gyre circulation changes associated with the North Atlantic Oscillation. Journal of Physical Oceanography 31:3374-3400.

Dowidar, N.M. 1984. Phytoplankton biomass and primary productivity of the south-eastern Mediterranean. Deep-Sea Research 31(6-8):983-1000.

Drakopoulos, P.G. and A. Lascaratos. 1999. Modelling the Mediterranean Sea: Climatological forcing. Journal of Marine Systems 20:157-173.
Duarte, C.M., S. Agustí, H. Kennedy, and D. Vaqué. 1999. The Mediterranean climate as a template for Mediterranean marine ecosystems: The example of the northeast Spanish littoral. Progress in Oceanography 44:245-270.
Eppley, R.W. 1972. Temperature and phytoplankton growth in the sea. Fishery Bulletin 70(4):1063-1085.
Faganeli, J., J. Pezdic, B. Ogorelec, M. Mišič, and M. Najdek. 1994. The origin of sedimentary organic matter in the Adriatic. Continental Shelf Research 14(4):365-384.
Fernández, V., D.E. Dietrich, R.L. Haney, and J. Tintoré. 2005. Mesoscale, seasonal and interannual variability in the Mediterranean Sea using a numerical ocean model. Progress in Oceanography 66:321-340.
Fiala-Médioni, A. 2003. Sources of energy for deep-sea benthos in Mediterranean mud volcanoes. CIESM Workshop Monographs 23:77-80.
Galil, B.S. 2004. The limit of the sea: The bathyal fauna of the Levantine Sea. Scientia Marina 68(Supplement 3):63-72.
Gasparini, G.P., A. Ortona, G. Budillon, M. Astraldi, and E. Sansone. 2005. The effect of the Eastern Mediterranean Transient on the hydrographic characteristics in the Strait of Sicily and in the Tyrrhenian Sea. Deep-Sea Research I 52:915-935.
Gibelin, A.-L. and M. Déqué. 2003. Anthropogenic climate change over the Mediterranean region simulated by a global variable resolution model. Climate Dynamics 20:327-339.
Gill, A.E. 1982. Atmosphere-Ocean dynamics. San Diego, California: Academic Press.
Goldman, J.C., J.J. McCarthy, and D.G. Peavey. 1979. Growth rate influence on the chemical composition of phytoplankton in oceanic waters. Nature 279:210-213.
Golnaraghi, M. 1993. Dynamical studies of the Mersa Matruh Gyre: Intense meander and ring formation events. Deep-Sea Research II 40(6):1247-1267.
Haines, K. and P. Wu. 1998. GCM studies of intermediate and deep waters in the Mediterranean. Journal of Marine Systems 18:197-214.
Hecht, A., N. Pinardi, and A.R. Robinson. 1988. Currents, water masses, eddies and jets in the Mediterranean Levantine basin. Journal of Physical Oceanography 18:1320-1353.
Hieke, W., H.B. Hirschleber, and G.A. Dehghani. 2003. The Ionian Abyssal Plain (central Mediterranean Sea): Morphology, subbottom structures and geodynamic history - an inventory. Marine Geophysical Researches 24:279-310.
Hu, Z.-Z. and B. Huang. 2006. Air-sea coupling in the North Atlantic during summer. Climate Dynamics 26:441-457.
Hurrell, J.W. 1995. Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. Science 269:676-679.
Hurrell, J.W., Y. Kushnir, and M. Visbeck. 2001. The North Atlantic Oscillation. Science 291:603-605.
Ignatiades, L., S. Psarra, V. Zervakis, K. Pagou, A. Souvermezoglou, G. Assimakopoulou, and O. Gotsis-Skretas. 2002. Phytoplankton size-based dynamics in the Aegean Sea (Eastern Mediterranean). Journal of Marine Systems 36:11-28.
Kallel, N., M. Paterne, L. Labeyrie, J.-C. Duplessy, and M. Arnold. 1997. Temperature and salinity records of the Tyrrhenian Sea during the last 18,000 years. Palaeogeography, Palaeoclimatology, Palaeoecology 135:97-108.
Koppelmann, R. and H. Weikert. 2003. Deep-sea zooplankton ecology of the Eastern Mediterranean. State-of-the-art and perspectives. CIESM Workshop Monographs 23:47-53.
Kostopoulou, E. and P.D. Jones. 2005. Assessment of climate extremes in the Eastern Mediterranean. Meteorology and Atmospheric Physics 89:69-85.
Kovačević, V., M. Gačić, and P.-M. Poulain. 1999. Eulerian current measurements in the Strait of Otranto and in the Southern Adriatic. Journal of Marine Systems 20:255-278.
Kovalev, A.V., M.G. Mazzocchi, A.E. Kideys, B. Toklu, and V.A. Skryabin. 2003. Seasonal changes in the composition and abundance of zooplankton in the seas of the Mediterranean basin. Turkish Journal of Zoology 27:205-219.
Krichak, S.O. and P. Alpert. 2005. Signatures of the NAO in the atmospheric circulation during wet winter months over the Mediterranean region. Theoretical and Applied Climatology 82:27-39.
Lacombe, H., P. Tchernia, and L. Gamberoni. 1985. Variable bottom water in the Western Mediterranean basin. Progress in Oceanography 14:319-338.

Lalli, C.M. and T.R. Parsons. 2000. Biological oceanography an introduction. Oxford, Great Britain: Elsevier.

Lampadariou, N., E. Hatziyanni, and A. Tselepides. 2003. Community structure of meiofauna and macrofauna in Mediterranean deep-hyper-saline anoxic basins. CIESM Workshop Monographs 23:55-60.

Larnicol, G., N. Ayoub, and P.Y. Le Traon. 2002. Major changes in Mediterranean Sea level variability from 7 years of TOPEX/Poseidon and ERS-1/2 data. Journal of Marine Systems 33-34:63-89.

Lascaratos, A., W. Roether, K. Nittis, and B. Klein. 1999. Recent changes in deep water formation and spreading in the eastern Mediterranean Sea: A review. Progress in Oceanography 44:5-36.

Leaman, K.D. and F.A. Schott. 1991. Hydrographic structure of the convection regime in the Gulf of Lions: Winter 1987. Journal of Physical Oceanography 21:575-598.

Lykousis, V., G. Chronis, A. Tselepides, N.B. Price, A. Theocharis, I. Siokou-Frangou, F. Van Wambeke, R. Danovaro, S. Stavrakakis, G. Duineveld, D. Georgopoulos, L. Ignatiades, A. Souvermezoglou, and F. Voutsinou-Taliadouri. 2002. Major outputs of the recent multidisciplinary biogeochemical researches undertaken in the Aegean Sea. Journal of Marine Systems 33-34:313-334.

Malanotte-Rizzoli, P. and A. Bergamasco. 1991. The wind and thermally driven circulation of the eastern Mediterranean Sea. Part II: The Baroclinic case. Dynamics of Atmospheres and Oceans 15:355-419.

Manca, B., M. Burca, A. Giorgetti, C. Coatanoan, M.-J. Garcia, and A. Iona. 2004. Physical and biochemical averaged vertical profiles in the Mediterranean regions: An important tool to trace the climatology of water masses and to validate incoming data from operational oceanography. Journal of Marine Systems 48:83-116.

Manca, B.B., V. Kovačević, M. Gačić, and D. Viezzoli. 2002. Dense water formation in the Southern Adriatic Sea and spreading into the Ionian Sea in the period 1997-1999. Journal of Marine Systems 33-34:133-154.

Mann, K.H. and J.R.N. Lazier. 1991. Dynamics of marine ecosystems: Biological-physical interactions in the oceans. Boston: Blackwell Scientific Publications.

Martin, J.-M. and J.D. Milliman. 1997. EROS 2000 (European River Ocean System). The western Mediterranean: An introduction. Deep-Sea Research II 44(3-4):521-529.

Marullo, S., R. Santoleri, P. Malanotte-Rizzoli, and A. Bergamasco. 1999a. The sea surface temperature field in the Eastern Mediterranean from advanced very high resolution radiometer (AVHRR) data. Part II. Interannual variability. Journal of Marine Systems 20:83-112.

Marullo, S., R. Santoleri, P. Malanotte-Rizzoli, and A. Bergamasco. 1999b. The sea surface temperature field in the Eastern Mediterranean from advanced very high resolution radiometer (AVHRR) data. Part I. Seasonal variability. Journal of Marine Systems 20:63-81.

Menard, H.W. and S.M. Smith. 1966. Hypsometry of ocean basin provinces. Journal of Geophysical Research 71(18):4305-4325.

Menzel, A., T.H. Sparks, N. Estrella, and S. Eckhardt. 2005. 'SSW to NNE' - North Atlantic Oscillation affects the progress of seasons across Europe. Global Change Biology 11:909-918.

Metaxas, A. 2003. Current challenges in the study of biological communities at deep-sea hydrothermal vents. CIESM Workshop Monographs 23:67-72.

Millán, M.M., M.J. Estrela, M.J. Sanz, E. Mantilla, M. Martín, F. Pastor, R. Salvador, R. Vallejo, L. Alonso, G. Gangoiti, J.L. Ilardia, M. Navazo, A. Albizuri, B. Artíñano, P. Ciccioli, G. Kallos, R.A. Carvalho, D. Andrés, A. Hoff, J. Werhahn, G. Seufert, and B. Versino. 2005. Climatic feedbacks and desertification: The Mediterranean model. Journal of Climate 18:684-701.

Molinero, J.C., F. Ibanez, P. Nival, E. Buecher, and S. Souissi. 2005. North Atlantic climate and northwestern Mediterranean plankton variability. Limnology and Oceanography 50(4):1213-1220.

Mote, P.W. and N.J. Mantua. 2002. Coastal upwelling in a warmer future. Geophysical Research Letters 29 (23),2138,doi:10.1029/2002GL016086.

Open University. 1995. Ocean circulation. Oxford, Great Britain: Pergamon Press.

Orfila, A., A. Álvarez, J. Tintoré, A. Jordi, and G. Basterretxea. 2005. Climate teleconnections at monthly time scales in the Ligurian Sea inferred from satellite data. Progress in Oceanography 66:157-170.

Özsoy, E., A. Hecht, and Ü. Ünlüata. 1989. Circulation and hydrography of the Levantine Basin. Results of POEM coordinated experiments 1985-1986. Progress in Oceanography 22:125-170.

Özsoy, E., A. Hecht, Ü. Ünlüata, S. Brenner, H.I. Sur, J. Bishop, M.A. Latif, Z. Rozentraub, and T. Oguz. 1993. A synthesis of the Levantine Basin circulation and hydrography, 1985-1990. Deep-Sea Research II 40(6):1075-1119.

Painter, S.C. and M.N. Tsimplis. 2003. Temperature and salinity trends in the upper waters of the Mediterranean Sea as determined from the MEDATLAS dataset. Continental Shelf Research 23:1507-1522.

Parsons, T.R., M. Takahashi, and B. Hargrave. 1984. Biological oceanographic processes. 3d ed. Oxford, United Kingdom: Pergamon Press.

Pedrós-Alió, C., J.-I. Calderón-Paz, N.G. Guixa-Boixereu, M. Estrada, and J.M. Gasol. 1999. Bacterioplankton and phytoplankton biomass and production during summer stratification in the northwestern Mediterranean Sea. Deep-Sea Research I 46:985-1019.

Pinardi, N. and E. Masetti. 2000. Variability of the large scale general circulation of the Mediterranean Sea from observations and modelling: A review. Palaeogeography, Palaeoclimatology, Palaeoecology 158:153-173.

Poulos, S.E., P.G. Drakopoulos, and M.B. Collins. 1997. Seasonal variability in sea surface oceanographic conditions in the Aegean Sea (Eastern Mediterranean): An overview. Journal of Marine Systems 13:225-244.

Rehault, J.-P., G. Boillot, and A. Mauffret. 1985. The Western Mediterranean Basin. Pages 101-129 in Stanley, D.J. and F.-C. Wezel, eds. Geological evolution of the Mediterranean Basin. New York, New York: Springer-Verlag New York, Inc.

Rîmbu, N., H. Le Treut, S. Janicot, C. Boroneanţ, and C. Laurent. 2001. Decadal precipitation variability over Europe and its relation with surface atmospheric circulation and sea surface temperature. Quarterly Journal of the Royal Meteorological Society 127:315-329.

Robinson, A.R., W.G. Leslie, A. Theocharis, and A. Lascaratos. 2001. Mediterranean Sea circulation. Pages 1689-1705 in Steele, J.H., K.K. Turekian, and S.A. Thorpe, eds. Encyclopedia of ocean sciences. Volume 3. San Diego, California: Academic Press.

Robinson, A.R., J. Sellschopp, A. Warn-Varnas, W.G. Leslie, C.J. Lozano, P.J. Haley, Jr., L.A. Anderson, and P.F.J. Lermusiaux. 1999. The Atlantic Ionian Stream. Journal of Marine Systems 20:129-156.

Roether, W., B. Klein, V. Beitzel, and B.B. Manca. 1998. Property distributions and transient-tracer ages in Levantine Intermediate Water in the Eastern Mediterranean. Journal of Marine Systems 18:71-87.

Rohling, E.J. and H.L. Bryden. 1992. Man-induced salinity and temperature increases in Western Mediterranean Deep Water. Journal of Geophysical Research 97(C7):11191-11198.

Rothwell, R.G., M.S. Reeder, G. Anastasakis, D.A.V. Stow, J. Thomson, and G. Kähler. 2000. Low sea-level stand emplacement of megaturbidites in the western and eastern Mediterranean Sea. Sedimentary Geology 135:75-88.

Roussenov, V., E. Stanev, V. Artale, and N. Pinardi. 1995. A seasonal model of the Mediterranean Sea general circulation. Journal of Geophysical Research 100(C7):13515-13538.

Sala, J.Q., A.G. Olcina, A.P. Cuevas, J.O. Cantos, A.R. Amoros, and E.M. Chiva. 2000. Climatic warming in the Spanish Mediterranean. Natural trend or urban effect. Clmatic Change 46:473-483.

Salat, J., M.A. Garcia, A. Cruzado, A. Palanques, L. Arín, D. Gomis, J. Guillén, A. de León, J. Puigdefàbregas, J. Sospedra, and Z.R. Velásquez. 2002. Seasonal changes of water mass structure and shelf slope exchanges at the Ebro Shelf (NW Mediterranean). Continental Shelf Research 22:327-348.

Sardà, F., A. Calafat, M.M. Flexas, A. Tselepides, M. Canals, M. Espino, and A. Tursi. 2004. An introduction to Mediterranean deep-sea biology. Scientia Marina 68(Supplement 3):7-38.

Schalles, J.F. 2006. Optical remote sensing techniques to estimate phytoplankton chlorophyll *a* concentrations in coastal waters with varying suspended matter and CDOM concentrations. Pages 27-79 in Richardson, L.L. and E.F. LeDrew, eds. Remote sensing of aquatic coastal ecosystem processes: Science and management applications. Netherlands: Springer.

Sestini, G. 1989. The impact of sea level rise on low lying Mediterranean coasts. Bollettino di Oceanologia Teorica ed Applicata VII(4):295-299.

Skliris, N. and A. Lascaratos. 2004. Impacts of the Nile River damming on the thermohaline circulation and water mass characteristics of the Mediterranean Sea. Journal of Marine Systems 52:121-143.

Smith, W.H.F. and D.T. Sandwell. 1997. Global sea floor topography from satellite altimetry and ship depth soundings. Science 277:1956-1961.

Socal, G., A. Boldrin, F. Bianchi, G. Civitarese, A. De Lazzari, S. Rabitti, C. Totti, and M.M. Turchetto. 1999. Nutrient, particulate matter and phytoplankton variability in the photic layer of the Otranto Strait. Journal of Marine Systems 20:381-398.

Stanley, D.J. and F.-C. Wezel, eds. 1985. Geological evolution of the Mediterranean Basin. New York, New York: Springer-Verlag New York, Inc.

Stenseth, N.C., G. Ottersen, J.W. Hurrell, A. Mysterud, M. Lima, K.-S. Chan, N.G. Yoccoz, and B. Ådlandsvik. 2003. Studying climate effects on ecology through the use of climate indices: The North Atlantic Oscillation, El Niño Southern Oscillation and beyond. Proceedings of the Royal Society B: Biological Sciences 270:2087-2096.

Struglia, M.V., A. Mariotti, and A. Filograsso. 2004. River discharge into the Mediterranean Sea: Climatology and aspects of the observed variability. Journal of Climate 17:4740-4751.

Taylor, A.H. and J.A. Stephens. 1998. The North Atlantic Oscillation and the latitude of the Gulf Stream. Tellus 50A:134-142.

The POEM (Physical Oceanography of the Eastern Mediterranean) group. 1992. General circulation of the Eastern Mediterranean. Earth-Science Reviews 32:285-309.

Theocharis, A., D. Georgopoulos, A. Lascaratos, and K. Nittis. 1993. Water masses and circulation in the central region of the Eastern Mediterranean: Eastern Ionian, South Aegean and Northwest Levantine, 1986-1987. Deep-Sea Research II 40(6):1121-1142.

Theocharis, A., E. Balopoulos, S. Kioroglou, H. Kontoyiannis, and A. Iona. 1999. A synthesis of the circulation and hydrography of the South Aegean Sea and the Straits of the Cretan Arc (March 1994-January 1995). Progress in Oceanography 44:469-509.

Thurman, H.V. 1997. Introductory oceanography. 8th ed. Upper Saddle River, New Jersey: Prentice Hall.

Tselepides, A., V. Zervakis, T. Polychronaki, R. Danovaro, and G. Chronis. 2000. Distribution of nutrients and particulate organic matter in relation to the prevailing hydrographic features of the Cretan Sea (NE Mediterranean). Progress in Oceanography 46:113-142.

Tsimplis, M.N., R. Proctor, and R.A. Flather. 1995. A two-dimensional tidal model for the Mediterranean Sea. Journal of Geophysical Research 100(C8):16223-16239.

Turley, C.M. 1999. The changing Mediterranean Sea - a sensitive ecosystem? Progress in Oceanography 44:387-400.

UNEP (United Nations Environment Programme). 1989. State of the Mediterranean marine environment. MAP Technical Reports Series No. 28. Athens, Greece: United Nations Environment Programme.

UNEP (United Nations Environment Programme). 1996. State of the marine and coastal environment in the Mediterranean Region. MAP Technical Reports Series No. 100. Athens, Greece: United Nations Environment Programme.

Vanney, J.-R. and M. Gennesseaux. 1985. Mediterranean seafloor features: Overview and assessment. Pages 3-32 in Stanley, D.J. and F.-C. Wezel, eds. Geological evolution of the Mediterranean Basin. New York, New York: Springer-Verlag New York, Inc.

Velaoras, D. and A. Lascaratos. 2005. Deep water mass characteristics and interannual variability in the North and Central Aegean Sea. Journal of Marine Systems 53:59-85.

Visbeck, M. 2002. The ocean's role in Atlantic climate variability. Science 297:2223-2224.

Vucetic, T. 1973. Zooplankton and the circulation pattern of the water masses in the Adriatic. Netherlands Journal of Sea Research 7:112-121.

Wiebe, P.H., R.H. Backus, E.H. Backus, D.A. Caron, P.M. Gilbert, J.F. Grassle, K. Powers, and J.B. Waterbury. 1987. Biological oceanography. Milliman, J.D. and W.R. Wright, eds. The marine environment of the U.S. Atlantic continental slope and rise. Boston/Woods Hole, Massachusetts: Jones and Bartlett Publishers.

Yentsch, C.S. and R.W. Lee. 1966. A study of photosynthetic light reactions, and a new interpretation of sun and shade phytoplankton. Journal of Marine Research 24:319-337.

Yüce, H. 1995. Northern Aegean water masses. Estuarine, Coastal and Shelf Science 41:325-343.

Zavatarelli, M. and G.L. Mellor. 1995. A numerical study of the Mediterranean Sea circulation. Journal of Physical Oceanography 25:1384-1414.

Zeri, C. and F. Voutsinou-Taliadouri. 2003. Processes affecting the distribution of dissolved trace metals in the North Aegean Sea (Eastern Mediterranean). Continental Shelf Research 23:919-934.

This page intentionally left blank

3.0 SPECIES OF CONCERN

This chapter provides detailed information on the protected marine species with known or potential occurrence in the eastern Mediterranean Study Area. Protected species include 22 marine mammal and 5 sea turtle species. Marine mammals are the taxon group with the largest number of federally protected species in the Study Area. All marine mammals are protected by the MMPA. Five large whales and one pinniped species are also listed as endangered and thus are afforded additional protection under the ESA. The five sea turtle species known to occur in the Study Area are all threatened or endangered under the ESA.

Section 3.1 of this chapter provides information on the marine mammal species with confirmed occurrence in the Study Area. The marine mammal species are presented by taxonomic order beginning with the endangered species. An overview of the taxon, as well as a brief introduction to acoustics and hearing, is included. A detailed narrative has been prepared for each marine mammal species and consists of a species description, status, habitat preferences, distribution (including a focus on the Study Area), behavior and life history, as well as an account of vocalizations and hearing capabilities (when available). Map figures of general migratory routes for some whale species are included in this section. Additional map figures depicting the seasonal occurrence records and the estimated occurrences for each species in the Study Area are found in **Appendix B** (**Figures B-1** through **B-23**).

Section 3.2 consists of an overview of sea turtle biology and life history as well as basic information on the hearing capabilities of these animals. Each of the sea turtle species found in the Study Area is described in detail by its physical description, status, habitat preferences, distribution (including an emphasis on the Study Area), and behavior and life history. Map figures showing known nesting, oceanic, and neritic habitats in the Study Area are also included in this section. Additional map figures depicting occurrence records and occurrence estimates for these species in the Study Area may be found in **Appendix C** (**Figures C-1** through **C-6**).

This page intentionally left blank

3.1 MARINE MAMMALS

3.1.1 Introduction

More than 120 species of marine mammals occur worldwide (Rice 1998). The term “marine mammal” is purely descriptive, referring to mammals that carry out all or a substantial part of their foraging in marine or, in some cases, freshwater environments. Marine mammals as a group are comprised of various species from three orders (Cetacea, Carnivora, and Sirenia).

The vast majority of the 22 marine mammal species potentially occurring in the eastern Mediterranean Study Area are cetaceans (whales and dolphins). Cetaceans are divided into two major suborders: Mysticeti and Odontoceti (baleen and toothed whales, respectively). Toothed whales use teeth to capture prey, while baleen whales use baleen plates to filter their food from the water. In addition to contrasts in feeding methods, there are life history and social organization differences (see Tyack 1986).

One species of pinniped occurs in the eastern Mediterranean Study Area. Pinnipeds are divided into three families: Phocidae (the “true” or earless seals); Otariidae (sea lions and fur seals); and Odobenidae (walruses). Of the pinnipeds, only phocids are expected to occur in the Study Area. Relative to otariids, phocids are more streamlined and better adapted to an aquatic lifestyle. Some of the more obvious distinctions of phocids are that they lack external ears; are unable to rotate the pelvis to position the hind limbs under the body, leading to relatively poor terrestrial locomotion; use of pelvic flippers for underwater propulsion; and have small pectoral appendages (which are used for steering; Riedman 1990). Beyond the physical differences, there are also life history differences (see Riedman 1990).

3.1.1.1 Adaptations to the Marine Environment: Sound Production and Reception

Marine mammals display a number of anatomical and physiological adaptations to an aquatic environment that are discussed in detail by Pabst et al. (1999). Sensory changes from the basic mammalian scheme have also taken place in response to the different challenges an aquatic environment imposes. Sound travels faster and farther in water than in air and is, therefore, an important sense. Touch and sight are also well developed in whales and dolphins (Wartzok and Ketten 1999). Pinnipeds are faced with two different environments (terrestrial and aquatic). As a result, they have compromised full underwater or full terrestrial adaptation to allow for functional vision and hearing in both media (Wartzok and Ketten 1999). The vibrissae (whiskers) of pinnipeds are extensively developed and provide the animal with information about contour and texture (Wartzok and Ketten 1999). A recent study has demonstrated that the whiskers of harbor seals are highly sensitive to water movements, and may be an important mechanism for seals hunting in the dark (or in murky waters) to detect water movements generated by fish (Dehnhardt et al. 2001; Vester et al. 2001).

Marine mammal vocalizations often extend both above and below the range of human hearing; vocalizations with frequencies lower than 18 hertz (Hz) are labeled as infrasonic and those higher than 20 kilohertz (kHz) are ultrasonic. Baleen whales primarily use the lower frequencies, producing tonal sounds in the frequency range of 20 to 3,000 Hz depending on the species. Clark and Ellison (2004) suggested that baleen whales use low frequency sounds not only for long-range communication but also as a simple form of echo ranging, using echoes to navigate and orient relative to physical features of the ocean. The toothed whales produce a wide variety of sounds which include species-specific broadband “clicks” with peak energy between 10 and 200 kHz, individually variable “burst pulse” click trains, and constant frequency or frequency-modulated (FM) whistles ranging from 4 to 16 kHz (Wartzok and Ketten 1999). The general consensus is that the tonal vocalizations (whistles) produced by toothed whales play an important role in maintaining contact between dispersed individuals, while broadband clicks are used during echolocation (Wartzok and Ketten 1999). Burst pulses have also been strongly implicated in communication, with some scientists suggesting that they play an important role in agonistic encounters (McCowan and Reiss 1995), while others have proposed that they represent “emotive” signals in a broader sense, possibly representing graded communication signals (Herzing 1996). Sperm whales, however, are known to produce only clicks, which are used for both communication and echolocation (Whitehead 2003).

Sounds produced by pinnipeds include airborne and underwater vocalizations (Thomson and Richardson 1995). Calls include grunts, barks, and growls in addition to the more conventional clicks and pulses. The majority of pinniped sounds are in the sonic range (20 Hz to 20 kHz; Ketten 1998; Wartzok and Ketten 1999). In general, phocids are far more vocal underwater than are otariids. Phocid calls are commonly between 100 Hz and 15 kHz, with peak spectra less than 5 kHz, but can range as high as 40 kHz (Ketten 1998; Wartzok and Ketten 1999). There is no evidence that pinnipeds echolocate (Schusterman et al. 2000).

Data on the hearing abilities of cetaceans are sparse, particularly for the larger cetaceans such as the baleen whales. The auditory thresholds of some of the smaller odontocetes have been determined in captivity. It is generally believed that cetaceans should at least be sensitive to the frequencies of their own vocalizations. Comparisons of the anatomy of cetacean inner ears and models of the structural properties and the response to vibrations of the ear's components in different species provide an indication of likely sensitivity to various sound frequencies. The ears of small toothed whales are optimized for receiving high-frequency sound, while baleen whale inner ears are best in low to infrasonic frequencies (Ketten 1992b, 1997; Ketten et al. 2000).

In comparison with toothed whales, pinnipeds tend to have lower best frequencies, lower high-frequency cutoffs, and poorer sensitivity at the best frequency (Richardson et al. 1995); however, some pinnipeds (especially phocids) may have better sensitivity at low frequencies (<1 kHz) than do toothed whales (Richardson et al. 1995). The pinniped ear appears to have been constrained during its evolution by the necessity of functioning in two acoustically dissimilar media (air and water). The patterns of air and water hearing sensitivity appear to correspond to the patterns of life history of the pinniped species (Kastak and Schusterman 1998). Comparisons of the hearing characteristics of otariids and phocids suggest two types of pinniped ears, with phocids being better adapted for underwater hearing (Richardson et al. 1995; Kastak and Schusterman 1998; Ketten 1998; Wartzok and Ketten 1999). In phocids tested, peak sensitivities ranged between 10 and 30 kHz, with a functional high frequency limit of about 60 kHz (Richardson et al. 1995; Ketten 1998; Wartzok and Ketten 1999).

General reviews of cetacean and pinniped sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), Au et al. (2000), and Hildebrand (2005). For a discussion of acoustic concepts, terminology, and measurement procedures, as well as underwater sound propagation, Urick (1983) and Richardson et al. (1995) are recommended.

3.1.1.2 Marine Mammal Distribution and Habitat Associations

Marine mammals inhabit most marine environments from deep ocean canyons to shallow estuarine waters. They are not randomly distributed. Marine mammal distribution is affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Bjørge 2002; Bowen et al. 2002; Forcada 2002; Stevick et al. 2002). Most information on marine mammal distribution has been obtained from shipboard and aerial observations, which provide a very limited perspective on their life at or near the surface and little insight into their behavior under the water where some species, particularly cetaceans, spend up to 90% of their time (e.g., Costa 1993).

Our knowledge of marine mammal habitats is often quite limited. Poor definition of spatiotemporal scales is the primary cause for confusion and disagreement among studies about factors that associate with marine mammal (in particular, cetacean) distribution (e.g., Jaquet 1996; Jaquet et al. 1996; Gregr and Trites 2001; Hamazaki 2002; Ferguson 2005). Marine mammals may not respond to instantaneous changes in ocean conditions. Instead, there might be a time lag between the change of oceanographic conditions and top-level predator responses. Time lags are particularly important when proxies such as chlorophyll data are used to indicate whale habitat (e.g. Littaye et al. 2004; Ferguson 2005). It is not the primary producers themselves that the whales eat but the squid and mesopelagic fishes several trophic levels higher up. Time lapses before energy and nutrients from the primary producers climb the food chain up to cetacean prey species. For baleen whales feeding on zooplankton, which are trophically close to primary production, this lag may be on the order of several weeks, whereas the lag might be considerably greater for sperm whales where the primary prey (cephalopods) are removed from primary production by approximately four months (Jaquet et al. 1996; Gregr and Trites 2001). Littaye et al. (2004)

determined that while food availability at a particular time and place was thought to be a function of environmental conditions occurring in previous months, the study provided evidence that fin whales in the Mediterranean Sea adapted their movements and group size directly to prey availability instead of instantaneous environmental conditions. Integrated approaches are underway in some areas to examine the temporal and spatial relationship of marine mammals to the structure and variability of their habitat (e.g., Croll et al. 1998). Efforts are also underway in habitat modeling, which predicts potential habitat in unsurveyed areas based on the relationships between species' presence and the environmental parameters observed in surveyed areas (e.g., Gregr and Trites 2001; Hamazaki 2002; Littaye et al. 2004; Ferguson 2005; Hastie et al. 2005; Laran and Gannier 2005b; Panigada et al. 2005; Kaschner et al. 2006; Monestiez et al. 2006; Redfern et al. 2006).

Even in the best-studied marine mammal species, determining the fundamental reasons behind the linkage between habitat variables and distribution can be problematic and often requires extensive datasets (e.g., Forney 2000; Gregr and Trites 2001; MacLeod and Zuur 2005). For example, although topography might increase primary productivity and, as a result, provide a local increased availability of prey, not every marine mammal species is necessarily concentrated in that area. Additional factors may be involved, such as habitat segregation between other species that share the same ecological niche (MacLeod and Zuur 2005). The degree of similarity in diet between two or more predators that occur in the same habitat will affect the level of competition between these predators. Competition between predators can result in the exclusion of one or more of them from a specific habitat. For example, MacLeod et al. (2003) suggested that an example of niche segregation might be that *Mesoplodon* spp. occupy a separate dietary niche from bottlenose whales (*Hyperoodon*) and Cuvier's beaked whales (*Ziphius*) although these species share the same overall distribution. In contrast, *Hyperoodon* and *Ziphius* appear to occupy very similar dietary niches but have geographically segregated distributions, with *Hyperoodon* occupying cold-temperate to polar waters and *Ziphius* occupying warm-temperate to tropical waters.

Movements are often related to feeding or breeding activity (Stevick et al. 2002). A migration is the periodic movement of all or significant components of an animal population from one habitat to one or more other habitats and back again. Migration is an adaptation that allows an animal to monopolize areas where favorable environmental conditions exist for feeding, breeding, and/or other phases of the animal's life history. Some baleen whale species, such as humpback whales, make extensive annual migrations to low-latitude mating and calving grounds in the winter and to high-latitude feeding grounds in the summer (Corkeron and Connor 1999). Migrations undoubtedly occur during these seasons due to the presence of highly productive waters and associated cetacean prey species at high latitudes and of warm water temperatures at low latitudes (Corkeron and Connor 1999; Stern 2002). The timing of migration is often a function of age, sex, and reproductive class. Females tend to migrate earlier than males and adults earlier than immature animals (Stevick et al. 2002; Craig et al. 2003). Pregnant females are believed to lead the migration to and from northern feeding grounds; however, not all baleen whales within any given population migrate. Globally, some individual gray (*Eschrichtius robustus*), fin, Bryde's, minke, and blue whales may stay in a specific area year-round.

Cetacean movements can also reflect the distribution and abundance of prey (Gaskin 1982; Payne et al. 1986; Kenney et al. 1996). Cetacean movements have been linked to indirect indicators of prey, such as temperature variations, sea-surface chlorophyll concentrations, and features such as bottom depth (Fiedler 2002). Oceanographic conditions such as upwelling zones, eddies, and turbulent mixing can create regionalized zones of enhanced productivity that are translated into zooplankton concentrations and/or entrain prey as density differences between two different water masses aggregate phytoplankton and zooplankton (Etnoyer et al. 2004). High concentrations of fish and invertebrate larvae along with high rates of primary productivity are associated with shelf break and pelagic frontal features (Roughgarden et al. 1988; Munk et al. 1995). Oceanographic frontal features tend to be ephemeral in space and time, shifting geographically by 10 to 1,000 km depending on the season, the year, and climate events (Thurman 1997).

Since most toothed whales do not have the fasting capabilities of the baleen whales, toothed whales probably follow seasonal shifts in preferred prey or are opportunistic feeders, taking advantage of whatever prey happens to be in the area. Small-scale hydrographic fronts may act as convergence zones

(Etnoyer et al. 2004). For instance, bottlenose dolphins have demonstrated a spatial association with the area near the surface features of tidal intrusion fronts, which could be related to increased foraging efficiency resulting from the accumulation of prey in the frontal region (Mendes et al. 2002).

Occurrence of cetaceans outside the area with which they are usually associated may reflect fluctuations in food availability. Some studies have correlated shifts in the distribution of some baleen whale and toothed whale populations with ecological shifts in prey patterns after intense fishing efforts by commercial fisheries in the western North Atlantic Ocean (Payne et al. 1986; 1990; Kenney et al. 1996). Based on current data on human population growth and marine mammal fisheries interactions, DeMaster et al. (2001) predicted that in the future the most common types of competitive interactions would be ones in which a fishery has an adverse effect on one or more marine mammal populations without necessarily overfishing the target species of the fishery.

Long-ranging movements are quite common in pinnipeds; hooded seals and northern elephant seals (*Mirounga angustirostris*) are both good examples, since they make extensive movements (Stewart and Huber 1993; Kovacs 2002). Pinniped movements depend on the abundance of prey, its energy content, and the seasonality of prey distribution (Forcada 2002). Additionally, the pinniped reproductive cycle mandates that individuals return to land or ice to pup (give birth), nurse, and rear their offspring and molt. Pinnipeds will also haul out for resting, thermoregulation, and to escape predators. As with migrating cetaceans, there are variations in the timing of these movements and in the patterns between age classes (Forcada 2002). Not all pinniped species are migratory. For example, the harbor seal is littoral in distribution and non-migratory; this species breeds and feeds in the same area throughout the year (Bigg 1981; Jeffries et al. 2000).

Pinniped movements, as noted earlier, are a reflection of both foraging ecology and the need to return to land for the purpose of breeding and molting. Like cetaceans, pinnipeds are often associated with either transient (oceanographic features such as frontal systems) or non-transient physical features that serve to concentrate prey. Individual seal foraging behavior is probably related to oceanographic features in the water column, such as thermal discontinuities that act to concentrate prey species (Field et al. 2001). McConnell and Fedak (1996) hypothesized that seals out in the open ocean may be influenced by mesoscale frontal systems with locally enhanced prey abundance. Thompson et al. (1991) observed that the spatial and temporal occurrence of feeding harbor seals was in response to fish distribution which also shifts spatially and temporally, with concentrations over trenches and holes more than 10 m deep during daylight hours.

All pinniped species leave the water periodically to haul out on land or ice to molt, sleep, mate, pup, or avoid marine predators (Riedman 1990). Seasonal changes in oceanographic conditions and ice cover condition affect the distribution of pinnipeds in the pack ice (Forcada 2002). Haul out by ice-associating pinnipeds seems to be affected by both weather and time of day during breeding and molting periods (Moulton et al. 2000). The incidence, biological significance, and controlling factors for haul out at other times of the year, when weather is coldest, are essentially unknown (Moulton et al. 2000). For harbor seals, tidal stage has a significant effect on haulout behavior (Schneider and Payne 1983). Human disturbance can affect haulout behavior by causing seals to return to the water, thereby reducing the amount of time mothers spend nursing pups (Schneider and Payne 1983; Moulton et al. 2000).

Climatic fluctuations have produced a growing concern about the effects of climate change on marine mammal populations (Learmonth et al. 2006). Responses of marine mammals to climate change are difficult to interpret due to the confounding effects of natural responses and human influences. Additionally, the time scale on which marine mammals respond to direct or indirect effects of climate change may be diluted or muted. Large-scale climatic events may affect the distribution and abundance of marine mammal species, either directly or indirectly, through alterations of habitat characteristics and distribution (Harwood 2001; Forcada et al. 2005; Keiper et al. 2005; MacLeod et al. 2005; Shelden et al. 2005; Simmonds and Isaac 2007).

In the North Atlantic region (including the Mediterranean Sea), climate variability has been directly linked to the NAO, which influences the abundance of marine mammal prey such as zooplankton and fish. In years when the NAO Index was positive, the average SST increased, and was followed by increases in

copepod (*Calanus finmarchicus*) abundance which is the principal prey of North Atlantic right whales (Conversi et al. 2001). In the 1970s and 1980s, the NAO conditions were generally positive; they were favorable to *Calanus* abundance and, in principal, to North Atlantic right whale calving rates; however, this cannot be verified because the North Atlantic right whale data series does not begin until 1982 (Greene et al. 2003). In the late 1980s and 1990s, the NAO Index was mainly positive but exhibited two substantial, multi-year reversals to negative values. This was followed by two major, multi-year declines in copepod prey abundance (Pershing et al. 2001; Drinkwater et al. 2003). Subsequently, the North Atlantic right whale calving rate declined for two periods, mirroring the copepod trend with a time lag (Greene et al. 2003). Although the NAO Index has been essentially positive for the past 25 yrs, models indicate that greenhouse warming and the subsequent rise in ocean temperature may lead to increased climatic variability and more severe fluctuations in the NAO Index. Such fluctuations would be expected to cause dramatic shifts in the reproductive rate of critically endangered North Atlantic right whales (Drinkwater et al. 2003; Greene et al. 2003) and possibly a northward shift in the location of right whale calving grounds (Kenney 2007). More details on the NAO and climate variability in the North Atlantic Ocean and Mediterranean Sea may be found in **Chapter 2**.

3.1.2 Marine Mammals of the Eastern Mediterranean Study Area

Twenty-two marine mammal species have confirmed or potential occurrence in the eastern Mediterranean Study Area (**Table 3-1**). There are 21 cetacean and 1 pinniped species. The Mediterranean monk seal is the only pinniped species that occurs in the Study Area; the harbor and hooded seals which are extralimital to the western Mediterranean Sea are not expected to occur in the eastern Mediterranean Sea. Some cetacean species occur regularly in the Study Area year-round while others are rare (such as the humpback whale) and only occur in the Study Area sporadically. Several species of cetaceans are considered extralimital in the Study Area based on their known distributions (**Table 3-1**). For instance, the harbor porpoise is considered extralimital to the Study Area, but a small, local population occurs regularly in the northern Aegean Sea. The Indo-Pacific humpback dolphin is also extralimital to the Study Area; occasional wanderings of this species have been recorded in the eastern Mediterranean Sea and are thought to be Lessepsian migrants that moved into the area from the Red Sea through the Suez Canal (e.g., Kerem et al. 2001). Lessepsian migration (named after the planner of the canal - Ferdinand de Lesseps) refers to migration across the Suez Canal, generally from the Red Sea to the Mediterranean Sea and rarely the other way (Por 1978). Other species, such as the false killer whale, rough-toothed dolphin, Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), and long-beaked common dolphin (*Delphinus capensis*) might enter the Mediterranean Sea via the Suez Canal, although there is currently no evidence to support this possibility (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006).

Several cetacean species have been reported in the Mediterranean Sea but are discounted based on the known distributions and habitat preferences of the species and the lack of evidence associated with the reports.

- Two strandings of a narwhal (*Monodon monoceros*): one reported by D. Viale off Corsica in 1960, the other reported by the local press on the Israeli coast in the late 1980s (Bompar 2000). The narwhal is confined to the Arctic Ocean; therefore, it is highly unlikely to make its way into the Mediterranean Sea. These reports were probably misidentified swordfish (*Xiphias gladius*) (Bompar 2000).
- Another Arctic species, the beluga (*Delphinapterus leucas*), made headlines in 1992 after an individual was discovered along the Turkish coast of the Black Sea (Bompar 2000). This individual was actually an escapee from a Soviet military base (Bompar 2000).
- There are several records for Atlantic white-sided dolphins (*Lagenorhynchus acutus*) and white-beaked dolphins (*Lagenorhynchus albirostris*) that were all rejected (Marchessaux 1980; Bompar 2000; Notarbartolo di Sciara, G., pers. comm., 9 February 2007).
- The pygmy killer whale (*Feresa attenuata*) and short-finned pilot whale (*Globicephala macrorhynchus*) are listed as having a Mediterranean Sea distribution (Jefferson et al. 1993; Culik 2004); however, there are no confirmed records of these species in the Mediterranean Sea (Reeves and Notarbartolo di Sciara 2006).

- Whaling takes of Bryde's whales (*Balaenoptera brydei/edeni*) near the Strait of Gibraltar were reported in the late 1940s; however, these specimens were likely misidentified since the listed measurements were much longer than the normal lengths of this species (Bompar 2000).
- A report of Atlantic spotted dolphins (*Stenella frontalis*) from the Italian Navy was documented in the framework of public sightings collected by The WWF in the late 1970s/early 1980s (Di Natale 1983b); the report is unconfirmed (Reeves and Notarbartolo di Sciara 2006).
- The blue whale (*Balaenoptera musculus*) has never been positively identified in the Mediterranean Sea (Notarbartolo-di-Sciara et al. 2003). There are records of whaling catches of blue whales on the Atlantic side of the Strait of Gibraltar (e.g., Sanpera and Aguilar 1992; Aguilar and Borrell 2007) and older literature often confused this species with the fin whale (Reeves and Notarbartolo di Sciara 2006).
- A photo of a beaked whale taken just inside the Strait of Gibraltar was thought to possibly be a True's beaked whale (*Mesoplodon mirus*); however, the quality of the photo was not good enough to confirm identity of the animal (MacLeod, C., Beaked Whale Research Project, pers. comm., 11 September 2006). This species could possibly occur near the Strait of Gibraltar, however, occurrence within the Mediterranean Sea is highly unlikely (MacLeod, C., Beaked Whale Research Project, pers. comm., 11 September 2006) though more information on the species is provided in the *Mesoplodon* spp. section.
- One sirenian species, the dugong (*Dugong dugon*), supposedly was found in Israel and considered to have moved into the eastern Mediterranean Sea from the Red Sea but was subsequently discounted as a misidentification (Por 1978; Jefferson, T.A., NMFS-SWFSC, pers. comm., 26 October 2006).

Oceanographic characteristics, such as currents and upwellings, are important factors determining marine mammal distribution in the eastern Mediterranean Sea. The overall circulation pattern of the Mediterranean Sea is dependent upon its sole connection to the open ocean at the Strait of Gibraltar (Sardà et al. 2004). The eastward flow of Atlantic water from the Strait of Gibraltar towards the Levantine Basin forms the Algerian Current in the western Mediterranean Sea (Ayoub et al. 1998). One branch of the Algerian Current passes through the Strait of Sicily and creates two streams, the AIS and the ATC, in the eastern Mediterranean Sea (Béranger et al. 2004). The AIS carries Atlantic water east across the central Ionian Basin to the Levantine Basin (Ayoub et al. 1998). External exchange occurs with the Black Sea through the Dardanelles and Bosphorus (Istanbul) straits in the Aegean Sea and the connection to the Red Sea via the Suez Canal (since 1869) (Crise et al. 1999). Currents in the Ionian Sea are generally cyclonic in nature, forming large gyres with two permanent gyres in the eastern reaches of the Ionian seas (Hecht et al. 1988; The POEM group 1992). There is a general cyclonic circulation in the Levantine Sea; this region is dominated seasonally by high mesoscale variability and numerous eddies (Ayoub et al. 1998; Alhammoud et al. 2005). These circulation patterns in the Strait of Sicily, Ionian Sea, and Levantine Sea are a major concern for cetaceans; the upwelling zones, gyres, and eddies formed by the currents are hotspots for marine mammal species because prey are attracted to the increased primary productivity associated with these areas. For instance, the Strait of Sicily is a highly productive area and is considered a biodiversity hotspot in the Mediterranean Sea. It is an important area for several cetacean species. For instance, fin whales concentrate around Lampedusa Island near the Strait of Sicily during winter to feed on locally abundant prey (Canese et al. 2006). Sperm whales are known to concentrate east of Sicily, based on data collected by acoustic sensors at an experimental deep station that is part of the Neutrino Mediterranean Observatory (NEMO) Project (e.g., Holden 2007; Pavan et al. 2007). The shallow waters of the Strait of Sicily may be a barrier to movements by some of the larger, deep water cetacean species and may account for the lack of confirmed records of *Mesoplodon* spp. in the eastern Mediterranean Sea (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006).

Coastal upwelling zones are among the most productive regions of the global ocean (Mote and Mantua 2002). The Mediterranean Sea is not well known for supporting upwelling-dominated marine ecosystems. In fact, the eastern Mediterranean Sea is considered to be one of the most oligotrophic regions in the world (Tselepides et al. 2000); the oligotrophic conditions increase across the basin from west to east (Ignatiades et al. 2002); however, vigorous upwelling zones in the eastern Mediterranean Sea are found in the eastern Aegean Sea and off the west coast of Greece (Bakun and Agostini 2001). A high diversity of cetacean species is found in this region, particularly in the Greek Seas (east Ionian, Aegean, and north

Libyan seas) (Frantzis et al. 2004b). Off the western coast of Greece, oceanographic conditions support substantial zooplankton biomass and, thus, possible feeding aggregations of fin whales (Notarbartolo-di-Sciara et al. 2003). This local enhanced productivity, as well as the steep continental slope of the Greek islands, appear to influence sperm whale distribution in this region (Drouot 2003). Western Greece, specifically the Ionian Sea and Kyparissiakos Gulf, has also been identified as a key area for beaked whales based on the regular occurrence of Cuvier's beaked whales in this area (Politi et al. 1992; Pulcini and Angradi 1994; MacLeod and Mitchell 2006). Cuvier's beaked whales and sperm whales are also common along the Aegean Arc, where the continental shelf drops steeply around the Aegean and Greek Ionian seas (Frantzis 1997).

In addition to general bottom depth characteristics (i.e., shelf, slope, abyssal plain), topographic features such as trenches influence cetacean distribution in the eastern Mediterranean Sea by enhancing the concentration of prey and increase local productivity. The Hellenic Trench, in particular, appears to be an important habitat. The deepest recorded depth (5,121 m) in the Mediterranean Sea is located within the Hellenic Trench which extends from the northeast Ionian Sea to the northwest Levant Basin (Vanney and Gennesseaux 1985; Sardà et al. 2004). The Hellenic Trench is a hotspot for sperm whales; predictable occurrences of sperm whales have been documented along the Hellenic Trench for over nine years (Reeves and Notarbartolo di Sciara 2006). Cuvier's beaked whales also are regular inhabitants of the trench (Frantzis et al. 2003).

The distribution of marine mammal records in the eastern Mediterranean Sea is presented for summer (29 May through 15 November) and winter (16 November through 28 May) in the maps in **Appendix B**. An occurrence record does not reflect the number of marine mammals; due to the social nature of cetaceans, multiple individuals of a species are often sighted at the same time at the same location. It should be noted that the number of marine mammal observations in this area is partially a function of the level of effort to collect this information, rather than just the actual marine mammal abundance in the area.

A listing and description of data sources used to determine each species's occurrence in the eastern Mediterranean Study Area is found in **Appendix A-2**, while the process used to create the map figures is described in **Section 1.4.2.2**. On the map figures, various types of shading and terminology designate the occurrence of marine mammals in the Study Area. "Area of primary occurrence" (area shaded in dark blue) is defined as the areas and habitats where the species is primarily found. "Area of secondary occurrence" (area shaded in medium blue) is the areas and habitats where the species may be found, especially during "anomalous" environmental conditions. "Area of rare occurrence" (light blue area) is the areas and habitats where the species is not expected to be found regularly. Areas of concentration are those regions where the species is known or suspected to concentrate because of favorable habitat (e.g., feeding hotspots).

Each marine mammal species is listed below with its description, status, habitat preference, distribution (including location and seasonal occurrence in the eastern Mediterranean Study Area), behavior and life history, and information on its acoustics and hearing abilities. Species appearance within the text begins with threatened and endangered marine mammals, while the remaining species follow the taxonomic order as presented in **Table 3-1**.

3.1.2.1 Threatened and Endangered Marine Mammals of the Eastern Mediterranean Study Area

Six marine mammal species with known or possible occurrence in the Study Area are currently listed as endangered under the ESA: four baleen whale species (North Atlantic right, humpback, sei, and fin whales), one toothed whale species (sperm whale), and one pinniped species (Mediterranean monk seal).

A combined map of the threatened and endangered cetacean species occurring in the eastern Mediterranean Study Area is located in **Appendix B**. The occurrence patterns for the endangered Mediterranean monk seal are considered separately and are described in the monk seal section of this chapter (**Figure B-9**).

- Information Specific to the Eastern Mediterranean Study Area—An area of primary occurrence of threatened and endangered cetaceans extends throughout the Study Area year-round and is based primarily on the occurrence patterns of the fin whale and the areas of concentration for fin and sperm whales (**Figure B-1**; **Figure B-2**). The eastern Ionian Sea and the east coast of Sicily regions are the only known areas of concentration of fin whales in the eastern Mediterranean Sea during summer (**Figure B-1**). During winter, the known area of fin whale concentration is around Lampedusa Island in the Strait of Sicily (**Figure B-2**). Known areas of concentration for sperm whales are consistent year-round and include the region east of Sicily, the Aegean Arc (Rodos-Karpathos-Kriti-southeast Peloponnisos), and the northern Aegean Sea (**Figure B-1**; **Figure B-2**). Records of unidentified rorquals and unidentified baleen whales are included in the figures since these are most likely fin whales (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006).

- **North Atlantic Right Whale (*Eubalaena glacialis*)**

Description—Adult North Atlantic right whales are robust and may reach 18 m in length (Jefferson et al. 1993). There is no dorsal fin on the broad back. The head is nearly one-third of its total body length. The jawline is arched and the upper jaw is very narrow in dorsal view. Right whales are overall black in color, although many individuals also have irregular white patches on their undersides (Reeves and Kenney 2003). The head is covered with irregular whitish patches called “callosities” (to which barnacles and whale lice attach) that assist researchers in individual identification (Kraus et al. 1986b).

Status—The North Atlantic right whale is one of the world’s most endangered large whale species (Clapham et al. 1999; Perry et al. 1999; IWC 2001b). The North Atlantic right whale is classified as endangered under both the ESA (NMFS 2005) and the IUCN Red List[1]. Because not much is known about this species’s genetics and movement patterns, it is possible that individuals from both western and eastern Atlantic populations might make their way into the Mediterranean Sea.

There is a provisional division of western and eastern North Atlantic stocks (IWC 2001a); however, this is largely unresolved (Brown, M., New England Aquarium, pers. comm., 6 September 2006). It is unclear whether animals found in the eastern North Atlantic Ocean represent a "relict" population or whether all or some animals are individuals from the known western North Atlantic population. Using mitochondrial deoxyribonucleic acid (DNA) extracted from museum specimens, including the only available analysis of eastern North Atlantic specimens, Rosenbaum et al. (2000) determined that the eastern and western populations were not historically distinct.

The eastern North Atlantic population is probably only in the low tens of animals at best (IWC 2001a). There are only two records of cow-calf pairs in the eastern North Atlantic Ocean; a sighting off southwestern Portugal during February 1995 was the first record of a cow-calf pair in the eastern North Atlantic Ocean since 1967 (Martin and Walker 1997).

Approximately 350 individuals, including about 70 mature females, are thought to occur in the western North Atlantic Ocean (Kraus et al. 2005). The most recent NOAA Stock Assessment Report (SAR) states that in a review of the photo-id recapture database for October 2005, 306 individually recognized whales were known to be alive during 2001 (Waring et al. 2007). This represents a minimum population size, and no estimate of abundance with an associated coefficient of variation has been calculated for this population (Waring et al. 2007).

This species is presently declining in number (Caswell et al. 1999; Kraus et al. 2005) and is considered to be reproductively dysfunctional, which means even if human induced mortality is eliminated, the species still likely faces extinction (Reeves et al. 2001a). Kraus et al. (2005) noted that the recent increases in birth rate are too small to overcome this decline.

Table 3-1. Marine mammal species with known or potential occurrence in the Mediterranean Study Area. Taxonomy follows IWC (2006) for cetaceans and Rice (1998) for pinnipeds. Their status under the ESA and the IUCN Red List is included. Occurrence is presented for both the western and eastern Mediterranean. [Regular = A species that occurs as a regular or normal part of the fauna of the area, regardless of how abundant or common it is; Rare = A species that only occurs in the area sporadically; Extralimital = A species that does not normally occur in the area, but for which there are one or more records that are considered beyond the normal range of the species].

	Scientific Name	ESA Status	IUCN Status	Occurrence	
				Western	Eastern
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Family Balaenidae (right whales)					
North Atlantic right whale	*Eubalaena glacialis*	Endangered	Endangered	Extralimital	Extralimital
Family Balaenopteridae (rorquals)					
Humpback whale	*Megaptera novaeangliae*	Endangered	Vulnerable	Rare	Rare
Common minke whale	*Balaenoptera acutorostrata*		Lower Risk	Rare	Rare
Sei whale	*Balaenoptera borealis*	Endangered	Endangered	Extralimital	Extralimital
Fin whale	*Balaenoptera physalus*	Endangered	Endangered	Regular	Regular
Suborder Odontoceti (toothed whales)					
Family Physeteridae (sperm whale)					
Sperm whale	*Physeter macrocephalus*	Endangered	Vulnerable	Regular	Regular
Family Kogiidae (pygmy sperm whales)					
Dwarf sperm whale	*Kogia sima*		Lower Risk	Extralimital	Extralimital
Family Ziphiidae (beaked whales)					
Cuvier's beaked whale	*Ziphius cavirostris*		Data Deficient	Regular	Regular
Blainville's beaked whale	*Mesoplodon densirostris*		Data Deficient	Extralimital	Extralimital
Gervais' beaked whale	*Mesoplodon europaeus*		Data Deficient	Extralimital	Extralimital
Northern bottlenose whale	*Hyperoodon ampullatus*		Lower Risk	Extralimital	Extralimital
Family Delphinidae (dolphins)					
Rough-toothed dolphin	*Steno bredanensis*		Data Deficient	Rare	Rare
Common bottlenose dolphin	*Tursiops truncatus*		Data Deficient	Regular	Regular
Striped dolphin	*Stenella coeruleoalba*		Lower Risk	Regular	Regular
Short-beaked common dolphin	*Delphinus delphis*		Lower Risk	Regular	Regular
Indo-Pacific humpback dolphin	*Sousa chinensis*		Data Deficient	—	Extralimital
Risso's dolphin	*Grampus griseus*		Data Deficient	Regular	Regular
False killer whale	*Pseudorca crassidens*		Lower Risk	Rare	Rare
Killer whale	*Orcinus orca*		Lower Risk	Rare[1]	Extralimital
Long-finned pilot whale	*Globicephala melas*		Lower Risk	Regular	Rare
Family Phocoenidae (porpoises)					
Harbor porpoise	*Phocoena phocoena*		Vulnerable	Extralimital	Extralimital[2]
Order Carnivora					
Suborder Pinnipedia (seals, sea lions, walruses)					
Family Phocidae (true seals)					
Mediterranean monk seal	*Monachus monachus*	Endangered	Critically Endangered	Regular	Regular
Harbor seal	*Phoca vitulina*		Lower Risk	Extralimital	—
Hooded seal	*Cystophora cristata*		Lower Risk	Extralimital	—

[1] Regular occurrence in the Strait of Gibraltar
[2] Regular occurrence in the northern Aegean Sea

One calving (waters off Georgia and northern Florida) and two feeding areas (off the northeastern U.S.) in U.S. waters are designated as critical habitat for North Atlantic right whales (NMFS 1994; NMFS 2005).

Habitat Preferences—The feeding areas are characterized by bottom topography, water column structure, currents, and tides that combine to physically concentrate zooplankton into extremely dense patches (Wishner et al. 1988; Murison and Gaskin 1989; Macaulay et al. 1995; Beardsley et al. 1996; Baumgartner et al. 2003a). Right whales in feeding areas tend to occur consistently in specific locations, often areas of low bathymetric relief near higher relief edges with distinct frontal zones. Shallow waters over the continental shelf are preferred for feeding; 75% of sightings are less than 30 km from land (including islands) (e.g., Mate and Baumgartner 2001). Locations of preferred habitat may change based on the temporal and spatial formations of zooplankton concentrations responding to annual fluctuations in oceanic conditions (Kenney 2001, 2007). For example, the near absence of right whales on their spring and early summer feeding ground in the Great South Channel in 1992 was attributed to a lack of sufficiently dense patches of *Calanus finmarchicus*. This prey depletion was probably caused by an anomalous influx of cold Scotian Shelf water, which began in the late winter and resulted in below average temperatures over much of Georges Bank through the spring (Kenney 2001, 2007). Some preliminary research has attempted to use remotely-sensed oceanographic data to predict right whale occurrence but is still under development (Brown and Winn 1989; Ward 1999). Satellite-tagged right whales in the Bay of Fundy have been found to move offshore, spending time at the edge of a warm-core ring and lingering in areas where upwelling occurs (Mate et al. 1997). Baumgartner et al. (2003a) found that annual increases in right whale occurrence appeared to be associated with decreases in SST, but they noted that the observation merits caution in light of the short (three year) duration of the study. Somewhat surprisingly, recent studies found that right whales did not show associations with oceanic fronts or regions with high phytoplankton densities (Baumgartner and Mate 2005).

Right whales on the winter calving grounds are most often found in very shallow, nearshore waters in cooler SSTs inshore of a mid-shelf front (Kraus et al. 1993; Ward 1999). High whale densities can extend more northerly than the current defined boundary of the calving critical habitat in response to interannual variability in regional SST distribution (e.g., Garrison 2005; Garrison et al. 2005; Glass et al. 2005). Warm Gulf Stream waters appear to represent a thermal limit (both southward and eastward) for right whales (Keller et al. 2006).

Distribution—Right whales occur in sub-polar to temperate waters. The North Atlantic right whale was historically widely distributed prior to serious declines in abundance due to intensive whaling (Reeves et al. 2007).

Due to a lack of sightings, current distribution and migration patterns of the eastern North Atlantic right whale population are unknown. In the eastern North Atlantic Ocean, right whales may originally have migrated along the coast from northern Europe to the northwest coast of Africa. Historically, the main calving grounds in the eastern North Atlantic Ocean were Cintra Bay off the western Sahara and the Bay of Biscay (**Figure 3-1**). Whalers reported sighting right whales between November and April, with a possible peak in sightings in January through February (Reeves and Mitchell 1986). The species migrated west of Britain and Ireland, where they were captured during the Scottish and Irish whale fisheries mainly in June, after which the species was thought to move to Scandinavian feeding areas during July and August (Aguilar 1986; Brown 1986; Reid et al. 2003). A few more recent sightings in British and Irish waters have occurred between May and September (Reid et al. 2003).

In the western North Atlantic Ocean, right whales are found primarily between Florida and Nova Scotia (Winn et al. 1986). During the spring through early summer, individuals are found on feeding grounds off the northeastern U.S. and Canada (**Figure 3-1**). The peak abundance is in August, September, and early October. Most sightings are concentrated within five high-use areas: coastal waters of the southeastern U.S. (Georgia and Florida), Cape Cod and Massachusetts Bays, the Great South Channel, the Bay of Fundy, and the Nova Scotian Shelf (Winn et al. 1986; NMFS 2005).

Isotopic analyses indicate that some right whales may be using the Labrador Sea as an alternative feeding ground (Summers et al. 2006).

During the winter (as early as November and through March), North Atlantic right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida (Winn et al. 1986; Kenney 2001). The waters off Georgia and northern Florida are the only known calving ground for western North Atlantic right whales. Calving occurs from December through March (NMFS 2005). A majority of the population, however, is not accounted for on the calving grounds, and not all reproductively-active females return to this area each year (Kraus et al. 1986a). It is likely that in non-calving years, some females may be feeding in Cape Cod Bay or other northern habitats during the winter, which is supported by sighting data, photo-identification effort, as well as scan isotopic analyses of baleen (e.g., Watkins and Schevill 1982; Summers et al. 2006).

In the western North Atlantic Ocean, sightings follow a well-defined seasonal migratory pattern through several consistently utilized habitats (Winn et al. 1986; **Figure 3-1**). It should be noted, however, that some individuals may be sighted in these habitats outside the typical time of year and that migration routes are poorly known (there may be a regular offshore component). The population migrates as two separate components, although some whales may remain on the feeding grounds throughout the winter (Winn et al. 1986; Kenney et al. 2001). Pregnant females and some juveniles migrate from the feeding grounds to the calving grounds off the southeastern U.S. in late fall to winter. The cow-calf pairs return northward in late winter to early spring. The majority of the right whale population leaves the feeding grounds for unknown habitats in the winter but returns to the feeding grounds coinciding with the return of the cow-calf pairs. Some individuals, including cow-calf pairs, can be seen through the fall and winter on the feeding grounds with feeding observed (e.g., Sardi et al. 2005).

Satellite-tagged animals have made extensive movements, sometimes traveling from the Gulf of Maine into deeper waters off the continental shelf (Mate et al. 1997). Mate et al. (1997) tagged one male that traveled into waters with a bottom depth of 4,200 m. Long-distance movements as far north as Newfoundland, the Labrador Basin, southeast of Greenland, Iceland, and Arctic Norway have been documented (Knowlton et al. 1992; IWC 2001a; Waring et al. 2007). One individually identified right whale was documented to make a two-way trans-Atlantic migration from the eastern coast of the U.S. to a location in northern Norway (Jacobsen et al. 2004). A female North Atlantic right whale was tagged with a satellite transmitter and tracked to nearly the middle of the Atlantic Ocean where she remained for a period of months.[5] The longest tracking of a right whale is of an adult female which migrated 1,928 km in 23 days (mean=3.5 kilometers per hour [km/hr]) from 40 km west of Browns Bank (Bay of Fundy) to Georgia (Mate and Baumgartner 2001).

- Information Specific to the Eastern Mediterranean Study Area—Any occurrences of the North Atlantic right whale in the Mediterranean Sea are considered to be extralimital. There are only two confirmed records for the region: (1) a sighting of two individuals in the Bay of Castiglione near Algiers, Algeria in late January 1888, with one whale later captured and killed (Pouchet and Beauregard 1888; Bompar 2000) and (2) a capture of one individual near Taranto, Italy in early February 1877 (Reeves and Notarbartolo di Sciara 2006). An alleged sighting of a right whale off southwestern Sardinia in May 1991 (Notarbartolo di Sciara 1996) could not be confirmed and is, therefore, considered questionable (Reeves and Notarbartolo di Sciara 2006).

  There is a rare occurrence for the right whale throughout the eastern Mediterranean Sea which takes into account the remote possibility of encountering this highly endangered species anywhere in coastal and offshore waters at any time of the year (**Figure B-3**).

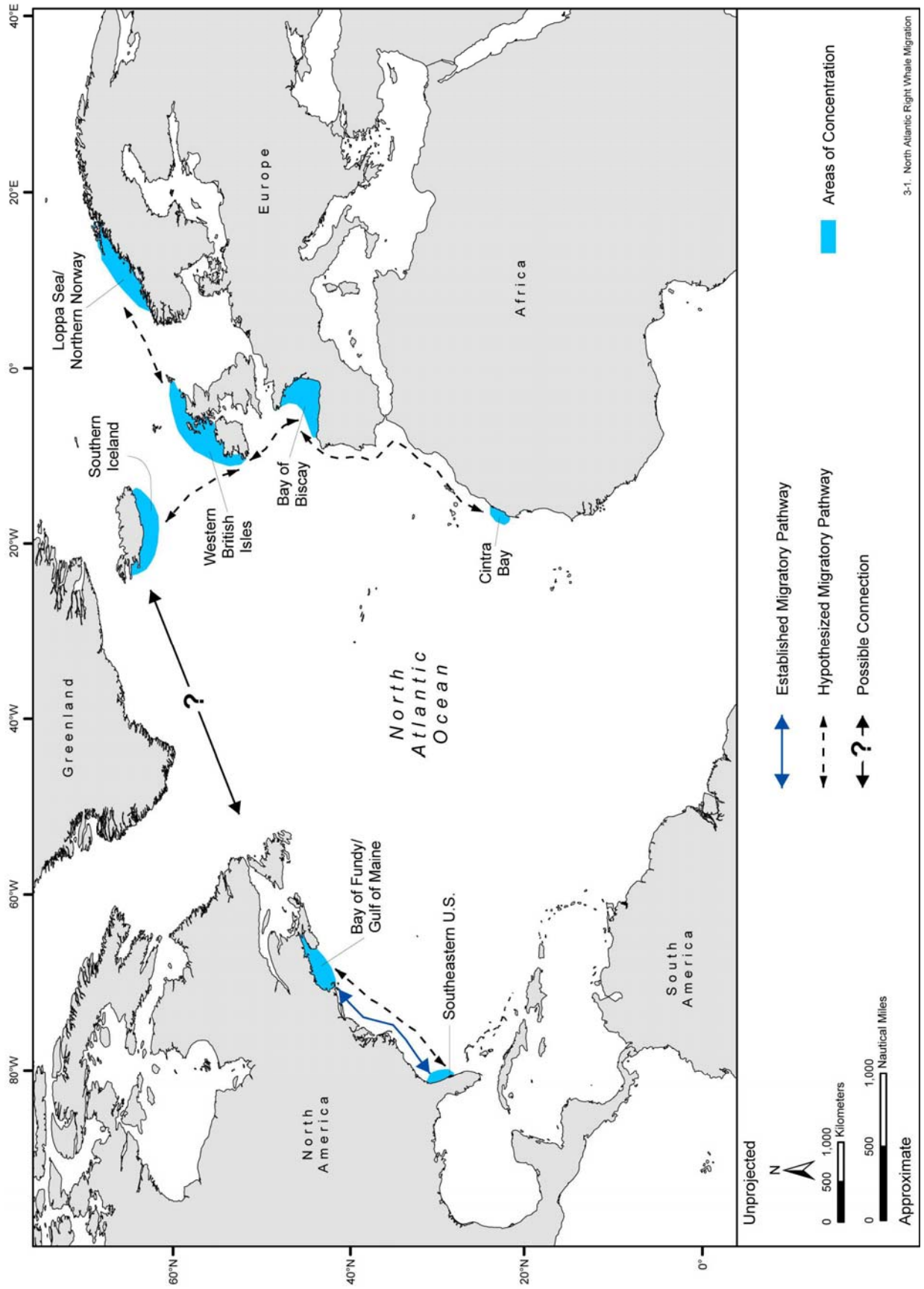


Figure 3-1. Current knowledge of the migration pathways of North Atlantic right whales. Current and historical areas of concentration and migratory pathways are depicted. Note that North Atlantic right whales also occur outside of these areas. Source information: Winn et al. (1986) and Smith et al. (2006).

Behavior and Life History—Right whales are most often seen as individuals or pairs (Jefferson et al. 1993). Right whales may aggregate in "surface active" groups, which appear to involve courtship and mating activity (Kraus and Hatch 2001; Parks and Tyack 2005). These groups have been observed year-round in all five high-use habitats; however, during the winter, they do not appear to involve adults.

North Atlantic right whale calves are born during December through March after 12 to 13 months of gestation (Kraus et al. 2001). Weaning occurs at 8 to 17 months (Hamilton et al. 1995). There is usually a 3-yr interval between calves (Kraus et al. 2001). Three puzzling population biology factors for the North Atlantic right whale population are the variation in interannual calf production; consistently low reproductive rates; and the number of adult females that have never been known to give birth. Genetic variability and inbreeding, potential effects of pollutants, and food supply limitations are all possible driving factors for these observations (Kraus et al. 2007).

North Atlantic right whales feed on zooplankton, particularly large calanoid copepods such as *Calanus* spp. (Kenney et al. 1985; Beardsley et al. 1996; Baumgartner et al. 2007). The food resource in the Great South Channel and the Bay of Fundy is believed to be composed almost exclusively of *Calanus finmarchicus*, while in Cape Cod Bay, their food resource is more diverse, consisting of *Centropages typicus* and *Pseudocalanus* spp. as well as *Calanus finmarchicus* (Mayo and Marx 1990; Jaquet et al. 2005). Differences in the nutritional content of zooplankton prey could have a considerable effect on the nutrition available to right whales (DeLorenzo Costa et al. 2006).

When feeding, right whales skim prey from the water (Pivorunas 1979; Mayo and Marx 1990; Baumgartner et al. 2007). Feeding can occur throughout the water column (Watkins and Schevill 1976, 1979; Goodyear 1993; Winn et al. 1995). Feeding behavior has been observed in all of the northern high-use areas but has not been observed on the calving grounds or during migration (Kraus et al. 1993; Slay 2002).

Dives of 5 to 15 min or longer have been reported (CETAP 1982; Baumgartner and Mate 2003) but can be much shorter when feeding (Winn et al. 1995). Foraging dives in the known feeding high-use areas are frequently near the bottom of the water column (Goodyear 1993; Mate et al. 1997; Baumgartner et al. 2003b). Baumgartner and Mate (2003) found that the average depth of a right whale dive was strongly correlated with both the average depth of peak copepod abundance and the average depth of the mixed layer's upper surface. Right whale feeding dives are characterized by a rapid descent from the surface to a particular depth between 80 and 175 m, remarkable fidelity to that depth for 5 to 14 min, and then rapid ascent back to the surface (Baumgartner and Mate 2003). Longer surface intervals have been observed for reproductively-active females and their calves (Baumgartner and Mate 2003).

Acoustics and Hearing—North Atlantic right whales produce a variety of sounds, including moans, screams, gunshots, blows, upcalls, downcalls, and warbles that are often linked to specific behaviors (Matthews et al. 2001; Laurinolli et al. 2003; Vanderlaan et al. 2003; Parks et al. 2005; Parks and Tyack 2005). Sounds can be divided into three main categories: (1) blow sounds; (2) broadband impulsive sounds; and (3) tonal call types (Parks and Clark 2007). Blow sounds are those coinciding with an exhalation; it is not known whether these are intentional communication signals or just produced incidentally (Parks and Clark 2007). Broadband sounds include non-vocal slaps (when the whale strikes the surface of the water with parts of its body) and the "gunshot" sound; data suggests that the latter serves a communicative purpose (Parks and Clark 2007). Tonal calls can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls (Parks and Clark 2007). Most of these sounds range in frequency from 0.02 to 15 kHz (dominant frequency range from 0.02 to less than 2 kHz; durations typically range from 0.01 to several seconds) with some sounds having multiple harmonics (Parks and Tyack 2005). Source levels for some of these sounds have been measured as ranging from 137 to 192 decibels at the reference level of one micropascal at one meter (dB re: 1 μPa-m) root mean square (rms) (Parks et al. 2005; Parks and Tyack 2005). In certain regions (i.e., eastern North Atlantic Ocean), preliminary

results indicate that right whales vocalize more from dusk to dawn than during the daytime (Leaper and Gillespie 2006).

Recent, morphometric analyses of North Atlantic right whale inner ears estimate a hearing range of approximately 0.01 to 22 kHz based on established marine mammal models (Parks et al. 2004; Parks and Tyack 2005; Parks et al. 2007). Nowacek et al. (2004) observed that exposure to short tones and down sweeps, ranging in frequency from 0.5 to 4.5 kHz, induced an alteration in behavior (received levels of 133 to 148 dB re: 1 μPa-m), but exposure to sounds produced by vessels (dominant frequency range of 0.05 to 0.5 kHz) did not produce any behavioral response (received levels of 132 to 142 dB re: 1 μPa-m).

- **Humpback Whale (*Megaptera novaeangliae*)**

Description—Adult humpback whales are 11 to 16 m in length and are more robust than other rorquals. The body is black or dark gray with very long (about one-third of the body length) flippers that are usually at least partially white (Jefferson et al. 1993; Clapham and Mead 1999). The head is larger than in other rorquals. The flukes have a concave, serrated trailing edge; the ventral side is variably patterned in black and white. Individual humpback whales may be identified using these patterns (Katona et al. 1979).

Status—Humpback whales are classified as endangered under the ESA; there is no designated critical habitat for this species. This species is designated as vulnerable on the IUCN Red List.[1] An estimated 11,570 humpback whales occur in the entire North Atlantic Ocean (Stevick et al. 2003a). The IWC considers the "feeding stock" to be the appropriate unit for management of humpback whales in the North Atlantic Ocean (COSEWIC 2003). Humpback whales in the North Atlantic Ocean are thought to belong to five different feeding stocks: Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland. There appears to be very little exchange between these separate feeding stocks (Katona and Beard 1990).

Habitat Preferences—Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves (Clapham and Mead 1999). Shallow banks or ledges with high sea-floor relief characterize feeding grounds (Payne et al. 1990; Hamazaki 2002). The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving. Breeding grounds are in tropical or subtropical waters, generally with shelter created by islands or reefs. Optimal calving conditions are warm water (24° to 28°C) and relatively shallow, low-relief ocean bottom in protected areas (i.e., behind reefs) (Sanders et al. 2005). These areas provide calm seas and minimize the possibility of predation by sharks and harassment by male humpbacks (Smultea 1994; Clapham 2000; Craig and Herman 2000). Females with calves occur in significantly shallower waters than other groups of humpback whales, and breeding adults use deeper, more offshore waters (Smultea 1994; Ersts and Rosenbaum 2003).

Distribution—Humpback whales are globally distributed in all major oceans and most seas. They are generally found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands where calving occurs.

In the North Atlantic Ocean, humpbacks are found from spring through fall south of New England to northern Norway (NMFS 1991). The most important feeding habitat for humpback whales in the North Atlantic Ocean is the shallow southwestern Gulf of Maine from Jeffreys Ledge south to the Great South Channel. The largest numbers of humpback whales are present from mid-April to mid-November. Other major feeding grounds in the North Atlantic Ocean are located in the Gulf of St. Lawrence; off Newfoundland, Labrador, and Greenland; near Iceland and Jan Mayen; and from coastal Norway into the Barents Sea (Whitehead 1982; Kenney and Winn 1986; Weinrich et al. 1997; Stevick et al. 2003a). Humpbacks typically return to the same feeding areas each year. Early

experience and maternal influence are important in a humpback whale's subsequent choice of local habitat and regional feeding area (see Weinrich 1998).

The distribution and abundance of sand lance are important factors underlying the distribution patterns of the humpback whale in the western North Atlantic Ocean (Kenney and Winn 1986). Changes in diets and feeding preferences are likely caused by changes in prey distribution and/or in the relative abundance of different prey species (sand lance and herring) (Payne et al. 1986; Payne et al. 1990; Kenney et al. 1996; Weinrich et al. 1997). Feeding most often occurs in relatively shallow waters over the inner continental shelf and sometimes in deeper waters. Large multi-species feeding aggregations (including humpback whales) have been observed over the shelf break on the southern edge of Georges Bank off the northeastern U.S. (CETAP 1982; Kenney and Winn 1987) and in shelf break waters off the U.S. mid-Atlantic coast (Smith et al. 1996).

During the winter, humpback whales are found on low-latitude breeding and calving grounds. Most of the North Atlantic population of humpback whales is believed to migrate south to calving grounds in the West Indies region (Whitehead and Moore 1982; Smith et al. 1999; Stevick et al. 2003b; **Figure 3-2**). The calving peak in the West Indies is January through March, with some animals arriving as early as December and a few not leaving until June. Photo-identification and genetic studies indicate that at least some humpback whales from the eastern North Atlantic winter in the West Indies (Palsbøll et al. 1997; Stevick et al. 1998). The West Indies is likely a main winter destination for humpback whales feeding off Norway in the Barents Sea based on genetic and photographic matches of individuals from both locations (Stevick et al. 1998; Bérubé et al. 2004). The West Indies is also a known migratory destination for some humpbacks that feed near Iceland (Martin et al. 1984). The Cape Verde Islands off the west coast of Africa is the other known breeding/calving ground in the North Atlantic Ocean (**Figure 3-2**). Based on historical whaling data, humpback whales in the eastern North Atlantic Ocean concentrated around the Cape Verde Islands during the winter and spring months (Mitchell and Reeves 1983; Reeves et al. 2002a; Smith and Reeves 2003; Reeves et al. 2004). Peak occurrence of humpback whales in this region was between February and April (Reeves et al. 2002a). Recent studies indicate that the Cape Verde Islands are still an important breeding and calving ground for humpbacks (Reiner et al. 1996; Jann et al. 2003); however, the density of humpback whales in this region appears to be much lower than in the past (Hazevoet and Wenzel 2000). Humpback whales occur there between December and April (Berrow 2006). Individuals in the Cape Verde Islands have also been sighted in Icelandic waters and off the coast of Norway, suggesting possible feeding ground destinations for humpbacks from the Cape Verde Islands (Jann et al. 2003; Wenzel et al. 2005).

Due to the temporal difference in occupancy of the West Indies between individuals from different feeding areas, coupled with sexual differences in migratory patterns, Stevick et al. (2003b) suggested the possibility that there are reduced mating opportunities between individuals from different high-latitude feeding areas. Not all Atlantic humpback whales migrate to the calving grounds, since some sightings (believed to be only a very small proportion of the population) are made during the winter in northern habitats (CETAP 1982; Whitehead 1982; Clapham et al. 1993; Swingle et al. 1993). The sex and age class of nonmigratory animals remains unclear.

Southbound and northbound migration routes are not known. Examination of whaling catches revealed that migrations are characterized by a staggering of sexual and maturational classes; lactating females are among the first to leave summer feeding grounds in the fall, followed by subadult males, mature males, non-pregnant females, and pregnant females (Clapham 1996). On the northward migration, this order is broadly reversed with newly pregnant females among the first to begin the return migration to high latitudes. Stevick et al. (2003b) reported sighting males 6.63 days earlier than females in the West Indies. There is also a staggering of arrival and departures dependent on feeding stock origin. Individuals identified on feeding grounds in the Gulf of Maine and eastern Canada arrived significantly earlier (9.97 days) than those animals identified in Greenland, Iceland, and Norway (Stevick et al. 2003b). During the northward migration, the whales are not believed to separate into discrete feeding groups until north of Bermuda (Katona and Beard 1990).

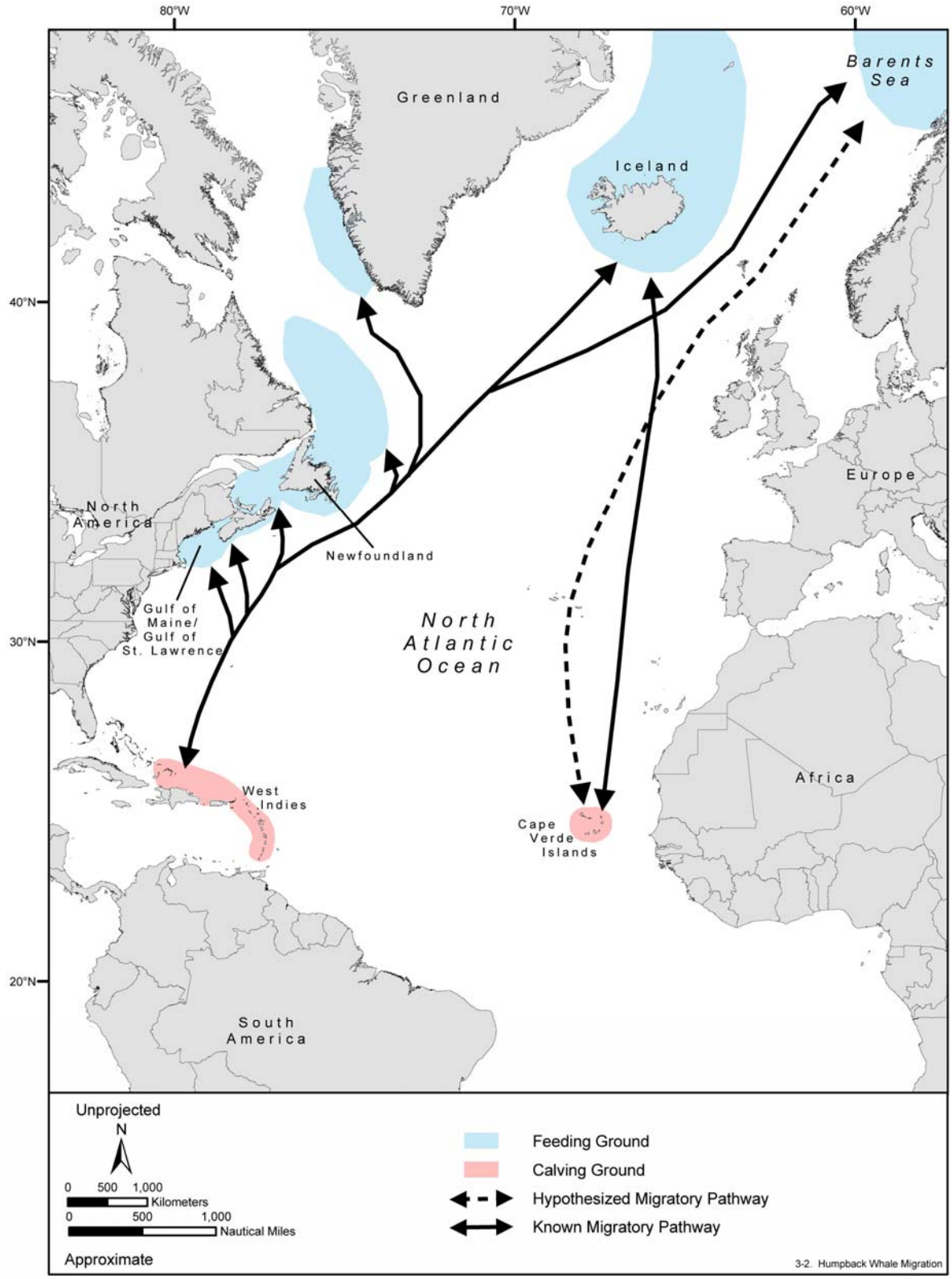


Figure 3-2. Current knowledge of the migration pathways of humpback whales in the North Atlantic Ocean. Current feeding and calving grounds and general migratory pathways are depicted. Note that humpback whales also occur outside these areas. Source information: Stevick et al. (1998), Jann et al. (2003), and Stevick et al. (2003b).

- Information Specific to the Eastern Mediterranean Study Area—Humpback whales rarely occur in the Mediterranean Sea. The Mediterranean Sea is not a feeding or breeding area for humpback whales, and it is not part of the migration path of this species. It is unknown whether any of the humpback whales recorded in the Mediterranean Sea are from any particular Atlantic stock (Frantzis et al. 2004a), but it is likely that they are strays from the northeastern Atlantic population that wandered into the Mediterranean Sea through the Strait of Gibraltar (Aguilar 1989). Since 1990, observations of humpback whales in the Mediterranean Sea have increased (Frantzis et al. 2004a), and sightings have been recorded as far east as Syria (Saad 2004). These occurrences are not fully understood. They might be due to temporal or permanent changes in the oceanographic conditions in the Strait of Gibraltar and the Mediterranean Sea. An increase in records could also be an indication of a growing population of humpback whales in the eastern North Atlantic Ocean (Frantzis et al. 2004a).

There are seven confirmed records of humpback whales in the eastern Mediterranean Sea. The eastern-most record is of a stranded individual found north of Tartous, Syria (Saad 2004). Additional records in the eastern Mediterranean Sea include an individual caught in the Gulf of Gabes, Tunisia in October 1992; a whale caught and released near Siracusa, Sicily, Italy in April 2004; a sighting off Senigallia, Italy in August 2002; two sightings in the Bay of Tolo and off Lefkada Island, Greece in April 2001 and July 2002, respectively; and a whale caught off Corfu Island, Greece in February 2004 (Chakroun 1994; Affronte et al. 2003; Frantzis et al. 2004a; Centro Studi Cetacei Onlus and Museo Civico di Storia Naturale di Milano 2006). Most of the records represent juveniles which have likely wandered into the Mediterranean Sea during migrations between feeding and calving grounds in the North Atlantic Ocean (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006); however, a review of the available records suggests that such occurrences could actually occur during any time of the year.

There is a rare occurrence of humpback whales throughout the Study Area to account for the possibility of encountering this species anywhere in coastal and offshore waters (**Figure B-4**). No seasonal differences in occurrence are anticipated for this species.

Behavior and Life History—Humpback whales are arguably the most social of all the baleen whales. Group size can range from single individuals to up to 20 or more whales. These groups are, however, typically small and unstable with the exception of cow-calf pairs (Clapham and Mead 1999). On the feeding grounds, relatively large numbers of humpbacks may be observed within a limited area to feed on a rich food source. While large aggregations are often observed, it is not clear if there are stable associations between individuals or if this is simply a reflection of a concentration of animals brought together by a common interest in locally abundant prey (Clapham 2000). On the breeding grounds, small groups of males may occur when competing for access to females (Tyack and Whitehead 1983; Baker and Herman 1984; Pack et al. 1998). Competitive groups have occasionally been observed on the feeding grounds (Weinrich 1995).

Humpback whales feed on a wide variety of invertebrates and small schooling fishes. The most common invertebrate prey are euphausiids (krill); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead 1999). These whales are lunge feeders, taking in huge batches of prey items as they lunge laterally, diagonally, or vertically through patches of prey (Clapham 2002). Feeding behavior is highly diverse, and humpbacks employ unusual behaviors, such as bubble netting, to corral prey (Jurasz and Jurasz 1979; Weinrich et al. 1992). This is the only species of baleen whale that shows some evidence of cooperation when feeding in large groups (D'Vincent et al. 1985). Humpback whales are not typically thought to feed on the breeding grounds; however, some feeding behavior has been observed there (Salden 1989; Gendron and Urbán R. 1993).

Female humpbacks become sexually mature at four to nine years of age (Clapham 1996). Gestation is approximately one year. Calves are weaned before one year of age. Calving intervals are usually

two to three years, although females occasionally give birth to calves in successive years (Clapham 1996). Males compete for access to receptive females by aggressive (sometimes violent) interactions as well as vocal displays (Clapham 1996; Pack et al. 1998).

Humpback whale diving behavior depends on the time of year (Clapham and Mead 1999). In summer, most dives last less than five min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min; dives of greater than 30 min have been recorded (Clapham and Mead 1999). Although humpback whales have been recorded to dive as deep as 500 m (Dietz et al. 2002), on the feeding grounds they spend the majority of their time in the upper 120 m of the water column (Dolphin 1987; Dietz et al. 2002). Recent DTAG work revealed that humpbacks are usually only a few meters below the water's surface while foraging (Ware et al. 2006). Humpback whales on the wintering grounds do dive deeply; Baird et al. (2000) recorded dives deeper than 100 m.

Acoustics and Hearing—Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) sounds made within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995).

The best-known types of sounds produced by humpback whales are songs, which are thought to be breeding displays used only by adult males (Helweg et al. 1992). Singing is most common on breeding grounds during the winter and spring months but is occasionally heard outside breeding areas and out of season (Mattila et al. 1987; Gabriele et al. 2001; Gabriele and Frankel 2002; Clark and Clapham 2004). Humpback song is an incredibly elaborate series of patterned vocalizations which are hierarchical in nature (Payne and McVay 1971). There is geographical variation in humpback whale song, with different populations singing different songs and all members of a population using the same basic song; however, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983).

Social calls are from 50 Hz to over 10 kHz, with dominant frequencies below 3 kHz (Silber 1986). Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity. The male song, however, is complex and changes between seasons. Components of the song range from under 20 Hz to 4 kHz and occasionally 8 kHz, with source levels measured between 151 and 189 dB re: 1 μPa-m and high-frequency harmonics extending beyond 24 kHz (Au et al. 2001; Au et al. 2006). Songs have also been recorded on feeding grounds (Mattila et al. 1987; Clark and Clapham 2004). The main energy lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz. "Feeding" calls, unlike song and social sounds, are highly stereotyped series of narrow-band trumpeting calls. They are 20 Hz to 2 kHz, less than 1 second [sec] in duration, and have source levels of 162 to 192 dB re: 1 μPa-m. The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985; Thompson et al. 1986).

While no empirical data on hearing ability are available for this species, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Houser et al. (2001) produced the first humpback whale audiogram (using a mathematical model). The predicted audiogram indicates sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Au et al. (2006) noted that if the popular notion that animals generally hear the totality of the sounds they produce is applied to humpback whales, this suggests that its upper frequency limit of hearing is as high as 24 kHz.

- **Sei Whale (*Balaenoptera borealis*)**

Description—Adult sei whales are up to 18 m in length and are mostly dark gray in color with a lighter belly, often with mottling on the back (Jefferson et al. 1993). They have a slightly arched rostrum with a down-turned tip and there is a single prominent ridge on the rostrum (Jefferson et al. 1993). The dorsal fin is prominent and very falcate. Sei whales are extremely similar in appearance to

Bryde's whales (*Balaenoptera edeni/brydei*), and it is difficult to differentiate them at sea and, in some cases, on the beach (Mead 1977).

Status—Sei whales are listed as endangered under the ESA (NMFS 1998) and by the IUCN Red List.[1] There is no designated critical habitat for this species.

The IWC recognizes three sei whale stocks in the North Atlantic Ocean: Nova Scotia, Iceland-Denmark Strait, and Northeast Atlantic Ocean (Perry et al. 1999), though NMFS (1998) notes that these stock divisions are based on little evidence. According to a sightings survey conducted in 1989 the abundance of sei whales in Icelandic and adjacent waters was 10,300 animals (Cattanach et al. 1993). There are no more recent published estimates, even though surveys were conducted in 1995 and 2001 (Øien, N., Havforskningsinstituttet, pers. comm., 21 March 2007).

Habitat Preferences—Sei whales are most often found in deep, oceanic waters of the cool temperate zone. Sei whales appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges (Kenney and Winn 1987; Schilling et al. 1992; Gregr and Trites 2001; Best and Lockyer 2002). These areas are often the location of persistent hydrographic features, which may be important factors in concentrating prey, especially copepods. On the feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 1987). In the North Pacific Ocean, sei whales are found feeding particularly along the cold eastern currents (Perry et al. 1999). Characteristics of preferred breeding grounds are unknown. Horwood (1987) noted that sei whales prefer oceanic waters and are rarely found in marginal seas; historical whaling catches were usually from deepwater, and land station catches were usually taken from along or just off the edges of the continental shelf.

Distribution—Sei whales have a worldwide distribution but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 1987). Sei whales are also known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades (Horwood 1987; Schilling et al. 1992; Clapham et al. 1997).

Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999; Gregr et al. 2000). For the most part, the location of winter breeding areas remains a mystery (Rice 1998; Perry et al. 1999).

In the eastern North Atlantic Ocean, sei whales winter south of Spain; move to the Spanish, Portuguese, and western Ireland coasts in early spring to northwest of the Shetland Islands, off the Hebrides, and west Norway in April through May; and summer off northern Norway, west Norway, the Shetland Islands, the Hebrides, and the Faroe Islands (Jonsgård and Darling 1977; Perry et al. 1999). It is thought that the Faroe-Shetland Channel (off northwest Scotland) is an important summer feeding ground for this species (e.g., MacLeod et al. 2006). More recently, a sei whale satellite-tagged in mid-April just north of the Azores followed the mid-Atlantic ridge for about a month northwards to the Charlie-Gibbs Fracture Zone (cuts across the mid-Atlantic ridge at about 52°N or between the northern tip of Newfoundland and the southern tip of Ireland) and then turned westwards and quickly moved towards Labrador after mid-May, suggesting that perhaps sei whales could appear at northern latitudes also in early summer (Øien, N., Havforskningsinstituttet, pers. comm., 21 March 2007).

- Information Specific to the Eastern Mediterranean Study Area—Sei whales are considered to be extralimital in the Mediterranean Sea (Reeves and Notarbartolo di Sciara 2006). All confirmed records are from the western Mediterranean Sea; there have been no documented occurrences since 1987 there (Reeves and Notarbartolo di Sciara 2006). Sei whales have a rare occurrence throughout the eastern Mediterranean Sea (**Figure B-5**) since it is very unlikely that sei whales would move through the shallow Strait of Sicily (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006). No seasonal patterns in occurrence are anticipated.

Behavior and Life History—Sei whales are typically found in groups of one to five individuals (Leatherwood et al. 1976). Sei whales typically follow a reproductive cycle of two years: a gestation period of about 10 to 12 months and a lactation period of 6 to 9 months (Gambell 1985; Horwood 1987). Most births take place in November and December (Lockyer and Martin 1983). The sei whale is atypical as a rorqual in that it primarily "skims" its food (although it also does some "gulping" as other rorquals do) (Pivorunas 1979). In the North Atlantic Ocean, the major prey species are copepods and krill (Kenney et al. 1985; Horwood 1987; Sigurjónsson 1995). Jonsgård and Darling (1977) noted that *Calanus finmarchicus* seems to predominate in the diet of eastern North Atlantic individuals. There is no published info on dive depths and durations for this species. Gambell (1985) states that sei whales are able to dive up to 20 min, but no supporting documentation is provided, and the information should be considered suspect.

Acoustics and Hearing—Sei whale vocalizations have been recorded only on a few occasions. Recordings from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 sec, separated by 0.4 to 1.0 sec) of 10 to 20 short (4 milliseconds [msec]) FM sweeps between 1.5 and 3.5 kHz; source level was not known (Thompson et al. 1979; Knowlton et al. 1991; Thomson and Richardson 1995). These mid-frequency calls are distinctly different from low-frequency tonal and frequency swept calls recently recorded in the Antarctic; the average duration of the tonal calls was 0.45±0.3 sec, with an average frequency of 433±192 Hz and a maximum source level of 156±3.6 dB re: 1 μPa-m (McDonald et al. 2005).

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- **Fin Whale (*Balaenoptera physalus*)**

Description—The fin whale is the second-largest whale species, with adults reaching 24 m in length (Jefferson et al. 1993). Based on stranding data, Mediterranean females attain mean lengths of 14.66 m while males reach lengths of 13.39 m (Notarbartolo-di-Sciara et al. 2003). The mean lengths appear to be low because all age classes were included in these calculations. Mean length at birth for Mediterranean fin whales is 5.2 m (Notarbartolo-di-Sciara et al. 2003). Fin whales have a very sleek body with a pale, V-shaped chevron on the back just behind the head. The dorsal fin is prominent but with a shallow leading edge and is set back two-thirds of the body length from the head (Jefferson et al. 1993). The head color is asymmetrical, with a lower jaw that is white on the right and black or dark gray on the left. Fin and sei whales are very similar in appearance and size which has resulted in confusion about the distribution of both species (NMFS 2006b).

Status—Fin whales are classified as endangered under the ESA (NMFS 2006b) and the IUCN Red List.[1] No critical habitat is designated for this species.

Fin whales in the Mediterranean Sea are genetically distinct from those in the North Atlantic Ocean, with limited gene flow with North Atlantic population(s) (Bérubé et al. 1998; Notarbartolo-di-Sciara et al. 2003; Palsbøll et al. 2004). Those historically captured during whaling operations in the Strait of Gibraltar (and in the adjacent Atlantic Ocean) were considered by Notarbartolo-di-Sciara et al. (2003) to belong to a non-Mediterranean population.

The fin whale is the most common large whale in the Mediterranean Sea (e.g., Notarbartolo-di-Sciara et al. 2003). Based on line-transect surveys conducted during Summer 1991, there are 3,583 fin whales estimated to occur during the summer in the northwestern Mediterranean Sea (Forcada et al. 1996). Line-transect surveys conducted during Summer (August) 1992 estimated 901 animals in the Corso-Ligurian-Provençal Basin (Forcada et al. 1995; Gannier 1997). Decreases in fin whale abundance in the Ligurian Sea have been noted (e.g., Panigada et al. 2005; Laran and Drouot-Dulau 2007). The causes for this decline are unknown, but may be related to a geographical shift in the whales' distribution, perhaps induced by shifting oceanographic conditions, altered prey distributions, or even a combination of human-induced threats (Panigada et al. 2005).

Habitat Preferences—Globally, the fin whale can be found in continental shelf, slope, and oceanic waters. In the Mediterranean Sea, the fin whale is primarily oceanic (Politi et al. 1992; Zanardelli et al. 1992; Notarbartolo di Sciara et al. 1993; Forcada et al. 1995; Forcada et al. 1996; Notarbartolo-di-Sciara et al. 2003; Panigada et al. 2005; Panigada et al. 2006a). Panigada et al. (2005) reported that bottom depth was the most significant variable in describing fin whale distribution in the Ligurian Sea, with more than 90% of sightings occurring in waters deeper than 2,000 m. Mean bottom depth was 2,317 m, with a mean distance from shore of 45.6 km (Panigada et al. 2005). Similar findings were reported by Gannier (2002b); Gannier, et.al (2002b); and D'Amico et al. (2003). Locations from the tagging of 11 individuals in the northwestern Mediterranean Sea were concentrated in waters with a bottom depth greater than 1,000 m (Mate and Guinet In prep).

The use of more shallow waters by fin whales has also been also documented. For example, sightings are reported for the shallow waters of the Strait of Sicily shelf near Lampedusa (Canese et al. 2006), the Ligurian Sea (Airoldi et al. 1999), and the Gulf of Lion (Beaubrun et al. 1999). Individuals in the Mediterranean Sea have been observed less than 2 km from shore, even entering small bays and harbors (Beaubrun et al. 1999). Additionally, off the northeastern U.S., fin whales are mostly observed in shallow waters (e.g., Hain et al. 1992; Woodley and Gaskin 1996).

This species tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Payne et al. 1986; Payne et al. 1990; Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003). In the western North Atlantic Ocean, Waring and Finn (1995) found a significant relationship in the distributions of fin whales and sand lance in the fall. In the lower Bay of Fundy, fin whales occur in shallow areas with high topographic variation that are likely well mixed or contain frontal boundaries between mixed and stratified waters and which tend to concentrate krill and herring (Woodley and Gaskin 1996). Fin whales have also been known to preferentially feed in areas within fine-scale eddies with highly concentrated prey; these eddies form around islands during tidal retreat (Johnston et al. 2005b). Clark and Gagnon (2004) determined that vocalizing fin whales show strong preferences for shelf breaks, seamounts, or other areas where food resources are known to occur, even during summer months. These same oceanographic characteristics influence fin whale distribution in the Mediterranean Sea. Zooplankton abundance and fin whale distribution are linked in the western Mediterranean Sea (e.g., Orsi Relini et al. 1999; Notarbartolo-di-Sciara et al. 2003; Littaye et al. 2004; Panigada et al. 2005; Panigada et al. 2006b). The feeding grounds in the western Mediterranean Sea in the Ligurian-Provençal Basin consist of a large dome of cold water that is characterized by upwelling currents and high productivity (and prey) (Pinca and Dallot 1995). Barale et al. (2002) found a correlation between high fin whale sighting frequencies during the summer in the Ligurian-Provençal Basin and the local lowest surface patterns of temperatures and highest chlorophyll-like pigments; Dubroca et al. (2004) reported a positive correlation between fin whale summer distribution and primary production in the same area. Individuals move from one patch of available zooplankton to another while feeding, adapting movements and group size directly to food availability (e.g., Mouillot and Viale 2001; Littaye et al. 2004). Modeling work is currently underway to predict fin whale spatiotemporal occurrence in the Ligurian Sea (e.g., Littaye et al. 2004; Laran and Gannier 2005b; Panigada et al. 2005; Monestiez et al. 2006; Panigada et al. 2006b). Fin whale distribution in the Mediterranean Sea has also been linked to frontal zones close to coastal areas (such as the Ligurian and Provenç provinces) or above the upwelling east of Bonifacio (southern tip of the island of Corsica) (Littaye et al. 2004).

Distribution—Fin whales are broadly distributed throughout the world's oceans, usually in temperate to polar latitudes and less commonly in the tropics (Reeves et al. 2002b). In general, fin whales are more common north of about 30ºN than they are in tropical zones (NMFS 2006b). Fin whales in the eastern North Atlantic Ocean occur mainly from Iceland and Norway south to the Iberian Peninsula (Jonsgård 1966; Reid et al. 2003); they are found throughout the Mediterranean Sea but are absent from the Black Sea (Notarbartolo-di-Sciara et al. 2003).

Generally, fin whales are believed to follow the typical baleen whale migratory pattern, with a population shift north into feeding grounds in the summer and south into breeding grounds in the

winter. The location and extent of the wintering grounds are poorly known, however (Aguilar 2002). Analysis of data from the Sound Surveillance System (SOSUS) hydrophone array revealed peak acoustic detections of fin whales occurring in winter throughout the deep water of the North Atlantic Ocean; however, acoustic activity is consistently high in the higher latitudes (i.e., off Norway) from September through April when animals are thought to be in lower latitudes (Clark 1995; Clark and Gagnon 2004).

Mediterranean fin whales do not follow the typical pattern of baleen whale migration. Sighting and acoustics data demonstrate that fin whales are found year-round in the Mediterranean Sea (e.g., Viale 1985; Clark et al. 2002; Notarbartolo-di-Sciara et al. 2003; Canese et al. 2006). It has been suggested that fin whales may have adapted to the Mediterranean environment – the guarantee of prey availability throughout the year and warm waters – by extending and overlapping both their calving and feeding seasons (Notarbartolo-di-Sciara et al. 1999; Notarbartolo-di-Sciara et al. 2003). For example, immature individuals (including calves) are seen in the Ligurian Sea even during the summer (e.g., Orsi Relini 2000; Notarbartolo-di-Sciara et al. 2003; Panigada et al. 2005). Additionally, fin whales are documented feeding during mid-winter off the island of Lampedusa (Canese et al. 2006).

The most important area to fin whales in the Mediterranean Sea, particularly during the summer, includes the Corso-Ligurian-Provençal Basin and Gulf of Lion (e.g., Gannier 1998a, 2002b; Notarbartolo-di-Sciara et al. 2003). Feeding grounds for the fin whale in the western Mediterranean Sea are included within the Pelagos Sanctuary for Mediterranean Marine Mammals. Areas of intermediate importance to the species (particularly during the summer) include the Western Basin (Spain, Morocco, and Algeria); the Tyrrhenian Basin (west coast of continental Italy except Liguria, northern and western Sicily, northern Tunisia, southern and eastern Sardinia, and eastern Corsica); the Adriatic Basin (eastern Italy, Slovenia, Croatia, Bosnia-Herzegovina, Montenegro, Albania), and the Ionian/Central Basin (eastern and southern Greece, Libya, Malta, eastern Tunisia, southern and eastern Sicily, south-eastern continental Italy) (Notarbartolo-di-Sciara et al. 2003; de Stephanis et al. 2004). Areas of lower importance to the fin whale include the Aegean Basin (eastern and northern continental Greece; western Turkey; and to the south a line from southeastern Greece to southwestern Turkey, connecting the islands of Crete, Karpathos and Rhodes), and the Levantine Basin (southern Turkey, Cyprus, Syria, Lebanon, Israel, Egypt, and the southern coast of Crete) (Notarbartolo-di-Sciara et al. 2003).

Limited movements between the Strait of Gibraltar and the Mediterranean Sea are known based on isotopic analyses of baleen, tagging data, genetic data, and visual observations (e.g., de Stephanis et al. 2004; Palsbøll et al. 2004; Guinet et al. 2005; Ruchonnet et al. 2006; Mate and Guinet In prep).

Movements within the Mediterranean Sea are not well understood, as noted by Notarbartolo-di-Sciara et al. (2003) in their review of fin whales in the Mediterranean Sea. A noticeable pattern of fin whale abundance occurs in the western Mediterranean Sea, with large numbers of fin whales occurring in the Ligurian Sea during the summer, with a decline during the fall. Marini et al. (1996b) noted peaks in sighting frequency during April through May and September through October farther south in the central Tyrrhenian Sea, suggesting possible movements to and from the feeding grounds in the Ligurian Sea through the Tyrrhenian Sea. Whales never completely leave the Corso-Ligurian-Provençal Basin, however, as evidenced by acoustic recordings during the winter (Clark et al. 2002). Instead of a 'true migration', Notarbartolo-di-Sciara et al. (1999; 2003) suggested that fin whales aggregate in certain hot spots with high productivity during the peak feeding season, then disperse over wider areas of the Mediterranean Sea, maintaining acoustic contact with one another. Winter distribution and movement patterns still need to be confirmed for the Mediterranean Sea (e.g., Notarbartolo-di-Sciara et al. 2003; Guinet et al. 2005; Laran and Drouot-Dulau 2007).

- Information Specific to the Eastern Mediterranean Study Area—

  - *Summer*—The entire eastern Mediterranean Study Area is an area of primary occurrence for this species (**Figure B-6**). This is based on the distribution of sighting records, acoustic detections, tagging results, and the habitat preferences of this species, primarily in the western Mediterranean Sea, but with some limited sighting and stranding information for the eastern Mediterranean Sea (e.g., Clark et al. 2002; Gannier et al. 2002b; Notarbartolo-di-Sciara et al. 2003; Notarbartolo di Sciara, G., pers. comm., 2-5 October 2006). Occurrence patterns, but not known areas of concentration, are anticipated to be similar year-round in this part of the Mediterranean Sea. The eastern Ionian Sea and the region off the east coast of Sicily are the only known areas of concentration of fin whales in the eastern Mediterranean Sea during this time of year, which reflect feeding areas (Catalano et al. 2004; Notarbartolo di Sciara, G., pers. comm., 2-5 October 2006).

    Notarbartolo-di-Sciara et al. (2003) noted areas of intermediate importance to the species here to include the Adriatic Basin and the Ionian/Central Basin. Areas of lower importance to the fin whale include the Aegean Basin and the Levantine Basin (Notarbartolo-di-Sciara et al. 2003).

  - *Winter*—The occurrence patterns are the same as summer, with the entire eastern Mediterranean Sea designated as an area of primary occurrence for the species (**Figure B-7**). The area around the island of Lampedusa in the Strait of Sicily is the only known area of concentration of fin whales in the eastern Mediterranean Sea during this time of year (Canese et al. 2006; Notarbartolo di Sciara, G., pers. comm., 2-5 October 2006). During late February and early March, fin whales concentrate around Lampedusa to feed on the euphausiid *Nyctiphanes couchi* that concentrates at the surface in very shallow waters for about a month during this time of year (Canese et al. 2006).

Behavior and Life History—Sightings of single fin whales are most frequent, although pairs and small groups are often seen during feeding bouts. Mean group sizes in the Mediterranean range between 1.3 and 1.7 whales, with as many as 30 individuals together (though these were likely feeding aggregations) (e.g., Forcada et al. 1996; Notarbartolo-di-Sciara et al. 2003; Panigada et al. 2005; Laran and Drouot-Dulau 2007). The possibility of cooperative feeding by Mediterranean fin whales was suggested by Canese et al. (2006). Marini et al. (1996a) described breaching behavior of Mediterranean fin whales.

Female fin whales in the North Atlantic Ocean mature between 8 and 11 yrs of age (Boyd et al. 1999). Peak calving in the Mediterranean Sea is between September and January (Viale 1985) after a gestation period of approximately 11 months. Weaning may occur at six months (Boyd et al. 1999). The calving interval for fin whales ranges between two and three years (Agler et al. 1993).

Fin whale feeding is accomplished by “gulping” (Orton and Brodie 1987; Lambertsen et al. 1995). The primary prey of fin whales in the Mediterranean Sea is *Meganyctiphanes norvegica* (Mediterranean krill) (Besson et al. 1982; Viale 1985; Mussi et al. 1999; Notarbartolo-di-Sciara et al. 2003) which they capture by diving to depths in excess of 470 m (Panigada et al. 1999). Canese et al. (2006) reported that in the coastal waters off the island of Lampedusa, fin whales feed on the euphausiid *Nyctiphanes couchi*. Fin whales have also been observed chasing fish in other parts of the Mediterranean Sea, such as the Alboran Sea and in the southern Tyrrhenian Sea (Cañadas et al. 1999; Mussi et al. 1999; respectively).

Fin whale dives are typically 5 to 15 min long and are separated by sequences of four to five blows at 10 to 20 sec intervals (CETAP 1982; Stone et al. 1992; Jahoda et al. 2003; Lafortuna et al. 2003). In the Ligurian Sea, fin whale dives exceeding 150 m (as deep as 470 m) have been reported; these coincide with the diel vertical migration of krill within the deep-scattering layer (Panigada et al. 1999; Panigada et al. 2003). Mean dive times of 3.79 min (standard deviation [S.D.] =± 2.2 min) and mean

surface times of 90 sec (S.D.=± 34.6 sec) were recorded by Jahoda et al. (2003) in the Ligurian Sea; these are both longer mean dive and surface times than in other regions, and as noted by Notarbartolo-di-Sciara et al. (2003), is probably due to different ecological conditions. Gannier (2005a) reported longer mean dive times during feeding of 8.6 min (S.D.=±3.8) with a maximum time of 19.5 min.

Off the U.S. Atlantic coast, Kopelman and Sadove (1995) found significant differences in blow intervals, dive times, and blows per hour between surface-feeding and non-surface-feeding fin whales. Similar findings were reported by Gannier (2005a) for the Mediterranean Sea. Off the Pacific coast of North America, Croll et al. (2001) determined that fin whales dived to a mean of 97.9 m (S.D.=±32.59 m) with a duration of 6.3 min (S.D.=±1.53 min) when foraging and to 59.3 m (S.D.=±29.67 m) with a duration of 4.2 min (S.D.=±1.67 min) when not foraging.

Acoustics and Hearing—Fin and blue whales produce calls with the lowest frequency and highest source levels of all cetaceans. Infrasonic, pattern sounds have been documented for fin whales (Watkins et al. 1987b; Clark and Fristrup 1997; McDonald and Fox 1999). Fin whales produce a variety of sounds with a frequency range up to 750 Hz. The long, patterned 15 to 30 Hz vocal sequence is most typically recorded; only males are known to produce these (Croll et al. 2002). The most typical fin whale sound is a 20 Hz infrasonic pulse (actually an FM sweep from about 23 to 18 Hz) with durations of about 1 sec and can reach source levels of 184 to 186 dB re: 1 μPa-m (maximum up to 200) (Watkins et al. 1987b; Thomson and Richardson 1995; Charif et al. 2002). Croll et al. (2002) recently suggested that these long, patterned vocalizations might function as male breeding displays, much like those that male humpback whales sing. The source depth, or depth of calling fin whales, has been reported to be about 50 m (Watkins et al. 1987b).

Fin whales in the Mediterranean Sea produce long, patterned sequences of infrasonic pulses of two types: (1) the typical fin whale '20 Hz' pulse (1 sec, 25 to 19 Hz), and (2) a narrow-band pulse type (1 sec, 22 to 19 Hz), referred to as a "backbeat" (Clark et al. 2002). Clark et al. (2002) noted that these basic acoustic features are different from those reported for fin whales elsewhere in the North Atlantic Ocean, suggesting population level differences.

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- **Sperm Whale (*Physeter macrocephalus*)**

Description—The sperm whale is the largest toothed whale species. Adult females can reach 12 m in length, while adult males measure as much as 18 m in length (Jefferson et al. 1993). The head is large (comprising about one-third of the body length) and squarish. The lower jaw is narrow and underslung. The blowhole is located at the front of the head and is offset to the left (Rice 1989). Sperm whales are brownish gray to black in color with white areas around the mouth and often on the belly. The flippers are relatively short, wide, and paddle-shaped. There is a low rounded dorsal hump and a series of bumps on the dorsal ridge of the tailstock (Rice 1989). The surface of the body behind the head tends to be wrinkled (Rice 1989).

Status—Sperm whales are classified as endangered under the ESA (NMFS 2006a). No critical habitat is designated for this species. The sperm whale is listed as vulnerable by the IUCN Red List[1]; the Mediterranean subpopulation was recently proposed to qualify as endangered (Reeves and Notarbartolo di Sciara 2006).

Mediterranean sperm whales can be differentiated from their North Atlantic counterparts genetically (Drouot et al. 2004c; Engelhaupt 2004) and acoustically (Drouot and Gannier 1999; Pavan et al. 2000; Drouot et al. 2004a). It has not yet been conclusively established whether Mediterranean sperm whales form a distinct population from the eastern North Atlantic Ocean (Drouot et al. 2004c). It is also unknown whether Atlantic male sperm whales enter the Mediterranean Sea to breed with females or whether 'resident' males and females co-exist in the Mediterranean Sea without

interbreeding with Atlantic animals (Drouot et al. 2004c). Acoustic data suggest a restricted exchange between groups of females and their offspring living in the Mediterranean Sea and adjacent Atlantic Ocean (Drouot et al. 2004a).

The sperm whale is the second most common large whale species observed in the Mediterranean Sea after the fin whale. Comprehensive assessment of sperm whale abundance in the Mediterranean Sea is precluded by the uneven distribution of effort throughout the area and the complete lack of effort in the southeastern region (Smith et al. 2005). The sperm whale is one of the priority species for broadscale abundance surveys being planned under the ACCOBAMS. Surveys are likely to take place in 2009 at the earliest (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006). While Gannier et al. (2002a) provided information on visual and acoustic encounter rates in a large portion of the Mediterranean Sea (Strait of Gibraltar to the island of Rhodes, Greece), no estimates of absolute abundance can be derived from their data, as noted by Reeves and Notarbartolo di Sciara (2006). The total number of sperm whales in the Mediterranean Sea is likely "in the hundreds" (Reeves and Notarbartolo di Sciara 2006). Reeves and Notarbartolo di Sciara (2006) noted that about 150 individual sperm whales (almost 100 along the Hellenic Trench and 21 in the Strait of Gibraltar) have been photo-identified during the last decade. Drouot-Dulau and Gannier (2007) photo-identified 44 individuals in the western Mediterranean Sea, including the Ligurian Sea, the Gulf of Lion, and waters off the Balearic Islands. Recent acoustic surveys conducted by the IFAW resulted in abundance estimates of 62 individuals for the Ionian Sea and 0 for the Strait of Sicily (Lewis et al. 2007).

Several authors have noted that the sperm whale in the northwestern Mediterranean Sea appears to be declining in abundance, when compared to historical records (e.g., Duguy et al. 1983; Di Natale and Mangano 1985; Viale 1985; Notarbartolo di Sciara et al. 2004; Reeves and Notarbartolo di Sciara 2006). Drouot (2003) commented on the absence of large (>14 m) bull sperm whales in the Mediterranean Sea, suggesting that this might be a result of heavy bycatch in driftnet fisheries that are now banned but continue to be used illegally (Cornax et al. 2006).

Habitat Preferences—Sperm whale distribution can be diverse but is generally associated with waters over the continental shelf edge, continental slope, and offshore waters (CETAP 1982; Hain et al. 1985; Christensen et al. 1992; Smith et al. 1996; Waring et al. 2001; Davis et al. 2002; Jochens et al. 2006). Sperm whales show a strong preference for deep waters (Rice 1989); however, on the southwestern and eastern Scotian Shelf and in the northern Gulf of California, adult males are reported to consistently inhabit shallow waters of 100 m or less (Whitehead et al. 1992; Scott and Sadove 1997; Croll et al. 1999; Garrigue and Greaves 2001; Waring et al. 2006). Worldwide, females rarely enter shallow waters over the continental shelf (Whitehead 2003).

Sperm whale densities have been correlated with high secondary productivity and steep underwater topography (Jaquet and Whitehead 1996). Sperm whales are frequently found in certain geographic areas which whalers learned to exploit (e.g., whaling "grounds" such as the Azores) (Townsend 1935). These main whaling grounds are usually correlated with areas of increased primary productivity caused by upwelling (Jaquet et al. 1996).

Mediterranean sperm whales appear to prefer continental slope waters (Reeves and Notarbartolo di Sciara 2006); however, waters deeper than 2,000 m are also frequented (Gannier et al. 2002a; D'Amico et al. 2003; Gannier and Praca 2007). Both visual and acoustic data show greater abundance in upper continental slope waters (e.g., Gordon et al. 2000; Drouot 2003). Cañadas et al. (2002) reported that sperm whales in the northwestern Mediterranean Sea preferred depths with a mean bottom depth of 933 m (range 400 to 1,400 m). Drouot (2003) reported sightings occurring at a mean bottom depth of 1,502 m and an apparent bimodal distribution in waters with a bottom depth of 500 to 1,300 m and 2,500 to 2,700 m. Gannier and Praca (2007) also commented on this apparent bimodal distribution, linking it to sperm whale feeding strategy. Sperm whales are also particularly abundant in waters over submarine canyons where vertical mixing of water masses creates zones of enhanced biological productivity (David 2000; Drouot 2003; David and Beaubrun 2004; Mussi et al. 2005), with acoustic data in particular demonstrating this preference (Drouot 2003). In fact, sperm

whale distribution in the northwestern Mediterranean Sea is mainly influenced by the numerous submarine canyon structures (Drouot 2003). Moulins and Würtz (2005) observed sperm whales foraging near a seamount off Monaco. D'Amico et al. (2003) reported that sperm whales were sighted most often in waters with a bottom depth between 2,000 and 3,000 m.

Gannier and Praca (2007) and Azzellino et al. (2005) reported that in offshore regions and away from any topographic features, hydrologic features such as SST and thermal fronts appear to aggregate sperm whales in the northwestern Mediterranean Sea. A preference has been noted for colder and more productive waters than the mean in the northwestern Mediterranean Sea (Gannier and Praca 2007). Survey and tagging data have demonstrated that Mediterranean sperm whales associate with areas of upwelling (D'Amico et al. 2003; Zimmer et al. 2003). The influence of frontal zones on sperm whales is recognized in other geographic locations as well. For example, sperm whales in the Gulf of Mexico aggregate along the continental slope in or near cyclonic (cold-core) eddies (Biggs et al. 2000; Davis et al. 2002; Jochens et al. 2006). These eddies are mesoscale features which produce upwelling of nutrients that enhance local plankton growth (Wormuth et al. 2000). Data suggest that sperm whales adjust their movements to stay in or near these cold-core rings (Davis et al. 2000; Davis et al. 2002), which demonstrate that sperm whales can shift their movements in response to prey density.

Off the eastern U.S., sperm whales are found in regions of pronounced horizontal temperature gradients, such as along the edges of the Gulf Stream and within warm-core rings (Waring et al. 1993; Jaquet et al. 1996; Griffin 1999). Fritts et al. (1983) reported sighting sperm whales associated with the Gulf Stream. It is likely that these features are regions of favorable oceanographic conditions to aggregate prey. Waring et al. (2003) conducted a deepwater survey south of Georges Bank in 2002 and examined fine-scale habitat use by sperm whales. Sperm whales were located in waters characterized by sea-surface temperatures of 23.2º to 24.9ºC and bottom depths of 325 to 2,300 m (Waring et al. 2003). Hamazaki's (2002) modeling work revealed an association between sperm whale distribution and frontal zones in the western North Atlantic Ocean.

Distribution—Sperm whales are found in polar to tropical waters in all oceans, from approximately 70ºN to 70ºS (Rice 1989). Females are normally restricted to areas with SSTs greater than 15ºC, whereas males, especially the largest males, can be found in waters bordering pack ice (Rice 1989). The thermal limits of female distribution roughly correspond to the 40º parallels (50º in the North Pacific Ocean) (Whitehead 2003). Stable isotope profiles examined from sperm whale teeth coincide with reported changes in schooling behavior and latitudinal movement to higher latitudes (Mendes et al. 2007). Males live separately from the social units of females and immatures; some males migrate latitudinally to join the social units living year-round in warmer waters. These males move between social groups, staying with them for only a few hours (Whitehead 2003).

Sperm whales are found year-round throughout the Mediterranean Sea. They are widely distributed from the Alboran Sea to the Levant Basin, not infrequent in parts of the Algerian-Ligurian Basin, Tyrrhenian and Ionian seas, off southern Crete, and possibly all along the Aegean Arc where the continental shelf drops steeply around the Aegean and Greek Ionian seas; predictably present in the North Aegean Sea during fall; rare in the Sicilian Channel; vagrant in the Adriatic Sea; and absent from the Black Sea (Gannier et al. 2002a; G. Notarbartolo di Sciara, ed. 2002; Drouot 2003; Frantzis et al. 2003). Higher relative abundances are found in the western basin (Gannier et al. 2002a). Based on acoustic and sighting data, areas of high sperm whale abundance are the Gulf of Lion, the southwestern basin (41-35ºN, 0-9ºE), and the Ionian Sea (Gannier et al. 2002a). Areas with few sightings were the Alboran and Tyrrhenian seas, with the Ligurian Sea being an intermediate area of abundance (Gannier et al. 2002a). Encounters with sperm whale cow-calf pairs in the Mediterranean Sea suggest that females remain in the Mediterranean Sea to breed (e.g., Di Natale and Mangano 1985; Frantzis et al. 2003; Drouot et al. 2004c; Laran and Gannier 2005a; Moulins and Würtz 2005; Mussi et al. 2005). Based on a very small sample size (isotopic analyses of two individuals [one of each sex]), Mendes et al. (2007), suggested that females might be resident to a particular area, whereas males might move between the western and eastern basins; however, more work is needed to confirm this possible movement pattern.

There is evidence of some spatial segregation (at least during the summer) (Gannier et al. 2002a; Drouot 2003; Drouot et al. 2004c). Subadult and adult males are mostly present in the northern regions of the Mediterranean Sea (north of the 41º parallel; Tyrrhenian Sea, Ionian Sea, and the southwestern basin) while groups of females and their young (referred to as social or breeding groups by various studies) are found farther south (Gannier et al. 2002a; Drouot et al. 2004c). Preliminary photo-identification analyses results from the western Mediterranean Sea reveal a north-south movement by some sexually mature males, including one individual undertaking such movements during two consecutive summer seasons, suggesting possible repeated use of the same breeding area (Drouot-Dulau and Gannier 2007); however, as noted by Drouot-Dulau and Gannier (2007), sperm whale social distribution and movement patterns in the Mediterranean Sea might be more complex than just a segregation of males in the north moving south to join females. Some adult males might occur with groups of females in the southern regions year-round, as evidenced off Crete, Greece (Frantzis et al. 2003). Drouot-Dulau and Gannier (2007) also noted that groups with calves are also not restricted to southern regions. Laran and Gannier (2005a) reported sighting social groups also during the winter (December) in the Pelagos Sanctuary, Mussi et al. (2005) reported August to October sightings off the island of Ischia, Italy in the Tyrrhenian Sea, and Moulins and Würtz (2005) described behaviors of a group with calves off Monaco during mid-December.

Feeding grounds in the Mediterranean Sea include the Gulf of Lion and the Ligurian Sea. Several studies confirm the presence of feeding sperm whales in these waters (e.g., Gordon et al. 2000; Gannier et al. 2002a; Laran and Gannier 2006). The Balearic Islands and the Greek seas were both suggested to be breeding grounds for sperm whales based on the consistent presence of calves within groups of females and visiting adult males (Frantzis et al. 2003; Drouot-Dulau and Gannier 2007). Other suggested breeding areas include the Tyrrhenian Sea (Notarbartolo di Sciara et al. 1993; Marini et al. 1996b; Drouot et al. 2004c).

Drouot (2003) noted that information is scarce concerning the migratory habits of sperm whales observed in the Mediterranean Sea. Bolognari (1951) assumed that sperm whales enter and leave the Mediterranean Sea through the Strait of Gibraltar, arriving from the Atlantic Ocean during the winter, and leaving the Mediterranean Sea the following fall or the following spring. These statements were based on opportunistic sightings of sperm whales collected from several Mediterranean places, and this issue remains unresolved.

- Information Specific to the Eastern Mediterranean Study Area—Primary occurrence for the sperm whale is in waters seaward of the shelf break. This takes into consideration the available occurrence records (either plotted in **Figure B-8** or discussed in the literature), as well as the known association of this species with deepwaters or regions of steeply sloping ocean bottom or localized regions of upwelling and fronts; these increase the availability of squid prey for this species within deeper waters. There is a secondary occurrence inshore of the shelf break that takes into account the distribution of records in waters over the continental shelf and the possibility of encountering this species here. No seasonal differences in occurrence patterns are expected.

  The Greek seas are suggested to be breeding grounds for sperm whales based on the consistent presence of calves within groups of females and cohabiting adult males (Frantzis et al. 2003). Known areas of concentration for sperm whales over the Hellenic Trench and an area of suspected concentration encompasses additional waters off the southeast corner of Crete eastward to Turkey, based on data collected by A. Frantzis (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 1 May 2007). An additional area of known concentration of sperm whales is east of Sicily, based on data collected by acoustic sensors at an experimental deep station that is part of the NEMO Project (e.g., Holden 2007; Pavan et al. 2007).

Behavior and Life History—For a review of sperm whale social organization, see Whitehead and Weilgart (2000) and Whitehead (2003). Female and immature sperm whales form highly-social groups, while large males typically occur singly or in pairs, at times joining adult female groups for breeding (e.g., Drouot 2003; Whitehead 2003; Coakes and Whitehead 2004). In the northern

Mediterranean Sea, sperm whales are generally observed in loose aggregations, rarely forming cohesive groups at the surface. While in the southern regions, they tend to form clusters of up to seven animals, generally including calves (Drouot et al. 2004c). Single individuals are often sighted in the northwestern Mediterranean Sea (e.g., Gannier et al. 2002a; D'Amico et al. 2003; Drouot et al. 2004c). Historically, groups with as many as 15 individuals were reported in the Mediterranean Sea (Bolognari 1951).

Sperm whale gestation lasts 14 to 15 months. Lactation is approximately two years, and the typical interbirth interval is 4 to 7 yrs (Best et al. 1984). Based on observations by amateurs in the Mediterranean Sea, Di Natale and Mangano (1985) reported observing mating behavior from winter through summer, with calving occurring during spring (March through June) and fall (September and November). Drouot (2003) instead reported that the presence of very small calves in early July suggests a shorter calving season of around May through June and a mating season in February through March. Based on stranding and fishery bycatch data, Moulins and Würtz (2005) reported that the highest concentration of very young sperm whales in the central and southern Tyrrhenian Sea is between February and October.

Sperm whales prey on mesopelagic squids and other cephalopods, as well as demersal fishes and benthic invertebrates (Rice 1989; Clarke 1996). The only published information for Mediterranean sperm whale prey comes from analyses of stomach contents of a dead individual first located floating a short distance off the southern coast of Crete (Roberts 2003). The stomach was filled almost exclusively with cephalopod parts, primarily of *Histioteuthis bonnellii* (umbrella squid) and *Octopoteuthis sicula* (Ruppell's octopus squid) to a much lesser degree (Roberts 2003).

Mediterranean sperm whales exhibit dive cycle parameters consistent with those measured in other parts of the world: approximately a 45 min dive duration, a 9 min surface period (i.e., inter-dive interval), with 5 blows per minute (blows/min), and 2.4 km horizontal displacement between dives (Drouot et al. 2004b). Tagged individuals in the Ligurian Sea were recorded to dive to depths of 700 to 1,000 m (in an area with a bottom depth of 2,600 m) (Zimmer et al. 2003). Palka and Johnson (2007) noted that dives as deep as 1,250 m are recorded for large whales in the Mediterranean Sea. Drouot et al. (2004b) interpreted from sperm whale sounds during dive cycles that foraging was likely taking place at 500 to 800 m below the surface; this is compatible with the tagging data reported by Zimmer et al. (2003) and acoustic data from the Strait of Gibraltar analyzed by Laplanche et al. (2004; 2005).

Sperm whales are capable of dives of over 2,000 m, with durations greater than 60 min (Watkins et al. 1993). Females spend prolonged periods of 1 to 5 hours (hrs) at the surface without foraging (Whitehead and Weilgart 1991; Amano and Yoshioka 2003). Males do not spend extended periods at the surface but spend up to 83% of daylight hours underwater (Jaquet et al. 2000; Amano and Yoshioka 2003). The average swimming speed is estimated to be 0.7 m/sec (Watkins et al. 2002). Dive descents for tagged individuals averaged 11 min at a rate of 1.52 m/sec (Watkins et al. 2002). Ascents averaged 11.8 min at a rate of 1.4 m/sec.

Acoustics and Hearing—Sperm whales typically produce short-duration (<30 msec), repetitive broadband clicks used for communication and echolocation. These clicks range in frequency from 0.1 to 30 kHz, with dominant frequencies between the 2 to 4 kHz and 10 to 16 kHz ranges (Thomson and Richardson 1995). Echolocating sperm whales emit usual click sequences interrupted by faster click trains (with an interclick interval less than 0.2 sec) and then silences. Sperm whales within social groups tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Male sperm whales may produce other rare sounds called slow clicks that are thought to serve a communicative function (Jaquet et al. 2001; Madsen et al. 2002).

Codas are shared between individuals of a social unit and are considered to be primarily for intragroup communication (Moore et al. 1993; Weilgart and Whitehead 1997; Pavan et al. 2000; Drouot et al. 2004a; Rendell and Whitehead 2004). Coda repertoires have also been found to vary

geographically and are categorized as dialects, similar to those of killer whales (Weilgart and Whitehead 1997; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997).

Recorded Mediterranean coda durations range from 200 to 2180 msec (Pavan et al. 1997; Pavan et al. 2000; Drouot et al. 2004a; Nuuttila and Rendell 2005). Pavan et al. (2000) reported that Mediterranean codas had an average duration of 908 msec and a standard deviation of 176 msec, while Nuuttila and Rendell (2005) found the mean to be 682 msec with a standard deviation of 200 msec. It was originally suggested that the coda repertoire of Mediterranean sperm whales was restricted to a 4 click construction of a "3+1" coda pattern (because the last click is emitted with a substantial interclick interval compared to the first three clicks) (e.g., Borsani et al. 1997; Pavan et al. 2000). At the island of Crete, Frantzis et al. (1999) were the first to record both the "3+1" and a "2+1" coda. A more comprehensive effort by Drouot et al. (2004a) to describe codas in the Mediterranean Sea demonstrated that the codas contained between 3 and 11 clicks, suggesting instead that there is no single, restricted coda pattern in the Mediterranean Sea in sharp contrast with other studies. This observation was also supported by Nuuttila and Rendell (2005) by recordings collected in the Balaeric Islands. Drouot et al. (2004a) noted that while the "Mediterranean" pattern ("3+1") was the most common recorded coda repertoire in the Mediterranean Sea, it was predominant in the Tyrrhenian Sea and southwestern basin but poorly represented in recordings from the Ionian Sea, suggesting some regional variation in coda repertoire between different basins of the Mediterranean Sea. Drouot et al. 2004 (2004a) reported that groups recorded in the Ionian Sea and southwestern basin display the greatest variability in their coda repertoire, with 24 categories of coda patterns identified; however, Nuuttila and Rendell (2005) also recorded 25 coda categories at the Balearic Islands.

The clicks of neonatal sperm whales are very different from those of adults. Neonatal clicks are of low-directionality, long-duration (2 to 12 msec), low-frequency (dominant frequencies around 0.5 kHz) with estimated source levels between 140 and 162 dB re: 1 μPa-m rms. They are hypothesized to function in communication with adults (Madsen et al. 2003). Source levels from adult sperm whales' highly directional (possible echolocation), short (100 microseconds [μsec]) clicks have been estimated up to 236 dB re: 1 μPa-m rms (Møhl et al. 2003). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are engaged in foraging behavior in the deepest portion of their dives with intervals between clicks and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005). It has been shown that sperm whales may produce clicks during 81% of their dive period, specifically 64% of the time during their descent phases (Watwood et al. 2006).

In addition to producing clicks, sperm whales in some regions like the Mediterranean Sea and off Sri Lanka have been recorded making what are called trumpets at the beginning of dives just before commencing click production (Drouot 2003; Teloni 2005). The estimated source level of one of these low intensity tonal signals (trumpets) was estimated to be 172 dB re: 1 μPa-m rms (Teloni et al. 2005). Sounds described as 'squeals' have been reported from nursery groups of sperm whales in both the Tyrrhenian and Ionian seas (Drouot 2003), mixed age/sex groups off Greece (Weir et al. 2007), and immature male sperm whales off Scotland (Goold 1999). Squeals are recorded only during social behavior, suggesting a communicative social function (Weir et al. 2007). Although squeals are perceived as tonal and appear spectrally as narrowband frequency-modulated structures with harmonics, they actually consist of pulses at high repetition rates exceeding 1600 clicks per second (clicks/sec), with entry at between 400 Hz and 22 kHz and peak energy at the relatively low frequency of 700 Hz (Weir et al. 2007).

The anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic frequency sounds. They may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992a). The auditory brainstem response (ABR) technique used on a stranded neonatal sperm whale indicated it could hear sounds from 2.5 to 60 kHz with best sensitivity to frequencies between 5 and 20 kHz (Ridgway and Carder 2001).

- **Mediterranean Monk Seal (*Monachus monachus*)**

Description—The Mediterranean monk seal is robust with a long, fusiform body and short flippers (Jefferson et al. 1993). Unlike other North Atlantic phocids, Mediterranean monk seals' nostrils are situated on top of their wide muzzles (Jefferson et al. 1993). Adults reach a maximum of 2.8 m in length and weigh 250 to 400 kilograms (kg) (Jefferson et al. 1993). Adult males may be slightly longer than females (Samaranch and González 2000). Coloration varies from dark brown to black or silvery-white, with countershading that is either a gradual blending or a sharp demarcation (Jefferson et al. 1993). Newborns have a dark pelage with a white-yellowish patch located on the ventral side of the body; the shape of the ventral patch is indicative of the animal's sex (Badosa et al. 1998). This sexual dimorphism in pup pelage morphology is lost with the postnatal molt, which generally occurs at 6 to 7 weeks of age (Samaranch and González 2000). Some Mediterranean monk seals with a reddish pelage have been observed; this coloring is likely due to iron oxide precipitates that collect on the hair shaft when seals swim near an iron ore source (Samaranch and González 2000).

Status—The Mediterranean monk seal is listed as endangered under the ESA and, therefore, is also designated as depleted under the MMPA. This species is listed as critically endangered on the IUCN Red List.[1] The total number of Mediterranean monk seals is estimated at 350 to 450 individuals (Gilmartin and Forcada 2002). The largest population of Mediterranean monk seals is found throughout the coasts of Greece and Turkey where there are an estimated 150 to 250 individuals (Güçlüsoy et al. 2004). The second largest population is found outside of the Mediterranean Sea on Cabo Blanco Peninsula in the western Sahara. After a mass mortality event in 1997, this colony was estimated at 109 individuals which is about one-third of its original size (Forcada et al. 1999). It is currently estimated at around 130 seals (UNEP 2005). There is also a small population of around 20 individuals in the Desertas Islands off the southeastern coast of the Madeira Islands in the eastern North Atlantic Ocean (Pires and Neves 2001).

Mediterranean monk seal populations are decreasing rapidly (Ronald and Healey 1982). The main cause of this decline is killings by fishermen. Monk seals interact with various fisheries in the Mediterranean Sea; monk seal mortality is often attributed to deliberate killings by fishermen because of perceived competition or damage to gear and accidental killings by entanglement in fishing gear (Androukaki et al. 1999; Costa Neves 1999; Reeves et al. 2001b; Güçlüsoy et al. 2004). Additional threats to Mediterranean monk seal survival include human disturbance, loss of habitat, pollution, lack of food due to overfishing, infectious diseases, and other catastrophes (Reijnders et al. 1993).

Habitat Preferences—Mediterranean monk seals are found on archipelagoes and cliff-bound mainland coastlines, particularly in areas that are inaccessible to humans (Sergeant et al. 1978). Breeding, whelping, and resting habitat primarily consists of seacaves or grottoes, some of them with underwater entrances (Bareham and A. Furreddu 1975). Caves offer protection from predators and human disturbance (Gazo et al. 2000). Breeding caves, in particular, are often characterized by an entrance with a protective barrier against strong waves, a chamber with a wide beach that is above sea level during high tide, and a shallow protected pool which provides a safe area for pups to learn to swim and keep cool during warm weather conditions (Gucu et al. 2004; Karamanlidis et al. 2004). Unlike Hawaiian monk seals, Mediterranean monk seals rarely haul out on open beaches (Gilmartin and Forcada 2002). Foraging habitat is generally in coastal waters (Johnson et al. 2006).

Two protected areas have been specifically developed for the protection of Mediterranean monk seals: the Desertas Islands Natural Reserve in the eastern North Atlantic Ocean and the National Marine Park of Alonnissos Northern Sporades in Greece.[2,3] In addition, a network of protected areas for the Mediterranean monk seal has been suggested for the Greek islands of Kimolos, Karpathos, and Fournoi based on the presence of monk seals and important monk seal habitats, particularly breeding caves (Adamantopoulou et al. 2000).

Distribution—Historically, the Mediterranean monk seal was distributed throughout the Mediterranean Basin, the western Black Sea, and the southeastern North Atlantic Ocean from the Azores Islands to the equator (Gilmartin and Forcada 2002). The Mediterranean monk seal's current

distribution is fragmented and ranges from the Atlantic coast of northwestern Africa and along the southern and eastern coasts in the Mediterranean Sea (Rigas and Ronald 1985). Mediterranean monk seals have practically disappeared from the Black Sea; only solitary individuals are sporadically sighted there (Birkun 2002; Güçlüsoy et al. 2004). Monk seals used to be regular inhabitants of the Adriatic Sea; however, they virtually disappeared from the area before many research studies were conducted (Gomercic et al. 2005). In the past few years, several monk seal sightings have been recorded in the northeastern Adriatic Sea along the coast of Croatia (Gomercic et al. 2005). All of these sightings were of a single individual; researchers believe that the sightings are of the same seal which may be a vagrant from the nearest population in the central Ionian Sea (Gomercic et al. 2005). Fishermen have also reported sightings along the coast of Albania in 1996, 2000, and 2004; monk seals originating from Greece likely use the southern Albanian coast as a secondary temporary habitat (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006).

The largest monk seal population in the Mediterranean Sea is located along the coasts of most of the Greek archipelagos in the Aegean and Ionian seas and the Sea of Crete as well as along the Aegean Turkish coasts and southwards to the Cilician region, the Gulf of Iskenderun, and Cyprus. Distribution throughout the rest of the Mediterranean Sea has not yet been completely assessed; smaller populations are believed to be present along stretches of the Moroccan Mediterranean coast (regions of Al Hoceima, Cap Trois Fourches, and Cap de l'Eau) and along Algeria and northern Tunisia (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006). Historical monk seal habitat sites have been identified in the La Galite Archipelago off the coast of northern Tunisia. It is speculated that monk seals may still inhabit this area and use the La Galite caves for hauling out (Ouerghi et al. 2001). There is also evidence of recent monk seal occurrence in Libya, particularly along the Cyrenaican coast in eastern Libya. Occurrence here is also based on sighting reports from fishermen and the identification of suitable habitats for the species (Hamza et al. 2003; Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006). In many cases, occurrence is only assumed based on sporadic sightings of individuals, observation records from fishermen, and the existence of potential suitable habitats. Countries that are adjacent to the above-mentioned locations may be exposed to sporadic sightings of individuals that venture into areas proximate to their birthing site. For instance, suitable caves have been identified along the coast of northern Syria, and monk seal sightings have been reported by fishermen (Mo et al. 2003). It is likely that these individuals originate from the nearby colony along the northern coasts of the Gulf of Iskenderun (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006).

Mediterranean monk seals have been considered extinct in Italy since the mid 1980s. Most sightings since then are thought to be vagrant individuals from nearby countries (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006). Sporadic sightings of monk seals have recently been recorded along the southern coast of Italy and in southern Sardinia (Mo 2002; Coppola 2005; Mo et al. in press) as well as off Pantelleria Island (Sicily) (Mo 2007). Most sightings have been of single seals although one pair of seals was sighted in September 2000 in southeastern Sardinia (Mo 2002). On 26 August 2005, two monk seals were observed 300 m off the coast of Capo Monte Santo in the Gulf of Orosei, Sardinia (Coppola 2005). Sightings in Sardinia may be of vagrants undertaking seasonal movements between that region and the coasts of Tunisia and Algeria (Mo 2000), while sightings in southern Italy may be of individuals originating from the nearby Greek Ionian coasts (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006).

It is unknown whether Mediterranean monk seals migrate; possible migration pathways are currently being researched between the Cilician coast and the Gulf of Iskenderun in the eastern Mediterranean Sea (Gucu et al. 2003). Long distance movements of Mediterranean monk seals have been recorded. Monk seals off the coast of Greece have covered 52 km in two days and 294 km within three months (Adamantopoulou 2000).

- Information Specific to the Eastern Mediterranean Study Area—Sea caves and other important Mediterranean monk seal habitats are found throughout the areas of occurrence for this species.

  Primary occurrence patterns are based on known current distribution and habitat preferences (i.e., suitable coastal caves and remote rocky coasts) for this species and extend throughout the Aegean Sea, along the southern coast of Turkey, the northern coast of Cyprus, and the eastern coast of Libya (**Figure B-9**). Areas of primary occurrence include the following known areas of concentration in the Aegean and Ionian seas: the National Marine Park of Alonnissos, Milos/Kymolos, Patmos/Arki/Lipsi, Karparthos, and Lefkada/Kefallonia.

  Secondary areas of occurrence are mostly based on the historical distribution and suitable habitat areas (i.e., rocky coasts, isolated stretches) where the species may occur because of its dispersal capacity from the primary occurrence areas (**Figure B-9**) (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006). These areas follow the coastline throughout most of the eastern Mediterranean Sea. Exceptions include the northwestern Adriatic Sea and the coasts of Lebanon, Israel, and Egypt which are all considered areas of rare occurrence. The Apulian coast region in southeast Italy is included as a secondary occurrence area based on monk seal sightings; the rocky, relatively pristine coasts; and the close proximity to the Greek population (Mo, G., The Institute Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare, pers. comm., 2 November 2006). The region between the Egadi and Pantelleria islands off Sicily is also considered an area of secondary occurrence due to the recent sightings of monk seals in this area and the close proximity to Tunisia. There is also an area of secondary occurrence that buffers the primary occurrence areas around the Aegean Sea region and the area between Turkey and Cyprus to account for possible movement of individuals between these two countries. Monk seals have a rare occurrence throughout the rest of the eastern Mediterranean Sea. No seasonal differences in occurrence are anticipated for this species.

Behavior and Life History—Mediterranean monk seals are often solitary when at sea (Panou et al. 1993). On land they often haul out singly or in small groups although large aggregations were historically reported and still occur in the Cabo Blanco colony where up to 100 individuals may be observed hauled out in selected breeding caves situated along the western Sahara (Samaranch and González 2000).

In the Mediterranean Sea, births have been documented between May and November with a peak in September (Sergeant et al. 1978). Mediterranean monk seals in the eastern Mediterranean Sea, particularly near the Cilician Basin, tend to give birth between August and November (Gucu et al. 2004). Females in the Cabo Blanco colony along the coast of the western Sahara in the Atlantic Ocean give birth year-round with a peak in October (Gazo et al. 1999; Pastor and Aguilar 2003). Female Mediterranean monk seals may give birth in successive years (Panou et al. 1993). There is substantial site fidelity of breeding females; most pups in the Cabo Blanco colony are born in just two caves (Gazo et al. 1999). Mediterranean monk seals reach sexual maturity at fours years of age (Antolovic 1998), although some females may be reproductively active at three years of age (Gilmartin and Forcada 2002). Pups are weaned at around 4 to 5 months which is an unusually long lactation period for a phocid (Gilmartin and Forcada 2002; Pastor and Aguilar 2003; Aguilar et al. 2007). Unlike most phocids, female Mediterranean monk seals leave pups unattended and feed during the nursing period (Pastor and Aguilar 2003; Gazo and Aguilar 2005); feeding bouts begin after the first week of birth (Aguilar et al. 2007). Foraging bouts up to around 17 hrs have been recorded for some nursing females (Gazo and Aguilar 2005).

Mediterranean monk seals feed opportunistically on a wide variety of organisms including striped red mullet (*Mullus surmuletus*), common dentex (*Dentex dentex*), bogues (*Boops boops*), flathead mullet (*Mugil cephalus*), mackerels (*Trachurus* spp.), various species of sparids such as seabreams, and rays, eels, crabs (*Pachygrapsus* spp.), limpets (*Patella* spp.), and cephalopods such as octopus (Kenyon 1981; Costa Neves 1999). They mainly prey on fish and cephalopods; however, they have been known to attack and feed on loggerhead turtles in Greece (Margaritoulis et al. 1996). Salman et

al. (2001) and Lagonika (2006) recently identified the musky octopus (*Eledone moschata*), globose octopus (*Bathypolypus sponsalis*), and common octopus (*Octopus vulgaris*) in the stomach contents of stranded monk seals in the Aegean Sea.

Mediterranean monk seals typically feed in waters less than 30 m in depth; maximum diving depths are unknown (Kenyon 1981). Gazo and Aguilar (2005) recorded a maximum dive depth of 78 m for a lactating female; mean dive depth was about 30 m. Mean dive durations of the female were around 5 min with a maximum duration of 15 min (Gazo and Aguilar 2005). Preliminary analysis of tagging data from a rehabilitated monk seal (approximately six months old) indicated a maximum diving depth of 180 m off the coast of Greece (Anonymous 2004); however, further analysis of this data resulted in a maximum depth of 123 m; this is the greatest depth ever recorded for this species (Dendrinos et al. 2007; Dendrinos, P., MOm/Hellenic Society for the Study and Protection of the Monk Seal, pers. comm., 20 April 2007). Kiraç et al. (2002) recorded mean dive durations of 6.4 min for adults and 6.8 min for juveniles. Pups begin foraging at the end of the nursing period. They are known to make relatively deep dives averaging around 12 m in depth (Gazo et al. 2006).

Two diving patterns have been observed in relation to feeding behavior: spot feeding and transit feeding (Costa Neves 1999). During spot feeding, seals dive continuously in the same location (generally in waters less than 6 m) for several hours; they spend about 12 min underwater and 1 min on the surface between dives. In transit feeding, monk seals move considerable distances along the shoreline and make continuous dives lasting up to 7 min each.

Acoustics and Hearing—There is no information available regarding Mediterranean monk seal vocalizations. The only available information from the Hawaiian monk seal is on the sounds they produce in the air. In-air sounds include: (1) a soft liquid bubble at 100 to 400 Hz; (2) a loud, brief guttural expiration below 800 Hz produced during short-distance agonistic encounters; (3) a roar, also to 800 Hz, for long-distance threats; and (4) a belch cough made by males when patrolling (Miller and Job 1992). Pups emit a <1.4 kHz call; Job et al. (1995) reported that there is apparent lack of vocal recognition of pups by adult females

There are no direct hearing data available for the Mediterranean monk seal (Southall, B., National Marine Fisheries Service – Protected Resources, pers. comm., 24 August 2006). An underwater audiogram obtained for the Hawaiian monk seal showed relatively poor hearing sensitivity, as well as a narrow range of best sensitivity and a relatively low upper frequency limit (Thomas et al. 1990). The data demonstrated best underwater hearing at 12 to 28 kHz and 60 to 70 kHz (Thomas et al. 1990). It should be noted that this audiogram is based on a single animal whose hearing curve had some characteristics suggesting its responses may have been affected by disease or age (Reeves et al. 2001b). This is the one audiogram that is radically different than that obtained for other phocid species (Southall, B., National Marine Fisheries Service – Protected Resources, pers. comm., 24 August 2006). Additionally, because this individual had very little training and the results were obtained over a short interval, the data from the audiogram may be misleading (Southall, B., National Marine Fisheries Service – Protected Resources, pers. comm., 24 August 2006).

It is likely more reasonable to consider the suite of underwater data from other phocids, specifically the closely related northern elephant seal (Southall, B., National Marine Fisheries Service – Protected Resources, pers. comm., 24 August 2006). The audiogram of the northern elephant seal indicates that this species is well-adapted for underwater hearing; sensitivity is best between 3.2 and 45 kHz, with greatest sensitivity at 6.4 kHz and an upper frequency cutoff of approximately 55 kHz (Kastak and Schusterman 1999). Elephant seals exhibit the greatest sensitivity to low frequency (<1 kHz) sound among seals in which hearing has been tested (Kastak and Schusterman 1998). In-air hearing is generally poor, but is best for frequencies between 3.2 and 15 kHz, with greatest sensitivity at 6.3 kHz (Kastak and Schusterman 1999). The upper frequency limit in air is approximately 20 kHz (Kastak and Schusterman 1999). Elephant seals are relatively good at detecting tonal signals over masking noise (Southall et al. 2000).

3.1.2.2 Non-Threatened and Non-Endangered Marine Mammal Species of the Eastern Mediterranean Sea Operating Area (OPAREA)

- **Common Minke Whale (*Balaenoptera acutorostrata*)**

Description—Common minke whales (hereafter referred to as minke whales) are small rorquals; adults reach lengths of just over 9 m (Jefferson et al. 1993). The head is pointed, and the median head ridge is prominent. The dorsal fin is tall (for a baleen whale), falcate, and located about two-thirds of the way back from the snout tip (Jefferson et al. 1993). The minke whale is dark gray dorsally, white beneath, with streaks of intermediate shades on the sides (Stewart and Leatherwood 1985). The most distinctive light marking is a brilliant white band across each flipper of Northern Hemisphere minke whales (Stewart and Leatherwood 1985).

Status—The minke whale is listed as lower risk (near threatened) on the IUCN Red List.[1] There are four recognized populations in the North Atlantic Ocean: Canadian East Coast, West Greenland, central North Atlantic Ocean, and northeastern North Atlantic Ocean (Donovan 1991). DNA studies of minke whales from Iceland and northern Norway suggested mixing of the three breeding eastern North Atlantic stocks (Bakke et al. 1996).

Stock identity of individuals found in the southeastern North Atlantic Ocean and Mediterranean Sea is not known, but these individuals are likely from the northeastern North Atlantic and/or central North Atlantic populations, although Van Waerebeek et al. (1999) also noted that an unrecognized local population in the Mediterranean Sea cannot be discounted.

The most recent large scale survey from which abundance estimates are available is the North Atlantic Sightings Survey (NASS) conducted cooperatively by Norway, Iceland, and the Faroe Islands and covering much of the North Atlantic Ocean north of 50° and west to Greenland. Skaug et al. (2003) reported that 107,205 minke whales are estimated for the central and northeastern North Atlantic Ocean from 1996-2001 surveys. This is likely negatively biased because the ship survey estimate is not corrected for whales missed by observers or diving whales.

Habitat Preferences—In general, throughout its distribution the minke whale occupies waters over the continental shelf, including inshore bays and some estuaries (Mitchell and Kozicki 1975; Ivashin and Votrogov 1981; Murphy 1995; Mignucci-Giannoni 1998; Weir et al. 2001; Calambokidis et al. 2004). Occurrences in deeper water are also well-known based on whaling catches, global surveys, and acoustics (Slijper et al. 1964; Horwood 1990; Øien et al. 1990; Mitchell 1991; Clark and Gagnon 2004).

Shifts in prey distribution and abundance affect minke whale distribution and abundance (K. MacLeod et al. 2004). Tetley (2004) found that minke whales off Scotland were most frequently encountered in areas of shallow depth, steep slope, northerly facing aspect, and sandy gravel sediment type. The sediment type parameter had the strongest association with minke whale distribution and was linked to the distribution of sandeels, an important prey item for this whale. Naud et al. (2003) found that minke whales are more frequent in the presence of underwater sand dunes in the Mingan Islands of the Gulf of St. Lawrence; this was also linked to habitat of the preferred prey. Minke whales have also been known to preferentially feed in highly concentrated prey areas within fine-scale eddies; these eddies form around islands during tidal retreat (Johnston et al. 2005b). Ingram et al. (2007) reported minke whales feeding in areas with headland wakes in the Bay of Fundy (functioning similarly to create areas of upwelling and fronts that can aggregate prey).

Distribution—Minke whales are distributed in polar, temperate, and tropical waters of the world (Jefferson et al. 1993); they are less common in the tropics than in cooler waters.

There appears to be a strong seasonal component to minke whale distribution (Horwood 1990). In the eastern North Atlantic Ocean, the minke whale is found as far north as Denmark Strait and Svalbard in the Barents Sea during the summer. The limited number of observations during winter in the

eastern North Atlantic Ocean makes it difficult to determine wintering grounds, but they are considered to extend at least as far south as the Strait of Gibraltar (Van Waerebeek et al. 1999; Perrin and Brownell 2002). It has also been suggested that some individuals may stay in northern waters throughout the winter. Groups of minke whales have fidelity to certain summer feeding areas at least for several years (Born et al. 2003).

Data from studies of minke whales in the Northern Hemisphere suggest that sex and age segregation occurs during the summer, with males migrating farther north in open seas while females remain in more southern and coastal waters and immature whales remaining slightly farther south.

- Information Specific to the Eastern Mediterranean Study Area—Reeves and Notarbartolo di Sciara (2006) reviewed and discussed occurrence records for this species in the Mediterranean Sea. The entire eastern Mediterranean Sea is an area of secondary occurrence year-round based on both habitat preferences and occurrence records for this species (**Figure B-10)** (Van Waerebeek et al. 1999; Reeves and Notarbartolo di Sciara 2006). Minke whales are found in waters over the continental shelf, as well as deeper waters.

Behavior and Life History—Minke whales are sighted alone or in small groups of 2 to 3 individuals, although aggregations of up to 400 sometimes occur in high-latitude areas (Perrin and Brownell 2002). Mating is thought to occur in October to March but has never been observed (Stewart and Leatherwood 1985). Minke whales reach sexual maturity at an age of 5 to 7 yrs (Stewart and Leatherwood 1985; Olsen and Sunde 2002). Gestation lasts 10 months and is followed by a 4- to 5-month lactation period (Stewart and Leatherwood 1985).

Minke whales are lunge-feeding “gulpers” like most other rorquals (Pivorunas 1979). In the eastern North Atlantic Ocean, the minke whale feeds on herring, cod, capelin, haddock, saithe (*Pollachius virens*), sandeels, euphausiids, and pteropods (Haug et al. 1995; Nordøy et al. 1995; Lindstrøm and Haug 2001; Olsen and Holst 2001). Minke whales tend to feed on whatever food source is most abundant in a given area.

Diel and seasonal variation in surfacing rates are documented for this species; this is probably due to changes in feeding patterns (Stockin et al. 2001). Dive durations of 7 to 380 sec are recorded in the eastern North Pacific and the eastern North Atlantic oceans (Lydersen and Øritsland 1990; Stern 1992; Stockin et al. 2001; Øien et al. 2003). Mean time at the surface averages 3.4 sec (S.D.=±0.3 sec) (Lydersen and Øritsland 1990).

Acoustics and Hearing—Recordings of minke whale sounds indicate the production of both high- and low-frequency sounds (range: 0.06 to 20 kHz) (Beamish and Mitchell 1973; Winn and Perkins 1976; Thomson and Richardson 1995; Mellinger et al. 2000). Minke whale sounds have a dominant frequency range of 0.06 to greater than 12 kHz, depending on sound type (Thomson and Richardson 1995; Edds-Walton 2000). Mellinger et al. (2000) described two basic forms of pulse trains: a “speed-up” pulse train (dominant frequency range: 0.2 to 0.4 kHz) with individual pulses lasting 40 to 60 msec, and a less common “slow-down” pulse train (dominant frequency range: 50 to 0.35 kHz) lasting for 70 to 140 msec. Source levels for this species have been estimated to range from 151 to 175 dB re: 1 μPa-m (Ketten 1998). Gedamke et al. (2001) recorded a complex and stereotyped sound sequence (“star-wars vocalization”) in the Southern Hemisphere that spanned a frequency range of 50 Hz to 9.4 kHz. Broadband source levels between 150 and 165 dB re: 1 μPa-m were calculated for this star-wars vocalization. “Boings” recorded in the North Pacific Ocean have many striking similarities to the star-wars vocalization in both structure and acoustic behavior. “Boings” are produced by minke whales and are suggested to be a breeding display, consisting of a brief pulse at 1.3 kHz followed by an amplitude-modulated call with greatest energy at 1.4 kHz, with slight frequency modulation over a duration of 2.5 sec (Rankin and Barlow 2005).

While no empirical data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes are most adapted to hear low to infrasonic frequencies.

- **Dwarf Sperm Whale (*Kogia sima*)**

Description—There are two species of *Kogia*: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale. Only the dwarf sperm whale is expected to occur in the Mediterranean Sea. Recent genetic evidence suggests that there might be two separate species of dwarf sperm whales globally; however, more data are needed to make such a determination (Chivers et al. 2005).

The dwarf sperm whale is similar in appearance to the pygmy sperm whale, but it has a larger dorsal fin, generally set nearer the middle of the back (Jefferson et al. 1993). The dwarf sperm whale also has a shark-like profile but with a more pointed snout than the pygmy sperm whale. Dwarf sperm whales reach body lengths of around 2.5 m, which is slightly smaller than pygmy sperm whales which reach 3 m (Plön and Bernard 1999).

Dwarf and pygmy sperm whales are difficult for the inexperienced observer to distinguish from one another at sea, and sightings of either species are often categorized as *Kogia* spp. The difficulty in identifying pygmy and dwarf sperm whales is exacerbated by their avoidance reaction towards ships and change in behavior towards approaching survey aircraft (Würsig et al. 1998). Based on the cryptic behavior of these species and their small group sizes (much like that of beaked whales), as well as similarity in appearance, many mis-identifications have been made.

Status—The dwarf sperm whale is listed as lower risk (least concern) on the IUCN Red List.[1] There are no abundance estimates for dwarf sperm whales or *Kogia* spp. in the eastern North Atlantic Ocean.

Habitat Preferences—*Kogia* occur in waters along the continental shelf break and over the continental slope (e.g., Baumgartner et al. 2001; McAlpine 2002). Data from the Gulf of Mexico suggest that *Kogia* may associate with frontal regions along the continental shelf break and upper continental slope, where higher epipelagic zooplankton biomass may enhance the densities of squids, their primary prey (Baumgartner et al. 2001). Dwarf sperm whales in The Bahamas were found in waters with bottom depths ranging from 94 to 883 m (C.D. MacLeod et al. 2004). In Hawaiian waters, this species was found in waters up to 3,200 m in depth (Baird 2005).

There appear to be some habitat preference differences between the two species of the genus *Kogia*. Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf break, while dwarf sperm whales tend to occur closer to shore, often over the outer continental shelf (Rice 1998; Wang et al. 2002; C.D. MacLeod et al. 2004). In particular, work on strandings and feeding habits in South Africa has indicated this (Ross 1979; Plön et al. 1998; Plön 2004); however, after first suggesting this, Ross (1984) later indicated that the difference may be more in terms of a difference between juveniles and adults, with juveniles being more coastal, perhaps in both species. Unfortunately, most studies are based on stranding records, which do not provide the best evidence on habitat selection, and they often appear to ignore Ross' (1984) reinterpretation of his own earlier conclusion.

More reliable is a conclusion that the pygmy sperm whale is more temperate, and the dwarf sperm whale more tropical since it is based at least partially on live sightings at sea from a large database from the eastern tropical Pacific Ocean (Wade and Gerrodette 1993). There, the pygmy sperm whale was not seen in truly tropical waters south of the southern tip of Baja California, but the dwarf sperm whale was common in those waters. This idea is also supported by the distribution of strandings in South American and South African waters (Muñoz-Hincapié et al. 1998; Plön 2004). Also, in the western tropical Indian Ocean, the dwarf sperm whale was much more common than the pygmy sperm whale, which is consistent with this hypothesis (Ballance and Pitman 1998).

In conclusion, although the dwarf sperm whale does appear to prefer more tropical waters, the exact habitat preferences of the two species are not well-known. Distribution at sea in relation to the shelf break requires further study. Both species have been seen in both continental shelf and more oceanic waters. It may be that earlier conclusions were misleading due to biases caused by the inadequacy of

stranding data, the lack of incorporation of age class effects, and possibly the local adaptation of each species to the conditions of specific areas.

Distribution—Both *Kogia* species apparently have a worldwide distribution in tropical and temperate waters (Jefferson et al. 1993). Stranding data indicate the dwarf sperm whales are distributed throughout tropical and temperate waters of the Pacific, Atlantic, and Indian oceans (Nagorsen 1985). In the eastern Atlantic Ocean, scattered records of dwarf sperm whales are documented on the coast of France (Duguy 1986); in the Gulf of Cadiz, Spain (Valverde and Camiñas 1997); in the Canary Islands (Hutterer 1994); and off Senegal, Africa (Maigret and Robineau 1981; Willis and Baird 1998). Two records have been reported in the Mediterranean Sea (Baccetti et al. 1991; Bortolotto et al. 2003).

- Information Specific to the Eastern Mediterranean Study Area—The dwarf sperm whale is not expected to occur in the Study Area; therefore, any occurrences are considered to be extralimital for this species. There are only two records of this species in the Mediterranean Sea. An individual stranded near Foce del Charone, Grosseto on the western coast of Italy in May 1988 (Centro Studi Cetacei 1990; Baccetti et al. 1991). Another dwarf sperm whale stranded near Eraclea Minoa, Agrigento on the southern coast of Sicily in September 2002 (Bortolotto et al. 2003; Centro Studi Cetacei 2004). These individuals probably strayed into the Mediterranean Sea from the western coast of Africa in the eastern North Atlantic Ocean (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006). There is a rare occurrence for the dwarf sperm whale throughout the Study Area which takes into account the remote possibility of encountering this species anywhere in coastal and offshore waters of the Mediterranean Sea during any time of the year (**Figure B-11**).

Behavior and Life History—*Kogia* species have small group sizes (mean group size is usually two individuals; Willis and Baird 1998). Dwarf sperm whales have been reported in groups of up to 10 individuals (Nagorsen 1985). A recent study of *Kogia* in South Africa has determined that these two species have a much earlier attainment of sexual maturity and shorter life span than other similarly-sized toothed whales (Plön 2004). Sexual maturity is attained at around four years in both sexes of both species; however, the onset of sexual maturity in males has been reported as early as 2.5 and 2.6 yrs for pygmy sperm whales and dwarf sperm whales, respectively (Plön 2004). Births have been recorded between December and March for dwarf sperm whales in South Africa (Plön 2004).

Kogia feed on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell 1989; McAlpine et al. 1997; Willis and Baird 1998; Santos et al. 2006). Willis and Baird (1998) reported that whales of the genus *Kogia* make dives of up to 25 min. Dive times ranging from 15 to 30 min (with 2 min surface intervals) have been recorded for a dwarf sperm whale in the Gulf of California (Breese and Tershy 1993). Median dive times of around 11 min are documented for *Kogia* (Barlow 1999). Most sightings of *Kogia* are brief; these whales are often difficult to approach and they sometimes actively avoid aircraft and vessels (Würsig et al. 1998).

Acoustics and Hearing—There is little published information on sounds produced by *Kogia* spp, although they are categorized as non-whistling smaller toothed whales. Recently, free-ranging dwarf sperm whales off La Martinique (Lesser Antilles) were recorded producing clicks at 13 to 33 kHz with durations of 0.3 to 0.5 sec (Jérémie et al. 2006). The only sound recordings for the pygmy sperm whale are from two stranded individuals. A stranded individual being prepared for release in the western North Atlantic Ocean emitted clicks of narrowband pulses with a mean duration of 119 µsec, interclick intervals between 40 and 70 msec, centroid frequency of 129 kHz, peak frequency of 130 kHz, and apparent source level of up to 175 dB re: 1 µPa-m (Madsen et al. 2005a). Another individual found stranded in Monterey Bay produced echolocation clicks ranging from 60 to 200 kHz, with a dominant frequency of 120 to 130 kHz (Marten 2000; Ridgway and Carder 2001).

No information on sound production or hearing is available for the dwarf sperm whale. An ABR study completed on a stranded pygmy sperm whale indicated a hearing range of 90 to 150 kHz (Ridgway and Carder 2001).

- **Cuvier's Beaked Whale (*Ziphius cavirostris*) and *Mesoplodon* spp.**

Description—The Cuvier's beaked whale and four members of the genus *Mesoplodon* (Blainville's, Gervais', Sowerby's, and True's beaked whales) have documented occurrence in the North Atlantic Ocean. Only the Cuvier's, Blainville's, and Gervais' beaked whales have confirmed occurrence records in the Mediterranean Sea. The Smithsonian Institution has developed an online system to facilitate species-level identification of stranded individuals (Allen et al. 2005), while MacLeod (2006) recently reviewed aspects of beaked whale body length and sexual dimorphism.

With the exception of the **Cuvier's beaked whale**, the before-mentioned beaked whale species are difficult to distinguish at sea (Coles 2001). Cuvier's beaked whales are relatively robust compared to other beaked whale species. Male and female Cuvier's beaked whales may reach 7.5 and 7.0 m in length, respectively (Jefferson et al. 1993). This species has a relatively short beak, which along with the curved jaw, resembles a goose beak. Adult males have two teeth which erupt from the tip of the lower jaw. The body is spindle shaped, and the dorsal fin and flippers are small which is typical for beaked whales. A useful diagnostic feature is a concavity on the top of the head, which becomes more prominent in older individuals. Cuvier's beaked whales are dark gray to light rusty brown in color, often with lighter color around the head. In adult males, the head and much of the back can be light gray to white in color, and they also often have many light scratches and circular scars on the body (Jefferson et al. 1993). Work is underway (including in the Mediterranean Sea) to classify individuals through patterns of scars on their body (Biassoni et al. 2003; Ballardini et al. 2006; Causer et al. 2006; Moulins et al. 2007; Rosso et al. 2007).

All mesoplodonts (***Mesoplodon* spp.**) have a relatively small head, large thorax and abdomen, and short tail. Mesoplodonts all have a pair of throat grooves on the ventral side of the head on the lower jaw. Mesoplodonts are characterized by the presence of a single pair of sexually dimorphic tusks, which erupt only in adult males. MacLeod (2000b) suggested that the variation in tusk position and shape acts as a species recognition signal for these whales.

Blainville's beaked whales are documented to reach a maximum length of around 4.7 m (Jefferson et al. 1993). Adults are blue-gray on their dorsal side and white below (Jefferson et al. 1993). The lower jaw of the Blainville's beaked whale is highly arched, and massive flattened tusks extend above the upper jaw in adult males (Jefferson et al. 1993).

Gervais' beaked whale males reach lengths of at least 4.5 m, while females reach at least 5.2 m (Jefferson et al. 1993). These beaked whales are dark gray dorsally with a light-gray belly. Adult males have one tooth evident per side, one-third of the distance from the snout tip to the corner of the mouth (Jefferson et al. 1993).

Status—The Cuvier's beaked whale is the only beaked whale species commonly found in the Mediterranean Sea (Notarbartolo di Sciara and Demma 1994; G. Notarbartolo di Sciara 2002; Podestà et al. 2006), particularly in the eastern basin (MacLeod, C., Beaked Whale Project, pers. comm., 30 August 2006). Cuvier's beaked whales in the Mediterranean Sea are genetically distinct from individuals in the eastern North Atlantic Ocean (Dalebout et al. 2005). Dalebout et al. (2005) suggested that individuals in the Mediterranean Sea should be considered an evolutionary significant unit. There are no abundance estimates available for Cuvier's beaked whale or *Mesoplodon* spp. in this area.

Habitat Preferences—World-wide, beaked whales normally inhabit continental slope and deep oceanic waters (>200 m) (e.g., Waring et al. 2001; Cañadas et al. 2002; Pitman 2002; Waring et al. 2003; MacLeod and Zuur 2005; Ward et al. 2005; Ferguson et al. 2006; MacLeod and D'Amico 2006; MacLeod and Mitchell 2006). Cuvier's and Blainville's beaked whales are generally sighted in waters with a bottom depth greater than 200 m and are frequently recorded at bottom depths greater than 1,000 m (e.g., Ritter and Brederlau 1999). Cañadas et al. (2002) reported that beaked whales off southern Spain showed a strong preference for deep waters (>600 m in bottom depth) with a steep bottom slope, and habitat models predicted the area of highest occurrence to be around the 1,000 m

isobath (Cañadas et al. 2005). D'Amico et al. (2003) reported that all sightings made during Sirena trials in the Ligurian Sea were in waters with a bottom depth greater than 1,000 m in regions of steep bathymetry, while Moulins et al. (2007) reported the majority of sightings in the Pelagos Sanctuary as taking place between 756 and 1,389 m; that the species did not appear to prefer areas with too much variation in slope; and most sightings were collected in a mid-basin where a barrier is created to the Liguro-Provençal Current and is an area of high squid concentrations. Four pairs of Cuvier's beaked whales sighted in the Central Tyrrhenian Sea in waters with a bottom depth of 1,200 to 1,800 m (Marini et al. 1992). Burgener (2004) determined that bathymetry plays an important role in Cuvier's beaked whale distribution in the Ionian Sea and southwest of Crete. Sightings off the Ionian Islands of Greece are in waters with a bottom depth greater than 650 m (Pulcini and Angradi 1994; Pulcini 1997). Frantzis et al. (2003) reported sightings in the Greek seas as taking place in waters with a bottom depth between 500 and 1,500 m.

Beaked whales are only occasionally reported in waters over the continental shelf (Pitman 2002). For example, a Cuvier's beaked whale was observed for 36 days in shallow coastal waters of the Adriatic Sea (30 to 50 m in bottom depth); this individual later stranded (Gomerčić et al. 2006; Holcer et al. 2007).

In the Eastern Tropical Pacific (ETP), beaked whales are found in waters over the continental slope to the abyssal plain, ranging from well-mixed to highly-stratified (Ferguson et al. 2006). As mentioned by MacLeod and D'Amico (2006), little survey effort has been conducted in the abyssal regions of the North Atlantic Ocean, so generalizations about species habitat preferences are difficult to make. As noted by MacLeod and D'Amico (2006), in many locales, occurrence patterns have been linked to physical features, in particular, the continental slope, canyons, escarpments, and oceanic islands. For example, such a preference has been noted in the Mediterranean Sea (e.g., D'Amico et al. 2003), in the Azores (Seabra et al. 2006), in The Bahamas (Claridge 2006), and off the northeastern U.S. (Waring et al. 2001).

MacLeod and D'Amico (2006) noted that more research was needed to determine how surface and deep water currents, levels of local productivity, and distribution of prey species may influence habitat usage. For example, in the Genoa Canyon, D'Amico et al. (2001) noted that Cuvier's beaked whale occurrence was linked to an apparent downwelling in the local water currents, which coupled with the canyon's topography, may create an area of high prey biomass. Beaked whale abundance off the eastern U.S. may be highest in association with the Gulf Stream and the warm-core rings it develops (Waring et al. 1992). Waring et al. (2003) conducted a deepwater survey south of Georges Bank in 2002 and examined fine-scale beaked whale habitat use, finding beaked whales located in waters with a mean SST of 20.7º to 24.9ºC.

Most ecological information on Blainville's beaked whales comes from the northern Bahamas (C.D. MacLeod et al. 2004; MacLeod and Zuur 2005; Claridge 2006). Most time is spent along these walls where bottom depths are less than 800 m (C.D. MacLeod et al. 2004; MacLeod and Zuur 2005; Claridge 2006). Adult Blainville's beaked whales in The Bahamas are found most often over the continental slope, while subadults are found in even deeper waters (Claridge 2006).

There is no available information on habitat preferences of Gervais' beaked whales as they have only rarely been identified at sea.

Distribution—Cuvier's beaked whales are the most widely-distributed of the beaked whales and are present in most regions of all major oceans (Heyning 1989; MacLeod et al. 2006). This species occupies almost all temperate, subtropical, and tropical waters, as well as subpolar and even polar waters in some areas (MacLeod et al. 2006). It was originally thought that Mediterranean Cuvier's beaked whales were individuals accidentally making their way from the North Atlantic Ocean into the Mediterranean Sea (Tortonese 1957), though genetic evidence now suggests that this species is regular in the region.

The ranges of most mesoplodonts are poorly known; these animals are known mostly from strandings (Mead 1989b; MacLeod 2000a; MacLeod et al. 2006). **Blainville's beaked whales** are thought to have a continuous distribution throughout tropical, subtropical, and warm-temperate waters of the world's oceans; they occasionally occur in cold-temperate areas (MacLeod et al. 2006). In the eastern North Atlantic Ocean, strandings have been recorded from Iceland, south to the Canaries, with the exception of the eastern Mediterranean Sea, where there are no records (MacLeod et al. 2006). The **Gervais' beaked whale** is restricted to warm-temperate and tropical Atlantic waters (MacLeod et al. 2006). Strandings records in the eastern North Atlantic Ocean range from Ireland to the Canaries, Mauritania, and Guinea-Bissau (MacLeod et al. 2006).

Site fidelity by some Cuvier's and Blainville's beaked whales to specific areas has been demonstrated by several long-term studies in various locales including Genoa Canyon (Ligurian Sea) (Ballardini et al. 2006), The Bahamas (Claridge 2006), and off the west coast of Hawai'i (McSweeney et al. 2007); however, as noted by MacLeod and D'Amico (2006), there are too few studies conducted to make any general conclusions on residency and habitat use.

- Information Specific to the Eastern Mediterranean Study Area—The occurrence patterns depicted for the Cuvier's beaked whale in **Figure B-12** takes into consideration the known preference of beaked whales for deep waters. As noted earlier, the Cuvier's beaked whale is the only beaked whale species commonly found in the Mediterranean Sea (Notarbartolo di Sciara and Demma 1994; G. Notarbartolo di Sciara 2002; Podestà et al. 2006). The area of primary occurrence for the Cuvier's beaked whale is in waters seaward of the 200 m isobath in the eastern Mediterranean Sea (**Figure B-13a**). The slope area (between the 200 and 2,000 m isobaths) is probably the favored habitat for this species in the Mediterranean Sea (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006). This is supported by various studies of Cuvier's beaked whales in the eastern Mediterranean Sea (e.g., Politi et al. 1992; Politi et al. 1994; Pulcini and Angradi 1994; Frantzis et al. 2003). There is an area of secondary occurrence between the 100 and 200 m isobaths, which takes into account that deep waters come very close to shore in some areas of this region, and that a sighting might take place in waters over the shelf. There is a rare occurrence in waters inshore of the 100 m isobath. Occurrence patterns are expected to be similar throughout the year, and no seasonal differences in the areas of known and suspected concentration for the Cuvier's beaked whale are currently anticipated.

  There are some areas of the Mediterranean Sea in which Cuvier's beaked whales have been reported more frequently. MacLeod and Mitchell (2006) consider the waters west of Greece and southern Albania a key area for beaked whales. The Cuvier's beaked whale is regularly sighted over the Hellenic Trench, from eastern Rodos Island to northwest Corfu Island (Politi et al. 1992; Politi et al. 1994; Pulcini and Angradi 1994; Frantzis et al. 2003; Burgener 2004) – over all steep depressions of the Aegean plateau, such as the sea areas between the Northern Sporades and the Chalkidiki peninsula, the trench north of Limnos Island (G. Notarbartolo di Sciara 2002; Frantzis et al. 2003).

  Podestà et al. (2006) reviewed stranding records for Cuvier's beaked whales in the Mediterranean Sea that included mass stranding events. Taylor et al. (2004) provides additional information on the mass stranding events. One highly publicized mass stranding event involved twelve Cuvier's beaked whales that live stranded along the coasts of the Kyparissiakos Gulf and subsequently died on 12 and 13 May 1996; this stranding event was associated with low frequency acoustic sonar tests conducted by the NATO (Frantzis 1998, 2004; Cox et al. 2006; D'Spain et al. 2006).

  The entire eastern Mediterranean Study Area is an area of rare occurrence for *Mesoplodon* spp. (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006; **Figure B-13a**). Based on few documented occurrences, *Mesoplodon* spp. probably has a very limited presence in the Mediterranean Sea (Notarbartolo di Sciara, Tethys Research Institute, pers. comm., 26 April 2007), with individuals sometimes wandering into the area from populations in

the eastern North Atlantic Ocean. Only extralimital occurrences of these species would be expected for the eastern Mediterranean Sea.

There are no confirmed occurrences of *Mesoplodon* spp. for the eastern Mediterranean Sea. The only *Mesoplodon* record for the eastern Mediterranean Sea appearing on **Figure B-13a** is from the NATO Undersea Research Centre (NURC) database, and refers to Frantzis et al. (2003) who identified a stranded beaked whale in the Peloponnesus in March 1989 as a Sowerby's beaked whale. Subsequent examination of the skull, however, confirmed that it was actually a Cuvier's beaked whale (Reeves and Notarbartolo di Sciara 2006). It also should be noted that the Podestà et al. (2006) erroneously identified this individual as a Sowerby's beaked whale in their review of *Mesoplodon* records for the Mediterranean Sea.

Behavior and Life History—Most beaked whales are difficult to approach and tend to actively avoid aircraft and vessels (Würsig et al. 1998; Barlow et al. 2006). Beaked whale life histories are poorly known and reproductive biology is generally undescribed.

Typical group size for a Cuvier's beaked whale is between 2 and 7 individuals (review by MacLeod and D'Amico 2006). In a study of Cuvier's beaked whale in the Pelagos Sanctuary, Moulins et al. (2007) reported an average group size of 2.3±1.5 individuals, with the largest group being 11 animals, and 34% being singletons. Preliminary results regarding interpretations of group composition were also presented by Moulins et al. (2007), with single individuals being mature adults, small groups could be immature individuals only, and that large groups consist of both mature and immature animals. Rosso et al. (2007) interpreted their photo-identification data from the Ligurian Sea and suggested that the Cuvier's beaked whale there seems to consist of loose associations between individuals. Additional data are obviously needed to further assess age and sex composition of groups in the Mediterranean Sea.

Blainville's beaked whales are found in groups ranging from 1 to 11 individuals (MacLeod and D'Amico 2006). As noted by MacLeod and D'Amico (2006), the Blainville's beaked whale is one of the few beaked whale species for which there is some good information on group composition, and that information is from the northeastern Bahamas. Groups there are usually comprised of females, calves, and/or juveniles. Some groups also include a mature or subadult male (Claridge 2005; MacLeod and D'Amico 2006).

Stomach content analyses of captured and stranded individuals suggest beaked whales are deep divers that feed by suction on mesopelagic fishes, squids, and deepwater benthic invertebrates (Heyning 1989). All species of beaked whales probably feed at or close to the bottom in deep oceanic waters, taking whatever suitable prey they encounter or feeding on whatever species are locally abundant (e.g., MacLeod et al. 2003; Ohizumi and Kishiro 2003). A Cuvier's beaked whale found stranded in Croatian waters of the Adriatic had embedded pieces of gravel around the tip of the lower and upper jaws (Gomerčić et al. 2006) that might suggest feeding on the bottom. Recently, Woodside et al. (2006) hypothesized that characteristic gouge marks found on eastern Mediterranean mud volcanoes might be formed by Cuvier's beaked whales during foraging dives; however, based on recent tagging data, Baird et al. (2006) suggested that feeding might actually occur in mid-water rather than only at or near the bottom. Tyack et al. (2006) reported that based on DTAG data, Blainville's beaked whales in the Canary Islands and Cuvier's beaked whales in the Ligurian Sea forage using echolocation at depths between 222 and 1,885 m in the water column.

Stomach contents of Cuvier's beaked whales rarely contain fishes, while stomach contents of mesoplodonts frequently do (Santos et al. 2001; MacLeod et al. 2003). Cuvier's beaked whales in the Mediterranean Sea primarily feed on members of the cephalopod family Histioteuthidae, with relatively high numbers of specimens also taken from the families Cranchiidae, Chtenopterygidae, and Chiroteuthidae (Cagnolaro 1965; Desportes 1985; Carlini et al. 1992; Podestà and Meotti 1992; Lefkaditou and Poulopoulos 1998; Blanco and Raga 2000). Mesoplodonts occupy a separate ecological niche from Cuvier's beaked whales by feeding on smaller squids which allows for the different beaked whale species to coexist (MacLeod et al. 2003; MacLeod 2005).

Rommel et al. (2006) reviewed aspects of beaked whale diving physiology and morphological/anatomical adaptations. Dives range from those near the surface where the animals are still visible to long, deep dives. Dive durations for *Mesoplodon* spp. are typically over 20 min (Barlow 1999; Baird et al. 2006). Tagging data from Cuvier's and Blainville's beaked whales from the Ligurian Sea and Canary Islands, respectively, has revealed: (1) dives to depths near 2 km and lasting nearly 1.5 hrs; (2) slow ascent rates; and (3) a series of 'bounce' dives to 100 to 400 m between the deeper, longer dives (Cox et al. 2006; Tyack et al. 2006). Both species make a series of shallow dives after a deep foraging dive to recover from oxygen debt; average intervals between foraging dives have been recorded as 63 min for Cuvier's beaked whales and 92 min for Blainville's beaked whales (Tyack et al. 2006). Tagged Cuvier's beaked whale dives with durations as long as 87 min and depths down to 1,990 m are recorded off the Hawaiian Islands (Baird et al. 2006). Tagged Blainville's beaked whales in the same area are recorded to dive as deep as 1,408 m and as long as 54 min (Baird et al. 2006). Baird et al. (2006) reported that several aspects of diving were similar between Cuvier's and Blainville's beaked whales: 1) both dove for 48 to 68 min to depths greater than 800 m, with one long dive occurring on average every 2 hrs; 2) ascent rates for long/deep dives were substantially slower than descent rates, while during shorter dives there were no consistent differences; and 3) both spent prolonged periods of time (66 to 155 min) in the upper 50 m of the water column.

Acoustics and Hearing—Sounds recorded from beaked whales are divided into two categories: whistles and pulsed sounds (clicks); whistles likely serve a communicative function and pulsed sounds are important in foraging and/or navigation (Johnson et al. 2004; Madsen et al. 2005b; MacLeod and D'Amico 2006; Tyack et al. 2006). Whistle frequencies are about 2 to 12 kHz, while pulsed sounds range in frequency from 300 Hz to 135 kHz; however, as noted by MacLeod and D'Amico (2006), higher frequencies may not be recorded due to equipment limitations. Whistles recorded from free-ranging Cuvier's beaked whales off Greece ranged in frequency from 8 to 12 kHz, with an upsweep of about 1 sec (Manghi et al. 1999), while pulsed sounds had a narrow peak frequency of 13 to 17 kHz, lasting 15 to 44 sec in duration (Frantzis et al. 2002). Short whistles and chirps from a subadult Blainville's beaked whale stranded in northeastern Florida ranged in frequency from slightly less than 1 to almost 6 kHz (Caldwell and Caldwell 1971). Rankin and Barlow (2007) recorded four mid-frequency sounds in close proximity to a group of Blainville's beaked whales in Hawaiian waters. These sounds included one frequency-modulated whistle, and three frequency- and amplitude-modulated pulsed sounds, with energy between 6 and 16 kHz (Rankin and Barlow 2007).

Recent studies incorporating DTAGs (miniature sound and orientation recording digital tag) attached to Blainville's beaked whales in the Canary Islands and Cuvier's beaked whales in the Ligurian Sea recorded high-frequency echolocation clicks (duration: 175 μsec for Blainville's and 200 to 250 μsec for Cuvier's) with dominant frequency ranges from about 20 to over 40 kHz (limit of recording system was 48 kHz) and only at depths greater than 200 m (Johnson et al. 2004; Madsen et al. 2005b; Zimmer et al. 2005; Tyack et al. 2006). The source level of the Blainville's beaked whales' clicks were estimated to range from 200 to 220 dB re: 1 μPa-m (Johnson et al. 2004), while they were 214 dB re: 1 μPa-m for the Cuvier's beaked whale (Zimmer et al. 2005).

From anatomical examination of their ears, it is presumed that beaked whales are predominantly adapted to best hear ultrasonic frequencies (MacLeod 1999; Ketten et al. 2000). Beaked whales have well-developed semi-circular canals (typically for vestibular function but may function differently in beaked whales) compared to other cetacean species, and they may be more sensitive than other cetaceans to low-frequency sounds (MacLeod 1999; Ketten et al. 2000). Ketten (2000) remarked on how beaked whale ears (computerized tomography [CT] scans of Cuvier's, Blainville's, Sowerby's, and Gervais' beaked whale heads) have anomalously well-developed vestibular elements and heavily reinforced (large bore, strutted) Eustachian tubes and noted that they may impart special resonances and acoustic sensitivities. The only direct measure of beaked whale hearing is from a stranded juvenile Gervais' beaked whale using auditory evoked potential techniques (Cook et al. 2006). The hearing range was 5 to 80 kHz, with greatest sensitivity at 40 and 80 kHz (Cook et al. 2006).

- **Northern Bottlenose Whale (*Hyperoodon ampullatus*)**

Description—Northern bottlenose whales are 7 to 9 m in length with rotund bodies, large bulbous heads, and small, well-defined beaks (Mead 1989a). Only mature males have erupted teeth. There is marked sexual dimorphism in the melon which is enlarged, flattened, and squared off in males (Mead 1989a). Gowans and Rendell (1999) observed head-butting by males and speculated that differences in head shape may be significant in male contests for mates. These whales range in color from green-brown to gray with lighter gray-white markings on the body and lighter coloring on the lower part of the flanks and ventral surface.

Status—The northern bottlenose whale is listed as lower risk (conservation dependent) on the IUCN Red List.[1] There is a rough estimate of about 40,000 northern bottlenose whales in the North Atlantic Ocean from the late 1980s which includes an adjustment to account for deep diving (NAMMCO 1995).

Habitat Preferences—Northern bottlenose whales are concentrated in cold waters seaward of the continental shelf break (Reeves et al. 1993). They are found in greatest abundance in waters deeper than 1,000 m (Reeves et al. 1993; Carlisle et al. 2001). Northern bottlenose whales have been observed in waters with SST ranging from -2°C to 17°C (Reeves et al. 1993). The importance of canyons on the Scotian Slope was reported by Wimmer and Whitehead (2004). In the southern Bay of Biscay, northern bottlenose whales occur regularly in deep canyons (Cresswell and Walker 2001). Compton (2004) used a predictive modeling approach and identified steep, shelf break waters; canyons; and seamounts as key habitats for northern bottlenose whales in the western North Atlantic Ocean.

Distribution—Northern bottlenose whales are restricted to northern latitudes of the North Atlantic Ocean. Sightings and whaling data are available for this species as far north as Davis Strait, Iceland, and the Norwegian Sea and as far south as the northeastern U.S., the Azores, and the western Mediterranean Sea. A stranding has also been recorded in the Canary Islands (MacLeod et al. 2006). There seem to be certain pockets of abundance, for example, around "the Gully", north of Sable Island, Nova Scotia, Canada; in the Arctic Ocean between Iceland and Jan Mayen, southwest of Svalbard and east off Iceland, north off the Faroes; and in Davis Strait off northern Labrador, Canada, especially around the entrance to Hudson Strait and Frobisher Bay. North Atlantic bottlenose whales are less common in the extreme southern part of their range. In European waters, this species is seen irregularly from the Canary Islands and the Azores north to the Barents Sea (Reid et al. 2003). There is evidence of seasonal shifts in abundance, particularly in the eastern North Atlantic Ocean (Walker et al. 2001; Reid et al. 2003).

- Information Specific to the Eastern Mediterranean Study Area—The northern bottlenose whale is extralimital to the Mediterranean Sea and has a rare occurrence throughout the Study Area (**Figure B-13b**). As noted by Reeves and Notarbartolo di Sciara (2006), there are several reports of northern bottlenose whales in the Mediterranean region; however, the vast majority are misidentified individuals or unconfirmed (no supporting documentation). There are five valid records for this species throughout the Mediterranean Sea: a live stranding of a mother/calf pair in the Gulf of Aigues-Mortes, Languedoc-Roussillon, France, during September 1880 (Bompar 2000) and four sightings (not displayed in **Figure B-13b**) in the northeastern Alboran Sea between 1992 and 2002 (Cañadas and Sagarminaga 2000; Cañadas et al. 2005).

Behavior and Life History—Most groups contain at least four whales (sometimes as many as 20), and in The Gully (Scotian Slope) there is some segregation by age and sex (Gowans et al. 2001). Sexual maturity for females and males occurs between 8 and 13 yrs and 7 and 9 yrs of age, respectively (Bloch et al. 1996). Northern bottlenose whales feed primarily on squids, particularly the genus *Gonatus*; they also take fish, large decapod crustaceans, sea stars, and sea cucumbers (Benjaminsen and Christensen 1979; Clarke and Kristensen 1980; Bloch et al. 1996). Tagged northern bottlenose whales off Nova Scotia were found to dive approximately every 80 min to over 800 m, with a maximum dive depth of 1,453 m for 70 min (Hooker and Baird 1999). Northern

bottlenose whale dives fall into two discrete categories: short-duration (mean=11.7 min) shallow dives and long-duration (mean=36.98 min) deep dives (Hooker and Baird 1999).

Acoustics and Hearing—Sounds recorded by Hooker and Whitehead (2002) were predominantly clicks, with two major types of click series. Loud clicks were produced by whales socializing at the surface and were rapid with short and variable interclick intervals. The frequency spectra was often multimodal, and peak frequencies ranged between 2 and 22 kHz (mean=11 kHz). Clicks received at low amplitude (produced by distant whales, presumably foraging at depth) were generally a unimodal frequency spectra with a mean peak frequency of 24 kHz and a 3 decibel (dB) bandwidth of 4 kHz. Winn et al. (1970) recorded sounds that were not only comprised of clicks but also whistles that they attributed to northern bottlenose whales. Hooker and Whitehead (2002) noted that it was more likely that long-finned pilot whales had produced the whistles, although they also noted that more recordings from this species while no other animals are around are needed to confirm whether or not the species actually produces whistles or not.

There is no empirical data on the hearing ability of the northern bottlenose whale. From anatomical examination of their ears, it is presumed that beaked whales are predominantly adapted to best hear ultrasonic frequencies (MacLeod 1999). Beaked whales have well-developed semi-circular canals (typically for vestibular function but may function differently in beaked whales) compared to other cetacean species, and they may be more sensitive than other toothed cetaceans to low-frequency sounds (MacLeod 1999). The only direct measure of beaked whale hearing is from a stranded juvenile Gervais' beaked whale using auditory evoked potential techniques (Cook et al. 2006). The hearing range was 5 to 80 kHz, with greatest sensitivity at 40 and 80 kHz (Cook et al. 2006).

- **Rough-toothed Dolphin (*Steno bredanensis*)**

Description—This is a relatively robust dolphin with a cone-shaped head; it is the only one with no demarcation between the melon and beak (Jefferson et al. 1993). The "forehead" slopes smoothly from the blowhole onto the long, narrow beak (Reeves et al. 2002b). The rough-toothed dolphin has large flippers that are set far back on the sides and a prominent falcate dorsal fin (Jefferson et al. 1993). The body is dark gray with a prominent narrow dorsal cape that dips slightly down onto the side below the dorsal fin. The lips and much of the lower jaw are white, and many individuals have white scratches and spots on the body from cookie-cutter sharks and other rough-toothed dolphins. The rough-toothed dolphin reaches 2.8 m in length (Jefferson et al. 1993).

Status—The rough-toothed dolphin is listed as data deficient on the IUCN Red List.[1] No abundance estimates are available for rough-toothed dolphins in the eastern North Atlantic Ocean or the Mediterranean Sea.

Habitat Preferences—The rough-toothed dolphin is regarded as an offshore species that prefers deep waters; however, it can occur in waters with variable bottom depths and may regularly frequent coastal waters and areas with shallow bottom depths (e.g., Gannier and West 2005). In the Mediterranean Sea, rough-toothed dolphins occur primarily beyond the continental slope (G. Notarbartolo di Sciara 2002). Rough-toothed dolphins in the Gulf of Mexico are mostly sighted in deep waters off the continental shelf (Davis et al. 1998; Mullin et al. 2004) but are also found on the shelf in the northern Gulf of Mexico (Wells et al. 1999; Fulling et al. 2003). Additionally, there are reports of rough-toothed dolphins over the continental shelf in shallow waters around La Gomera, Canary Islands (Ritter 2002); Utila, Honduras (Kuczaj II and Yeater 2007); Puerto Rico and the Virgin Islands (Mignucci-Giannoni 1998); The Bahamas (Banick and Borger 2005); and in coastal waters off Brazil, including even in a lagoon system (Flores and Ximenez 1997; Lodi and Hetzel 1999).

Tagging data for this species from the Gulf of Mexico and western North Atlantic Ocean provide important information on habitat preferences. Four stranded rough-toothed dolphins (three with satellite-linked transmitters) were rehabilitated and released in 1998 off the Gulf Coast of Florida (Wells et al. 1999). Water depth at tracking locations of these individuals averaged 195 m off the Florida Panhandle (Wells et al. 1999). In March 2005, Mote Marine Laboratory released three

dolphins from the 2004 mass stranding at Hutchinson Island, Florida. The dolphins were tagged with satellite-linked transmitters and released southeast of Fort Pierce in waters with a bottom depth of about 110 m (Manire and Wells 2005). The animals moved within the Gulf Stream and parallel to the continental shelf off Florida, Georgia, and South Carolina, in waters with a bottom depth of 400 to 800 m. They later moved northeast into waters with a bottom depth greater than 4,000 m (Manire and Wells 2005). In April 2005, two dolphins from the March 2005 mass stranding in the Florida Keys were released off Miami, one with a satellite-linked transmitter (Wells, R., Mote Marine Laboratory, pers. comm., 29 January 2007). The tagged animal moved north as far as Charleston, South Carolina, before returning to the Miami area, remaining in relatively shallow waters. During May 2005, seven more rough-toothed dolphins (stranded in the Florida Keys in March 2005 and rehabilitated) were tagged and released (Wells, R., Mote Marine Laboratory, pers. comm., 29 January 2007). During an initial period of apparent disorientation in the shallow waters west of Andros Island, they continued to the east, then moved north through Crooked Island Passage, and paralleled the West Indies. The last signal placed them northeast of the Lesser Antilles. During September 2005, two more individuals (stranded with the previous group in the Florida Keys in March 2005 and rehabilitated) were satellite-tagged and released east of the Florida Keys. The tagging data demonstrated that these individuals proceeded south to a deep trench close to the north coast of Cuba (Wells, R., Mote Marine Laboratory, pers. comm., 29 January 2007).

Distribution—Rough-toothed dolphins are found in tropical to warm-temperate waters globally, rarely ranging north of 40°N or south of 35°S (Miyazaki and Perrin 1994). Rough-toothed dolphins occur in low densities throughout the ETP where surface water temperatures are generally above 25°C (Perrin and Walker 1975); however, they may also be found in waters lower than 25°C, particularly off La Gomera, Canary Islands (Ritter 2002).

This species is generally not a commonly-encountered species in the areas where it is known to occur (Jefferson 2002). Rough-toothed dolphins occasionally occur in the Mediterranean Sea. Watkins et al. (1987a) suggested that the population of rough-toothed dolphins in the Mediterranean Sea may be larger than previously thought, but more information is needed to verify this.

- Information Specific to the Eastern Mediterranean Study Area—Rough-toothed dolphins rarely occur in the Study Area. There are confirmed records of this species in the Ionian Sea and off the coast of Sicily (Watkins et al. 1987a; Centro Studi Cetacei 2004; Lacey et al. 2005). There is a small concentration of stranding records along the coast of Israel (Goffman et al. 2000; Goffman et al. 2006; Reeves and Notarbartolo di Sciara 2006). In the past few years, all the strandings recorded in Israel have occurred between February and April (Scheinin et al. 2004b). Sightings off Israel include a group of 30 rough-toothed dolphins which entered the port of Haifa in March 2005 (Kerem 2005). It is possible that rough-toothed dolphins recorded from this area may be coming from the Red Sea where this species is known to occur (Baldwin et al. 1999; Notarbartolo di Sciara, G., pers. comm., 2-5 October 2006).

There is an area of primary occurrence seaward of the shelf break throughout the eastern Mediterranean Sea based on the preference of this species for deep waters (**Figure B-14**). Secondary occurrence is between the shoreline and the shelf break which takes into account the possibility of encountering rough-toothed dolphins in waters over the shelf. No seasonal differences in occurrence are anticipated for this species.

Behavior and Life History—Small groups of 10 to 20 rough-toothed dolphins are most common, with herds up to 50 animals reported (Miyazaki and Perrin 1994; Reeves et al. 1999). A large aggregation of around 160 animals in 8 groups of about 20 each was recorded in the Strait of Sicily (Watkins et al. 1987a). Rough-toothed dolphins often associate with other cetacean species (e.g., Miyazaki and Perrin 1994; Nekoba-Dutertre et al. 1999; Ritter 2002; Wedekin et al. 2004; Jefferson et al. 2006). In the ETP and Gulf of Mexico, rough-toothed dolphins have a tendency to associate with floating objects and *Sargassum* (Pitman and Stinchcomb 2002; Fulling et al. 2003). Off the coast of

Honduras, rough-toothed dolphins associate with seaweed, seagrass, and foreign objects such as pieces of plastic (Kuczaj II and Yeater 2007).
Cephalopods and fish, including large fish, such as common dolphinfish, are prey (Miyazaki and Perrin 1994; Reeves et al. 1999; Pitman and Stinchcomb 2002). Gannier and West (2005) observed rough-toothed dolphins feeding during the daytime on epipelagic fishes, including flying fishes. Female rough-toothed dolphins reach sexual maturity between 4 and 6 yrs of age; males attain sexual maturity between 5 and 10 yrs (Mead et al. 2001). Rough-toothed dolphins may stay submerged for up to 15 min (Miyazaki and Perrin 1994) and are known to dive as deep as 150 m (Manire and Wells 2005) and probably much deeper.

Acoustics and Hearing—The rough-toothed dolphin produces a variety of sounds, including broadband echolocation clicks and whistles. Echolocation clicks (duration <250 µsec) typically have a frequency range of 0.1 to 200 kHz, with a dominant frequency of 25 kHz (Miyazaki and Perrin 1994; Yu et al. 2003; Chou 2005). Whistles (duration <1 sec) have a wide frequency range of 0.3 to greater than 24 kHz but dominate in the 2 to 14 kHz range (Miyazaki and Perrin 1994; Yu et al. 2003).

Auditory evoked potential (AEP) measurements were performed on six individuals involved in a mass stranding event on Hutchinson Island, Florida in August 2004 (Cook et al. 2005). The rough-toothed dolphin can detect sounds between 5 and 80 kHz and is most likely capable of detecting frequencies much higher than 80 kHz (Cook et al. 2005).

- **Common Bottlenose Dolphin (*Tursiops truncatus*)**

Description—Common bottlenose dolphins are large and robust, varying in color from light gray to charcoal. The genus *Tursiops* is named for its short, stocky snout that is distinct from the melon (Jefferson et al. 1993). The dorsal fin is tall and falcate. There are striking regional variations in body size, with adult lengths from 1.9 to 3.8 m (Jefferson et al. 1993).

The taxonomy of the genus *Tursiops* has been debated for decades and continues to be contested. Two *Tursiops* species are currently recognized: the common bottlenose dolphin (*Tursiops truncatus*) and Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998; IWC 2005). It is likely that additional taxonomy will be recognized based on future genetic and morphometric analyses (Natoli et al. 2004a). Indo-Pacific bottlenose dolphins are found in coastal Indo-Pacific tropical waters (Curry and Smith 1997), while all other forms are considered to be common bottlenose dolphins. Indo-Pacific bottlenose dolphins might enter the Mediterranean via the Suez Canal, although there is currently no evidence to support this (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006). Therefore, only *Tursiops truncatus* (hereafter referred to as bottlenose dolphin) is expected to occur in the Study Area.

Scientists currently recognize several nearshore (coastal) and offshore forms of bottlenose dolphins, which are distinguished by external and cranial morphology, hematology, diet, and parasite load (Duffield et al. 1983; Hersh and Duffield 1990; Mead and Potter 1995; Curry and Smith 1997). There is also a clear genetic distinction between nearshore and offshore bottlenose dolphins worldwide (Curry and Smith 1997; Hoelzel et al. 1998). It has been suggested that the two forms should be considered different species (Curry and Smith 1997; Kingston and Rosel 2004), but no official taxonomic revisions have yet been made.

Status—The bottlenose dolphin is listed as data deficient on the IUCN Red List[1]; however, the Mediterranean subpopulation was recently proposed to qualify as vulnerable based on factors such as habitat loss and degradation, high levels of contamination, and substantial bycatch, all of which have likely contributed to the suspected 30% decline in this subpopulation since 1946 (Reeves and Notarbartolo di Sciara 2006). The Black Sea subspecies (*Tursiops truncatus ponticus*) has been proposed to be listed as endangered (Reeves and Notarbartolo di Sciara 2006).

There seems to be a relatively high level of gene flow between the Mediterranean Sea and eastern North Atlantic populations through the Strait of Gibraltar (Natoli et al. 2005a). Studies suggest that the

Almeria-Oran Front, rather than the Strait of Gibraltar, may be more of a boundary to gene flow between these two populations. This oceanic front is where the Atlantic oceanic waters encounter warmer, denser Mediterranean waters; this front may serve as a barrier to the movement of some prey species (Natoli et al. 2005a). Genetic differentiation has also been observed between bottlenose dolphins in the western and eastern basins (Natoli et al. 2005a). The Black Sea population also differs genetically from the Mediterranean and eastern North Atlantic populations (Natoli et al. 2005a); however, limited gene flow between the Black and Mediterranean seas through the Turkish Straits System is possible (Natoli et al. 2005a; Viaud et al. 2005). Based on these genetic studies, it is possible that individuals from both the Black Sea and the eastern North Atlantic Ocean may occur in the Study Area.

In addition to the possible population structuring caused by frontal boundaries as mentioned above, further population structuring in the Mediterranean Sea may coincide with boundaries produced by habitat differences in bottom topography, surface salinity, productivity, and temperature (Natoli et al. 2005a). For instance, differences in pollutant concentrations in bottlenose dolphins from the Balearic Islands and the Iberian mainland may be attributed to geographic isolation due to the deep-water corridor that separates these areas (Borrell et al. 2006). This study suggests possible separate coastal and offshore populations of bottlenose dolphins in the Mediterranean Sea; however, more research is needed to clarify the population identity of individuals observed offshore verses inshore in the Mediterranean Sea.

Two forms of bottlenose dolphins are recognized in the western North Atlantic Ocean: inshore (coastal) and offshore morphotypes (Waring et al. 2007). Natoli and Hoelzel (2000) compared the phylogeographic structure of the Mediterranean bottlenose dolphin population with data from these morphotypes of the western North Atlantic Ocean, the eastern North Atlantic population, and the South African population and found that Mediterranean bottlenose dolphins are more closely related to the offshore morphotype from the western North Atlantic Ocean. These data further support the indication of gene flow between the Mediterranean and North Atlantic populations (Natoli and Hoelzel 2000).

The total size of the Mediterranean bottlenose dolphin population is unknown; however, the population may be in the low 10,000s based on regional studies (Reeves and Notarbartolo di Sciara 2006). No basin-wide surveys have been conducted for bottlenose dolphins; therefore, abundance estimates are only available for small portions of this species's range in the Mediterranean Sea (Reeves and Notarbartolo di Sciara 2006). High estimates of abundance have been calculated for some of the local subpopulations in the western Mediterranean Sea: around the Balearic Islands and Catalonia, Spain (7,654 dolphins); the northern Alboran Sea (584 dolphins); and central east Spain (1,333 dolphins) (Forcada et al. 2004; Cañadas and Hammond 2006; Gómez de Segura et al. 2006). Relatively smaller populations have been surveyed in the Strait of Gibraltar, Gulf of Vera, Gulf of Lion, Corsica, Lampedusa Island, Tunisian waters, eastern Ionian Sea, Amvrakikos Gulf, Adriatic Sea, and Israeli waters (Ripoll et al. 2004; Cañadas et al. 2006; Pérez et al. 2006; Reeves and Notarbartolo di Sciara 2006). The total size of the Black Sea population is unknown; however, recent survey data indicate a population of several thousand individuals (Reeves and Notarbartolo di Sciara 2006).

Habitat Preferences—Bottlenose dolphins likely take advantage of habitat features that aggregate locally abundant prey species; because these features can vary from region to region, distribution of dolphins by depth may vary greatly in different regions of the Mediterranean Sea (Cañadas et al. 2002). Bottlenose dolphins are found primarily in continental shelf waters of the Mediterranean Sea but also occur in deep waters near the continental slope, particularly in the Alboran and Balearic seas, and in offshore waters (Cañadas et al. 2002; Gannier 2005b; Cañadas and Hammond 2006; Reeves and Notarbartolo di Sciara 2006). Bottlenose dolphins are also found along steep coasts with no continental shelf, such as in southern Crete (Frantzis et al. 2003). Sightings in waters with a maximum bottom depth of 1,300 m are recorded for bottlenose dolphins in the northeastern Alboran Sea (Cañadas et al. 2002). They have also strayed into the very shallow waters of the Venice Lagoon where they opportunistically feed (Bearzi and Ferretti 2000). Bottlenose dolphins in the Black Sea are often found in lagoons, estuaries, and rivers (Reeves and Notarbartolo di Sciara 2006).

Bottlenose dolphins in the Alboran Sea have a preference for waters between 200 and 600 m in depth and steep sea bottom areas, such as the area around the Seco de los Olivos seamount which is an important upwelling zone (Cañadas 2006; Cañadas and Hammond 2006). In fact, distribution of bottlenose dolphins in this region appears to be linked to water depth and not necessarily to distance from shore or other features (Cañadas and Hammond 2006). Cañadas et al. (2002) found that bottlenose dolphins preferred continental shelf and shelf edge waters and tended to avoid depths over 600 m in the northeastern Alboran Sea. This region of the Alboran Sea is important habitat for this species; it has enhanced primary and secondary production which aggregates several preferred prey species of bottlenose dolphins (García-Tiscar et al. 2004).

The Balearic Islands region, in particular, may also be an important habitat for bottlenose dolphins in the Mediterranean Sea based on the relatively high abundance of bottlenose dolphins found around the islands. In fact, Forcada et al. (2004) suggested that the inshore waters of the islands may be critical habitat for this species.

Distribution—The overall range of the bottlenose dolphin is worldwide in tropical and temperate waters. This species occurs in all three major oceans and many seas. Dolphins of the genus *Tursiops* generally do not range poleward of 45º except around the U.K. and northern Europe (Jefferson et al. 1993). Climate changes can contribute to range extensions, as witnessed in association with the 1982/83 El Niño event when the range of some bottlenose dolphins known to the San Diego, California area was extended 600 km northward to Monterey Bay (Wells et al. 1990). Bottlenose dolphins continue to occur in Monterey Bay to this day.

In the eastern North Atlantic Ocean, bottlenose dolphins occur as far north as Norway (Wells and Scott 1999). They are common in nearshore waters off the coast of Spain, Portugal, northwest France, western Ireland, the Irish Sea, and northeast Scotland (particularly the Moray Firth) (Reid et al. 2003). Bottlenose dolphins are widely distributed throughout the Mediterranean and Black seas. Contiguous populations of bottlenose dolphins exist from the Black Sea to Scotland (Natoli et al. 2005a). The Mediterranean bottlenose dolphin subpopulation consists of small scattered and fragmented units. Key areas of distribution include the Alboran Sea, Balearic Sea, Adriatic Sea, Tunisian and Malta plateaus, Aegean Sea, Turkish Straits System, and other areas of the continental shelf such as Algerian coastal waters and Middle East waters (G. Notarbartolo di Sciara, ed. 2002). Possible areas of critical habitat for the bottlenose dolphin include the coastal area of southern Crimea, Ukraine, comprised between Cape Sarych and Cape Khersones (Black Sea bottlenose dolphins) and the waters of the Losinj-Cres Archipelago, Croatia, and the Balearic Islands region (Mediterranean bottlenose dolphins) (Bearzi 2003; Forcada et al. 2004).

- Information Specific to the Eastern Mediterranean Study Area—Bottlenose dolphins regularly occur throughout the eastern Mediterranean Sea year-round. This species is common throughout the Greek seas (east Ionian, Aegean, and north Libyan seas) and is the most frequently sighted cetacean in the Cyclades Archipelago (Frantzis 1997). Bottlenose dolphins are present in all coastal areas, straits, and gulfs as well as between islands in the Ionian and Aegean seas (Frantzis et al. 2003). They are the only cetaceans that occur in the shallow and enclosed Amvrakikos Gulf; these bottlenose dolphins may represent an isolated population unit (Frantzis et al. 2003). This species is also common off Tunisia, Israel, and Egypt (Marchessaux 1980; Goffman et al. 2000; Arcangeli et al. 2001).

  There is an area of primary occurrence for the bottlenose dolphin from the shoreline to the 500 m isobath based on this species's preference for coastal and inshore waters of the Mediterranean Sea (**Figure B-15**) (Gannier 2005b). Secondary occurrence is between the 500 and 2,000 m isobaths and accounts for deep waters near the continental slope and steep sea bottom areas such as the region off southern Crete where bottlenose dolphins are regularly found (Frantzis et al. 2003). Rare occurrence is seaward of the 2,000 m isobath throughout the rest of the eastern Mediterranean Sea. No seasonal changes in occurrence are anticipated.

Behavior and Life History—Bottlenose dolphins are gregarious and typically found in groups of 2 to 15 individuals, although groups of 100s and even >1,000 individuals have been reported (Saayman and Tayler 1973; Shane et al. 1986; Kerr et al. 2005). Water depth has a significant influence on group size (Shane et al. 1986). Shallow, confined water areas typically support smaller group sizes, some degree of regional site fidelity, and limited movement patterns (Wells et al. 1987). In contrast, semi-open habitats often sustain larger group sizes, diminished levels of site fidelity, and wider home ranges (Defran and Weller 1999). This may be due to habitat structure and prey distribution. This appears to hold true for bottlenose dolphins in the Mediterranean Sea where average groups sizes are generally smaller in coastal waters and larger in offshore waters (e.g., Marini et al. 1996b; Bearzi et al. 1997; Carpentieri et al. 1999; Cañadas and Hammond 2006). For instance, average group size in shallow waters of the eastern Ionian Sea and Adriatic Sea is around seven individuals (Bearzi et al. 1997; Bearzi et al. 2005; Fortuna 2006). In contrast, average group size in the northern Alboran Sea is generally less than 30 (e.g., Forcada et al. 2004; Cañadas and Hammond 2006).

Based on photo-identification of dorsal fin shapes and markings (Würsig and Würsig 1977; Würsig and Jefferson 1990), bottlenose dolphins are known to have a fluid social organization (Connor et al. 2000). Bottlenose dolphins frequently associate with other marine mammal species; associations with striped dolphins, short-beaked common dolphins, and long-finned pilot whales are documented in the Mediterranean Sea (Pilleri and Knuckey 1969; Notarbartolo di Sciara et al. 1993; Barberis et al. 1997; Scheinin et al. 2004a).

Age at sexual maturity varies geographically, and while there is no information specific to the Mediterranean Sea, 12 yrs is the age of maturity reported for bottlenose dolphins in the Croatian Adriatic (Pribanić et al. 2000). Gestation lasts roughly one year (Caldwell and Caldwell 1972). Calves typically remain with their mothers for 3 to 4 yrs or longer (Wells et al. 1987; Bearzi et al. 1997). A calving interval of two years has been suggested (Odell 1975). Bottlenose dolphins are flexible in their timing of reproduction. Calving seasons likely respond to seasonal patterns of local resource availability (Urian et al. 1996). There is no information specific to the western Mediterranean Sea, but in the adjoining Adriatic Sea, a peak calving period during summer (June through August) is reported (Bearzi et al. 1997).

Bottlenose dolphins are opportunistic feeders that utilize numerous strategies to prey upon a variety of fishes, cephalopods, and shrimps (Shane et al. 1986; Wells and Scott 1999). Bottlenose dolphins likely detect and orient to fishes by hearing sounds they produce (Barros and Myrberg 1987; Gannon and Waples 2004; Gannon et al. 2005). Nearshore bottlenose dolphins prey predominately on coastal fish and cephalopods, while offshore individuals prey on pelagic cephalopods and a large variety of epipelagic and mesopelagic fish species (Walker 1981). Mediterranean bottlenose dolphins have a mixed diet of cephalopods, fishes, and crustaceans (Astruc and Beaubrun 2005). Important prey species include hake (*Merluccius merluccius*) and blue whiting (*Micromesistius poutassou*) (Orsi Relini et al. 1994; Blanco et al. 2001); these species are also important prey for bottlenose dolphins off Portugal and northwestern Spain (Silva and Sequeira 1997; Santos et al. 2007). Bottlenose dolphins are often found near fish farms off northeastern Sardinia (Díaz López and Bernal Shirai 2007). Wild fish tend to aggregate near these fish farms allowing for concentration of bottlenose dolphin food resources (Díaz López et al. 2005). In the Adriatic Sea, bottlenose dolphins are often observed following fishing vessels (trawlers) and possibly feeding on discards (Bearzi et al. 1999). This species also associates with trammel nets of an artisanal fishery in Italy (Blasi and Pace 2006). It is unknown whether dolphins are depredating catches or actively preying on other fish predators (Fortuna 2006).

Navy bottlenose dolphins have been trained to reach maximum diving depths of about 300 m (Ridgway et al. 1969). Reeves et al. (2002b) noted that the presence of deep-sea fish in the stomachs of some individual offshore bottlenose dolphins suggests that they dive to depths of more than 500 m. A tagged individual near Bermuda had maximum recorded dives of 600 to 700 m and durations of 11 to 12 min (Klatsky et al. 2007). Dive durations up to 15 min have been recorded for trained individuals (Ridgway et al. 1969). Dive data from a tagged individual off Bermuda indicated a

possible diel dive cycle in search of mesopelagic prey in the deep scattering layer (Klatsky et al. 2007). Typical dives, however, are more shallow and of a much shorter duration.

Acoustics and Hearing—Sounds emitted by bottlenose dolphins have been classified into two broad categories: pulsed sounds (including clicks and burst-pulses) and narrow-band continuous sounds (whistles), which usually are frequency modulated. Clicks and whistles have a dominant frequency range of 110 to 130 kHz and a source level of 218 to 228 dB re: 1 μPa-m (Au 1993) and 3.4 to 14.5 kHz and 125 to 173 dB re: 1 μPa-m, respectively (Ketten 1998). Whistles are primarily associated with communication and can serve to identify specific individuals (i.e., signature whistles) (Caldwell and Caldwell 1965; Janik et al. 2006). Up to 52% of whistles produced by bottlenose dolphin groups with mother-calf pairs can be classified as signature whistles (Cook et al. 2004). Sound production is also influenced by group type (single or multiple individuals), habitat, and behavior (Nowacek 2005). Bray calls (low-frequency vocalizations; majority of energy below 4 kHz), for example, are used when capturing fishes, specifically sea trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*), in some regions (i.e., Moray Firth, Scotland) (Janik 2000). Additionally, whistle production has been observed to increase while feeding (Acevedo-Gutiérrez and Stienessen 2004; Cook et al. 2004). Furthermore, both whistles and clicks have been demonstrated to vary geographically in terms of overall vocal activity, group size, and specific context (e.g., feeding, milling, traveling, and socializing) (Jones and Sayigh 2002; Zaretsky et al. 2005; Baron, S., National Marine Fisheries Service-Southeast Fisheries Science Center, pers. comm., 31 August 2006). For example, preliminary research indicates that characteristics of whistles from populations in the northern Gulf of Mexico significantly differ (i.e., in frequency and duration) from those in the western North Atlantic Ocean (Zaretsky et al. 2005; Baron, S., National Marine Fisheries Service-Southeast Fisheries Science Center, pers. comm., 31 August 2006).

Bottlenose dolphins can typically hear within a broad frequency range of 0.04 to 160 kHz (Au 1993; Turl 1993). Electrophysiological experiments suggest that the bottlenose dolphin brain has a dual analysis system: one specialized for ultrasonic clicks and another for lower-frequency sounds, such as whistles (Ridgway 2000). Scientists have reported a range of highest sensitivity between 25 and 70 kHz, with peaks in sensitivity at 25 and 50 kHz (Nachtigall et al. 2000). Recent research on the same individuals indicates that auditory thresholds obtained by electrophysiological methods correlate well with those obtained in behavior studies, except at the some lower (10 kHz) and higher (80 and 100 kHz) frequencies (Finneran and Houser 2006).

Temporary threshold shifts (TTS) in hearing have been experimentally induced in captive bottlenose dolphins using a variety of noises (i.e., broad-band, pulses) (Ridgway et al. 1997; Schlundt et al. 2000; Nachtigall et al. 2003; Finneran and Schlundt 2004; Finneran et al. 2005; Mooney et al. 2005; Mooney, T.A., University of Hawaii, Marine Mammal Research Program, pers. comm., 29 August 2006; Breese et al. 2007). For example, TTS has been induced with exposure to a 3 kHz, one-second pulse with sound exposure level (SEL) of 195 decibels at the reference level of 1 micropascal-squared second (dB re: 1 $\mu Pa^2 s$) (Finneran and Schlundt 2004; Finneran et al. 2005), one-second pulses from 3 to 20 kHz at 192 to 201 dB re: 1 μPa-m (Schlundt et al. 2000), and octave band noise (4 to 11 kHz) for 50 minutes at 179 dB re: 1 μPa-m (Nachtigall et al. 2003). Preliminary research indicates that TTS and recovery after noise exposure are frequency dependent and that an inverse relationship exists between exposure time and sound pressure level associated with exposure (Mooney et al. 2005; Mooney, T.A., University of Hawaii, Marine Mammal Research Program, pers. comm., 29 August 2006). Observed changes in behavior were induced with an exposure to a 75 kHz one-second pulse at 178 dB re: 1 μPa-m (Ridgway et al. 1997; Schlundt et al. 2000). Finneran et al. (2005) concluded that a SEL of 195 dB re: 1 $\mu Pa^2 s$ is a reasonable threshold for the onset of TTS in bottlenose dolphins exposed to midfrequency tones. Breese et al. (2007) recently reported that TTS was frequency dependent and recovery time depended on shift and frequency, but with full recovery being relatively rapid, usually within 20 and always within 40 min. Breese et al. (2007) suggested that the bottlenose dolphin has a protective mechanism that reduces harmful physiological noise damage at shorter duration exposures.

Striped Dolphin (*Stenella coeruleoalba*)

Description—The striped dolphin is uniquely marked with black lateral stripes from eye to flipper and eye to anus. There is also a white V-shaped "spinal blaze" originating above and behind the eye and narrowing to a point below and behind the dorsal fin (Leatherwood and Reeves 1983). There is a dark cape and white belly. This is a relatively robust dolphin with a long, slender beak and prominent dorsal fin. This species reaches 2.6 m in length.

Status—The striped dolphin is listed as a species of lower risk (conservation dependent) on the IUCN Red List.[1] The Mediterranean subpopulation of this species was recently proposed to qualify as vulnerable based mainly on the substantial recent and ongoing mortality of this species in fishing gear and the residual effects of the large-scale die-off caused by an epizootic in the early 1990s (Reeves and Notarbartolo di Sciara 2006). Over 1,000 striped dolphins died during this epizootic outbreak which covered the entire western Mediterranean Sea and the Aegean and Ionian seas (Aguilar and Raga 1993; Cebrian 1995). Surveys conducted after the main epizootic outbreak estimated abundances of 117,880 and 217,806 striped dolphins for the western Mediterranean Sea, excluding the Tyrrhenian Sea (Forcada et al. 1994; Forcada and Hammond 1998). An average abundance of 15,778 striped dolphins was estimated specifically for central Spanish Mediterranean waters (Gómez de Segura et al. 2006). High densities of striped dolphins have been calculated in this area using line transect sampling and spatial modelling (Gómez de Segura et al. 2006; Gómez de Segura et al. 2007). Striped dolphin abundance in the Corso-Ligurian basin region has been estimated at 25,614 individuals (Forcada et al. 1995). No abundance estimates are available for the eastern Mediterranean Sea.

Genetic studies suggest that the Mediterranean and eastern North Atlantic populations of striped dolphins are isolated from each other with little or no genetic exchange through the Strait of Gibraltar (García-Martinez et al. 1996; Valsecchi et al. 2004). Regional variations in morphology, genetic structure, and the accumulation patterns of trace elements in the tissues of striped dolphins indicate that population subdivision may exist within the Mediterranean Sea (Calzada and Aguilar 1995; Monaci et al. 1998; Gaspari et al. 2004). In fact, recent genetic studies indicate that the western Mediterranean population may be further subdivided (Bourret et al. 2007). Gaspari et al. (2007) recently found evidence of genetic differentiation between striped dolphins in the Adriatic and Tyrrhenian seas as well as differentiation between striped dolphins found inshore verses offshore in the Tyrrhenian Sea. More studies, however, are needed to determine the population structure of striped dolphins in the Mediterranean Sea.

***Habitat Preference*s**—Striped dolphins are usually found beyond the continental shelf, typically over the continental slope out to oceanic waters and are often associated with convergence zones and waters influenced by upwelling (Au and Perryman 1985). In the eastern Pacific Ocean, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au and Perryman 1985; Reilly 1990). This species appears to avoid waters with sea temperatures of less than 20°C (Van Waerebeek et al. 1998).

In the Mediterranean Sea, striped dolphins are wide-ranging and generally prefer highly productive, open waters seaward of the shelf break (Notarbartolo di Sciara et al. 1993; Forcada et al. 1994; Cañadas et al. 2002; Frantzis et al. 2003; Gannier 2005b). They exhibit a strong preference for waters deeper than 1,000 m (Gordon et al. 2000; Gannier 2005b). They occur close to shore in some areas, such as southern Crete and in the Gulf of Corinth, where steep depressions and trenches are located near the coast (Frantzis et al. 2003). Visual and acoustic surveys in the western Mediterranean Sea suggest that striped dolphins may concentrate along the shelf break at night to feed and then move offshore during the day (Gannier 1999; Meissner and Ridoux 2006). They also feed in canyons and their extensions at dawn and during the evening (Cretton et al. 2003).

Distribution—The striped dolphin has a worldwide distribution in cool-temperate to tropical waters. In the eastern North Atlantic Ocean, this species is commonly found south of the U.K. along the coasts of France, Spain, and Portugal (Archer II and Perrin 1999). Striped dolphins are also found

throughout the Mediterranean Sea (Wilson et al. 1987); however, there are no records of this species in the Black Sea (G. Notarbartolo di Sciara 2002). They are rare in the Red Sea (Notarbartolo di Sciara et al. 2007).

- Information Specific to the Eastern Mediterranean Study Area—Striped dolphins are the most abundant cetaceans in the Mediterranean Sea, and they regularly occur throughout the eastern Mediterranean Sea year-round. Most records of this species in the eastern Mediterranean Sea have been reported off the coast of Israel (Goffman et al. 2000) and Turkey (Kinzelbach 1997; Öztürk and Öztürk 1998) and in the Greek Seas (Frantzis et al. 2003).

There is an area of primary occurrence for the striped dolphin seaward of the shelf break based on this species's preference for offshore waters (**Figure B-16**). Secondary occurrence is between the 100 m isobath and the shelf break which takes into account possible sightings in shallow shelf waters (e.g., Frantzis et al. 2003). Note that in many areas of the Mediterranean Sea the 100 m isobath is just beyond the shelf break. There is a rare occurrence for this species between the shoreline and the 100 m isobath due to the occasional occurrence of striped dolphins in narrow, shallow channels of the Mediterranean Sea (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006). For instance, Mayol (2004) mentions a small group of striped dolphins that were consistently sighted in shallow waters in a port in southern France for around two weeks. No seasonal differences in occurrence patterns are known for this species.

Behavior and Life History—Striped dolphins are typically found in groups numbering between 100 and 500 individuals although sometimes they gather in the thousands. Average group sizes in the Mediterranean Sea are generally less than 50 individuals (e.g., Azzali et al. 1994; Beaubrun et al. 1997; Forcada and Hammond 1998; Carpentieri et al. 1999; Forcada et al. 2004); however, groups of up to 400 dolphins are recorded here (Gannier 2005b). Larger groups tend to be found farther offshore (Gordon et al. 2000). Striped dolphins often associate with seabirds and other marine mammals (Baird et al. 1993). In the Mediterranean Sea, they are often found with common and Risso's dolphins (Forcada et al. 1994; Frantzis and Herzing 2002) and fin whales (Notarbartolo-di-Sciara et al. 2003).

Females in the Mediterranean Sea attain sexual maturity at an average of 12 yrs of age (Calzada et al. 1996). Calving in the northwestern Mediterranean Sea generally occurs during the late summer and fall with a peak around September and October (Aguilar 1991; Di-Méglio and Collet 1994). Frantzis et al. (2003) suggested that striped dolphins in the Greek Seas may have a calving peak at the end of July and the beginning of August, although births may also occur in late spring or early summer. Mediterranean striped dolphins have a typical calving interval of four years (Calzada et al. 1996).

Striped dolphins often feed in pelagic or benthopelagic zones along the continental slope or just beyond it in oceanic waters. A majority of their prey possesses luminescent organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 200 to 700 m to reach potential prey (Archer II and Perrin 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's (DSL's) diurnal vertical movements. Small, mid-water fishes (in particular, myctophids or lanternfish) and squids are the dominant prey (Perrin et al. 1994; Ringelstein et al. 2006). Important cephalopod species in the diet of Mediterranean striped dolphins include the common squid (*Loligo vulgaris*), flying squid (*Todarodes sagittatus*), Pfeffer's enope squid (*Abraliopsis pfefferi*), common clubhook squid (*Onychoteuthis banksii*), and common arm squid (*Brachioteuthis riisei*) (Blanco et al. 1995; Astruc and Beaubrun 2003). Bony fishes and occasionally crustaceans are also taken (e.g., Würtz and Marrale 1993; Meotti and Podestà 1997; Astruc and Beaubrun 2003).

Acoustics and Hearing—Zanardelli et al. (1990) reported on three sound types recorded from striped dolphins in the Ligurian and Tyrrhenian seas: (1) pure-tone, FM whistles; (2) burst-pulse sounds (variable pulse-rate click trains reaching 900 clicks/sec); and (3) echolocation clicks. Striped

dolphin whistles are variable in form and range from 6 to greater than 24 kHz, with dominant frequencies ranging from 8 to 12.5 kHz (Busnel et al. 1968; Zanardelli et al. 1990; Thode et al. 2000; Oswald et al. 2003).

A stranded, rehabilitated striped dolphin's hearing range using standard psycho-acoustic techniques, was determined to be from 0.5 to 160 kHz with best sensitivity at 64 kHz (Kastelein et al. 2003; Kastelein et al. 2006). In trying to obtain information on hearing capability from a different stranded individual, André et al. (2003; 2007) instead found evidence of deafness for that animal, noting that the data collected could not be considered a standard for the species.

- **Short-beaked Common Dolphin (*Delphinus delphis*)**

Description—Two species are currently recognized in the genus *Delphinus*: the long-beaked common dolphin (*Delphinus capensis*) and the short-beaked common dolphin (Heyning and Perrin 1994; Rosel et al. 1994). A third species, the Indian Ocean common dolphin (*Delphinus tropicalis*), was proposed (e.g., Rice 1998), though as noted by Perrin (2002), the taxonomic status is still uncertain. Jefferson and Waerebeek (2002) instead proposed that this was actually a subspecies of the long-beaked common dolphin (*Delphinus capensis tropicalis*); this appears to be the favored interpretation by cetacean taxonomists (Jefferson, T.A., National Marine Fisheries Service–Southwest Fisheries Science Center, pers. comm., 3 May 2007). The short-beaked common dolphin is the only *Delphinus* species expected to occur in the Study Area; therefore, all references to "common dolphins" throughout this report are understood to mean this species.

Delphinus are moderately-robust dolphins with a moderate-length beak and a tall, slightly falcate dorsal fin. The short-beaked common dolphin has a beak that is shorter than in long-beaked common dolphins, and the melon rises from the beak at a steeper angle (Heyning and Perrin 1994). *Delphinus* are distinctively marked with a V-shaped saddle caused by a dip in the cape below the dorsal fin, yielding an hourglass pattern on the side of the body (Jefferson et al. 1993). The back is dark brownish-gray, the belly is white, and the anterior flank patch is tan to cream in color. The lips are dark, and there is a dark stripe from the eye to the apex of the melon and another one from the chin to the flipper (the latter is diagnostic to the genus). There are often variable light patches on the flippers and dorsal fin. Length ranges up to about 2.3 m (females) and 2.6 m (males); however, there is substantial geographic variation (Jefferson et al. 1993). Mediterranean common dolphins have an intermediate size for the species (maximum 2.1 m for males and 2.2 for females) (Heyning and Perrin 1994).

Status—The common dolphin is designated as a species of lower risk (least concern) on the IUCN Red List.[1] However, the Mediterranean subpopulation of this species is listed as endangered.[4] The Black Sea subspecies (*Delphinus delphis ponticus*), which possibly includes individuals from the northern Aegean Sea, has recently been proposed to qualify for listing as endangered (Reeves and Notarbartolo di Sciara 2006).

The common dolphin was once one of the most abundant cetacean species in the Mediterranean Sea; however, over the past 30 to 50 yrs, the Mediterranean subpopulation has declined dramatically (Bearzi et al. 2003). Possible causes of this decline include contaminants, increased water temperatures, incidental mortality in fishing gear, and reduced prey availability (Bearzi et al. 2003). There are currently no abundance estimates for common dolphins in the Mediterranean Sea; however, 14,736 common dolphins are estimated for the whole Alboran Sea and Gulf of Vera based on summer shipboard survey data collected during the summers of 1991 (August and September) and 1992 (June) (Forcada and Hammond 1998). Cañadas (2006) estimated 19,428 common dolphins for the northern Alboran Sea and Gulf of Vera during summers between 2000 and 2004 and observed a seasonal shift in higher densities towards deeper water in winter, which is possibly a response to a change in prey availability. Common dolphins are relatively abundant around the Maltese Islands; high densities have been calculated in this region based on data from shipboard and aerial surveys between 1997 and 2003 (Vella 2005).

Not much is known about the population structure of common dolphins in the Mediterranean Sea. Genetic studies indicate limited gene flow between populations in the western and eastern basins (Natoli et al. 2005b). There is evidence of a significant level of divergence between Mediterranean and Atlantic populations (Natoli et al. 2004b), with limited genetic exchange between the eastern North Atlantic population and the Alboran Sea population (Natoli et al. 2004b). Recent genetic studies indicate that some level of gene flow may exist between populations from the Black Sea, the Canary Islands, and the eastern North Atlantic Ocean (Amaral et al. 2007). More studies are needed to determine the relationship between common dolphins in the Mediterranean and the Black seas.

Habitat Preferences—*Delphinus* occupy a variety of habitats, including shallow continental shelf waters, waters along the continental shelf break, and continental slope and oceanic areas. They often occur over prominent underwater topography (Hui 1979; Evans 1994; Bearzi 2005). Common dolphin occurrence has been associated with warm SSTs (12.3°C) in the eastern North Atlantic Ocean (MacLeod et al. 2007). In tropical regions, *Delphinus* spp. are routinely sighted in upwelling-modified (or otherwise high productivity) waters (Au and Perryman 1985; Ballance and Pitman 1998).

In the Mediterranean Sea, common dolphin habitat ranges from extremely coastal areas to deep, offshore waters. Common dolphins along the western shore of Greece in the Ionian Sea are often sighted in shallow waters (bottom depth <200 m) and within a few 100 m from shore (Politi et al. 1992; Notarbartolo di Sciara, G., pers. comm., 1 June 2007). Most observations of this species in the Greek Seas are from shallow, coastal areas (Frantzis et al. 2003). In other regions of the Mediterranean Sea, common dolphins typically occur in slope and offshore waters (less than 1,000 m) (Franco et al. 1995; Gannier 1998b; García et al. 2000; Cañadas et al. 2002; Gannier 2005b). For instance, common dolphins in the Alboran Sea exhibit a preference for slope waters (100 to 400 m in depth) and deep waters (800 to 1,200 m) (Cañadas 2006). Sightings in waters with a maximum bottom depth of 1,300 m have been recorded (Franco et al. 1995; Cañadas et al. 2002). In the southeastern Tyrrhenian Sea, common dolphins are sighted over the submarine canyon of Cuma, an area of high productivity (Mussi et al. 2002; Mussi and Miragliuolo 2005).

Distribution—*Delphinus* are widely distributed in temperate, subtropical, and tropical seas from about 40 to 60°N to about 50°S (Jefferson et al. 1993; Heyning and Perrin 1994). The short-beaked common dolphin occurs from southern Norway to West Africa in the eastern Atlantic Ocean (including the Mediterranean and Black seas) (Perrin 2002). Some studies suggest that this species increases in abundance southward of 38°N in the Mediterranean Sea (Notarbartolo di Sciara et al. 1993; Politi et al. 1994; Frantzis et al. 2004b). In the eastern North Atlantic Ocean, the common dolphin mainly occurs south of 60°N (Reid et al. 2003). The long-beaked common has a disjunct distribution in the Atlantic Ocean, occurring in the waters of West Africa in the east and from Venezuela to Argentina in the west, as well as in the Indo-Pacific oceans (Jefferson and Van Waerebeek 2002; Perrin 2002). *Delphinus capensis tropicalis* occurs in the Red Sea (Smeenk et al. 1996; Jefferson and Van Waerebeek 2002; Notarbartolo di Sciara et al. 2007).

- Information Specific to the Eastern Mediterranean Study Area—Common dolphins occur in the Study Area year-round. They are seasonally abundant around the Maltese Islands, particularly in September and October (Vella 2005). Common dolphins are frequently sighted in the eastern Ionian Sea, predominantly in the Gulf of Corinth (Frantzis and Herzing 2002) and around the island of Kalamos where this species exhibits high levels of site fidelity (Politi et al. 1992). Based on sighting and stranding data, this species is also common in the Aegean Sea, particularly around the Northern Sporades Islands (Frantzis 1997), around the Dodecanese Islands (Carpentieri et al. 1999; Frantzis et al. 2003; Notarbartolo di Sciara, G., pers. comm., 16 June 2007), along the coast of Turkey (Öztürk and Öztürk 1998), and in the Saronic and South Evvoikos gulfs (Frantzis et al. 2003). Common dolphins are locally abundant in the Thracian Sea which is part of the northern Aegean Sea (Frantzis et al. 2004b). There are also sporadic records of this species off the coast of Israel (Goffman et al. 2000; Scheinin et al. 2004a). Reliable data on the occurrence of common dolphins in the rest of the eastern Mediterranean Sea is scarce. As noted earlier, *Delphinus capensis tropicalis* occurs in the Red Sea (Smeenk et al. 1996; Jefferson and Van Waerebeek 2002; Notarbartolo di Sciara et al. 2007). Therefore, it should be noted that it

is possible, though it has not been confirmed, that individuals from that region could make their way into the Mediterranean Sea via the Suez Canal, as humpback dolphins have on rare occasions.

There is an area of primary occurrence for common dolphins throughout the entire eastern Mediterranean Sea (**Figure B-17**). Occurrence is based on this species's preference for variable habitats which include extremely coastal and offshore waters of the Mediterranean Sea (Bearzi et al. 2003). No seasonal differences in occurrence patterns are anticipated for this species.

Behavior and Life History—The common dolphin is a very gregarious species; group sizes range from several dozen to over 10,000 individuals. In the Mediterranean Sea, groups of 50 to 70 individuals are generally observed (Notarbartolo di Sciara et al. 1993; Mussi et al. 2002; Vella 2005); however, group sizes tend to be much smaller (less than 15) in some areas such as the eastern Ionian Sea (Politi et al. 1992; Bearzi et al. 2005). There is some evidence that a community of common dolphins in the eastern Ionian Sea exhibits a highly fluid social system (Bruno et al. 2004). In the Mediterranean Sea, associations with striped dolphins have been recorded in the Gulf of Corinth, Alboran Sea, and southern Tyrrhenian Sea (García et al. 2000; Frantzis and Herzing 2002; Mussi et al. 2002). Common dolphins have also been sighted with Risso's dolphins, long-finned pilot whales, and bottlenose dolphins (Notarbartolo di Sciara et al. 1993; Cañadas et al. 2002; Frantzis and Herzing 2002; Podiadis et al. 2006).

Calving peaks differ among stocks (Jefferson et al. 1993); in the eastern North Atlantic Ocean it has been reported to be between May and September (Murphy et al. 2005). Di Natale (1983a) reports calving peaks during spring and summer in the Mediterranean Sea. Ages of sexual maturity in common dolphins vary regionally. Males in the eastern North Atlantic Ocean reach sexual maturity at about 11 to 12 yrs of age and 9 yrs for females (Murphy et al. 2005; Murphy and Rogan 2006). Ages of sexual maturity of common dolphins from the Black Sea are around three and four years for males and females, respectively (Perrin 2002). Gestation is approximately 11 months, with mating occurring between May to September in the eastern North Atlantic Ocean (Murphy et al. 2005; Murphy and Rogan 2006).

Common dolphins feed on a wide variety of epipelagic and mesopelagic schooling fishes and squids associated with the DSL. They feed opportunistically on those species most abundant locally and change their diet according to fluctuations in the abundance and availability of prey (Young and Cockcroft 1994). In the Mediterranean Sea, anchovies and sardines are important prey (Agazzi et al. 2004; Agazzi and Bearzi 2005), with Atlantic saury (*Scomberesox saurus*) and cephalopods also taken (Boutiba and Abdelghani 1995; Mussi et al. 2002). Orsi Relini and Relini (1993) examined stomach contents of three individuals caught in fishing gear and reported that in addition to fishes and cephalopods, pelagic shrimp (decapod crustaceans) such as the pink glass shrimp (*Pasiphaea multidentata)* and scarlet sergestid (*Sergia robusta*) are also taken. Diel fluctuations in vocal activity of this species (more vocal activity during late evening and early morning) appear to be linked to feeding on the DSL as it rises (Goold 2000). Common dolphins in the Mediterranean Sea often engage in surface feeding (Ferretti et al. 1999; Agazzi et al. 2004). Foraging dives to 200 m in depth were recorded off southern California (Perrin 2002). Recent evidence of common dolphin associations with fisheries is scarce, possibly due to the decline in abundance of this species (Bearzi et al. 2003); however, common dolphins are known to depredate on anchovy gillnets in the Ligurian Sea. Cooperative fishing between common dolphins and local fishermen in the Gulf of Naples has been reported since the 20th century (Bearzi et al. 2003).

Acoustics and Hearing—Recorded *Delphinus* spp. vocalizations include whistles, chirps, barks, and clicks (Ketten 1998). Clicks range from 0.2 to 150 kHz with dominant frequencies between 23 and 67 kHz and estimated source levels of 170 dB re: 1μPa-m. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 24 kHz (Fish and Turl 1976; Thomson and Richardson 1995; Ketten 1998; Oswald et al. 2003; Ansmann et al. 2007). Maximum source levels are approximately 180 dB 1 μPa-m (Fish and Turl 1976).

This species's hearing range extends from 10 to 150 kHz; sensitivity is greatest from 60 to 70 kHz (Popov and Klishin 1998).

- **Indo-Pacific Humpback Dolphin (*Sousa chinensis*)**

Description—Indo-Pacific humpback dolphins are moderate-sized dolphins, growing to a maximum length of about 2.8 m and weights of 250 to 280 kg (Ross et al. 1994; Jefferson and Karczmarski 2001). They are relatively robust but have a long, slender beak. Although the beak is well-defined from the forehead, there is generally no crease between the two. The dorsal fin ranges from wide-based and slightly falcate (generally in the eastern portions of the species's range) to very small and falcate; it sits atop a massive hump of connective tissue (in the western part of the range) (see Jefferson and Karczmarski 2001). Coloration is similarly variable, ranging from dark gray on the back and sides and slightly lighter below (with calves lighter than adults) in the western Indian Ocean to largely white, often with some spotting (calves are darker than adults) in the eastern Indian and western Pacific oceans (Ross et al. 1994; Jefferson and Karczmarski 2001).

Status—The taxonomy of the genus *Sousa* continues to be in a state of disarray. Although Rice (1998) recognized three species, only two are currently recognized by the IWC (IWC 2006) (see also Jefferson and Van Waerebeek 2002); however, a more definitive answer awaits the completion of an extensive molecular genetic study currently in progress (Jefferson, T., National Marine Fisheries Service–Southwest Fisheries Science Center, pers. comm., 9 July 2006).

The Indo-Pacific humpback dolphin is designated as data deficient on the IUCN Red List.[1] Few estimates of abundance are available for this species; there are even fewer reliable indications of population status or trends (see review in Jefferson and Karczmarski 2001). There are no estimates of abundance for the Red Sea.

Habitat Preferences—Indo-Pacific humpback dolphins are found virtually exclusively over the continental shelf. These dolphins primarily inhabit waters within a few kilometers of land and with a bottom depth less than 20 m; in fact, bottom depth is probably the main factor limiting their offshore distribution (Jefferson and Karczmarski 2001). Some populations favor specific habitats, such as sandy beaches, enclosed bays, coastal lagoons, mangrove swamps, sea grass meadows, and rocky or even coral reefs, but turbid estuaries appear to be almost universally favored (Jefferson and Karczmarski 2001).

Distribution—The Indo-Pacific humpback dolphin is found in coastal waters of the Indian and western Pacific oceans from at least central Australia and southern China in the east to South Africa in the west (Ross et al. 1994; Jefferson and Karczmarski 2001). The range includes the Red Sea, Persian Gulf, Gulf of Thailand, and other shallow coastal seas but does not extend into deep, offshore waters or to most oceanic archipelagoes. This species appears to occur as a series of more-or-less distinct coastal populations, often centered around river mouths and extending some distance up the associated estuaries.

- <u>Information Specific to the Eastern Mediterranean Study Area</u>—The Indo-Pacific humpback dolphin does not normally occur in the Mediterranean Sea (or anywhere in the adjacent North Atlantic Ocean). There is, however, one reported case of a single humpback dolphin that was seen several times during January 2000 off the Mediterranean coast of Israel (Kerem et al. 2001). This individual is thought to have moved into the area from the Red Sea through the Suez Canal and undoubtedly represents an extralimital wandering. Kerem et al. (2001) also discussed an earlier report by W.J.F. Morzer-Bruyns (cited in Marchessaux 1980) of a humpback dolphin observed near the harbor of Port Said, Egypt, which indicates that such occurrences may happen infrequently.

  There is a rare occurrence of the Indo-Pacific humpback dolphin along the continental shelf in the area within approximately 300 to 500 km of the mouth of the Suez Canal (**Figure B-18**). This is based on the previously-mentioned extralimital sightings and takes into consideration the coastal

habits of this species (Jefferson and Karczmarski 2001). No seasonality in occurrence is anticipated for this species.

Behavior and Life History—Most groups of Indo-Pacific humpback dolphins are relatively small (<25 individuals); they are most often composed of less than 10 animals (Jefferson and Karczmarski 2001). It is not uncommon to see single individuals, but groups of up to 100 have also been sighted (Parsons 2004). Generally, groups are composed of a variety of different age and sex classes, with adults usually making up one-half to two-thirds of larger groups (Saayman and Tayler 1979; Karczmarski 1999; Jefferson 2000). In most areas, group structure is highly fluid, resembling the fission/fusion society of bottlenose dolphins (Karczmarski 1999; Jefferson 2000), but in at least one area, Maputa Bay, Mozambique, social structure seems to be more rigid (Guissamulo and Cockcroft 2004).

Life history of humpback dolphins has only been studied in detail in two areas: South Africa and southern China. Calving in this tropical/subtropical species generally occurs throughout the year, but with a peak in spring and/or summer (Cockcroft 1989; Jefferson 2000). Female dolphins become sexually mature at about 9 to 10 yrs of age, with males probably maturing a few years later (Cockcroft 1989). Feeding habits have only been studied in detail in three areas: southern Africa, Australia, and southern China (see Jefferson and Karczmarski 2001). These dolphins feed on a wide variety of prey that includes fishes, cephalopods, and crustaceans. Interactions with coastal fishing operations tend to be common, particularly with trawlers (Corkeron 1990; Jefferson 2000).

There is very little information available on diving habits of this species as they have never been tagged with time/depth recording devices. Because of the shallow waters where they generally live, dives deeper than about 20 to 30 m would likely be rare (Jefferson, T., National Marine Fisheries Service–Southwest Fisheries Science Center, pers. comm., 9 July 2006). Some dives may last as long as 4 to 5 min, but most surface intervals are much shorter (generally <1 min) (Pilleri and Gihr 1972; Karczmarski and Cockcroft 1999; Jefferson 2000).

Acoustics and Hearing—Van Parijs and Corkeron (2001) classified Indo-Pacific humpback dolphin vocalizations into five different categories: broad band clicks, barks, quacks, grunts, and whistles. Broad band clicks were high in frequency (8 kHz to >22 kHz), and they were directly related to foraging behavior; these clicks may also play a role in social behavior. “Barks” and “quacks” were burst pulse sounds (frequency: 0.6 kHz to >22 kHz, duration: 0.1 ± 8 sec) and were associated with both foraging and social behavior. The “grunt” vocalization is a low frequency narrow-band sound (frequency 0.5 ± 2.6 kHz, duration 0.06 ± 2 sec) and was only heard during socializing. Seventeen different whistle types (with two being predominant) were recorded (Van Parijs and Corkeron 2001). Whistles have a frequency range of 0.9 to 22 kHz (Schultz and Corkeron 1994; Van Parijs and Corkeron 2001). Goold and Jefferson (2004) recorded Indo-Pacific humpback dolphin clicks with a broadband energy of up to at least 200 kHz.

There are no empirical data on the hearing ability of this species; however, the most sensitive hearing range for odontocetes generally includes high frequencies (Ketten 1997).

- **Risso’s Dolphin (*Grampus griseus*)**

Description—Risso’s dolphins are moderately large, robust animals reaching at least 3.8 m in length (Jefferson et al. 1993). The head is blunt and squarish without a distinct beak, and there is a vertical crease on the front of the melon. The dorsal fin is very tall and falcate. Young Risso’s dolphins range from light gray to dark, brownish gray and are relatively unmarked (Jefferson et al. 1993). Adults range from dark gray to nearly white and are heavily covered with white scratches and splotches.

Status—The Risso’s dolphin is listed as data deficient on the IUCN Red List.[1] Risso’s dolphins in the Mediterranean Sea are genetically distinct from the eastern North Atlantic population and, therefore, constitute a distinct population (Gaspari et al. 2006). There are no large-scale abundance estimates for Risso’s dolphins in the Mediterranean Sea; however, Gómez de Segura et al. (2006) estimated an

average abundance of 493 Risso's dolphins (estimated density of 0.015 dolphins per km^2) in the central Spanish Mediterranean waters between 2001 and 2003 based on aerial surveys. Estimates of 242 and 267 individuals have been calculated from mark-recapture surveys (based on photo-identification efforts) of Risso's dolphins in the Ligurian Sea between 1998 and 2000 (Airoldi et al. 2005).

Habitat Preferences—Several studies have noted that Risso's dolphins are found offshore, along the continental slope, and over the continental shelf (CETAP 1982; Green et al. 1992; Baumgartner 1997; Davis et al. 1998; Mignucci-Giannoni 1998; Kruse et al. 1999; Cañadas et al. 2002). Risso's dolphins are also found over submarine canyons, such as the Cuma submarine canyon in the southern Tyrrhenian Sea (Mussi et al. 2004). Sightings of Risso's dolphins in the northwestern Mediterranean Sea generally occur in waters with a bottom depth between 70 and 2,700 m with an average depth of approximately 1,000 m (Di-Meglio et al. 1999; Airoldi et al. 2000). Baumgartner (1997) hypothesized that the fidelity of Risso's dolphins to the steeper portions of the upper continental slope in the Gulf of Mexico is most likely the result of cephalopod prey distribution in the same area. This is likely also true in the Mediterranean Sea where Risso's dolphins exhibit a preference for middle slope waters between 600 and 800 m in bottom depth (Blanco et al. 2006).

While Risso's dolphins typically prefer continental slope waters, they have an extensive distribution in the western Mediterranean Sea and are often sighted much farther offshore possibly while traveling between feeding areas (Casacci and Gannier 2000). In the Mediterranean Sea, the abundance of Risso's dolphins is concentrated in the Ligurian-Corso-Provencal basin where the continental shelf is close to the coast (Reeves and Notarbartolo di Sciara 2006). Leatherwood et al. (1979) and Shane (1994) reported sightings of Risso's dolphins in shallow northeastern Pacific waters near oceanic islands, where the shelf is narrow and deep water is closer to the shore (Leatherwood et al. 1979; Gannier 2000, 2002a).

Distribution—Risso's dolphins are distributed worldwide in cool-temperate to tropical waters from roughly 60ºN to 60ºS, where sea-surface temperatures are generally greater than 10ºC (Kruse et al. 1999). Changes in the local distribution and abundance of Risso's dolphins occur occasionally (Kruse et al. 1999). For instance, water temperature appears to affect Risso's dolphin distributions in the Pacific Ocean, with local distributional shifts occurring off California during El Niño periods when protracted warm-water events occur (Shane 1994; Kruse et al. 1999).

- Information Specific to the Eastern Mediterranean Study Area—This species is regularly found throughout the Mediterranean Sea year-round. In contrast to the western Mediterranean Sea, there are relatively fewer records of Risso's dolphins in the eastern Mediterranean Sea (e.g., Kinzelbach 1986; Carpentieri et al. 1999; Goffman et al. 2000; Shoham-Frider et al. 2002; Frantzis et al. 2004b). The paucity of records of this species in the eastern Mediterranean Sea is likely due to the lack of survey effort in this region (Reeves and Notarbartolo di Sciara 2006).

  Primary occurrence for the Risso's dolphin is between the shelf break and the 2,000 m isobath throughout the eastern Mediterranean Sea (**Figure B-19**). This is based on this species's preference for deep, offshore waters over the shelf break and continental slope. There is an area of secondary occurrence seaward of the 2,000 m isobath and between the 100 m isobath and the shelf break to account for possible sightings in these areas. Rare occurrence is from the shoreline to the 100 m isobath. No seasonal differences in occurrence are anticipated for this species.

Behavior and Life History—Little is known about the life history of this species. In the North Atlantic Ocean, there appears to be a summer calving peak (Jefferson et al. 1993); this may also be true for the Mediterranean Sea (Podesta et al. 1997). Risso's dolphins are quite social; groups usually average about 30 individuals but can range up to over several hundred (Kruse et al. 1999) or even several thousand (CETAP 1982). Average group sizes recorded in the Mediterranean Sea are typically less than 20 individuals (e.g., Podesta et al. 1997; Mussi et al. 1998; Carpentieri et al. 1999; Airoldi et al. 2000; Cañadas et al. 2005).

Risso's dolphins form relatively stable, age- and sex-segregated groups, which interact fluidly within a larger population (e.g., Gaspari et al. 2000). This species commonly associates with other cetacean species, especially smaller delphinid species (CETAP 1982; Frantzis and Herzing 2002; Podiadis et al. 2006).

Individuals may remain submerged on dives up to 30 min and dive as deep as 600 m (DiGiovanni et al. 2005). Cephalopods are the primary prey (Clarke 1996). The flying squid (*Todarodes sagittatus*), long finned squid (*Loligo forbesii*), and reverse jewell squid (*Histioteuthis reversa*) are popular prey species for Mediterranean Risso's dolphins (Würtz et al. 1992; Bello and Bentivegna 1994). Pelagic octopods, such as the common paper nautilus (*Argonauta argo*), have also been identified as a prey species in the Mediterranean Sea (Blanco et al. 2006).

Acoustics and Hearing—Risso's dolphin sounds include broadband clicks, barks, buzzes, grunts, chirps, whistles, and combined whistle and burst-pulse sounds that range in frequency from 0.4 to 22 kHz and in duration from less than a second to several seconds (Corkeron and Van Parijs 2001). The combined whistle and burst pulse sound (2 to 22 kHz, mean duration of 8 sec) appears to be unique to the species (Corkeron and Van Parijs 2001). Risso's dolphins also produce echolocation clicks (40 to 70 µsec duration) with a dominant frequency range of 50 to 65 kHz and estimated source levels up to 222 dB re: 1 µPa-m peak-to-peak (Thomson and Richardson 1995; Philips et al. 2003; Daziens 2004; Madsen et al. 2004). Impetuoso et al. (2001) recorded Risso's dolphin vocalizations in waters around Ischia Island (Italy) as having a peak frequency of 400 Hz.

Baseline research on the hearing ability of this species was conducted by Nachtigall et al. (1995) in a natural setting (included natural background noise) using behavioral methods on one older individual. This individual could hear frequencies ranging from 1.6 to 100 kHz and was most sensitive between 8 and 64 kHz. Recently, the auditory brainstem response technique has been used to measure hearing in a stranded infant (Nachtigall et al. 2005; 2007). This individual could hear frequencies ranging from 4 to 150 kHz, with best sensitivity at 90 kHz. This study demonstrated that this species can hear higher frequencies than previously reported.

- **False Killer Whale (*Pseudorca crassidens*)**

Description—The false killer whale is a large, dark gray to black dolphin with a faint gray patch on the chest and sometimes light gray areas on the head (Jefferson et al. 1993). The false killer whale has a long slender body, a rounded overhanging forehead, and little or no beak (Jefferson et al. 1993). The dorsal fin is falcate and slender. The flippers have a characteristic hump on the S-shaped leading edge—this is perhaps the best characteristic for distinguishing this species from the other "blackfish" (an informal grouping that is often taken to include pygmy killer, melon-headed, and pilot whales; Jefferson et al. 1993). Individuals reach maximum lengths of 6.1 m (Jefferson et al. 1993).

Status—The false killer whale is listed as a species of lower risk (least concern) on the IUCN Red List.[1] There are no abundance estimates available for this species in the North Atlantic or Mediterranean Sea.

Habitat Preferences—This species is found primarily in oceanic and offshore areas, although they do approach close to shore at some places like oceanic islands (Baird 2002), in the inshore waters of Washington State and British Columbia (Baird et al. 1989), the coast and estuaries of China (Zhou et al. 1982), the Marquesas Islands of French Polynesia (Gannier 2002a), and Lembata Island of the Indonesian archipelago (Rudolph et al. 1997). Inshore movements are occasionally associated with movements of prey and shoreward flooding of warm ocean currents (Stacey et al. 1994). In the Mediterranean Sea, false killer whales primarily occur in deep waters but are also found over steep slope areas and shelf waters (G. Notarbartolo di Sciara 2002).

Distribution—False killer whales are found in tropical and temperate waters, generally between 50°S and 50°N latitude with a few records north of 50°N in the Pacific and the Atlantic oceans (Baird et al.

1989; Odell and McClune 1999). False killer whales occasionally occur in the Mediterranean Sea but are absent from the Black Sea (Reeves and Notarbartolo di Sciara 2006).

- Information Specific to the Eastern Mediterranean Study Area—False killer whales rarely occur in the Study Area. There are confirmed records of this species off the coasts of Croatia, Greece, Italy, Egypt, Israel, Malta, Syria, and Turkey in the eastern Mediterranean Sea (e.g., Hirtz 1937; Wassif 1956; Paulus 1963; Centro Studi Cetacei 1990; Kasparek 1997; Öztürk and Öztürk 1998; Frantzis et al. 2003; Scheinin et al. 2004b; Reeves and Notarbartolo di Sciara 2006). The record from Egypt was of a skull found two miles north of Baltim near the Nile's Delta (Wassif 1956). No exact date is given but the report was received in September 1955. No exact location is given for the Malta record; therefore, this record is also not included in **Figure B-20**. Individuals may stray into the Mediterranean Sea through the Strait of Gibraltar or also possibly from the Red Sea through the Suez Canal (G. Notarbartolo di Sciara 2002).

  There is an area of primary occurrence for the false killer whale seaward of the shelf break throughout the eastern Mediterranean Sea (**Figure B-20**). This is based on the wide range of habitat preferences of this species (Jefferson, T.A., National Marine Fisheries Service–Southwest Fisheries Science Center, pers. comm., 2-5 October 2006). Secondary occurrence is between the shoreline and the shelf break. No seasonal differences in occurrence are anticipated for this species.

Behavior and Life History—False killer whales may occur in groups as large as 1,000 individuals (Cummings and Fish 1971), although groups of less than 100 are most common. Group sizes of around 20 individuals have been recorded off the coast of Israel (Kerem and Goffman 2004). No breeding seasons are known for false killer whales (Jefferson et al. 1993). Gestation is estimated to be 15 to 16 months, followed by an 18 to 24 month period before weaning (Leatherwood et al. 1989). Sexual maturity is reached after 8 to 14 yrs (Leatherwood et al. 1989). Few diving data are available, although individuals are documented to dive as deep as 500 m (Odell and McClune 1999). Shallower dive depths (maximum of 53 m; averaging from 8 to 12 m) have been recorded for false killer whales in Hawaiian waters; this behavior is likely a result of surface-oriented prey, such as common dolphinfish (*Coryphaena hippurus*) and yellow fin tuna (*Thunnus albacares*) (Ligon and Baird 2001). Deepwater cephalopods and fishes are their primary prey (Odell and McClune 1999), but large pelagic species, such as common dolphinfish, have been taken. False killer whales also take tuna from longlines (e.g., Mitchell 1975; Baird and Gorgone 2005). They have been observed preying on bluefin tuna caught on fishery hooks in the Strait of Messina (Scordìa 1939; Orsi Relini and Cagnolaro 1996). This account was initially thought to be of long-finned pilot whales; however, Orsi Relini and Cagnolaro (1996) determined that it was actually false killer whales that attacked the tuna based on morphological evidence from one of the attacking whales. Occasional attacks on marine mammals such as other delphinids, (Perryman and Foster 1980; Stacey and Baird 1991), sperm whales (Palacios and Mate 1996), and baleen whales (Hoyt 1983; Jefferson 2006) have been observed.

Acoustics and Hearing—Dominant frequencies of false killer whale whistles are from 4 to 9.5 kHz, and those of their echolocation clicks are from either 20 to 60 kHz or 100 to 130 kHz depending on ambient noise and target distance (Thomson and Richardson 1995). Click source levels typically range from 200 to 228 dB re: 1 μPa-m (Ketten 1998). Recently, false killer whales recorded in the Indian Ocean produced echolocation clicks with dominant frequencies of about 40 kHz and estimated source levels of 201-225 dB re: 1 μPa-m (Madsen et al. 2004).

False killer whales can hear frequencies ranging from approximately 2 to 115 kHz with best hearing sensitivity ranging from 16 to 64 kHz (Thomas et al. 1988). Additional behavioral audiograms of false killer whales support a range of best hearing sensitivity between 16 and 24 kHz, with peak sensitivity at 20 kHz (Yuen et al. 2005). The same study also measured audiograms using the ABR technique, which came to similar results, with a range of best hearing sensitivity between 16 and 22.5 kHz, peaking at 22.5 kHz (Yuen et al. 2005). Behavioral audiograms in this study consistently resulted in lower thresholds than those obtained by ABR.

- **Killer Whale (*Orcinus orca*)**

Description—Killer whales are probably the most instantly-recognizable of all the cetaceans. The black-and-white color pattern of the killer whale is striking, as is the tall, erect dorsal fin of the adult male (1.0 to 1.8 m in height). The white oval eye patch and variably-shaped saddle patch, in conjunction with the shape and notches in the dorsal fin, help in identifying individuals. The killer whale has a blunt head with a stubby, poorly-defined beak and large, oval flippers. Females may reach 7.7 m in length and males 9.0 m (Dahlheim and Heyning 1999). This is the largest member of the dolphin family.

Status—This species is designated as lower risk (conservation dependent) on the IUCN Red List.[1] Reeves and Notarbartolo di Sciara (2006) proposed that the Strait of Gibraltar subpopulation qualifies for listing as critically endangered. There are no abundance estimates available for the killer whale in the Mediterranean Sea; however, there are three pods that make up the Strait of Gibraltar subpopulation with about 32 individuals total in the Strait of Gibraltar based on photo-identification efforts since 1999 (de Stephanis et al. 2005; Reeves and Notarbartolo di Sciara 2006). It is possible that a few more individuals are present in the population and have not been photo-identified, but it is very unlikely that the total number of animals using the Strait of Gibraltar is greater than 50 individuals (Reeves and Notarbartolo di Sciara 2006). There is no information available on whether the Strait of Gibraltar subpopulation is genetically distinct from killer whales occurring in the wider eastern North Atlantic Ocean (Notarbartolo di Sciara, Tethys Research Institute, pers. comm., 12 July 2007).

Habitat Preferences—Killer whales have been observed in virtually every marine habitat from the tropics to the poles and from shallow, inshore waters (and even rivers) to deep, oceanic regions (Dahlheim and Heyning 1999). In coastal areas, killer whales often enter shallow bays, estuaries, and river mouths (Leatherwood et al. 1976). Based on a review of historical sighting and whaling records, killer whales in the eastern North Atlantic Ocean are found most often in oceanic waters (Hammond and Lockyer 1988). In the Strait of Gibraltar, killer whales are seen in waters with a bottom depth ranging from 20 to 300 m (de Stephanis 2005).

Distribution—This is a cosmopolitan species found throughout all oceans and contiguous seas, from equatorial regions to the polar pack ice zones of both hemispheres. Although found in tropical waters and the open ocean, killer whales as a species are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999). The killer whale is widely distributed in eastern North Atlantic waters mainly around Iceland, the Lofoten Islands and off Andenes in western Norway, and in northern Scotland (Hammond and Lockyer 1988; Weir 2002; Reid et al. 2003). They are occasionally seen south to the Iberian Peninsula, Azores, Madeira, and rarely into the Mediterranean Sea, with regular occurrence in the Strait of Gibraltar (Reid et al. 2003).

- Information Specific to the Study Area for the Eastern Mediterranean MRA—Killer whales are only sporadically reported within the Mediterranean Sea itself (Casinos and Filella 1981; Raga et al. 1985; Notarbartolo-di-Sciara 1987; Hammond and Lockyer 1988; G. Notarbartolo di Sciara, ed. 2002; Reeves and Notarbartolo di Sciara 2006). The killer whale is extralimital to the eastern Mediterranean Sea and, therefore, has a rare occurrence throughout the Study Area year-round (**Figure B-21**). It is not known from where killer whales come that have been occasionally seen in the Mediterranean Sea, and although it is likely that they come from the Strait of Gibraltar community, this is not confirmed (Notarbartolo di Sciara, Tethys Research Institute, pers. comm., 12 July 2007).

Behavior and Life History—Killer whales have the most stable social system known among all cetaceans. In all areas where longitudinal studies have been carried out, there appear to be long-term associations between individuals and limited dispersal from maternal groups called pods (Bigg et al. 1990; Baird 2000). The largest recorded group size in the Mediterranean Sea is nine individuals (Gimeno et al. 2004). Buisson et al. (2005) reported finding three stable matrilines composed of an

adult female and two of her juvenile and/or adult offspring in the Strait of Gibraltar; two of the matrilines were always seen together.

Little has been published on killer whales in the eastern North Atlantic Ocean, south of Scandanavia. Christensen (1984) reported that female and male killer whales in Norway attain sexual maturity at about 8 and 15 yrs of age, respectively. This is comparable to Pacific Northwest killer whales. Among resident killer whales in the northeastern Pacific Ocean, females typically give birth for the first time at 11 to 15 yrs of age (Ford and Ellis 1999). Based on work in captivity, sexually mature males are 13 yrs and older (Robeck and Monfort 2006). Killer whales feed on an incredibly wide variety of prey types, including bony fishes, elasmobranchs, cephalopods, seabirds, sea turtles, and other marine mammals (e.g., Jefferson et al. 1991; Fertl et al. 1996). Killer whales in the eastern North Atlantic Ocean have been observed pursuing tuna schools (e.g., Hammond and Lockyer 1988), cooperatively feeding on herring (*Clupea harengus*) in Norwegian fjords (Similä and Ugarte 1993; Similä et al. 1996), feeding on salmon (*Salmo salar*) off Ireland and on marine mammals off Shetland (e.g., Weir 2002), and feeding in association with trawling activities (Luque et al. 2006). In the Mediterranean Sea, there are recorded observations of interactions with trapnet and drop line fisheries for bluefin tuna (*Thunnus thynnus*) in the Strait of Gibraltar during spring and summer (de Stephanis 2004; Buisson et al. 2005), attacks on fin whales (de Stephanis 2004), and feeding on a Cuvier's beaked whale (Notarbartolo-di-Sciara 1987). Additionally, predation on ocean sunfish (*Mola mola*), blackspot seabream (*Pagellus bogaraveo*), Atlantic pomfret (*Brama brama*), and cephalopds has been observed here (Gallego et al. 2007). Interestingly, there have also been observations of long-finned pilot whales in the Mediterranean Sea harassing killer whales in the Strait of Gibraltar (Gallego and Lott 2005). Bluefin tuna is the primary prey between February and November in the Strait of Gibraltar.

Killer whales apparently use passive listening as a primary means of locating prey and use different echolocation patterns for different hunting strategies (Barrett-Lennard et al. 1996). For example, they mask their clicks and encode their signals in background noise when hunting other cetaceans, prey that can hear their high-frequency clicks (Barrett-Lennard et al. 1996; Deecke et al. 2005; Saulitis et al. 2005). In contrast, killer whales do not mask their high-frequency signals when hunting fish that do not hear in this frequency range (Hawkins and Johnstone 1978; Au et al. 2004).

The maximum depth recorded for free-ranging killer whales diving off British Columbia is 264 m (Baird et al. 2005). On average, however, for seven tagged individuals, less than 1% of all dives examined were to depths greater than 30 m (Baird et al. 2003b). A trained killer whale dove to a maximum of 260 m (Dahlheim and Heyning 1999). The longest duration of a recorded dive from a radio-tagged killer whale was 17 min (Dahlheim and Heyning 1999).

Acoustics and Hearing—Killer whales produce a wide variety of clicks and whistles, but most of this species's social sounds are pulsed, with frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz) (Thomson and Richardson 1995). Echolocation clicks recorded for Canadian killer whales foraging on salmon have source levels ranging from 195 to 224 dB re: 1 μPa-m peak-to-peak, a center frequency ranging from 45 to 80 kHz, and durations of 80 to 120 μsec (Au et al. 2004). Echolocation clicks from Norwegian killer whales were considerably lower than the previously-mentioned study and ranged from 173 to 202 re: 1 μPa-m peak-to-peak. The clicks had a center frequency ranging from 22 to 49 kHz and durations of 31 to 203 μsec (Simon et al. 2007). Source levels associated with social sounds have been calculated to range from 131 to 168 dB re: 1 μPa-m and have been demonstrated to vary with vocalization type (e.g., whistles: average source level of 140.2 dB re: 1 μPa-m, variable calls: average source level of 146.6 dB re: 1 μPa-m, and stereotyped calls: average source level 152.6 dB re: 1 μPa-m) (Veirs 2004). Additionally, killer whales modify their vocalizations depending on social context or ecological function (i.e., short-range vocalizations [<10 km range] are typically associated with social and resting behaviors and long-range vocalizations [10 to 16 km range] are associated with travel and foraging) (Miller 2006). Likewise, echolocation clicks are adapted to the type of fish prey (Simon et al. 2007).

Acoustic studies of resident killer whales in British Columbia have found that they possess dialects, which are highly stereotyped, repetitive discrete calls that are group-specific and are shared by all

group members (Ford 2002b). These dialects likely are used to maintain group identity and cohesion and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely-related whales (Ford 1991, 2002b). Dialects have been documented in northern Norway (Ford 2002a) and southern Alaskan killer whales populations (Yurk et al. 2002) and are likely occur in other regions as well.

Both behavioral and ABR techniques indicate killer whales can hear a frequency range of 1 to 100 kHz and are most sensitive at 20 kHz, which is one of the lowest maximum-sensitivity frequencies known among toothed whales (Szymanski et al. 1999).

- **Long-Finned Pilot Whale (*Globicephala melas*)**

Description—There are two species of pilot whales worldwide—the short-finned pilot whale (*Globicephala macrorhynchus*) and the long-finned pilot whale. Only the long-finned pilot whale is expected to occur in the Study Area. Pilot whales are among the largest members of the family Delphinidae. In general, the long-finned pilot whale is larger than the short-finned pilot whale and potentially reaches 5.7 m (females) and 6.7 m (males) in length (Jefferson et al. 1993).

Pilot whales have bulbous heads, with a forehead that sometimes overhangs the rostrum, and little or no beak. The falcate dorsal fin is distinctive; it is generally longer than it is high, with a rounded tip and is set well forward of the body's mid-length. The flippers of long-finned pilot whales are extremely long, sickle shaped, and slender with pointed tips and an angled leading edge that forms an "elbow". Long-finned pilot whale flippers range from 18 to 27% of the total body length (Jefferson et al. 1993). Both pilot whales are black, with a light-gray saddle patch behind the dorsal fin in some individuals. There is also a white to light-gray anchor-shaped patch on the chest (Jefferson et al. 1993).

Status—The long-finned pilot whale is listed as a species of lower risk (least concern) on the IUCN Red List.[1] The Mediterranean subpopulation of this species was recently proposed to qualify as data deficient due to the lack of adequate data to assess the extinction risk of this species (Reeves and Notarbartolo di Sciara 2006). Population estimates of long-finned pilot whales in the Mediterranean Sea are only available for the Strait of Gibraltar. Based on mark-recapture studies (using photo-identification) between 1999 and 2005, population estimates for this area ranged from 249 to 270 individuals (Verborgh et al. 2006). Abundance of long-finned pilot whales throughout the rest of the Mediterranean Sea is unknown. Approximately 778,000 long-finned pilot whales are estimated for the eastern North Atlantic Ocean (Buckland et al. 1993). It is unknown whether individuals found in the Mediterranean Sea are part of the eastern North Atlantic population(s) (Reeves and Notarbartolo di Sciara 2006).

Habitat Preferences—Pilot whales occur along the continental shelf break, in continental slope waters, and in areas of high-topographic relief (Olson and Reilly 2002). They also are found close to shore at oceanic islands where the shelf is narrow and deeper waters are nearby (Mignucci-Giannoni 1998; Gannier 2000; Anderson 2005). Occurrences of long-finned pilot whales have also been linked to deep waters with high chlorophyll concentrations and warm SST (>10.9°C) (MacLeod et al. 2007).

Long-finned pilot whales in the Mediterranean Sea prefer deep waters seaward of the continental shelf and slope; preferred habitats are generally in waters deeper than 500 m (Cañadas et al. 2002; Cañadas et al. 2005). Cañadas and Sagarminaga (2000) recorded sightings of long-finned pilot whales between the 500 and 1,200 m isobaths in the northeastern Alboran Sea with a peak between 900 and 1,000 m. The occurrence of long-finned pilot whales is correlated with even deeper waters in the central and northwestern Mediterranean Sea. For instance, sightings in waters with a bottom depth as great as 2,500 m are recorded in the Ligurian and Tyrrhenian seas (Notarbartolo di Sciara et al. 1993). Gannier (2005b) recorded an average bottom depth of approximately 2,000 m for pilot whales in the major basins of the western Mediterranean Sea. While long-finned pilot whales are typically distributed seaward of the shelf break, they have also been sighted close to shore in the western Mediterranean Sea. For example, Podesta and Magnaghi (1988) reported sighting this species in coastal waters off Italy in the Ligurian Sea. Long-finned pilot whales in the western

Mediterranean Sea appear to be abundant in areas where a permanent frontal system increases productivity (Frantzis et al. 2003).

Distribution—The apparent ranges of the two pilot whale species in the eastern North Atlantic Ocean overlap in waters off southern Europe and the Azores (Bernard and Reilly 1999). Sighting data in the eastern North Atlantic Ocean for the long-finned pilot whale indicate a broad band of distribution from roughly 40°N to 75°N (Abend and Smith 1999).

Long-finned pilot whales are distributed throughout the western Mediterranean Sea; there are very few records of this species in the eastern Mediterranean Sea (G. Notarbartolo di Sciara 2002; Reeves and Notarbartolo di Sciara 2006). High relative densities of long-finned pilot whales have been recorded in the Strait of Gibraltar and from the deep waters south of Granada and Almería to southeast of Cabo de Gata. They are also frequently sighted in the deep waters (>500 m) of the Gulf of Vera (Cañadas 2006). The distribution of pilot whales is concentrated in the Ligurian Sea (Abend and Smith 1999).

Long-finned pilot whales are thought to make north-south seasonal movements throughout their range of distribution (Abend and Smith 1999); however, specific seasonal movements within the Mediterranean Sea are unknown. This species is found year-round in some areas such as the Strait of Gibraltar (Verborgh et al. 2006). Long-finned pilot whales are seasonally resident in other regions; a small group of about five individuals are seasonally resident off Ventotene Island in the southern Tyrrhenian Sea between June and October with a peak occurrence in September (Mussi et al. 1998; Mussi et al. 2000). Several studies in different regions suggest that pilot whale distributions and seasonal inshore and offshore movements coincide closely with the abundance of their preferred squid prey (Hui 1985; Payne and Heinemann 1993; Waring and Finn 1995; Abend and Smith 1999; Bernard and Reilly 1999; Gannier 2005b).

- Information Specific to the Eastern Mediterranean Study Area—Long-finned pilot whales rarely occur in the Study Area. According to Marchessaux (1980) and Frantzis et al. (2003), there are no confirmed records of this species in the eastern Mediterranean Basin; however, there is a record of a floating carcass reported in the Gulf of Taranto (Centro Studi Cetacei 1996) and several sightings and strandings along the southeast coast of Italy are included in the NURC database. Raga et al. (1985) mentions a sighting of three individuals near the mouth of the Gulf of Taranto. There are also unconfirmed sightings of this species off the coast of Turkey and Greece (McBrearty et al. 1986; Reeves and Notarbartolo di Sciara 2006).

  There is an area of secondary occurrence throughout the eastern Mediterranean Sea based on the known distribution of long-finned pilot whales and the few confirmed records of this species in the eastern basin (**Figure B-22**). No seasonality in occurrence is anticipated for this species.

Behavior and Life History—Pilot whales are known to be highly social and are found in relatively stable maternal groups of a few to 100s of individuals (Jefferson et al. 1993). Group sizes of 350 individuals have been recorded in the Alboran Sea; groups here tend to be larger than those reported in other areas of the Mediterranean Sea (Cañadas and Sagarminaga 2000).

Genetic studies of long-finned pilot whales hunted in the Faroese drive fishery suggest that this species may live in groups of mixed age and sex in which adult males and females are related and the males do not sire offspring in the group (Amos et al. 1993b; Amos et al. 1993a). In contrast, a recent behavioral study of long-finned pilot whales off Nova Scotia suggests that groups are ephemeral, with short-term associations between individuals over hours to days and long-term associations with a subset of those individuals over years (Ottensmeyer and Whitehead 2003). This study could not account for the variation in social structure between geographic areas but recommended genetic sampling of behaviorally studied populations.

Average age at sexual maturity is 8 yrs for eastern North Atlantic females (6 yrs for western North Atlantic females) and 12 yrs for males (Bernard and Reilly 1999). Long-finned pilot whales have a

gestation period of 15 months and a mean calving interval of 3.3 yrs. Calving can occur at any time of the year (Jefferson et al. 1993). The calving peak for long-finned pilot whales is from July to September in the Northern Hemisphere (Bernard and Reilly 1999). In the Ligurian Sea, calves have been sighted in July, September, and December (Vallon et al. 1976; Podestà and Magnaghi 1988).

Pilot whales frequently associate with other cetaceans (Bernard and Reilly 1999). Mixed schools of pilot whales and bottlenose dolphins are often sighted in the western Mediterranean Sea (Pilleri and Knuckey 1969). Long-finned pilot whales have been reported to chase killer whales in the Strait of Gibraltar (Gallego and Lott 2005; Martínez Serrano and Villar Sagredo 2006). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al. 1996) and energetically interacting with sperm whales in the southern Tyrrhenian Sea (Notarbartolo di Sciara et al. 1993).

Pilot whales are deep divers, staying submerged for up to 27 min and routinely diving to 600 to 800 m (Baird et al. 2003a; Aguilar de Soto et al. 2005). The deepest dive recorded for the long-finned pilot whale is 824 m, for a tagged individual in the Ligurian Sea (Airoldi et al. 2003). Tagged individuals in the Ligurian Sea were found to make their deepest dives (up to 648 m) after dark (Baird et al. 2002). Airoldi et al. (2003) recorded short (<3 min) and shallow (0-16 m) dives during the day and much longer (mean = 14.6 min) and deeper (mean = 800 m) dives at night during the diel vertical migration of the DSL. Mate (1989) described movements of a satellite-tagged, rehabilitated long-finned pilot whale released off Cape Cod and also found that deep diving occurred mainly at night, when prey within the DSL approached the surface.

Both pilot whale species feed primarily on squids but also take fishes (Bernard and Reilly 1999). Pilot whales are not generally known to prey on other marine mammals; however, records from the ETP suggest that the short-finned pilot whale does occasionally chase, attack, and may eat dolphins during fishery operations (Perryman and Foster 1980). The diet of long-finned pilot whales in the Mediterranean Sea is not well known. It is presumed that they have similar diets to pilot whales in the North Atlantic Ocean. Long-finned pilot whales around the Faroe Islands in the eastern North Atlantic Ocean predominantly prey on squids, particularly the flying squid (*Todarodes sagittatus*); however, some fish such as greater argentine (*Argentina silus*) and blue whiting (*Micromesistius poutassou*) are also taken (Desportes and Mouritsen 1993). Scordia (1939) reported long-finned pilot whales preying on bluefin tuna caught on fishery hooks in the Strait of Messina; however, Orsi Relini and Cagnolaro (1996) disputed this account and determined that it was actually false killer whales that attacked the tuna.

Acoustics and Hearing—Long-finned pilot whale whistles range in frequency from 1 to 8 kHz while clicks range between 1 and 18 kHz (Ketten 1998). Daziens (2004) reported sound source levels of pilot whale whistles to be about 138 to 178 dB re: 1 µPa-m. Rendell and Gordon (1999) recorded whistles during vocal responses by pilot whales to military sonar in the Ligurian Sea; whistles had a frequency range from 4.1 to 8.8 kHz and mean duration of 0.93 sec. Delmas and Gannier (2005) commented on the wide variety of tonal signals produced by the long-finned pilot whale in the Mediterranean Sea, but no detailed results were provided. Mussi et al. (2003) collected pilot whale whistle information in the Mediterranean Sea, those results also were not detailed, though the authors suggested that signature whistles were produced. Impetuoso et al. (2004) analyzed pulses recorded in Ischia (Italy) waters for this species, with a peak frequency at 250 Hz, with two other peaks at 400 Hz and at 750 Hz.

There are no hearing data available for either pilot whale species; however, the most sensitive hearing range for odontocetes generally includes high frequencies (Ketten 1997).

- **Harbor Porpoise (*Phocoena phocoena*)**

Description—Harbor porpoises are the smallest cetaceans in the North Atlantic Ocean with a maximum length of 2.0 m (Jefferson et al. 1993). The body is stocky, dark gray to black dorsally and white ventrally. There may be a dark stripe from the mouth to the flipper. The head is blunt, with no

distinct beak. The flippers are small and pointed and the dorsal fin is short and triangular, located slightly behind the middle of the back.

Status—The harbor porpoise is listed as vulnerable on the IUCN Red List.[1] Abundance of harbor porpoises in the North Atlantic Ocean is estimated at over half a million (Donovan and Bjørge 1995; Hammond et al. 2002). The Black Sea/Sea of Azov population is listed as vulnerable on the IUCN Red List but was recently proposed to qualify for endangered status (Reeves and Notarbartolo di Sciara 2006). Current abundance estimates of this population are not available, but recent information suggests that the population size is at least several thousand individuals (Reeves and Notarbartolo di Sciara 2006).

Populations in the North Pacific Ocean, North Atlantic Ocean, and Black Sea/Sea of Azov are geographically isolated from each other. The Black Sea/Sea of Azov population is recognized as a subspecies (*Phocoena phocoena relicta*), and subspecific status has been proposed for the other isolated populations based on genetic variation (Rosel et al. 1995; Wang et al. 1996). Viaud-Martínez et al. (2007) recently suggested that harbor porpoises from the entire eastern region (Black Sea, Sea of Marmara, and northern Aegean Sea) be recognized as the subspecies *Phocoena phocoena relicta* based on morphological and genetic differences with eastern North Atlantic harbor porpoises. All confirmed records of harbor porpoises in the Mediterranean Sea have occurred close to the known range of the species in the Black Sea and the eastern North Atlantic Ocean (Rey and Cendrero 1981; Frantzis et al. 2001); therefore, harbor porpoises found in or near the Study Area may be from the North Atlantic or Black Sea populations. It is unknown whether the small population in the northern Aegean Sea is a remnant of a distinct Mediterranean population or if it is actually part of the Black Sea population (Frantzis et al. 2001). Recent genetics studies suggest that this small population originated from the Black Sea population through the Bosporus (Istanbul) Strait, the Marmara Sea, and the Dardanelles Straits (Rosel et al. 2003). Therefore, residents in the northern Aegean Sea are likely a subpopulation of the Black Sea subspecies (Reeves and Notarbartolo di Sciara 2006). Population estimates of harbor porpoises in the northern Aegean Sea are not available.

Habitat Preferences—Harbor porpoises appear restricted to relatively cool waters where prey aggregations are concentrated (Watts and Gaskin 1985). Harbor porpoises are seldom found in waters warmer than 17ºC (Read 1999) and closely mirror the movements of their primary prey, Atlantic herring (*Clupea harengus harengus*) in the North Atlantic Ocean (Gaskin 1992). Harbor porpoises are generally scarce in areas without significant coastal fronts or topographically-generated upwellings (Gaskin 1992; Skov et al. 2003). Fine-scale oceanographic features (i.e., island and headland wakes) aggregate prey and are important feeding habitats for harbor porpoises (Johnston et al. 2005a). Harbor porpoises occur most frequently over the continental shelf (NMFS 2001; Birkun 2002; MacLeod et al. 2007); however, pelagic drift net bycatches and movements of a satellite-tracked individual, which swam offshore into water over 1,800 m deep, indicate a potential offshore component to their distribution in the western North Atlantic Ocean (Read et al. 1996; Westgate et al. 1998).

Harbor porpoises in the Black Sea occur along the continental shelf around the perimeter of the Black Sea (Birkun 2002) and are also known to occur in estuaries of large rivers, coastal brackish and saline lagoons, and freshwater lakes connected with the sea by rivers (Reeves and Notarbartolo di Sciara 2006). Recent survey data indicate that harbor porpoises also occur in deep, offshore waters in the central Black Sea (Krivokhizhin et al. 2006). The Sea of Marmara is likely an important breeding, calving, and feeding area for Black Sea harbor porpoises (Birkun 2002). The northern Aegean Sea habitat is similar to that of the Black Sea; the northern Aegean Sea is generally cooler and less saline than other regions of the eastern Mediterranean Sea due to the influx of water from the Black Sea (Poulos et al. 1997). These characteristics provide further evidence supporting the possibility of movement of harbor porpoises between the Black Sea and the eastern Mediterranean Sea (Rosel et al. 2003).

Distribution—Harbor porpoises occur in subpolar to cool-temperate waters in the North Atlantic and Pacific oceans (Read 1999). In the eastern North Atlantic Ocean, harbor porpoises are distributed

discontinuously from the Barents Sea to Senegal off the coast of Africa (Smeenk et al. 1992; IWC 1996). This range includes populations off Iceland, the Faroe Islands, northern Norway and the Barents Sea, the North Sea, Kattegat and adjacent waters, the Baltic Sea, Ireland and the western U.K., Iberian Peninsula and the Bay of Biscay, and northwestern Africa (IWC 1996). The Strait of Gibraltar is the northern boundary of this African population (Donovan and Bjørge 1995). Recent evidence also suggests the existence of a small population of harbor porpoises near the Azores (Barreiros et al. 2006). The seasonal movements of harbor porpoises in the eastern North Atlantic Ocean are not well known. Genetic evidence suggests limited trans-Atlantic movement (Rosel et al. 1999).

Historical records suggest that harbor porpoises were possibly present in the Mediterranean Sea until the end of the 19th century (Viale 1985; Frantzis et al. 2001). Today the distribution of harbor porpoises in the Mediterranean Sea is limited to a small area in the northern Aegean Sea; exact range and degree of residency of this local population are unknown (Frantzis et al. 2001). The harbor porpoise is absent from other areas of the Mediterranean Sea except sporadic occurrences near Gibraltar and a recently confirmed stranding along the coast of Turkey in the southern Aegean Sea (Güçlüsoy 2007). Harbor porpoise distribution near the Mediterranean Sea includes the region west of the Strait of Gibraltar, the Black Sea, the Sea of Azov, the Marmara Sea, the Bosporus (Istanbul) Strait, and likely the Dardanelles Straits (Öztürk and Öztürk 1997; Reeves and Notarbartolo di Sciara 2006). Harbor porpoises in this region are known to make seasonal movements; they move from the Sea of Azov and the northwestern Black Sea before winter and return in the spring. Primary wintering areas are in the southeastern Black Sea, Georgian waters, and possibly Turkish territorial waters (Reeves and Notarbartolo di Sciara 2006).

- Information Specific to the Eastern Mediterranean Study Area—Although harbor porpoises occur regularly in the northern Aegean Sea, they are not expected to occur in the Study Area. It is possible, however, that individuals from the northern Aegean Sea may wander into the Study Area during any time of the year. Any occurrences in the Study Area would be considered extralimital for this species. A few strandings and sightings have been recorded in the southern Aegean Sea (Frantzis et al. 2001; Frantzis et al. 2003; Frantzis et al. 2004b). There are no confirmed records of this species in the rest of the eastern Mediterranean Sea. A skull of a harbor porpoise was found in the northern Adriatic Sea in the early 18th century; however, the origin of the skull is questionable and conceivably may have been from a fishing vessel that came from the Aegean Sea (Notarbartolo di Sciara, G., Tethys Research Institute, pers. comm., 2-5 October 2006).

  There is a rare occurrence throughout the eastern Mediterranean Sea, except from the shoreline to the shelf break in the northern Aegean Sea which is an area of primary occurrence due to the local presence of harbor porpoises in this area (**Figure B-23**). No seasonal differences in occurrence are anticipated for this species.

Behavior and Life History—Harbor porpoises are not known to form stable social groupings (Read 1999), which is the typical situation for species in the porpoise family. In most areas, harbor porpoises are found in small groups consisting of just a few individuals.

In contrast to other toothed whales, harbor porpoises mature at an earlier age, reproduce more frequently, and live for shorter periods (Read and Hohn 1995). Females generally mature at around three years of age and give birth to one calf each year. The calving season varies geographically; in most areas, calves are born between May and August (Bjørge and Tolley 2002). Many females are pregnant and lactating simultaneously (Read 1990; Read and Hohn 1995). Relative to other cetaceans, harbor porpoises seem to allocate a larger percentage of their total body mass to blubber (McLellan et al. 2002), which helps them meet the energetic demands of living in a cold-water environment.

Harbor porpoises feed on a variety of small, schooling clupeoid (herring-like) and gadid (cod-like) fishes usually less than 30 cm in length (Read 1999). In the eastern North Atlantic Ocean, there is

evidence of a long-term shift from predation on clupeid fish to predation on sand eels and gadoid fish (Santos and Pierce 2003). There is also regional variation in prey species in the eastern North Atlantic Ocean; harbor porpoises in more northern areas appear to prefer pelagic and mesopelagic species, while demersal fish are the dominant prey in the south (Donovan and Bjørge 1995). Harbor porpoises in the Black Sea are known to feed on shad, sprat, anchovy, whiting, pickerel, gobies, and Far East haarder (Krivokhizhin et al. 2000). At four to seven months of age (Read and Hohn 1995), harbor porpoise calves begin feeding on small, slow-moving krill and juvenile fishes (Smith and Read 1992; Gannon et al. 1998).

Harbor porpoises make brief dives, generally lasting less than 5 min (Westgate et al. 1995; Otani et al. 1998). Tagged harbor porpoise individuals spend 3 to 7% of their time at the surface and 33 to 60% in the upper 2 m (Westgate et al. 1995; Read and Westgate 1997). Average dive depths range from 14 to 41 m with a maximum known dive depth of 226 m and average dive durations ranging from 44 to 103 sec (Westgate et al. 1995). Westgate and Read (1998) noted that dive records of tagged porpoises did not reflect the vertical migration of their prey; porpoises made deep dives during both day and night.

Acoustics and Hearing—Harbor porpoise vocalizations include clicks and pulses (Ketten 1998), as well as whistle-like signals (Verboom and Kastelein 1995). Harbor porpoise acoustic signals contain low-frequency components at about 2 kHz and high-frequency components at about 120 kHz (Verboom and Kastelein 1995). The dominant frequency range is 110 to 150 kHz, with source levels between 135 and 205 dB re: 1 μPa-m (Ketten 1998; Villadsgaard et al. 2007). Echolocation signals include one or two low-frequency components in the 1.4 to 2.5 kHz range (Verboom and Kastelein 1995).

A behavioral audiogram of a harbor porpoise indicated the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re: 1 μPa-m (Andersen 1970); however, auditory-evoked potential studies showed a much higher frequency of approximately 125 to 130 kHz (Bibikov 1992). The auditory-evoked potential method suggests that the harbor porpoise actually has two frequency ranges of best sensitivity. More recent psycho-acoustic studies found the range of best hearing to be 16 to 140 kHz, with a reduced sensitivity around 64 kHz (Kastelein et al. 2002). Maximum sensitivity occurs between 100 and 140 kHz (Kastelein et al. 2002).

3.1.3 Websites Assessed

[1] The IUCN red list of threatened species. Accessed 14 February 2007. http://www.iucnredlist.org/.
[2] IFAW supports the Mediterranean monk seal. Accessed 1 November 2006. www.ifaw.org/ifaw/general/default.aspx?oid=64989.
[3] The network of managers of marine protected areas in the Mediterranean. Accessed 1 November 2006. http://www.medpan.org/.
[4] *Delphinus delphis* (Mediterranean subpopulation); 2006 IUCN Red List of Threatened Species. Accessed 16 January 2007. http://www.iucnredlist.org/search/details.php/41762/all.
[5] Metompkin's movements. Accessed April 2001. http://whale.wheelock.edu/whalenet-stuff/stop_data.html.

3.1.4 Literature Cited

Abend, A.G. and T.D. Smith. 1999. Review of distribution of the long-finned pilot whale (*Globicephala melas*) in the North Atlantic and Mediterranean. NOAA Technical Memorandum NMFS-NE-117:1-22.

Acevedo-Gutiérrez, A. and S.C. Stienessen. 2004. Bottlenose dolphins (*Tursiops truncatus*) increase number of whistles when feeding. Aquatic Mammals 30(3):357-362.

Adamantopoulou, S. 2000. Network gathers data. Monachus Guardian 3(2):12.

Adamantopoulou, S., K. Anagnostopoulou, P. Dendrinos, S. Kotomatas, N. Labadariou, V. Pipinis, G. Stroufliotis, E. Tounta, and V. Zavras. 2000. Conserving critical habitats for the Mediterranean

monk seal in Greece through the creation of a network of protected areas. European Research on Cetaceans 14:163.

Affronte, M., L.A. Stanzani, and G. Stanzani. 2003. First record of a humpback whale, *Megaptera novaeangliae* (Borowski, 1781) from the Adriatic Sea. Annals of Istrian and Mediterranean Studies 13(1):51-54.

Agazzi, S. and G. Bearzi. 2005. Diet overlap between short-beaked common dolphins and large tuna in eastern Ionian Sea inshore waters: Insight from scales of fish prey sampled during surface foraging. Page 81 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Agazzi, S., G. Bearzi, and E. Politi. 2004. Short-beaked common dolphin prey species in the eastern Ionian Sea: Insight from fish scales sampled during surface foraging. Pages 351-353 in Abstracts, Eighteenth Annual Conference of the European Cetacean Society. 28-31 March 2004. Kolmården, Sweden.

Agler, B.A., R.L. Schooley, S.E. Frohock, S.K. Katona, and I.E. Seipt. 1993. Reproduction of photographically identified fin whales, *Balaenoptera physalus*, from the Gulf of Maine. Journal of Mammalogy 74(3):577-587.

Aguilar, A. 1986. A review of old Basque whaling and its effect on the right whales (*Eubalaena glacialis*) of the North Atlantic. Reports of the International Whaling Commission (Special Issue 10):191-199.

Aguilar, A. 1989. A record of two humpback whales, *Megaptera novaeangliae*, in the western Mediterranean Sea. Marine Mammal Science 5(3):306-309.

Aguilar, A. 1991. Calving and early mortality in the western Mediterranean striped dolphin, *Stenella coeruleoalba*. Canadian Journal of Zoology 69:1408-1412.

Aguilar, A. 2002. Fin whale *Balaenoptera physalus*. Pages 435-438 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Aguilar, A. and J.A. Raga. 1993. The striped dolphin epizootic in the Mediterranean Sea. Ambio 22(8):524-528.

Aguilar, A. and A. Borrell. 2007. Open-boat whaling on the Straits of Gibraltar ground and adjacent waters. Marine Mammal Science 23(2):322-342.

Aguilar, A., L.H. Cappozzo, M. Gazo, T. Pastor, J. Forcada, and E. Grau. 2007. Lactation and mother-pup behaviour in the Mediterranean monk seal *Monachus monachus*: An unusual pattern for a phocid. Journal of the Marine Biological Association of the United Kingdom 87:93-99.

Aguilar de Soto, N., M.P. Johnson, and P.T. Madsen. 2005. Deep foraging of pilot and beaked whales: DTag results. Pages 13-14 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Airoldi, L., A. Azzellino, V. Fadda, S. Gaspari, B. Nani, M. Zanardelli, G. Notarbartolo di Sciara, and M. Mariani. 2000. Social ecology of Risso's dolphins in the Ligurian Sea: Premiminary results. European Research on Cetaceans 14:213-218.

Airoldi, S., F. Bendinoni, A. Azzellino, V. Fadda, and A. Profice. 2005. Abundance estimate of Risso's dolphins (*Grampus griseus*) in the western Ligurian Sea through photographic mark-recapture. Page 109 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Airoldi, S., D. Fasano, N. Gavazzi, A. Miragliuolo, B. Mussi, and M. Mariani. 2003. Diving behaviour and reactions to tagging of long-finned pilot whales in the central Mediterranean Sea. Abstracts, Seventeenth Conference of the European Cetacean Society. 9-13 March 2003. Las Palmas de Gran Canaria, Spain.

Airoldi, S., A. Azzellino, B. Nani, M. Ballardini, C. Bastoni, G. Notarbartolo di Sciara, and A. Sturlese. 1999. Whale watching in Italy: Results of the first three years of activity. European Research on Cetaceans 13:153-156.

Alhammoud, B., K. Béranger, L. Mortier, M. Crépon, and I. Dekeyser. 2005. Surface circulation of the Levantine Basin: Comparison of model results with observations. Progress in Oceanography 66:299-320.

Allen, B.M., D.E. Pitassy, J.G. Mead, and C.W. Potter. 2005. Beaked whale identification reference on the web: A tool for stranding responders. Page 11 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Amano, M. and M. Yoshioka. 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. Marine Ecology Progress Series 258:291-295.

Amaral, A.R., M. Sequeira, J. Martínez-Cedeira, and M.M. Coelho. 2007. New insights on population genetic structure of *Delphinus delphis* from the northeast Atlantic and phylogenetic relationships within the genus inferred from two mitochondrial markers. Marine Biology 151:1432-1793.

Amos, B., C. Schlotterer, and D. Tautz. 1993a. Social structure of pilot whales revealed by analytical DNA profiling. Science 260:670-672.

Amos, B., D. Bloch, G. Desportes, T.M.O. Majerus, D.R. Bancroft, J.A. Barrett, and G.A. Dover. 1993b. A review of molecular evidence relating to social organisation and breeding system in the long-finned pilot whale. Reports of the International Whaling Commission (Special Issue 14):209-217.

Andersen, S. 1970. Auditory sensitivity of the harbour porpoise *Phocoena phocoena*. Investigations on Cetacea 2:255-259.

Anderson, R.C. 2005. Observations of cetaceans in the Maldives, 1990-2002. Journal of Cetacean Research and Management 7(2):119-135.

André, M., A. Supin, E. Delory, C. Kamminga, E. Degollada, and J.M. Alonso. 2003. Evidence of deafness in a striped dolphin, *Stenella coeruleoalba*. Aquatic Mammals 29(1):3-8.

André, M., E. Delory, E. Degollada, J.-M. Alonos, J. del Rio, M. van Der Schaar, J.V. Castell, and M. Morell. 2007. Identifying cetacean hearing impairment at stranding sites. Aquatic Mammals 33(1):100-109.

Androukaki, E., S. Adamantopoulou, P. Dendrinos, E. Tounta, and S. Kotomatas. 1999. Causes of mortality in the Mediterranean monk seal (*Monachus monachus*) in Greece. Contributions to the Zoology and Ecology of the Eastern Mediterranean Region 1:405-411.

Anonymous. 2004. Orphaned seal criss-crosses the Sporades Marine Park, sets new diving record. Monachus Guardian 7(2):10-11.

Ansmann, I.C., J.C. Goold, P.G.H. Evans, M. Simmonds, and S.G. Keith. 2007. Variation in the whistle characteristics of short-beaked common dolphins, *Delphinus delphis*, at two locations around the British Isles. Journal of the Marine Biological Association of the United Kingdom 87(1):19-26.

Antolovic, J. 1998. Mediterranean monk seal (*Monachus monachus*) habitat in Vis Archipelago, the Adriatic Sea. Monachus Guardian 1(2):1-4.

Arcangeli, A., G. Caltavuturo, L. Marini, E. Salvati, M. Tringali, T. Valentini, and G. Villetti. 2001. Avvistamenti invernali di cetacei nel Canale di Sicilia (Winter sightings of cetaceans in the Channel of Sicily). Natura - Societa Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 90(2):5-9.

Archer II, F.I. and W.F. Perrin. 1999. *Stenella coeruleoalba*. Mammalian Species 603:1-9.

Astruc, G. and P.C. Beaubrun. 2003. Relations between striped dolphin diet items and their own preys [sic] along the French Mediterranean continental coasts. Abstracts, Seventeenth Annual Conference of the European Cetacean Society. 9-13 March 2003. Las Palmas Canarias de Gran Canaria, Spain.

Astruc, G. and P. Beaubrun. 2005. Do Mediterranean cetaceans exploit the same ressources [sic]? Page 81 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Au, D.W.K. and W.L. Perryman. 1985. Dolphin habitats in the eastern tropical Pacific. Fishery Bulletin 83(4):623-643.

Au, W., J. Darling, and K. Andrews. 2001. High-frequency harmonics and source level of humpback whale songs. Journal of the Acoustical Society of America 110(5):2770.

Au, W.W.L. 1993. The sonar of dolphins. New York, New York: Springer-Verlag.

Au, W.W.L., A.N. Popper, and R.R. Fay, eds. 2000. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Au, W.W.L., J.K.B. Ford, J.K. Horne, and K.A. Newman Allman. 2004. Echolocation signals of free-ranging killer whales (*Orcinus orca*) and modeling of foraging for chinook salmon (*Oncorhynchus tshawytscha*). Journal of the Acoustical Society of America 115(2):901-909.

Au, W.W.L., A.A. Pack, M.O. Lammers, L.M. Herman, M.H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. Journal of the Acoustical Society of America 120(2):1103-1110.

Ayoub, N., P.-Y. Le Traon, and P. De Mey. 1998. A description of the Mediterranean surface variable circulation from combined ERS-1 and TOPEX/POSEIDON altimetric data. Journal of Marine Systems 18:3-40.

Azzali, M., L. Casini, and C.V. Lamberti. 1994. Relationships between dolphins, type of prey aggregation, and their geographical distribution. European Research on Cetaceans 8:183-187.

Azzellino, A., D. Fasano, S. Airoldi, and P. Patti. 2005. Sperm whale (*Physeter macrocephalus*) distribution in the western Ligurian Sea: Does a correlation exist with sea surface temperature? Page 20 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Baccetti, N., F. Cancelli, and T. Renieri. 1991. First record of *Kogia simus* (Cetacea, Physeteridae) from the Mediterranean Sea. Mammalia 55(1):152-154.

Badosa, E., E. Grau, F. Aparicio, J.F. Layna, and M.A. Cedenilla. 1998. Individual variation and sexual dimorphism of coloration in Mediterranean monk seal pups (*Monachus monachus*). Marine Mammal Science 14(2):390-393.

Baird, R.W. 2000. The killer whale: Foraging specializations and group hunting. Pages 127-153 in Mann, J., R.C. Connor, P.L. Tyack, and H. Whitehead, eds. Cetacean societies: Field studies of dolphins and whales. Chicago, Illinois: University of Chicago Press.

Baird, R.W. 2002. False killer whale *Pseudorca crassidens*. Pages 411-412 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Baird, R.W. 2005. Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. Pacific Science 59(3):461-466.

Baird, R.W. and A.M. Gorgone. 2005. False killer whale dorsal fin disfigurements as a possible indicator of long-line fishery interactions in Hawaiian waters. Pacific Science 59(4):593-601.

Baird, R.W., K.M. Langelier, and P.J. Stacey. 1989. First records of false killer whales, *Pseudorca crassidens*, in Canada. Canadian Field-Naturalist 103:368-371.

Baird, R.W., P.J. Stacey, and H. Whitehead. 1993. Status of the striped dolphin, *Stenella coeruleoalba*, in Canada. Canadian Field-Naturalist 107(4):455-465.

Baird, R.W., A.D. Ligon, and S.K. Hooker. 2000. Sub-surface and night-time behavior of humpback whales off Maui, Hawaii: A preliminary report. Contract number 40ABNC050729 Prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary, Kihei, Hawaii by the Hawaii Wildlife Fund, Paia, Hawaii.

Baird, R.W., M.B. Hanson, and L.M. Dill. 2005. Factors influencing the diving behaviour of fish-eating killer whales: Sex differences and diel and interannual variation in diving rates. Canadian Journal of Zoology 83:257-267.

Baird, R.W., J.F. Borsani, M.B. Hanson, and P.L. Tyack. 2002. Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. Marine Ecology Progress Series 237:301-305.

Baird, R.W., D.J. McSweeney, M.R. Heithaus, and G.J. Marshall. 2003a. Short-finned pilot whale diving behavior: Deep feeders and day-time socialites. Page 10 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14-19 December 2003. Greensboro, North Carolina.

Baird, R.W., M.B. Hanson, E.E. Ashe, M.R. Heithaus, and G.J. Marshall. 2003b. Studies of foraging in "southern resident" killer whales during July 2002: Dive depths, bursts in speed, and the use of a "Crittercam" system for examining sub-surface behavior. Order Number AB133F-02-SE-1744 Prepared for the National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Washington.

Baird, R.W., D.L. Webster, D.J. McSweeney, A.D. Ligon, G.S. Schorr, and J. Barlow. 2006. Diving behaviour of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawai'i. Canadian Journal of Zoology 84:1120-1128.

Baker, C.S. and L.M. Herman. 1984. Aggressive behavior between humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. Canadian Journal of Zoology 62:1922-1937.

Bakke, I., S. Johansen, Ø. Bakke, and M.R. El-Gewely. 1996. Lack of population subdivision among the minke whales (*Balaenoptera acutorostrata*) from Icelandic and Norwegian waters based on mitochondrial DNA sequences. Marine Biology 125:1-9.

Bakun, A. and V.N. Agostini. 2001. Seasonal patterns of wind-induced upwelling/downwelling in the Mediterranean Sea. Scientia Marina 65(3):243-257.

Baldwin, R., M. Gallagher, and K. Van Waerebeek. 1999. A review of cetaceans from waters off the Arabian Peninsula. Pages 161-189 in Fisher, M., A. Spalton, and S. Gazanfar, eds. Oman's natural history. Leiden, Netherlands: Backhuys Publishers.

Ballance, L.T. and R.L. Pitman. 1998. Cetaceans of the western tropical Indian Ocean: Distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. Marine Mammal Science 14(3):429-459.

Ballardini, M., M. Rosso, A. Moulins, T. Pusser, and M. Würtz. 2006. Photographic identification of Cuvier's beaked whales (*Ziphius cavirostris*): Using natural marks to identify different individuals. Page 192 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Banick, K. and J.L. Borger. 2005. A mass-stranding event of rough-toothed dolphins (*Steno bredanensis*) in the Florida Keys (Florida, USA): II. Release and tracking. Page 24 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Barale, V., S. Panigada, and M. Zanardelli. 2002. Habitat preferences of fin whales (*Balaenoptera physalus*) in the northwestern Mediterranean Sea: A comparison between in situ and remote sensing data. Proceedings of the Seventh International Conference on Remote Sensing for Marine and Coastal Environments. 20-22 May 2002. Miami, Florida.

Barberis, S., A. Davico, L. Davico, M. Massajoli, and R. Trucchi. 1997. The third WWF research campaign in the Ligurian Sea. European Research on Cetaceans 11:99.

Bareham, J.R. and S.J. A. Furreddu. 1975. Observations on the use of grottos by Mediterranean Monk seals *(Monachus monachus)*. Journal of Zoology, London 175:291-298.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209-221 in Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, eds. Marine mammal survey and assessment methods. Rotterdam, Netherlands: A.A. Balkema.

Barlow, J., M.C. Ferguson, W.F. Perrin, L. Ballance, T. Gerrodette, G. Joyce, C.D. MacLeod, K. Mullin, D.L. Palka, and G. Waring. 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). Journal of Cetacean Research and Management 7(3):263-270.

Barreiros, J.P., M. Teves, and J. Rodeia. 2006. First record of the harbour porpoise, *Phocoena phocoena* (Cetacea: Phocoenidae) in the Azores (NE Atlantic). aqua: Journal of Ichthyology and Aquatic Biology 11(2):45-46.

Barrett-Lennard, L.G., J.K.B. Ford, and K.A. Heise. 1996. The mixed blessing of echolocation: Differences in sonar use by fish-eating and mammal-eating killer whales. Animal Behaviour 51:553-565.

Barros, N.B. and A.A. Myrberg, Jr. 1987. Prey detection by means of passive listening in bottlenose dolphins (*Tursiops truncatus*). Journal of the Acoustical Society of America 82(Supplement 1):S65.

Baumgartner, M.F. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. Marine Mammal Science 13(4):614-638.

Baumgartner, M.F. and B.R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. Marine Ecology Progress Series 264:123-135.

Baumgartner, M.F. and B.R. Mate. 2005. Summer and fall habitat of North Atlantic right whales (*Eubalaena glacialis*) inferred from satellite telemetry. Canadian Journal of Fisheries and Aquatic Sciences 62:527-543.

Baumgartner, M.F., C.A. Mayo, and R.D. Kenney. 2007. Enormous carnivores, microscopic food, and a restaurant that's hard to find. Pages 138-171 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Baumgartner, M.F., K.D. Mullin, L.N. May, and T.D. Leming. 2001. Cetacean habitats in the northern Gulf of Mexico. Fishery Bulletin 99:219-239.

Baumgartner, M.F., T.V.N. Cole, P.J. Clapham, and B.R. Mate. 2003a. North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. Marine Ecology Progress Series 264:137-154.

Baumgartner, M.F., T.V.N. Cole, R.G. Campbell, G.J. Teegarden, and E.G. Durbin. 2003b. Associations between North Atlantic right whales and their prey, *Calanus finmarchicus*, over diel and tidal time scales. Marine Ecology Progress Series 264:155-166.

Beamish, P. and E. Mitchell. 1973. Short pulse length audio frequency sounds recorded in the presence of a Minke whale (*Balaenoptera acutorostrata*). Deep-Sea Research 20(4):375-386.

Beardsley, R.C., A.W. Epstein, C. Chen, K.F. Wishner, M.C. Macaulay, and R.D. Kenney. 1996. Spatial variability in zooplankton abundance near feeding right whales in the Great South Channel. Deep-Sea Research 43(7-8):1601-1625.

Bearzi, G. 2003. Towards a conservation plan for common bottlenose dolphins in the Mediterranean Sea. Document presented at the 2nd Meeting of the ACCOBAMS Scientific Committee. 20-22 November. Istanbul, Turkey.

Bearzi, G. and S. Ferretti. 2000. Rare report of a bottlenose dolphin foraging in the Venice Lagoon, Italy. European Research on Cetaceans 14:110-114.

Bearzi, G., G. Notarbartolo-di-Sciara, and E. Politi. 1997. Social ecology of bottlenose dolphins in the Kvarneric (northern Adriatic Sea). Marine Mammal Science 13(4):650-668.

Bearzi, G., E. Politi, and G. Notarbartolo di Sciara. 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric (northern Adriatic Sea). Marine Mammal Science 15(4):1065-1097.

Bearzi, G., E. Politi, S. Agazzi, S. Bruno, M. Costa, and S. Bonizzoni. 2005. Occurrence and present status of coastal dolphins (*Delphinus delphis* and *Tursiops truncatus*) in the eastern Ionian Sea. Aquatic Conservation: Marine and Freshwater Ecosystems 15:243-257.

Bearzi, G., R.R. Reeves, G. Notarbartolo-di-Sciara, E. Politi, A. Cañadas, A. Frantzis, and B. Mussi. 2003. Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. Mammal Review 33(3):224-252.

Bearzi, M. 2005. Habitat partitioning by three species of dolphins in Santa Monica Bay, California. Bulletin of the Southern California Academy of Sciences 104(3):113-124.

Beaubrun, P., L. David, J.L. Fabre, and M. Muller. 1999. Exceptional apperance of fin whales *(Balaenoptera physalus)*, during the summer 1997, in the Gulf of Lion (French Mediterranean Coast). European Research on Cetaceans 13:162-164.

Beaubrun, P., L. David, N. Di-Méglio, A. Gannier, and O. Gannier. 1997. First aerial survey in the north-west Mediterranean: Preliminary results. European Research on Cetaceans 11:100-103.

Bello, G. and F. Bentivegna. 1994. Cephalopod remains from the stomach of a Risso's dolphin, *Grampus griseus* (Cetacea: Delphinidae), stranded along the eastern Tyrrhenian coast. Atti Della Società Italiana di Scienze Naturali e Del Museo Civico di Storia Naturale di Milano 135(2):467-469.

Benjaminsen, T. and I. Christensen. 1979. The natural history of the bottlenose whale, *Hyperoodon ampullatus* (Forster). Pages 143-164 in Winn, H.E. and B.L. Olla, eds. Behavior of marine animals: Current perspectives in research. Volume 3: Cetaceans. New York, New York: Plenum Press.

Béranger, K., L. Mortier, G.-P. Gasparini, L. Gervasio, M. Astraldi, and M. Crépon. 2004. The dynamics of the Sicily Strait: A comprehensive study from observations and models. Deep-Sea Research II 51:411-440.

Bernard, H.J. and S.B. Reilly. 1999. Pilot whales *Globicephala* Lesson, 1828. Pages 245-279 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Berrow, S. 2006. Cape Verde 2006. Kilrush, Ireland: The Irish Whale and Dolphin Group.

Bérubé, M., M.B. Rew, T. Cole, S.L. Swartz, E. Zolman, N. Øien, and P.J. Palsbøll. 2004. Genetic identification of an individual humpback whale between the eastern Caribbean and the Norwegian Sea. Marine Mammal Science 20(3):657-663.

Bérubé, M., A. Aguilar, D. Dendanto, F. Larsen, G. Notarbartolo di Sciara, R. Sears, J. Sigurjónsson, J. Urban-R., and P.J. Palsbøll. 1998. Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus (*Linnaeus 1758): Analysis of mitochondrial and nuclear loci. Molecular Ecology 7:585-599.

Besson, J., R. Duguy, and G. Tardy. 1982. Note sur un cas de multiparité chez un rorqual commun *(Balaenoptera physalus)* (Note on case of multiparity in the fin whale (*Balaenoptera physalus))*. Mammalia 46(3):408.

Best, P.B. and C.H. Lockyer. 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. South African Journal of Marine Science 24:111-133.

Best, P.B., P.A.S. Canham, and C.D. MacLeod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Reports of the International Whaling Commission (Special Issue 6):51-79.

Biassoni, N., P.J.O. Miller, M. Podestà, M. Johnson, A. Sturlese, P. Tyack, and A. Bocconcelli. 2003. Behavioral observations and non-invasive tagging of Cuvier's beaked whales, *Ziphius cavirostris*, in the Ligurian Sea. Abstracts, Seventeenth Conference of the European Cetacean Society. 9-13 March 2003. Las Palmas de Gran Canaria, Spain.

Bibikov, N.G. 1992. Auditory brainstem responses in the harbor porpoise (*Phocoena phocoena*). Pages 197-211 in Thomas, J.A., R.A. Kastelein, and A.Y. Supin, eds. Marine mammal sensory systems. New York, New York: Plenum Press.

Bigg, M. 1981. Harbour seal *Phoca vitulina* and *P. largha*. Pages 55-87 in Ridgway, S.H. and R.J. Harrison, eds. Handbook of marine mammals. Volume 2: Seals. San Diego, California: Academic Press.

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Reports of the International Whaling Commission (Special Issue 12):383-405.

Biggs, D.C., R.R. Leben, and J.G. Ortega-Ortiz. 2000. Ship and satellite studies of mesoscale circulation and sperm whale habitats in the northeast Gulf of Mexico during GulfCet II. Gulf of Mexico Science 2000(1):15-22.

Birkun, A., Jr. 2002. Cetacean habitat loss and degradation in the Black Sea. Pages 8.1-8.19 in Notarbartolo di Sciara, G., ed. Cetaceans of the Mediterranean and Black Seas: State of knowledge and conservation strategies. Monaco: ACCOBAMS.

Bjørge, A. 2002. How persistent are marine mammal habitats in an ocean of variability? Pages 63-91 in Evans, P.G.H. and J.A. Raga, eds. Marine mammals: Biology and conservation. New York, New York: Kluwer Academic/Plenum Publishers.

Bjørge, A. and K.A. Tolley. 2002. Harbor porpoise (*Phocoena phocoena*). Pages 549-551 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Blanco, C. and J.A. Raga. 2000. Cephalopod prey of two *Ziphius cavirostris* (Cetacea) stranded on the western Mediterranean coast. Journal of the Marine Biological Association of the United Kingdom 80:381-382.

Blanco, C., J. Aznar, and J.A. Raga. 1995. Cephalopods in the diet of the striped dolphin *Stenella coeruleoalba* from the western Mediterranean during an epizootic in 1990. Journal of Zoology, London 237(1):151-158.

Blanco, C., O. Salomón, and J.A. Raga. 2001. Diet of the bottlenose dolphin (*Tursiops truncatus*) in the western Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 81:1053-1058.

Blanco, C., M.Á. Raduán, and J.A. Raga. 2006. Diet of Risso's dolphin (*Grampus griseus)* in the western Mediterranean Sea. Scientia Marina 70(3):407-411.

Blasi, M.F. and D.S. Pace. 2006. Interactions between bottlenose dolphin (*Tursiops truncatus*) and the artisanal fishery in Filicudi Island (Italy). Page 114 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Bloch, D., G. Desportes, M. Zachariassen, and I. Christensen. 1996. The northern bottlenose whale in the Faroe Islands, 1584-1993. Journal of Zoology, London 239:123-140.

Bolognari, A. 1951. La migrazione del Capodoglio nel Mediterraneo (The migration of the sperm whale in the Mediterranean). Bollettino di Zoologia 18:253-256.

Bompar, J.-M. 2000. Les cétacés de Méditerranée (Cetaceans of the Mediterranean). Aix-en-Provence, France: Édisud.

Born, E.W., P. Outridge, F.F. Riget, K.A. Hobson, R. Dietz, N. Øien, and T. Haug. 2003. Population substructure of North Atlantic minke whales (*Balaenoptera acutorostrata*) inferred from regional variation of elemental and stable isotopic signatures in tissues. Journal of Marine Systems 43:1-17.

Borrell, A., A. Aguilar, V. Tornero, M. Sequeira, G. Fernandez, and S. Alis. 2006. Organochlorine compounds and stable isotopes indicate bottlenose dolphin subpopulation structure around the Iberian Peninsula. Environment International 32:516-523.

Borsani, J.F., G. Pavan, J.C.D. Gordon, and G. Notarbartolo di Sciara. 1997. Regional vocalizations of the sperm whale: Mediterranean codas. European Research on Cetaceans 10:78-81.

Bortolotto, A., L. Papini, G. Insacco, C. Gili, G. Tumino, S. Mazzariol, G. Pavan, and B. Cozzi. 2003. First record of a dwarf sperm whale, *Kogia sima* (Owen, 1866) stranded alive along the coasts of Italy. Poster presentation, Thirty-first Symposium of the European Association for Aquatic Mammals. 14-17 March 2003. Tenerife, Canary Islands.

Bourret, V.J.R., M.R.J.M. Macé, and B. Crouau-Roy. 2007. Genetic variation and population structure of western Mediterranean and northern Atlantic *Stenella coeruleoalba* populations inferred from microsatellite data. Journal of the Marine Biological Association of the United Kingdom 87:265-269.

Boutiba, Z. and F. Abdelghani. 1995. Food of the common dolphin (*Delphinus delphis*, L) in Algerian waters. European Research on Cetaceans 9:182.

Bowen, W.D., C.A. Beck, and D.A. Austin. 2002. Pinniped ecology. Pages 911-921 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Boyd, I.L., C. Lockyer, and H.D. Marsh. 1999. Reproduction in marine mammals. Pages 218-286 in Reynolds III, J.E. and S.A. Rommel, eds. Biology of marine mammals. Washington, D.C.: Smithsonian Institution Press.

Breese, D. and B.R. Tershy. 1993. Relative abundance of cetacea in the Canal de Ballenas, Gulf of California. Marine Mammal Science 9(3):319-324.

Breese, M., T.A. Mooney, P.E. Nachtigall, W.W.L. Au, and S. Vlachos. 2007. Temporary threshold shift in the bottlenose dolphin (*Tursiops truncatus*): The effects of varying noise duration and intensity. Pages 19-20 in Abstracts, Twenty-first Conference of the European Cetacean Society. 22-25 April 2007. Donostia-San Sebastián, Spain.

Brown, D.H. and H.E. Winn. 1989. Relationship between the distribution pattern of right whales, *Eubalaena glacialis*, and satellite-derived sea surface thermal structure in the Great South Channel. Continental Shelf Research 9:247-260.

Brown, S.G. 1986. Twentieth-century records of right whales (*Eubalaena glacialis*) in the northeast Atlantic Ocean. Reports of the International Whaling Commission (Special Issue 10):121-127.

Bruno, S., E. Politi, and G. Bearzi. 2004. Social organisation of a common dolphin community in the eastern Ionian Sea: Evidence of a fluid fission-fusion society. European Research on Cetaceans 18:49-51.

Buckland, S.T., D. Bloch, K.L. Cattanach, T.H. Gunnlaugsson, K. Hoydal, S. Lens, and J. Sigurjónsson. 1993. Distribution and abundance of long-finned pilot whales in the North Atlantic, estimated from NASS-87 and NASS-89 data. Reports of the International Whaling Commission (Special Issue 14):33-49.

Buisson, L., R. de Stephanis, and C. Guinet. 2005. An assessment of the amount, distribution and social organizations of killer whales (*Orcinus orca*) in the Strait of Gibraltar. Page 73 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Burgener, V. 2004. Présence et Distribution du Cachalot (*Physeter macrocephalus*) et de la Baleine à bec de Cuvier (*Ziphius cavirostris*) au Sud-Ouest de la Crète et le long de la Faille hellénique (Occurrence and distribution of the sperm whale (*Physeter macrocephalus*) and the Cuvier's beaked whale (*Ziphius cavirostris*) south-west of Crete along the Hellenic Trench). Ph.D. diss, Université de Neuchâtel.

Busnel, R.-G., G. Pilleri, and F.C. Fraser. 1968. Notes concernant le dauphin *Stenella styx* Gray 1846 (Notes concerning the dolphin *Stenella styx* Gray 1846). Mammalia 32(2):192-203.

Cagnolaro, L. 1965. Osservazioni su di un giovanissimo *Ziphius cavirostris* G. Cuv. arenatosi a Genova il 20 aprile 1964 (*Cetacea, Ziphiidae*) (Observations of a young *Ziphius cavirostris* G. Cuv. stranded at Genova on 20 April 1964 (*Cetacea, Ziphiidae*)). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 104(4):377-382.

Calambokidis, J., G.H. Steiger, D.K. Ellifrit, B.L. Troutman, and C.E. Bowlby. 2004. Distribution and abundance of humpback whales (*Megaptera novaeangliae*) and other marine mammals off the northern Washington coast. Fishery Bulletin 102:563-580.

Caldwell, D.K. and M.C. Caldwell. 1971. Sounds produced by two rare cetaceans stranded in Florida. Cetology 4:1-6.

Caldwell, D.K. and M.C. Caldwell. 1972. The world of the bottlenosed dolphin. Philadelphia, Pennsylvania: J.B. Lippincott Company.

Caldwell, D.K. and M.C. Caldwell. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. Pages 235-260 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. London, United Kingdom: Academic Press.

Caldwell, M.C. and D.K. Caldwell. 1965. Individualized whistle contours in bottlenosed dolphins (*Tursiops truncatus)*. Nature 207:434-435.

Calzada, N. and A. Aguilar. 1995. Geographical variation of body size in western Mediterranean striped dolphins (*Stenella coeruleoalba*). Zeitschrift für Säugetierkunde 60:257-264.

Calzada, N., A. Aguilar, T.B. Sørensen, and C. Lockyer. 1996. Reproductive biology of female striped dolphin (*Stenella coeruleoalba*) from the western Mediterranean. Journal of Zoology, London 240:581-591.

Cañadas, A. 2006. Towards conservation of dolphins in the Alborán Sea. Ph.D. diss., Universidad Autónoma de Madrid.

Cañadas, A. and R. Sagarminaga. 2000. The northeastern Alboran Sea, an important breeding and feeding ground for the long-finned pilot whale (*Globicephala melas*) in the Mediterranean Sea. Marine Mammal Science 16(3):513-529.

Cañadas, A. and P.S. Hammond. 2006. Model-based abundance estimates for bottlenose dolphins off southern Spain: Implications for conservation and management. Journal of Cetacean Research and Management 8(1):13-27.

Cañadas, A., R. Sagarminaga, and S. García-Tiscar. 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. Deep-Sea Research I 49:2053-2073.

Cañadas, A., R. Sagarminaga, L. Hernández-Falcón, E. Fernández, and M. Fernández. 1999. Fin whales (*Balaenoptera physalus*) in the northern part of the Alboran Sea and Straits of Gibraltar. European Research on Cetaceans 13:300-304.

Cañadas, A., R. Sagarminaga, R. de Stephanis, E. Urquiola, and P.S. Hammond. 2005. Habitat preference modelling as a conservation tool: Proposals for marine protected areas for cetaceans in southern Spanish waters. Aquatic Conservation: Marine and Freshwater Ecosystems 15:495-521.

Cañadas, A., R. de Stephanis, S. Pérez, S. García, P. Verborgh, and P.S. Hammond. 2006. Methods for estimating cetacean abundance: Model-based line transect and mark-recapture compared. IWC Working Document SC/58/IA13 presented to the IWC Scientific Committee. 26 May - 6 June. St. Kitts and Nevis.

Canese, S., A. Cardinali, C.M. Fortuna, M. Giusti, G. Lauriano, E. Salvati, and S. Greco. 2006. The first identified winter feeding ground of fin whales *(Balaenoptera physalus)* in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 86:903-907.

Carlini, R., M. Pulcini, and M. Wurtz. 1992. Cephalopods from the stomach of Cuvier's beaked whale (*Ziphius cavirostris* Cuvier, 1823) stranded at Fiumino, central Tyrrhenian Sea. European Research on Cetaceans 5:190-191.

Carlisle, A., P. Coles, G. Cresswell, J. Diamond, L. Gorman, C. Kinley, G. Rondel, D. Sellwood, C. Still, M. Telfer, and D. Walker. 2001. A report on the whales, dolphins and porpoises of the Bay of Biscay and English Channel 1999. Pages 5-53 in Cresswell, G. and D. Walker, eds. A report on the whales, dolphins and seabirds of the Bay of Biscay and English Channel. Shetland Islands, United Kingdom: Organisation Cetacea (ORCA).

Carpentieri, P., M. Corsini, and L. Marini. 1999. Contribute to the knowledge of the presence and distribution of cetaceans in the Aegean Sea. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 140:65-75.

Casacci, C. and A. Gannier. 2000. Habitat variability and site fidelity of the Risso's dolphin in the northwestern Mediterranean: Defining a home range for a nomad. European Research on Cetaceans 14:19-22.

Casinos, A. and S. Filella. 1981. Notes on cetaceans of the Iberian coasts: IV. A specimen of *Mesoplodon densirostris* (Cetacea, Hyperoodontidae) stranded on the Spanish Mediterranean littoral. Saügetierkundliche Mitteilungen 29(4):61-67.

Caswell, H., M. Fujiwara, and S. Brault. 1999. Declining survival probability threatens the North Atlantic right whale. Proceedings of the National Academy of Sciences of the United States of America 96:3308-3313.

Catalano, D., L.M. Tringali, R. Petralia, and G. Caltavuturo. 2004. Mediterranean fin whales, *Balaenoptera physalus*, foraging off the eastern coast of Sicily, Ionian Sea. European Research on Cetaceans 15:56-58.

Cattanach, K.L., J. Sigurjónsson, S.T. Buckland, and T. Gunnlaugsson. 1993. 1992 Sei whale abundance in the North Atlantic estimated from NASS-87 and NASS-89 data. Reports of the International Whaling Commission 43:315-321.

Causer, J., P. White, and A. Williams. 2006. The use of scale invariant features to aid the photo-identification of Cuvier's beaked whales. Page 186 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Cebrian, D. 1995. The striped dolphin *Stenella coeruleoalba* epizootic in Greece, 1991-1992. Biological Conservation 74:143-145.

Centro Studi Cetacei. 1990. Cetacei spiaggiati lungo le coste italiane. IV. Rendiconto 1989. (Cetacean strandings along the Italian coasts. IV. Statement 1989). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 131(27):413-432.

Centro Studi Cetacei. 1996. Cetacei spiaggiati lungo le coste italiane. VIII. Rendiconto 1993 (Mammalia). (Cetaceans stranded along the Italian coasts. VIII. Statement 1993 (Mammalia)). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 135(II):437-450.

Centro Studi Cetacei. 2004. Cetacei spiaggiati lungo le coste italiane. XVII. Rendiconto 2002 (Mammalia) (Cetacean strandings along the Italian coasts. XVII. Statement 2002 (Mammalia)). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 145(1):155-169.

Centro Studi Cetacei Onlus and Museo Civico di Storia Naturale di Milano. 2006. Cetacei spiaggiati lungo le coste italiane. XIX. Rendiconto 2004 (Cetaceans stranded in Italy. XIX. Statement 2004 (Mammalia)). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 147(1):145-157.

CETAP (Cetacean and Turtle Assessment Program). 1982. Characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf. Contract AA551-CT8-48 Prepared for U.S. Bureau of Land Management, Washington, D.C. by Cetacean and Turtle Assessment Program, University of Rhode Island, Graduate School of Oceanography, Kingston, Rhode Island.

Chakroun, F. 1994. Status of cetaceans in Tunisian marine waters. European Research on Cetaceans 8:107.

Charif, R.A., D.K. Mellinger, K.J. Dunsmore, K.M. Fristrup, and C.W. Clark. 2002. Estimated source levels of fin whale (*Balaenoptera physalus*) vocalizations: Adjustments for surface interference. Marine Mammal Science 18(1):81-98.

Chivers, S.J., R.G. LeDuc, K.M. Robertson, N.B. Barros, and A.E. Dizon. 2005. Genetic variation of *Kogia* spp. with preliminary evidence for two species of *Kogia sima*. Marine Mammal Science 21(4):619-634.

2005. Personal communication via email between Dr. Lien-Siang Chou, National Taiwan University, Taipei, Taiwan, and Dr. Amy R. Scholik, Geo-Marine, Inc., Hampton, Virginia, 11 January.

Christensen, I. 1984. Growth and reproduction of killer whales, *Orcinus orca*, in Norwegian coastal waters. Report of the International Whaling Commission (Special Issue 6):253-258.

Christensen, I., T. Haug, and N. Øien. 1992. Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. ICES Journal of Marine Science 49:341-355.

Clapham, P., S. Leatherwood, I. Szczepaniak, and R.L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.

Clapham, P.J. 1996. The social and reproductive biology of humpback whales: An ecological perspective. Mammal Review 26(1):27-49.

Clapham, P.J. 2000. The humpback whale: Seasonal feeding and breeding in a baleen whale. Pages 173-196 in Mann, J., R.C. Connor, P.L. Tyack, and H. Whitehead, eds. Cetacean societies: Field studies of dolphins and whales. Chicago, Illinois: University of Chicago Press.

Clapham, P.J. 2002. Humpback whale *Megaptera novaeangliae*. Pages 589-592 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Clapham, P.J. and J.G. Mead. 1999. *Megaptera novaeangliae*. Mammalian Species 604:1-9.

Clapham, P.J., S.B. Young, and R.L. Brownell, Jr. 1999. Baleen whales: Conservation issues and the status of the most endangered populations. Mammal Review 29(1):35-60.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71:440-443.

Claridge, D.E. 2005. Age-class segregation of Blainville's beaked whale (*Mesoplodon densirostris*) groups in The Bahamas. Pages 59-60 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Claridge, D.E. 2006. Fine-scale distribution and habitat selection of beaked whales. Master's thesis, University of Aberdeen.

Clark, C.W. 1995. Annex M. Matters arising out of the discussion of blue whales: Annex M1. Application of US Navy underwater hydrophone arrays for scientific research on whales. Reports of the International Whaling Commission 45:210-212.

Clark, C.W. and K.M. Fristrup. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. Reports of the International Whaling Commission 47:583-600.

Clark, C.W. and G.J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics (US Navy) 52(3).

Clark, C.W. and P.J. Clapham. 2004. Acoustic monitoring on a humpback whale (*Megaptera novaeangliae*) feeding ground shows continual singing into late spring. Proceedings of the Royal Society B: Biological Sciences 271:1051-1057.

Clark, C.W. and W.T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: Evidence from models and empirical measurements. Pages 564-582 in Thomas, J.A., C.F. Moss, and M. Vater, eds. Echolocation in bats and dolphins. Chicago, Illinois: University of Chicago Press.

Clark, C.W., J.F. Borsani, and G. Notarbartolo-di-Sciara. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Marine Mammal Science 18(1):286-295.

Clarke, M.R. 1996. Cephalopods as prey. III. Cetaceans. Philosophical Transactions of the Royal Society of London, Series B 351:1053-1065.

Clarke, M.R. and T.K. Kristensen. 1980. Cephalopod beaks from the stomachs of two northern bottlenosed whales (*Hyperoodon ampullatus)*. Journal of the Marine Biological Association of the United Kingdom 60:151-156.

Coakes, A.K. and H. Whitehead. 2004. Social structure and mating system of sperm whales off northern Chile. Canadian Journal of Zoology 82:1360-1369.

Cockcroft, V.G. 1989. Biology of Indopacific humpback dolphins (*Sousa plumbea*) off Natal South Africa. Abstracts, Eighth Biennial Conference on the Biology of Marine Mammals. 7-11 December 1989. Pacific Grove, California.

Coles, P. 2001. Identifying beaked whales at sea in North Atlantic waters. Pages 81-90 in Cresswell, G. and D. Walker, eds. A report on the whales, dolphins and seabirds of the Bay of Biscay and English Channel. Shetland Islands, United Kingdom: Organisation Cetacea (ORCA).

Compton, R.C. 2004. Predicting key habitat and potential distribution of northern bottlenose whales (*Hyperoodon ampullatus*) in the northwest Atlantic Ocean. Master's thesis, University of Plymouth.

Connor, R.C., R.S. Wells, J. Mann, and A.J. Read. 2000. The bottlenose dolphin: Social relationships in a fission-fusion society. Pages 91-126 in Mann, J., R.C. Connor, P.L. Tyack, and H. Whitehead, eds. Cetacean societies: Field studies of dolphins and whales. Chicago, Illinois: University of Chicago Press.

Conversi, A., S. Piontkovski, and S. Hameed. 2001. Seasonal and interannual dynamics of *Calanus finmarchicus* in the Gulf of Maine (northeastern US shelf) with reference to the North Atlantic Oscillation. Deep-Sea Research II 48:519-530.

Cook, M.L.H., C.A. Manire, and D.A. Mann. 2005. Auditory evoked potential (AEP) measurements in stranded rough-toothed dolphins (*Steno bredanensis*). Journal of the Acoustical Society of America 117(4, Part 2):2441.

Cook, M.L.H., L.S. Sayigh, J.E. Blum, and R.S. Wells. 2004. Signature-whistle production in undisturbed free-ranging bottlenose dolphins (*Tursiops truncatus)*. Proceedings of the Royal Society B: Biological Sciences 271:1043-1049.

Cook, M.L.H., R.A. Varela, J.D. Goldstein, S.D. McCulloch, G.D. Bossart, J.J. Finneran, D. Houser, and D.A. Mann. 2006. Beaked whale auditory evoked potential hearing measurements. Journal of Comparative Physiology A 192:489-495.

Coppola, E. 2005. Summer sightings at Orosei. The Monachus Guardian 8(2):12.

Corkeron, P.J. 1990. Aspects of the behavioral ecology of inshore dolphins *Tursiops truncatus* and *Sousa chinensis* in Moreton Bay, Australia. Pages 285-293 in Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, California: Academic Press.

Corkeron, P.J. and R.C. Connor. 1999. Why do baleen whales migrate? Marine Mammal Science 15(4):1228-1245.

Corkeron, P.J. and S.M. Van Parijs. 2001. Vocalizations of eastern Australian Risso's dolphins, *Grampus griseus*. Canadian Journal of Zoology 79(1):160-164.

Cornax, M.J., X. Pastor, and R. Aguilar. 2006. Italian driftnetters 2006: The Oceana report. Madrid, Spain: Oceana.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003. COSEWIC assessment and status report on the humpback whale *Megaptera novaeangliae* in Canada. Ottawa, Ontario: Committee on the Status of Endangered Wildlife in Canada.

Costa, D.P. 1993. The secret life of marine mammals: Novel tools for studying their behavior and biology at sea. Oceanography 6(3):120-128.

Costa Neves, H. 1999. Preliminary findings on the feeding behaviour and general ecology of the Mediterranean monk seal *Monachus monachus* - (Pinnipedia: Monachinae) on the Desertas Islands. Boletim do Museu Municipal do Funchal (Supplement 5):263-271.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D.C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3):177-187.

Craig, A.S. and L.M. Herman. 2000. Habitat preferences of female humpback whales *Megaptera novaeangliae* in the Hawaiian Islands are associated with reproductive status. Marine Ecology Progress Series 193:209-216.

Craig, A.S., L.M. Herman, C.M. Gabriele, and A.A. Pack. 2003. Migratory timing of humpback whales (*Megaptera novaeangliae*) in the central North Pacific varies with age, sex and reproductive status. Behaviour 140:981-1001.

Cresswell, G. and D. Walker, eds. 2001. A report on the whales, dolphins and seabirds of the Bay of Biscay and English Channel. Shetland Islands, United Kingdom: Organisation Cetacea (ORCA).

Cretton, C., P. Beaubrun, and M. Bouzelboudjen. 2003. Importance of canyons and their extensions for the striped dolphin (*Stenella coeruleoalba*) in the northern part of the Mediterranean: Exploitation of results from acoustic and visual detections using Geographic Information System. Page 40 in Abstracts, Seventeenth Annual Conference of the European Cetacean Society. 9-13 March 2003. Las Palmas de Gran Canaria, Spain.

Crise, A., J.I. Allen, J. Baretta, G. Crispi, R. Mosetti, and C. Solidoro. 1999. The Mediterranean pelagic ecosystem response to physical forcing. Progress in Oceanography 44:219-243.

Croll, D.A., B.R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical report for LFA EIS. Prepared for the U.S. Navy by Institute of Marine Sciences, University of California, Santa Cruz, California.

Croll, D.A., A. Acevedo-Gutiérrez, B.R. Tershy, and J. Urbán-Ramírez. 2001. The diving behavior of blue and fin whales: Is dive duration shorter than expected based on oxygen stores? Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology 129:797-809.

Croll, D.A., C.W. Clark, A. Acevedo, B. Tershy, S. Flores, J. Gedamke, and J. Urban. 2002. Only male fin whales sing loud songs. Nature 417:809.

Croll, D.A., B.R. Tershy, R.P. Hewitt, D.A. Demer, P.C. Fiedler, S.E. Smith, W. Armstrong, J.M. Popp, T. Kiekhefer [sic], V.R. Lopez, J. Urban, and D. Gendron. 1998. An integrated approch [sic] to the foraging ecology of marine birds and mammals. Deep-Sea Research II 45:1353-1371.

Culik, B.M. 2004. Review of small cetaceans. Distribution, behaviour, migration and threats. Marine Mammal Action Plan / Regional Seas Reports and Studies Number 177 Bonn, Germany: United Nations Environment Programme (UNEP) and the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals (CMS).

Cummings, W.C. and J.F. Fish. 1971. A synopsis of marine animal underwater sounds in eight geographic areas. San Diego, California: Naval Undersea Research and Development Center. .

Curry, B.E. and J. Smith. 1997. Phylogeographic structure of the bottlenose dolphin (*Tursiops truncatus*): Stock identification and implications for management. Pages 227-247 in Dizon, A.E., S.J. Chivers, and W.F. Perrin, eds. Molecular genetics of marine mammals. Lawrence, Kansas: Society for Marine Mammalogy.

D'Amico, A., F. Mineur, A. Alverez, C. Mori, M. Podestà, N. Portunato, M. Ballardini, and B. Nani. 2001. Oceanographic correlations with the distribution of Cuvier's beaked whales (*Ziphius cavirostris*) in the Ligurian Sea. Pages 52-53 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 2001. Vancouver, British Columbia.

D'Amico, A., A. Bergamasco, P. Zanasca, S. Carniel, E. Nacini, N. Portunato, V. Teloni, C. Mori, and R. Barbanti. 2003. Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. IEEE Journal of Oceanic Engineering 28(1):29-43.

D'Spain, G.L., A. D'Amico, and D.M. Fromm. 2006. Properties of the underwater sound fields during some well documented beaked whale mass stranding events. Journal of Cetacean Research and Management 7(3):223-238.

D'Vincent, C.G., R.M. Nilson, and R.E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. Scientific Reports of the Whales Research Institute 36:41-47.

Dahlheim, M.E. and J.E. Heyning. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). Pages 281-322 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Dalebout, M.L., K.M. Robertson, A. Frantzis, D. Engelhaupt, A.A. Mignucci-Giannoni, R.J. Rosario-Delestre, and C.S. Baker. 2005. Worldwide structure of mtDNA diversity among Cuvier's beaked whales (*Ziphius cavirostris*): Implications for threatened populations. Molecular Ecology 14:3353-3371.

David, L. 2000. Rôle et importance des Canyons sous-marins sur la marge continentale dans la distribution estivale des cétacés de Méditerranée Nord-Occidentale (Role and importance of submarine canyons on the continental margin for the summer distribution of cetaceans in the North-western Mediterranean Sea). Ph.D. diss., École Pratique des Hautes Études.

David, L. and P. Beaubrun. 2004. Role and importance of submarine canyons on the continental margin for the summer distribution of cetaceans in the north-western Mediterranean Sea. European Research on Cetaceans 15:64-68.

Davis, R.W., W.E. Evans, and B. Würsig, eds. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. USGS/BRD/CR-1999-0006 and OCS Study MMS 2000-003 New Orleans, Louisiana: Minerals Management Service.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Marine Mammal Science 14(3):490-507.

Davis, R.W., J.G. Ortega-Ortiz, C.A. Ribic, W.E. Evans, D.C. Biggs, P.H. Ressler, R.B. Cady, R.R. Leben, K.D. Mullin, and B. Würsig. 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. Deep-Sea Research I 49:121-142.

Daziens, J.M. 2004. Assessing the performance of omni-directional receivers for passive acoustic detection of vocalizing odontocetes. Master's thesis, Naval Postgraduate School.

de Stephanis, R. 2004. Interactions between killer whales and the bluefin tuna fishery in the Strait of Gibraltar. FINS (Newsletter of ACCOBAMS) 1(2):6-7.

de Stephanis, R. 2005. Distribución de cetáceos en el Estrecho de Gibraltar en función de parámetros oceanográficos en condiciones estivales (Cetacean distribution in the Strait of Gibraltar as a function of oceanographic parameters). Master's thesis, Universidad de Cádiz.

de Stephanis, R., C. Guinet, L. Buisson, P. Verborgh, and P. Dominici. 2005. Population status, social organisation and feeding strategies of killer whales (*Orcinus orca*) in the Strait of Gibraltar. Page 80 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

de Stephanis, R., A. Cañadas, N. Villalba, N. Perez-Gimeno, R. Sargarminaga, A. Segura, M. Fernández-Casado, and C. Guinet. 2004. Fin whale (*Balaenoptera physalus*) migration through the Strait of Gibraltar? European Research on Cetaceans 15:382-383.

Deecke, V.B., J.K.B. Ford, and P.J.B. Slater. 2005. The vocal behaviour of mammal-eating killer whales: Communicating with costly calls. Animal Behaviour 69:395-405.

Defran, R.H. and D.W. Weller. 1999. Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (*Tursiops truncatus*) off San Diego, California. Marine Mammal Science 15(2):366-380.

Dehnhardt, G., B. Mauck, W. Hanke, and H. Bleckmann. 2001. Hydrodynamic trail-following in harbor seals (*Phoca vitulina*). Science 293:102-104.

Delmas, A. and A. Gannier. 2005. Acoustic repertoire of the long-finned pilot whale in the northwestern Mediterranean Sea. Pages 41-42 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

DeLorenzo Costa, A., E.G. Durbin, and C.A. Mayo. 2006. Variability in the nutritional value of the major copepods in Cape Cod Bay (Massachusetts, USA) with implications for right whales. Marine Ecology 27:109-123.

DeMaster, D.P., C.W. Fowler, S.L. Perry, and M.F. Richlen. 2001. Predation and competition: The impact of fisheries on marine-mammal populations over the next one hundred years. Journal of Mammalogy 82(3):641-651.

Dendrinos, P., A.A. Karamanlidis, E. Androukaki, and B.J. McConnell. 2007. Diving development and behavior of a rehabilitated Mediterranean monk seal (*Monachus monachus*). Marine Mammal Science 23(2):387-397.

Desportes, G. 1985. La nutrition des odontocetes en Atlantique nord - est (côtes Françaises - iles Feroë) (Nutrition of odontocetes in the northeast Atlantic (French coast - Faroe Islands). Ph.D. diss, Universite de Poitiers.

Desportes, G. and R. Mouritsen. 1993. Preliminary results on the diet of long-finned pilot whales off the Faroe Islands. Reports of the International Whaling Commission (Special Issue 14):305-324

Di-Meglio, N., L. David, and P. Beaubrun. 1999. Spatio-temporal distribution of Risso's dolphin *Grampus griseus* (Cuvier, 1812) in summer in the north-western Mediterranean Sea. European Research on Cetaceans 13:195-200.

Di-Méglio, N. and A. Collet. 1994. Reproductive parameters in striped dolphins from the Mediterranean and Atlantic coast of France. European Research on Cetaceans 8:145-147.

Di Natale, A. 1983a. Distribution, frequence [sic] and biology of the common dolphin, *Delphinus delphis* Linneus, in the central Mediterranean Sea. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 28(5):199-200.

Di Natale, A. 1983b. A sighting of bridled dolphin, *Stenella frontalis* (G. Cuvier) in the Mediterranean Sea. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 28(5):191-192.

Di Natale, A. and A. Mangano. 1985. Mating and calving of the sperm whale in the central Mediterranean Sea. Aquatic Mammals 1:7-9.

Díaz López, B. and J.A. Bernal Shirai. 2007. Bottlenose dolphin (*Tursiops truncatus*) presence and incidental capture in a marine fish farm on the north-eastern coast of Sardinia (Italy). Journal of the Marine Biological Association of the United Kingdom 87:113-117.

Díaz López, B., L. Marini, and F. Polo. 2005. The impact of a fish farm on a bottlenose dolphin population in the Mediterranean Sea. Thalassas 21(2):65-70.

Dietz, R., J. Teilmann, M.-P.H. Jørgensen, and M.V. Jensen. 2002. Satellite tracking of humpback whales in West Greenland. Roskilde, Denmark: National Environmental Research Institute Technical Report 411.

DiGiovanni, R.A., Jr., K.F. Durham, J.N. Wocial, R.P. Pisciotta, R. Hanusch, A.M. Chaillet, A.D. Hallett, A.M. Sabrosky, and R.A. Scott. 2005. Rehabilitation and post release monitoring of a male Risso's dolphin (*Grampus griseus*) released in New York waters. Page 76 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Dolphin, W.F. 1987. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology 65:83-90.

Donovan, G.P. 1991. A review of IWC stock boundaries. Reports of the International Whaling Commission (Special Issue 13):39-68.

Donovan, G.P. and A. Bjørge. 1995. Harbour porpoises in the North Atlantic: Edited extract from the report of the IWC Scientific Committee, Dublin 1995. Reports of the International Whaling Commission (Special Issue 16):3-25.

Drinkwater, K.F., A. Belgrano, A. Borja, A. Conversi, M. Edwards, C.H. Greene, G. Ottersen, A.J. Pershing, and H. Walker. 2003. The response of marine ecosystems to climate variability associated with the North Atlantic Oscillation. Geophysical Monograph 134:211-234.

Drouot-Dulau, V. and A. Gannier. 2007. Movements of sperm whale in the western Mediterranean Sea: Preliminary photo-identification results. Journal of the Marine Biological Association of the United Kingdom 87:195-200.

Drouot, V. 2003. Ecology of sperm whale (*Physeter macrocephalus*) in the Mediterranean Sea. Ph.D. diss., University of Wales.

Drouot, V. and A. Gannier. 1999. New sperm whale vocalizations recorded in the Mediterranean Sea. European Research on Cetaceans 13:30–32.

Drouot, V., J.C. Goold, and A. Gannier. 2004a. Regional diversity in the social vocalizations of sperm whale in the Mediterranean Sea. Revue d'Ecologie: La Terre et la Vie 59:545-558.

Drouot, V., A. Gannier, and J.C. Goold. 2004b. Diving and feeding behaviour of sperm whales (*Physeter macrocephalus*) in the northwestern Mediterranean Sea. Aquatic Mammals 30(3):419-426.

Drouot, V., A. Gannier, and J.C. Goold. 2004c. Summer social distribution of sperm whales (*Physeter macrocephalus*) in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 84:675-680.

Dubroca, L., J.-M. André, P. Beaubrun, E. Bonin, L. David, J.-P. Durbec, P. Monestiez, and C. Guinet. 2004. Summer fin whales (*Balaenoptera physalus*) distribution in relation to oceanographic conditions: Implications for conservation. CIESM Workshop Monographs 25:77-84.

Duffield, D.A., S.H. Ridgway, and L.H. Cornell. 1983. Hematology distinguishes coastal and offshore forms of dolphins (*Tursiops*). Canadian Journal of Zoology 61:930-933.

Duguy, R. 1986. Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France XVI - Année 1986 (Annual report on cetaceans and pinnipeds found along the coast of France XVI - Year 1986). Annales de la Société des Sciences Naturelles de la Charente-Maritime 7(5):617-639.

Duguy, R., A. Casinos, D. Di Natale, S. Filella, F. Ktari-Chakroun, R. LLoze, and D. Marchessaux. 1983. Repartition et frequence des mammiferes marins en Mediterranee (Distribution and frequency of marine mammals in the Mediterranean). Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 28(5):223-230.

Edds-Walton, P.L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics 8:47-60.

Edds-Walton, P.L. 2000. Vocalizations of minke whales *Balaenoptera acutorostrata* in the St. Lawrence Estuary. Bioacoustics 11:31-50.

Engelhaupt, D.T. 2004. Phylogeography, kinship and molecular ecology of sperm whale *(Physeter macrocephalus)*. Ph.D. diss., University of Durham.

Ersts, P.J. and H.C. Rosenbaum. 2003. Habitat preference reflects social organization of humpback whales (*Megaptera novaeangliae*) on a wintering ground. Journal of Zoology, London 260:337-345.

Etnoyer, P., D. Canny, B. Mate, and L. Morgan. 2004. Persistent pelagic habitats in the Baja California to Bering Sea (B2B) Ecoregion. Oceanography 17(1):90-101.

Evans, W.E. 1994. Common dolphin, white-bellied porpoise *Delphinus delphis* Linnaeus, 1758. Pages 191-224 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Ferguson, M.C. 2005. Cetacean population density in the eastern Pacific Ocean: Analyzing patterns with predictive spatial models. Ph.D. diss., University of California.

Ferguson, M.C., J. Barlow, S.B. Reilly, and T. Gerrodette. 2006. Predicting Cuvier's *(Ziphius cavirostris)* and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. Journal of Cetacean Research and Management 7(3):287-299.

Ferretti, S., G. Bearzi, and E. Politi. 1999. Comparing behaviour of inshore bottlenose and common dolphins in the Eastern Ionian Sea through focal group surfacing pattern analysis. European Research on Cetaceans 12:209.

Fertl, D., A. Acevedo-Gutiérrez, and F.L. Darby. 1996. A report of killer whales (*Orcinus orca*) feeding on a carcharhinid shark in Costa Rica. Marine Mammal Science 12(4):606-611.

Fiedler, P.C. 2002. Ocean environment. Pages 824-830 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Field, I., M. Hindell, D. Slip, and K. Michael. 2001. Foraging strategies of southern elephant seals (*Mirounga leonina*) in relation to frontal zones and water masses. Antarctic Science 13(4):371-379.

Finneran, J.J. and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. Technical report 1913 Prepared for Chief of Naval Operations by Research and Animal Care Branch, Biosciences Division, SSC San Diego, San Diego, California.

Finneran, J.J. and D.S. Houser. 2006. Comparison of in-air evoked potential and underwater behavioral hearing thresholds in four bottlenose dolphins (*Tursiops truncatus*). Journal of the Acoustical Society of America 119(5):3181-3192.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal of the Acoustical Society of America 118(4):2696-2705.

Fish, J.F. and C.W. Turl. 1976. Acoustic source levels of four species of small whales. NUC TP 547 San Diego, California: Naval Undersea Center.

Flores, P.A.C. and A. Ximenez. 1997. Observations on the rough-toothed dolphin *Steno bredanensis* off Santa Catarina Island, southern Brazilian coast. Biotemas 10(1):71-79.

Forcada, J. 2002. Distribution. Pages 327-333 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Forcada, J. and P. Hammond. 1998. Geographical variation in abundance of striped and common dolphins of the western Mediterranean. Journal of Sea Research 39:313-325.

Forcada, J., G. Notarbartolo di Sciara, and F. Fabbri. 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. Mammalia 59(1):127-140.

Forcada, J., P.S. Hammond, and A. Aguilar. 1999. Status of the Mediterranean monk seal *Monachus monachus* in the western Sahara and the implications of a mass mortality event. Marine Ecology Progress Series 188:249-261.

Forcada, J., P.N. Trathan, K. Reid, and E.J. Murphy. 2005. The effects of global climate variability in pup production of Antarctic fur seals. Ecology 86(9):2408-2417.

Forcada, J., A. Aguilar, P.S. Hammond, X. Pastor, and R. Aguilar. 1994. Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. Marine Mammal Science 10(2):137-150.

Forcada, J., A. Aguilar, P. Hammond, X. Pastor, and R. Aguilar. 1996. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the western Mediterranean Sea during the summer. Journal of Zoology, London 238(1):23-34.

Forcada, J., M. Gazo, A. Aguilar, J. Gonzalvo, and M. Fernández-Contreras. 2004. Bottlenose dolphin abundance in the NW Mediterranean: Addressing heterogeneity in distribution. Marine Ecology Progress Series 275:275-287.

Ford, J.K.B. 1991. Vocal traditions among resident killer whales (*Orcinus orca*) in coastal waters of British Columbia. Canadian Journal of Zoology 69:1454-1483.

Ford, J.K.B. 2002a. Dialects. Pages 322-323 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Ford, J.K.B. 2002b. Killer whale *Orcinus orca*. Pages 669-676 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Ford, J.K.B. and G.M. Ellis. 1999. Transients: Mammal-hunting killer whales of British Columbia, Washington, and southeastern Alaska. Vancouver, B.C. and Seattle, Washington: UBC Press and University of Washington Press.

Forney, K.A. 2000. Environmental models of cetacean abundance: Reducing uncertainty in population trends. Conservation Biology 14(5):1271-1286.

Fortuna, C.M. 2006. Ecology and conservation of bottlenose dolphins (*Tursiops truncatus*) in the north-eastern Adriatic Sea. Ph.D. diss, University of St. Andrews.

Franco, I., J. Mas, and C. Rodriguez. 1995. Cetacean sightings in the Alboran Sea, July 1993. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 34:243.

Frantzis, A. 1997. Cetaceans and cetology in the Hellenic Seas. European Research on Cetaceans 10:114-118.

Frantzis, A. 1998. Does acoustic testing strand whales? Nature 392:29.

Frantzis, A. 2004. The first mass stranding that was associated with the use of active sonar (Kyparissiakos Gulf, Greece, 1996). European Cetacean Society Newsletter 42(Special Issue):14-20.

Frantzis, A. and D.L. Herzing. 2002. Mixed-species associations of striped dolphins (*Stenella coeruleoalba*), short-beaked common dolphins (*Delphinus delphis*), and Risso's dolphins (*Grampus griseus*) in the Gulf of Corinth (Greece, Mediterranean Sea). Aquatic Mammals 28(2):188-197.

Frantzis, A., J. Gordon, G. Hassidis, and A. Komnenoy. 2001. The enigma of harbor porpoise presence in the Mediterranean Sea. Marine Mammal Science 17(4):937-944.

Frantzis, A., O. Nikolaou, J.-M. Bompar, and A. Cammedda. 2004a. Humpback whale (*Megaptera novaengliae*) occurrence in the Mediterranean Sea. Journal of Cetacean Research and Management 6(1):25-28.

Frantzis, A., J.C. Goold, E.K. Skarsoulis, M.I. Taroudakis, and V. Kandia. 2002. Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L). Journal of the Acoustical Society of America 112(1):34-37.

Frantzis, A., P. Alexiadou, E. Politi, A. Gannier, and M. Corsini-Foka. 2004b. Cetacean fauna of the Greek Seas: Unexpectedly high species diversity. European Research on Cetaceans 15:421-425.

Frantzis, A., R. Swift, D. Gillespie, C. Menhennett, J. Gordon, and S. Gialinakis. 1999. Sperm whale presence off south-west Crete, Greece, Eastern Mediterranean. European Research on Cetaceans 13:214-217.

Frantzis, A., P. Alexiadou, G. Paximadis, E. Politi, A. Gannier, and M. Corsini-Foka. 2003. Current knowledge of the cetacean fauna of the Greek Seas. Journal of Cetacean Research and Management 5(3):219-232.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. FWS/OBS-82/65 Washington, D.C.: U.S. Fish and Wildlife Service.

Fulling, G.L., K.D. Mullin, and C.W. Hubard. 2003. Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico. Fishery Bulletin 101:923-932.

Gabriele, C. and A. Frankel. 2002. The occurrence and significance of humpback whale songs in Glacier Bay, southeastern Alaska. Arctic Research of the United States 16:42-47.

Gabriele, C., A. Frankel, and T. Lewis. 2001. Frequent humpback whale songs recorded in Glacier Bay, Alaska in Fall 2000. Pages 77-78 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November - 3 December 2001. Vancouver, British Columbia.

Gallego, P. and R. Lott. 2005. Long-finned pilot whales chase killer whales in the Strait of Gibraltar. Page 100 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Gallego, P., E. Andréu, A. Cosentino, R. Lott, and A. Scullion. 2007. Killer whale (*Orcinus orca*) diet in the Strait of Gibraltar. Page 103 in Abstracts, Twenty-first Conference of the European Cetacean Society. 22-25 April 2007. Donostia-San Sebastián, Spain.

Gambell, R. 1985. Sei whale *Balaenoptera borealis* Lesson, 1828. Pages 155-170 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Gannier, A. 1997. Estimation de l'abondance estivale du rorqual commun *Balaenoptera physalus* (Linné, 1758) dans le bassin Liguro-Provençal (Méditerranée occidentale) (Abundance estimates of the fin whale *Balaenoptera physalus* (Linné, 1758) in the Ligurian-Provençal Basin (western Mediterranean)). Revue d'Ecologie: La Terre et la Vie 52:69-86.

Gannier, A. 1998a. Variation saisonnière de l`affinité bathymétrique des cétacés dans le bassin liguro-provençal (Méditerranée Occidentale) (Seasonal variation of the bathymetric distribution of cetaceans in the Liguro-Provençal basin (Western Mediterranean)). Vie Milieu 48(1):25-34.

Gannier, A. 1998b. A contribution to the knowledge of the cetological fauna in the waters of western Sardinia. Hystrix 10(2):21-27.

Gannier, A. 1999. Diel variations of the striped dolphin distribution off the French Riviera (Northwestern Mediterranean Sea). Aquatic Mammals 25(3):123-134.

Gannier, A. 2000. Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys. Aquatic Mammals 26(2):111-126.

Gannier, A. 2002a. Cetaceans of the Marquesas Islands (French Polynesia): Distribution and relative abundance as obtained from a small boat dedicated survey. Aquatic Mammals 28(2):198-210.

Gannier, A. 2002b. Summer distribution of fin whales *(Balaenoptera physalus)* in the Northwestern Mediterranean Marine Mammals Sanctuary. Revie d'Ecologie (La Tierre et la Vie) 57:135-150.

Gannier, A. 2005a. Summer activity pattern of fin whales (*Balaenoptera physalus*) in the northwerstern [sic] mediterranean [sic] pelagos [sic] sanctuary [sic]. Mésogée 61:35-41.

Gannier, A. 2005b. Summer distribution and relative abundance of delphinids in the Mediterranean Sea. Revue d'Ecologie: La Terre et la Vie 60:223-238.

Gannier, A. and K.L. West. 2005. Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands (French Polynesia). Pacific Science 59(1):17-24.

Gannier, A. and E. Praca. 2007. SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 87:187-193.

Gannier, A., V. Drouot, and J.C. Goold. 2002a. Distribution and relative abundance of sperm whales in the Mediterranean Sea. Marine Ecology Progress Series 243:281-293.

Gannier, A., S. Bourreau, V. Drouot, O. Gannier, and S. Laran. 2002b. Summer distribution of fin whale (*Balaenoptera physalus*) in the Mediterranean Sea. Mésogée 60:17-25.

Gannon, D.P. and D.M. Waples. 2004. Diets of coastal bottlenose dolphins from the U.S. mid-Atlantic coast differ by habitat. Marine Mammal Science 20(3):527-545.

Gannon, D.P., J.E. Craddock, and A.J. Read. 1998. Autumn food habits of harbor porpoises, *Phocoena phocoena*, in the Gulf of Maine. Fishery Bulletin 96:428-437.

Gannon, D.P., N.B. Barros, D.P. Nowacek, A.J. Read, D.M. Waples, and R.S. Wells. 2005. Prey detection by bottlenose dolphins, *Tursiops truncatus*: An experimental test of the passive listening hypothesis. Animal Behaviour 69:709-720.

García-Martinez, J., J.A. Raga, and A. Latorre. 1996. Population structure of striped dolphins (*Stenella coeruleoalba*) in European waters based on mitochondrial DNA. European Research on Cetaceans 10:303.

García-Tiscar, S., R. Sagarminaga, and A. Cañadas. 2004. Arrival and permanence of an immigrant group of bottlenose dolphins (*Tursiops truncatus*) in the north-eastern Alboran Sea. European Research on Cetaceans 15:225-227.

García, S., D. Knouse, R. Sagarminaga, and A. Cañadas. 2000. An insight on the biological significance of mixed groups of common dolphins (*Delphinus delphis*) and striped dolphins (*Stenella coeruleoalba*) in the Alboran Sea. European Research on Cetaceans 14:135-137.

Garrigue, C. and J. Greaves. 2001. Cetacean records for the New Caledonian area (Southwest Pacific Ocean). Micronesica 34(1):27-33.

Garrison, L.P. 2005. Applying a spatial model to evaluate the risk of interactions between vessels and right whales in the southeast U.S. critical habitat. Miami, Florida: Southeast Fisheries Science Center.

Garrison, L.P., R.D. Baumstark, C. Keller, and L.I. Ward-Geiger. 2005. A spatial model of the North Atlantic right whale calving habitat in the southeastern United States. Page 102 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Gaskin, D.E. 1982. The ecology of whales and dolphins. Portsmouth, New Hampshire: Heinemann.

Gaskin, D.E. 1992. Status of the harbour porpoise, *Phocoena phocoena*, in Canada. Canadian Field-Naturalist 106(1):36-54.

Gaspari, S., S. Airoldi, and A.R. Hoelzel. 2004. Molecular ecology of striped dolphins (*Stenella coeruleoalba)* in the Mediterranean Sea. European Research on Cetaceans 15:309-310.

Gaspari, S., S. Airoldi, and A.R. Hoelzel. 2006. Risso's dolphins (*Grampus griseus*) in UK waters are differentiated from a population in the Mediterranean and genetically less diverse. Conservation Genetics doi 10.1007/s10592-006-9205-y.

Gaspari, S., A. Azzellino, S. Airoldi, and A.R. Hoelzel. 2000. Association patterns of Risso's dolphins (*Grampus griseus*) in the north-west Mediterranean. European Research on Cetaceans 14:138.

Gaspari, S., A. Azzellino, S. Airoldi, and A.R. Hoelzel. 2007. Social kin associations and genetic structuring of striped dolphin populations (*Stenella coeruleoalba*) in the Mediterranean Sea. Molecular Ecology 16(4):2922-2933.

Gazo, M. and A. Aguilar. 2005. Maternal attendance and diving behavior of a lactating Mediterranean monk seal. Marine Mammal Science 21(2):340-345.

Gazo, M., C. Lydersen, and A. Aguilar. 2006. Diving behaviour of Mediterranean monk seal pups during lactation and post weaning. Marine Ecology Progress Series 308:303-309.

Gazo, M., F. Aparicio, M.A. Cedenilla, J.F. Layna, and L.M. González. 2000. Pup survival in the Mediterranean monk seal (*Monachus monachus*) colony at Cabo Blanco Peninsula (western Sahara-Mauritania). Marine Mammal Science 16(1):158-168.

Gazo, M., J.F. Layna, F. Aparicio, M.A. Cedenilla, L.M. González, and A. Aguilar. 1999. Pupping season, perinatal sex ratio and natality rates of the Mediterranean monk seal (*Monachus monachus*) from the Cabo Blanco colony. Journal of Zoology, London 249:393-401.

Gedamke, J., D.P. Costa, and A. Dunstan. 2001. Localization and visual verification of a complex minke whale vocalization. Journal of the Acoustical Society of America 109(6):3038-3047.

Gendron, D. and J. Urbán R. 1993. Evidence of feeding by humpback whales (*Megaptera novaeangliae*) in the Baja California breeding ground, Mexico. Marine Mammal Science 9(1):76-81.

Gilmartin, W.G. and J. Forcada. 2002. Monk seals *Monachus monachus, M. tropicalis,* and *M. schauinslandi*. Pages 756-759 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Gimeno, N.P., R. de Stephanis, M. Fernandez-Casado, P. Gozalbes, E. Poncelet, and C. Guinet. 2004. Interactions between killer whales (*Orcinus orca*) and the red tuna (*Thunnus thynnus*) fishery in the Strait of Gibraltar. European Research on Cetaceans 15:82-83.

Glass, A.H., C.R. Taylor, and D. Cupka. 2005. Monitoring North Atlantic right whale (*Eubalaena glacialis*) distribution north of the Southeastern U.S. calving ground critical habitat Pages 106-107 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Goffman, O., M. Roditi, T. Shariv, E. Spanier, and D. Kerem. 2000. Cetaceans from the Israeli coast of the Mediterranean Sea. Israel Journal of Zoology 46:143-147.

Goffman, O., S.-L. Granit, N. Hadar, D. Kerem, V. Podiadis, R. Kent, E. Ratner, M. Roditi-Elasar, A. Scheinin, and E. Spanier. 2006. Cetacean species in Israeli Mediterranean waters: Update 2000-2006. Abstracts, Third Annual Meeting of the Israeli Association for Aquatic Sciences, . 23 May 2006. Haifa, Israel.

Gomerčić, H., M.Đ. Gomerčić, T. Gomerčić, H. Lucić, M. Dalebout, A. Galov, D. Škrtić, S. Ćurković, S. Vuković, and Đ. Huber. 2006. Biological aspects of Cuvier's beaked whale (*Ziphius cavirostris)* recorded in the Croatian part of the Adriatic Sea. European Journal of Wildlife Research 52:182-187.

Gomercic, M.D., T. Gomercic, D. Huber, and H. Gomercic. 2005. Recent sightings of the monk seal in Croatian areas of the Adriatic. Monachus Guardian 8(2).

Gómez de Segura, A., P.S. Hammond, A. Cañadas, and J.A. Raga. 2007. Comparing cetacean abundance estimates derived from spatial models and design-based line transect methods. Marine Ecology Progress Series 329:289-299

Gómez de Segura, A., E.A. Crespo, S.N. Pedraza, P.S. Hammond, and J.A. Raga. 2006. Abundance of small cetaceans in waters of the central Spanish Mediterranean. Marine Biology 150:149-160.

Goodyear, J.D. 1993. A sonic/radio tag for monitoring dive depths and underwater movements of whales. Journal of Wildlife Management 57(3):503-513.

Goold, J.C. 1999. Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. Journal of the Marine Biological Association of the United Kingdom 79:541-550.

Goold, J.C. 2000. A diel pattern in vocal activity of short-beaked common dolphins, *Delphinus delphis*. Marine Mammal Science 16(1):240-244.

Goold, J.C. and T.A. Jefferson. 2004. A note on clicks recorded from free-ranging Indo-Pacific humpback dolphins, *Sousa chinensis*. Aquatic Mammals 30(1):175-178.

Gordon, J.C.D., J.N. Matthews, S. Panigada, A. Gannier, J.F. Borsani, and G. Notarbartolo di Sciara. 2000. Distribution and relative abundance of striped dolphins, and distribution of sperm whales in the Ligurian Sea cetacean sanctuary: Results from a collaboration using acoustic monitoring techniques. Journal of Cetacean Research and Management 2(1):27-36.

Gowans, S. and L. Rendell. 1999. Head-butting in northern bottlenose whales (*Hyperoodon ampullatus*): A possible function for big heads. Marine Mammal Science 15(4):1342-1350.

Gowans, S., H. Whitehead, and S.K. Hooker. 2001. Social organization in northern bottlenose whales, *Hyperoodon ampullatus*: Not driven by deep-water foraging? Animal Behaviour 62:369-377.

Green, G.A., J.J. Brueggeman, R.A. Grotefendt, C.E. Bowlby, M.L. Bonnell, and K.C. Balcomb III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pages 1-1 to 1-100 in Brueggeman, J.J., ed. Oregon and Washington marine mammal and seabird surveys. OCS Study MMS 91-0093. Los Angeles, California: Minerals Management Service.

Greene, C.H., A.J. Pershing, R.D. Kenney, and J.W. Jossi. 2003. Impact of climate variability on the recovery of endangered North Atlantic right whales. Oceanography 16(4):98-103.

Gregr, E.J. and A.W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 58:1265-1285.

Gregr, E.J., L. Nichol, J.K.B. Ford, G. Ellis, and A.W. Trites. 2000. Migration and population structure of northeastern Pacific whales off coastal British Columbia: An analysis of commercial whaling records from 1908-1967. Marine Mammal Science 16(4):699-727.

Griffin, R.B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Marine Mammal Science 15(1):33-51.

Güçlüsoy, H. 2007. The first confirmed report of the harbour porpoise (*Phocoena phoceana*) in the Turkish Aegean Sea. JMBA2-Biodiversity Records Published Online.

Güçlüsoy, H., C.O. Kiraç, N.O. Veryeri, and Y. Savas. 2004. Status of the Mediterranean monk seal, *Monachus monachus* (Hermann, 1779) in the coastal waters of Turkey. E.U. Journal of Fisheries & Aquatic Sciences 21(3-4):201-210.

Gucu, A.C., M. Ok, and H. Örek. 2003. Seeking answers in the Gulf of Iskenderun: Do eastern Mediterranean monk seals migrate. Monachus Guardian 6(2):54-56.

Gucu, A.C., G. Gucu, and H. Orek. 2004. Habitat use and preliminary demographic evaluation of the critically endangered Mediterranean monk seal (*Monachus monachus*) in the Cilician Basin (Eastern Mediterranean). Biological Conservation 116:417-431.

Guinet, C., B. Mate, I. Bentaleb, J.-M. André, P. Mayzaud, and R. de Stephanis. 2005. Where are the Mediterranean fin whales when the summer is over? Page 24 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Guissamulo, A. and V.G. Cockcroft. 2004. Ecology and population estimates of Indo-Pacific humpback dolphins (*Sousa chinensis)* in Maputo Bay, Mozambique. Aquatic Mammals 30(1):94-102.

Hain, J.H.W., M.A.M. Hyman, R.D. Kenney, and H.E. Winn. 1985. The role of cetaceans in the shelf-edge region of the northeastern United States. Marine Fisheries Review 47(1):13-17.

Hain, J.H.W., M.J. Ratnaswamy, R.D. Kenney, and H.E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42:653-669.

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, U.S.A. to Nova Scotia, Canada). Marine Mammal Science 18(4):920-937.

Hamilton, P.K., M.K. Marx, and S.D. Kraus. 1995. Weaning in North Atlantic right whales. Marine Mammal Science 11(3):386-390.

Hammond, P.S. and C. Lockyer. 1988. Distribution of killer whales in the eastern North Atlantic. Rit Fiskideildar: Journal of the Marine Research Institute Reykjavik 11:24-41.

Hammond, P.S., P. Berggren, H. Benke, D.L. Borchers, A. Collet, M.P. Heide-Jørgensen, S. Heimlich, A.R. Hiby, M.F. Leopold, and N. Øien. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology 39:361-376.

Hamza, A., G. Mo, and K. Tayeb. 2003. Results of a preliminary mission carried out in Cyrenaica, Lybia, to assess monk seal presence and potential coastal habitat. Monachus Guardian 6(1):1-3.

Harwood, J. 2001. Marine mammals and their environment in the Twenty-First Century. Journal of Mammalogy 82(3):630-640.

Hastie, G.D., R.J. Swift, G. Slesser, P.M. Thompson, and W.R. Turrell. 2005. Environmental models for predicting oceanic dolphin habitat in the northeast Atlantic. ICES Journal of Marine Science 62:760-770.

Haug, T., H. Gjøsæter, U. Lindstrøm, and K.T. Nilssen. 1995. Diet and food availability for North-east Atlantic minke whales (*Balaenoptera acutorostrata*), during the summer of 1992. ICES Journal of Marine Science 52(1):77-86.

Hawkins, A.D. and A.D.F. Johnstone. 1978. The hearing of the Atlantic salmon, *Salmo salar*. Journal of Fish Biology 13:655-673.

Hazevoet, C.J. and F.W. Wenzel. 2000. Whales and dolphins (Mammalia, Cetacea) of the Cape Verde Islands, with special reference to the Humpback Whale *Megaptera novaeangliae* (Borowski, 1781). Contributions to Zoology 69(3):197-211.

Hecht, A., N. Pinardi, and A.R. Robinson. 1988. Currents, water masses, eddies and jets in the Mediterranean Levantine basin. Journal of Physical Oceanography 18:1320-1353.

Helweg, D.A., A.S. Frankel, J.R. Mobley, Jr., and L.M. Herman. 1992. Humpback whale song: Our current understanding. Pages 459-483 in Thomas, J.A., R.A. Kastelein, and A.Y. Supin, eds. Marine mammal sensory systems. New York, New York: Plenum Press.

Hersh, S.L. and D.A. Duffield. 1990. Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. Pages 129-139 in Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, California: Academic Press.

Herzing, D.L. 1996. Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis* and bottlenose dolphins, *Tursiops truncatus*. Aquatic Mammals 22(2):61-79.

Heyning, J.E. 1989. Cuvier's beaked whale - *Ziphius cavirostris* (G. Cuvier, 1823). Pages 289-308 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. San Diego, California: Academic Press.

Heyning, J.E. and W.F. Perrin. 1994. Evidence for two species of common dolphins (genus *Delphinus*) from the eastern North Pacific. Los Angeles County Museum Contributions in Science 442:1-35.

Hildebrand, J. 2005. Impacts of anthropogenic sound. Pages 100-123 in Reynolds III, J.E., W.F. Perrin, R.R. Reeves, S. Montgomery, and T.J. Ragen, eds. Marine mammal research: Conservation beyond crisis. Baltimore, Maryland: Johns Hopkins University Press.

Hirtz, M. 1937. Rijetke vrste delfina u vodama Korčule. Priroda 27:25-28.

Hoelzel, A.R., C.W. Potter, and P.B. Best. 1998. Genetic differentiation between parapatric 'nearshore' and 'offshore' populations of the bottlenose dolphin. Proceedings of the Royal Society B: Biological Sciences 265:1177-1183.

Holcer, D., G. Notarbartolo di Sciara, C.M. Fortuna, B. Lazar, and V. Onofri. 2007. Occurrence of Cuvier's beaked whales in the southern Adriatic Sea: Evidence of an important Mediterranean habitat. Journal of the Marine Biological Association of the United Kingdom 87:359-362.

Holden, C. 2007. Whale sensing. Science 315:1199.

Hooker, S.K. and R.W. Baird. 1999. Deep-diving behaviour of the northern bottlenose whale, *Hyperoodon ampullatus* (Cetacea: Ziphiidae). Proceedings of the Royal Society B: Biological Sciences 266:671-676.

Hooker, S.K. and H. Whitehead. 2002. Click characteristics of northern bottlenose whales (*Hyperoodon ampullatus*). Marine Mammal Science 18(1):69-80.

Horwood, J. 1987. The sei whale: Population biology, ecology, & management. New York, New York: Croom Helm in association with Methuen, Inc.

Horwood, J. 1990. Biology and exploitation of the minke whale. Boca Raton, Florida: CRC Press.

Houser, D.S., D.A. Helweg, and P.W.B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27(2):82-91.

Hoyt, E. 1983. Great winged whales: Combat and courtship rites among humpbacks, the ocean's not-so-gentle giants. Equinox 10:25-47.

Hui, C.A. 1979. Undersea topography and distribution of dolphins of the genus *Delphinus* in the Southern California Bight. Journal of Mammalogy 60:521-527.

Hui, C.A. 1985. Undersea topography and the comparative distributions of two pelagic cetaceans. Fishery Bulletin 83(3):472-475.

Hutterer, R. 1994. Dwarf sperm whale *Kogia simus* in the Canary Islands. Lutra 37:89-92.

Ignatiades, L., S. Psarra, V. Zervakis, K. Pagou, A. Souvermezoglou, G. Assimakopoulou, and O. Gotsis-Skretas. 2002. Phytoplankton size-based dynamics in the Aegean Sea (Eastern Mediterranean). Journal of Marine Systems 36:11-28.

Impetuoso, A., W. Antollovich, M. Battaglia, R. Dernowski, A. Miragliuolo, B. Mussi, and M. Azzali. 2001. Comparison of acoustic signals among three odontocete species (*Grampus griseus*, *Physeter macrocephalus*, *Globicephala melas*) recorded in a natural environment. European Research on Cetaceans 15:36-39.

Impetuoso, A., W. Antollovich, M. Battaglia, R. Dernowski, A. Miragliuolo, B. Mussi, and M. Azzali. 2004. Comparison of acoustic signals among three odontocete species (*Grampus griseus, Physeter macrocephalus, Globicephala melas*) recorded in a natural environment. European Research on Cetaceans 15:36-39.

Ingram, S.N., L. Walshe, D. Johnston, and E. Rogan. 2007. Habitat partitioning and the influence of benthic topography and oceanography on the distribution of fin and minke whales in the Bay of Fundy, Canada. Journal of the Marine Biological Association of the United Kingdom 87:149-156.

Ivashin, M.V. and L.M. Votrogov. 1981. Minke whales, *Balaenoptera acutorostrata davidsoni*, inhabiting inshore waters of the Chukotka coast. Reports of the International Whaling Commission 31:231.

IWC (International Whaling Commission). 1996. Annex H. Report of the Sub-Committee on Small Cetaceans. Reports of the International Whaling Commission 46:160-179.

IWC (International Whaling Commission). 2001a. Report of the Workshop on Status and Trends of Western North Atlantic Right Whales. Journal of Cetacean Research and Management (Special Issue 2):61-87.

IWC (International Whaling Commission). 2001b. Report of the Workshop on the Comprehensive Assessment of Right Whales: A worldwide comparison. Journal of Cetacean Research and Management (Special Issue 2):1-60.

IWC (International Whaling Commission). 2005. Classification of the Order Cetacea (whales, dolphins and porpoises). Journal of Cetacean Research and Management 7(1):xi-xii.

IWC (International Whaling Commission). 2006. Proposed IWC list of recognised species of cetaceans. Journal of Cetacean Research and Management 8(Supplement):232.

Jacobsen, K.O., M. Marx, and N. Øien. 2004. Two-way trans-Atlantic migration of a North Atlantic right whale (*Eubalaena glacialis*). Marine Mammal Science 20(1):161-166.

Jahoda, M., C.L. Lafortuna, N. Biassoni, C. Almirante, A. Azzellino, S. Panigada, M. Zanardelli, and G. Notarbartolo di Sciara. 2003. Mediterranean fin whale's (*Balaenoptera physalus*) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science 19(1):96-110.

Janik, V.M. 2000. Food-related bray calls in wild bottlenose dolphins *(Tursiops truncatus)*. Proceedings of the Royal Society B: Biological Sciences 267:923-927.

Janik, V.M., L.S. Sayigh, and R.S. Wells. 2006. Signature whistle shape conveys identity information to bottlenose dolphins. Proceedings of the National Academy of Sciences of the United States of America 103(21):8293-8297.

Jann, B., J. Allen, M. Carrillo, S. Hanquet, S.K. Katona, A.R. Martin, R.R. Reeves, R. Seton, P.T. Stevick, and F.W. Wenzel. 2003. Migration of a humpback whale (*Megaptera novaeangliae*) between the Cape Verde Islands and Iceland. Journal of Cetacean Research and Management 5(2):125-129.

Jaquet, N. 1996. How spatial and temporal scales influence understanding of sperm whale distribution: A review. Mammal Review 26(1):51-65.

Jaquet, N. and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. Marine Ecology Progress Series 135:1-9.

Jaquet, N., H. Whitehead, and M. Lewis. 1996. Coherence between 19th century sperm whale distributions and satellite-derived pigments in the tropical Pacific. Marine Ecology Progress Series 145:1-10.

Jaquet, N., S. Dawson, and E. Slooten. 2000. Seasonal distribution and diving behaviour of male sperm whales off Kaikoura: Foraging implications. Canadian Journal of Zoology 78:407-419.

Jaquet, N., S. Dawson, and L. Douglas. 2001. Vocal behavior of male sperm whales: Why do they click? Journal of the Acoustical Society of America 109(5, Part 1):2254-2259.

Jaquet, N., C.A. Mayo, O.C. Nichols, M.K. Bessinger, D. Osterberg, M.K. Marx, and C.L. Browning. 2005. Surveillance, monitoring and management of North Atlantic right whales in Cape Cod Bay and adjacent waters - 2005. Provincetown, Massachusetts: Provincetown Center for Coastal Studies.

Jefferson, T.A. 2000. Population biology of the Indo-Pacific hump-backed dolphin in Hong Kong waters. Wildlife Monographs 144:1-65.

Jefferson, T.A. 2002. Rough-toothed dolphin *Steno bredanensis*. Pages 1055-1059 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

2006. Personal communication via e-mail between Dr. Thomas A. Jefferson, National Marine Fisheries Service-Southwest Fisheries Science Center, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 25 August.

Jefferson, T.A. and L. Karczmarski. 2001. *Sousa chinensis*. Mammalian Species 655:1-9.

Jefferson, T.A. and K. Van Waerebeek. 2002. The taxonomic status of the nominal dolphin species *Delphinus tropicalis* Van Bree, 1971. Marine Mammal Science 18(4):787-818.

Jefferson, T.A., P.J. Stacey, and R.W. Baird. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review 21(4):151-180.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine mammals of the world. Rome, Italy: Food and Agriculture Organization of the United Nations.

Jefferson, T.A., D. Fertl, M. Michael, and T.D. Fagin. 2006. An unusual encounter with a mixed school of melon-headed whales *(Peponocephala electra)* and rough-toothed dolphins *(Steno bredanensis)* at Rota, Northern Mariana Islands. Micronesica 38(2):239-244.

Jeffries, S.J., P.J. Gearin, H.R. Huber, D.L. Saul, and D.A. Pruett. 2000. Atlas of seal and sea lion haulout sites in Washington. Olympia, Washington: Washington Department of Fish and Wildlife.

Jérémie, S., A. Gannier, S. Bourreau, and J.-C. Nicolas. 2006. Acoustic monitoring of cetaceans in territorial waters off La Martinique (FWI), Lesser Antilles: Global abundance and first description of *Kogia simus* vocalisations (November-December 2004). Page 91 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Job, D.A., D.J. Boness, and J.M. Francis. 1995. Individual variation in nursing vocalizations of Hawaiian monk seal pups, *Monachus schauinslandi* (Phocidae, Pinnipedia), and lack of maternal recognition. Canadian Journal of Zoology 73:975-983.

Jochens, A., D. Biggs, D. Engelhaupt, J. Gordon, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, J. Wormuth, and B. Würsig. 2006. Sperm whale seismic study in the Gulf of Mexico. Summary report, 2002-2004. OCS Study MMS 2006-034. New Orleans, Louisiana: Minerals Management Service.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N. Aguilar de Soto, and P.L. Tyack. 2004. Beaked whales echolocate on prey. Proceedings of the Royal Society B: Biological Sciences 271:S383-S386.

Johnson, W.M., A.A. Karamanlidis, P. Dendrinos, P. Fernández de Larrinoa, M. Gazo, L. Mariano González, H. Güçlüsoy, R. Pires, and M. Schnellmann. 2006. Monk seal fact files: Biology, behaviour, status and conservation of the Mediterranean monk seal, *Monachus monachus*. Accessed 13 April 2007. http://www.monachus-guardian.org/factfiles/medit01.htm.

Johnston, D.W., A.J. Westgate, and A.J. Read. 2005a. Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises *Phocoena phocoena* in the Bay of Fundy. Marine Ecology Progress Series 295:279-293.

Johnston, D.W., L.H. Thorne, and A.J. Read. 2005b. Fin whales *Balaenoptera physalus* and minke whales *Balaenoptera acutorostrata* exploit a tidally driven island wake ecosystem in the Bay of Fundy. Marine Ecology Progress Series 305:287-295.

Jones, G.J. and L.S. Sayigh. 2002. Geographic variation in rates of vocal production of free-ranging bottlenose dolphins. Marine Mammal Science 18(2):374-393.

Jonsgård, Å. 1966. Biology of the North Atlantic fin whale, *Balaenoptera physalus* (L): Taxonomy, distribution, migration and food. Hvalrådets Skrifter 49:1-62.

Jonsgård, Å. and K. Darling. 1977. On the biology of the eastern North Atlantic sei whale, *Balaenoptera borealis* Lesson. Reports of the International Whaling Commission (Special Issue 1):124-129.

Jurasz, C.M. and V.P. Jurasz. 1979. Feeding modes of the humpback whale, *Megaptera novaeangliae*, in southeast Alaska. Scientific Reports of the Whales Research Institute 31:69-83.

Karamanlidis, A.A., R. Pires, N.C. Silva, and H.C. Neves. 2004. The availability of resting and pupping habitat for the critically endangered Mediterranean monk seal *Monachus monachus* in the archipelago of Madeira. Oryx 38(2):180-185.

Karczmarski, L. 1999. Group dynamics of humpback dolphins (*Sousa chinensis*) in the Algoa Bay region, South Africa. Journal of Zoology, London 249:283-293.

Karczmarski, L. and V.G. Cockcroft. 1999. Daylight behaviour of humpback dolphins, *Sousa chinensis* in Algoa Bay, South Africa. Zeitschrift für Säugetierkunde 64:19-29.

Kaschner, K., R. Watson, A.W. Trites, and D. Pauly. 2006. Mapping world-wide distributions of marine mammal species using a relative environmental suitability (RES) model. Marine Ecology Progress Series 316:285-310.

Kasparek, M. 1997. The false killer whale, *Pseudorca crassidens* (Cetacea: Delphinidae), new for Syria. Zoology in the Middle East 14:23-26.

Kastak, D. and R.J. Schusterman. 1998. Low-frequency amphibious hearing in pinnipeds: Methods, measurements, noise, and ecology. Journal of the Acoustical Society of America 103(4):2216-2228.

Kastak, D. and R.J. Schusterman. 1999. In-air and underwater hearing sensitivity of a northern elephant seal (*Mirounga angustirostris*). Canadian Journal of Zoology 77:1751-1758.

Kastelein, R.A., M. Hagedoorn, W.W.L. Au, and D. de Haan. 2003. Audiogram of a striped dolphin (*Stenella coeruleoalba*). Journal of the Acoustical Society of America 113(2):1130-1137.

Kastelein, R.A., P. Bunskoek, M. Hagedoorn, W.W.L. Au, and D. de Haan. 2002. Audiogram of a harbor porpoise (*Phocoena phocoena*) measured with narrrow-band frequency-modulated signals. Journal of the Acoustical Society of America 112(1):334-344.

Kastelein, R.A., N. Jennings, W.C. Verboom, D. de Haan, and N.M. Schooneman. 2006. Differences in the response a striped dolphin (*Stenella coeruleoalba*) and a harbour porpoise (*Phocoena phocoena*) to an acoustic alarm. Marine Environmental Research 61:363-378.

Katona, S.K. and J.A. Beard. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Reports of the International Whaling Commission (Special Issue 12):295-305.

Katona, S.K., B. Baxter, O. Brizier, S.D. Kraus, J. Perkins, and H. Whitehead. 1979. Identification of humpback whales by fluke photographs. Pages 33-44 in Winn, H.E. and B.L. Olla, eds. Behavior of marine animals: Current perspectives in research. Volume 3: Cetaceans. New York, New York: Plenum Press.

Keiper, C.A., D.G. Ainley, S.G. Allen, and J.T. Harvey. 2005. Marine mammal occurrence and ocean climate off central California, 1986 to 1994 and 1997 to 1999. Marine Ecology Progress Series 289:285-306.

Keller, C.A., L.I. Ward-Geiger, W.B. Brooks, C.K. Slay, C.R. Taylor, and B.J. Zoodsma. 2006. North Atlantic right whale distribution in relation to sea-surface temperature in the southeastern United States calving grounds. Marine Mammal Science 22(2):426-445.

Kenney, R.D. 2001. Anomalous 1992 spring and summer right whale (*Eubalaena glacialis*) distributions in the Gulf of Maine. Journal of Cetacean Research and Management (Special Issue 2):209-223.

Kenney, R.D. 2007. Right whales and climate change: Facing the prospect of a greenhouse future. Pages 436-459 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Kenney, R.D. and H.E. Winn. 1986. Cetacean high-use habitats of the northeast United States continental shelf. Fishery Bulletin 84(2):345-357.

Kenney, R.D. and H.E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. Continental Shelf Research 7:107-114.

Kenney, R.D., M.A.M. Hyman, and H.E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States outer continental shelf. NOAA Technical Memorandum NMFS-F/NEC-41:1-99.

Kenney, R.D., C.A. Mayo, and H.E. Winn. 2001. Migration and foraging strategies at varying spatial scales in western North Atlantic right whales: A review of hypotheses. Journal of Cetacean Research and Management (Special Issue 2):251-260.

Kenney, R.D., P.M. Payne, D.W. Heinemann, and H.E. Winn. 1996. Shifts in northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. Pages 169-196 in Sherman, K., N.A. Jaworski, and T.J. Smayda, eds. The Northeast Shelf Ecosystem: Assessment, sustainability, and management. Cambridge, Massachusetts: Blackwell Science.

Kenney, R.D., G.P. Scott, T.J. Thompson, and H.E. Winn. 1997. Estimates of prey consumption and trophic impacts of cetaceans in the USA Northeast Continental Shelf ecosystem. Journal of Northwest Atlantic Fishery Science 22:155-171.

Kenyon, K.W. 1981. Monk seals, *Monachus* Fleming, 1822. Pages 195-203 in Ridgway, S.H. and R.J. Harrison, eds. Handbook of marine mammals, Volume 2: Seals. London, England: Academic Press.

Kerem, D. 2005. Rough-toothed dolphins "invading" the port of Haifa. FINS (Newsletter of ACCOBAMS) 2(1):19.

Kerem, D. and O. Goffman. 2004. The Israel Marine Mammal Research and Assistance Center (IMMRAC), 2004 update. R.I.M.S. News (Newsletter of the University of Haifa, Leon Recanati Institute for Maritime Studies) 30:25-27.

Kerem, D., O. Goffman, and E. Spanier. 2001. Sighting of a single humpback dolphin (*Sousa* sp.) along the Mediterranean coast of Israel. Marine Mammal Science 17(1):170-171.

Kerr, K.A., R.H. Defran, and G.S. Campbell. 2005. Bottlenose dolphins (*Tursiops truncatus)* in the Drowned Cayes, Belize: Group size, site fidelity and abundance. Caribbean Journal of Science 41(1):172-177.

Ketten, D., W. Dolphin, A. Quick, S. Mumford, E. Chittick, and E. Melvin. 2000. Acoustic fatheads: Parallel evolution of underwater sound reception mechanisms in dolphins, seals, turtles, and sea birds. Conference of Association for Research in Otolaryngology. February 2000.

Ketten, D.R. 1992a. The cetacean ear: Form, frequency, and evolution. Pages 53-75 in Thomas, J.A., R.A. Kastelein, and A.Y. Supin, eds. Marine mammal sensory systems. New York, New York: Plenum Press.

Ketten, D.R. 1992b. The marine mammal ear: Specializations for aquatic audition and echolocation. Pages 717-750 in Webster, D.B., R.R. Fay, and A.N. Popper, eds. The evolutionary biology of hearing. Berlin, Germany: Springer-Verlag.

Ketten, D.R. 1997. Structure and function in whale ears. Bioacoustics 8:103-135.

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NMFS-SWFSC-256:1-74.

Kingston, S.E. and P.E. Rosel. 2004. Genetic differentiation among recently diverged delphinid taxa determined using AFLP markers. Journal of Heredity 95(1):1-10.

Kinzelbach, R. 1986. First record of Risso's dolphin, *Grampidelphis griseus*, in the eastern Mediterranean Sea. Zoology in the Middle East 1:17-19.

Kinzelbach, R. 1997. A record of striped dolphin *Stenella coeruleoalba* (Meyen, 1833) from the Turkish Mediterranean Sea coast. Zoology in the Middle East 15:15-18.

Kiraç, C.O., Y. Savas, and H. Güçlüsoy. 2002. Observations on diving behaviour of free ranging Mediterranean monk seals *Monachus monachus* on Turkish coasts. Monachus Guardian 5(1):-3641.

Klatsky, L.J., R.S. Wells, and J.C. Sweeney. 2007. Offshore bottlenose dolphins (*Tursiops truncatus*) movement and dive behavior near the Bermuda Pedestal Journal of Mammalogy 88(1):59-66.

Knowlton, A., C.W. Clark, and S. Kraus. 1991. Sounds recorded in the presence of sei whale, *Balaenoptera borealis*. Journal of the Acoustical Society of America 89(4B):1968.

Knowlton, A.R., J. Sigurjónsson, J.N. Ciano, and S.D. Kraus. 1992. Long-distance movements of North Atlantic right whales (*Eubalaena glacialis*). Marine Mammal Science 8(4):397-405.

Kopelman, A.H. and S.S. Sadove. 1995. Ventilatory rate differences between surface-feeding and non-surface-feeding fin whales (*Balaenoptera physalus*) in the waters off eastern Long Island, New York, U.S.A., 1981-1987. Marine Mammal Science 11(2):200-208.

Kovacs, K.M. 2002. Hooded seal *Cystophora cristata*. Pages 580-582 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Kraus, S.D. and J.J. Hatch. 2001. Mating strategies in the North Atlantic right whale (*Eubalaena glacialis*). Journal of Cetacean Research and Management (Special Issue 2):237-244.

Kraus, S.D., R.M. Pace III, and T.R. Frasier. 2007. High investment, low return: The strange case of reproduction in *Eubalaena glacialis*. Pages 172-199 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Kraus, S.D., J.H. Prescott, A.R. Knowlton, and G.S. Stone. 1986a. Migration and calving of right whales (*Eubalaena glacialis*) in the western North Atlantic. Reports of the International Whaling Commission (Special Issue 10):139-144.

Kraus, S.D., R.D. Kenney, A.R. Knowlton, and J.N. Ciano. 1993. Endangered right whales of the southwestern North Atlantic. OCS Study MMS 93-0024. Herndon, Virginia: Minerals Management Service.

Kraus, S.D., P.K. Hamilton, R.D. Kenney, A.R. Knowlton, and C.K. Slay. 2001. Reproductive parameters of the North Atlantic right whale. Journal of Cetacean Research and Management (Special Issue 2):231-236.

Kraus, S.D., K.E. Moore, C.A. Price, M.J. Crone, W.A. Watkins, H.E. Winn, and J.H. Prescott. 1986b. The use of photographs to identify individual North Atlantic right whales (*Eubalaena glacialis*). Reports of the International Whaling Commission (Special Issue 10):145-151.

Kraus, S.D., M.W. Brown, H. Caswell, C.W. Clark, M. Fujiwara, P.K. Hamilton, R.D. Kenney, A.R. Knowlton, S. Landry, C.A. Mayo, W.A. McLellan, M.J. Moore, D.P. Nowacek, D.A. Pabst, A.J. Read, and R.M. Rolland. 2005. North Atlantic right whales in crisis. Science 309:561-562.

Krivokhizhin, S., A. Birkun Jr., O. Shpak, and L. Mukhametov. 2006. "Offshore" harbour porpoises in the central Black Sea. Page 210 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Krivokhizhin, S.V., A.A. Birkun Jr., and J.V. Nessonova. 2000. Prey species of Black Sea cetaceans. European Cetacean Society 14:229.

Kruse, S., D.K. Caldwell, and M.C. Caldwell. 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). Pages 183-212 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Kuczaj II, S.A. and D.B. Yeater. 2007. Observations of rough-toothed dolphins (*Steno bredanensis*) off the coast of Utila, Honduras. Journal of the Marine Biological Association of the United Kingdom 87:141-148.

Lacey, C., T. Lewis, and A. Moscrop. 2005. Sightings made during surveys of the Mediterranean Sea in 2003 and 2004 including and [sic] unusual encounter with rough-toothed dolphins (*Steno bredanensis*) in the Ionian Sea. Page 113 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Lafortuna, C.L., M. Jahada, A. Azzellino, F. Saibene, and A. Colombini. 2003. Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (*Balaenoptera physalus*). European Journal of Applied Physiology 90:387-395.

Lagonika, C.I. 2006. Preliminary results in on the feeding habits of the monk seal. Monachus Guardian 18:10.

Lambertsen, R., N. Ulrich, and J. Straley. 1995. Frontomandibular stay of Balaenopteridae: A mechanism for momentum recapture during feeding. Journal of Mammalogy 76:877-899.

Laplanche, C., O. Adam, M. Lopatka, and J.-F. Motsch. 2005. Male sperm whale acoustic behavior observed from multipaths at a single hydrophone. Journal of the Acoustical Society of America 118(4):2677-2687.

Laplanche, C., R. de Stephanis, O. Adam, M. Lopakta, X. Demoulin, O. Savanier, F. Rondepierre, N. Pérez Gimeno, P. Verborgh, C. Guinet, and J.F. Motsch. 2004. The Strait of Gibraltar as a feeding ground for sperm whale (*Physeter macrocephalus*). Abstracts, Eighteenth Annual Conference of the European Cetacean Society. 28-31 March 2004. Kolmården, Sweden.

Laran, S. and A. Gannier. 2005a. Variation saisonnière de la présence du cachalot (*Physeter macrocephalus*) dans le Sanctuaire Pelagos (Mer Ligure) (Seasonal variations of sperm whale's

occurrence (*Physeter macrocephalus*) in the Pelagos Sanctuary (Liguarian Sea)). Mésogée 61:71-77.

Laran, S. and A. Gannier. 2005b. Spatiotemporal prediction of fin whale distribution in the Ligurian Sea (NW Mediterranean Sea). Page 164 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Laran, S. and A. Gannier. 2006. Variation saisonnière de la présence du cachalot (*Physeter macrocephalus*) dans le Sanctuaire Pelagos (Mer Ligure) (Seasonal variations of sperm whale's occurrence (*Physeter macrocephalus*) in the Pelagos Sanctuary (Liguarian Sea)). Mésogée 61:71-77.

Laran, S. and V. Drouot-Dulau. 2007. Seasonal variation of striped dolphins, fin- and sperm whales' abundance in the Ligurian Sea (Mediterranean Sea). Journal of the Marine Biological Association of the United Kingdom 87:345-352.

Laurinolli, M.H., A.E. Hay, F. Desharnais, and C.T. Taggart. 2003. Localization of North Atlantic right whale sounds in the Bay of Fundy using a sonobuoy array. Marine Mammal Science 19(4):708-723.

Leaper, R. and D. Gillespie, eds. 2006. Report of the Second Workshop on Right Whale Acoustics: Practical Applications in Conservation. 4 November 2005. New Bedford Whaling Museum, Massachusetts.

Learmonth, J.A., C.D. MacLeod, M.B. Santos, G.J. Pierce, H.Q.P. Crick, and R.A. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: An Annual Review 44:431-464.

Leatherwood, S. and R.R. Reeves. 1983. The Sierra Club handbook of whales and dolphins. San Francisco, California: Sierra Club Books.

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: A guide to their identification. NOAA Technical Report NMFS CIRC-396:1-176.

Leatherwood, S., C.L. Hubbs, and M. Fisher. 1979. First records of Risso's dolphin (*Grampus griseus*) from the Gulf of California with detailed notes on a mass stranding. Transactions of the San Diego Society of Natural History 19(3):45-51.

Leatherwood, S., D. McDonald, R.W. Baird, and M.D. Scott. 1989. The false killer whale, *Pseudorca crassidens* (Owen, 1846); A summary of information available through 1988. Oceans Unlimited Technical Report 89-001:1-114.

Lefkaditou, E. and Y. Poulopoulos. 1998. Cephalopod remains in the stomach-content of beaked whales, *Ziphius cavirostris* (Cuvier, 1823), from the Ionian Sea. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 35:460-461.

Lewis, T., D. Gillespie, C. Lacey, J. Matthews, M. Danbolt, R. Leaper, R. McLanaghan, and A. Moscrop. 2007. Sperm whale abundance estimates from acoustic surveys of the Ionian Sea and Straits of Sicily in 2003. Journal of the Marine Biological Association of the United Kingdom 87:353-357.

Ligon, A.D. and R.W. Baird. 2001. Diving behaviour of false killer whales off Maui and Lana'i, Hawaii. Page 126 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 2001. Vancouver, British Columbia.

Lindstrøm, U. and T. Haug. 2001. Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer. Journal of Cetacean Research and Management 3(3):239-249.

Littaye, A., A. Gannier, S. Laran, and J.P.F. Wilson. 2004. The relationship between summer aggregation of fin whales and satellite-derived environmental conditions in the northwestern Mediterranean Sea. Remote Sensing of Environment 90:44-52.

Lockyer, C. and A.R. Martin. 1983. The sei whale off western Iceland. II. Age, growth and reproduction. Reports of the International Whaling Commission 33:465-476.

Lodi, L. and B. Hetzel. 1999. Rough-toothed dolphin, *Steno bredanensis*, feeding behaviors in Ilha Grande Bay, Brazil. Biociências 7(1):29-42.

Luque, P.L., C.G. Davis, D.G. Reid, J. Wang, and G.J. Pierce. 2006. Opportunistic sightings of killer whales from Scottish pelagic trawlers fishing for mackerel and herring off North Scotland (UK) between 2000 and 2006. Aquatic Living Resources 19:403-410.

Lydersen, C. and N.A. Øritsland. 1990. Surface and submerging intervals in minke whale, *Balaenoptera acutorostrata*, diving cycles. Fauna Norvegica 11(Series A):35-37.

Macaulay, M.C., K.F. Wishner, and K.L. Daly. 1995. Acoustic scattering from zooplankton and micronekton in relation to a whale feeding site near Georges Bank and Cape Cod. Continental Shelf Research 15(4/5):509-537.

MacLeod, C., W.F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). Journal of Cetacean Research and Management 7(3):271-286.

MacLeod, C.D. 1999. A review of beaked whale acoustics, with inferences on potential interactions with military activities. European Research on Cetaceans 13:35-38.

MacLeod, C.D. 2000a. Review of the distribution of *Mesoplodon* species (order Cetacea, family Ziphiidae) in the North Atlantic. Mammal Review 30(1):1-8.

MacLeod, C.D. 2000b. Species recognition as a possible function for variations in position and shape of the sexually dimorphic tusks of *Mesoplodon* whales. Evolution 54(6):2171-2173.

MacLeod, C.D. 2005. Niche partitioning, distribution and competition in North Atlantic beaked whales. Ph.D. diss., University of Aberdeen.

MacLeod, C.D. 2006. How big is a beaked whale? A review of body length and sexual size dimorphism in the family Ziphiidae. Journal of Cetacean Research and Management 7(3):301-308.

MacLeod, C.D. and A.F. Zuur. 2005. Habitat utilization by Blainville's beaked whales off Great Abaco, northern Bahamas, in relation to seabed topography. Marine Biology 147:1-11.

MacLeod, C.D. and G. Mitchell. 2006. Key areas for beaked whales worldwide. Journal of Cetacean Research and Management 7(3):309-322.

MacLeod, C.D. and A. D'Amico. 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. Journal of Cetacean Research and Management 7(3):211-221.

MacLeod, C.D., M.B. Santos, and G.J. Pierce. 2003. Review of data on diets of beaked whales: Evidence of niche separation and geographic segregation. Journal of the Marine Biological Association of the United Kingdom 83:651-665.

MacLeod, C.D., N. Hauser, and H. Peckham. 2004. Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. Journal of the Marine Biological Association of the United Kingdom 84:469-474.

MacLeod, C.D., C.R. Weir, C. Pierpoint, and E.J. Harland. 2007. The habitat preferences of marine mammals west of Scotland (UK). Journal of the Marine Biological Association of the United Kingdom 87:157–164.

MacLeod, C.D., S.M. Bannon, G.J. Pierce, C. Schweder, J.A. Learmonth, J.S. Herman, and R.J. Reid. 2005. Climate change and the cetacean community of north-west Scotland. Biological Conservation 124:477-483.

MacLeod, K., R. Fairbairns, A. Gill, B. Fairbairns, J. Gordon, C. Blair-Myers, and E.C.M. Parsons. 2004. Seasonal distribution of minke whales *Balaenoptera acutorostrata* in relation to physiography and prey off the Isle of Mull, Scotland. Marine Ecology Progress Series 277:263-274.

Madsen, P.T., M. Wahlberg, and B. Møhl. 2002. Male sperm whale (*Physeter macrocephalus*) acoustics in a high-latitude habitat: Implications for echolocation and communication. Behavioral Ecology and Sociobiology 53(1):31-41.

Madsen, P.T., I. Kerr, and R. Payne. 2004. Echolocation clicks of two free-ranging, oceanic delphinids with different food preferences: False killer whales *Pseudorca crassidens* and Risso's dolphins *Grampus griseus*. Journal of Experimental Biology 207:1811-1823.

Madsen, P.T., D.A. Carder, K. Bedholm, and S.H. Ridgway. 2005a. Porpoise clicks from a sperm whale nose - convergent evolution of 130 kHz pulses in toothed whale sonars? Bioacoustics 15:195-206.

Madsen, P.T., M. Johnson, N. Aguilar de Soto, W.M.X. Zimmer, and P. Tyack. 2005b. Biosonar performance of foraging beaked whales (*Mesoplodon densirostris*). Journal of Experimental Biology 208(2):181-194.

Madsen, P.T., D.A. Carder, W.W.L. Au, P.E. Nachtigall, B. Møhl, and S.H. Ridgway. 2003. Sound production in neonate sperm whales (L). Journal of the Acoustical Society of America 113(6):2988-2991.

Maigret, J. and D. Robineau. 1981. Le genre *Kogia* (Cetacea, Physeteridae) sur les côtes du Sénégal (The genus *Kogia* (Cetacea, Physeteridae) on the coast of Senegal). Mammalia 45(2):199-204.

Manghi, M., G. Montesi, C. Fossati, G. Pavan, M. Priano, and V. Teloni. 1999. Cuvier's beaked whales in the Ionian Sea: First recordings of their sounds. European Research on Cetaceans 13:39-42.

Manire, C.A. and R.S. Wells. 2005. Rough-toothed dolphin rehabilitation and post-release monitoring. Mote Marine Laboratory Technical Report No. 1047 Sarasota, Florida: Mote Marine Laboratory.

Marchessaux, D. 1980. A review of the current knowledge of the cetaceans in the eastern Mediterranean Sea. Vie Marine 2:59-66.

Margaritoulis, D., D. Karavellas, and C. Irvine. 1996. Predation of adult loggerheads by Mediterranean monk seals. Pages 193-196 in Keinath, J.A., D.E. Barnard, J.A. Musick, and B.A. Bell, eds. Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-387.

Marini, L., C. Consiglio, M. Angrandi, and A. Sanna. 1992. Four sightings of Ziphiidae (Cetacea, Odontoceti) in the central Tyrrhenian Sea. Hystrix 4(1):85-89.

Marini, L., C. Consiglio, B. Catalano, T. Valentini, and G. Villetti. 1996a. Aerial behavior in fin whales (*Balaenoptera physalus*) in the Mediterranean Sea. Marine Mammal Science 12(3):489-495.

Marini, L., C. Consiglio, A.M. Angradi, B. Catalano, A. Sanna, T. Valentini, M.G. Finoia, and G. Villetti. 1996b. Distribution, abundance and seasonality of cetaceans sighted during scheduled ferry crossings in the central Tyrrhenian Sea: 1989-1992. Italian Journal of Zoology 63:381-388.

Marten, K. 2000. Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks. Aquatic Mammals 26(1):45-48.

Martin, A.R. and B.K. Walker. 1997. Sighting of right whale *(Eubalaena glaciais)* with calf off S.W. Portugal. Marine Mammal Science 13(1):139-140.

Martin, A.R., S.K. Katona, D. Mattila, D. Hembree, and T.D. Waters. 1984. Migration of humpback whales between the Caribbean and Iceland. Journal of Mammalogy 65(2):330-333.

Martínez Serrano, M. and S. Villar Sagredo. 2006. Registers of persecutions of pilot whale (*Globicephala melas*) group on orca (*Orcinus orca*) group in the Strait of Gibraltar. Pages 104-105 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Mate, B. 1989. Satellite-monitored radio tracking as a method for studying cetacean movements and behaviour. Reports of the International Whaling Commission 39:389-391.

Mate, B. and M. Baumgartner. 2001. Summer feeding season movements and fall migration of North Atlantic right whales from satellite-monitored radio tags. Page 137 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 2001. Vancouver, British Columbia.

Mate, B.R. and C. Guinet. In prep. Movements and surfacing rates of fin whales tagged in the Mediterranean Sea.

Mate, B.R., S.L. Nieukirk, and S.D. Kraus. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61(4):1393-1405.

Matthews, J.N., S. Brown, D. Gillespie, M. Johnson, R. McLanaghan, A. Moscrop, D. Nowacek, R. Leaper, T. Lewis, and P. Tyack. 2001. Vocalisation rates of the North Atlantic right whale (*Eubalaena glacialis*). Journal of Cetacean Research and Management 3(3):271-281.

Mattila, D.K., L.N. Guinee, and C.A. Mayo. 1987. Humpback whale songs on a North Atlantic feeding ground. Journal of Mammalogy 68(4):880-883.

Mayo, C.A. and M.K. Marx. 1990. Surface foraging behaviour of the North Atlantic right whale, *Eubalaena glacialis*, and associated zooplankton characteristics. Canadian Journal of Zoology 68:2214-2220.

Mayol, P. 2004. The behaviour of a group of striped dolphins *Stenella coeruleolba* [sic] living in a port for a while. European Research on Cetaceans 15:78-79.

McAlpine, D.F. 2002. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. Pages 1007-1009 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

McAlpine, D.F., L.D. Murison, and E.P. Hoberg. 1997. New records for the pygmy sperm whale, *Kogia breviceps* (Physeteridae) from Atlantic Canada with notes on diet and parasites. Marine Mammal Science 13(4):701-704.

McBrearty, D.A., M.A. Message, and G.A. King. 1986. Observations on small cetaceans in the north-east Atlantic Ocean and the Mediterranean Sea: 1978-1982. Pages 225-249 in Bryden, M.M. and R. Harrison, eds. Research on dolphins. Oxford, England: Clarendon Press

McConnell, B.J. and M.A. Fedak. 1996. Movements of southern elephant seals. Canadian Journal of Zoology 74:1485-1496.

McCowan, B. and D. Reiss. 1995. Maternal aggressive contact vocalizations in captive bottlenose dolphins (*Tursiops truncatus*): Wide-band, low-frequency signals during mother/aunt-infant interactions. Zoo Biology 14:293-309.

McDonald, M.A. and C.G. Fox. 1999. Passive acoustic methods applied to fin whale population density estimation. Journal of the Acoustical Society of America 105(5):2643-2651.

McDonald, M.A., J.A. Hildebrand, S.M. Wiggins, D. Thiele, D. Glasgow, and S.E. Moore. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America 118(6):3941-3945.

McLellan, W.A., H.N. Koopman, S.A. Rommel, A.J. Read, C.W. Potter, J.R. Nicolas, A.J. Westgate, and D.A. Pabst. 2002. Ontogenetic allometry and body composition of harbour porpoises (*Phocoena phocoena,* L.) from the western North Atlantic. Journal of Zoology, London 257:457-471.

McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the island of Hawai'i. Marine Mammal Science 23(3):666-687.

Mead, J., K. West, and C. Potter. 2001. Reproduction in the rough-toothed dolphin, *Steno bredanensis*: Attainment of sexual maturity. Page 141 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 2001. Vancouver, British Columbia.

Mead, J.G. 1977. Records of sei and Bryde's whales from the Atlantic coast of the United States, the Gulf of Mexico, and the Caribbean. Reports of the International Whaling Commission (Special Issue 1):113-116.

Mead, J.G. 1989a. Bottlenose whales *Hyperoodon ampullatus* (Forster, 1770) and *Hyperoodon planiforns* Flower, 1882. Pages 321-348 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. London, England: Academic Press.

Mead, J.G. 1989b. Beaked whales of the genus-*Mesoplodon*. Pages 349-430 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. London, England: Academic Press.

Mead, J.G. and C.W. Potter. 1995. Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations. IBI Reports 5:31-44.

Meissner, A.M. and V. Ridoux. 2006. Feeding strategy of striped dolphins in a near shore area. Page 46 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Mellinger, D.K., C.D. Carson, and C.W. Clark. 2000. Characteristics of minke whale (*Balaenoptera acutorostrata*) pulse trains recorded near Puerto Rico. Marine Mammal Science 16(4):739-756.

Mendes, S., W. Turrell, T. Lütkebohle, and P. Thompson. 2002. Influence of the tidal cycle and a tidal intrusion front on the spatio-temporal distribution of coastal bottlenose dolphins. Marine Ecology Progress Series 239:221-229.

Mendes, S., J. Newton, R.J. Reid, A.F. Zuur, and G.J. Pierce. 2007. Stable carbon and nitrogen isotope ratio profiling of sperm whale teeth reveals ontogenetic movements and trophic ecology. Oecologia 151:605-615.

Meotti, C. and M. Podestà. 1997. Stomach contents of striped dolphins, *Stenella coeruleoalba* (Meyen, 1833), from the western Ligurian Sea (Cetacea, Delphinidae). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 137(I-II):5-15.

Mignucci-Giannoni, A.A. 1998. Zoogeography of cetaceans off Puerto Rico and the Virgin Islands. Caribbean Journal of Science 34(3-4):173-190.

Miller, E.H. and D.A. Job. 1992. Airborne acoustic communication in the Hawaiian monk seal, *Monachus schauinslandi*. Pages 485-531 in Thomas, J.A., R.A. Kastelein, and A.Y. Supin, eds. Marine mammal sensory systems. New York, New York: Plenum Press.

Miller, P.J.O. 2006. Diversity in sound pressure levels and estimated active space of resident killer whale vocalizations. Journal of Comparative Physiology A 192:449-459.

Miller, P.J.O., M.P. Johnson, and P.L. Tyack. 2004. Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. Proceedings of the Royal Society B: Biological Sciences 271:2239-2247.

Mitchell, E. and V.M. Kozicki. 1975. Supplementary information on minke whale (*Balaenoptera acutorostrata*) from Newfoundland fishery. Journal of the Fisheries Research Board of Canada 32(7):985-994.

Mitchell, E. and R.R. Reeves. 1983. Catch history, abundance, and present status of northwest Atlantic humpback whales. Reports of the International Whaling Commission (Special Issue 5):153-212.

Mitchell, E., ed. 1975. Report of the Meeting on Smaller Cetaceans, Montreal, April 1-11, 1974. Subcommittee on Smaller Cetaceans, International Whaling Commission. Journal of the Fisheries Research Board of Canada 32(7):889-983.

Mitchell, E.D., Jr. 1991. Winter records of the minke whale (*Balaenoptera acutorostrata acutorostrata* Lacépède 1804) in the southern North Atlantic. Reports of the International Whaling Commission 41:455-457.

Miyazaki, N. and W.F. Perrin. 1994. Rough-toothed dolphin-*Steno bredanensis* (Lesson, 1828). Pages 1-21 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Mo, G. 2000. Sighting spurs government action. Monachus Guardian 3(2):14-19.

Mo, G. 2002. Sporadic sightings continue in southern Italy. Monachus Guardian 5(1):13-14.

Mo, G. 2007. Sports fisherman reports monk seal sighting in Pantelleria (Sicily). Monachus Guardian 10(1):19.

Mo, G., S. Agnesi, T. Di Nora, and L. Tunesi. in press. Mediterranean monk seal sightings in Italy through interviews: Validating the information (1998-2006). Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 38.

Mo, G., H. Bazairi, L. Tunesi, D. Nachite, and I. Sadki. 2003. Results of a first field mission in the National Park of Al Hoceima, Morocco: Monk seal habitat suitability and presence. Monachus Guardian 6(1):41-45.

Møhl, B., M. Wahlberg, P.T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. Journal of the Acoustical Society of America 114(2):1143-1154.

Monaci, F., A. Borrel, C. Leonzio, L. Marsili, and N. Calzada. 1998. Trace elements in striped dolphins (*Stenella coeruleoalba*) from the western Mediterranean. Environmental Pollution 99:61-68.

Monestiez, P., L. Dubroca, E. Bonnin, J.-P. Durbec, and C. Guinet. 2006. Geostatistical modelling of spatial distribution of *Balaenoptera physalus* in the northwestern Mediterranean Sea from sparse count data and heterogeneous observation efforts. Ecological Modelling 193:615-628.

Mooney, T.A., P.E. Nachtigall, W.W.L. Au, M. Breese, and S. Vlachos. 2005. Bottlenose dolphin: Effects of noise duration, intensity, and frequency. Page 197 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Moore, K.E., W.A. Watkins, and P.L. Tyack. 1993. Pattern similarity in shared codas from sperm whales (*Physeter catodon*). Marine Mammal Science 9(1):1-9.

Mote, P.W. and N.J. Mantua. 2002. Coastal upwelling in a warmer future. Geophysical Research Letters 29 (23),2138,doi:10.1029/2002GL016086.

Mouillot, D. and D. Viale. 2001. Satellite tracking of a fin whale (*Balaenoptera physalus*) in the north-western Mediterranean Sea and fractal analysis of its trajectory. Hydrobiologia 452:163-171.

Moulins, A. and M. Würtz. 2005. Occurrence of a herd of female sperm whales and their calves (*Physeter catodon*), off Monaco, in the Ligurian Sea. Journal of the Marine Biological Association of the United Kingdom 85:213-214.

Moulins, A., M. Rosso, B. Nani, and M. Würtz. 2007. Aspects of the distribution of Cuvier's beaked whale (*Ziphius cavirostris*) in relation to topographic features in the Pelagos Sanctuary (north-western Mediterranean Sea). Journal of the Marine Biological Association of the United Kingdom 87(1):177-186.

Moulton, V.D., E.H. Miller, and H. Ochoa-Acuña. 2000. Haulout behaviour of captive harp seals (*Pagophilus groenlandicus*): Incidence, seasonality, and relationships to weather. Applied Animal Behaviour Science 65:367-378.

Mullin, K.D., W. Hoggard, and L.J. Hansen. 2004. Abundance and seasonal occurrence of cetaceans in outer continental shelf and slope waters of the north-central and northwestern Gulf of Mexico. Gulf of Mexico Science 2004(1):62-73.

Munk, P., P.O. Larsson, D. Danielsen, and E. Moksness. 1995. Larval and small juvenile cod *Gadus morhua* concentrated in the highly productive areas of a shelf break front. Marine Ecology Progress Series 125:21-30.

Muñoz-Hincapié, M.F., D.M. Mora-Pinto, D.M. Palacios, E.R. Secchi, and A.A. Mignucci-Giannoni. 1998. First osteological record of the dwarf sperm whale in Colombia, with notes on the zoogeography of *Kogia* in South America. Revista Academia Colombiana de Ciencias 22(84):433-444.

Murison, L.D. and D.E. Gaskin. 1989. The distribution of right whales and zooplankton in the Bay of Fundy, Canada. Canadian Journal of Zoology 67:1411-1420.

Murphy, M.A. 1995. Occurrence and group characteristics of minke whales, *Balaenoptera acutorostrata*, in Massachusetts Bay and Cape Cod Bay. Fishery Bulletin 93:577-585.

Murphy, S. and E. Rogan. 2006. External morphology of the short-beaked common dolphin, *Delphinus delphis:* Growth, allometric relationships and sexual dimorphism. Acta Zoologica (Stockholm) 87:315-329.

Murphy, S., A. Collet, and E. Rogan. 2005. Mating strategy in the male common dolphin (*Delphinus delphis*): What gonadal analysis tells us. Journal of Mammalogy 86(6):1247-1258.

Mussi, B. and A. Miragliuolo. 2005. Short-beaked common dolphin in the waters of Ischia Island: A relic population unit of primary importance in the Italian seas. European Cetacean Society Newsletter 45(Special Issue):30-36.

Mussi, B., A. Miragliuolo, and B. Díaz López. 2000. Social structure and male parental care in a long finned pilot whale (*Globicephala melas)* pod off Ventotene Island (Southern Tyrrhenian Sea, Italy). European Research on Cetaceans 14:141-145.

Mussi, B., A. Miragliuolo, and G. Bearzi. 2002. Short-beaked common dolphins around the Island of Ischia, Italy (Southern Tyrrhenian Sea). Presentation, Sixteenth Annual Conference of the European Cetacean Society. 7-11 April 2002. Liege, Belgium.

Mussi, B., A. Miragliuolo, and M. Battaglia. 2003. Signature whistles in a long finned pilot whale (Globicephala melas) pod off Ventotene Island (Southern Tyrrhenian Sea, Italy). Page 42 in Abstracts, Seventeenth Annual Conference of the European Cetacean Society. 9-13 March 2003. Las Palmas de Gran Canaria, Spain.

Mussi, B., A. Miragliuolo, and D.S. Pace. 2005. Acoustic and behaviour of sperm whales' nursery groups in the waters of Ischia, Italy. Page 48 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Mussi, B., R. Gabriele, A. Miragliuolo, and M. Battaglia. 1998. Cetacean sightings and interactions with fisheries in the archipelago Pontino Campano, southern Tyrrhenian Sea, 1991-1995. European Research on Cetaceans 12:63-65.

Mussi, B., A. Miragliuolo, E. Monzini, B. Diaz Lopez, and M. Battaglia. 1999. Fin whale *(Balaenoptera physalus)* feeding ground in the coastal waters of Ischia (Archipelago Campano). European Research on Cetaceans 13:330-335.

Mussi, B., A. Miragliuolo, T. De Pippo, M.C. Gambi, and D. Chiota. 2004. The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect. European Research on Cetaceans 15:178-179.

Nachtigall, P.E., D.W. Lemonds, and H.L. Roitblat. 2000. Psychoacoustic studies of dolphin and whale hearing. Pages 330-363 in Au, W.W.L., A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America 113(6):3425-3429.

Nachtigall, P.E., W.W.L. Au, J.L. Pawloski, and P.W.B. Moore. 1995. Risso's dolphin (*Grampus griseus*) hearing thresholds in Kaneohe Bay, Hawaii. Pages 49-53 in Kastelein, R.A., J.A. Thomas, and P.E. Nachtigall, eds. Sensory systems of aquatic mammals. Woerden, The Netherlands: De Spil Publishers.

Nachtigall, P.E., M.M.L. Yuen, T.A. Mooney, and K.A. Taylor. 2005. Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. Journal of Experimental Biology 208:4181-4188.

Nachtigall, P.E., T.A. Mooney, K.A. Taylor, and M.M.L. Yuen. 2007. Hearing and auditory evoked potential methods applied to odontocete cetaceans. Aquatic Mammals 33(1):6-13.

Nagorsen, D. 1985. *Kogia simus*. Mammalian Species 239:1-6.

NAMMCO (North Atlantic Marine Mammal Commission). 1995. Report of the third meeting of the Scientific Committee. Pages 67-171 in NAMMCO annual report 1995. Tromsø, Norway: North Atlantic Marine Mammal Commission.

Natoli, A. and A.R. Hoelzel. 2000. Genetic diversity in a Mediterranean population of the bottlenose dolphin in the context of world-wide phylogeography. European Research on Cetaceans 14:343.

Natoli, A., V.M. Peddemors, and A.R. Hoelzel. 2004a. Population structure and speciation in the genus *Tursiops* based on microsatellite and mitochondrial DNA analyses. Journal of Evolutionary Biology 17:363-375.

Natoli, A., A. Birkun, A. Aguilar, A. Lopez, and A.R. Hoelzel. 2005a. Habitat structure and the dispersal of male and female bottlenose dolphins (*Tursiops truncatus*). Proceedings of the Royal Society B: Biological Sciences 272:1217-1226.

Natoli, A., A. Canadas, C. Vaquero, E. Politi, J. Fernandez-Piqueras, and A.R. Hoelzel. 2004b. Phylogeography of Mediterranean and North Atlantic common dolphin populations. European Research on Cetaceans 15:315.

Natoli, A., A. Cañadas, C. Vaquero, E. Politi, J. Fernández-Piqueras, and A.R. Hoelzel. 2005b. Conservation genetics of the short-beaked common dolphin (*Delphinus delphis*) in the Mediterranean Sea and in the eastern North Atlantic Ocean. Pages 118-119 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Naud, M.-J., B. Long, J.-C. Brêthes, and R. Sears. 2003. Influences of underwater bottom topography and geomorphology on minke whale (*Balaenoptera acutorostrata*) distribution in the Mingan Islands (Canada). Journal of the Marine Biological Association of the United Kingdom 83:889-896.

Nekoba-Dutertre, N., M. Poole, and B. Bilgre. 1999. Rough-tooth dolphins (*Steno bredanensis*) in French Polynesia. Page 133 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November - 3 December 1999. Wailea, Hawaii.

NMFS (National Marine Fisheries Service). 1991. Recovery plan for the humpback whale (*Megaptera novaeangliae*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1994. Designated critical habitat; northern right whale. Federal Register 59(106):28793-28808.

NMFS (National Marine Fisheries Service). 1998. Draft recovery plan for the fin whale *Balaenoptera physalus* and sei whale *Balaenoptera borealis*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2001. Final review of the biological status of the Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena*) pursuant to the Endangered Species Act. Silver Spring, Maryland.

NMFS (National Marine Fisheries Service). 2005. Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2006a. Draft recovery plan for the sperm whale (*Physeter macrocephalus)*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2006b. Draft recovery plan for the fin whale (*Balaenoptera physalus)*. Silver Spring, Maryland: National Marine Fisheries Service.

Nordøy, E.S., L.P. Folkow, P.-E. Mårtensson, and A.S. Blix. 1995. Food requirements of northeast Atlantic minke whales. Pages 307-317 in Blix, A.S., L. Walløe, and Ø. Ulltang, eds. Whales, seals, fish and man. New York, New York: Elsevier Science B.V.

Notarbartolo-di-Sciara, G. 1987. Killer whale, *Orcinus orca*, in the Mediterranean Sea. Marine Mammal Science 3(4):356-360.

Notarbartolo-di-Sciara, G., C.W. Clark, M. Zanardelli, and S. Panigada. 1999. Migration patterns of fin whales, *Balaenoptera physalus*: Shaky old paradigms and local anomalies. European Research on Cetaceans 12:118.

Notarbartolo-di-Sciara, G., M. Zanardelli, M. Jahoda, S. Panigada, and S. Airoldi. 2003. The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea. Mammal Review 33(2):105-150.

Notarbartolo di Sciara, G. 1996. Right whale sighting in the Mediterranean Sea. Marine Mammal Society Newsletter 4(4):2.

Notarbartolo di Sciara, G. 2002. Cetacean species occurring in the Mediterranean and Black Seas. Pages 3.1-3.18 in Notarbartolo di Sciara, G., ed. Cetaceans of the Mediterranean and Black Seas: State of knowledge and conservation strategies. Monaco: ACCOBAMS.

Notarbartolo di Sciara, G. and M. Demma. 1994. Guida dei mammiferi marini del Mediterraneo (Guide to marine mammals of the Mediterranean). Padova, Italy: Franco Muzzio Editore.

Notarbartolo di Sciara, G., G. Bearzi, A. Cañadas, and A. Frantzis. 2004. High mortality of sperm whales in the north-western Mediterranean, 1971-2003. IWC Working Document SC/56/BC10 presented to the IWC Scientific Committee. 19-22 July. Sorrento, Italy.

Notarbartolo di Sciara, G., M. Addink, R.M. Baldwin, and C. Smeenk. 2007. A review of cetaceans from the Red Sea. Page 132 in Abstracts, Twenty-first Conference of the European Cetacean Society. 22-25 April 2007. Donostia-San Sebastián, Spain.

Notarbartolo di Sciara, G., M.C. Venturino, M. Zanardelli, G. Bearzi, F.J. Borsani, and B. Cavalloni. 1993. Cetaceans in the central Mediterranean Sea: Distribution and sighting frequencies. Bolletino di Zoologia 60:131-138.

Notarbartolo di Sciara, G., ed. 2002. Cetaceans of the Mediterranean and Black Seas: State of knowledge and conservation strategies. Monaco: ACCOBAMS.

Nowacek, D.P. 2005. Acoustic ecology of foraging bottlenose dolphins (*Tursiops truncatus*), habitat-specific use of three sound types. Marine Mammal Science 21(4):587-602.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society B: Biological Sciences 271:227-231.

Nuuttila, H.K. and L. Rendell. 2005. Coda repertoire and group-specific coda variations of sperm whales (*Physeter macrocephalus*) in the Balaeric Sea. Pages 48-49 in Abstracts, Nineteenth Annual Conference of the European Cetacean Society. 2-7 April 2005. La Rochelle, France.

Odell, D.K. 1975. Status and aspects of the life history of the bottlenose dolphin, *Tursiops truncatus*, in Florida. Journal of the Fisheries Research Board of Canada 32:1055-1058.

Odell, D.K. and K.M. McClune. 1999. False killer whale *Pseudorca crassidens* (Owen, 1846). Pages 213-243 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Ohizumi, H. and T. Kishiro. 2003. Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan. Aquatic Mammals 29(1):99-103.

Øien, N., L. Folkow, and C. Lydersen. 1990. Dive time experiments on minke whales in Norwegian waters during the 1988 season. Reports of the International Whaling Commission 40:337-341.

Øien, N., G. Bøthun, and L. Kleivane. 2003. Surfacing rates of minke whales in the Norwegian Sea. Abstracts, Seventeenth Conference of the European Cetacean Society. 9-13 March 2003. Las Palmas de Gran Canaria, Spain.

Olsen, E. and J.C. Holst. 2001. A note on common minke whale (*Balaenoptera acutorostrata*) diets in the Norwegian Sea and the North Sea. Journal of Cetacean Research and Management 3(2):179-183.

Olsen, E. and J. Sunde. 2002. Age determination of minke whales (*Balaenoptera acutorostrata*) using the aspartic acid racemization technique. Sarsia 87:1-8.

Olson, P.A. and S.B. Reilly. 2002. Pilot whales *Globicephala melas* and *G. macrorhynchus*. Pages 898-903 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Orsi Relini, L. 2000. Il santuario dei cetacei del Mar Ligure: Un motivo in Più (The cetacean sanctuary in the Ligurian Sea: A further reason). Biologia Marina Mediterranea 7(3):117-126.

Orsi Relini, L. and M. Relini. 1993. The stomach content of some common dolphins (*Delphinus delphis* L.) from the Ligurian Sea. European Research on Cetaceans 7:99-102.

Orsi Relini, L. and L. Cagnolaro. 1996. Does the long-finned pilot whale feed on tuna? - A mistake in the Mediterranean literature. European Research on Cetaceans 9:183-184.

Orsi Relini, L., M. Cappello, and R. Poggi. 1994. The stomach content of some bottlenose dolphins (*Tursiops truncatus)* from the Ligurian Sea. European Research on Cetaceans 8:192-195.

Orsi Relini, L., G. Relini, G. Palandri, M. Relini, F. Garibaldi, C. Cima, G. Torchia, and C. Costa. 1999. Notes on ecology of the Mediterranean krill, a mirror of the behaviour of Mediterranean fin whales. European Research on Cetaceans 12:119.

Orton, L.S. and P.F. Brodie. 1987. Engulfing mechanics of fin whales. Canadian Journal of Zoology 65:2898-2907.

Oswald, J.N., J. Barlow, and T.F. Norris. 2003. Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. Marine Mammal Science 19(1):20-37.

Otani, S., Y. Naito, A. Kawamura, M. Kawasaki, S. Nishiwaki, and A. Kato. 1998. Diving behavior and performance of harbor porpoises, *Phocoena phocoena*, in Funka Bay, Hokkaido, Japan. Marine Mammal Science 14(2):209-220.

Ottensmeyer, C.A. and H. Whitehead. 2003. Behavioural evidence for social units in long-finned pilot whales. Canadian Journal of Zoology 81:1327-1338.

Ouerghi, A., G. Mo, F. Di Domenico, and H. Majhoub. 2001. Assessment of Mediterranean monk seal (*Monachus monachus*) habitat at La Galite, Tunisia: Towards a monk seal conservation strategy in northern Tunisia and nearby waters. Tunis, Tunisia: RAC/SPA; Rome, Italy: ICRAM; Tunisia: ANPE:1-3.

Öztürk, B. and A.A. Öztürk. 1997. Preliminary study on dolphin occurrence in the Turkish Straits System. European Research on Cetaceans 11:79-82.

Öztürk, B. and A.A. Öztürk. 1998. Cetacean strandings in the Aegean and Mediterranean coasts of Turkey. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 35:476-477.

Pabst, D.A., S.A. Rommel, and W.A. McLellan. 1999. The functional morphology of marine mammals. Pages 15-72 in Reynolds III, J.E. and S.A. Rommel, eds. Biology of marine mammals. Washington, D.C.: Smithsonian Institution.

Pack, A.A., D.R. Salden, M.J. Ferrari, D.A. Glockner-Ferrari, L.M. Herman, H.A. Stubbs, and J.M. Straley. 1998. Male humpback whale dies in competitive group. Marine Mammal Science 14(4):861-873.

Palacios, D.M. and B.R. Mate. 1996. Attack by false killer whales (*Pseudorca crassidens*) on sperm whales (*Physeter macrocephalus*) in the Galápagos Islands. Marine Mammal Science 12(4):582-587.

Palka, D. and M. Johnson. 2007. Cooperative research to study dive patterns of sperm whales in the Atlantic Ocean. OCS Study MMS 2007-033. New Orleans, Louisiana: Minerals Management Service.

Palsbøll, P.J., M. Bérubé, A. Aguilar, G. Notarbartolo-di-Sciara, and R. Nielsen. 2004. Discerning between recurrent gene flow and recent divergence under a finite-site mutation model applied to North Atlantic and Mediterranean Sea fin whale (*Balaenoptera physalus*) populations. Evolution 58(3):670-675.

Palsbøll, P.J., J. Allen, M. Bérubé, P.J. Clapham, T.P. Feddersen, P.S. Hammond, R.R. Hudson, H. Jørgensen, S. Katona, A.H. Larsen, F. Larsen, J. Lien, D.K. Mattila, J. Sigurjónsson, R. Sears, T. Smith, R. Sponer, P. Stevick, and N. Oien. 1997. Genetic tagging of humpback whales. Nature 388:767-769.

Panigada, S., G. Notarbartolo di Sciara, and M. Zanadelli Panigada. 2006a. Fin whales summering in the Pelagos Sanctuary (Mediterranean Sea): Overview of studies on habitat use and diving behaviour. Chemistry and Ecology 22(Supplement 1):S255-S263.

Panigada, S., M. Zanardelli, S. Canese, and M. Jahoda. 1999. How deep can baleen whales dive? Marine Ecology Progress Series 187:309-311.

Panigada, S., G. Pesante, M. Zanadelli, and S. Oehen. 2003. Day and night-time behavior of fin whales in the western Ligurian Sea. Pages 466-471 in Proceedings, Oceans 2003 MTS/IEEE Conference. 22-26 September 2003. San Diego, California.

Panigada, S., G. Notarbartolo di Sciara, M.Z. Panigada, S. Airoldi, J.F. Borsani, and M. Jahoda. 2005. Fin whales (*Balaenoptera physalus*) summering in the Ligurian Sea: Distribution, encounter rate, mean group size and relation to physiographic variables. Journal of Cetacean Research and Management 7(2):137-145.

Panigada, S., M. Zanardelli, M. MacKenzie, C. Donovan, F. Mélin, and P.S. Hammond. 2006b. Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (western Mediterranean Sea). Page 32 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Panou, A., J. Jacobs, and D. Panos. 1993. The endangered Mediterranean monk seal *Monachus monachus* in the Ionian Sea, Greece. Biological Conservation 64:129-140.

Parks, S.E. and P.L. Tyack. 2005. Sound production by North Atlantic right whales (*Eubalaena glacialis*) in surface active groups. Journal of the Acoustical Society of America 117(5):3297-3306.

Parks, S.E. and C.W. Clark. 2007. Acoustic communication: Social sounds and the potential impacts of noise. Pages 310-332 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Parks, S.E., D.R. Ketten, J. Trehey O'Malley, and J. Arruda. 2004. Hearing in the North Atlantic right whale: Anatomical predictions. Journal of the Acoustical Society of America 115(5, Part 2):2442.

Parks, S.E., P.K. Hamilton, S.D. Kraus, and P.L. Tyack. 2005. The gunshot sound produced by male North Atlantic right whales (*Eubalaena glacialis*) and its potential function in reproductive advertisement. Marine Mammal Science 21(3):458-475.

Parks, S.E., D.R. Ketten, J.T. O'Malley, and J. Arruda. 2007. Anatomical predictions of hearing in the North Atlantic right whale. Anatomical Record 290:734-744.

Parsons, E.C.M. 2004. The behavior and ecology of the Indo-Pacific humpback dolphin (*Sousa chinensis*). Aquatic Mammals 30(1):38-55.

Pastor, T. and A. Aguilar. 2003. Reproductive cycle of the female Mediterranean monk seal in the western Sahara. Marine Mammal Science 19(2):318-330.

Paulus, M. 1963. Étude ostéographique et ostéomètrique sur un pseudorque (*Pseudorca crassidens Owen* 1846) capturé au large de Port-de-Bouc (Bouches-du-Rhône) en Novembre 1948 (Osteographic and osteometric study of a false killer whale (*Pseudorca crassidens Owen* 1846) captured off Port-de-Bouc (Bouches-du-Rhône) in November 1948). Bulletin du Museum d'Histoire Naturelle de Marseille 23:29-67.

Pavan, G., G. La Manna, F. Zardin, and G. Riccobene. 2007. Long term acoustic monitoring of sperm whales off Catania (east coast of Sicily, Italy). Abstracts, Twenty-first Conference of the European Cetacean Society. 22-25 April 2007. Donostia-San Sebastián, Spain.

Pavan, G., D. Nascetti, M. Manghi, M. Priano, C. Fossati, and J.F. Borsani. 1997. Bioacoustic research on Sperm Whales in cooperation with the Italian Navy. European Research on Cetaceans 10:82-86.

Pavan, G., T.J. Hayward, J.F. Borsani, M. Priano, M. Manghi, C. Fossati, and J. Gordon. 2000. Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. Journal of the Acoustical Society of America 107(6):3487-3495.

Payne, K., P. Tyack, and R. Payne. 1983. Progressive changes in the songs of humpback whales (*Megaptera novaeangliae*): A detailed analysis of two seasons in Hawaii. Pages 9-57 in Payne, R., ed. Communication and behavior of whales. Volume AAAS Selected Symposia Series 76. Boulder, Colorado: Westview Press.

Payne, P.M. and D.W. Heinemann. 1993. The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf-edge and slope waters of the Northeastern United States, 1978-1988. Reports of the International Whaling Commission (Special Issue 14):51-68.

Payne, P.M., J.R. Nicolas, L. O'Brien, and K.D. Powers. 1986. The distribution of the humpback whale, *Megaptera novaeangliae,* on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus*. Fishery Bulletin 84:271-277.

Payne, P.M., D.N. Wiley, S.B. Young, S. Pittman, P.J. Clapham, and J.W. Jossi. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fishery Bulletin 88:687-696.

Payne, R.S. and S. McVay. 1971. Songs of humpback whales. Science 173:585-597.

Pérez, S., R. de Stephanis, P. Verborgh, and A. Sánchez. 2006. Absolute abundance of botllenose [sic] dolphins in the Strait of Gibraltar. Page 232 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Perrin, W.F. 2002. Common dolphins *Delphinus delphis, D. capensis,* and *D. tropicalis*. Pages 245-248 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Perrin, W.F. and W.A. Walker. 1975. The rough-toothed porpoise, *Steno bredanensis*, in the eastern tropical Pacific. Journal of Mammalogy 56(4):905-907.

Perrin, W.F. and R.L. Brownell, Jr. 2002. Minke whales *Balaenoptera acutorostrata* and *B. bonaerensis*. Pages 750-754 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Perrin, W.F., C.E. Wilson, and F.I. Archer II. 1994. Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). Pages 129-159 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Perryman, W.L. and T.C. Foster. 1980. Preliminary report on predation by small whales, mainly the false killer whale, *Pseudorca crassidens*, on dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern tropical Pacific. NMFS-SWFSC Administrative Report LJ-80-05:1-9.

Pershing, A.J., C.H. Greene, C. Hannah, D. Sameoto, E. Head, D.W. Mountain, J.W. Jossi, M.C. Benfield, P.C. Reid, and T.G. Durbin. 2001. Oceanographic responses to climate in the Northwest Atlantic. Oceanography 14(3):76-82.

Philips, J.D., P.E. Nachtigall, W.W.L. Au, J.L. Pawloski, and H.L. Roitblat. 2003. Echolocation in the Risso's dolphin, *Grampus griseus*. Journal of the Acoustical Society of America 113(1):605-616.

Pilleri, G. and J. Knuckey. 1969. Behaviour patterns of some Delphinidae observed in the western Mediterranean. Zeitschrift für Tierpsychologie 26:48-72.

Pilleri, G. and M. Gihr. 1972. Contribution to the knowledge of the cetaceans of Pakistan with particular reference to the genera *Neomeris, Sousa*, *Delphinus* and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaeorientalis)*. Investigations on Cetacea 4:107-162.

Pinca, S. and S. Dallot. 1995. Meso- and macrozooplankton composition patterns related to hydrodynamic structures in the Ligurian Sea (Trophos-2 experiment, April-June 1986). Marine Ecology Progress Series 126:49-65.

Pires, R. and H.C. Neves. 2001. Mediterranean monk seal *Monachus monachus* conservation: A case study in the Desertas Islands. Mammalia 65(3):301-308.

Pitman, R.L. 2002. Mesoplodont whales *Mesoplodon* spp. Pages 738-742 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Pitman, R.L. and C. Stinchcomb. 2002. Rough-toothed dolphins (*Steno bredanensis*) as predators of mahimahi (*Coryphaena hippurus*). Pacific Science 56(4):447-450.

Pivorunas, A. 1979. The feeding mechanisms of baleen whales. American Scientist 67:432-440.

Plön, S. 2004. The status and natural history of pygmy (*Kogia breviceps*) and dwarf (*K. sima*) sperm whales off southern Africa. Ph.D. diss., Rhodes University.

Plön, S. and R. Bernard. 1999. The fast lane revisited: Life history strategies of *Kogia* from southern Africa. Page 149 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Hawaii.

Plön, S.E.E., R.W. Harris, P.M. Illgner, and V.G.C. Cockcroft. 1998. Analysis of pygmy (*Kogia breviceps*) and dwarf (*Kogia simus*) sperm whale strandings along the South African coastline using a geographic information system. Page 108 in Abstracts, The World Marine Mammal Science Conference. 20-24 January 1998. Monte Carlo, Monaco.

Podesta, M., L. Magnaghi, and G.G. Gorlier. 1997. Sightings of Risso's dolphin in the Ligurian waters. European Research on Cetaceans 11:167-169.

Podestà, M. and L. Magnaghi. 1988. Sightings of pilot whales, *Globicephala melaena* (Traill, 1809), in the Ligurian Sea, 1981-1988 (Mammalia, Cetacea). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 129(4):478-482.

Podestà, M. and C. Meotti. 1992. The stomach contents of a Cuvier's beaked whale *Ziphius cavirostris* and a Risso's dolphin *Grampus griseus* stranded in Italy. European Research on Cetaceans 5:58-61.

Podestà, M., A. D'Amico, G. Pavan, A. Drougas, A. Komnenou, and N. Portunato. 2006. A review of Cuvier's beaked whale strandings in the Mediterranean Sea. Journal of Cetacean Research and Management 7(3):251-261.

Podiadis, V., E. Karpouzli, T. Genov, F. Sinischalci, G. Verriopoulos, C. Neofitou, and A. Exadactylos. 2006. Preliminary results of an acoustic survey across the Mediterranean Sea. Page 83 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Politi, E., S. Airoldi, and G. Notarbartolo di Sciara. 1994. A preliminary study of the ecology of cetaceans in the waters adjacent to Greek Ionian islands. European Research on Cetaceans 8:111-115.

Politi, E., M. Bearzi, G. Notarbartolo di Sciara, E. Cussino, and G. Gnone. 1992. Distribution and frequency of cetaceans in the waters adjacent to the Greek Ionian Islands. European Research on Cetaceans 6:75-78.

Popov, V.V. and V.O. Klishin. 1998. EEG study of hearing in the common dolphin, *Delphinus delphis*. Aquatic Mammals 24(1):13-20.

Por, F.D. 1978. Lessepsian migration: The influx of Red Sea biota into the Mediterranean by way of the Suez Canal. New York, New York: Springer-Verlag Berlin Heidelberg.

Pouchet, G. and H. Beauregard. 1888. Sur la présence de deux baleines franches dans les eaux d'Alger (On the presence of two right whales in water of Algiers). Comptes-Rendus de l'Académie des Sciences, Paris 106:875-876.

Poulos, S.E., P.G. Drakopoulos, and M.B. Collins. 1997. Seasonal variability in sea surface oceanographic conditions in the Aegean Sea (Eastern Mediterranean): An overview. Journal of Marine Systems 13:225-244.

Pribanić, S., D. Mioković, and D. Kovačić. 2000. Growth rate and body lengths of the bottlenose dolphins *Tursiops truncatus* (Montagu, 1821) from the Adriatic Sea. Natura Croatica 9(3):179-188.

Pulcini, M. 1997. Note about the presence of Cuvier's beaked whale *Ziphius cavirostris* in the Ionian islands of Greece. European Research on Cetaceans 10:176.

Pulcini, M. and A.M. Angradi. 1994. Observations of Cuvier's beaked whale *Ziphius cavirostris* (Cetacea, Odontoceti) in the Ionian Islands of Greece. European Research on Cetaceans 8:116-119.

Raga, J.A., M.A. Raduán, and C. Blanco. 1985. Contribución al estudio de la distribución de cetáceos en el Mediterráneo y Atlánticó Ibérico (Contribution to the study of distribution of cetaceans in the Mediterranean and Iberian Atlantic waters). Miscellania Zoologica 9:361-366.

Rankin, S. and J. Barlow. 2005. Source of the North Pacific "boing" sound attributed to minke whales. Journal of the Acoustical Society of America 118(5):3346-3351.

Rankin, S. and J. Barlow. 2007. Sounds recorded in the presence of Blainville's beaked whales, *Mesoplodon densirostris*, near Hawai'i (L). Journal of the Acoustical Society of America 122(1):42-45.

Read, A.J. 1990. Age at sexual maturity and pregnancy rates of harbour porpoises *Phocoena phocoena* from the Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences 47:561-565.

Read, A.J. 1999. Harbour porpoise *Phocoena phocoena* (Linnaeus, 1758). Pages 323-355 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Read, A.J. and A.A. Hohn. 1995. Life in the fast lane: The life history of harbor porpoises from the Gulf of Maine. Marine Mammal Science 11(4):423-440.

Read, A.J. and A.J. Westgate. 1997. Monitoring the movements of harbour porpoises (*Phocoena phocoena*) with satellite telemetry. Marine Biology 130:315-322.

Read, A.J., J.R. Nicolas, and J.E. Craddock. 1996. Winter capture of a harbor porpoise in a pelagic drift net off North Carolina. Fishery Bulletin 94:381-383.

Redfern, J.V., M.C. Ferguson, E.A. Becker, K.D. Hyrenbach, C. Good, J. Barlow, K. Kaschner, M.F. Baumgartner, K.A. Forney, L.T. Ballance, P. Fauchald, P. Halpin, T. Hamazaki, A.J. Pershing, S.S. Qian, A. Read, S.B. Reilly, L. Torres, and F. Werner. 2006. Techniques for cetacean-habitat modeling. Marine Ecology Progress Series 310:271-295.

Reeves, R. and G. Notarbartolo di Sciara, eds. and compilers. 2006. The status and distribution of cetaceans in the Black Sea and Mediterranean Sea. Malaga, Spain: IUCN Centre for Mediterranean Cooperation

Reeves, R.R. and E. Mitchell. 1986. American pelagic whaling for right whales in the North Atlantic. Reports of the International Whaling Commission (Special Issue 10):221-254.

Reeves, R.R. and R.D. Kenney. 2003. Baleen whales: Right whales and allies. Pages 425-463 in Feldhamer, G.A., B.C. Thompson, and J.A. Chapman, eds. Wild mammals of North America: Biology, management, and conservation. 2d ed. Baltimore, Maryland: Johns Hopkins University Press.

Reeves, R.R., E. Mitchell, and H. Whitehead. 1993. Status of the northern bottlenose whale, *Hyperoodon ampullatus*. Canadian Field-Naturalist 107(4):490-508.

Reeves, R.R., R. Rolland, and P.J. Clapham. 2001a. Causes of reproductive failure in North Atlantic right whales: New avenues of research: Report of a workshop held 26-28 April 2000, Falmouth, Massachusetts. Northeast Fisheries Science Center Reference Document 01-16. Woods Hole, Massachusetts: National Marine Fisheries Service.

Reeves, R.R., A.J. Read, and G. Notarbartolo di Sciara, eds. 2001b. Report of the Workshop on Interactions between Dolphins and Fisheries in the Mediterranean: Evaluation of Mitigation Alternatives, Roma, 4-5 May 2001. Rome, Italy: Istituto Centrale per la Ricerca Applicata al Mare.

Reeves, R.R., P.J. Clapham, and S.E. Wetmore. 2002a. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. Journal of Cetacean Research and Management 4(3):235-253.

Reeves, R.R., T.D. Smith, and E.A. Josephson. 2007. Near-annihilation of a species: Right whaling in the North Atlantic. Pages 39-74 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Reeves, R.R., S. Leatherwood, G.S. Stone, and L.G. Eldredge. 1999. Marine mammals in the area served by the South Pacific Regional Environment Programme. Apia, Samoa: South Pacific Regional Environment Programme.

Reeves, R.R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002b. National Audubon Society guide to marine mammals of the world. New York, New York: Alfred A. Knopf, Inc.

Reeves, R.R., T.D. Smith, E.A. Josephson, P.J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: Clues to migratory routes and possibly additional feeding grounds. Marine Mammal Science 20(4):774-786.

Reid, J.B., P.G.H. Evans, and S.P. Northridge, compilers and eds. 2003. Atlas of cetacean distribution in north-west European waters. Petersborough, United Kingdom: Joint Nature Conservation Committee.

Reijnders, P., S. Brasseur, J. van der Toorn, P. van der Wolf, I. Boyd, J. Harwood, D. Lavigne, and L. Lowry. 1993. Seals, fur seals, sea lions, and walrus. Pages 5-64 in Status survey and conservation action plan. Gland, Switzerland: IUCN/SSC Seal Specialist Group.

Reilly, S.B. 1990. Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. Marine Ecology Progress Series 66:1-11.

Reiner, F., M.E. Dos Santos, and F.W. Wenzel. 1996. Cetaceans of the Cape Verde Archipelago. Marine Mammal Science 12(3):434-443.

Rendell, L. and H. Whitehead. 2004. Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. Animal Behaviour 67:865-874.

Rendell, L.E. and J.C.D. Gordon. 1999. Vocal response of long-finned pilot whales (*Globicephala melas*) to military sonar in the Ligurian Sea. Marine Mammal Science 15(1):198-204.

Rey, J.C. and O. Cendrero. 1981. Nouvelles informations sur cétacés et pinnipèdes vus et échoués sur les côtes espagnoles en 1980, et trouvailles en 1981 (New information on cetaceans and pinnipeds stranded on Spanish coasts in 1980 and the first months of 1981). Unpublished meeting document. ICES C.M. 1981/N:3 Copenhagen, Denmark: International Council for the Exploration of the Sea.

Rice, D.W. 1989. Sperm whale--*Physeter macrocephalus* (Linnaeus, 1758). Pages 177-234 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. San Diego, California: Academic Press.

Rice, D.W. 1998. Marine mammals of the world: Systematics and distribution. Lawrence, Kansas: Society for Marine Mammalogy.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, California: Academic Press.

Ridgway, S.H. 2000. The auditory central nervous system. Pages 273-293 in Au, W.W.L., A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Ridgway, S.H. and D.A. Carder. 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. Aquatic Mammals 27(3):267-276.

Ridgway, S.H., B.L. Scronce, and J. Kanwisher. 1969. Respiration and deep diving in the bottlenose porpoise. Science 166:1651-1654.

Ridgway, S.H., D.A. Carder, R.R. Smith, T. Kamolnick, C.E. Schlundt, and W.R. Elsberry. 1997. Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, *Tursiops truncatus*, to 1-second tones of 141 to 201 dB re 1 μPa. Technical Report 1751, Revision 1 San Diego, California: Naval Sea Systems Command.

Riedman, M. 1990. The pinnipeds: Seals, sea lions, and walruses. Berkeley, California: University of California Press.

Rigas, G. and K. Ronald. 1985. Observations on the biology and behaviour of the Mediterranean monk. Aquatic Mammals 1:23-26.

Ringelstein, J., C. Pusineri, S. Hassani, L. Meynier, R. Nicolas, and V. Ridoux. 2006. Food and feeding ecology of striped dolphin, *Stenella coeruleoalba,* in the oceanic waters of the north-east Atlantic. Journal of the Marine Biological Association of the United Kingdom 86:909-918.

Ripoll, T., F. Dhermain, D. Barril, R. Trucchi, B. Bonsignori, E. Roussel, L. David, and P. Beaubrun. 2004. First summer population estimate of bottlenose dolphins along the north-western coasts of the occidental Mediterranean Basin. European Research on Cetaceans 15:393-395.

Ritter, F. 2002. Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. Aquatic Mammals 28(1):46-59.

Ritter, F. and B. Brederlau. 1999. Behavioural observations of dense beaked whales (*Mesoplodon densirostris*) off La Gomera, Canary Islands (1995-1997). Aquatic Mammals 25(2):55-61.

Robeck, T.R. and S.L. Monfort. 2006. Characterization of male killer whale (*Orcinus orca)* sexual maturation and reproductive seasonality. Theriogenology 66:242-250.

Roberts, S.M. 2003. Examination of the stomach contents from a Mediterranean sperm whale found south of Crete, Greece. Journal of the Marine Biological Association of the United Kingdom 83:667-670.

Rommel, S.A., A.M. Costidis, A. Fernández, P.D. Jepson, D.A. Pabst, W.A. McLellan, D.S. Houser, T.W. Cranford, A.L. van Helden, D.M. Allen, and N.B. Barros. 2006. Elements of beaked whale anatomy and diving physiology and some hypothetical causes of sonar-related stranding. Journal of Cetacean Research and Management 7(3):189-209.

Ronald, K. and P.J. Healey. 1982. The monk seal (*Monachus monachus*). Pages 243-252 in FAO Advisory Committee on Marine Resources Research - Working Party on Marine Mammals, ed. Mammals in the seas. Volume IV: Small cetaceans, seals, sirenians and otters. Rome, Italy: Food and Agriculture Organization of the United Nations.

Rosel, P.E., A.E. Dizon, and J.E. Heyning. 1994. Genetic analysis of sympatric morphotypes of common dolphins (genus *Delphinus*). Marine Biology 119:159-167.

Rosel, P.E., A.E. Dizon, and M.G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena,* on interoceanic and regional scales. Canadian Journal of Fisheries and Aquatic Science 52:1210-1219.

Rosel, P.E., R. Tiedemann, and M. Walton. 1999. Genetic evidence for limited trans-Atlantic movements of the harbor porpoise *Phocoena phocoena*. Marine Biology 133:583-591.

Rosel, P.E., A. Frantzis, C. Lockyer, and A. Komnenou. 2003. Source of Aegean Sea harbour porpoises. Marine Ecology Progress Series 247:257-261.

Rosenbaum, H.C., M.G. Egan, P.J. Clapham, R.L. Brownell Jr., S. Malik, M.W. Brown, B.N. White, P. Walsh, and R. Desalle. 2000. Utility of North Atlantic right whale museum specimens for assessing changes in genetic diversity. Conservation Biology 14(6):1837-1842.

Ross, G.J.B. 1979. Records of pygmy and dwarf sperm whales, genus Kogia, from southern Africa, with biological notes and some comparisons. Annals of the Cape Provincial Museums (Natural History) 11(4):259-327.

Ross, G.J.B. 1984. The smaller cetaceans of the south east coast of southern Africa. Annals of the Cape Provincial Museums (Natural History) 15, Part 2:173-410.

Ross, G.J.B., G.E. Heinsohn, and V.G. Cockcroft. 1994. Humpback dolphins--*Sousa chinensis* (Osbeck, 1765), *Sousa plumbea* (G. Cuvier, 1829) and *Sousa teuszii* (Kukenthal, 1892). Pages 23-42 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Rosso, M., A. Moulins, M. Ballardini, and M. Wurtz. 2007. Preliminary results on Cuvier's beaked whale social structure in the northern Ligurian Sea. Abstracts, Twenty-first Conference of the European Cetacean Society. 22-25 April 2007. Donostia-San Sebastián, Spain.

Roughgarden, J., S. Gaines, and H. Possingham. 1988. Recruitment dynamics in complex life cycles. Science 241(4872):1460-1466.

Ruchonnet, D., M. Boutoute, C. Guinet, and P. Mayzaud. 2006. Fatty acid composition of Mediterranean fin whale *Balaenoptera physalus* blubber with respect to body heterogeneity and trophic interaction. Marine Ecology Progress Series 311:165-174.

Rudolph, P., C. Smeenk, and S. Leatherwood. 1997. Preliminary checklist of Cetacea in the Indonesian Archipelago and adjacent waters. Zoologische Verhandelingen 312:1-48.

Saad, A. 2004. First record of a humpback whale stranding on the coast of Syria (Eastern Mediterranean). FINS (Newsletter of ACCOBAMS) 1(1):10.

Saayman, G.S. and C.K. Tayler. 1973. Social organisation of inshore dolphins (*Tursiops aduncus* and *Sousa*) in the Indian Ocean. Journal of Mammalogy 54(4):993-996.

Saayman, G.S. and C.K. Tayler. 1979. The socioecology of humpback dolphins (*Sousa* sp.). Pages 165-226 in Winn, H.E. and B.L. Olla, eds. Behavior of marine animals: Current perspectives in research. Volume 3: Cetaceans. New York, New York: Plenum Press.

Salden, D.R. 1989. An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. Page 58 in Abstracts, Eighth Biennial Conference on the Biology of Marine Mammals. 7-11 December 1989. Pacific Grove, California.

Salman, A., M. Bilecenoglu, and H. Güçlüsoy. 2001. Stomach contents of two Mediterranean monk seals (*Monachus monachus*) from the Aegean Sea, Turkey. Journal of the Marine Biological Association of the United Kingdom 81:719-720.

Samaranch, R. and L.M. González. 2000. Changes in morphology with age in Mediterranean monk seals (*Monachus monachus*). Marine Mammal Science 16(1):141-157.

Sanders, I.M., J.C. Barrios-Santiago, and R.S. Appeldoorn. 2005. Distribution and relative abundance of humpback whales off western Puerto Rico during 1995-1997. Caribbean Journal of Science 41(1):101-107.

Sanpera, C. and A. Aguilar. 1992. Modern whaling off the Iberian Peninsula during the 20th century. Reports of the International Whaling Commission 42:723-730.

Santos, M.B. and G.J. Pierce. 2003. The diet of harbour porpoise *(Phocoena phocoena)* in the northeast Atlantic. Oceanography and Marine Biology: An Annual Review 41:355-390.

Santos, M.B., R. Fernández, A. López, J.A. Martínez, and G.J. Pierce. 2007. Variability in the diet of bottlenose dolphin, *Tursiops truncatus*, in Galician waters, north-western Spain, 1990-2005. Journal of the Marine Biological Association of the United Kingdom 87(1):231-241.

Santos, M.B., G.J. Pierce, A. López, R.J. Reid, V. Ridoux, and E. Mente. 2006. Pygmy sperm whales *Kogia breviceps* in the Northeast Atlantic: New information on stomach contents and strandings. Marine Mammal Science 22(3):600-616.

Santos, M.B., G.J. Pierce, J. Herman, A. López, A. Guerra, E. Mente, and M.R. Clarke. 2001. Feeding ecology of Cuvier's beaked whale (*Ziphius cavirostris*): A review with new information on the diet of this species. Journal of the Marine Biological Association of the United Kingdom 81:687-694.

Sardà, F., A. Calafat, M.M. Flexas, A. Tselepides, M. Canals, M. Espino, and A. Tursi. 2004. An introduction to Mediterranean deep-sea biology. Scientia Marina 68(Supplement 3):7-38.

Sardi, K.A., M.T. Weinrich, and R.C. Connor. 2005. Social interactions of humpback whale (*Megaptera novaeangliae*) morther/calf pairs on a North Atlantic feeding ground. Behaviour 142:731-750.

Saulitis, E.L., C.O. Matkin, and F.H. Fay. 2005. Vocal repertoire and acoustic behavior of the isolated AT1 killer whale subpopulation in southern Alaska. Canadian Journal of Zoology 83:1015-1029.

Scheinin, A., D. Kerem, O. Goffman, and E. Spanier. 2004a. Status of common dolphins along the Israeli Mediterranean coast. FINS (Newsletter of ACCOBAMS) 1(2):13-14.

Scheinin, A., D. Kerem, O. Goffman, and E. Spanier. 2004b. Rare occurrences of cetaceans along the Isreali Mediterranean coast. FINS (Newsletter of ACCOBAMS) 1(1):10-11.

Schilling, M.R., I. Seipt, M.T. Weinrich, S.E. Frohock, A.E. Kuhlberg, and P.J. Clapham. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. Fishery Bulletin 90:749-755.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107(6):3496-3508.

Schneider, D.C. and P.M. Payne. 1983. Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts. Journal of Mammalogy 64(3):518-520.

Schultz, K.W. and P.J. Corkeron. 1994. Interspecific differences in whistles produced by inshore dolphins in Moreton Bay, Queensland, Australia. Canadian Journal of Zoology 72:1061-1068.

Schusterman, R.J., D. Kastak, D.H. Levenson, C.J. Reichmuth, and B.L. Southall. 2000. Why pinnipeds don't echolocate. Journal of the Acoustical Society of America 107(4):2256-2264.

Scordìa, C. 1939. Intorno alle incursioni del *Globicephalus melas* (Trail) nello Stretto di Messina, e ai danni che ne vengono apportati alla pesca del tonno (About the incursions of *Globicephalus*

melas (Trail) in the Strait of Messina, and of the impact they cause on the tuna fisheries). Memorie di Biologia Marina e di Oceanografia 6(2):1-7.

Scott, T.M. and S.S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science 13(2):317-321.

Seabra, M.I., M.A. Silva, M. Figueiredo, S. Magalhães, R. Prieto, and R.S. Santos. 2006. Habitat preference models for beaked whales (Fam. Ziphiidae) in the Azores (Portugal). Page 137 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Sergeant, D., K. Ronald, J. Boulva, and F. Berkes. 1978. The recent status of *Monachus monachus*, the Mediterranean monk seal. Biological Conservation 14:259-287.

Shane, S.H. 1994. Occurrence and habitat use of marine mammals at Santa Catalina Island, California from 1983-91. Bulletin of the Southern California Academy of Sciences 93:13-29.

Shane, S.H., R.S. Wells, and B. Würsig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: A review. Marine Mammal Science 2(1):34-63.

Shelden, K.E.W., S.E. Moore, J.M. Waite, P.R. Wade, and D.J. Rugh. 2005. Historic and current habitat use by North Pacific right whales *Eubalaena japonica* in the Bering Sea and Gulf of Alaska. Mammal Review 35(2):129-155.

Shoham-Frider, E., S. Amiel, M. Roditi-Elasar, and N. Kress. 2002. Risso's dolphin *(Grampus griseus)* stranding on the coast of Israel (eastern Mediterranean). Autopsy results and trace metal concentrations. Science of the Total Environment 295:157-166.

Sigurjónsson, J. 1995. On the life history and autecology of North Atlantic rorquals. Pages 425-441 in Blix, A.S., L. Walløe, and Ø. Ulltang, eds. Whales, seals, fish and man. New York, New York: Elsevier Science B.V.

Silber, G.K. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Canadian Journal of Zoology 64:2075-2080.

Silva, M.A. and M. Sequeira. 1997. Stomach contents of marine mammals stranded on the Portuguese coast. European Research on Cetaceans 11:176-179.

Simão, S.M. and S.C. Moreira. 2005. Vocalizations of female humpback whale in Arraial do Cabo (RJ, Brazil). Marine Mammal Science 21(1):150-153.

Similä, T. and F. Ugarte. 1993. Surface and underwater observations of cooperatively feeding killer whales in northern Norway. Canadian Journal of Zoology 71:1494-1499.

Similä, T., J.C. Holst, and I. Christensen. 1996. Occurrence and diet of killer whales in northern Norway: Seasonal patterns relative to the distribution and abundance of Norwegian spring-spawning herring. Canadian Journal of Fisheries and Aquatic Sciences 53:769-779.

Simmonds, M.P. and S.J. Isaac. 2007. The impacts of climate change on marine mammals: Early signs of significant problems. Oryx 41(1):19-26.

Simon, M., M. Wahlberg, and L.E. Miller. 2007. Echolocation clicks from killer whales (*Orcinus orca*) feeding on herring (*Clupea harengus*) (L). Journal of the Acoustical Society of America 121(2):749-752.

Skaug, H.J., N. Øien, T. Schweder, and G. Bøthun. 2003. Current abundance of minke whales in the northeastern Atlantic; variability in time and space. IWC Working Document SC/55/NAM1 presented to the IWC Scientific Committee. 16-19 June. Berlin, Germany.

Skov, H., J. Durinck, and D. Bloch. 2003. Habitat characteristics of the shelf distribution of the harbour porpoise (*Phocoena phocoena*) in the waters around the Faroe Islands during summer. NAMMCO Scientific Publications 5:31-40.

2002. Personal communication via e-mail between Mr. Chris Slay, New England Aquarium, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 1 August.

Slijper, E.J., W.L. van Utrecht, and C. Naaktgeboren. 1964. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. Bijdragen Tot de Dierkunde 34:3-93.

Smeenk, C., M.F. Leopold, and M.J. Addink. 1992. Note on the harbour porpoise *Phocena phocoena* in Mauritania, West Africa. Lutra 35:98-104.

Smeenk, C., M.J. Addink, A.B. van den Berg, C.A.W. Bosman, and G.C. Cadée. 1996. Sightings of *Delphinus* cf. *tropicalis* Van Bree, 1971 in the Red Sea. Bonner Zoologische Beitraege 46(1-4):389-398.

Smith, R.J. and A.J. Read. 1992. Consumption of euphausiids by harbor porpoise (*Phocoena phocoena*) calves in the Bay of Fundy. Canadian Journal of Zoology 70:1629-1632.

Smith, T.D. and R.R. Reeves. 2003. Estimating American 19th century catches of humpback whales in the West Indies and Cape Verde Islands. Caribbean Journal of Science 39(3):286-297.

Smith, T.D., R.R. Reeves, and J.L. Bannister, eds. 2005. Report of the International Cachalot Assessment Research Planning Workshop, Woods Hole, Massachusetts, 1-3 March 2005. NOAA Technical Memorandum NMFS-F/SPO-72:1-45.

Smith, T.D., K. Barthelmess, and R.R. Reeves. 2006. Using historical records to relocate a long-forgotten summer feeding ground of North Atlantic right whales. Marine Mammal Science 22(3):723-734.

Smith, T.D., R.B. Griffin, G.T. Waring, and J.G. Casey. 1996. Multispecies approaches to management of large marine predators. Pages 467-490 in Sherman, K., N.A. Jaworski, and T.J. Smayda, eds. The Northeast Shelf Ecosystem: Assessment, sustainability, and management. Cambridge, Massachusetts: Blackwell Science.

Smith, T.D., J. Allen, P.J. Clapham, P.S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, P.J. Palsbøll, J. Sigurjónsson, P.T. Stevick, and N. Øien. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science 15(1):1-32.

Smultea, M.A. 1994. Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii. Canadian Journal of Zoology 72:805-811.

Southall, B.L., R.J. Schusterman, and D. Kastak. 2000. Masking in three pinnipeds: Underwater, low-frequency critical ratios. Journal of the Acoustical Society of America 108(3, Part 1):1322-1326.

Stacey, P.J. and R.W. Baird. 1991. Status of the false killer whale, *Pseudorca crassidens*, in Canada. Canadian Field-Naturalist 105(2):189-197.

Stacey, P.J., S. Leatherwood, and R.W. Baird. 1994. *Pseudorca crassidens*. Mammalian Species 456:1-6.

Stern, S.J. 1992. Surfacing rates and surfacing patterns of minke whales (*Balaenoptera acutorostrata*) off central California, and the probability of a whale surfacing within visual range. Reports of the International Whaling Commission 42:379-385.

Stern, S.J. 2002. Migration and movement patterns. Pages 742-748 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Stevick, P.T., N. Øien, and D.K. Mattila. 1998. Migration of a humpback whale (*Megaptera novaeangliae*) between Norway and the West Indies. Marine Mammal Science 14(1):162-166.

Stevick, P.T., B.J. McConnell, and P.S. Hammond. 2002. Patterns of movement. Pages 185-216 in Hoelzel, A.R., ed. Marine mammal biology: An evolutionary approach. Oxford, United Kingdom: Blackwell Science.

Stevick, P.T., J. Allen, P.J. Clapham, N. Friday, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003a. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258:263-273.

Stevick, P.T., J. Allen, M. Bérubé, P.J. Clapham, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Robbins, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003b. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology, London 259:231-237.

Stewart, B.S. and S. Leatherwood. 1985. Minke whale *Balaenoptera acutorostrata* Lacepede, 1804. Pages 91-136 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Stewart, B.S. and H.R. Huber. 1993. *Mirounga angustirostris*. Mammalian Species 449:1-10.

Stockin, K.A., R.S. Fairbairns, E.C.M. Parsons, and D.W. Sims. 2001. Effects of diel and seasonal cycles on the dive duration of the minke whale (*Balaenoptera acutorostrata*). Journal of the Marine Biological Association of the United Kingdom 81:189-190.

Stone, G.S., S.K. Katona, A. Mainwaring, J.M. Allen, and H.D. Corbett. 1992. Respiration and surfacing rates of fin whales (*Balaenoptera physalus*) observed from a lighthouse tower. Reports of the International Whaling Commission 42:739-745.

Summers, E.L., J.A. Estrada, and S.I. Zeeman. 2006. A note on geographic and seasonal fluctuations in the isotopic composition of baleen in four North Atlantic right whales (*Eubalaena glacialis*). Journal of Cetacean Research and Management 8(3):241-245.

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McLellan, and D.A. Pabst. 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3):309-315.

Szymanski, M.D., D.E. Bain, K. Kiehl, S. Pennington, S. Wong, and K.R. Henry. 1999. Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. Journal of the Acoustical Society of America 106(2):1134-1141.

Taylor, B., J. Barlow, R. Pitman, L. Ballance, T. Klinger, D. DeMaster, J. Hildebrand, J. Urban, D. Palacios, and J. Mead. 2004. A call for research to assess risk of acoustic impact on beaked whale populations. IWC Working Document SC/56/E36 presented to the IWC Scientific Committee. 19-22 July. Sorrento, Italy.

Teloni, V. 2005. Patterns of sound production in diving sperm whales in the northwestern Mediterranean. Marine Mammal Science 21(3):446-457.

Teloni, V., W.M.X. Zimmer, and P.L. Tyack. 2005. Sperm whale trumpet sounds. Bioacoustics 15(2):163-174.

Tetley, M.J. 2004. The distribution and habitat preference of the North Atlantic minke whale (*Balaenoptera acutorostrata acutorostrata*) in the southern outer Moray Firth, NE Scotland. Master's thesis, University of Wales, Bangor.

The POEM (Physical Oceanography of the Eastern Mediterranean) group. 1992. General circulation of the Eastern Mediterranean. Earth-Science Reviews 32:285-309.

Thode, A., T. Norris, and J. Barlow. 2000. Frequency beamforming of dolphin whistles using a sparse three-element towed array. Journal of the Acoustical Society of America 107(6):3581-3584.

Thomas, J., N. Chun, W. Au, and K. Pugh. 1988. Underwater audiogram of a false killer whale (*Pseudorca crassidens*). Journal of the Acoustical Society of America 84(3):936-940.

Thomas, J., P. Moore, R. Withrow, and M. Stoermer. 1990. Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). Journal of the Acoustical Society of America 87(1):417-420.

Thompson, P.M., G.J. Pierce, J.R.G. Hislop, D. Miller, and J.S.W. Diack. 1991. Winter foraging by common seals (*Phoca vitulina*) in relation to food availability in the inner Moray Firth, N.E. Scotland. Journal of Animal Ecology 60:283-294.

Thompson, P.O., W.C. Cummings, and S.J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. Journal of the Acoustical Society of America 80(3):735-740.

Thompson, T.J., H.E. Winn, and P.J. Perkins. 1979. Mysticete sounds. Pages 403-431 in Winn, H.E. and B.L. Olla, eds. Behavior of marine animals: Current perspectives in research. Volume 3: Cetaceans. New York, New York: Plenum Press.

Thomson, D.H. and W.J. Richardson. 1995. Marine mammal sounds. Pages 159-204 in Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson, eds. Marine mammals and noise. San Diego, California: Academic Press.

Thurman, H.V. 1997. Introductory oceanography. 8th ed. Upper Saddle River, New Jersey: Prentice Hall.

Tortonese, E. 1957. Il cetaceo odontocete *Ziphius cavirostris* G. Cuv. nel golfo di Genova (The odontocete cetacean *Ziphius cavirostris* G. Cuv. in the Gulf of Genoa). DORIANA- Supplemento agli Annali del Museo civico di storia naturale 'G. Doria' 2(71):1-7.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19(1):3-50.

Tselepides, A., V. Zervakis, T. Polychronaki, R. Danovaro, and G. Chronis. 2000. Distribution of nutrients and particulate organic matter in relation to the prevailing hydrographic features of the Cretan Sea (NE Mediterranean). Progress in Oceanography 46:113-142.

Turl, C.W. 1993. Low-frequency sound detection by a bottlenose dolphin. Journal of the Acoustical Society of America 94(5):3006-3008.

Tyack, P. 1986. Population biology, social behavior and communication in whales and dolphins. Trends in Ecology & Evolution 1(6):144-150.

Tyack, P. and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. Behaviour 83:132-153.

Tyack, P.L., M. Johnson, N. Aguilar Soto, A. Sturlese, and P.T. Madsen. 2006. Extreme diving of beaked whales. Journal of Experimental Biology 209:4238-4253.

UNEP (United Nations Environment Programme). 2005. Information report on the status of the monk seal in the Mediterranean. Mediterranean Action Plan. Tunis, CEDEX: United Nations Environment Programme.

Urian, K.W., D.A. Duffield, A.J. Read, R.S. Wells, and E.D. Shell. 1996. Seasonality of reproduction in bottlenose dolphins, *Tursiops truncatus*. Journal of Mammalogy 77(2):394-403.

Urick, R.J. 1983. Principles of underwater sound. 3rd ed. Los Altos, California: Peninsula Publishing.

Vallon, D., C. Guigo, and R. Duguy. 1976. Le Globicéphale noir, *Globicephala melaena (*Traill*,* 1809*)* en Méditerranée occidentale (The pilot whale, *Globicephala melaena (*Traill*,* 1809) in the western Mediterranean). Paper presented at Plenary Assembly, XXV Congress, International Commission for the Exploration of the Mediterranean Sea. 22-30 October 1976. Split, Croatia.

Valsecchi, E., W. Amos, J.A. Raga, M. Podestà, and W. Sherwin. 2004. The effects of inbreeding on mortality during a morbillivirus outbreak in the Mediterranean striped dolphin (*Stenella coeruleoalba*). Animal Conservation 7:139-146.

Valverde, J.A. and J.A. Camiñas. 1997. On dwarf sperm whale *Kogia simus* (Owen, 1866), Physeteroidea, in Spain: A correction. European Research on Cetaceans 10:168-171.

Van Parijs, S.M. and P.J. Corkeron. 2001. Vocalizations and behaviour of Pacific humpback dolphins *Sousa chinensis*. Ethology 107:701-716.

Van Waerebeek, K., F. Félix, B. Haase, D.M. Palacios, D.M. Mora-Pinto, and M. Muñoz-Hincapié. 1998. Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America. Reports of the International Whaling Commission 48:525-532.

Van Waerebeek, K., M. André, M. Sequeira, V. Martín, D. Robineau, A. Collet, V. Papastavrou, and E. Ndiaye. 1999. Spatial and temporal distribution of the minke whale, *Balaenoptera acutorostrata* (Lacépède, 1804), in the southern northeast Atlantic Ocean and the Mediterranean Sea, with reference to stock identity. Journal of Cetacean Research and Management 1(3):223-237.

Vanderlaan, A.S.M., A.E. Hay, and C.T. Taggart. 2003. Characterization of North Atlantic right-whale (*Eubalaena glacialis*) sounds in the Bay of Fundy. IEEE Journal of Oceanic Engineering 28(2):164-173.

Vanney, J.-R. and M. Gennesseaux. 1985. Mediterranean seafloor features: Overview and assessment. Pages 3-32 in Stanley, D.J. and F.-C. Wezel, eds. Geological evolution of the Mediterranean Basin. New York, New York: Springer-Verlag.

Veirs, V. 2004. Source levels of free-ranging killer whale (*Orcinus orca*) social vocalizations. Journal of the Acoustical Society of America 116(4, Part 2):2615.

Vella, A. 2005. Common dolphins (*Delphinus delphis*) status in the central and southern Mediterranean around the Maltese Islands. European Cetacean Society Newsletter 45(Special Issue):4-12.

Verboom, W.C. and R.A. Kastelein. 1995. Acoustic signals by harbour porpoises (*Phocoena phocoena*). Pages 1-39 in Nachtigall, P.E., J. Lien, W.W.L. Au, and A.J. Read, eds. Harbour porpoises: Laboratory studies to reduce bycatch. Woerden, the Netherlands: De Spil Publishers.

Verborgh, P., R. de Stephanis, S. Pérez, A. Sanchez, and C. Guinet. 2006. Population estimation and survival rate of long-finned pilot whales (*Globicephala melas*) in the Strait of Gibraltar and interactions with the maritime traffic. Page 59 in Abstracts, Twentieth Annual Conference of the European Cetacean Society. 2-7 April 2006. Gdynia, Poland.

Vester, H.I., L.P. Folkow, and A.S. Blix. 2001. Underwater sound production from captive hooded and harp seals during live fish hunting. Page 224 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 2001. Vancouver, British Columbia.

Viale, D. 1985. Cetaceans in the northwestern Mediterranean: Their place in the ecosystem. Oceanography and Marine Biology: An Annual Review 23:491-571.

Viaud-Martínez, K.A., M.M. Vergara, P.E. Gol'din, V. Ridoux, A.A. Öztürk, B. Öztürk, P.E. Rosel, A. Frantzis, A. Komnenou, and A.J. Bohonak. 2007. Morphological and genetic differentiation of the Black Sea harbour porpoise *Phocoena phocoena*. Marine Ecology Progress Series 338:281-294.

Viaud, K.A., R.L. Brownell, Jr., A. Komnenou, and A.J. Bohonak. 2005. Genetic isolation and morphological divergence of Black Sea bottlenose dolphins. Page 292 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Villadsgaard, A., M. Wahlberg, and J. Tougaard. 2007. Echolocation signals of wild harbour porpoises, *Phocoena phocoena*. Journal of Experimental Biology 210:56-64.

Wade, P.R. and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Reports of the International Whaling Commission 43:477-493.

Walker, D., M. Telfer, and G. Cresswell. 2001. The status and distribution of beaked whales (Ziphiidae) in the Bay of Biscay. European Research on Cetaceans 15:278-282.

Walker, W.A. 1981. Geographical variation in morphology and biology of bottlenose dolphins (*Tursiops*) in the eastern North Pacific. NMFS-SWFC Administrative Report LJ-81-03C:1-17.

Wang, J.Y., D.E. Gaskin, and B.N. White. 1996. Mitochondrial DNA analysis of harbour porpoise, *Phocoena phocoena,* subpopulations in North American waters. Canadian Journal of Fisheries and Aquatic Sciences 53:1632-1645.

Wang, M.-C., W.A. Walker, K.-T. Shao, and L.-S. Chou. 2002. Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. Acta Zoologica Taiwanica 13(2):53-62.

Ward, J.A. 1999. Right whale (*Balaena glacialis*) South Atlantic Bight habitat characterization and prediction using remotely sensed oceanographic data. Master's thesis, University of Rhode Island.

Ward, J.A., G.H. Mitchell, A.M. Farak, and E.P. Keane. 2005. Beaked whale habitat characterization and prediction. NUWC-NPT Technical Report 11,548. Newport, Rhode Island: Naval Undersea Warfare Center Division.

Ware, C., R. Arsenault, M. Plumlee, and D. Wiley. 2006. Visualizing the underwater behavior of humpback whales. IEEE Computer Graphics and Applications 26(4):14-18.

Waring, G., D. Belden, M. Vecchione, and R. Gibbons. 2003. Mid-water prey in beaked whale and sperm whale deep-water habitat south of Georges Bank. Page 172 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14-19 December 2003. Greensboro, North Carolina.

Waring, G.T. and J.T. Finn. 1995. Cetacean trophic interactions off the northeast USA inferred from spatial and temporal co-distribution patterns. Unpublished meeting document. ICES C.M. 1995/N:7 Copenhagen, Denmark: International Council for the Exploration of the Sea.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1992. Cetaceans associated with Gulf Stream features off the northeastern USA Shelf. Unpublished meeting document. ICES C.M. 1992/N:12 Copenhagen, Denmark: International Council for the Exploration of the Sea.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. Fisheries Oceanography 2(2):101-105.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley, eds. 2006. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2005. NOAA Technical Memorandum NMFS-NE-194:1-346.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley, eds. 2007. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2006. NOAA Technical Memorandum NMFS-NE-201:1-378.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker. 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. Marine Mammal Science 17(4):703-717.

Wartzok, D. and D.R. Ketten. 1999. Marine mammal sensory systems. Pages 117-175 in Reynolds III, J.E. and S.A. Rommel, eds. Biology of marine mammals. Washington, D.C.: Smithsonian Institution Press.

Wassif, K. 1956. *Pseudorca crassidens* Owen from Mediterranean shores of Egypt. Journal of Mammalogy 37(3):456.

Watkins, W.A. and W.E. Schevill. 1976. Right whale feeding and baleen rattle. Journal of Mammalogy 57:58-66.

Watkins, W.A. and W.E. Schevill. 1977. Sperm whale codas. Journal of the Acoustical Society of America 62(6):1485-1490.

Watkins, W.A. and W.E. Schevill. 1979. Aerial observation of feeding behavior in four baleen whales: *Eubalaena glacialis, Balaenoptera borealis, Megaptera novaeangliae,* and *Balaenoptera physalus*. Journal of Mammalogy 60(1):155-163.

Watkins, W.A. and W.E. Schevill. 1982. Observations of right whales, *Eubalaena glacialis*, in Cape Cod waters. Fishery Bulletin 80(4):875-880.

Watkins, W.A., P. Tyack, K.E. Moore, and G. Notarbartolo-di-Sciara. 1987a. *Steno bredanensis* in the Mediterranean Sea. Marine Mammal Science 3(1):78-82.

Watkins, W.A., P. Tyack, K.E. Moore, and J.E. Bird. 1987b. The 20-Hz signals of finback whales (*Balaenoptera physalus*). Journal of the Acoustical Society of America 82(6):1901-1912.

Watkins, W.A., M.A. Daher, K.M. Fristrup, T.J. Howald, and G. Notarbartolo di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Marine Mammal Science 9(1):55-67.

Watkins, W.A., M.A. Daher, N.A. DiMarzio, A. Samuels, D. Wartzok, K.M. Fristrup, P.W. Howey, and R.R. Maiefski. 2002. Sperm whale dives tracked by radio tag telemetry. Marine Mammal Science 18(1):55-68.

Watts, P. and D.E. Gaskin. 1985. Habitat index analysis of the harbor porpoise (*Phocoena phocoena*) in the southern coastal Bay of Fundy, Canada. Journal of Mammalogy 66:733-744.

Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen, and P.L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales *(Physeter macrocephalus)*. Journal of Animal Ecology 75:814-825.

Wedekin, L.L., A. Freitas, M.H. Engel, and I. Sazima. 2004. Rough-toothed dolphins (*Steno bredanensis*) catch diskfishes while interacting with humpback whales (*Megaptera novaeangliae*) off Abrolhos Bank breeding ground, southwest Atlantic. Aquatic Mammals 30(2):327-329.

Weilgart, L. and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40:277-285.

Weinrich, M. 1995. Humpback whale competitive groups observed on a high-latitude feeding ground. Marine Mammal Science 11(2):251-254.

Weinrich, M. 1998. Early experience in habitat choice by humpback whales (*Megaptera novaeangliae*). Journal of Mammalogy 79(1):163-170.

Weinrich, M., M. Martin, R. Griffiths, J. Bove, and M. Schilling. 1997. A shift in distribution of humpback whales, *Megaptera novaeangliae*, in response to prey in the southern Gulf of Maine. Fishery Bulletin 95(4):826-836.

Weinrich, M.T., M.R. Schilling, and C.R. Belt. 1992. Evidence for acquisition of a novel feeding behaviour: Lobtail feeding in humpback whales, *Megaptera novaeangliae*. Animal Behaviour 44:1059-1072.

Weir, C.R. 2002. Killer Whales (*Orcinus orca*) in UK waters. British Wildlife 14(2):106-108.

Weir, C.R., C. Pollock, C. Cronin, and S. Taylor. 2001. Cetaceans of the Atlantic Frontier, north and west of Scotland. Continental Shelf Research 21:1047-1071.

Weir, C.R., A. Frantzis, P. Alexiadou, and J.C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). Journal of the Marine Biological Association of the United Kingdom 87:39–46.

Weller, D.W., B. Würsig, H. Whitehead, J.C. Norris, S.K. Lynn, R.W. Davis, N. Clauss, and P. Brown. 1996. Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. Marine Mammal Science 12(4):588-594.

Wells, R., C. Mainire, H. Rhinehart, D. Smith, A. Westgate, F. Townsend, T. Rowles, A. Hohn, and L. Hansen. 1999. Ranging patterns of rehabilitated rough-toothed dolphins, *Steno bredanensis*, released in the northeastern Gulf of Mexico. Page 199 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Hawaii.

Wells, R.S. and M.D. Scott. 1999. Bottlenose dolphin--*Tursiops truncatus* (Montagu, 1821). Pages 137-182 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Wells, R.S., M.D. Scott, and A.B. Irvine. 1987. The social structure of free-ranging bottlenose dolphins. Pages 247-305 in Genoways, H.H., ed. Current mammalogy. Volume 1. New York, New York: Plenum Press.

Wells, R.S., L.J. Hansen, A. Baldridge, T.P. Dohl, D.L. Kelly, and R.H. Defran. 1990. Northward extension of the range of bottlenose dolphins along the California coast. Pages 421-431 in Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, California: Academic Press.

Wenzel, F.W., J. Allen, S. Berrow, B. Jann, and R.E. Seton. 2005. Humpback whales (*Megaptera novaeangliae*) of the Cape Verde Islands. Page 301 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Westgate, A.J. and A.J. Read. 1998. Applications of new technology to the conservation of porpoises. Marine Technology Society Journal 32:70-81.

Westgate, A.J., A.J. Read, P. Berggren, H.N. Koopman, and D.E. Gaskin. 1995. Diving behaviour of harbour porpoises, *Phocoena phocoena*. Canadian Journal of Fisheries and Aquatic Sciences 52:1064-1073.

Westgate, A.J., A.J. Read, T.M. Cox, T.D. Schofield, B.R. Whitaker, and K.E. Anderson. 1998. Monitoring a rehabilitated harbor porpoise using satellite telemetry. Marine Mammal Science 14(3):599-604.

Whitehead, H. 1982. Populations of humpback whales in the northwest Atlantic. Reports of the International Whaling Commission 32:345-353.

Whitehead, H. 2003. Sperm whales: Social evolution in the ocean. Chicago, Illinois: University of Chicago Press.

Whitehead, H. and M.J. Moore. 1982. Distribution and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60:2203-2211.

Whitehead, H. and L. Weilgart. 1991. Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. Behaviour 118:276-296.

Whitehead, H. and L. Weilgart. 2000. The sperm whale: Social females and roving males. Pages 154-172 in Mann, J., R.C. Connor, P.L. Tyack, and H. Whitehead, eds. Cetacean societies: Field studies of dolphins and whales. Chicago, Illinois: University of Chicago Press.

Whitehead, H., S. Brennan, and D. Grover. 1992. Distribution and behaviour of male sperm whales on the Scotian Shelf, Canada. Canadian Journal of Zoology 70:912-918.

Willis, P.M. and R.W. Baird. 1998. Status of the dwarf sperm whale, *Kogia simus*, with special reference to Canada. Canadian Field-Naturalist 112(1):114-125.

Wilson, C.E., W.F. Perrin, J.W. Gilpatrick, Jr., and S. Leatherwood. 1987. Summary of worldwide locality records of the striped dolphin, *Stenella coeruleoalba*. NOAA Technical Memorandum NMFS-SWFC-90:1-65.

Wimmer, T. and H. Whitehead. 2004. Movements and distribution of northern bottlenose whales, *Hyperoodon ampullatus*, on the Scotian Slope and in adjacent waters. Canadian Journal of Zoology 82:1782-1794.

Winn, H.E. and P.J. Perkins. 1976. Distribution and sounds of the minke whale, with a review of mysticete sounds. Cetology 19:1-12.

Winn, H.E., P.J. Perkins, and L. Winn. 1970. Sounds and behavior of the northern bottle-nosed whale. Pages 53-59 in Proceedings of the Seventh Annual Conference on Biological Sonar and Diving Mammals. 23-24 October 1970. Menlo Park, California.

Winn, H.E., C.A. Price, and P.W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Reports of the International Whaling Commission (Special Issue 10):129-138.

Winn, H.E., J.D. Goodyear, R.D. Kenney, and R.O. Petricig. 1995. Dive patterns of tagged right whales in the Great South Channel. Continental Shelf Research 15:593-611.

Wishner, K., E. Durbin, A. Durbin, M. Macaulay, H. Winn, and R. Kenney. 1988. Copepod patches and right whales in the Great South Channel off New England. Bulletin of Marine Science 43(3):825-844.

Woodley, T.H. and D.E. Gaskin. 1996. Environmental characteristics of North Atlantic right and fin whale habitat in the lower Bay of Fundy, Canada. Canadian Journal of Zoology 74:75-84.

Woodside, J.M., L. David, A. Frantzis, and S.K. Hooker. 2006. Gouge marks on deep-sea mud volcanoes in the eastern Mediterranean: Caused by Cuvier's beaked whales? Deep Sea Research I 53:1762-1771.

Wormuth, J.H., P.H. Ressler, R.B. Cady, and E.J. Harris. 2000. Zooplankton and micronekton in cyclones and anticyclones in the northeast Gulf of Mexico. Gulf of Mexico Science 2000(1):23-34.

Würsig, B. and M. Würsig. 1977. The photographic determination of group size, composition, and stability of coastal porpoises (*Tursiops truncatus*). Science 198:755-756.

Würsig, B. and T.A. Jefferson. 1990. Methods of photo-identification for small cetaceans. Reports of the International Whaling Commission (Special Issue 12):43-52.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24(1):41-50.

Würtz, M. and D. Marrale. 1993. Food of striped dolphin, *Stenella coeruleoalba*, in the Ligurian Sea. Journal of the Marine Biological Association of the United Kingdom 73:571-578.

Würtz, M., R. Poggi, and M.R. Clarke. 1992. Cephalopods from the stomachs of a Risso's dolphin (*Grampus griseus*) from the Mediterranean. Journal of the Marine Biological Association of the United Kingdom 72:861-867.

Young, D.D. and V.G. Cockcroft. 1994. Diet of common dolphins (*Delphinus delphis*) off the south-east coast of southern Africa: Opportunism or specialization? Journal of Zoology, London 234:41-53.

Yu, H.-y., H.-K. Mok, R.-C. Wei, and L.-S. Chou. 2003. Vocalizations of a rehabilitated rough-toothed dolphin, *Steno bredanensis*. Page 183 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14-19 December 2003. Greensboro, North Carolina.

Yuen, M.M.L., P.E. Nachtigall, M. Breese, and A.Y. Supin. 2005. Behavioral and auditory evoked potential audiograms of a false killer whale (*Pseudorca crassidens*). Journal of the Acoustical Society of America 118(4):2688-2695.

Yurk, H., L. Barrett-Lennard, J.K.B. Ford, and C.O. Matkin. 2002. Cultural transmission within maternal lineages: Vocal clans in resident killer whales in southern Alaska. Animal Behaviour 63:1103-1119.

Zanardelli, M., G. Notarbartolo di Sciara, and G. Pavan. 1990. Underwater acoustic signals by the striped dolphin *Stenella coeruleoalba*. European Research on Cetaceans 4:69.

Zanardelli, M., G. Notarbartolo-di-Sciara, and M. Acquarone. 1992. Cetacean sighting reports by amateurs: A two-sided coin. European Research on Cetaceans 6:79-82.

Zaretsky, S.C., A. Martinez, L.P. Garrison, and E.O. Keith. 2005. Differences in acoustic signals from marine mammals in the western North Atlantic and northern Gulf of Mexico. Page 314 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Zhou, K., Q. Weijuan, and L. Yuemin. 1982. *Pseudorca crassidens* (Owen) from the coastal waters of China. Investigations on Cetacea 13:263-269.

Zimmer, W.M.X., M.P. Johnson, A. D'Amico, and P.L. Tyack. 2003. Combining data from a multisensor tag and passive sonar to determine the diving behavior of a sperm whale (*Physeter macrocephalus*). IEEE Journal of Oceanic Engineering 28(1):13-28.

Zimmer, W.M.X., M.P. Johnson, P.T. Madsen, and P.L. Tyack. 2005. Echolocation clicks of free-ranging Cuvier's beaked whales (*Ziphius cavirostris*). Journal of the Acoustical Society of America 117(6):3919-3927.

3.2 SEA TURTLES

Sea turtles are long-lived reptiles found throughout the world's tropical, sub-tropical, and temperate seas. There are seven living species of sea turtles from two distinct families, the Cheloniidae (hard-shelled sea turtles) and the Dermochelyidae (leatherback sea turtle, *Dermochelys coriacea*). Sea turtles in these two families are distinguished from one another based upon their carapace structure. The black sea turtle (*Chelonia agassizii*), is occasionally recognized as an eighth species, yet DNA and morphological studies suggest that they are more accurately classified as a subspecies of green turtle (*Chelonia mydas*) (Karl and Bowen 1999).

3.2.1 Introduction

Sea turtles are highly adapted for life in the marine environment. Unlike terrestrial and freshwater turtles, they possess powerful, modified forelimbs (flippers) that enable them to swim continuously for extended periods of time (Wyneken 1997). A compact and streamlined body plan reduces drag while underwater. Additionally, sea turtles have evolved physiological traits and behavioral patterns allowing them to spend as little as 3 to 6% of their time at the water's surface, as well as permitting highly efficient foraging and traveling (Lutcavage and Lutz 1997). Sea turtles often travel thousands of miles between their nesting beaches, mating areas, nursery habitats, developmental habitats, and adult feeding grounds (Meylan 1995); these migratory activities would not be possible without the aforementioned suite of adaptations. Sea turtle physical traits and behaviors also provide protection from predators. Sea turtles have a tough outer shell and grow to a large size as adults; mature leatherback turtles can weigh up to 916 kg (Eckert and Luginbuhl 1988). Sea turtles cannot withdraw their head or limbs into their shell, so growing to a large size as adults is important. As juveniles, some species of sea turtles evade predation by residing in habitats that are either structurally complex or moderately shallow. This prohibits marine predators such as sharks, marine crocodiles, and large fishes from easy access (Musick and Limpus 1997).

For additional information on the biology, life history, and conservation of sea turtles, the following websites are extremely useful: seaturtle.org (http://www.seaturtle.org), NOAA Fisheries-Office of Protected Resources (http://www.nmfs.noaa.gov/pr/species/turtles/), MTSG (http://www.iucn-mtsg.org/), MEDASSET (http:// www.medasset.org/medas.htm), and the Caribbean Conservation Corporation (CCC; http://www.cccturtle.org). Other important resources include Proceedings from the Annual Symposia on Sea Turtle Biology and Conservation (http://www.nmfs.noaa.gov/pr/species/turtles/symposia.htm), Bjorndal (1995), Lutz and Musick (1997); Bolten and Witherington (2003), and Lutz et al. (2003).

3.2.2 Sea Turtle Life History

Although specialized for life at sea, sea turtles begin their lives on land. Their brief terrestrial period lasts approximately three months as eggs and an additional few minutes to a few hours as hatchlings scrambling to the surf. Aside from this time, sea turtles are rarely encountered out of the water, and return to land primarily to nest or if injured, although certain species in Hawaii return in order to bask (Spotila et al. 1997). These activities are infrequent yet vital to the continued existence of a sea turtle (Musick and Limpus 1997). Although basking sea turtles are predominantly females, males may bask as well (Balazs 1980). Basking may aid in thermoregulation as well as evasion from predators (Balazs 1980; Whittow and Balazs 1982; Spotila et al. 1997). Females may be more commonly observed basking on land than males due to attempts to avoid harmful mating encounters and, potentially, to accelerate the development of their eggs (Spotila et al. 1997).

Sea turtles nest in tropical, subtropical, and warm-temperate latitudes, often in the same region where they were born (Miller 1997). Upon selecting a suitable nesting beach, female sea turtles tend to re-nest in relatively close proximity during subsequent nesting attempts. Some sea turtles, however, fail to nest when emerging from the ocean. Non-nesting emergences, also known as false crawls, occur when sea turtles are either obstructed from laying their eggs (by debris, rocks, or roots) or distracted by conditions on the nesting beach (such as noise, lighting, or human presence). Female sea turtles that are successful at nesting usually lay several clutches of eggs during a nesting season, with each clutch containing between 50 and 200 eggs depending upon the species (Witzell 1983; Dodd 1988; Hirth 1997). Most

females, with the possible exception of Kemp's ridleys (*Lepidochelys kempii*), do not nest in consecutive years; instead they will often skip two or three years before returning (Marquez-M. 1994; Ehrhart 1995). Nesting success is vital to the long-term existence of sea turtles, as roughly only one in every 1,000 sea turtle hatchlings survives long enough to reproduce (Frazer 1986).

During the nesting season, daytime temperatures on tropical, subtropical, and warm-temperate beaches can be lethal. As a result, nesting by adult sea turtles and hatchlings emerging from their nests often takes place at night (Miller 1997). After emerging from the nest, sea turtle hatchlings use visual cues (e.g., light intensity or certain wavelengths of light) to orient themselves towards the sea (Lohmann et al. 1997). Hatchlings have a strong tendency to crawl in the direction of the brightest light, which on most beaches is towards the ocean/sky horizon (Witherington and Martin 2003). Some hatchlings, however, never make it into the water. On the beach, sea turtle hatchlings are easy prey for seabirds during the day, and scavenging crabs and mammals at night (Ehrhart 1995; Miller 1997). Hatchlings can also become disoriented if artificial beachfront lighting appears brighter than the seaward horizon (Lutcavage et al. 1997; Witherington and Martin 2003).

3.2.3 Sea Turtle Distribution and Behavior

Hatchlings spend the first few years of their lives in oceanic waters, drifting in convergence zones and *Sargassum* rafts where they find refuge and food (pelagic invertebrates and other items that accumulate in surface circulation features) (Carr 1987b; Witherington 2007). Upon leaving the nesting beach, hatchlings are immediately picked up by the nearest major current, transporting them to a system in which they are carried around the ocean basin (Carr 1987b). Originally labeled the "lost year," this stage in a sea turtle's life history is now known to be much longer in duration, possibly lasting a decade or more (Bjorndal et al. 2000). Available evidence now indicates that this lost year involves at least several years of drifting in oceanic gyre systems in a passive migration that may circumnavigate entire ocean basins (Bowen et al. 1995; Bolten et al. 1998; Lahanas et al. 1998). Recent tagging work has demonstrated that young turtles are not passive drifters in major ocean currents, but are able to move all directions through energetic and complex habitat (e.g., Bolten 2003b; Polovina et al. 2006). Post-hatchling sea turtles spend nearly a decade growing in the pelagic "early juvenile nursery habitat" before migrating to neritic feeding grounds, which are known as the "later juvenile developmental habitats" (Musick and Limpus 1997). Later juvenile developmental habitat for hard-shelled sea turtles is commonly shallow nearshore and inshore waters. Depending upon the season, leatherback turtles use coastal feeding areas in temperate waters or offshore feeding areas in tropical waters as later developmental habitat (Frazier 2001).

Once in the later juvenile developmental habitat, sea turtles may modify their foraging behavior from surface feeding to benthic feeding, beginning to prey upon larger items such as crustaceans, mollusks, sponges, coelenterates, fishes, and seagrasses (Bjorndal 1997). An exception is the leatherback turtle, which will feed on pelagic soft-bodied invertebrates at the surface and at great depths (S.A. Eckert et al. 1989). Although sea turtles do not have teeth, their jaws have modified "beaks" suited to their particular diet (Mortimer 1995). The diet exhibited by a sea turtle varies according to the habitat in which it feeds and its preferred prey. Sea turtles possess a specialized digestive system so that a diverse array of food items can be consumed (Mortimer 1995).

Sea turtle diving behavior has been mostly studied during the internesting interval (time period between successive egg-layings). Post-nesting diving activity likely differs from that recorded during the internesting periods since diving behavior (depending on species) can display spatial and temporal variations, being influenced by environmental factors such as water temperature or local availability and vertical distribution of food resources. As a result, diving behavior can be expected to show a high degree of variation for and across individuals. Few satellite tags have been placed on male sea turtles.

Sea turtles undergo complex seasonal movements, influenced by changes in ocean currents, turbidity, salinity, and food availability (e.g., Musick and Limpus 1997). Oceanographic currents and gyres are particularly influential to juvenile sea turtles (e.g., Luschi et al. 2003). In addition, the distribution of many sea turtle species is often dependent upon water temperature (Epperly et al. 1995; Davenport 1997; Coles and Musick 2000). Most sea turtles become lethargic at temperatures below 10°C and above 40°C

(Spotila et al. 1997), and may even become cold-stunned in extremely cold waters when rapid temperature drops occur. One strategy to avoid cold water temperatures is for animals to migrate to warmer waters; this has been observed for turtles in the northeastern U.S. (Musick and Limpus 1997). Alternatively, in some locales (such as the Mediterranean Sea and off Florida), some individual green and loggerhead turtles escape cold conditions by resting on the seabed or burying themselves in the bottom sediment and brumating or hibernating (Ogren and McVea 1982; Hochscheid et al. 2005), conducting very long dives, sometimes more than 5 hrs in duration (Hochscheid et al. 2005). The preferred temperature ranges of sea turtles vary across age classes and species as well as seasons. The leatherback turtle has a wider range of preferred water temperatures than other species due to its ability to maintain a warm body temperature in temperate waters and avoid overheating in tropical waters (Spotila et al. 1997; Southwood et al. 2005; Wallace et al. 2005). Leatherback turtles can remain active even in very cold water, down to at least 0.4°C (M.C. James et al. 2006).

Climatic fluctuations have produced a growing concern about the effects of climate change on various marine species, including sea turtles. Responses of sea turtles to climate change are difficult to interpret due to the confounding effects of natural responses and human influences. Additionally, the time scale on which sea turtles respond to direct or indirect effects of climate change may be diluted or muted. Global warming will likely increase the foraging range of leatherback turtles further into temperate and boreal waters as isotherms shift (M.C. James et al. 2006; McMahon and Hays 2006). Large-scale climatic events may affect turtles by loss of nesting beaches as sea levels rise (Vagg and Hepworth 2006). Nesting biology of sea turtles is strongly affected by temperature, both in timing and in the sex-ratio of hatchlings; the effects of climate change may upset the natural ratio of male to female hatchlings, as higher temperatures during incubation tend to produce more females (e.g., Hays et al. 2003; Hawkes et al. 2007). Earlier nesting and longer nesting seasons are being correlated with warmer sea surface temperatures (e.g., Weishampel et al. 2004; Hawkes et al. 2007).

3.2.4 Sea Turtle Sensory Adaptations

Although sea turtles are nearsighted out of water, their vision underwater is very good (Bartol et al. 2002). For turtles, odors might be important for locating feeding sites and nesting beaches and in social/mating interactions (Lohmann et al. 1999; Vogt et al. 2002). Sea turtle hearing sensitivity, in air and underwater, is not well-studied. Reception of sound is through bone conduction, with the skull and shell acting as receiving structures (Lenhardt et al. 1983). Sea turtles appear to be low-frequency specialists (Moein Bartol and Ketten 2006). Typically, sea turtles hear frequencies from 30 to 2,000 Hz and have a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994). Moein Bartol et al. (1999) reported that juvenile loggerhead turtles hear sounds between 250 (lowest frequency that could be tested due to equipment) and 1,000 Hz (most sensitive at 250 Hz) using the ABR technique, while Lenhardt (2002) found that adults can hear sounds from 30 to 1,000 Hz (most sensitive at 400 to 500 Hz) using startle response (i.e., contract neck or dive) and ABR techniques. Ridgway et al. (1969) reported that juvenile green turtles can hear sounds ranging from 60 to 1,000 Hz and are most sensitive to airborne sounds ranging from 300 to 400 Hz. Analysis of recently acquired ABR data revealed that subadult green turtles detect frequencies between 100 and 800 Hz; their most sensitive hearing is between 200 and 700 Hz (Moein Bartol and Ketten 2006). Two juvenile Kemp's ridley also recently tested had a more restricted range at 100 to 500 Hz with their most sensitive hearing between 100 and 200 Hz (Moein Bartol and Ketten 2006).

Adult loggerheads have also been observed to initially respond (i.e., increase swimming speeds) and avoid air guns when received levels range from 151 to 175 decibels at the reference level of one micropascal (dB re: 1 μPa), but they eventually habituate to these sounds (Lenhardt 2002). Though, one turtle in study did exhibit TTS for up to two weeks after exposure to these levels (Lenhardt 2002). Juveniles also have been found to avoid low-frequency sound (less than 1,000 Hz) produced by airguns (O'Hara and Wilcox 1990). In a separate study, green and loggerhead sea turtles exposed to seismic air guns displayed an increase in swimming activity and made more changes in swimming direction when received levels reached 155 dB re: 1 $\mu Pa^2 s$ for green turtles and 166 dB re: 1 $\mu Pa^2 s$ for loggerhead turtles (McCauley et al. 2000).

Though, auditory data has never been collected for the leatherback turtle, there is an anecdotal observation of this species responding to the sound of a boat motor (ARPA 1995). It is unclear what frequencies of the sound this species was detecting. In terms of sound production, nesting leatherback turtles have been recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Mrosovsky 1972; Cook and Forrest 2005).

3.2.5 Sea Turtles of the Mediterranean Sea

Among the five sea turtle species known to occur in the Mediterranean Sea, only the loggerhead, the green, and leatherback occur regularly in the Study Area (**Table 3-2**). The loggerhead and green are the two most commonly encountered species; they are also the only two that nest regularly on the beaches of the Mediterranean Sea. The loggerhead is the most common and most widely distributed of the two (e.g., Broderick et al. 2002). Nesting by both the green and loggerhead turtles is confined almost exclusively to the easternmost portion of the Mediterranean Sea (Margaritoulis 2003).

Loggerhead turtles are found throughout the entire Mediterranean region. Loggerheads here are primarily of Mediterranean origin; there are significant nesting sites in Greece, Libya, Turkey, and Cyprus (WWF 2005). Large numbers of loggerheads occur in the western Mediterranean Sea. Individuals from the Atlantic Ocean do make their way in through the Strait of Gibraltar to mix with Mediterranean stocks in the western Mediterranean Sea. The green turtle is almost exclusive to the eastern Mediterranean Sea. Its major nesting sites are in Turkey, Cyprus, and Syria and the most important feeding areas for the species are between Turkey and Egypt (WWF 2005).

The WWF (2005) ranked the three turtle species with expected occurrence in the Mediterranean Sea by priority of conservation concern as: (1) green turtle (2) loggerhead turtle, and (3) leatherback turtle; this was based on the fact that the the Mediterranean population of the green turtle is particularly small, geographically restricted, and reproductively isolated.

Various areas throughout both the eastern and western Mediterranean seas serve as neritic and oceanic habitats for the loggerhead and green turtle. Two major areas are the Gulf of Gabes and the northern Adriatic Sea (Gerosa and Casale 1999; Margaritoulis 2003). Both the loggerhead and green turtle utilize areas off the Mediterranean African coast of Egypt; additionally, the Gulf of Gabes (Tunisia) and the coast of Libya are important habitat for the loggerhead turtle. The Gulf of Iskenderun (Turkey) and nearby nearshore waters are identified as important habitat for the loggerhead and the green turtle, as well as parts of the Adriatic Sea. The Turkish coast of the Aegean Sea is also considered important habitat for the green turtle, as well as Lakonikos Bay in Greece. The Ionian and Alboran seas are known vital habitat for the loggerhead turtle, and the neritic environment at Cyprus is important to both loggerhead and green turtles (Godley and Broderick 1995; Hochscheid et al. 1999; Houghton et al. 2002).

The distribution of all available sea turtle occurrence records in the Mediterranean Sea and by season (fall/winter: October through February; spring/summer: March through September) is presented in **Appendix C**, **Figures 1-6**. A listing and description of the data sources used as an aid in determining each species' occurrence is found in **Appendix A-3**, while the process used to create the map figures is described in **Chapter 1**. On the map figures, various types of shading and terminology designate the occurrence of sea turtles in the Study Area. "Area of primary occurrence" (area shaded in dark blue) is defined as the areas and habitats where the species is primarily found. "Area of secondary occurrence" (area shaded in medium blue) is the areas and habitats where the species may be found, especially during "anomalous" environmental conditions. "Area of rare occurrence" (light blue area) is the areas and habitats where the species is not expected to be found regularly. As noted in **Chapter 1**, a conservative approach was taken to delineate areas of occurrence for threatened and endangered marine mammals (since these species have low numbers/densities). Consideration is still primarily based upon the available occurrence data for the Study Area, the species' known habitat preferences, and regional expert opinion.

Table 3-2. Sea turtle species of the Mediterranean Study Area. Taxonomy follows Pritchard (1997). Occurrence is presented for both the western and eastern Mediterranean seas. [Regular = A species that occurs as a regular or normal part of the fauna of the area, regardless of how abundant or common it is; Rare = A species that only occurs in the area sporadically; Extralimital = A species that does not normally occur in the area, but for which there are one or more records that are considered beyond the normal range of the species]

	Scientific Name	ESA Status	IUCN Status	Occurrence	
				Western	Eastern
Order Testudines (turtles): Suborder Cryptodira (hidden-necked turtles)					
Family Cheloniidae (hard-shelled sea turtles)					
Green turtle	*Chelonia mydas*	Threatened	Endangered	Rare	Regular
Loggerhead turtle	*Caretta caretta*	Threatened	Endangered	Regular	Regular
Hawksbill turtle	*Eretmochelys imbricata*	Endangered	Critically endangered	Extralimital	Extralimital
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered	Critically endangered	Extralimital	Extralimital
Family Dermochelyidae (leatherback sea turtle)					
Leatherback turtle	*Dermochelys coriacea*	Endangered	Critically endangered	Rare	Rare

Each sea turtle species is listed below, following the taxonomic order as presented in **Table 3-2**, with its description, status, habitat preference, distribution (including occurrence in the Mediterranean Study Area), and behavior and life history information. **Figure C-1** is a combined map of all sea turtles (including unidentified sea turtles) since all sea turtles are listed as threatened or endangered.

- Information Specific to the Mediterranean Study Area—Sea turtles have a primary occurrence throughout the Study Area year-round due to the presence shallow water benthic habitats utilized by juvenile and adult loggerhead sea turtles and the preference of deepwater oceanic habitats by most leatherback sea turtles and juvenile loggerheads (**Figure C-1**). Occurrence is based primarily on the loggerhead turtle, which is the most abundant sea turtle species in the area.

- **Leatherback Turtle (*Dermochelys coriacea*)**

Description—The leatherback, the single representative of the family Dermochelyidae, is the largest turtle and the largest living reptile in the world. This species is placed in a separate family from all other sea turtles, in part because of its unique carapace structure; this is the only sea turtle species that lacks a hard, bony shell. The carapace is composed of a flexible layer of dermal bones underlying tough, oily connective tissue and smooth skin. The body of a leatherback is barrel-shaped and tapered to the rear, with seven longitudinal dorsal ridges, and is almost completely black with variable spotting (Gulko and Eckert 2004). All adults possess a pink spot on the dorsal surface of their head, a marking that has been used by scientists to identify specific individuals (McDonald and Dutton 1996). The front flippers lack claws and scales and are proportionally longer than those in other sea turtles; back flippers are paddle-shaped. The ridged carapace and large flippers are characteristics that make the leatherback uniquely equipped for long distance foraging migrations. Mature males and females can be as long as 2 m curved carapace length (CCL) (NMFS and USFWS 1998a; P. Casale et al. 2003). Specimens less than 145 cm CCL are considered to be juveniles (NMFS-SEFSC 2001; Eckert 2002). Adult leatherbacks weigh between 200 and 700 kg (NMFS and USFWS 1992), although larger individuals are documented (Eckert and Luginbuhl 1988).

Status—Leatherback turtles are listed as endangered under the ESA and critically endangered by the IUCN (NMFS and USFWS 1992).1 The species qualifies as data deficient at the Mediterranean

regional level (Casale 2006). Critical habitat for leatherbacks is designated in the Caribbean Sea at Sandy Point, St. Croix, U.S. Virgin Islands (USVI) (NMFS 1979).

The most recent (1995) estimate of the worldwide leatherback population was 34,500 nesting females (ranging from 26,200 to 42,900) (Spotila et al. 1996). No attempts have been made to assess the status of foraging populations. Known genetic stocks for leatherbacks world-wide are outlined by Dutton (2007). Leatherbacks found in the Mediterranean Sea are considered to originate from the Atlantic Ocean (Margaritoulis 1986; P. Casale et al. 2003; Casale 2006). Genetic data are unresolved to provide the specific nesting beach origins (Casale 2006). It is unlikely that leatherbacks from the African nesting colonies in Gabon (West African stock) are found in the the Mediterranean Sea, since they forage off Brazil, Uruguay and Argentina (Eckert, S., Wider Caribbean Sea Turtle Conservation Network, pers. comm., 8 February 2007). This suggests instead that individuals found in the Mediterranean Sea are probably from western Atlantic stocks (Eckert, S., Wider Caribbean Sea Turtle Conservation Network, pers. comm., 8 February 2007).

Habitat Preferences—Throughout their lives, leatherbacks are essentially oceanic, yet they enter into coastal waters for foraging and reproduction. There is limited information available regarding the habitats utilized by post-hatchling and early juvenile leatherbacks as these age classes are entirely oceanic (NMFS and USFWS 1992). These life stages are restricted to waters greater than 26°C and, therefore, spend much time in tropical waters (Eckert 2002). They are not considered to associate with *Sargassum* or other flotsam, as is the case for all other sea turtles species in the North Atlantic Ocean (NMFS and USFWS 1992). Upwelling areas, such as the Equatorial Convergence Zones, serve as nursery grounds for post-hatchling and early juvenile leatherbacks; these areas also provide a high biomass of gelatinous prey (Musick and Limpus 1997).

Late juvenile and adult leatherback turtles are known to range from mid-ocean to the continental shelf and nearshore waters (Schroeder and Thompson 1987; Shoop and Kenney 1992; Grant and Ferrell 1993). Juvenile and adult foraging habitats include both coastal feeding areas in temperate waters and offshore feeding areas in tropical waters (Frazier 2001). The movements of adult leatherbacks appear to be linked to the seasonal availability of their prey and the requirements of their reproductive cycle (Collard 1990; Davenport and Balazs 1991). Leatherbacks commonly nest on wide sandy beaches which are inclined and backed with vegetation (Eckert 1987; Hirth and Ogren 1987).

Distribution—The leatherback turtle is distributed circumglobally in tropical, subtropical, and warm-temperate waters throughout the year and into cooler temperate waters during warmer months (NMFS and USFWS 1992; James et al. 2005b) as far north as Nova Scotia, Newfoundland, Labrador, Iceland, the British Isles, and Norway (Bleakney 1965; Brongersma 1972; Threlfall 1978; Goff and Lien 1988). The leatherback is the most oceanic and wide-ranging of sea turtles, undertaking extensive migrations along distinct depth contours for hundreds to thousands of kilometers (Morreale et al. 1996; Hughes et al. 1998). Adult leatherback turtles forage in temperate and subpolar regions in all oceans and migrate to tropical nesting beaches between 30°N and 20°S. Trans-Atlantic movements have been reported (Thompson et al. 2001; Ferraroli et al. 2004; Hays et al. 2004b; Billes et al. 2006; Hays et al. 2006). Only adults and large juveniles are found in the Mediterranean Sea (P. Casale et al. 2003); small juveniles are restricted to tropical waters (Eckert 2002).

Leatherback nesting occurs on isolated mainland beaches in tropical (mainly Atlantic and Pacific oceans, few in the Indian Ocean) and temperate oceans (southwest Indian Ocean) (NMFS and USFWS 1992) and to a lesser degree on some islands, such as the Greater and Lesser Antilles. Female leatherbacks nest from the southeastern U.S. to southern Brazil in the western Atlantic Ocean and from Mauritania to Angola in the eastern Atlantic Ocean (Sternberg 1981; Spotila et al. 1996). The most significant nesting beaches in the Atlantic Ocean, and the world, are in French Guiana and Suriname in the western Atlantic Ocean and Gabon in the eastern Atlantic Ocean (Spotila et al. 1996; The SWOT Team 2007a). Among the Caribbean Islands, leatherbacks regularly nest on Dominican Republic, Puerto Rico and the accompanying islands of Culebra and Vieques, St. Croix in the USVI, Trinidad, and Tobago (Sternberg 1981; Spotila et al. 1996; The SWOT Team 2007a). As noted earlier, individuals found in the Mediterranean Sea are most likely from western

Atlantic stocks (Eckert, S., Wider Caribbean Sea Turtle Conservation Network, pers. comm., 8 February 2007). Evans et al. (2007) recently reported on a tagged leatherback that crossed the Atlantic Ocean from a nesting beach in Central America to north of the Azores. As noted by the Turtle Expert Working Group (TEWG) (2007) there are no reports of tagged leatherbacks from the western North Atlantic assemblages entering the Mediterranean Sea, though this probably due more to a lack of data than actual movement patterns.

- Information Specific to the Mediterranean Study Area—The leatherback turtle is present year-round in the Mediterranean Sea (P. Casale et al. 2003). Leatherback turtles have been noted in almost every area within the Mediterranean region (Casale 2006), though available data suggests that the species frequents the western Mediterranean Sea more. Casale et al. (2003); however, note that there is no strong evidence of a west-east gradient in the Mediterranean Sea. Primary occurrence is in waters seaward of the 100 m isobath (**Figure C-2**); this takes into account the known preference of this species for deep waters. Waters inshore of the 100 m isobath are an area of rare occurrence for the leatherback based on available occurrence data and the fact that this species is not expected here in shallower waters since there are very rare reports of leatherback nesting in the Mediterranean region. Leatherbacks might concentrate in particular areas, the Tyrhenian and Aegean seas (P. Casale et al. 2003; Casale 2006).

  Most observations are of isolated individuals (e.g., Margaritoulis 1986; Camiñas 1998; Taşkavak and Farkas 1998; P. Casale et al. 2003). These are most likely to be large juveniles and adults of both sexes (P. Casale et al. 2003; Camiñas 2004b). The rare fishery bycatches reported for this species for the Mediterranean Sea (Casale 2006) suggest that the density of this species is very low in this region.

  There are no nesting sites for this species in the Mediterranean region (WWF 2005).

Behavior and Life History—The wide distribution of leatherbacks is likely due to their highly evolved thermoregulatory capabilities. Adult leatherbacks possess the ability to maintain an elevated internal body temperature well above ambient water temperature (Frair et al. 1972; James and Mrosovsky 2004). For example, a leatherback caught off Nova Scotia in water that was 7.5°C had a body temperature of 25.5°C (Frair et al. 1972). As juveniles grow in size, it is expected that this ability is enhanced, allowing leatherbacks to expand their ranges into the cooler waters that are considered their primary habitat (Eckert 2002). A variety of studies have shown that leatherbacks have a range of anatomical and physiological adaptations that enable them to regulate internal body temperatures (Mrosovsky and Pritchard 1971; Greer et al. 1973; Neill and Stevens 1974; Paladino et al. 1990; Bradshaw et al. 2007). The high oil content of leatherback flesh may also aid thermoregulatory functions by slowing the process of heat loss from the body (Goff and Stenson 1988).

Mating is thought to occur prior to or during the migration from temperate to tropical waters (Eckert and Eckert 1988). Nesting season in the Atlantic Ocean and Caribbean Sea may extend from early March to October, with low-level nesting occurring throughout the rest of the year, depending on the exact locale. Typical clutches are 50 to over 150 eggs, with the incubation period lasting around 65 days. Females lay an average of 5 to 7 clutches in a single season (with a maximum of 11) at 8- to 10-day intervals or longer (NMFS and USFWS 1992). Females remain in the general vicinity of the nesting habitat during internesting intervals, with total residence in the nesting/inter-nesting habitat lasting up to four months (K.L. Eckert et al. 1989; Keinath and Musick 1993). The species shows only moderate philopatry, more to a region than to a specific beach. For example, they may nest on several islands in an archipelago during the course of a single nesting season (Pritchard 1982); however, Boulon et al. (1996) have claimed that most adult females return to nest on their natal beach every 2 to 3 yrs. Remigration intervals between 1 and 5 yrs have been recorded (Boulon et al. 1996).

Leatherbacks feed throughout the epipelagic and into the mesopelagic zones of the water column (Eisenberg and Frazier 1983; Davenport 1988; S.A. Eckert et al. 1989; Grant and Ferrell 1993; Salmon et al. 2004; James et al. 2005a). Prey is predominantly gelatinous zooplankton such as

cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas) (NMFS and USFWS 1992; Grant and Ferrell 1993; Bjorndal 1997; James and Herman 2001; Salmon et al. 2004). There is very limited data on the diet of the leatherback when it is in the Mediterranean Sea; stomach content analyses have revealed cephalopods such as umbrella squid (Histioteuthis bonnellii), tunicates (e.g., Pyrosoma atlanticum), and benthic organisms (e.g., Neptune grass Posidonia oceanica) (e.g., Travaglini et al. 2006). Diel patterns in dive behavior off St. Croix (at night, more time was spent diving and dives tended to be shallow, while, during the day, less time was spent diving but dives tended to be deeper), suggest an interaction between leatherback diving and vertical movements of the DSL, but the details of this interaction remain unclear (S.A. Eckert et al. 1989). It also is not known whether this is a widespread phenomenon.

Eighty percent of the leatherback's time at sea is spent diving (e.g., Fossette et al. 2007). The leatherback is the deepest diving sea turtle with a recorded maximum depth of 1,230 m (Hays et al. 2004a), though most dives are much shallower than this (usually <200 m) (e.g., Hays et al. 2004a; Sale et al. 2006). Leatherbacks spend the majority of their time in the upper 65 m of the water column regardless of their behavior (Jonsen et al. 2007). The aerobic dive limit for the leatherback turtle is estimated between 33 and 67 min (e.g., Southwood et al. 1999; Hays et al. 2004c; Wallace et al. 2005). Tagging data has revealed that changes in individual turtle diving activity appear to be related to water temperature, suggesting an influence of seasonal prey availability on their diving behavior (e.g., Hays et al. 2004c).

Leatherbacks dive deeper and longer in the lower latitudes versus the higher (south versus the north) (James et al. 2005a). In northern waters, they are also known to dive to waters with temperatures just above freezing (M.C. James et al. 2006; Jonsen et al. 2007). James et al. (2006) noted that there is considerable variability in surface time both within and among leatherbacks. Dives in the north are punctuated by longer surface intervals (equating to much more time spent at the surface per 24-hr period), with individuals spending up to 50% of their time at or near the surface in northern foraging areas, perhaps in part to thermoregulate (i.e., bask). There is no information available regarding leatherback turtle diving behavior in the Mediterranean Sea.

Leatherback diving behavior has been mostly studied during the internesting interval when turtles are at their tropical and sub-tropical nesting areas. Diving activity (including surface time) is influenced by a suite of environmental factors (water temperature or local availability and vertical distribution of food resources) that result in spatial and temporal variations in dive behavior (e.g., M. C. James et al. 2006; Sale et al. 2006). Dives are probably constrained by bathymetry adjacent to nesting sites during this time (Myers and Hays 2006). For example, in areas where deep waters are close to shore, patterns of relatively deep diving are recorded off St. Croix in the Caribbean Sea (Eckert et al. 1986) and Grenada (Myers and Hays 2006). A maximum depth of 475 m was recorded by Eckert et al. (1986); even deeper dives have been inferred when some dives were deeper than the maximum range of the time depth recorder tag (S.A. Eckert et al. 1989). Where shallow water is close to the nesting beach, shallow diving occurs in the China Sea (Eckert et al. 1996), Costa Rica (Southwood et al. 1999), and French Guiana (Fossette et al. 2007). Sale et al. (2006) reported post-nesting dives were typically shorter than 8 min, with maximum durations of up to 82 min off South Africa.

While transiting, leatherbacks make longer, deeper dives (e.g., Jonsen et al. 2007). It is suggested that leatherbacks make scouting dives while transitting as an efficient means for sampling prey density and perhaps also feed opportunistically at these times (e.g., M. C. James et al. 2006; Jonsen et al. 2007).

- **Loggerhead Turtle (*Caretta caretta*)**

Description—The loggerhead turtle is a large hard-shelled sea turtle that is named for its disproportionately large head. Adult loggerheads usually possess a reddish-brown carapace with scutes and yellowish underneath (NMFS and USFWS 1998b). The average straight carapace length (SCL) of an adult female loggerhead is between 90 and 95 cm and the average weight is 100 to 150 kg (Dodd 1988; NMFS and USFWS 1998b). Nesting loggerheads in the Mediterranean Sea are

significantly smaller that those in other parts of the world (Margaritoulis 1982; Broderick and Godley 1996; Margaritoulis 1998); nesting females here vary from 50.0 to 83.8 cm (Margaritoulis et al. 2003).

Status—Loggerhead turtles are listed as threatened under the ESA and endangered under the IUCN (NMFS and USFWS 1998b).[1] The loggerhead turtle is the most abundant species in Mediterranean waters (Margaritoulis et al. 2003). Broderick et al. (2002) estimate that 2,280 to 2,787 loggerheads nest annually in the Mediterranean Sea, while Margaritoulis et al. (2003) calculated a total nesting effort for the loggerhead as 3,375 to 7,085 nests per season (Margaritoulis et al. 2003).

Studies have shown that although loggerheads nesting in Greece and Cyprus share common haplotypes with those nesting in the western Atlantic Ocean, they seem to have diverged genetically as a result of reduced gene flow (Bowen et al. 1993; Laurent et al. 1998). This genetic isolation is more prominent in the case of colonies nesting in Turkey (Laurent et al. 1998). Mitochondrial DNA analyses have identified demographically independent nesting colonies in the Mediterranean Sea (e.g., Encalada et al. 1998; Carreras et al. 2006a). There are at least four independent units within the eastern Mediterranean Sea: (1) the nesting beaches located on mainland Greece and the adjoining Ionian islands, (2) eastern Turkey, (3) Israel, and (4) Cyprus (Carreras et al. 2006a). Genetic analyses among loggerheads from different nesting areas in Turkey have shown further differentiation (Schroth et al. 1996; Carreras et al. 2006a), providing evidence of subpopulations (Margaritoulis et al. 2003). There is no evidence for female exchange between nesting beaches; genetic analyses by Carreras et al. (2006a) demonstrates that some male loggerheads in the Mediterranean Sea mate with females of other units here. Crete appears to play a central role in the male-mediated gene flow between Mediterranean populations (Carreras et al. 2006a).

Genetic analyses of loggerheads in the western Mediterranean Sea reveals the presence of individuals from both Atlantic and eastern Mediterranean nesting origins (e.g., Laurent et al. 1998; Bolten 2003b; Carreras et al. 2006a; Maffucci et al. 2006). Recent work by Carreras et al. (2006a) has revealed genetic structuring that is reflective of water circulation patterns. Specifically, off the African coast of the Mediterranean Sea and Gimnesies Islands (northern Balearic Islands, Spain) are mainly turtles of the Atlantic stocks, whereas turtles off the European shore of the western Mediterranean Sea are primarily from eastern Mediterranean rookeries. Additionally, recent genetics data also suggests that a small proportion of the Atlantic juveniles utilize the neritic areas along the Italian coasts along with their Mediterranean counterparts (Maffucci et al. 2006).

The only recent abundance estimate available for the species in the Mediterranean Sea is from aerial surveys conducted off the Spanish Mediterranean coast between 2001 and 2003 (see **Appendix A** for more information on the survey); an absolute abundance of 18,954 loggerheads (after dive corrections) was calculated for this area (Gómez de Segura et al. 2006).

Habitat Preferences—The loggerhead turtle occurs worldwide in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd 1988). Tagging data has revealed that migratory routes may be coastal or may involve crossing deep oceanic waters; an oceanic route may be taken even when a coastal route is an option (Schroeder et al. 2003). The species may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. In Laganas Bay on the island of Zakynthos (Greece), loggerheads have been observed resting on the seabed (e.g., Houghton et al. 2000). Schofield et al. (2007) recently commented on aggression between turtles suggesting that these resting sites may represent an optimal resource over which individuals compete.

There is a generally accepted life-history model for the species, which was summarized well by Musick and Limpus (1997), Bolten (2003a), and Hawkes et al. (2006). Hatchlings travel to oceanic habitats, often occurring in *Sargassum* drift lines (Carr 1986, 1987a; Witherington and Hirama 2006). When juveniles reach sizes between 40 and 60 cm carapace length (about 14 yrs old), some individuals begin to recruit to the neritic zone (benthic habitat in shallow coastal waters) close to their natal area, while others remain in the oceanic habitat or move back and forth between the two (e.g.,

Musick and Limpus 1997; Laurent et al. 1998). Turtles either may utilize the same neritic developmental habitat all through maturation, or they may move among different areas and finally settle in an adult foraging habitat. At sexual maturity (about 30 yrs old), adults switch from subadult to adult neritic foraging habitats (Musick and Limpus 1997; Godley et al. 2003a). In direct contrast with the accepted life-history model for this species), Hawkes et al. (2006) recently reported that tagging work at the Cape Verde Islands (Africa) revealed two distinct adult foraging strategies that appear to be linked to body size. The larger turtles foraged in coastal waters, whereas smaller individuals foraged oceanically. Likewise, off Japan, epipelagic foraging has been recorded for adult female loggerheads (Hatase et al. 2002). Hawkes et al. (2006) also found that movements of adult loggerheads off Cape Verde were in part driven by local surface currents, with active movement by individuals to remain in areas of high productivity.

McCarthy (2006) reported that based on tagging data, juvenile loggerheads in the North Atlantic Ocean were more likely to move with geostrophic currents when they are traveling and that they spend more time in high chlorophyll areas, likely due to foraging effort. Polovina et al. (2006) found that juvenile loggerheads in the western North Pacific Ocean at times swam against geostrophic currents and were attracted to mesocale features with high surface chlorophyll. Results from tagging data of juvenile loggerheads in both the eastern and western North Atlantic Ocean suggest that the location of currents and associated frontal eddies is important to the foraging ecology of the pelagic stage of this species (McClellan 2007). Lazar et al. (2000) noted that while the migratory pathway of loggerheads in the Adriatic Sea cannot be precisely constructed, it appears to overlap with the current that enters the Adriatic along the eastern coast, suggesting that it influences the direction of loggerhead migration.

The neritic juvenile stage and adult foraging stage both occur in the neritic (nearshore) zone. The turtles here are active and feed primarily on the bottom (epibenthic/demersal), though prey is also captured throughout the water column (Bjorndal 2003; Bolten 2003a). The neritic zone not also provides crucial foraging habitat, but can also provide inter-nesting and overwintering habitat. For example, Zbinden et al. (2007) tagged four turtles at Laganas Bay (Zakynthos, Greece) and found that three of the four had 80% of their locations with a median bottom depth of 6.5 to 15.5 m.

Loggerheads typically nest on high-energy beaches close to reef formations and adjacent to warm-temperature currents (Dodd 1988). Nesting beaches facing the open ocean or situated along narrow bays are preferred (NMFS and USFWS 1991b). In the Mediterranean Sea, loggerheads emerge primarily on beaches fronted by mostly sandy areas (Le Vin et al. 1998). Areas with vegetation do not appear to be suitable locations (e.g., Hays and Speakman 1993). At Sekania beach on Zakynthos island (Ionian Sea), it was concluded that where sand salinity is high enough to prevent vegetation development, wet sand is located at a threshold depth for excavating an egg chamber (Karavas et al. 2005). Well-sorted sand grains favored nesting activity on the beach, and increased fine sand was proportional with a reduction in nest density (Karavas et al. 2005).

Distribution—Loggerhead turtles are widely distributed in subtropical and temperate waters throughout the world is widely distributed in tropical and subtropical waters in the Atlantic, Pacific, and Indian oceans, and Mediterranean Sea. Loggerheads (post-hatchlings/oceanic-stage juveniles and adults) are commonly found foraging in eastern North Atlantic waters around and north of the Azores to about 42°N, eastward to the Atlantic coast of Spain, and in the waters around the Madeira, Canary, and Cape Verde islands, as well as the Mediterranean Sea (Brongersma 1972; Ehrhart et al. 2003; Bowen et al. 2004). The oceanic stage juveniles found here and in the Mediterranean Sea are from the Americas, carried east by the North Atlantic Gyre System (Brongersma 1972; Bolten et al. 1998; Laurent et al. 1998; Bolten 2003b; Ehrhart et al. 2003; Bowen et al. 2004). Genetic evidence demonstrates that pelagic loggerheads found near the Azores are often derived from the nesting populations in the southeastern U.S. (Bolten et al. 1994; Bolten et al. 1998).

The Strait of Gibraltar is considered to be a significant barrier to the movement of young juveniles out of the Mediterranean Sea, though it is known that a few Mediterranean individuals do move out through the Strait (Revelles et al. 2007). Genetic analyses have revealed that some individuals from

the Mediterranean Sea move into Atlantic feeding grounds close to the Mediterranean Sea (Revelles et al. 2007). Future work with microsatellites will be able to resolve if they move further out in the Atlantic Ocean. Tagging data has also revealed limited movements between the western North Atlantic Ocean and the Mediterranean Sea (and vice-versa), as well as from the eastern North Atlantic Ocean to the Mediterranean Sea (and vice-versa) (reviewed by Bolten 2003b). One interesting individual was a head-started loggerhead turtle that was released off southern Texas and captured in fishing gear four years later in the Adriatic Sea (Manzella and Fontaine 1988). More recently, a loggerhead tagged in the western Mediterranean Sea was later recovered in Cuban waters (Camiñas 2004a). Two juveniles released with satellite tags in the Strait of Gibraltar moved out into the western North Atlantic Ocean -- one had its tag stop transmitting approximately 950 km south of Nova Scotia, while the other was moving towards The Bahamas (Cejudo et al. 2006). The adult loggerheads in the eastern North Atlantic Ocean are probably from the Moroccan and Cape Verde Islands nesting populations (Brongersma 1972; Ehrhart et al. 2003). After reaching a certain size, early juvenile loggerheads will then make a trans-oceanic crossing back towards the western Atlantic Ocean (Musick and Limpus 1997; (Bolten 2003b), actively swimming to neritic feeding grounds near their natal beach of origin (Bowen et al. 2004).

In the Mediterranean Sea, as juveniles, loggerheads inhabit the oceanic waters of both the eastern and western basins (Argano et al. 1992; Laurent et al. 1998; Margaritoulis et al. 2003). Loggerheads from the western Atlantic Ocean apparently leave the Mediterranean Sea before they mature and reproduce, and therefore, are genetically isolated (Laurent et al. 1998; Carreras et al. 2006b).

Loggerhead movements between the eastern basin and the central area of the Mediterranean Sea are well-documented by tag-returns, bycatch, and satellite tagging studies (e.g., Margaritoulis 1988; Hays et al. 1991; Argano et al. 1992; Laurent and Lescure 1994; Camiñas and de la Serna 1995; Tomas et al. 2001b; Bentivegna 2002; Godley et al. 2003a; Margaritoulis et al. 2003; Lazar et al. 2004; Bentivegna et al. 2007). Post-nesting movements of turtles tagged in Greece show a wide dispersion predominantly in the eastern basin, although females have been recovered in the western basin (Margaritoulis 1988; Margaritoulis et al. 2003). Sea turtles nesting in Greece have been re-observed sometimes as far as 1,500 km away in Tunisian, Libyan, and Italian waters (Margaritoulis 1988; Margaritoulis et al. 2003; Rees and Margaritoulis 2005; Zbinden et al. 2005) and 1,200 km away in the northern Adriatic (Lazar et al. 2000; Lazar et al. 2004). More recently, a tagged adult male loggerhead was tracked between Tunisia and Greece, as well as its return back to Tunisia (Bradai et al. 2005).

Bentivegna (2002) and Bentivegna et al. (2007) suggested that the loggerhead turtle in the central (Italy) and eastern Mediterranean Sea (Greece, Turkey, Cyrpus) makes seasonal migrations in the Mediterranean Sea based on census data suggesting higher population densities along the Italian coasts during spring/summer months. Tagging data support long-distance migrations between the central and eastern Mediterranean Sea following a seasonal pattern (Bentivegna 2002; Bentivegna et al. 2007). The four turtles tagged by Bentivegna et al. (2007) all left the Tyrrhenian Sea in the fall through the Strait of Messina, then following different routes into the eastern Mediterranean Sea, either to coastal overwintering sites in Greece and Libya or oceanic feeding sites. These movements might be reflective of adult and subadult migrations in the eastern-central basin.

Known important oceanic and neritic habitats for the loggerhead throughout the Mediterranean Sea are shown in **Figure 3-3**. Benthic foraging habitats are found primarily in the eastern Mediterranean Sea (Margaritoulis 1988; Argano et al. 1992; Laurent et al. 1998; Lazar et al. 2000; Margaritoulis et al. 2003; Affronte and Franzelliti 2004; Lazar et al. 2004). The areas of the northern and the central Adriatic represent important feeding habitats and recent data point to the significance of the central Adriatic (especially the northeastern portion) as an over-wintering area for part of the Mediterranean loggerhead sea turtle population (Argano et al. 1992; Margaritoulis 2003; Margaritoulis et al. 2003; Affronte and Franzelliti 2004; Casale et al. 2004; Lazar et al. 2004). Casale et al. (2005) recently suggested that the Ionian/South Adriatic Sea is an important developmental oceanic habitat for loggerheads in the Mediterranean Sea. The Gulf of Gabes serves as both an important wintering area for adult loggerheads nesting in Greece, as well as juvenile feeding habitat (Margaritoulis 1988;

Argano et al. 1992; Laurent and Lescure 1994; Margaritoulis et al. 2003; Rees and Margaritoulis 2005; Zbinden et al. 2005). Other important habitats are found within Mersin and Iskenderun bays (Turkey), the Nile Delta region (Egypt), the Gulf of Naples, Strait of Gibraltar, Alboran Sea, and the Balaeric Islands (Figure 3-3; Camiñas and de la Serna 1995; Bentivegna and Paglialonga 2000; Margaritoulis et al. 2003; Cardona et al. 2005; Gómez de Segura et al. 2006). The waters of Cyprus, Syria, Gulf of Lion, and Corsica also serve as foraging grounds (Delaugerre 1987; Laurent 1991; Godley et al. 2003a), as well as overwintering areas (Broderick et al. 2007).

Loggerhead nesting grounds are located in warm, temperate, and subtropical regions (between 40°N and 40°S), with some scattered nesting in the tropics (The SWOT Team 2007b) Loggerheads are the only marine turtles that nest predominantly outside of the Tropics (Ehrhart et al. 2003). The world's largest nesting colonies in 2005 were in southeast Florida (about 40,000 nests per year [nests/yr]) and Masirah Island, Oman (bordering the Arabian Sea; about 30,000 nests/yr) (Hutchinson, B., IUCN-SSC MTSG Group, personal communication, 7 March 2007).

Major nesting by this species is not considered to occur in the Mediterranean Sea in comparison to other locales world-wide. Loggerhead nesting in the Mediterranean Sea is confined almost exclusively to the eastern basin, the main nesting concentrations are found in Cyprus, Greece, and Turkey (Margaritoulis et al. 2003) as listed in **Table 3-3** and shown in **Figure 3-3**. Substantial nesting in Libya is also known, but as of yet, unquantified (Margaritoulis 2003). The single most important nesting site known at present time, which has also the highest nest density, is Laganas Bay in Zakynthos, Greece (Margaritoulis 2005). According to WWF (2005), there are about 5,600 nests laid annually on monitored beaches in the major nesting areas — approximately 3,000 in Greece, 600 in Cyprus (Margaritoulis et al. 2003), and 2,000 or more in Turkey (Canbolat 2004). Other major and minor loggerhead nesting beaches in the Mediterranean Sea are listed in **Table 3-3** and shown in **Figure 3-3**. There are very rare nesting occurrences west of these areas (e.g., Llorente et al. 1992/93; Tomás et al. 2002; Delaugerre and Cesarini 2004; Bentivegna et al. 2005; Mingozzi et al. 2006); the western-most nest was recorded from southeast Spain in the Almeria province (Vera) (Tomás et al. 2002).

- Information Specific to the Eastern Mediterranean—The entire eastern Mediterranean Study Area is considered to be an area of primary occurrence for the loggerhead sea turtle (**Figure C-3**). This takes into consideration known available bycatch, tagging, sighting, and stranding data and the presence of neritic and oceanic foraging habitats in the area. There is currently not enough information available for determination of any seasonality in occurrence.

  As noted earlier, loggerhead nesting in the Mediterranean Sea is confined almost exclusively to the eastern basin, the main nesting concentrations are found in Cyprus, Greece, and Turkey (Margaritoulis et al. 2003) (listed in **Table 3-3** and shown in **Figure 3-3**). Post-nesting movements of turtles tagged in Greece show a wide dispersion predominantly in the eastern basin (e.g., Margaritoulis 1988; Margaritoulis et al. 2003).

  Analysis of fishery bycatch and tag recoveries suggests that important neritic habitats are mainly found in the eastern basin (Figure 3-3; Laurent et al. 1998; Margaritoulis et al. 2003). The northern Adriatic Sea is a known important wintering area for loggerheads and a foraging area shared by both adult and juvenile loggerheads (Affronte and Franzelliti 2004; Lazar et al. 2004). Casale et al. (2005) recently suggested that the Ionian/South Adriatic Sea is an important developmental oceanic habitat for loggerheads in the Mediterranean Sea. Other important habitats are found within Mersin and Iskenderun bays (Turkey) and the Nile Delta region (Egypt).

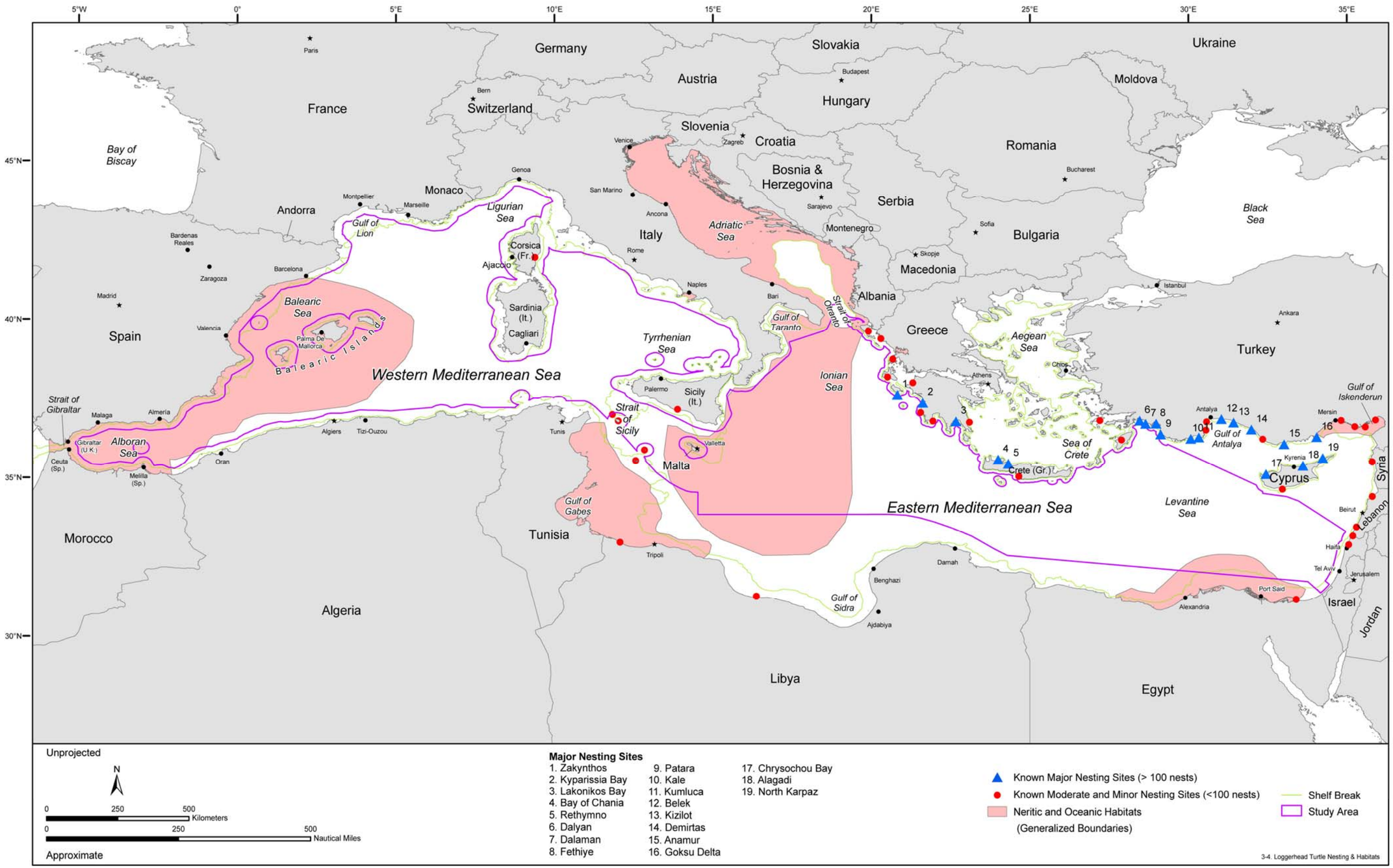


Figure 3-3. Known major and minor nesting areas for the loggerhead turtle in the Mediterranean Study Area. Also depicted are known neritic and oceanic habitats for the species. Source information: Broderick and Godley (1996); Margaritoulis et al. (2003); Canbolat (2004); and Taskavak, E., Ege Üniversitesi, pers comm., 22 January 2007.

Table 3-3. Nesting status of the loggerhead turtle in the Mediterranean Study Area. [Major nesting beaches are those with an average of >100 nests/year; moderate are those with an average of >20; discrete refers to diffuse nesting of an average of <20 nests/year]. Source information: Margaritoulis (2003) and Taskavak, E., Ege Üniversitesi, pers. comm., 8 February 2007.

Country/Nesting Beaches	Status
Greece	
Bay of Chania, Crete	Major
Kyparissia Bay, Peloponnesus	Major
Lakonikos Bay, Peloponnesus	Major
Rethymno, Crete	Major
Zakynthos (Bay of Laganas)	Major
Bay of Messara, Crete	Moderate
Ipirus Coast	Moderate
Kefalonia (Mounda Beach)	Moderate
Kerkyra	Moderate
Koroni	Moderate
Kos	Moderate
Kotychi	Moderate
Lefkas	Moderate
Rhodes	Discrete
Romanos	Moderate
Southeast Peloponnesus (includes Kythira)	Moderate
Cyprus	
Akrotiri/Episkopi	Moderate
Alagadi	Major
Chrysochou Bay	Major
North Karpaz	Major
Turkey	
Agyatan	Moderate
Akyatan	Discrete
Anamur	Major
Belek	Major
Cirali (Olympos)	Moderate
Dalaman	Moderate
Dalyan	Major
Demirtas	Moderate
Fethiye	Major
Gazipasa	Major
Goksu Delta	Moderate
Kale	Moderate
Kazanli	Moderate
Kizilot	Major
Kumluca	Major
Patara	Moderate
Samandag	Moderate
Tekirova	Moderate
Yumurtalik	Moderate
Syria	
Lattakia	Moderate
Lebanon	
El Mansouri	Moderate

Table 3-3. Continued.

Country/Nesting Beaches	Status
Lebanon (*continued*)	
Palm Island	Moderate
Qasmiye	Moderate
Israel	
Bezet	Moderate
Egypt	
Eastern coasts	Moderate
Libya	
Mistarah to Sirte, Tunisian border	Moderate
Tunisia	
Kuriat Islands	Discrete

The importance of the seabed for loggerheads in Cyprus is evident from tagging work by Houghton et al. (2002) and Godley et al. (2003a). Overwintering turtles are found in Croatia (Lazar et al. 2004) and Greece (Bentivegna 2002). From data gathered from tagging studies, adult females nesting at beaches in Greece and Cyprus with final destinations of the continental shelf region off Tunisia have to move through waters of the Strait of Sicily (Margaritoulis et al. 2003). The loggerhead sea turtle movements between the two Mediterranean basins appear to be seasonally recurrent (Bentivegna 2002).The Strait of Sicily is likely to be an important migratory area for both juveniles and adults.

The extended satellite tracking of four loggerhead turtles after incidental capture in Italian trawl fisheries has shown how these turtles make far-ranging movements and reveal plasticity of behavior, e.g., moving between the pelagic and neritic environment (Bentivegna 2002; Bentivegna et al. 2007). The loggerhead sea turtle movements between the central (Italy) and eastern Mediterranean Sea (Greece, Turkey, Cyprus) appear to be seasonally recurrent (Bentivegna 2002; Bentivegna et al. 2007). In summer, the turtles remained in the Tyrrhenian Sea, and moved to eastern Mediterranean waters at the beginning of fall, through the Strait of Messina (Bentivegna 2002; Bentivegna et al. 2007). A released turtle in the western Mediterranean Basin during Fall 1999 over-wintered in eastern waters and returned to the western basin in Summer 2000 (Bentivegna 2002; Bentivegna et al. 2007). During fall 2000, the turtle migrated again to the eastern basin. Seasonal migrations of the loggerhead sea turtle in the Mediterranean Sea are supported by census data of a higher population density along the Italian coasts in spring/summer months (Bentivegna and Paglialonga 1998).

Behavior and Life History—The nesting season for the Mediterranean loggerhead turtle is between late May and early August, with peaks from mid-June to mid-July (Broderick and Godley 1996; Margaritoulis 2005), while the hatchling season ranges from mid-July to late September, with a peak in mid-August (Broderick and Godley 1996; Margaritoulis 2005). There are substantial differences, particularly in nesting female size and clutch size, among the Mediterranean nesting colonies (Margaritoulis et al. 2003). Average clutch size in the Mediterranean Sea ranges from 65 (Turkey) to 130.4 eggs (Greece) (Margaritoulis et al. 2003). Globally, females typically nest 3 to 5 times per season at about 2-week intervals (Dodd 1988). The modal inter-nesting interval for loggerheads in the Mediterranean Sea (specifically, Cyprus) is reported as 13 days by Broderick et al. (2002), though intervals as long as 21 days are known (south of Italy: Nannarelli et al. 2006). Tagging data off Cyprus suggests that nesting females remain close to the shore during the internesting interval (Houghton et al. 2000). The most common remigration interval for the female loggerhead turtle in the Mediterranean Sea is two years (Broderick et al. 2002).

The diet of the loggerhead turtles progressively changes with age and size (e.g., Godley et al. 1998). The gut contents of post-hatchlings found in masses of *Sargassum* contained parts of *Sargassum*, zooplankton, jellyfish, larval shrimp and crabs, and gastropods (Carr and Meylan 1980; Richardson and McGillivary 1991; Witherington 1994). Juvenile and subadult loggerhead turtles are omnivorous, foraging on pelagic crabs, mollusks, jellyfish, and vegetation captured at or near the surface (Dodd 1988; Frick et al. 1999). Adult loggerheads are generally carnivorous, often choosing to forage on benthic invertebrates (mollusks, crustaceans, and coelenterates) and sometimes fish in nearshore waters (Dodd 1988).

Knowledge of the diet of loggerhead turtles in the Mediterranean Sea is based on both stomach content analyses and direct behavioral observations. Tomas et al. (2001a) noted that western Mediterranean loggerheads are opportunistic feeders based on stomach content analyses. In the western Mediterranean Sea, numerically, fish made up the most important prey group, followed by pelagic tunicates, crustaceans, mollusks and other invertebrates (Tomas et al. 2001b). The authors noted that the importance of fish as a food resource has been rarely reported for this species, and that it is possible that the fish are being consumed as discarded bycatch. In the central Mediterranean Sea (closer to Sicily), gastropods, crustaceans, and echinoids were more commonly found to be taken (Abbitt and Scott 2001). Four individuals found stranded in Sicily had a large number of blue jack mackerel (*Trachurus picturatus*) and blue runner or hardtail (*Caranx crysos*) in their stomachs (Russo et al. 1999). Male loggerheads at Kefalonia (Greece) have been observed to feed preferentially on the blue or Mediterranean mussel (*Mytilus galloprovincialis*), the seagrass *Posidonia oceanica* (Neptune grass), and fish entrails discarded by fishermen (Houghton et al. 2000; White 2004). Schofield et al. (2006) video-taped individual green turtles underwater in Laganas Bay (Zakynthos, Greece) digging ("mining") for bivalves (species not identified). Individuals off Tunisia actively feed on benthic invertebrates, mostly gastropods, hermit crabs, holothurians, lamellibranchs, and sponges (Laurent and Lescure 1994). Ocana et al. (2005) reported that the portunid crab, Henslow's swimming crab (*Polybius henslowii*), was a main food resource for loggerheads off the coast of northwest Africa. Stomach content analyses of individuals in Cyprus contained gastropod, bivalve, and crustacean species (Godley et al. 1997). Stomach contents of loggerheads found stranded along the Adriatic Sea were found to primarily contain gastopods, bivalves, echinoids, sponges, and occasionally, fish (Lazar et al. 2002; Gracan et al. 2007).

On average, loggerhead turtles spend over 90% of their time underwater (Byles 1988; Renaud and Carpenter 1994; Narazaki et al. 2006). Loggerheads tend to remain at depths shallower than 100 m (e.g., Houghton et al. 2002; Polovina et al. 2003; Hawkes et al. 2006; Narazaki et al. 2006; McClellan 2007). Routine dive depths are typically shallower than 30 m (e.g., Houghton et al. 2002), although dives of up to 233 m were recorded for a post-nesting female loggerhead off Japan (Sakamoto et al. 1990). Routine dives typically can last from 4 to 676 min (Byles 1988; (Sakamoto et al. 1990; Renaud and Carpenter 1994; Bentivegna et al. 2003; Dodd and Byles 2003). In the Mediterranean Sea, loggerhead turtles were found to alter their diving behavior relative to water temperature, with longer dives during cooler temperatures (Bentivegna et al. 2003). Hochsheid et al. (2005) recorded hibernation dives off Greece that had durations as long as seven hours. Bentivegna et al. (2007) determined from tagging data of three Mediterranean individuals that during long-distance movements towards a neritic feeding or nesting area, regardless of whether they were moving with or against currents, moved at a constant speed. During oceanic feeding, however, passive drifting with the currents was more likely to occur, allowing the individual to instead use its energy for vertical feeding movements and at the same time rest within eddies that transport high prey concentrations (Bentivegna et al. 2007). The authors noted that similar observations were made for oceanic loggerheads in the North Pacific Ocean (Polovina et al. 2003).

Low water temperatures affect loggerhead turtle activity. Loggerheads become lethargic at about 13° to 15°C and adopt a stunned floating posture in water around 10°C (Mrosovsky 1980). Cold-stunned loggerheads have been found in various locales, including off the northeastern U.S. and in the South Adriatic Sea (Morreale et al. 1992; Bentivegna et al. 2002). Immature loggerheads inhabiting cool-temperate areas in the western North Atlantic Ocean usually migrate seasonally to avoid cold-stunning (Musick and Limpus 1997); a similar latitudinal migration has been reported along the Italian

coast (Bentivegna 2002) and might occur off the Balaeric Archipelago (moving southwards during fall) (Camiñas and de la Serna 1995). Some loggerheads are believed to escape cold conditions by burying themselves in the bottom sediment and hibernating (Carr et al. 1980; Ogren and McVea 1982; Hochscheid et al. 2005); this is known to occur within the Mediterranean region.

- **Green Turtle (*Chelonia mydas*)**

Description—The green turtle is the largest hard-shelled sea turtle; adults commonly reach 100 cm in carapace length and 150 kg in weight (NMFS and USFWS 1991a). Nesting females in the Mediterranean Sea are approximately 91 to 92 cm in CCL (Broderick and Godley 1996; Rees et al. 2005). Adult carapaces range in color from solid black to gray, yellow, green, and brown in muted to conspicuous patterns; the plastron is a much lighter yellow to white. Hatchlings are distinctively black on the dorsal surface and white on the ventral. Greens are distinguishable by their four costal lateral scutes on the carapace and a serrated jaw, likely adapted for grazing.

Status—The green turtle is classified as threatened under the ESA, with the Florida and Mexican Pacific coast nesting populations listed as endangered (NMFS and USFWS 1991a). The IUCN lists green turtles as endangered (Seminoff and MTSG Green Turtle Task Force 2004).1

The Mediterranean green turtle population is the most endangered green turtle population in the world (Seminoff and MTSG Green Turtle Task Force 2004). It is a genetically distinct population (Bowen et al. 1992; Encalada et al. 1996; Kaska 2000). Evidence from studies of DNA strongly suggest that there is some genetic interchange between green turtles in the Mediterranean Sea and those elsewhere in the Atlantic Ocean (Roberts et al. 2004). Male-mediated gene flow is thought to contribute importantly to this interchange (Roberts et al. 2004). Until recently, the Mediterranean subpopulation of the green turtle was considered to be critically endangered subpopulation by the IUCN; however, due to a lack of supporting documentation for definition as a subpopulation, they are no longer listed separately from the species as a whole (Mast et al. 2006; Mrosovsky 2006).

The Mediterranean green turtle nesting population has plummeted – data suggests as much as a 93% decline in nesting numbers has occurred (Seminoff and MTSG Green Turtle Task Force 2004). In total, between 339 and 360 green turtle females nest annually on Mediterranean beaches (Broderick et al. 2002). Annual nesting numbers remain speculative due to lack of standardized monitoring on several nesting beaches especially in Libya and Turkey (Rees et al. 2005).

Habitat Preferences—Post-hatchling and early-juvenile green turtles reside in convergence zones in the open ocean, where they spend an undetermined amount of time in the pelagic environment (Carr 1987b). The distinct coloration patterns of hatchlings and early-juvenile greens, a darker dorsal surface and lighter ventral surface, are ideal for an oceanic lifestyle. In laboratory experiments, Mellgren et al. (1994) found that hatchling green turtles did not orient to or congregate in artificial weed beds or in real seaweeds; however, Carr and Meylan (1980) found green turtle hatchlings taking refuge in and around *Sargassum* rafts off Panama, and Witherington and Hirama (2006) reported captures in *Sargassum* off the U.S.. Mellgren et al. (1994) found green turtle post-hatchlings to spend a greater amount of time in the open ocean than other species known to associate with *Sargassum*. The suggested green turtle-*Sargassum* association may be due to the juvenile and *Sargassum* being passively brought together by convergence zones (Carr 1995).

Once carapace length reaches 30 to 40 cm, green turtles leave the pelagic habitat and enter benthic foraging areas in coastal waters where they spend the majority of their lives as late juveniles and adults (Bjorndal 1997; Hirth 1997; Musick and Limpus 1997). Both the developmental habitat for late juveniles and the feeding grounds for both adults (typically) and juveniles are shallow, coastal waters. Some green turtles are known to maintain distinct home ranges or site fidelity within foraging grounds (e.g., Musick and Limpus 1997). Little is known on habitat usage by the green turtle in the Mediterranean Sea. Tagged adult female greens that migrated to North Africa were found to maintain home ranges that did not overlap one another (Godley et al. 2002). In the eastern Mediterranean

Sea, green turtlesoften forage in coastal waters less than 10 m in bottom depth (e.g., Hays et al. 2002a).

Since late juvenile and adult greens feed on seagrasses, they can find very little food in the open ocean and they presumably stay in the neritic environment. Satellite telemetry, however, recently conducted in Japan has suggested that green turtles may not be obligate herbivores in neritic areas (Hatase et al. 2006). Hatase et al. (2006) also reported that off Japan some adult female green turtles are using mainly oceanic habitats, while others mainly use neritic habitat.

Distribution—The green turtle has a circumglobal distribution, occurring throughout tropical and, to a lesser extent, subtropical waters (Seminoff and MTSG Green Turtle Task Force 2004). The most important nesting and feeding grounds lie within the tropics (Sternberg 1981; Pritchard 1997).

Juvenile green turtles are known to move through a series of developmental feeding habitats. These developmental feeding habitats are often separated by thousands of kilometers (Hirth 1997; Musick and Limpus 1997). Mixed-stock analyses on juvenile foraging populations have revealed that developmental feeding habitats likely contain green turtles from multiple stocks (Dutton and McDonald 1990; Nichols et al. 2000); however, little is known regarding the stock compositions of juvenile foraging populations in the Mediterranean Sea.

Adult green turtles are known to undertake extensive migrations, the longest of which are between their foraging habitats and nesting beaches. The migration distance can be thousands of kilometers (e.g., Hays et al. 2002c). Godley et al. (2002) reported three distinct phases in tagged post-nesting female greens in the Mediterranean Sea: (1) a period in the coastal waters of Cyprus; (2) an open-sea crossing; and (3) a movement through coastal waters. The authors also reported discovered that the speed of post-nesting movements was significantly greater during the open-sea crossing than during periods within coastal waters of Cyprus or Turkey (Godley et al. 2002).

Important habitats for juvenile and adult green turtles in the Mediterranean Sea are shown in **Figure 3-4**. The most important foraging area for the species is in the easternmost part of the Mediterranean Basin (between Turkey and Egypt). Important resident areas in the Mediterranean Sea where adult green turtles feed and rest are off Turkey at Mersin Bay, Iskenderun Bay, Yumurtalik Lagoon, and include areas around Samandağ beach; the Nile Delta region in Egypt; and Libya (Baran and Kasparek 1989; Laurent et al. 1996; Nada 2001; Oruç 2001; Godley et al. 2002; Yalçin-Özdilek and Aureggi 2006). The Mediterranean Africa coast is also utilized as overwintering and foraging habitat by adult, female green turtles (Godley et al. 2002; Rees and Jony 2007). The waters of Cyprus and Syria also serve as foraging grounds (Hochscheid et al. 1999; Godley et al. 2002; Godley et al. 2003b).

As noted by Yalçin-Özdilek and Aureggi (2006), the locations of juvenile developmental areas in the Mediterranean Sea are still not clearly defined. Lazar et al. (2004) noted that juvenile greens have been recorded in the eastern and western Mediterranean seas, Adriatic Sea, and the Black Sea; it is the eastern Mediterranean Sea that hosts the largest numbers. The eastern part of the Levantine basin has been suggested to be a juvenile developmental area (Laurent et al. 1996; Godley et al. 1998). Developmental habitat for green turtles is recognized in Lakonikos Bay, Greece (Margaritoulis and Teneketzis 2003). Although the presence of juvenile greens in the Adriatic is not well-known, it has been hypothesized that the southern waters may host developmental habitat for the species (Lazar et al. 2004). It has also been suggested that the area off Fethiye beach (Turkey) might be a feeding habitat (e.g., Yalçin-Özdilek and Aureggi 2006). There is also evidence that Libyan waters are frequented by juveniles (Taskavak, E., Ege Üniversitesi, pers. comm., 8 February 2007). Syria may also provide possibly important foraging areas for juvenile green turtles (Rees et al. 2005).

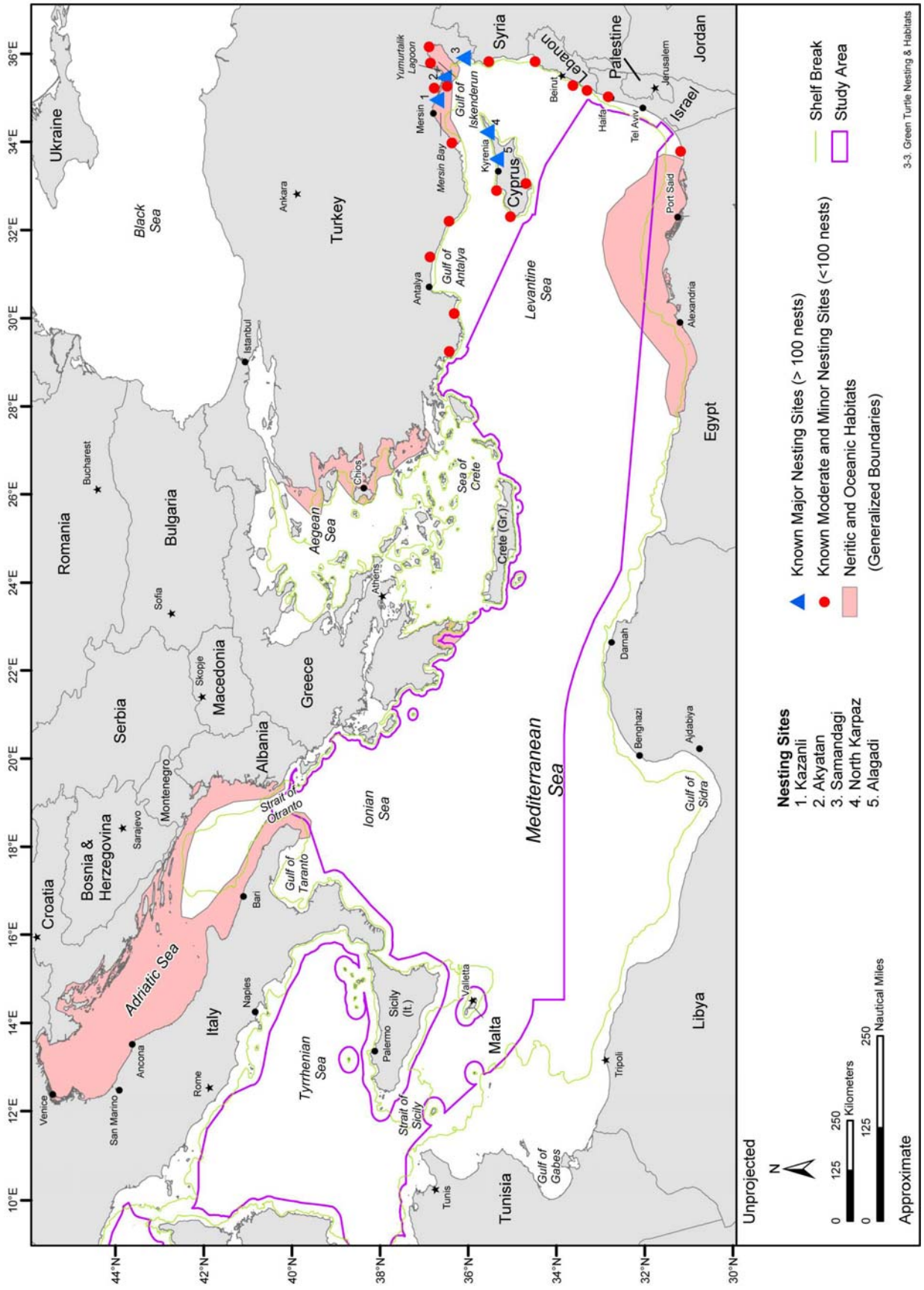


Figure 3-4. Known major and minor nesting areas for the green turtle in the Mediterranean Study Area. Also depicted are known neritic and oceanic habitats for the species. Source information: Türkozan and Durmus (2000): Kasparek (2001): Margaritoulis (2003):

There are active green turtle nesting colonies in the easternmost parts of the Mediterranean Basin (Turkey, Cyprus, Syria, Lebanon, Israel and Egypt) (**Figure 3-4**). Ninety-nine percent of all recorded nesting in the Mediterranean Sea occurring in Turkey and Cyprus, and 71% of all nests concentrated at only five key nesting beaches, i.e., Akyatan, Kazanli and Samandağ in Turkey and Alagadi and the Karpaz Peninsula in Cyprus (**Table 3-4**; Kasparek et al. 2001). Turkey holds by far the largest share of the Mediterranean population, and nesting is mostly concentrated on three beaches, ranked in level of importance: Akyatan, Kazanli and Samandağ (Kasparek et al. 2001). Low-level nesting (<10 nests/yr) occurs at scattered locations throughout the numerous beaches of Syria, Lebanon, Israel, and Egypt, as well as Turkey and Cyprus. No green turtle nesting has been confirmed yet in central and western parts of the Mediterranean Basin.

Green turtles nesting in the Mediterranean Sea are suspected to remain year-round in the Mediterranean Sea; for example, all females tracked after nesting in Cyprus have remained inside the Mediterranean Sea (Godley et al. 2002; Broderick et al. 2006). Post-nesting satellite tracking of adult females revealed that the waters of Cyprus, Turkey, Israel, and Egypt host migratory pathways and wintering areas for adults (Godley et al. 2002).

Table 3-4. Nesting status of the green turtle in the Mediterranean Study Area. [Major nesting beaches are those with an average of >100 nests/year; moderate are those with an average of >20; discrete refers to diffuse nesting of an average of <20 nests/year]. Source information: Kasparek (2001).

Country/Nesting Beaches	Status
Cyprus	
North Karpaz	
Beach numbers 51-56	Major
Alagadi	Major
Akamas Peninsula (five beaches)	Moderate
West Coast	
Beach number 82	Moderate
Beach numbers 83-84	Moderate
North Coast	
Beach numbers 73-75	Moderate
South Karpaz	
Beach numbers 45-46	Moderate
Beach numbers 38-39	Moderate
Beach numbers 34-35	Moderate
Beach numbers 32-33	Moderate
Turkey	
Akyatan	Major
Kazanh	Major
Samandag	Major
Goksu Delta	Moderate
Tuzla	Discrete
Kumluca	Discrete
Belek	Discrete
Agyatan and Yelkoma Beaches	Discrete
Patara	Discrete
Side-Kizilot Area	Discrete
Israel	Discrete
Lebanon	Discrete
Egypt	
Northern Sinai	Discrete

- Information Specific to the Eastern Mediterranean Study Area—Mediterranean green turtles are considered to primarily occur in the eastern Mediterranean Sea, based on the location of nesting beaches (e.g., Kasparek et al. 2001), satellite tagging data of adult females (e.g., Godley et al. 2002), and available information on juvenile distribution (e.g., Margaritoulis 2003; Lazar et al. 2004). Primary occurrence for the green turtle is inshore of the 100 m isobath; this takes into account the most probable habitat for foraging and resting (shallow, coastal waters with seagrasses) by juveniles and adults, as well as overwintering habitat (e.g., Godley et al. 2002; Hays et al. 2002c). Green turtles are known to use oceanic waters for migration and very young green turtles in the oceanic stage are probably also found in these waters, so there is a secondary occurrence throughout the eastern Mediterranean Sea in waters seaward of the 100 m isobath. The occurrence patterns shown in **Figure C-4** take the before-mentioned factors into consideration, as well as the fact that much of the North African coastline has not been properly surveyed and assessed to determine sea turtle occurrence and habitat usage.

Behavior and Life History—Generally, female green turtles do not reproduce every year, and the period between reproductive seasons is about 2.86 yrs (Miller 1997). Gravid green turtle females nest several times in a season (typically 3 to 5 times) at approximately 10 to 15 day intervals (Miller 1997). The nesting season for Mediterranean green turtles commences in late May and early June, peaks between mid-June and early August, and tapers off in late August and early September ((Demetropoulos and Hadjichristophorou 1989; Broderick and Godley 1996). The peak season is recognized as between 15 and 30 June in Turkey (Baran and Kasparek 1989) and Syria (Kasparek 1995). From 1992 through 1995, green turtle nests at northern Cyprus contained an average of 115.5 (absolute range 23 to 199) eggs with a mean incubation period of 51.1 days (range 44 to 59) (Broderick and Godley 1996). Long emergence periods (mean=6.7 to 8.3 days) are documented for loggerhead hatchlings in Greece (Hays et al. 1992; Adam et al. 2007). The inter-nesting interval for green turtles at Cyprus ranges from 10 to 16 days (e.g., Hays et al. 2002b). In the green turtle, numbers of nests fluctuate dramatically and are likely to be related to inter-annual variations in quantity and quality of forage driven by prevailing weather patterns (Broderick and Godley 1996; Broderick et al. 2001; Mazaris et al. 2004). Temperature also appears to affect the inter-nesting interval – when the water is warmer, the interval is shorter (Hays et al. 2002b). Broderick and Godley (1997) reported observing mating at and on Alagadi Beach (northern Cyprus).

The green turtle is the only herbivorous sea turtle. Very young green turtles are omnivorous, leaning to carnivory (Bjorndal 1985; Bjorndal 1997). Salmon et al. (2004) reported that posthatchling green turtles were found to feed near the surface on floating *Thalassia* and *Sargassum* or at shallow depths on ctenephores and unidentified gelatinous eggs but ignored large jellyfish (Aurelia) off southeastern Florida. Adult green turtles feed primarily on seagrasses (e.g., turtle grass [*Thalassia testudinum*], manatee grass [*Syringodium filliforme*], shoal grass [*Halodule wrightii*], and eelgrass [*Zostera marina*]), macroalgae, and reef-associated organisms (Burke et al. 1992; Bjorndal 1997). They also consume jellyfish, salps, and sponges (Mortimer 1995; Bjorndal 1997).

In the Mediterranean Sea, it is assumed that juvenile green turtles feed on seagrasses such as *Cymodocea nodosa* (lesser Neptune grass), *Zostera* spp., *Posidonia oceanica*, *Halophila stipulacea*, and algae (Yalçin-Özdilek and Aureggi 2006). Analysis of stomach contents of two green turtles at Lakonikos Bay, Greece revealed almost exclusive consumption of leaves and roots of *Cymodocea nodosa*, with few leaves belonging to *Zostera marina* (common eelgrass) (Margaritoulis and Teneketzis 2003). At Cyprus, Hays et al. (2002b) reported that stomach contents of adult females found dead during the nesting season were full of seagrasses (species not identified), indicating that the animals had been recently feeding. Analyses of stomach contents revealed only lesser Neptune grass (*Cymodocea nodosa*) (Taskavak, E., Ege Üniversitesi, pers. comm., 8 February 2007). A stranded green turtle at Samandağ beach, Turkey was found to have its stomach full of seagrass (species not identified) (Yalçin-Özdilek and Aureggi 2006). Observations of foraging adult green turtles suggest that when benthic age classes feed, they generally lie down on the sea bottom and, when food is no longer within reach, they crawl or swim to a nearby site (Hochscheid et al. 1999). In Cyprus, where foraging material is widely found, individuals have been shown to perform both foraging and resting dives on the sea bed (Hochscheid et al. 1999). More recently, it has been

speculated that green turtles are not obligate herbivores (restricted to a grass diet), but also actively feed on other organisms. For example, Hatase et al. (2006) recently reported that based on tagging data off Japan that some adult females forage on macroplankton that exhibit diel vertical migration. Heithaus et al. (2002) using animal-borne video cameras demonstrated that green turtles in western Australia also consume scyphozoans (jellyfish). Godley et al. (1998) suggested that based on stable isotope analysis, green turtles in the Mediterranan and eastern North Atlantic Ocean do not feed solely on plant material, but also feed on animal tissue (the authors were not able to to determine though whether this is incidentally taken while eating grasses or intentional). Additionally, Godley et al. (1998) determined based on their analyses that some individual greens might be feeding primarily in a pelagic environment, while others are feeding on sea grasses.

Green turtles typically make dives shallower than 30 m (Hays et al. 1999; Hochscheid et al. 1999; Hays et al. 2000; Godley et al. 2002; Hays et al. 2002a; Hatase et al. 2006). Green turtles have been known to forage and also rest at depths of 20 to 50 m (Balazs 1980; Brill et al. 1995). During the inter-nesting interval in the Mediterranean Sea, Hochscheid et al. (2006) recorded a maximum dive depth of 27 m and maximum duration of 13 min off northern Cyprus, with the majority of the time spent just below the water's surface. Green turtles have been observed to dive to depths of 73 to 110 m in the eastern Pacific Ocean (Berkson 1967), and in 1997, a maximum dive depth of 164.5 m was recorded for a post-nesting female from Japan's Ogasawara Islands (Matsuzawa, Y., Sea Turtle Association of Japan, pers. comm., 7 and 18 August 2005). The maximum dive time recorded for a juvenile green turtle around the Hawaiian Islands is 66 min (Brill et al. 1995). In the Mediterranean Sea, post-nesting green turtles were found to alter their diving behavior seasonally (Godley et al. 2002). During winter, tagged individuals dove for longer periods of time (over 90 min) and had decreased times at the surface (Godley et al. 2002). The authors even suggested that dives as long as (and even in excess of) 360 min could be expected (Godley et al. 2002).

Low water temperatures affect green turtle activity (e.g., Moon et al. 1997). Greens adopt a stunned floating posture in water around 9°C (Schwartz 1978). Cold-stunned greens have been found off the northeastern and southeastern U.S. (Morreale et al. 1989) and (Schroeder et al. 1989), respectively. Dormant green sea turtles have been reported off the coast of southern California and northern Mexico (Felger et al. 1976). Immature greens inhabiting cool-temperate areas in the western North Atlantic Ocean usually migrate seasonally to avoid cold-stunning (Musick and Limpus 1997). Godley et al. (2002) reported that green turtles in the Mediterranean Sea moved offshore to deeper wintering sites when water temperatures were generally below 25°C, and as noted earlier, switched from relatively short dives to very long dives. These extended dive durations are consistent with turtles entering a state of diapause (time when activity is diminished) (Godley et al. 2002), much like that recently determined for loggerheads in the Mediterranean Sea (see loggerhead writeup above).

- **Hawksbill Turtle (*Eretmochelys imbricata*)**

Description—The hawksbill turtle is a small to medium-sized sea turtle; adults range between 65 and 90 cm in carapace length and typically weigh around 80 kg (Witzell 1983; NMFS and USFWS 1993). Hawksbills are distinguished by their hawk-like beaks (NMFS and USFWS 1993). The carapace color is 'tortoiseshell', ranging from golden to dark brown with red, black and orange streaks. The posterior edge is serrated, especially in young animals, and the scutes overlap one another. Each flippers usually bears two claws (is often brown or amber with irregularly radiating streaks of yellow, orange, black, and reddish-brown (Gulko and Eckert 2004).

Status—The hawksbill turtle is listed as endangered under the ESA; the IUCN lists it as critically endangered (NMFS and USFWS 1993).1 This species is second only to the Kemp's ridley in terms of endangerment (NMFS and USFWS 1993; Bass 1994). In the Caribbean Sea, designated critical habitat includes the waters surrounding Mona and Monito islands, Puerto Rico (NMFS 1998).

Habitat Preferences—Hawksbill turtles inhabit oceanic waters as post-hatchlings and early juveniles, where they are sometimes associated with driftlines and floating patches of *Sargassum* (NMFS and USFWS 1993; Parker 1995; Hasbún 2002; Witherington and Hirama 2006). Small juvenile hatchlings

may utilize *Sargassum* drift communities as developmental habitat (Witherington and Hirama 2006). Hawksbills recruit to benthic foraging grounds when they are 20 to 25 cm in length (Witzell 1983).

Coral reefs are recognized as optimal hawksbill habitat for juveniles, sub-adults, and adults (NMFS and USFWS 1993; Diez et al. 2003). Ledges, caves, and root systems, often interspersed among these habitats, provide hawksbills refuge and shelter (NMFS and USFWS 1993). Sparse hard-bottom communities, cliff-wall habitats with soft corals and invertebrates are also considered important developmental habitat (Diez et al. 2003). Hawksbills prefer alternate sites for resting and foraging. Resting sites tend to be of greater depths than foraging areas, although bottom topography influences site selection as well (Houghton et al. 2003).

The developmental habitats for juvenile benthic-stage hawksbills are the same as the primary feeding grounds for adults; these include tropical, nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Shallow seagrass beds may also serve as important developmental habitats for late juvenile hawksbills (Bjorndal and Bolten 1988; Diez et al. 2003). Several sporadic reports exist of hawksbills residing in seagrass habitats; for example, there is a development habitat for juvenile hawksbills at Saona Island, Dominican Republic (Diez et al. 2003).

In neritic habitats, resting areas for late juvenile and adult hawksbills are typically located in deeper waters, such as sandy bottoms at the base of a reef flat, than their foraging areas (Houghton et al. 2003). Late juveniles generally reside on shallow reefs less than 18 m deep; however, as they mature into adults, hawksbills move to deeper habitats and may forage to depths greater than 90 m. Benthic-stage hawksbills are seldom found in waters beyond the continental or insular shelf, unless they are in transit between distant foraging or nesting grounds (NMFS and USFWS 1993).

Hawksbill turtles prefer to nest on low- and high-energy beaches in tropical regions, often nesting on the same high-energy beaches as green turtles (NMFS and USFWS 1993). Although hawksbills exhibit a wide tolerance for nesting substrate type, they prefer undisturbed, deep-sand beaches underneath vegetative cover (NMFS and USFWS 1993; Comer 2002). The hawksbill's small size and agility allows it to access nesting sites atop narrow and steeply sloped beaches as well as across fringing reefs, areas that are rarely accessible to other sea turtle species (NMFS and USFWS 1993; Comer 2002).

Distribution—Hawksbill turtles are circum-tropical in distribution, generally occurring from 30°N to 30°S within the Atlantic, Pacific, and Indian oceans (Witzell 1983). Virtually all nesting is restricted between latitudes 25ºN and 35ºS. The hawksbill turtle has only rarely been recorded away from the tropics. In the Atlantic Ocean, this species is found throughout the Gulf of Mexico, the Greater and Lesser Antilles, and southern Florida, as well as along the mainland of Central America south to Brazil (NMFS and USFWS 1993). There are very few reports for this species in the eastern North Atlantic Ocean (Brongersma 1972; Witzell 1983; Pascual 1985), including the Mediterranean Sea (Laurent and Lescure 1991). In the Indo-Pacific oceans, hawksbill turtles occur around the Torres Straits, in the Red Sea, Gulf of Aden, Australia, Persian Gulf islands, and Oman (e.g., Frazier and Salas 1984; NMFS and USFWS 1993; Ross and Barwani 1995; Broderick and Moritz 1996; Pilcher and Miller 2007).

Hawksbills were originally thought to be a non-migratory species due to the close proximity of suitable nesting beaches to coral reef feeding habitats and high rates of local recaptures, however, they are now known to travel long distances over the course of their lives (Meylan 1999) mainly between nesting and foraging areas. A subadult tagged in Sueste Bay on the archipelago of Fernando de Noronha, Brazil and captured at Cap Esterias, Gabon represents the longest documented movements for this species – a straight line distance of 4,669 km (Bellini et al. 2000). A juvenile tagged in Brazil and captured and killed in Dakar, Senegal traveled at least 3,680 km in a 6-month period (Marcovaldi and Fillippini 2001). The 1,600 km journey of a post-nesting female, traveling between Santa Isabel Island, Soloman Islands and Port Moresby, Papua New Guinea is also noteworthy (Meylan et al. 1995). Similarly, an analysis of ML (maximum likelihood) indicated that the hawksbill feeding ground population at Mona Island, Puerto Rico, received significant contributions

from at least four Caribbean rookeries greater than 100 km from the feeding ground, but a Brazilian breeding population 7,000 km from the Mona Island feeding ground made no detectable contribution (Lahanas et al. 1998).

Tag return, genetic, and telemetry studies indicate that individuals in the Caribbean Sea utilize multiple developmental habitats as they progress from one age class to another. Developmental habitats typically include shallow (<20 m) coral reefs and estuaries with mangroves (Musick and Limpus 1997). Within a given life stage, such as the later juvenile stage, some hawksbills might develop long-term residency within a specific developmental habitat for a period of time lives (Meylan 1999). For example, in February 1985, a benthic-stage juvenile was captured from the coastal waters surrounding an islet in the southern Ryukyu Islands. A year and a half later, the same individual was recaptured in a lagoon only 9 km away from its original capture site (Kamezaki 1987).

- Information Specific to the Eastern Mediterranean Study Area—The Mediterranean Sea is an area of rare occurrence for the hawksbill turtle (**Figure C-5**). Any occurrences are considered to be extralimital. Laurent and Lescure (1991) reviewed the seven documented records for the hawksbill in the Mediterranean Sea. There were two captures near Marseille and Albania; two collected close to the southern Sicilian coast and Malta; and three individuals captured in nets in French coastal waters. Demirayak et al. (2002) reported that in southern Lebanon, the fishermen interviewed insisted that they were seeing the hawksbill turtle; however, this identification should be treated with scientific caution since immature loggerhead turtles may be identified as hawksbills turtles (Taskavak, E., Ege Üniversitesi, pers. comm., 8 February 2007).

  The origin of hawksbills in the Mediterranean Sea is speculative; individuals either are coming from the Atlantic Ocean via the Strait of Gibraltar or the Red Sea via the Suez Canal, with the latter hypothesis being the most favored. The hawksbill is the most abundant sea turtle in the Red Sea, and as noted by Laurent and Lescure (1991), several hawksbill nesting sites occur on the shores of the Red Sea in Egypt and Sudan (Meylan and Donnelly 1999).

Behavior and Life History—Early juveniles are believed to occur in areas of advection where flotsam accumulates, yet little is known about their diets during this stage (Witzell 1983). *Sargassum* and floating debris have been found in the stomach of stranded post-hatchlings (NMFS and USFWS 1993). Hawksbills are considered to be omnivorous during the later juvenile stage, feeding on encrusting organisms such as sponges, tunicates, bryozoans, algae, mollusks, and a variety of other items such as crustaceans and jellyfish (Bjorndal 1997). Older juveniles and adults are more specialized and feed primarily on sponges. Adult hawksbills are more specialized, feeding primarily on sponges, which comprise as much as 95% of their diet in some locations (Witzell 1983; Meylan 1988). Hawksbills serve a vital role in reef ecosystems as they feed on organisms that compete with coral reefs for space (León and Bjorndal 2002).

Hawksbill turtles often nest in multiple, small, scattered colonies with mating activities believed to take place in the shallow waters adjacent to the nesting beach. Much of what is known about hawksbill nesting has been learned from studies at rookeries in the Caribbean Sea, Indian Ocean, and tropical areas of the western Pacific Ocean. The 6-month nesting season of hawksbills is the longest of all sea turtles. At tropical latitudes, nesting is most often nocturnal on beaches with sufficient vegetative cover. A female nests an average 4 to 5 times per season with an inter-nesting interval of about 14 days (NMFS and USFWS 1993). The typical remigration interval is two to three years. Clutch sizes are relatively large at approximately 140 eggs in the U.S. and Caribbean, although nests with greater than 200 eggs have been recorded (NMFS and USFWS 1993). Incubation time is approximately 60 days (NMFS and USFWS 1993). Hawksbills exhibit strong philopatry for nesting beaches and return to specific beach areas (NMFS and USFWS 1993).

Hawksbills may have one of the longest routine dive times of all the sea turtles. Starbird et al. (1999) reported that inter-nesting females at Buck Island, USVI averaged 56.1 min dives with a maximum dive time of 73.5 min. Average dives during the day ranged from 34 to 65 min, while those at night were between 42 and 74 min. Storch et al. (2006) reported mean dive times of 57.3 mins in the USVI

before a hurricane and 42 min during the hurricane. Data from time-depth recorders have indicated that foraging dives of immature hawksbills in Puerto Rico range from 8.6 to 14 min in duration, with a mean depth of 4.7 m (Van Dam and Diez 1996). These individuals were found to be most active during the day. Changes in water temperature have an effect on the behavioral ecology of hawksbill turtles, with an increase in nocturnal dive duration with decreasing water temperatures during the winter (Storch et al. 2005).

- **Kemp's Ridley Turtle (*Lepidochelys kempii*)**

Description—The Kemp's ridley is the smallest living sea turtle. This species has a SCL of approximately 60 to 70 cm (with shell length and width being nearly equal) and weigh about 450 kg (USFWS and NMFS 1992; Gulko and Eckert 2004). The carapace is round to somewhat heart-shaped and distinctly light gray.

Status—The Kemp's ridley turtle is classified as endangered under the ESA and as critically endangered on the IUCN Red List (USFWS and NMFS 1992).1 This is considered the world's most endangered sea turtle species (USFWS and NMFS 1992) .

The worldwide population declined from tens of thousands of nesting females in the late 1940s to approximately 300 nesting females in 1985 (TEWG 2000). From 1985 to 1999, the number of nests at Rancho Nuevo, Tamaulipas (eastern coast of Mexico) increased at a mean rate of 11.3% per year (TEWG 2000). Approximately 5,373 nests and 2,339 nesting females were recorded at Rancho Nuevo in 2003; however, these numbers represent a 94% decrease from historical records (Márquez-M. et al. 2005). In 2005, 6,947 nests were recorded in Rancho Nuevo (USFWS 2005). Positive trends in 2005 were also recorded in other areas of the Mexican Gulf Coast at Barra del Tordo (701 nests) and Barra de Tepehuajes (1,610 nests). Nests at Veracruz decreased from 164 nests during 2002 to 62 nests in 2005 (USFWS 2005). Nesting levels at Padre Island National Seashore (PINS) in Texas, the site of a Kemp's ridley head-starting and imprinting program from 1978 to 1988, have shown a slow but steady rise throughout time (e.g., Shaver and Wibbels 2007). During 2002, 38 Kemp's ridley nests were recorded at PINS, as opposed to 13 nests in 1998 and 16 nests in 1999 (Márquez-M. et al. 2005). In 2006, 64 nests were recorded at PINS (NPS 2006).

Habitat Preferences—Kemp's ridley turtles occur in open-ocean and *Sargassum* habitats of the North Atlantic Ocean as post-hatchlings and small juveniles (e.g., Manzella et al. 1991; Witherington and Hirama 2006). They move as large juveniles and adults to benthic, nearshore feeding grounds along the U.S. Atlantic and Gulf coasts (Morreale and Standora 2005). Habitats frequently utilized include warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where preferred food, including the blue crab (*Callinectes sapidus*), occurs (Lutcavage and Musick 1985; Landry and Costa 1999; Seney and Musick 2005). Models indicate that the most suitable habitats are less than 10 m in bottom depth with sea surface temperatures between 22° and 32°C (Coyne et al. 2000). Postnesting Kemp's ridleys travel along coastal corridors generally shallower than 50 m in bottom depth (Morreale et al. 2007).

Offshore water temperatures play a major role in determining the number of Kemp's ridleys present in the North Atlantic Ocean. Temperature is a limiting factor in their distribution; in temperatures less than 13°C they tend to float, make awkward movements (Marquez-M. 1994), and may even die of cold-stunning (Burke et al. 1991). Still et al. (2005) reported on seasonality to cold-stunning of juvenile turtles in Cape Cod Bay, Massachusetts. The authors determined that Kemp's ridleys were found to withstand cold temperatures for a shorter period of time (with cold-stunned individuals already frequently being recovered in November) than larger turtles, such as loggerheads, (recovered later, due to cold-stunning, in December).

Distribution—The Kemp's ridley is restricted to the North Atlantic Ocean (Marquez-M. 1994). Individuals occur primarily in the Gulf of Mexico and in moderate numbers along the eastern U.S. coast as far north as Nova Scotia (Lazell 1980; Morreale et al. 1992). Isolated occurrences are noted

for the eastern North Atlantic Ocean, Caribbean Sea, and the Mediterranean region (e.g., Brongersma 1995; Tomás et al. 2003; Renaud and Williams 2005).

Nesting occurs primarily on a single nesting beach at Rancho Nuevo, Tamaulipas, on the eastern coast of Mexico (USFWS and NMFs 1992), with a few additional nests in Veracruz (Mexico), Texas, Florida, Georgia, South Carolina, and North Carolina (Meylan et al. 1990; Weber 1995; Foote and Mueller 2002; Williams et al. 2006).

Oceanic transport of hatchling Kemp's ridleys is controlled primarily by hydrography in the Gulf of Mexico (Collard 1990). Upon leaving the nesting beach of Rancho Nuevo, hatchling Kemp's ridleys enter the Mexican Current, and are swept eastward into the northern Gulf of Mexico (Musick and Limpus 1997). Many juveniles are retained in the northern Gulf until they migrate inshore to demersal habitat. Others may be carried south from the northern Gulf into the Loop Current, where they are swept into the Florida Current and, subsequently, the Gulf Stream (Musick and Limpus 1997). Once they reach a size of approximately 20 to 30 cm, or 2 yrs of age, individuals actively migrate to neritic developmental habitats along the U.S. Atlantic Coast (Musick and Limpus 1997). Alternatively, the North Atlantic Gyre may work in conjunction with the Gulf Stream to carry juveniles into the eastern North Atlantic Ocean, to areas such as the Azores and Madeira (Brongersma 1995; Musick and Limpus 1997).

Feeding grounds and developmental areas are found on the Atlantic and Gulf coasts of the U.S. Henwood (1987) and Gitschlag (1996) documented sightings and movements of juveniles within and among preferred habitats along both the Atlantic and Gulf coasts. It is mostly juveniles that occupy the northern part of the range (Keinath et al. 1987; Morreale and Standora 2005), due to the presence of important developmental habitats along the U.S. Atlantic Coast; these areas include Cape Cod Bay, Long Island Sound, Chesapeake Bay, and the bays and sounds from North Carolina south (Lazell 1980; Lee and Palmer 1981; Lutcavage and Musick 1985; Barnard et al. 1989; Weber 1995). Kemp's ridleys utilize developmental habitats in North Carolina, South Carolina, and Georgia from April through October (Morreale and Standora 2005) and are present in Florida waters year-round. Some Kemp's ridley juveniles may migrate as north as New York and New England, arriving in these areas around June (Morreale and Standora 2005). During the winter, they are prompted by cooler water temperatures to leave northern developmental habitats and migrate south to warmer waters in Florida (Marquez-M. 1994).

The western coast of Florida (particularly the Cedar Keys area), the eastern coast of Alabama, the mouth of the Mississippi River, and the coastal waters off western Louisiana and eastern Texas are identified as important developmental regions for the Kemp's ridley (Márquez-M. 1990; USFWS and NMFS 1992; Marquez-M. 1994; Schmid et al. 2002). The Gulf of Campeche in the southern Gulf of Mexico is also important foraging habitat.

Individuals are known to overwinter in areas south of Cape Hatteras, North Carolina, although the majority of Kemp's ridleys stay in Florida near Cape Canaveral (Henwood and Ogren 1987). Overwintering individuals may occasionally bury in the mud to hibernate (Schwartz 1989; Marquez-M. 1994). Individuals that overwinter in southern North Carolina may subsequently move into warmer waters (e.g., Gulf Stream or areas off South Carolina) during the mid-winter (Renaud 1995; Morreale and Standora 2005). For example, an individual tagged in Beaufort in 1989 was tracked to stay the winter in Onslow Bay, North Carolina, and subsequently move into the Gulf Stream when temperatures cooled close to shore in January 1990 (Renaud 1995). Seasonal movements continue until turtles reach sexual maturity, at which time, they return to breeding grounds in the Gulf of Mexico (Henwood and Ogren 1987).

Migrations tend to take place in nearshore waters along the mid-Atlantic coast (Morreale and Standora 2005; Morreale et al. 2007); juvenile and adults typically travel inshore of the 18 m isobath (Renaud and Williams 2005). Concentrations of Kemp's ridley increase during fall and spring migrations, especially near Cape Hatteras, North Carolina, where the migration corridor becomes constricted (Morreale and Standora 2005). This migratory corridor is a narrow band running within

continental shelf waters, possibly spanning the entire length of the U.S. Atlantic Coast (Morreale and Standora 2005; Morreale et al. 2007).

Adults appear to remain in the Gulf of Mexico, with occasional occurrences in the Atlantic Ocean. Renaud (1995) indicated that adult Kemp's ridley turtles may travel along the entire U.S. Gulf Coast while looking for an optimal foraging habitat. Satellite-tracking results of an adult Kemp's ridley of unknown sex showed a travel route from the Gulf of Mexico through the Florida Straits and into the Atlantic Ocean (Renaud and Williams 2005). Adult females in the Gulf of Mexico movements are expected to be more extensive than those of males, and likely influenced by foraging and reproductive needs; Renaud and Williams (2005) tracked one adult female from her foraging grounds offshore Louisiana to the nesting beach in Rancho Nuevo, Mexico. Adult male Kemp's ridleys exhibit small range movements and may reside offshore nesting beaches year-round due to prey availability and mating opportunities (Shaver et al. 2005; Morreale et al. 2007).

- Information Specific to the Western Mediterranean Study Area—Although it is known that individuals do make trans-Atlantic crossings (e.g., Wibbels 1983; Fontaine et al. 1985), the Mediterranean Sea represents an area of rare occurrence for the Kemp's ridley sea turtle (**Figure C-6**). There are only five documented records for this species in the Mediterranean: (1) an October 1929 capture off the island of Malta; (2) a July 2001 capture in the Gulf of Lion; (3) an October 2001 capture in a gillnet in shallow waters off Santa Pola, Spain (between the island of Tabarca and Guardamar del Seguera); (4) a capture to the west of the Strait of Gibraltar in the Gulf of Cadiz in September 2005; (5) a capture near Valencia, Spain in July 2006 (Tomás et al. 2003; Oliver and Pigno 2005; Carreras et al. 2006a; Tomás and Raga 2007).

Behavior and Life History—Kemp's ridley turtles feed primarily on portunids and other types of crabs, but are also known to prey on mollusks, shrimp, fish, jellyfish, and plant material (Marquez-M. 1994; Frick et al. 1999). Blue crabs and spider crabs (*Libinia* spp.) are important prey species for the Kemp's ridley (Lutcavage and Musick 1985; Keinath et al. 1987; Seney and Musick 2005). Kemp's ridleys may also feed on shrimp fishery bycatch (Landry and Costa 1999).

Kemp's ridleys are unique in that they nest during the daytime, sometimes solitary and other times synchronously in arribadas (Spanish for "arrivals") (Márquez-M. 1990; Weber 1995; Witzell et al. 2005). Kemp's ridleys are generally accepted to reach matururity at approximately 65 cm carapace length (Miller 1997; Zug et al. 1997). Age of maturity for nesting females is approximately 10 to 20 yrs and 60 cm carapace length (Shaver et al. 2005; Snover et al. 2007). Mature males may be smaller in size than nesting females (Witzell et al. 2005). There is a mating period in March followed by a three-month nesting period, spanning mid-April through mid-July (Rostal 2005). Individuals nest approximately every two years (Rostal 2005, 2007). A typical female produces about three clutches averaging 110 eggs at 20- to 28-day intervals (Miller 1997), although larger turtles may produce larger clutches (Witzell et al. 2005). Incubation time from deposition to emergence is 46 to 57 days (Witzell et al. 2005).

Few data are available on the maximum dive duration. Satellite-tagged juvenile Kemp's ridley turtles demonstrate different mean surface intervals and dive depths depending on whether the individual is located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). Dive times range from a few seconds to a maximum of 167 min, with routine dives lasting between 16.7 and 33.7 min (Mendonça and Pritchard 1986; Renaud 1995). In Cedar Keys, Florida, the average submergence duration was found to be approximately 8.4 min (Schmid et al. 2002). Renaud and Willimas (2005) noted seasonal differences in dive durations, with longer dives (>30 min) during the winter and 15 mins the remainder of the year. Sasso and Witzell (2006) reported longer dives at night than during the day for this species. Over a 12-hr period, Kemp's ridleys spend as long as 96% of their time submerged (Byles 1989; Gitschlag 1996; Renaud and Williams 2005; Sasso and Witzell 2006).

3.2.6 Website Accessed

[1] The IUCN red list of threatened species. Accessed 14 February 2007. http://www.iucnredlist.org/.

3.2.7 Literature Cited

Abbitt, R.J.F. and J.M. Scott. 2001. Examining differences between recovered and declining endangered species. Conservation Biology 15(5):1274-1284.

Adam, V., C. Tur, A.F. Rees, and J. Tomás. 2007. Emergence pattern of loggerhead turtle (*Caretta caretta*) hatchlings from Kyparissia Bay, Greece. Marine Biology 151:1743-1749.

Affronte, M. and S. Franzelliti. 2004. Recoveries of two post-hatchling loggerhead turtles in the Northern Adriatic Sea. Marine Turtle Newsletter 104:10-11.

Argano, R., R. Basso, M. Cocco, and G. Gerosa. 1992. Nuovi dati sugli spostamenti di tartaruga marina comune *(Caretta caretta)* in Mediterraneo (New data on loggerhead (*Caretta caretta*) movements within Mediterranean). Bollettino dei Musei e degli Istituti Biologici dell'Universitá di Genova 56-57:137-163.

ARPA (Advanced Research Projects Agency). 1995. Final environmental impact statement for the Kauai Acoustic Thermometry of Ocean Climate project and its associated marine mammal research program: Volumes I and II. Prepared for the Office of Conservation and Environmental Affairs, Honolulu, Hawaii by the Advanced Research Projects Agency and the National Oceanic and Atmospheric Administration (NOAA).

Balazs, G.H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. NOAA Technical Memorandum NMFS-SWFC-7:1-141.

Baran, I. and M. Kasparek. 1989. On the whereabout of immature sea turtles (*Caretta caretta* and *Chelonia mydas)* in the eastern Mediterranean. Zoology in the Middle East 3:31-36.

Barnard, D.E., J.A. Keinath, and J.A. Musick. 1989. Distribution of ridley, green, and leatherback turtles in Chesapeake Bay and adjacent waters. Pages 201-203 in Eckert, S.A., K.L. Eckert, and T.H. Richardson, eds. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Bartol, S.M., J.A. Musick, and A.L. Ochs. 2002. Visual acuity thresholds of juvenile loggerhead sea turtles (*Caretta caretta):* An electrophysiological approach. Journal of Comparative Physiology A 187:953-960.

Bass, A.L. 1994. Population structure of hawksbill rookeries in the Caribbean and western Atlantic. Page 17 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Bellini, C., T.M. Sanches, and A. Formia. 2000. Hawksbill turtle tagged in Brazil captured in Gabon, Africa. Marine Turtle Newsletter 87:11-12.

Bentivegna, F. 2002. Intra-Mediterranean migrations of loggerhead sea turtles (*Caretta caretta*) monitored by satellite telemetry. Marine Biology 141:795-800.

Bentivegna, F. and A. Paglialonga. 1998. Status of the sea turtles in the Gulf of Naples and preliminary study of migration. Pages 152-155 in Epperly, S.P. and J. Braun, eds. Proceedings of the Seventeenth Annual Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-415.

Bentivegna, F. and A. Paglialonga. 2000. Identification of the Gulf of Naples as a feeding ground and migratory path for *Caretta caretta* in the Mediterranean Sea. Pages 95-97 in Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez-Millán, and L. Sarti-Martínez, eds. Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Bentivegna, F., P. Breber, and S. Hochscheid. 2002. Cold stunned loggerhead turtles in the South Adriatic Sea. Marine Turtle Newsletter 97:1-3.

Bentivegna, F., S. Hochscheid, and C. Minucci. 2003. Seasonal variability in voluntary dive duration of the Mediterranean loggerhead turtle, *Caretta caretta*. Scientia Marina 67(3):371-375.

Bentivegna, F., G. Treglia, and S. Hochscheid. 2005. The first report of a loggerhead turtle *Caretta caretta* nest on the central Tyrrhenian coast (western Mediterranean). JMBA2 - Biodiversity Records Published online.

Bentivegna, F., F. Valentino, P. Falco, E. Zambianchi, and S. Hochscheid. 2007. The relationship between loggerhead turtle (*Caretta caretta*) movement patterns and Mediterranean currents. Marine Biology 151:1605–1614.

Berkson, H. 1967. Physiological adjustments to deep diving in the Pacific green turtle (*Chelonia mydas agassizii*). Comparative Biochemistry and Physiology 21:507-524.

Billes, A., J. Fretey, B. Verhage, B. Huijbregts, B. Giffoni, L. Prosdocimi, D.A. Albareda, J.-Y. Georges, and M. Tiwari. 2006. First evidence of leatherback movement from Africa to South America. Marine Turtle Newsletter 111:13-14.

Bjorndal, K. 1997. Foraging ecology and nutrition of sea turtles. Pages 199-231 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Bjorndal, K.A. 1985. Nutritional ecology of sea turtles. Copeia 1985(3):736-751.

Bjorndal, K.A. 2003. Roles of loggerhead sea turtles in marine ecosystems. Pages 235-254 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Bjorndal, K.A. and A.B. Bolten. 1988. Growth rates of juvenile loggerheads, *Caretta caretta*, in the southern Bahamas. Journal of Herpetology 22(4):480-482.

Bjorndal, K.A., A.B. Bolten, and H.R. Martins. 2000. Somatic growth model of juvenile loggerhead sea turtles *Caretta caretta*: Duration of pelagic stage. Marine Ecology Progress Series 202:265-272.

Bjorndal, K.A., ed. 1995. Biology and conservation of sea turtles. Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Bleakney, J.S. 1965. Reports of marine turtles from New England and eastern Canada. Canadian Field-Naturalist 79:120-128.

Bolten, A.B. 2003a. Variation in sea turtle life history patterns: Neritic vs. oceanic developmental stages. Pages 243-258 in Lutz, P.L., J.A. Musick, and J. Wyneken, eds. The biology of sea turtles, Volume 2. Boca Raton, Florida: CRC Press.

Bolten, A.B. 2003b. Active swimmers--Passive drifters: The oceanic juvenile stage of loggerheads in the Atlantic system. Pages 63-78 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Bolten, A.B. and B.E. Witherington, eds. 2003. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Bolten, A.B., K.A. Bjorndal, and H.R. Martins. 1994. Biology of pelagic-stage loggerheads in the Atlantic. Pages 19-20 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Bolten, A.B., K.A. Bjorndal, H.R. Martins, T. Dellinger, M.J. Biscoito, S.E. Encalada, and B.W. Bowen. 1998. Transatlantic developmental migrations of loggerhead sea turtles demonstrated by mtDNA sequence analysis. Ecological Applications 8:1-7.

Boulon, R.H., Jr., P.H. Dutton, and D.L. McDonald. 1996. Leatherback turtles (*Dermochelys coriacea*) on St. Croix, U.S. Virgin Islands: Fifteen years of conservation. Chelonian Conservation and Biology 2(2):141-147.

Bowen, B.W., A.B. Meylan, J.P. Ross, C.J. Limpus, G.H. Balazs, and J.C. Avise. 1992. Global population structure and natural history of the green turtle (*Chelonia mydas*) in terms of matriarchal phylogeny. Evolution 46(4):865-881.

Bowen, B.W., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis, and S.R. Hopkins-Murphy. 1993. Population structure of loggerhead turtles (*Caretta caretta*) in the northwestern Atlantic Ocean and Mediterranean Sea. Conservation Biology 7(4):834-844.

Bowen, B.W., F.A. Abreu-Grobois, G.H. Balazs, N. Kamezaki, C.J. Limpus, and R.J. Ferl. 1995. Trans-Pacific migrations of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences of the United States of America 92:3731-3734.

Bowen, B.W., A.L. Bass, S.-M. Chow, M. Bostrom, K.A. Bjorndal, A.B. Bolten, T. Okuyama, B.M. Bolker, S. Epperly, E. Lacasella, D. Shaver, M. Dodd, S.R. Hopkins-Murphy, J.A. Musick, M. Swingle, K. Rankin-Baransky, W. Teas, W.N. Witzell, and P.H. Dutton. 2004. Natal homing in juvenile loggerhead turtles *(Caretta caretta)*. Molecular Ecology 13:3797-3808.

Bradai, M.N., F. Bentivegna, I. Jribi, A. El Ouaer, K. Maatoug, and A. El Abed. 2005. Monitoring of a loggerhead sea turtle *Caretta caretta* in the central Mediterranean via satellite telemetry. Page 13

in Abstracts, Second Mediterranean Conference on Marine Turtles. 4-7 May 2005. Kemer, Antalya, Turkey.

Bradshaw, C.J.A., C.R. McMahon, and G.C. Hays. 2007. Behavioral inference of diving metabolic rate in free-ranging leatherback turtles. Physiological and Biochemical Zoology 80:209-219.

Brill, R.W., G.H. Balazs, K.N. Holland, R.K.C. Chang, S. Sullivan, and J. George. 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian Islands. Journal of Experimental Marine Biology and Ecology 185:203-218.

Broderick, A.C. and B.J. Godley. 1996. Population and nesting ecology of the green turtle, *Chelonia mydas*, and the loggerhead turtle, *Caretta caretta,* in northern Cyprus. Zoology in the Middle East 13:27-46.

Broderick, A.C. and B.J. Godley. 1997. Observations of reproductive behavior of male green turtles (*Chelonia mydas)* at a nesting beach in Cyprus. Chelonian Conservation and Biology 2(4):615-616.

Broderick, A.C., B.J. Godley, and G.C. Hays. 2001. Trophic status drives interannual variability in nesting numbers of marine turtles. Proceedings of the Royal Society B: Biological Sciences 268:1481-1487.

Broderick, A.C., F. Glen, B.J. Godley, and G.C. Hays. 2002. Estimating the number of green and loggerhead turtles nesting annually in the Mediterranean. Oryx 36(3):1-9.

Broderick, A.C., M.S. Coyne, W.J. Fuller, F. Glen, and B.J. Godley. 2007. Fidelity and overwintering of sea turtles. Proceedings of the Royal Society B: Biological Sciences 274:1533-1538.

Broderick, A.C., R. Frauenstein, F. Glen, G.C. Hayes, A.L. Jackson, T. Pelembe, G.D. Ruxton, and B.J. Godley. 2006. Are green turtles globally endangered? Global Ecology and Biogeography 15:21-26.

Broderick, D. and C. Moritz. 1996. Hawksbill breeding and foraging populations in the Indo-Pacific region. Pages 119-128 in Bowen, B.W. and W.N. Witzell, eds. Proceedings of the International Symposium on Sea Turtle Conservation Genetics. NOAA Technical Memorandum NMFS-SEFSC-396.

Brongersma, L.D. 1972. European Atlantic turtles. Zoologische Verhandelingen 121:1-318.

Brongersma, L.D. 1995. Marine turtles of the eastern Atlantic Ocean. Pages 407-416 in Bjorndal, K.A., ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Burke, V.J., E.A. Standora, and S.J. Morreale. 1991. Factors affecting strandings of cold-stunned juvenile Kemp's ridley and loggerhead sea turtles in Long Island, New York. Copeia 1991(4):1136-1138.

Burke, V.J., S.J. Morreale, P. Logan, and E.A. Standora. 1992. Diet of green turtles (*Chelonia mydas*) in the waters of Long Island, N.Y. Pages 140-142 in Salmon, M. and J. Wyneken, eds. Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-302.

Byles, R.A. 1988. Behavior and ecology of sea turtles from Chesapeake Bay, Virginia. Ph.D. diss., College of William and Mary in Virginia.

Byles, R.A. 1989. Satellite telemetry of Kemp's ridley sea turtle, *Lepidochelys kempi*, in the Gulf of Mexico. Pages 25-26 in Eckert, S.A., K.L. Eckert, and T.H. Richardson, eds. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Camiñas, J.A. 1998. Is the leatherback (*Dermochelys coriacea* Vandelli, 1761), a permanent species in the Mediterranean Sea? Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 35(2):388-389.

Camiñas, J.A. 2004a. Una tortuga boba recuperada en Cuba tras ser marcada en el Mediterráneo occidental (Loggerhead turtle recovered in Cuba that was tagged in the western Mediterranean). Quercus 219:14-15.

Camiñas, J.A. 2004b. Sea turtles of the Mediterranean Sea: Population dynamics, sources of mortality and relative importance of fisheries impacts. FAO Fisheries Report 738(Supplement):27-84.

Camiñas, J.A. and J.M. de la Serna. 1995. The loggerhead distribution in the Western Mediterranean Sea as deduced from captures by the Spanish Long Line Fishery. Scientia Herpetologica 1995:316-323.

Canbolat, A.F. 2004. A review of sea turtle nesting activity along the Mediterranean coast of Turkey. Biological Conservation 116:81-91.

Cardona, L., M. Revelles, C. Carreras, M. San Félix, M. Gazo, and A. Aguilar. 2005. Western Mediterranean immature loggerhead turtles: Habitat use in spring and summer assessed through satellite tracking and aerial surveys. Marine Biology 147:583-591.

Carr, A. 1986. Rips, FADS, and little loggerheads. BioScience 36(2):92-100.

Carr, A. 1987a. Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. Marine Pollution Bulletin 18(6B):352-356.

Carr, A. 1987b. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1(2):103-121.

Carr, A. 1995. Notes on the behavioral ecology of sea turtles. Pages 19-26 in Bjorndal, K.A., ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Carr, A. and A.B. Meylan. 1980. Evidence of passive migration of green turtle hatchlings in *Sargassum*. Copeia 1980(2):366-368.

Carr, A., L.H. Ogren, and C. McVea. 1980. Apparent hibernation by the Atlantic loggerhead turtle *Caretta caretta* off Cape Canaveral, Florida. Biological Conservation 19:7-14.

Carreras, C., S. Pont, F. Maffucci, M. Pascual, A. Barceló, F. Bentivegna, L. Cardona, F. Alegre, M. SanFélix [sic], G. Fernández, and A. Aguilar. 2006a. Genetic structuring of immature loggerhead sea turtles (*Caretta caretta)* in the Mediterranean Sea reflects water circulation patterns. Marine Biology 149(5):1269-1279.

Carreras, C., L. Cardona, A. Marco, M. Pascual, A. Aguilar, D. Margaritoulis, A. Rees, J.J. Castillo, J. Tomás, J.A. Raga, G. Fernández, M. SanFelix, O. Turkozan, Y. Levy, A. Gasith, M. Aureggi, M. Khalil, C. Rico, and S. Roques. 2006b. Degree of isolation of the Mediterranean nesting populations of the loggerhead sea turtle using nuclear markers. Page 186 in Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. 3-8 April 2006. Island of Crete, Greece.

Casale, P. 2006. Marine Turtle Specialist Group status assessment of *Dermochelys coriacea* in the Mediterranean Sea. Prepared for the International Union for Conservation of Nature and Natural Resources, Malaga, Spain.

Casale, P., L. Laurent, and G. De Metrio. 2004. Incidental capture of marine turtles by the Italian trawl fishery in the north Adriatic Sea. Biological Conservation 119:287-295.

Casale, P., D. Freggi, R. Basso, and R. Argano. 2005. Oceanic habitats for loggerhead turtles in the Mediterranean Sea. Marine Turtle Newsletter 107:10-11.

Casale, P., P. Nicolosi, D. Freggi, M. Turchetto, and R. Argano. 2003. Leatherback turtles (*Dermochelys coriacea*) in Italy and in the Mediterranean Basin. Herpetological Journal 13:135-139.

Casale, P., R. Argano, R. Basso, D. Freggi, and G. Gerosa. 2003. Loggerhead sea turtle (*Caretta caretta*) records from Italian waters. Page 106 in Margaritoulis, D. and A. Demetropoulos, eds. Proceedings, First Mediterranean Conference on Marine Turtles. 24-28 October 2001. Rome, Italy.

Cejudo, D., N. Varo-Cruz, A. Liria, J.J. Castillo, J.J. Bellido, and L.F. López-Jurado. 2006. Transatlantic migration of juvenile loggerhead turtles (*Caretta caretta L.)* from the Strait of Gibraltar. Marine Turtle Newsletter 114:9-11.

Coles, W.C. and J.A. Musick. 2000. Satellite sea surface temperature analysis and correlation with sea turtle distribution off North Carolina. Copeia 2000(2):551-554.

Collard, S.B. 1990. The influence of oceanographic features in post-hatchling sea turtle distribution and dispersion in the pelagic environment. Pages 111-114 in Richardson, T.H., J.I. Richardson, and M. Donnelly, eds. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278.

Comer, K.E. 2002. Habitat suitability index models for nesting sea turtles at the U.S. Naval Station Guantanamo Bay, Cuba. Master's thesis, San Diego State University.

Cook, S.L. and T.G. Forrest. 2005. Sounds produced by nesting leatherback sea turtles (*Dermochelys coriacea*). Herpetological Review 36(4):387-390.

Coyne, M.S., M.E. Monaco, and A.M. Landry, Jr. 2000. Kemp's ridley habitat suitability index model. Page 60 in Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez-Millán, and L. Sarti-Martínez, eds. Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Davenport, J. 1988. Do diving leatherbacks pursue glowing jelly? British Herpetological Society Bulletin 24:20-21.

Davenport, J. 1997. Temperature and the life-history strategies of sea turtles. Journal of Thermal Biology 22(6):479-488.

Davenport, J. and G.H. Balazs. 1991. 'Fiery bodies' -- Are pyrosomas an important component of the diet of leatherback turtles? British Herpetological Society Bulletin 37:33-38.

Delaugerre, M. 1987. Statut des tortues marines de la Corse (et de la Mediterranee) (Status of marine turtles in the Mediterranean [with particular reference to Corsica]). Vie Milieu 37(3/4):243-264.

Delaugerre, M. and C. Cesarini. 2004. Confirmed nesting of loggerhead turtle in Corsica. Marine Turtle Newsletter 104:12.

Demetropoulos, A. and M. Hadjichristophorou. 1989. Sea turtle conservation in Cyprus. Marine Turtle Newsletter 44:4-6.

Demirayak, F., R. Sadek, S. Hraoui-Bloquet, and M. Khalil. 2002. Marine turtle nesting activity assessment on the Lebanon coast. Phase I: Survey to identify nesting sites and fishery interaction. Tunis, Tunisia and Athens, Greece: RAC/SPA and MEDASSET.

Diez, C.E., X. Vélez-Zuazo, and R.P. Van Dam. 2003. Hawksbill turtles in seagrass beds. Marine Turtle Newsletter 102:8-10.

Dodd, C.K. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). Biological Report 88(14). Washington, D.C.: U.S. Fish and Wildlife Service.

Dodd, C.K., Jr. and R. Byles. 2003. Post-nesting movements and behavior of loggerhead sea turtles (*Caretta caretta*) departing from east-central Florida nesting beaches. Chelonian Conservation and Biology 4(3):530-536.

Dutton, P. 2007. Building our knowledge of the leatherback stock structure. SWOT Report-State of the World's Sea Turtles 1:10-11.

Dutton, P. and D. McDonald. 1990. Status of sea turtles in San Diego Bay: 1989-1990. SWRI Technical Report 90-225. San Diego, California: Sea World Research Institute.

Eckert, K.L. 1987. Environmental unpredictability and leatherback sea turtle (*Dermochelys coriacea*) nest loss. Herpetologica 43(3):315-323.

Eckert, K.L. and C. Luginbuhl. 1988. Death of a giant. Marine Turtle Newsletter 43:2-3.

Eckert, K.L. and S.A. Eckert. 1988. Pre-reproductive movements of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Caribbean. Copeia 1988(2):400-406.

Eckert, K.L., S.A. Eckert, T.W. Adams, and A.D. Tucker. 1989. Inter-nesting migrations by leatherback sea turtles (*Dermochelys coriacea*) in the West Indies. Herpetologica 45(2):190-194.

Eckert, S.A. 2002. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. Marine Ecology Progress Series 230:289-293.

Eckert, S.A., D.W. Nellis, K.L. Eckert, and G.L. Kooyman. 1986. Diving patterns of two leatherback sea turtles (*Dermochelys coriacea*) during internesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands. Herpetologica 42(3):381-388.

Eckert, S.A., K.L. Eckert, P. Ponganis, and G.L. Kooyman. 1989. Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). Canadian Journal of Zoology 67:2834-2840.

Eckert, S.A., H.C. Liew, K.L. Eckert, and E.H. Chan. 1996. Shallow water diving by leatherback turtles in the South China Sea. Chelonian Conservation and Biology 2(2):237-243.

Ehrhart, L.M. 1995. A review of sea turtle reproduction. Pages 29-38 in Bjorndal, K.A., ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: Geographic distribution, abundance, and population status. Pages 157-174 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Eisenberg, J.F. and J. Frazier. 1983. A leatherback turtle (*Dermochelys coriacea*) feeding in the wild. Journal of Herpetology 17(1):81-82.

Encalada, S.E., P.N. Lahanas, K.A. Bjorndal, A.B. Bolten, M.M. Miyamoto, and B.W. Bowen. 1996. Phylogeography and population structure of the Atlantic and Mediterranean green turtle *Chelonia mydas*: A mitochondrial DNA control region sequence assessment. Molecular Ecology 5:473-483.

Encalada, S.E., K.A. Bjorndal, A.B. Bolten, J.C. Zurita, B. Schroeder, E. Possardt, C.J. Sears, and B.W. Bowen. 1998. Population structure of loggerhead turtle (*Caretta caretta*) nesting colonies in the Atlantic and Mediterranean as inferred from mitochondrial DNA control region sequences. Marine Biology 130:567-573.

Epperly, S.P., J. Braun, A.J. Chester, F.A. Cross, J.V. Merriner, and P.A. Tester. 1995. Winter distribution of sea turtles in the vicinity of Cape Hatteras and their interactions with the summer flounder trawl fishery. Bulletin of Marine Science 56:547-568.

Evans, D., C. Ordoñez, S. Troëng, and C. Drews. 2007. Satellite tracking of leatherback turtles from Caribbean Central America reveals unexpected foraging grounds. Pages 70-71 in Abstracts, Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. 22-28 February 2007. Myrtle Beach, South Carolina.

Felger, R.S., K. Cliffton, and P.J. Regal. 1976. Winter dormancy in sea turtles: Independent discovery and exploitation in the Gulf of California by two local cultures. Science 191:283-285.

Ferraroli, S., J.Y. Georges, P. Gaspar, and Y. Le Maho. 2004. Where leatherback turtles meet fisheries. Nature 429:521-522.

Fontaine, C.T., K.T. Marvin, T.D. Williams, W.J. Browning, R.M. Harris, K.L. Williams Indelicato, G.A. Shattuck, and R.A. Sadler. 1985. The husbandry of hatchling to yearling Kemp's ridley sea turtles (*Lepidochelys kempi*). NOAA Technical Memorandum NMFS-SEFC-158:1-34.

Foote, J.J. and T.L. Mueller. 2002. Two Kemp's ridley (*Lepidochelys kempii*) nests on the central Gulf coast of Sarasota County Florida (USA). Pages 252-253 in Mosier, A., A. Foley, and B. Brost, eds. Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

Fossette, S., J.-Y. Georges, H. Tanaka, Y. Ropert-Coudert, S. Ferraroli, N. Arai, K. Sato, Y. Naito, and Y.L. Maho. 2007. Dispersal and dive patterns in gravid leatherback turtles during the nesting season in French Guiana. Marine Ecology Progress Series 338:233-247.

Frair, W., R.G. Ackman, and N. Mrosovsky. 1972. Body temperature of *Dermochelys coriacea*: Warm turtle from cold water. Science 177:791-793.

Frazer, N.B. 1986. Survival from egg to adulthood in a declining population of loggerhead turtles, *Caretta caretta*. Herpetologica 42(1):47-55.

Frazier, J. and S. Salas. 1984. The status of marine turtles in the Egyptian Red Sea. Biological Conservation 30:41-67.

Frazier, J.G. 2001. General natural history of marine turtles. Pages 3-17 in Eckert, K.L. and F.A. Abreu-Grobois, eds. Proceedings: Marine Turtle Conservation in the Wider Caribbean Region: A Dialogue for Effective Regional Management. 16-18 November 1999. Santo Domingo, Dominican Republic.

Frick, M.G., C.A. Quinn, and C.K. Slay. 1999. *Dermochelys coriacea* (leatherback sea turtle), *Lepidochelys kempi* (Kemp's ridley sea turtle), and *Caretta caretta* (loggerhead sea turtle). Pelagic feeding. Herpetological Review 30(3):165.

Gerosa, G. and P. Casale. 1999. Interaction of marine turtles with fisheries in the Mediterranean. Tunis Cedex, Tunisia: Regional Activity Centre for Specially Protected Areas.

Gitschlag, G.R. 1996. Migration and diving behavior of Kemp's ridley (Garman) sea turtles along the U.S. southeastern Atlantic coast. Journal of Experimental Marine Biology and Ecology 205:115-135.

Godley, B. and A. Broderick. 1995. Northern Cyprus is critical habitat for Mediterranean turtles. Marine Turtle Newsletter 69:18-19.

Godley, B.J., S.M. Smith, P.F. Clark, and J.D. Taylor. 1997. Molluscan and crustacean items in the diet of the loggerhead turtle, *Caretta caretta* (Linnaeus, 1758) [Testudines: Chelonidae] in the eastern Mediterranean. Journal of Molluscan Studies 63:474-476.

Godley, B.J., D.R. Thompson, S. Waldron, and R.W. Furness. 1998. The trophic status of marine turtles as determined by stable isotope analysis. Marine Ecology Progress Series 166:277-284.

Godley, B.J., A.C. Broderick, F. Glen, and G.C. Hays. 2003a. Post-nesting movements and submergence patterns of loggerhead marine turtles in the Mediterranean assessed by satellite tracking. Journal of Experimental Marine Biology and Ecology 287:119-134.

Godley, B.J., S. Richardson, A.C. Broderick, M.S. Coyne, F. Glen, and G.C. Hays. 2002. Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. Ecography 25(3):352-362.

Godley, B.J., E.H.S.M. Lima, S. Åkesson, A.C. Broderick, F. Glen, M.H. Godfrey, P. Luschi, and G.C. Hays. 2003b. Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging. Marine Ecology Progress Series 253:279-288.

Goff, G.P. and G.B. Stenson. 1988. Brown adipose tissue in leatherback sea turtles: A thermogenic organ in an endothermic reptile? Copeia 1988(4):1071-1075.

Goff, G.P. and J. Lien. 1988. Atlantic leatherback turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. Canadian Field-Naturalist 102(1):1-5.

Gómez de Segura, A., J. Tomás, S.N. Pedraza, E.A. Crespo, and J.A. Raga. 2006. Abundance and distribution of the endangered loggerhead turtle in Spanish Mediterranean waters and the conservation implications. Animal Conservation 9:199-206.

Gracan, R., J. Katic, M. Bursic, D. Zavodnik, N. Tvrtkovic, and B. Lazar. 2007. Loggerhead sea turtles as bioturbators in marine ecosystems. Page 152 in Abstracts, Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. 22-28 February 2007. Myrtle Beach, South Carolina.

Grant, G.S. and D. Ferrell. 1993. Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelidae): Notes on near-shore feeding behavior and association with cobia. Brimleyana 19:77-81.

Greer, A.E., Jr., J.D. Lazell, Jr., and R.M. Wright. 1973. Anatomical evidence for a counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). Nature 244:181.

Gulko, D.A. and K.L. Eckert. 2004. Sea turtles: An ecological guide. Honolulu, Hawaii: Mutual Publishing.

Hasbún, C.R. 2002. Observations on the first day dispersal of neonatal hawksbill turtles (*Eretmochelys imbricata*). Marine Turtle Newsletter 96:7-10.

Hatase, H., Y. Matsuzawa, W. Sakamoto, N. Baba, and I. Miyawaki. 2002. Pelagic habitat use of an adult Japanese male loggerhead turtle *Caretta caretta* examined by the Argos satellite system. Fisheries Science 68:945-947.

Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto. 2006. Individual variation in feeding habitat use by adult female green sea turtles (*Chelonia mydas):* Are they obligately neritic herbivores? Oecologia 149:52-64.

Hawkes, L.A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, and B.J. Godley. 2007. Only some like it hot--Quantifying the environmental niche of the loggerhead sea turtle. Diversity and Distributions 13:447-457.

Hawkes, L.A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, L.-F. Lopez-Jurado, P. Lopez-Suarez, S.E. Merino, N. Varo-Cruz, and B.J. Godley. 2006. Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. Current Biology 16:990-995.

Hays, G.C. and J.R. Speakman. 1993. Nest placement by loggerhead turtles, *Caretta caretta*. Animal Behaviour 45:47-53.

Hays, G.C., J.R. Speakman, and J.P. Hayes. 1992. The pattern of emergence by loggerhead turtle (*Caretta caretta*) hatchlings on Cephalonia, Greece. Herpetologica 48(4):396-401.

Hays, G.C., J.D. Metcalfe, and A.W. Walne. 2004a. The implications of lung-regulated buoyancy control for dive depth and duration. Ecology 85(4):1137-1145.

Hays, G.C., J.D.R. Houghton, and A.E. Myers. 2004b. Pan-Atlantic leatherback turtle movements. Nature 429:522.

Hays, G.C., A.C. Broderick, F. Glen, and B.J. Godley. 2003. Climate change and sea turtles: A 150-year reconstruction of incubation temperatures at a major marine turtle rookery. Global Change Biology 9:642-646.

Hays, G.C., P.I. Webb, J.P. Hayes, I.G. Priede, and J. French. 1991. Satellite tracking of a loggerhead turtle (*Caretta caretta*) in the Mediterranean. Journal of the Marine Biological Association of the United Kingdom 71:743-746.

Hays, G.C., P. Luschi, F. Papi, C. Del Seppia, and R. Marsh. 1999. Changes in behaviour during the inter-nesting period and post-nesting migration for Ascension Island green turtles. Marine Ecology Progress Series 189:263-273.

Hays, G.C., F. Glen, A.C. Broderick, B.J. Godley, and J.D. Metcalfe. 2002a. Behavioural plasticity in a large marine herbivore: Contrasting patterns of depth utilisation between two green turtle (*Chelonia mydas*) populations. Marine Biology 141:985-990.

Hays, G.C., V.J. Hobson, J.D. Metcalfe, D. Righton, and D.W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. Ecology 87:2647-2656.

Hays, G.C., A.C. Broderick, F. Glen, B.J. Godley, J.D.R. Houghton, and J.D. Metcalfe. 2002b. Water temperature and internesting intervals for loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles. Journal of Thermal Biology 27:429-432.

Hays, G.C., J.D.R. Houghton, C. Isaacs, R.S. King, C. Lloyd, and P. Lovell. 2004c. First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. Animal Behaviour 67:733-743.

Hays, G.C., C.R. Adams, A.C. Broderick, B.J. Godley, D.J. Lucas, J.D. Metcalfe, and A.A. Prior. 2000. The diving behaviour of green turtles at Ascension Island. Animal Behaviour 59:577-586.

Hays, G.C., A.C. Broderick, B.J. Godley, P. Lovell, C. Martin, B.J. McConnell, and S. Richardson. 2002c. Biphasal long-distance migration in green turtles. Animal Behaviour 64:895-898.

Heithaus, M.R., A. Frid, and L.M. Dill. 2002. Shark-inflicted injury frequencies, escape ability, and habitat use of green and loggerhead turtles. Marine Biology 140:229-236.

Henwood, T.A. 1987. Movements and seasonal changes in loggerhead turtle *Caretta caretta* aggregations in the vicinity of Cape Canaveral, Florida (1978-84). Biological Conservation 40:191-202.

Henwood, T.A. and L.H. Ogren. 1987. Distribution and migrations of immature Kemp's ridley turtles (*Lepidochelys kempi*) and green turtles (*Chelonia mydas*) off Florida, Georgia, and South Carolina. Northeast Gulf Science 9(2):153-159.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). Biological Report 97(1). Washington, D.C.: U.S. Fish and Wildlife Service

Hirth, H.F. and L.H. Ogren. 1987. Some aspects of the ecology of the leatherback turtle *Dermochelys coriacea* at Laguna Jalova, Costa Rica. NOAA Technical Report NMFS 56:1-14.

Hochscheid, S., F. Bentivegna, and G.C. Hays. 2005. First records of dive durations for a hibernating sea turtle. Biology Letters 1:82-86.

Hochscheid, S., B.J. Godley, A.C. Broderick, and R.P. Wilson. 1999. Reptilian diving: Highly variable dive patterns in the green turtle *Chelonia mydas*. Marine Ecology Progress Series 185:101-112.

Hochscheid, S., B.J. Godley, A.C. Broderick, and R.P. Wilson. 2006. Green turtle (*Chelonia mydas)* inter-nesting behaviour in the eastern Mediterranean determined using data-logging devices. Pages 99-101 in Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez-Millán, and L. Sarti-Martínez, eds. Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Houghton, J.D.R., A. Woolmer, and G.C. Hays. 2000. Sea turtle diving and foraging behaviour around the Greek Island of Kefalonia. Journal of the Marine Biological Association of the United Kingdom 80:761-762.

Houghton, J.D.R., M.J. Callow, and G.C. Hays. 2003. Habitat utilization by juvenile hawksbill turtles (*Eretmochelys imbricata*, Linnaeus, 1766) around a shallow water coral reef. Journal of Natural History 37:1269-1280.

Houghton, J.D.R., A.C. Broderick, B.J. Godley, J.D. Metcalfe, and G.C. Hays. 2002. Diving behaviour during the internesting interval for loggerhead turtles *Caretta caretta* nesting in Cyprus. Marine Ecology Progress Series 227:63-70.

Hughes, G.R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. Journal of Experimental Marine Biology and Ecology 229:209-217.

James, M.C. and T.B. Herman. 2001. Feeding of *Dermochelys coriacea* on medusae in the northwest Atlantic. Chelonian Conservation and Biology 4(1):202-205.

James, M.C. and N. Mrosovsky. 2004. Body temperatures of leatherback turtles (*Dermochelys coriacea*) in temperate waters off Nova Scotia, Canada. Canadian Journal of Zoology 82:1302-1306.

James, M.C., R.A. Myers, and C.A. Ottensmeyer. 2005a. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society B: Biological Sciences 272:1547-1555.

James, M.C., S.A. Eckert, and R.A. Myers. 2005b. Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea)*. Marine Biology 147:845-853.

James, M.C., J. Davenport, and G.C. Hays. 2006. Expanded thermal niche for a diving vertebrate: A leatherback turtle diving into near-freezing water. Journal of Experimental Marine Biology and Ecology 335:221-226.

James, M.C., C.A. Ottensmeyer, S.A. Eckert, and R.A. Myers. 2006. Changes in diel diving patterns accompany shifts between northern foraging and southward migration in leatherback turtles. Canadian Journal of Zoology 84:754-765.

Jonsen, I.D., R.A. Myers, and M.C. James. 2007. Identifying leatherback turtle foraging behaviour from satellite telemetry using a switching state-space model. Marine Ecology Progress Series 337:255-264.

Kamezaki, N. 1987. Recapture of the hawksbill turtle, *Eretmochelys imbricata* (Linne), in the Yaeyama Islands, Ryukyu Archipelago. Galaxea 6:17-20.

Karavas, N., K. Georghiou, M. Arianoutsou, and D. Dimopoulos. 2005. Vegetation and sand characteristics influencing nesting activity of *Caretta caretta* on Sekania beach. Biological Conservation 121:177-188.

Karl, S.A. and B.W. Bowen. 1999. Evolutionary significant units versus geopolitical taxonomy: Molecular systematics of an endangered sea turtle (genus *Chelonia*). Conservation Biology 13(5):990-999.

Kaska, Y. 2000. Genetic structure of Mediterranean sea turtle populations. Turkish Journal of Zoology 24:191-197.

Kasparek, M. 1995. The nesting of marine turtles on the coast of Syria. Zoology in the Middle East 11:51-62.

Kasparek, M., B.J. Godley, and A.C. Broderick. 2001. Nesting of the Green Turtle, *Chelonia mydas*, in the Mediterranean: A review of status and conservation needs. Zoology in the Middle East 24:45-74.

Keinath, J.A. and J.A. Musick. 1993. Movements and diving behavior of a leatherback turtle, *Dermochelys coriacea*. Copeia 1993(4):1010-1017.

Keinath, J.A., J.A. Musick, and R.A. Byles. 1987. Aspects of the biology of Virginia's sea turtles: 1979-1986. Virginia Journal of Science 38(2):81.

Lahanas, P.N., K.A. Bjorndal, A.B. Bolten, S.E. Encalada, M.M. Miyamoto, R.A. Valverde, and B.W. Bowen. 1998. Genetic composition of a green turtle (*Chelonia mydas*) feeding ground population: Evidence for multiple origins. Marine Biology 130:345-352.

Landry, A.M., Jr. and D. Costa. 1999. Status of sea turtle stocks in the Gulf of Mexico with emphasis on the Kemp's ridley. Pages 248-268 in Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, Massachusetts: Blackwell Science.

Laurent, L. 1991. Les Tortues marines des côtes françaises méditerranéennes continentales (Marine turtles of the Atlantic and Mediterranean coasts of France). Faune de Provence (CEEP) 7:76–90.

Laurent, L. and J. Lescure. 1991. Hawksbill turtles in the Mediterranean Sea. Marine Turtle Newsletter 54:12-13.

Laurent, L. and J. Lescure. 1994. L'hivernage des tortues Caouannes *Caretta caretta* (L.) dans le sud Tunisien (The wintering of the Mediterranean Loggerhead turtle *Caretta caretta* (L.) in southern Tunisia). Revue d'Ecologie (la Terre et la Vie) 49:63-86.

Laurent, L., E.M. Abd El-Mawla, M.N. Bradai, F. Demirayak, and A. Oruç. 1996. Reducing sea turtle mortality induced by Mediterranean fisheries: Trawling activity in Egypt, Tunisia and Turkey. WWF International Project 9E0103. Prepared for the WWF International Mediterranean Programme.

Laurent, L., P. Casale, M.N. Bradai, B.J. Godley, G. Gerosa, A.C. Broderick, W. Schroth, B. Schierwater, A.M. Levy, D. Freggi, E.M. Abd El-Mawla, D.A. Hadoud, H.E. Gomati, M. Domingo, M. Hadjichristophorou, L. Kornaraky, F. Demirayak, and C. Gautier. 1998. Molecular resolution of marine turtle stock composition in fishery bycatch: A case study in the Mediterranean. Molecular Ecology 7:1529-1542.

Lazar, B., D. Margaritoulis, and N. Tvrtkovic. 2000. Migrations of the loggerhead sea turtle (*Caretta caretta)* into the Adriatic Sea. Pages 101-102 in Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez-Millán, and L. Sarti-Martínez, eds. Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Lazar, B., D. Margaritoulis, and N. Tvrtković. 2004. Tag recoveries of the loggerhead sea turtle *Caretta caretta* in the eastern Adriatic Sea: Implications for conservation. Journal of the Marine Biological Association of the United Kingdom 84:475-480.

Lazar, B., D. Zavodnik, I. Grbac, and N. Tvrtkovic. 2002. Diet composition of the loggerhead sea turtle, *Caretta caretta*, in the northern Adriatic Sea: A preliminary study. Pages 146-147 in Mosier, A., A. Foley, and B. Brost, eds. Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

Lazell, J.D., Jr. 1980. New England waters: Critical habitat for marine turtles. Copeia 1980(2):290-295.

Le Vin, D.A., A.C. Broderick, and B.J. Godley. 1998. Effects of off-shore features on the emergence point of marine turtles in Northern Cyprus. Pages 91-92 in Byles, R. and Y. Fernandez, eds. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.

Lee, D.S. and W.M. Palmer. 1981. Records of leatherback turtles, *Dermochelys coriacea* (Linnaeus), and other marine turtles in North Carolina waters. Brimleyana 5:95-106.

Lenhardt, M. 2002. Sea turtle auditory behavior. Journal of the Acoustical Society of America 112(5, Part 2):2314.

Lenhardt, M.L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pages 238-241 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Lenhardt, M.L., S. Bellmund, R.A. Byles, S.W. Harkins, and J.A. Musick. 1983. Marine turtle reception of bone-conducted sound. Journal of Auditory Research 23:119-125.

León, Y.M. and K. Bjorndal. 2002. Selective feeding in the hawksbill turtle, an important predator in coral reef ecosystems. Marine Ecology Progress Series 245:249-258.

Llorente, G.A., M.A. Carretero, X. Pascual, and A. Perez. 1992/93. New record of a nesting loggerhead turtle *Caretta caretta* in western Mediterranean. British Herpetological Society Bulletin 42:14-17.

Lohmann, K.J., J.T. Hester, and C.M.F. Lohmann. 1999. Long-distance navigation in sea turtles. Ethology Ecology & Evolution 11:1-23.

Lohmann, K.J., B.E. Witherington, C.M.F. Lohmann, and M. Salmon. 1997. Orientation, navigation, and natal beach homing in sea turtles. Pages 107-136 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Luschi, P., G.C. Hays, and F. Papi. 2003. A review of long-distance movements by marine turtles, and the possible role of ocean currents. Oikos 103:293-302.

Lutcavage, M. and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985(2):449-456.

Lutcavage, M.E. and P.L. Lutz. 1997. Diving physiology. Pages 277-296 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Lutz, P.L. and J.A. Musick, eds. 1997. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Lutz, P.L., J.A. Musick, and J. Wyneken, eds. 2003. The biology of sea turtles, Volume 2. Boca Raton, Florida: CRC Press.

Maffucci, F., W.H.C.F. Kooistra, and F. Bentivegna. 2006. Natal origin of loggerhead turtles, *Caretta caretta,* in the neritic habitat off the Italian coasts, Central Mediterranean. Biological Conservation 127:183-189.

Manzella, S., J. Williams, B. Schroeder, and W. Teas. 1991. Juvenile head-started Kemp's ridleys found in floating grass mats. Marine Turtle Newsletter 52:5-6.

Manzella, S.A. and C.T. Fontaine. 1988. Loggerhead sea turtle travels from Padre Island, Texas to the mouth of the Adriatic Sea. Marine Turtle Newsletter 42:7.

Marcovaldi, M.Â. and A. Fillippini. 2001. Trans-Atlantic movement by a juvenile hawksbill turtle. Marine Turtle Newsletter 52:3.

Margaritoulis, D. 1982. Observations on loggerhead sea turtle *Caretta caretta* activity during three nesting seasons (1977-1979) in Zakynthos, Greece. Biological Conservation 24:193-204.

Margaritoulis, D. 1988. Post-nesting movements of loggerhead sea turtles tagged in Greece. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 31(2):283-284.

Margaritoulis, D. 1998. In the Island of Crete: A new nesting area of the loggerhead turtle in the Mediterranean. Pages 98-100 in Byles, R. and Y. Fernandez, eds. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.

Margaritoulis, D. 2003. The status of marine turtles in the Mediterranean. Pages 51-61 in Margaritoulis, D. and A. Demetropoulos, eds. Proceedings, First Mediterranean Conference on Marine Turtles. 24-28 October 2001. Rome, Italy.

Margaritoulis, D. 2005. Nesting activity and reproductive output of loggerhead sea turtles, C*aretta caretta,* over 19 seasons (1984-2002) at Laganas Bay, Zakynthos, Greece: The largest rookery in the Mediterranean. Chelonian Conservation and Biology 4(4):916-929.

Margaritoulis, D. and K. Teneketzis. 2003. Identification of a developmental habitat of the green turtle in Lakonikos Bay, Greece. Pages 170-175 in Margaritoulis, D. and A. Demetropoulos, eds.

Proceedings, First Mediterranean Conference on Marine Turtles. 24-28 October 2001. Rome, Italy.

Margaritoulis, D., R. Argano, I. Baran, F. Bentivegna, M.N. Bradai, J.A. Camiñas, P. Casale, G. De Metrio, A. Demetropoulos, G. Gerosa, B.J. Godley, D.A. Haddoud, J. Houghton, L. Laurent, and B. Lazar. 2003. Loggerhead turtles in the Mediterranean Sea: Present knowledge and conservation perspectives. Pages 175-198 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Margaritoulis, D.N. 1986. Captures and strandings of the leatherback sea turtle, *Dermochelys coriacea*, in Greece (1982-1984). Journal of Herpetology 20(3):471-474.

Márquez-M., R. 1990. FAO species catalogue: Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date. FAO Fisheries Synopsis. No. 125, Volume11. Rome, Italy: Food and Agriculture Organization of the United Nations.

Márquez-M., R., P.M. Burchfield, J. Díaz-F., M. Sánchez-P., M. Carrasco-A., C. Jiménez-Q., A. Leo-P., R. Bravo-G., and J. Peña-V. 2005. Status of the Kemp's ridley sea turtle, *Lepidochelys kempii*. Chelonian Conservation and Biology 4(4):761-766.

Marquez-M., R., compiler. 1994. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempi* (Garman, 1880). NOAA Technical Memorandum NMFS-SEFSC-343:1-91.

Mast, R.B., J.A. Seminoff, B.J. Hutchinson, and N.J. Pilcher. 2006. The role of the IUCN Marine Turtle Specialist Group in setting priorities for sea turtle conservation. Marine Turtle Newsletter 113:16-18.

Mazaris, A.D., E. Kornaraki, Y.G. Matsinos, and D. Margaritoulis. 2004. Modeling the effect of sea surface temperature on sea turtle nesting activities by investigating seasonal trends. Natural Resource Modeling 17(4):445-465.

McCarthy, A.L. 2006. Defining habitat preferences of pelagic loggerhead sea turtles (*Caretta caretta*) in the North Atlantic through analysis of behavior and bycatch. Master's thesis, Oregon State University.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Bentley, Australia: Curtin University of Technology, Centre for Marine Science and Technology.

McClellan, C.M., C.G. Hudson, and A.J. Read. 2007. Use of oceanic habitats by loggerhead sea turtles (*Caretta caretta*). Pages 77-78 in Abstracts, Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. 22-28 February 2007. Myrtle Beach, South Carolina.

McDonald, D.L. and P.H. Dutton. 1996. Use of PIT tags and photoidentification to revise remigration estimates of leatherback turtles (*Dermochelys coriacea*) nesting in St. Croix, U.S. Virgin Islands, 1979-1995. Chelonian Conservation and Biology 2(2):148-152.

McMahon, C.R. and G.C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12:1-9.

Mellgren, R.L., M.A. Mann, M.E. Bushong, S.R. Harkins, and V.K. Krumke. 1994. Habitat selection in three species of captive sea turtle hatchlings. Pages 259-261 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Mendonça, M.T. and P.C.H. Pritchard. 1986. Offshore movements of post-nesting Kemp's ridley sea turtles (*Lepidochelys kempi*). Herpetologica 42:373-381.

Meylan, A. 1995. Sea turtle migration - evidence from tag returns. Pages 91-100 in Bjorndal, K.A., ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the state of Florida, 1979-1992. Florida Marine Research Publications No. 52. St. Petersburg, Florida: Florida Department of Natural Resources.

Meylan, A., P. Castaneda, C. Coogan, T. Lozon, and J. Fletemeyer. 1990. First recorded nesting by Kemp's ridley in Florida, USA. Marine Turtle Newsletter 48:8-9.

Meylan, A.B. 1988. Spongivory in hawksbill turtles: A diet of glass. Science 239:393-395.

Meylan, A.B. 1999. International movements of immature and adult hawksbill turtles (*Eretmochelys imbricata*) in the Caribbean region. Chelonian Conservation and Biology 3(2):189-194.

Meylan, A.B. and M. Donnelly. 1999. Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 *IUCN Red List of Threatened Animals*. Chelonian Conservation and Biology 3(2):200-224.

Miller, J.D. 1997. Reproduction in sea turtles. Pages 51-81 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Mingozzi, T., G. Masciari, G. Paolillo, B. Pisani, M. Russo, and A. Massolo. 2006. Discovery of regular nesting area of loggerhead turtle *Caretta caretta* in southern Italy: A new perspective for national conservation. Biodiversity and Conservation DOI 10.1007/s10531-006-9098-6.

Moein Bartol, S. and D.R. Ketten. 2006. Turtle and tuna hearing. Pages 98-103 in Swimmer, Y. and R. Brill, eds. Sea turtle and pelagic fish sensory biology: Developing techniques to reduce sea turtle bycatch in longline fisheries. NOAA Technical Memorandum NMFS-PIFSC-7.

Moein Bartol, S., J.A. Musick, and M.L. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 1999(3):836-840.

Moon, D.-Y., D.S. MacKenzie, and D.W. Owens. 1997. Simulated hibernation of sea turtles in the laboratory: I. Feeding, breathing frequency, blood pH, and blood gases. Journal of Experimental Zoology 278:372-380.

Morreale, S.J. and E.A. Standora. 2005. Western North Atlantic waters: Crucial developmental habitat for Kemp's ridley and loggerhead sea turtles. Chelonian Conservation and Biology 4(4):872-882.

Morreale, S.J., A. Meylan, and B. Baumann. 1989. Sea turtles in Long Island Sound, New York: An historical perspective. Pages 121-123 in Eckert, S.A., K.L. Eckert, and T.H. Richardson, eds. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Morreale, S.J., A.B. Meylan, S.S. Sadove, and E.A. Standora. 1992. Annual occurrence and winter mortality of marine turtles in New York waters. Journal of Herpetology 26:301-308.

Morreale, S.J., E.A. Standora, J.R. Spotila, and F.V. Paladino. 1996. Migration corridor for sea turtles. Nature 384:319-320.

Morreale, S.J., P.T. Plotkin, D.J. Shaver, and H.J. Kalb. 2007. Adult migration and habitat utilization: Ridley turtles in their element. Pages 213-229 in Plotkin, P., ed. Biology and conservation of ridley sea turtles. Baltimore, Maryland: Johns Hopkins University Press.

Mortimer, J.A. 1995. Feeding ecology of sea turtles. Pages 103-109 in Bjorndal, K.A., ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Mrosovsky, N. 1972. Spectrographs of the sounds of leatherback turtles. Herpetologica 28:256-258.

Mrosovsky, N. 1980. Thermal biology of sea turtles. American Zoologist 20(3):531-547.

Mrosovsky, N. 2006. Does the Mediterranean green turtle exist? Marine Turtle Newsletter 111:1-2.

Mrosovsky, N. and P.C.H. Pritchard. 1971. Body temperatures of *Dermochelys coriacea* and other sea turtles. Copeia 1971(4):624-631.

Musick, J.A. and C.J. Limpus. 1997. Habitat utilization and migration of juvenile sea turtles. Pages 137-163 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Myers, A.E. and G.C. Hays. 2006. Do leatherback turtles *Dermochelys coriacea* forage during the breeding season? A combination of data-logging devices provide new insights. Marine Ecology Progress Series 322:259-267.

Nada, M.A. 2001. Observations on the trade in sea turtles at the fish market of Alexandria, Egypt. Zoology in the Middle East 24:109-118.

Nannarelli, S., A. De Lucia, A. Dominici, and S. Piovao. 2006. Nesting activity of the loggerhead sea turtle *Caretta caretta* on the pocket beach of Linosa Island (south of Italy): Recent data (2004-2005). Page 309 in Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. 3-8 April 2006. Island of Crete, Greece.

Narazaki, T., K. Sato, and N. Miyazaki. 2006. Fine-scale diving behaviour of migrating turtles revealed by auto releasing logger system. Pages 107-108 in Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. 3-8 April 2006. Island of Crete, Greece.

Neill, W.H. and E.D. Stevens. 1974. Thermal inertia versus thermoregulation in "warm" turtles and tunas. Science 184:1008-1010.

Nichols, W.J., P.H. Dutton, J.A. Seminoff, E. Bixby, F.A. Abreu, and A. Resendiz. 2000. *Poi* or *papas*: Do Hawaiian and Mexican green turtles feed together in Baja California waters? Pages 14-15 in

Kalb, H. and T. Wibbels, eds. Proceedings of the Nineteenth Annual Symposium on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-443.

NMFS-SEFSC (National Marine Fisheries Service-Southeast Fisheries Science Center). 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455:1-343.

NMFS (National Marine Fisheries Service). 1979. Determination of critical habitat for the leatherback sea turtle. Federal Register 44(58):17710-17712.

NMFS (National Marine Fisheries Service). 1998. Designated critical habitat; green and hawksbill sea turtles. Final rule. Federal Register 63(170):46693-46701.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1991a. Recovery plan for U.S. population of Atlantic green turtle. Washington, D.C.: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1991b. Recovery plan for U.S. population of loggerhead turtle. Washington, D.C.: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. Washington, D.C.: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1993. Recovery plan for hawksbill turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. St. Petersburg, Florida: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1998a. Recovery plan for U.S. Pacific populations of the leatherback turtle (*Dermochelys coriacea*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1998b. Recovery plan for U.S. Pacific populations of the loggerhead turtle (*Caretta caretta*). Silver Spring, Maryland: National Marine Fisheries Service.

O'Hara, J. and J.R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia 1990(2):564-567.

Ocana, O., A.G. de los Rios, and L. Huertos. 2005. A new foraging area for *Caretta caretta* in the Mediterranean Sea: The crab *Polybius henslowii* (*Decapoda: Brachyura*) as a main food resource from north west Africa. Page 33 in Abstracts, Second Mediterranean Conference on Marine Turtles. 4-7 May 2005. Kemer, Antalya, Turkey.

Ogren, L. and C. McVea, Jr. 1982. Apparent hibernation by sea turtles in North American waters. Pages 127-132 in Bjorndal, K.A., ed. Biology and conservation of sea turtles. Washington, D.C.: Smithsonian Institution Press.

Oliver, G. and A. Pigno. 2005. Première observation d'une Tortue de Kemp, *Lepidochelys kempii* (Garman, 1880), (Reptilia, Chelonii, Cheloniidae) sur les côtes françaises de Méditerranée. Bulletin de la Société Herpétologique de France 116:31-38.

Oruç, A. 2001. Trawl fisheries in the eastern Mediterranean and their impact on marine turtles. Zoology in the Middle East 24:119-125.

Paladino, F.V., M.P. O'Connor, and J.R. Spotila. 1990. Metabolism of leatherback turtles, gigantothermy and thermoregulation of dinosaurs. Nature 344:858-860.

Parker, L.G. 1995. Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. Marine Turtle Newsletter 71:19-22.

Pascual, X. 1985. Contribución al estudio de las tortugas marinas en las costas españolas. I. Distribución (Contributions to the studies of marine turtles on the Spanish coast. I. Distribution). Miscellania Zoologica 9:287-294.

Pilcher, N. and J. Miller. 2007. Sea turtles in the Middle East. SWOT Report-State of the World's Sea Turtles 2:28-29.

Polovina, J., I. Uchida, G. Balazs, E.A. Howell, D. Parker, and P. Dutton. 2006. The Kuroshio Extension Bifurcation Region: A pelagic hotspot for juvenile loggerhead sea turtles. Deep-Sea Research II 53:326-339.

Polovina, J.J., E. Howell, D.M. Parker, and G.H. Balazs. 2003. Dive-depth distribution of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin 101(1):189-193.

Pritchard, P.C.H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea* in Pacific Mexico, with a new estimate of the world population status. Copeia 1982(4):741-747.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. Pages 1-28 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Rees, A.F. and D. Margaritoulis. 2005. International migration of loggerhead turtles from Greece to Turkey and Libya tracked by satellite. Page 37 in Abstracts, Second Mediterranean Conference on Marine Turtles. 4-7 May 2005. Kemer, Antalya, Turkey.

Rees, A.F. and M. Jony. 2007. The first satellite tracking of a sea turtle from Syria: The post-nesting migration of a green sea turtle (*Chelonia mydas*). Page 86 in Abstracts, Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. 22-28 February 2007. Myrtle Beach, South Carolina.

Rees, A.F., A. Saad, and M. Jony. 2005. Tagging green turtles (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*) in Syria. Testudo 6(2):51-55.

Renaud, M.L. 1995. Movements and submergence patterns of Kemp's ridley turtles (*Lepidochelys kempii*). Journal of Herpetology 29:370-374.

Renaud, M.L. and J.A. Carpenter. 1994. Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. Bulletin of Marine Science 55:1-15.

Renaud, M.L. and J.A. Williams. 2005. Kemp's ridley sea turtle movements and migrations. Chelonian Conservation and Biology 4(4):808-816.

Revelles, M., L. Cardona, A. Aguilar, M. San Félix, and G. Fernández. 2007. Habitat use by immature loggerhead sea turtles in the Algerian Basin (western Mediterranean): Swimming behaviour, seasonality and dispersal pattern. Marine Biology 151:1501–1515.

Revelles, M., L. Cardona, J.J. Bellido, J.A. Camiñas, M.L. Parga, J. Tómas, F. Alegre, A. Raga, A. Aguilar, A. Bertolero, and G. Oliver. 2007 Limited exchange of immature loggerhead sea turtles between adjoining Mediterranean basins revealed by tagging and stable isotopes. Pages 160-161 in Abstracts, Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. 22-28 February 2007. Myrtle Beach, South Carolina.

Richardson, J.I. and P. McGillivary. 1991. Post-hatchling loggerhead turtles eat insects in *Sargassum* community. Marine Turtle Newsletter 55:2-5.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonia mydas*. Proceedings of the National Academy of Sciences of the United States of America 64:884-890.

Roberts, M.A., T.S. Schwartz, and S.A. Karl. 2004. Global population genetic structure and male-mediated gene flow in the green sea turtle (*Chelonia mydas):* Analysis of microsatellite loci. Genetics 166:1857-1870.

Ross, J.P. and M.A. Barwani. 1995. Review of sea turtles in the Arabian Sea. Pages 373-383 in Bjorndal, K.A., ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Rostal, D.C. 2005. Seasonal reproductive biology of the Kemp's ridley sea turtle (*Lepidochelys kempii*): Comparison of captive and wild populations. Chelonian Conservation and Biology 4:788-800.

Rostal, D.C. 2007. Reproductive physiology of the ridley sea turtle. Pages 151-165 in Plotkin, P., ed. Biology and conservation of ridley sea turtles. Baltimore, Maryland: Johns Hopkins University Press.

Russo, G., P. Gianguzza, and B. Zava. 1999. Osservazioni sulla dieta di *Caretta caretta* (Linnaeus, 1758) in Mediterraneo (Observations on the diet of *Caretta caretta* (Linnaeus, 1758) in the Mediterranean Sea). Biologia Marina Mediterranea 6(1):602-604.

Sakamoto, W., I. Uchida, Y. Naito, K. Kureha, M. Tujimura, and K. Sato. 1990. Deep diving behavior of the loggerhead turtle near the frontal zone. Nippon Suisan Gakkaishi 56(9):1435-1443.

Sale, A., P. Luschi, R. Mencacci, P. Lambardi, G.R. Hughes, G.C. Hays, S. Benvenuti, and F. Papi. 2006. Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. Journal of Experimental Marine Biology and Ecology 328:197-210.

Salmon, M., T.T. Jones, and K.W. Horch. 2004. Ontogeny of diving and feeding behavior in juvenile seaturtles: Leatherback seaturtles (*Dermochelys coriacea* L) and green seaturtles (*Chelonia mydas* L) in the Florida Current. Journal of Herpetology 38(1):36-43.

Sasso, C.R. and W.N. Witzell. 2006. Diving behaviour of an immature Kemp's ridley turtle (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, south-west Florida. Journal of the Marine Biological Association of the United Kingdom 86:919-925.

Schmid, J.R., A.B. Bolten, K.A. Bjorndal, and W.J. Lindberg. 2002. Activity patterns of Kemp's ridley turtles, *Lepidochelys kempii*, in the coastal waters of the Cedar Keys, Florida. Marine Biology 140:215-228.

Schofield, G., K.A. Katselidis, P. Dimopoulos, J.D. Pantis, and G.C. Hays. 2006. Behaviour analysis of the loggerhead sea turtle *Caretta caretta* from direct in-water observation. Endangered Species Research 2:71-79.

Schofield, G., K.A. Katselidis, J.D. Pantis, P. Dimopoulos, and G.C. Hays. 2007. Female-female aggression: Structure of interaction and outcome in loggerhead sea turtles. Marine Ecology Progress Series 336:267-274.

Schroeder, B.A. and N.B. Thompson. 1987. Distribution of the loggerhead turtle, *Caretta caretta*, and the leatherback turtle, *Dermochelys coriacea*, in the Cape Canaveral, Florida area: Results of aerial surveys. Pages 45-53 in Witzell, W.N., ed. Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop. NOAA Technical Report NMFS 53.

Schroeder, B.A., A.M. Foley, and D.A. Bagley. 2003. Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. Pages 114-124 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Schroeder, B.A., L.M. Ehrhart, J.L. Guseman, R.D. Owen, and W.E. Redfoot. 1989. Cold stunning of marine turtles in the Indian River Lagoon system, Florida, December 1989. Pages 67-69 in Eckert, S.A., K.L. Eckert, and T.H. Richardson, eds. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Schroth, W., B. Streit, and B. Schierwater. 1996. Evolutionary handicap for turtles. Nature 384:521-522.

Schwartz, F.J. 1978. Behavioral and tolerance responses to cold water temperatures by three species of sea turtles (Reptilia, Cheloniidae) in North Carolina. Pages 16-18 in Henderson, G.E., ed. Proceedings of the Florida and Interregional Conference on Sea Turtles, 24-25 July 1976, Jensen Beach, Florida. Florida Marine Research Publications No. 33. St. Petersburg, Florida: Florida Department of Natural Resources.

Schwartz, F.J. 1989. Biology and ecology of sea turtles frequenting North Carolina. Pages 307-331 in George, R.Y. and A.W. Hulbert, eds. North Carolina Coastal Oceanography Symposium. National Undersea Research Program Research Report 89-2. Silver Spring, Maryland: National Oceanic and Atmospheric Administration.

Seminoff, J.A. and MTSG (Marine Turtle Specialist Group) Green Turtle Task Force. 2004. Marine Turtle Specialist Group review: 2004 global status assessment, green turtle (*Chelonia mydas*). Prepared for the IUCN SCC (The World Conservation Union Species Survival Commission) Red List Authority.

Seney, E.E. and J.A. Musick. 2005. Diet analysis of Kemp's ridley sea turtles *(Lepidochelys kempii)* in Virginia. Chelonian Conservation and Biology 4(4):864-871.

Shaver, D.J. and T. Wibbels. 2007. Head-starting the Kemp's ridley sea turtle. Pages 297-323 in Plotkin, P., ed. Biology and conservation of ridley sea turtles. Baltimore, Maryland: Johns Hopkins University Press.

Shaver, D.J., A.F. Amos, B. Higgins, and J. Mays. 2005. Record 42 Kemp's ridley nests found in Texas in 2004. Marine Turtle Newsletter 108:1-3.

Shoop, C.R. and R.D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

Snover, M.L., A.A. Hohn, L.B. Crowder, and S.S. Heppell. 2007. Age and growth in Kemp's ridley sea turtles: Evidence from mark-recapture and skeletochronology. Pages 89-105 in Plotkin, P., ed. Biology and conservation of ridley sea turtles. Baltimore, Maryland: Johns Hopkins University Press.

Southwood, A.L., R.D. Andrews, F.V. Paladino, and D.R. Jones. 2005. Effects of diving and swimming behavior on body temperatures of Pacific leatherback turtles in tropical seas. Physiological and Biochemical Zoology 78(2):285-297.

Southwood, A.L., R.D. Andrews, M.E. Lutcavage, F.V. Paladino, N.H. West, R.H. George, and D.R. Jones. 1999. Heart rates and diving behavior of leatherback sea turtles in the eastern Pacific Ocean. Journal of Experimental Biology 202:1115-1125.

Spotila, J.R., M.P. O'Connor, and F.V. Paladino. 1997. Thermal biology. Pages 297-314 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):209-222.

Starbird, C.H., Z. Hillis-Starr, J.T. Harvey, and S.A. Eckert. 1999. Internesting movements and behavior of hawksbill turtles (*Eretmochelys imbricata*) around Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Chelonian Conservation and Biology 3(2):237-243.

Sternberg, J., compiler. 1981. The worldwide distribution of sea turtle nesting beaches. Washington, D.C.: Center for Environmental Education.

Still, B.M., C.R. Griffin, and R. Prescott. 2005. Climatic and oceanographic factors affecting daily patterns of juvenile sea turtle cold-stunning in Cape Cod Bay, Massachusetts. Chelonian Conservation and Biology 4(4):883-890.

Storch, S., R.P. Wilson, Z.-M. Hillis-Starr, and D. Adelung. 2005. Cold-blooded divers: Temperature-dependent dive performance in the wild hawksbill turtle *Eretmochelys imbricata*. Marine Ecology Progress Series 293:263-271.

Storch, S., G.C. Hays, Z. Hillis-Starr, and R.P. Wilson. 2006. The behaviour of a hawksbill turtle data-logged during the passage of Hurricane Georges through the Caribbean. Marine and Freshwater Behaviour and Physiology 39(4):307-313.

Taşkavak, E. and B. Farkas. 1998. On the occurrence of the Leatherback Turtle, *Dermochelys coriacea,* in Turkey (Testudines: Dermochelyidae). Zoology in the Middle East 16:71-75.

TEWG (Turtle Expert Working Group). 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-444:1-115.

TEWG (Turtle Expert Working Group). 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555:1-116.

The SWOT Team. 2007a. Worldwide leatherback nesting sites. SWOT Report-State of the World's Sea Turtles 2:18-19.

The SWOT Team. 2007b. Worldwide loggerhead nesting sites 2005. SWOT Report-State of the World's Sea Turtles 2:24-25.

Thompson, N.B., J.R. Schmid, S.P. Epperly, M.L. Snover, J. Braun-McNeill, W.N. Witzell, W.G. Teas, L.A. Csuzdi, and R.A. Myers. 2001. Stock assessment of leatherback sea turtles of the western North Atlantic. Pages 67-104 in NMFS-SEFSC (National Marine Fisheries Service-Southeast Fisheries Science Center), ed. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (*Dermochelys coriacea*) from Labrador. Canadian Field-Naturalist 92(3):287.

Tomas, J., F.J. Aznar, and J.A. Raga. 2001a. Feeding ecology of the loggerhead turtle *Caretta caretta* in the western Mediterranean. Journal of Zoology, London 255:525-532.

Tomas, J., A. Dominici, S. Nannarelli, L. Forni, F.J. Badillo, and J.A. Raga. 2001b. From hook to hook: The odyssey of a loggerhead sea turtle in the Mediterranean. Marine Turtle Newsletter 92:13-14.

Tomás, J. and J.A. Raga. 2007. Occurrence of Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean. JMBA2-Biodiversity Records: http://www.mba.ac.uk/jmba/jmba2biodiversityrecords.php.

Tomás, J., A. Formia, M. Fernández, and J.A. Raga. 2003. Occurrence and genetic analysis of a Kemp's Ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean Sea. Scientia Marina 67(3):367-369.

Tomás, J., J.L. Mons, J.J. Martín, J.J. Bellido, and J.J. Castillo. 2002. Study of the first reported nest of loggerhead sea turtle, *Carretta caretta*, in the Spanish Mediterranean coast. Journal of the Marine Biological Association of the United Kingdom 82:1005-1007.

Travaglini, A., G. Treglia, G. De Martino, and F. Bentivegna. 2006. Preliminary observations on dietary habits of leatherback turtles found in the mid-southern Tyrrhenian Sea, Italy. Page 205 in Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. 3-8 April 2006. Island of Crete, Greece.

Türkozan, O. and S.H. Durmus. 2000. A feeding ground for juvenile green turtles, *Chelonia mydas*, on the western coast of Turkey. British Herpetological Society Bulletin 71:1-5.

USFWS (U.S. Fish and Wildlife Service). 2005. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas and Veracruz, Mexico. 2005. Prepared by Gladys Porter Zoo, Secretaria de Medio Ambiente y Recursos Naturales, and Secretaria de Obras Publicas Desarrollo Urbano y Ecologia.

USFWS (U.S. Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). St. Petersburg, Florida: National Marine Fisheries Service.

Vagg, R. and H. Hepworth. 2006. Migratory species and climate change: Impacts of a changing environment on wild animals. Bonn, Germany: United Nations Environment Programme and the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals.

Van Dam, R.P. and C.E. Diez. 1996. Diving behavior of immature hawksbills (*Eretmochelys imbricata*) in a Caribbean cliff-wall habitat. Marine Biology 127:171-178.

Vogt, R.G., M. Vieyra, and D. Anderson. 2002. New discoveries in the olfactory capability of sea turtles. PFRP Newsletter 7(2):6-9.

Wallace, B.P., C.L. Williams, F.V. Paladino, S.J. Morreale, R.T. Lindstrom, and J.R. Spotila. 2005. Bioenergetics and diving activity of internesting leatherback turtles *Dermochelys coriacea* at Parque Nacional Marino Las Baulas, Costa Rica. Journal of Experimental Biology 208:3873-3884.

Weber, M. 1995. Kemp's ridley sea turtle, *Lepidochelys kempii*. Pages 109-122 in Plotkin, P.T., ed. Status reviews of sea turtles listed under the Endangered Species Act of 1973. Silver Spring, Maryland: National Marine Fisheries Service.

Weishampel, J.F., D.A. Bagley, and L.M. Ehrhart. 2004. Earlier nesting by loggerhead sea turtles following sea surface warming. Global Change Biology 10:1424-1427.

White, M. 2004. Observations of loggerhead turtles feeding on discarded fish catch at Argostoli, Kefalonia. Marine Turtle Newsletter 105:7-9.

Whittow, G.C. and G.H. Balazs. 1982. Basking behavior of the Hawaiian green turtle (*Chelonia mydas*). Pacific Science 36(2):129-139.

Wibbels, T. 1983. A transatlantic movement of a headstarted Kemp's ridley. Marine Turtle Newsletter 24:15-16.

Williams, K.L., M.G. Frick, and J.B. Pfaller. 2006. First report of green, *Chelonia mydas,* and Kemp's ridley, *Lepidochelys kempii* turtle nesting on Wassaw Island, Georgia, USA. Marine Turtle Newsletter 113:8.

Witherington, B. 2007. The mystery of lost little turtles: Where do sea turtles spend their first years of life? SWOT Report-State of the World's Sea Turtles 2:7-8.

Witherington, B. and S. Hirama. 2006. Sea turtles of the epi-pelagic sargassum drift community. Page 209 in Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. 3-8 April 2006. Island of Crete, Greece.

Witherington, B.E. 1994. Flotsam, jetsam, post-hatchling loggerheads, and the advecting surface smorgasbord. Pages 166-168 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Witherington, B.E. and R.E. Martin. 2003. Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. Florida Marine Research Institute Technical Report TR-2. 3rd ed. rev. St. Petersburg, Florida: Florida Fish and Wildlife Conservation Commission.

Witzell, W.N. 1983. Synopsis of biological data on the hawksbill turtle *Eretmochelys imbricata* (Linnaeus, 1766). FAO Fisheries Synopsis 137. Rome, Italy: Food and Agriculture Organization of the United Nations.

Witzell, W.N., A. Salgado-Quintero, and M. Garduño-Dionte. 2005. Reproductive parameters of the Kemp's ridley sea turtle *(Lepidochelys kempii)* at Rancho Nuevo, Tamaulipas, Mexico. Chelonian Conservation and Biology 4(4):781-787.

WWF (World Wildlife Fund). 2005. WWF's species action plan for the conservation of marine turtles in the Mediterranean Sea. World Wildlife Fund.

Wyneken, J. 1997. Sea turtle locomotion: Mechanics, behavior, and energetics. Pages 165-198 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Yalçin-Özdilek, Ş. and M. Aureggi. 2006. Strandings of juvenile green turtles at Samandağ, Turkey. Chelonian Conservation and Biology 5(1):152-154.

Zbinden, J.A., A. Aebischer, D. Margaritoulis, and R. Arlettaz. 2007. Insights into management of sea turtle internesting area through satellite telemetry. Biological Conservation 137:157-162.

Zbinden, J.A., A. Aebischer, A.F. Rees, D. Margaritoulis, and R. Arlettaz. 2005. Post-nesting movements of loggerhead sea turtles from a major Mediterranean nesting area assessed by satellite telemetry. Page 45 in Abstracts, Second Mediterranean Conference on Marine Turtles. 4-7 May 2005. Kemer, Antalya, Turkey.

Zug, G.R., H.J. Kalb, and S.J. Luzar. 1997. Age and growth in wild Kemp's ridley seaturtles *Lepidochelys kempii* from skeletochronological data. Biological Conservation 80:261-268.

4.0 HABITATS OF THE EASTERN MEDITERRANEAN SEA STUDY AREA

4.1 INTRODUCTION

The Mediterranean Sea consists of the western (approximately 0.85 million km^2) and eastern (approximately 1.65 million km^2) basins which are separated by the Strait of Sicily (Sardà et al. 2004). The Mediterranean Sea is connected to the Atlantic Ocean by the relatively narrow Strait of Gibraltar, to the Sea of Marmara by the Strait of Dardanelles, and the Red Sea by the Canal of Suez. Average water depth of the Mediterranean Sea is 1,500 m. Water depths of the Mediterranean Sea reach 5,121 m in the eastern Mediterranean Sea (Matapan-Vavilov Deep, off the southern coast of Greece). The deep sea physiography and biocenoses are more diversified in the eastern basin compared to the western basin (Fredj and Laubier 1985; Sardà et al. 2004).

With the exception of areas adjacent to large rivers (e.g., Rhône River, Nile River), waters of the Mediterranean Sea are typically oligotrophic, particularly in the eastern Mediterranean Sea (Fredj and Laubier 1985; WWF/IUCN 2004). More than half of the Mediterranean Sea coastline is rocky. The continental shelf is typically narrow, covers less than 25% of the total seafloor area, and supports ecosystems of high ecological value including seagrass beds (*Posidonia oceanica*; Pasqualini et al. 1998a; Sardà et al. 2004).

The Mediterranean biota are mostly derived from Atlantic Ocean species. There is a relatively high level of endemism in the Mediterranean Sea compared to the nearby Atlantic Ocean (Cinelli 1985; Fredj and Laubier 1985; Torcu and Mater 2000). Incursions of invasive species from the Ponto-Caspian region and Lessepsian migrants from the Red Sea have modified the fauna and flora of the western and eastern Mediterranean basins (Torcu and Mater 2000; Flagella and Abdulla 2005).

The eastern Mediterranean Study Area encompasses three main habitat regions (physiographic provinces), continental shelf, continental slope, and abyssal plain (**Figure 4-1**). Parts of the continental shelf are part of the Study Area, and most of the continental slope and abyssal plain are contained within the Study Area. Main areas of the shelf that are contained within the Study Area are the Strait of Sicily; and the area between Sicily and Malta. The Study Area and the Strait of Sicily have a 4,987 km^2 overlap and water depths in this area range from 73 to 150 m. The area between Sicily and Malta is split in two areas totaling 4,225 km^2 and separated by a deep channel. The part of the Study Area immediately south of Sicily amounts to 1,939 km^2 and ranges in depth from 89 to 150 m. The part of the Study Area due east of Malta covers 2,286 km^2 and ranges in depth from 53 to 150 m. There are two other small shelf areas of the eastern Mediterranean Sea contained within the Study Area. These are located off Calabria, Italy in the northwestern Ionian Sea (24 km^2; 130 to 150 m water depth) and off Preveza, Greece in the northeastern Ionian Sea (30 km^2; 75 to 150 m water depth). Note that the area between Alexandria and Port Said, Egypt in the southern Levantine Sea (20 to 150 m water depth) and the area offshore of the Gaza Strip in the eastern Levantine Sea (70 to 150 m water depth) are not discussed in this section.

Sections 4-2 through 4-4 provide general characteristics of the main habitat regions: continental shelf, continental slope, and abyssal plain contained within the Study Area as well as descriptions of the benthic biological resources particular to these regions and the artificial habitats. Benthic biological resources are associated with habitats ranging in size from kilometers to tens of kilometers (megahabitats; e.g., *Posidonia* beds, coralligenous bioherms; Pergent et al. 1994; Pasqualini et al. 1998a; Ballesteros 2006), meters to a kilometer (mesohabitats; e.g., chemosynthetic communities; Charlou et al. 2003), and 1 to 10 meters (macrohabitats; e.g., coral banks, artificial reefs; Coll et al. 1998; Tursi et al. 2004). Sections 4.3 and 4.4 selectively review seagrass beds, maërl beds, rocky reefs, shallow-water and deep-sea corals, chemosynthetic communities, and artificial habitats that occur within the Study Area.

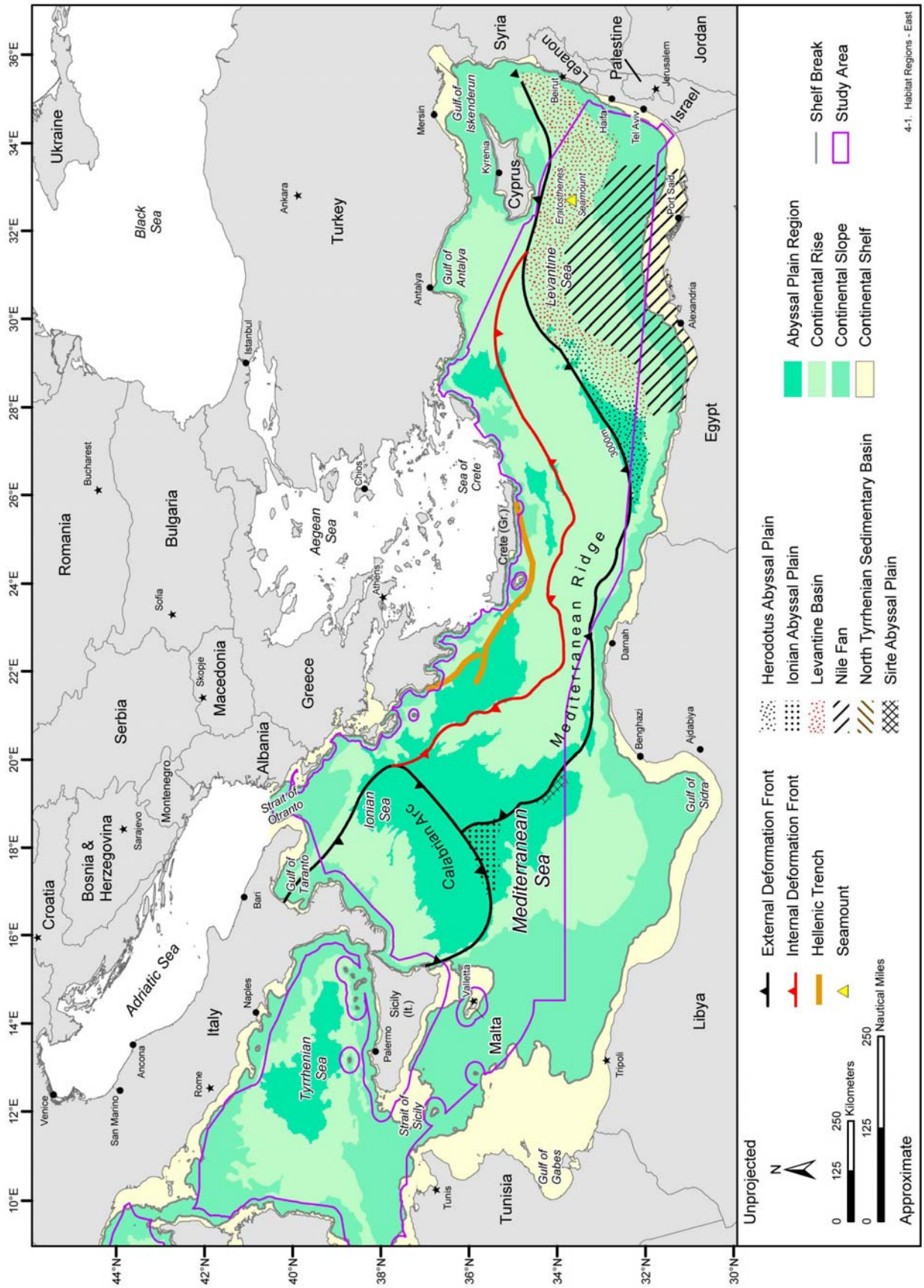


Figure 4-1. The benthic habitat regions of the eastern Mediterranean Sea including abyssal plain, continental rise, continental slope, and continental shelf. Map adapted from: Charlou et al. (2003) and WWF/IUCN (2004).

4.2 HABITAT REGIONS

The major benthic habitat regions of the eastern Mediterranean Study Area are the continental shelf, continental slope and rise, and abyssal plain (**Figure 4-1**). The Mediterranean continental shelf (0 to 150 m) makes up approximately 15% of the Mediterranean seafloor. The continental slope and rise (approximately 150 to 3,000 m) encompass approximately 72% of the Mediterranean seafloor and the remaining 13% is the abyssal zone (approximately 3,000 to 5,093 m; **Figure 4-1**; Emig and Geistdoerfer 2004). The productivity of the world's continental shelf ecosystems is estimated to be five times higher than the productivity of the oceans (Karakassis and Eleftheriou 1997). The continental shelf ecosystem is regulated by both pelagic and benthic components. In contrast to the continental shelf, the effect of benthos on total deep-sea system metabolism is negligible, while in the shallow intertidal zone, the pelagic component is insignificant with benthos dominating the total system metabolism. The benthos of the outer shelf is below the mixing depth over the greater part of the year and is dominated by deposit-feeders. This benthos uses the organic material in the sediment bed which contributes significantly to the remineralization process. During deep mixing periods, the nutrients supplied to the upper water column due to this remineralization process influence pelagic production and provide indirect feedback. Thus, quantitative information on benthic ecosystems is an important element to understanding the continental shelf ecosystem (Karakassis and Eleftheriou 1997). Of the three habitat regions of the Mediterranean Sea discussed here, the continental shelves are impacted by a substantial amount of commercial fishing with the benthos and epibenthos affected by physically destructive fishing methods (e.g., trawling, dredging; Sardà et al. 2004).

4.2.1 Continental Shelf

The eastern Mediterranean continental shelf encompasses a depth range of 0 to 150 m. The most extensive continental shelves in the Mediterranean Sea are located near major river mouths (Rhône in the Gulf of Lion, Ebro in the Gulf of Valencia, Nile River in the Levantine Sea, and Po River in the Adriatic Sea) because of the large sediment supply (Sardà et al. 2004); however, a large part of the Mediterranean Sea has a very small continental shelf with deep water very near to shore (WWF/IUCN 2004). The shelf break is typically contained between the 100 to 150 m depth range; but this can vary; for example the widest point of the Nile continental shelf reaches a depth of 260 m (Sardà et al. 2004).

The benthos of the continental shelf is characterized by high concentrations of macro-epibenthic filter-feeding and suspension-feeding organisms especially near the shelf break (Sardà et al. 2004). On the continental shelf, the seafloor is shallow enough to allow light to reach the benthos and provide significant habitats composed of a variety of flora. Within the eastern Mediterranean Study Area, depths less than 150 m only occur in a few areas within the Aegean Sea. **Figure 4-1** shows all areas in the Study Area where the following continental shelf habitats have the potential to occur. The continental shelf ecosystem of the eastern Mediterranean Sea has received little research effort in comparison to that of the western basin. On the Cretan shelf, 547 species were identified, among these, 238 were polychaetes, 165 crustaceans, 89 molluscs, 23 echinoderms, 14 sipunculans, and 18 that were not identified to species (Karakassis and Eleftheriou 1997). Karakassis and Eleftheriou (1997) found depth to be the main factor influencing the benthos on the continental shelf and slope; typically, the benthos abundance, biomass (dry weight), and species diversity decreased with depth. This resulted in a rather impoverished benthos towards the outer shelf; however, the benthos can vary with season especially in the shallow- waters and populations are usually higher in summer and spring and lower in autumn and winter. Surface deposit-feeders were the dominant feeding type accounting for 55 to 60% at all depths. On the Cretan shelf, Kallianiotis (2000) found that on the upper and nearshore part of the shelf, the benthos is governed by hydrodynamic processes and sedimentary characteristics, while at the deeper and offshore part of the shelf, the benthos is governed by food availability (limitation for population growth; Karakassis and Eleftheriou 1997; Kallianiotis et al. 2000).

In many of the coastal regions and the continental shelf of the Mediterranean Sea, sand banks are significant features that occur where the sediments are abundant and currents are strong enough to move sediment. Sand banks can be located in the mouths of estuaries, adjacent to headlands and beaches, on the exposed shelf, and close to the continental shelf edge. The environmental significance of sand banks

is multifold. First, sand banks can form benthic habitats of importance; for instance, they can have different sediment characteristics and hydrography from the surrounding seafloor. They can also be areas of great importance to many fish species because sand banks are important nursery and feeding grounds. Second, sand banks that are close to shore may help stabilize and protect the coastal zone and its habitats (e.g., sea cliffs, beaches, estuaries, and salt marshes) by providing a source of sediment and dissipating erosional wave energy (Dyer and Huntley 1999). Finally, sand banks interact with surrounding topography such as other banks and/or the coastal environments. For instance, sand banks can exchange sediments with surrounding areas. In addition, via wave diffraction the direction of wave propagation can orient wave energy on specific regions of a coastline. Consequently, patterns of coastal sedimentary drift can be modified by sand banks possibly resulting in changes to the adjacent coastline and its habitats. Sand banks have already been recognized in legal and marine policy frameworks for their significance as a natural coastal defense, a supplier or store of sediments, and a particular habitat. For example, management policies have been enacted to regulate certain human-induced activities which may affect the banks themselves and/or their role as natural coastal defenses (e.g., marine aggregate and/or navigational dredging).[1]

4.2.2 Continental Slope

The three types of continental margins (progressive, intermediate, and abrupt) are defined by the steepness of the slope and its relation to the continental shelf. In the Mediterranean Sea, the 200 m depth isobath is commonly used to separate the continental shelf from the continental slope (Sardà et al. 2004). The continental slope separates the outer continental shelf (approximately at a 150 m water depth) from the continental rise (approximate water depth: 1,500 m) and abyssal plain (approximate water depth: 4,500 m; Kennett 1982) and constitute a relatively narrow area (up to few tens of kilometers; Sardà et al. 2004).

Classically, two main facies define the Mediterranean continental slope: soft bottom communities and hard bottom communities (WWF/IUCN 2004). The soft bottom communities are characterized by three depth horizons: upper, middle, and lower slope horizons. The upper continental slope extends from about 400 to 500 m of depth and is comprised largely of eurybathic species, characteristically, sea pen, (*Funiculina quadrangularis*), and crustaceans, deepwater rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*). The middle continental slope has more firm and compact muds that harbor the most extensive benthos on the slope. The middle continental slope represents a “hotspot” of diversity and recently there has been interest in conservation efforts for these specific areas of the Mediterranean Sea slope (Briand 2003). It is characterized by the gorgonian, *Isidella elongata*, and the crustaceans, red shrimp (*Aristeus antennatus*) and giant red shrimp (*Aristaeomorpha foliacea*). The lower continental slope is not as well studied as the other horizons; however, some indicative benthos include bathyal decapod crustaceans such as the deep-sea lobsters, *Polycheles sculptus* and *Nematocarcinus exilis*, and the deep-sea shrimp, *Acanthephyra eximia*, and bathyaldemersal fishes, such as Mediterranean spiderfish (*Bathypterois dubius*), Risso’s smooth-head (*Alepocephalus rostratus*), Mediterranean codling (*Lepidion lepidion*), and Gunther’s grenadier (*Coryphaenoides guentheri*). Hardbottoms occur in water depths ranging from 300 to 1,000 m in areas of high flow where sedimentation and erosion prevail and expose bare rock (WWF/IUCN 2004).

Similarly to the continental shelf, species richness decreases with increasing depth. More particularly, on the continental slope, between 250 and 1,000 m depth, there is a strong decrease in the species richness with depth. Below 1,000 m, the number of species becomes more constant (Stora et al. 1999); however, depth is not necessarily the defining factor for the structuring of the benthos in the Mediterranean Sea. As discussed above, the species assemblages and communities of the continental slope have drastic vertical variability; however, the WWF/IUCN (2004) showed that between 250 and 2,000 m water depth that on the Mediterranean Sea continental slope, the bathyal assemblages are mainly comprised of eurybathic species (species tolerant of a wide range in depth). Most species below 150 m are eurybathic, with the exception of the characteristic deep species of the bathyal or abyssal zones, most likely, because the Mediterranean Sea water mass is uniform below 150 m with a stable thermal (14.0º to 14.8ºC in the eastern basin) and saline (38.5 to 38.6 psu) signature. Thus, the patterns of distribution and zonation of the Mediterranean Sea benthos on the continental slope may be also governed by trophic and biological

factors (WWF/IUCN 2004). Additional factors that influence species distribution and zonation of the continental slope benthos may be of physical (temperature, pressure, geochemical characteristics, sediment grain size, particle sedimentation, and hydrography) or of biological origin (life-history tactics, interspecific competition and predation, and trophic strategy; Stora et al. 1999).

On typical continental slopes, carnivores/scavengers and suspension-feeders dominate on the upper slope, suspension-feeders alone dominate on the mid-slope, and deposit-feeders dominate on the lower slope. On the continental slope of the Mediterranean Sea, suspension-feeders dominate on shelf side of the shelf-slope break on the upper slope. Deposit-feeders dominate on the region between the upper and mid-slope. Contrary to typical continental slopes, suspension-feeders are not well represented on Mediterranean slopes. This is most likely due to the low tidal range in the Mediterranean Sea which consequently reduces the occurrence of strong, regular currents at the shelf break governing the distribution of trophic assemblages. With increasing depth, characteristic species of the bathyal zone or abyssal species may be increasingly found on the mid to lower continental slope and with a distinct decrease in the dominance by eurybathic species (Stora et al. 1999).

The continental slope of the eastern Mediterranean Sea is very similar to that of the western Mediterranean Sea. In a study conducted on the continental margin of Crete in the oligotrophic northeastern Mediterranean Sea, the benthos biomass, abundance, and diversity of the continental slope decreased with depth. There is a major transition zone at approximately 540 m, beyond which abrupt declines in benthos biomass, abundance, and diversity take place (Tselepides et al. 2000). The upper slope at the shelf break is characterized by deposit-feeding polychaetes and high diversity. The middle and lower slope are characterized by bathyal and abyssal species (carnivorous and filter-feeding polychaetes) and very low diversity (Tselepides et al. 2000).

4.2.3 Continental Rise and Abyssal Plain

The Mediterranean Sea continental rise or bathyal zone starts at approximately 1,000 to 1,100 m of depth (or the end of the continental slope) to approximately 2,000 to 3,000 m of depth; it makes up about 72% of the entire Mediterranean Sea. The Mediterranean abyssal zone starts at approximately 2,000 to 3,000 m of depth and the deepest point in the Mediterranean Sea occurs in the eastern Mediterranean Sea at 5,093 m of depth; the abyssal zone makes up about 13% of the entire Mediterranean Sea (O'Dor 2003; Emig and Geistdoerfer 2004). The continental rise (or bathyal zone) and abyssal plain are relatively flat expanses of sea floor that are covered with fine particles that constantly rain down from the overlying water column. These particles, fine, clay-sized sediments and the remains of marine life, drift slowly downward filling in depressions on the irregular rocky ocean floor. They have accumulated to form a thick sediment bed (up to a 5 km thickness) that constitutes the largest portion of the oceans. Because of this thick layer of sediment, the bathyal zone and abyssal plain are among the smoothest surfaces on the planet, with less than 1.5 m of vertical variation for every mile. The deep Mediterranean Sea is, however, a dynamic environment that is driven and characterized by the dynamics of major geomorphological features including the Mediterranean ridge system, deep hypersaline anoxic basins (DHABs), mud volcanoes, cold and hydrothermal seepage, seamounts, submarine canyons, and the Nile deep-sea fan (Airamé et al. 2003). The bathyal zone and abyssal plain environment is typically characterized by extremely cold water, complete darkness, and highly diverse marine biota (Wilson 1976; Beaulieu 2001b, 2001a; Cunha and Wilson 2003; O'Dor 2003).

Significant physical, chemical, and biological interactions occur between the upper ocean and the deep benthos on time scales of days to millennia (Smith 1991). Benthic communities that live within, upon, or associated with the ocean bottom rely upon the primary production in the surface waters; this sinking detritus provides the primary source of nutrients for bathypelagic and deep-sea communities (Smith 1991). On average, less than 3% of primary production sinks through the water column to the deep-sea. Deep benthic fauna living on or in the benthos grow more slowly, live longer, have smaller broods than animals living in shallow waters, and although consumption is slow, once organic matter reaches the seafloor, it is almost entirely consumed, a very small portion of the organic matter may dissolve or become buried in sediments (Airamé et al. 2003). Although the eastern and western basins occur at more or less the same latitude, the maximum surface offshore primary productivity in the western

Mediterranean Sea reaches approximately 400 mgC/m^2/d; whereas, in the oligotrophic eastern Mediterranean Sea, the maximum surface offshore primary productivity reaches only about 60 mgC/m^2/d (Danovaro et al. 1999). Therefore, there is a much lower flux of organic matter to the eastern benthos than to the western benthos causing distinct differences in the quantity and quality of organic matter deposited on the bathyal zone and abyssal plain between the two basins, which has important biological consequences (Briand 2003).

The bathyal zone and abyssal plains of the deep Mediterranean Sea are generally considered to be a "biological desert" (Emig and Geistdoerfer 2004). The benthos of the eastern Mediterranean Sea bathyal and abyssal regions are characterized by low-density and low-diversity conditions. In the Catalan Sea of the western Mediterranean Sea, the bathyal benthos had relatively high diversity at mid-bathyal depths when compared with the eastern Mediterranean Sea. There are three main factors responsible for the general impoverishment of the deep-sea Mediterranean Sea benthos: biogeographic and geological history, high prevailing temperatures (13° to 14°C) below 200 m depth, and scarcity of food supply. The benthos of the bathyal zone and abyssal plains is comprised of mainly eurybathic species; however, there are 20 to 30 true abyssal species (Emig and Geistdoerfer 2004). In the western Mediterranean Sea, where depth does not exceed 3,000 m, the abyssal benthos is 2 to 25 times more abundant than in the deeper eastern basin; however, in the trenches of the eastern Mediterranean Sea (Matapan trench, Hellenic trench, and Pliny trench) abyssal species are dominant and have occasional benthic hot spots in areas of accumulating organic matter (Tselepides et al. 2004). In general, for the Mediterranean benthos as a whole (represented by about 7,200 macrofauna species) the impoverishment in species is from west to east and species that occur in the both western and eastern basins are always encountered in deeper waters in the eastern basin (Emig and Geistdoerfer 2004).

The eastern Mediterranean Sea encompasses the Ionian Basin and the Levantine Basin (**Figure 4-1**). The Ionian abyssal basin is located between the south of Italy, and Greece and Libya. This triangular shaped abyssal plain is characterized by the sharp, small, broken topography of several basin plains. It is bordered by the Calabrian arc to the northwest, the Mediterranean Ridge to the east, and the Sirte rise and megafault system of the Sicily-Malta escarpment to the west. The Basin can be subdivided into three sub-basin plains: Messina Plain, Sirte Plain, and Hellenic Trough abyssal plain. The Messina Plain is located in the northern part of the basin; it is bounded by the 3,600 m isobath and reaches a depth of 4,100 m. The Sirte Plain is located just west of the Mediterranean Ridge (at the 3,900 m isobath) and the Herodotus Trough (3,000 to 3,500 m depth depression at the base of the continental slope of Libya). The Hellenic Trough abyssal plain is located between the Mediterranean Ridge and the base of the continental slope of western Greece; it is bounded by the 3,000 m isobath and reaches a depth of 5,093 m (deepest point in the Mediterranean Sea). It has a complex bathymetry defined by a series of discontinuous seamounts and trenches; the trenches (e.g., North Matapan-Vavilov Trench) are irregularly shaped depressions that form smaller basins at different depths.

The Levantine Basin is separated from the Ionian Basin by a submarine ridge between western Crete and Libya. The Levantine Basin can be divided into several abyssal plains which border the Mediterranean Ridge: Herodotus Abyssal Plain, Rhodes Basin, Antalya Basin, and Cyprus Abyssal Plain. The Herodotus Abyssal Plain is located between the Mediterranean Ridge in the north and by continental margin of Africa in the south just seaward of the northwestern part of the Nile Cone. It is bounded by the 2,800 or 3,000 m isobath and it is the largest abyssal plain in the eastern Mediterranean Sea reaching a depth of 3,156 m. The Rhodes Basin, Antalya Basin, and Cyprus Abyssal Plain are located between the Turkish continental margin in the north and the Mediterranean Ridge in the south (Sardà et al. 2004).

It is generally accepted that the deep-water benthos of the Ionian and Levantine basins is characterized by low diversity and low-density, and the most impoverished of the Mediterranean Sea (Tselepides and Lampadariou 2004). The benthos is comprised of autochthonous, self-sustaining populations of opportunistic, eurybathic species with a strong dependence on inputs of organic matter from the sea surface (Galil 2004; Tselepides and Lampadariou 2004). Primary production in the oligotrophic surface waters of the eastern Mediterranean Sea is insufficient to sustain a well-structured benthos in the Ionian and Levantine basins in depths greater than 2,500 m (Basso et al. 2004). Thus, the unpredictable and highly variable input and distribution of organic matter to the benthos does not provide any "insurance" for

the sustainability of the deep-sea faunal assemblages in the long term; this leads to an uncoupling between resource availability and distribution of organisms (Gambi and Danovaro 2006).

4.3 BENTHIC BIOLOGICAL RESOURCES

The benthic biological resources of the eastern Mediterranean Sea Study Area include seagrass beds, maërl beds, rocky reefs, shallow-water and deep-sea corals, and chemosynthetic communities (hydrothermal vents, cold seeps and gas hydrates, mud volcanoes, and DHABs; **Figures 4-2, 4-3,** and **4-4**).

4.3.1 Seagrass Beds

Seagrasses are aquatic flowering plants that form extensive underwater meadows (or beds). They are a group of approximately 60 species and are found in shallow-water depths and various temperature and salinity ranges throughout many parts of the world (Thayer et al. 1984). Most seagrasses have flattened leaves that help them adjust to light restrictions and slow rates of gas diffusion in the water column (Thayer et al. 1984). Their extensive rhizome (root) system forms dense and tough belowground mats that function in anchorage and the absorption of nutrients.

Geographic distributions of seagrasses are based upon individual species tolerances to hydrological and atmospheric conditions (i.e., water temperature, salinity, irradiance, depth, substrate, and exposure; CalEPPC 1999). Seagrasses can occur from mean sea level down to a maximum recorded depth of 90 m (stargrass [*Halophila engelmannii*], Dry Tortugas, Florida; den Hartog 1970). Seagrass depth limits are largely defined by light attenuation (Duarte 1991). In general, seagrasses require an underwater irradiance in excess of 11% of the irradiance at the surface (Duarte 1991). The upper limit of seagrasses is governed by requirements for submersion and resistance to wave energy and, in northern latitudes, ice scour (Hemminga and Duarte 2000). Seagrasses require salinity in excess of 5 psu to develop (Hemminga and Duarte 2000). Most seagrasses grow on soft substrata, ranging from sandy to muddy sediments while some species (e.g., surfgrass [*Phyllospadix* spp.]) grow on rocky substrates (Terrados et al. 1999; Hemminga and Duarte 2000; Koch 2001).

Seagrasses form highly productive ecosystems that rival with the most productive biomes on earth (Duarte and Chiscano 1999). Seagrasses cover an estimated 0.1 to 0.2% or 0.6 x 10^6 km^2 of the global oceans (Duarte 2002) and their net production is about 0.6 x 10^{15} grams of carbon per year (gC/yr) (Duarte and Chiscano 1999).

In addition to their high primary production, seagrass ecosystems provide other benefits including provision of food for coastal food webs; provision of oxygen supply to waters and sediments; carbon sequestration from the atmosphere; organic carbon export to adjacent ecosystems; sediment stabilization; prevention of sediment resuspension; improvement of water transparency; wave attenuation; shoreline protection; habitat for microbes, invertebrates and vertebrates, often endangered or commercially important; and trapping and cycling of nutrients (Brouns and Heijs 1986; Phillips and Meñez 1988; Duarte 2002).

The widespread loss of seagrasses is largely a consequence of the rapid growth in human activities and the transformation of the coastal zone (Duarte et al. 2004). Specifically, seagrass loss can result from direct human impacts, indirect human impacts and natural causes: mechanical damage (by dredging, fishing, and anchoring); eutrophication; aquaculture; siltation; effects of coastal construction; foodweb alterations; erosion caused by rising sea level; increased storms; increased ultraviolet irradiance; cyclones; and floods (Duarte 2002).

Mediterranean Seagrasses—There are four species of seagrasses that are native to Mediterranean Sea waters, eelgrass (*Zostera marina*), dwarf eelgrass (*Zostera noltii*), seahorse grass (*Cymodocea nodosa*), and *Posidonia oceanica.*

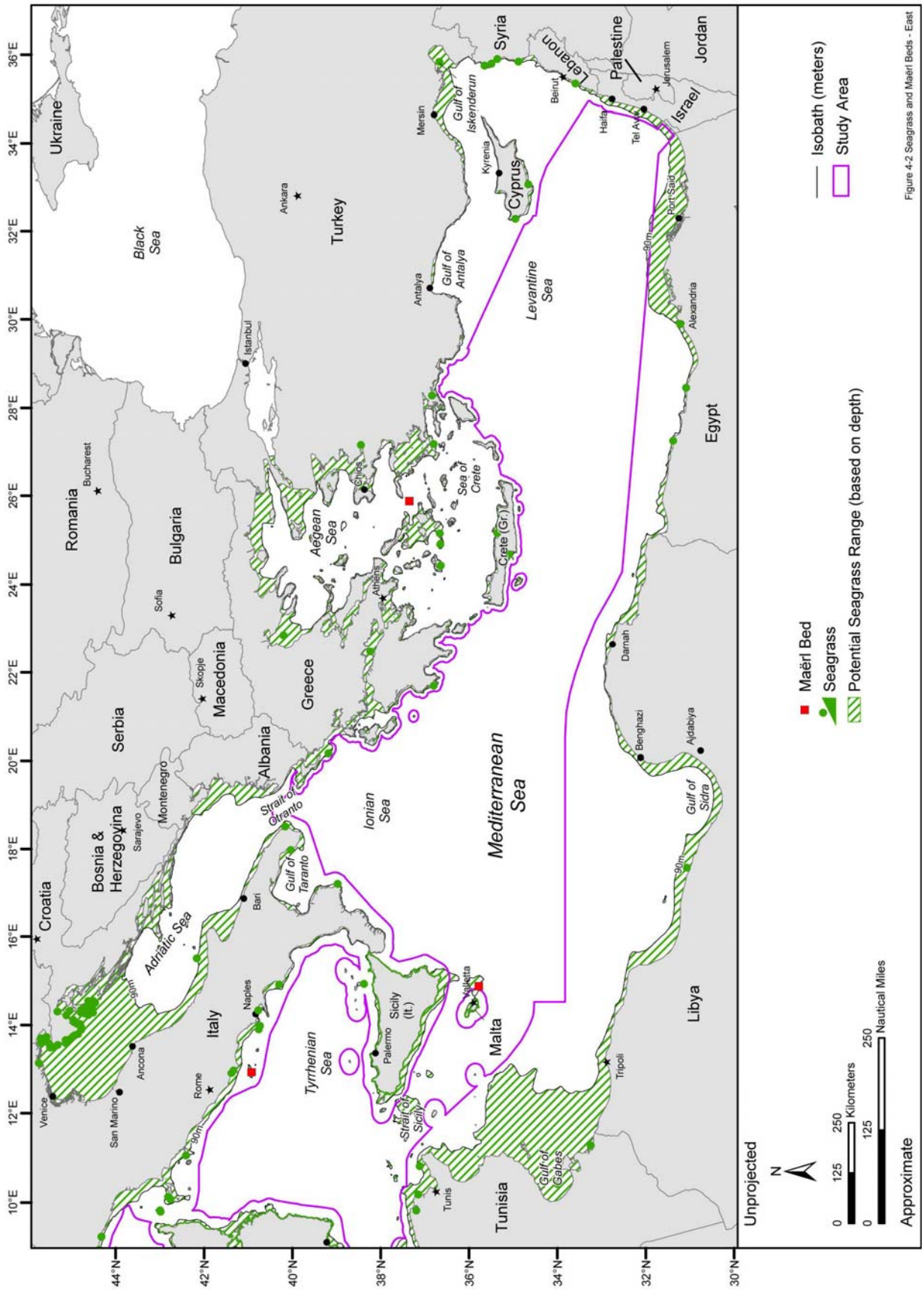


Figure 4-2. Seagrass and maërl bed habitat locations in the eastern Mediterranean Sea. Potential seagrass bed habitat was restricted to a depth of 90 m: the deepest that seagrass bed habitats have been found in the Mediterranean. Source data: Foster (2001). Map adapted from: Basso (1998), BIOMAËRL Team (2003), and UNEP-WCMC[10].

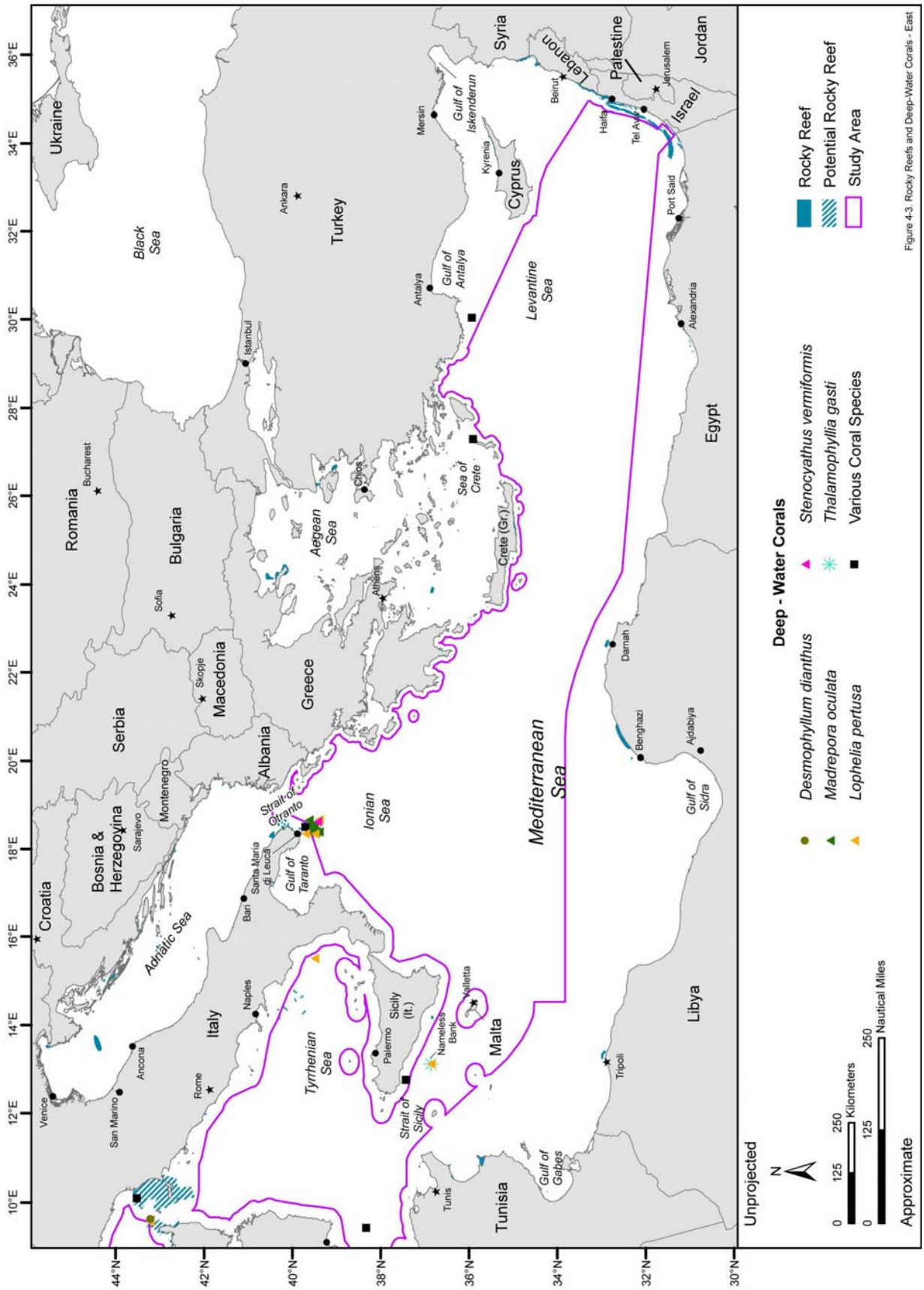


Figure 4-3. Distribution of rocky reefs and deep-water corals in the eastern Mediterranean Sea. Source information: Tursi et al. (2004), WWF/IUCN (2004), Longo et al. (2005), Taviani et al. (2005b), Zibrowius and Taviani (2005), and D'Onghia et al. (2006).

- Eelgrass (*Zostera marina*) is found generally in lagoons, subtidally to depths of 10 to 15 m (depending on water clarity). Eelgrass (*Z. marina*) is generally rare throughout the Mediterranean Sea and occurs as small isolated stands, but there are instances of dense beds in the Mediterranean Sea (Borum and Greve 2004). It is considered to be a relict species in the Mediterranean Sea where it forms perennial meadows on sandy and muddy substrate (i.e., lagoons; Procaccini et al. 2003).

- Dwarf eelgrass (*Zostera noltii*) forms dense beds in the muddy sand of intertidal areas, where eelgrass (*Zostera marina*) is sparse due to its lower tolerance to desiccation. It also occurs subtidally but often seems to be out-competed by other seagrasses where the water cover is permanent (Borum and Greve 2004). In enclosed and sheltered areas, it can form mixed beds with seahorse grass (*Cymodocea nodosa*; Procaccini et al. 2003).

- Seahorse grass (*Cymodocea nodosa*) is widely distributed throughout the Mediterranean Sea. It is a warm water species that is most commonly found in the shallow subtidal but can reach exceptional depths of up to 60 m in areas with clear water (Procaccini et al. 2003). Shallow and deep stands are generally discontinuous and found on sandy substrate and in protected areas. Appropriate to its name, seahorse grass (*C. nodosa*) provides the characteristic habitat for seahorses (Borum and Greve 2004).

- *Posidonia oceanica* is the endemic and dominant seagrass in the Mediterranean Sea; it occupies between 25,000 and 45,000 km^2 and covers about 25% of the seafloor between 0 and 45 m (Pasqualini et al. 1998b; Borum et al. 2004). *Posidonia oceanica* is one of the climax communities in the Mediterranean Sea (Panayotidis and Drakopoulou 2000; Procaccini et al. 2003). It grows from the shallow subtidal and is the deepest (up to a water depth of 80 m) growing species in the Mediterranean Sea; its average depth of growth is 55 m (Duarte 1991). It is common on different types of substrata (from rocks to sand) but is generally not found in estuaries where the input of freshwater and fine sediment is high (Procaccini et al. 2003). *Posidonia oceanica* has a characteristically slow growth rate and, unlike other seagrasses in the Mediterranean Sea, can form large biogenic reefs of rhizome and sedimentary material (Borum and Greve 2004).

There are invasive species in addition to these four native species of seagrasses. For example, *Halophila stipulacea* was introduced from the Red Sea through the Suez Channel into the eastern Mediterranean Sea where it has been observed since the beginning of the 19th century (Procaccini et al. 2003). Currently, this warm water species is invading the western Mediterranean Sea (reported in 1988) and has reached the southern coasts of Italy (Borum and Greve 2004).

Posidonia oceanica and seahorse grass (*Cymodocea nodosa*) are the dominant seagrass species within the Mediterranean Sea. Seahorse grass (*C. nodosa*) is a pioneer species that often grows in shallower depths than *P. oceanica* which is considered a climax species (Duarte 1991). *Posidonia oceanica* beds cover approximately 1 to 2% of the entire Mediterranean seafloor and is listed as a protected plant species in France ('Arrêté' of 19 July 1988, confirmed by the 'Décret' of 20 September 1989; Pasqualini et al. 1998a).

Posidonia oceanica is a larger, longer-lived, deeper, and slower growing species than seahorse grass (*Cymodocea nodosa*). Olesen et al. (2002) found that seahorse grass (*C. nodosa*) responds faster to changing light conditions whereas *P. oceanica* is able to survive longer at low irradiance due to low growth and respiratory maintenance rates. Inherently, *P. oceanica* responds more slowly to environmental perturbations compared to seahorse grass (*C. nodosa*); at the same time, high growth rates enables seahorse grass (*C. nodosa*) to grow much faster during suitable periods allowing it to survive fluctuating environmental conditions (Olesen et al. 2002). Furthermore, Cunha et al. (2004) noted that recolonization of *Zostera* spp. and seahorse grass (*C. nodosa*) is relatively rapid, extending from months to a few years; whereas, the recolonization of *P. oceanica* is much slower, extending from decades to several centuries.

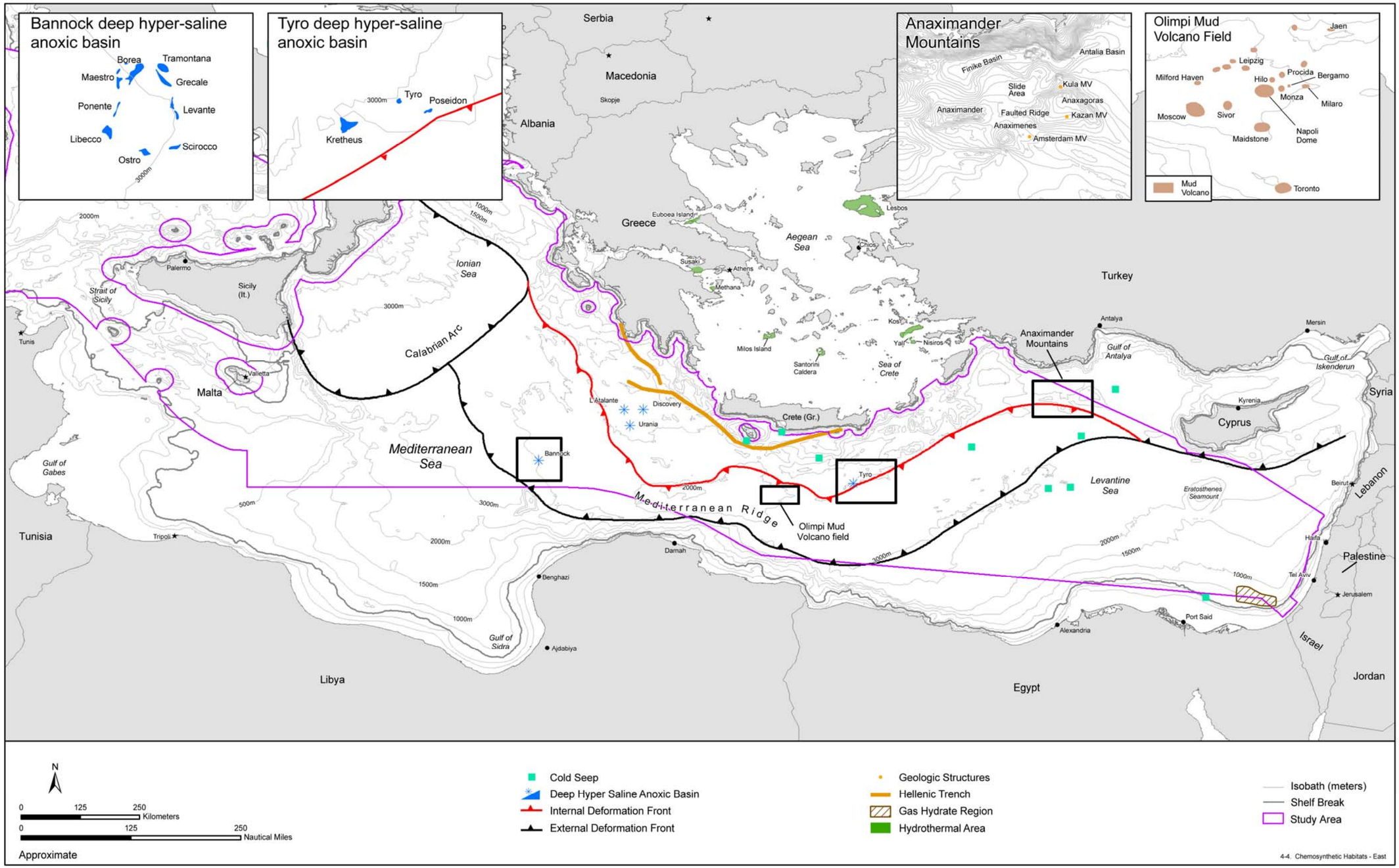


Figure 4-4. Chemosynthetic habitats of the eastern Mediterranean Sea including the locations of mud volcanoes, deep hyper saline anoxic basins, gas hydrates, cold seeps, and hydrothermal vents. Source data: Interridge[11]. Source maps (scanned): De Lange et al. (1990) and Aloisi et al. (2000). Map adapted from: Corselli and Basso (1996), Dando et al. (1999), Coleman and Ballard (2001), Charlou et al. (2003), Lampadariou et al. (2003), and WWF/IUCN (2004).

Posidonia oceanica is a unique seagrass in that it is a reef-building seagrass that constructs a mat of living and dead rhizomes and roots, with the interstices filled with sediment (Pergent 1990). This mat allows *P. oceanica* to form long-lived meadows, some being more than 4,000 yrs old (Duarte 2002). In addition, the *P. oceanica* mat allows for long-term sediment retention. Consequently, this mat is important for coastal stability and preventing beach erosion in the coastal zone (Gacia and Duarte 2001)

The primary production of *Posidonia oceanica* (130 to 1,284 grams of dry weight per square meter per year [g dry wt/m^2/yr]) and its leaf epiphytes plays a major role in the benthic primary production in the Mediterranean Sea (Pergent-Martini et al. 1994). Primary production of *P. oceanica* was measured at 22 sites in the Mediterranean Sea (Corsica, France, Italy, Sardinia, and Turkey), between 1983 and 1992. In general, the highest values of primary production were recorded from the healthiest (i.e., densest) meadows (e.g., Ischia [Italy], Calvi [Corsica] and Port-Cros [France]) and the lowest values were recorded from the most impacted beds (e.g., the Sardinian coast [Alghero and Olbia]; Pergent-Martini et al. 1994; Pergent et al. 1994).

Posidonia oceanica is highly dynamic on both shorter and longer time scales and has strong seasonal, spatial, and temporal variations (Krause-Jensen et al. 2004). Seasonally, maximum growth occurred in July and August and a minimum was reached between November and December (Gacia and Duarte 2001). Spatially, primary production decreased with increasing depth.

In the Mediterranean Sea, seagrass ecosystems are known to support an extremely rich assemblage of fauna and flora. *Posidonia oceanica* beds are nursery grounds for the juveniles of many commercially important species of fishes (e.g., dentex/seabreams [Sparidae], combers/groupers [Serranidae], wrasses [Labridae], and rockfishes/scorpionfishes [Scorpaenidae]) and invertebrates (e.g., sea urchin, *Paracentrotus lividus*). These ecosystems also support various rare and endangered species such as the short-snouted seahorse (*Hippocampus hippocampus*), endemic sea star (*Asterina pancerii*), and bivalve (*Pinna nobilis*); these species are protected or are included among species requiring a specific legislation for protection. These ecosystems also provide essential feeding grounds for cephalopods, crustaceans, shellfish, and finfish. In fact, seagrass beds produce more than 80% of the annual fish yield in the Mediterranean Sea.[1] To protect these important habitats, specific fisheries legislation does not allow destructive fishing (e.g., trawling); however, this legislation is often violated. Small fisheries that use standing nets and cages are the only fisheries allowed in *P. oceanica* habitats (Procaccini et al. 2003). In Annex 1 of the Council Directive 92/43/EEC (European Community [EC] Habitats Directive, 21 May 1992), *P. oceanica* beds are considered priority habitat among Mediterranean Sea ecosystems (Panayotidis and Drakopoulou 2000).

<u>Impacts on Mediterranean Seagrasses</u>—The coastlines of the Mediterranean Sea suffer from a progressive impact via industrial, economic, touristic, and urban development. These impacts cause degradation and regression of a vulnerable and endangered environment (Pasqualini et al. 1998a). For instance, *Posidonia oceanica* covers approximately 50,000 km^2 of the Mediterranean seafloor and is currently experiencing widespread loss due to direct human impacts and large-scale change (Gacia and Duarte 2001). In addition to direct human impacts, the introduced green algae (*Caulerpa taxifolia*) and grape *Caulerpa* (*C. racemosa*) grow throughout the entire depth range of Mediterranean seagrasses and can overwhelm them (Procaccini et al. 2003). There are several studies that have documented extreme *P. oceanica* habitat loss.

<u>Seagrass Distribution in the Mediterranean Sea</u>—Taking into account depth and the area in zones of high human activity versus that of relatively pristine zones, the potential Mediterranean Sea surface area occupied by *Posidonia oceanica* can be conservatively estimated to be between 2.5 and 4.5 million hectares (ha; representing a mean of 23% of the sea bottom between 0 and 50 m of the Mediterranean basin; Pasqualini et al. 1998b). This estimate can be confirmed with previous estimates proposed by Bethoux and Copin-Montegut (1986).

4.3.2 Maërl Beds

Maërl (rhodoliths) are free-living non-geniculate (i.e., lacking uncalcified joints) coralline algae (or calcareous rhodophytes) that are slow growing and may be long lived (>100 yrs; Foster 2001). At high densities, accumulations of living and dead unattached maërl form biogenic structures known as maërl beds (or rhodolith beds; BIOMAËRL team 2003). In the present day Mediterranean Sea, biogenic structures of maërl beds fulfill an important role for the Mediterranean Sea ecosystem (Basso 1998). Maërl beds are ecologically interesting habitats for several reasons:

- Form successful beds in deep waters with little light; the depth limit is primarily governed by the degree of light penetration (BIOMAËRL team 2003).
- Develop on softbottom substrates and form 3D structures that creates a spatial heterogeneity that is intermediate in character between hard and soft bottoms (Bordehore et al. 2000b).
- Support a highly diverse biota including several commercially exploited organisms and even some rare or endemic species.
- Grow very slowly and may take hundreds of years to develop. For this reason, maërl beds are considered a non-renewable resource (BIOMAËRL team 2003).

These habitats are particularly abundant throughout the Mediterranean Sea (**Figure 4-2**); however, they are widely distributed in the world's oceans, from the intertidal to depths of over 150 m (Bordehore et al. 2000a; Foster 2001; BIOMAËRL team 2003). In general, well-developed maërl beds occur between the lower infralittoral where *Posidonia oceanica* reaches its lower bathymetric limit and the upper circalittoral (between depths of 25 and 100 m; Bordehore et al. 2000a). In the western Mediterranean Sea, they are found down to a depth of 90 to 100 m, while in the eastern Mediterranean Sea they can grow to depths of approximately 180 m (BIOMAËRL team 2003).

Maërl bed distribution is controlled by physical processes such as hydrodynamics and sedimentation and biological processes such as bioturbation (Foster 2001). In addition, maërl beds are grazed, fouled, buried, and exhumed from sediments. When environmentally stressed maërl beds become bleached. Typically, large concentrations of living maërl beds are found in areas of favorable irradiance and water flow (Steller and Foster 1995; Foster 2001).

Maërl beds can occur in high concentrations over large areas and may be one of the Earth's "Big Four" benthic communities that are dominated by marine macrophytes, ranking with kelp forests, seagrass beds, and non-geniculate coralline reefs (Foster 2001). Fundamentally, maërl beds are structurally and functionally complex habitats that support a very rich biodiversity (BIOMAËRL team 2003). In comparison with other continental shelf sedimentary habitats, the high fauna and flora diversity that is supported by maërl beds is substantial and of particular international conservation interest. Maërl beds can be considered "habitat modifiers" that, by virtue of their rigid structural complexity, provide relatively stable microhabitats for other organisms such as free-living corals and other invertebrates (e.g., bryozoans, hydroids, sponges; Steller and Foster 1995). For example, preliminary surveys of a maërl bed located in Scottish waters found 460 species of associated fauna (particularly polychaetes, crustaceans, and mollusks) and 63 species of flora (Foster 2001).

In the eastern Mediterranean Study Area, there have been very few surveys on the maërl habitats; however, the most extensive maërl beds known to date occur on the northeastern coast of Malta (Mifsud 2000). One study recorded *Lithothamnion minervae* as deep as 184 m in the clear waters of the eastern Mediterranean Sea (Basso 1998).

Maërl beds are economically important; they provide important hard and soft bottom habitats for recruitment, nursery grounds for commercial species of fish and shellfish, and habitat for burrowing invertebrates and commercially important bivalves (Foster 2001; BIOMAËRL team 2003). Worldwide, maërl beds are fished for fauna such as scallops and shrimp; Mediterranean maërl beds are often

targeted for demersal fish and cephalopods. Fishing the maërl beds, often by dredging or bottom trawling, can cause long-lasting ecosystem degradation via community population dilapidation and increases in turbidity, fouling, and sedimentation. In addition, organic enrichment related to eutrophication from sewers, fish and shellfish farms, and disturbance in adjacent watersheds can cause harm to maërl bed habitats. In addition to their significance as a habitat, maërl beds are also of global significance in that they produce much more carbonate than any other coastal communities in the Mediterranean Sea. This substantial production of carbonates by benthic communities may affect the Earth's climate (BIOMAËRL team 2003). Based upon the generally slow growth rates, high diversity, high carbonate production, and important habitat resources, maërl beds should be considered an ecologically important and essentially non-renewable resource (Foster 2001).

In the Mediterranean Sea, maërl bed habitats are experiencing direct threats from human activities. These threats include land reclamation (e.g., creation of artificial beaches); coastal modification (e.g., breakwaters, quays, sea-walls and yacht marinas); effluent discharges (e.g., domestic and/or industrial); offshore dumping (e.g., domestic and/or sewage sludge and industrial waste); dumping of dredged sediments; extraction (i.e., direct exploitation of maërl for human uses); ground fisheries (i.e., dredging and trawling); aquaculture; recreation (i.e., benthic damage from boats); and invasive species (e.g., Caulerpa taxifolia; BIOMAËRL team 2003).

In the Mediterranean Sea, maërl habitats are considered an endangered landscape by the UNEP/IUCN/GIS but they are not explicitly protected. By the Habitat European Union (EU) Directive 43/92, Annex V, some individual maërl-forming species are protected: *Lithophyllum lichenoides*, *Lithothamnion corallioides*, and *Phymatolithon calcareum* (Bordehore et al. 2000b). Conservation management and proposed measures include: recognition that maërl bed habitats cannot sustain direct exploitation and are non-renewable; ground fishing (trawling) prohibitions; limitations on aquaculture; monitoring of existing exploited, impacted, and healthy maërl bed habitats; the designation of 'no-take' reserves; water quality management; outreach education on their ecological significance; a higher conservation status; and further research on maërl ecosystems (BIOMAËRL team 2003).

4.3.3 Rocky Reefs

One of the main characteristics of the Mediterranean Sea is the presence of steep, often rocky margins that contain ecologically important and diverse habitats (Vanney and Gennesseaux 1985). Nearshore rocky reefs in the North Mediterranean Sea are usually characterized by a heterogeneous hard substrate rich in crevices and other shelter, and a dense cover of erect macroalgae (Guidetti 2000; Ruitton et al. 2000).

According to Bellan-Santini (1985), one of the richest benthic communities in the Mediterranean Sea is made of photolithic algae growing on hard substrate in the infralittoral zone (0 to 40 to 50 m). The circalittoral zone extends from 30 to 40 m to the lower limit of the photic zone (approximately 120 m). Two types of hard substrates are found within this zone: submarine canyons or caves; and banks that formed the aggregation of coarse components in soft substrates (Bellan-Santini 1985).

Above the 30 m isobath, benthic communities, comprised of animals and plants, colonize the substrate and co-exist in a competitive manner; however, these communities respond to modifications in their environment, whether man-made or natural through variations in the environmental factors, and may become spatially displaced (Bellan 1985). Rocky reefs, unlike soft bottoms, have been demonstrated to support benthic communities despite proximity to urban sewage outputs (Sala 2004). Hydrodynamism can play an important role in communities established on rocky substrates in polluted environments (Bellan 1985). Organisms on rocky reefs are attached to the substrate without benefit or detriment to the host. In a hydrodynamic environment, over-oxygenation and the subsequent transport of water masses may result in these rocky reef communities being less susceptible to anthropogenic stressors (Bellan 1985). In contrast, communities existing on or in soft or sedimentary substrate which drains poorly, are more susceptible to stress (Bellan 1985).

Rocky reefs can be comprised of a variety of substrates including sedimentary bedrock, coral skeletons, volcanic upwellings, submarine canyons, hydrothermal vents, cold seeps, and extensions of rocky coastlines. In the Mediterranean Sea, the skeletons of cold-water corals such as *Lophelia pertusa* create a mosaic framework that traps and retains sediments, eventually producing a reef (Roberts and Freiwald 2005). *Lophelia* reefs are a conglomeration of live coral colonies, dead coral framework, and deposits of coral rubble mixed with cement (Roberts and Freiwald 2005). The diversity of microhabitats within *Lophelia* reefs produces a wide range of physical niches for marine life to occupy (Roberts and Freiwald 2005). Fauna typical of these rocky reefs include sponges, bryozoans, tunicates, and crinoids (Roberts and Freiwald 2005).

The continental shelf along the south coast of Italy and Sicily is generally very narrow and varies in depths between 30 and 100 m (D'Onghia et al. 2006). At the north reaches of the Ionian Sea, the continental shelf is broad between the Taranto Valley (east side) and the Apulia (west side, Italy) and consists of terraces, bioclastic calcareous deposits with coral rocks (D'Onghia et al. 2006). Although rocky bottoms dominate the continental shelf off the Apulia coast, other habitat types present include seamounts, coralligenous bioherms, and seagrass meadows (D'Onghia et al. 2006).

Though not located in the Study Area, the Ugento seamounts are located in the Gulf of Taranto and range in depth from 40 to 80 m (D'Onghia et al. 2006). Marine caves are numerous in this area as well (D'Onghia et al. 2006). The eastern Levantine Sea is characterized by shore-parallel rocky walls and ridges that serve as dams behind which mud and sand are trapped on the inner shelf (Vanney and Gennesseaux 1985).

Flora and Fauna of Rocky Reefs—Benthic communities on rocky reefs are subjected to dominant environmental factors including hydrodynamism, nature of the substrate (e.g., rock quality gradient, cavernous nature), and illumination which is not entirely dependent on depth (Bellan 1985). Diversity of benthic communities is often higher on rocky reefs than on soft or sandy bottoms (Bellan 1985); however, zonation on rocky reefs in the Mediterranean Sea is not as clearly defined as on soft bottom substrates (Bellan 1985). For example, a zone devoid of all life has been described for soft bottom substrates, but no similar depauperate zone for rocky reefs has been observed (Bellan 1985).

Common flora and fauna on rocky reefs include algae, sea urchins, sponges, sea anemones, bryozoans, sea cucumbers, and cnidarians (**Table 4-1**). Except for algae, most of the species in **Table 4-1** have a wide distribution and are common for temperate Mediterranean waters (Cocito et al. 2000; Cebrián and Ballesteros 2004).

In shallow rocky reefs in the Mediterranean Sea, sea urchins strongly influence benthic communities by creating transition zones between erect macroalgal assemblages and coralline barrens (Ruitton et al. 2000; Guidetti 2004). Commercially important fish species such as white seabream (*Diplodus sargus*), common two-banded seabream (*D. vulgaris*), and Mediterranean rainbow wrasse (*Coris julis*) are the main predators of these sea urchins (Guidetti 2004). A decrease in the abundance of these predators (by fishing pressure) may result in a decrease in the sea urchin population which consequently may significantly alter the entire benthic community in shallow rocky reefs (Ruitton et al. 2000; Guidetti 2004).

Similar to other locations around the world, fish species richness, fish abundances, fish condition, and reproductive potential in the Mediterranean Sea have been connected to habitat structure (García-Rubies and Macpherson 1995; Guidetti 2000; Lloret and Planes 2003). Rocky reefs serve as essential spawning and nursery habitats for commercial and recreational marine species (Lloret and Planes 2003). Rocky substrates also are important habitats for some fishery species in deep water and submarine canyons (Lloret and Planes 2003). Numerous commercially, recreationally, and ecologically important species use rocky substrates which may indicate their importance as essential fish habitats (EFH; Lloret and Planes 2003).

Guidetti (2000) found that rocky-algal reefs and seagrass meadows share similar high diversity values and also share many of the same species between the two different habitat types. Several species within the families of Labridae (wrasses), Sparidae (dentex/seabreams), and Serranidae (combers/groupers)

have been closely associated with rocky reefs high in algal cover (**Table 4-2**; García-Rubies and Macpherson 1995; Guidetti 2000; García-Charton et al. 2004). Measures of fish condition (weight, liver size, lipid content in muscle and liver), reproductive potential, and abundances were found to be higher on rocky reefs than in other habitat types in the Mediterranean Sea (García-Charton et al. 2004). Lloret (2003) found the highest concentration of lipid in muscle and livers from fish obtained from rocky habitats. Harmelin-Vivien (1995) assigned rocky substratum in the northwestern Mediterranean Sea into four topographic categories: horizontal rocks, sloping rocks, boulders, and pebbles. Juvenile sparids were two to four times more likely to settle on rocky substrates than other habitat types and particularly to boulders and pebbles (**Table 4-3**; Harmelin-Vivien et al. 1995).

Considerable research has been conducted in the Mediterranean Sea on rocky shore assemblages in shallow areas; however, few studies or information exist for deeper rocky-coast assemblages found in the Study Area (Virgilio et al. 2006). Rocky substrates are far less prevalent in the deep Mediterranean Sea than soft sediments (Bellan-Santini 1985; Fredj and Laubier 1985).

Table 4-1. Common flora and fauna on rocky reefs in the Mediterranean Sea (Cocito et al. 2000; Cebrián and Ballesteros 2004).

Flora and Fauna Scientific Name	Common Name	Depth
Algae		
Lithophyllum stictaeforme	red coralline	deep
Mesophyllum alternans	red coralline	deep
Peyssonnelia spp.	red coralline	deep
Acetabularia	green macroalgae	shallow
Amphiroa	red macroalgae	shallow
Caulerpa	feather, grape, and razor macroalgae	shallow
Cladostephus	brown macroalgae	shallow
Corallina	red macroalgae	shallow
Cystoseira spp.	brown macroalgae	shallow
Cystoseira zosteroides	brown macroalgae	deep
Dasycladus	green macroalgae	shallow
Dictyota	brown macroalgae	shallow
Flabellia petiolata	green macroalgae	deep
Halimeda tuna	green macroalgae	deep
Halopteris filicina	brown macroalgae	deep
Halopteris spp.	brown macroalgae	shallow
Laurencia	red macroalgae	shallow
Liagora	red macroalgae	shallow
Padina	brown macroalgae	shallow
Echinoderm		
Arbacia lixula	sea urchin	shallow
Paracentrotus lividus	sea urchin	shallow
Sponge		
Crambe	sponge	shallow
Ircinia	sponge	shallow
Sarcotragus	sponge	shallow

Table 4-2. Common fish species associated with rocky reefs high in algal cover in the Mediterranean Sea.

Scientific Name	Common Name	Source
Apogonidae	**Cardinalfish**	
Apogon imberbis	Cardinalfish	(Frau et al. 2003)
Congridae	**Conger eels**	
Conger conger	European conger	(Guidetti 2000)
Gobiidae	**Gobies**	
Gobius cruentatus	Red-mouthed goby	(Guidetti 2000)
Labridae	**Wrasses**	
Coris julis	Mediterranean rainbow wrasse	(Guidetti 2000)
Ctenolabrus rupestris	Goldsinny wrasse	(García-Rubies and Macpherson 1995)
Labrus viridis	no common name	(Guidetti 2000)
Symphodus doderleini	no common name	(García-Rubies and Macpherson 1995)
Symphodus mediterraneus	Axillary wrasse	(Guidetti 2000)
Symphodus melanocercus	no common name	(García-Rubies and Macpherson 1995)
Symphodus ocellatus	no common name	(García-Rubies and Macpherson 1995)
Symphodus roissali	Five-spotted wrasse	(Guidetti 2000)
Symphodus tinca	East Atlantic peacock wrasse	(Guidetti 2000)
Thalassoma pavo	Ornate wrasse	(García-Rubies and Macpherson 1995)
Mugilidae	**Mullets**	
Mugil spp.	Mullet	(Frau et al. 2003)
Phycidae	**Phycid Hakes**	
Phycis phycis	Forkbeard	(Frau et al. 2003)
Pomacentridae	**Damselfish**	
Chromis chromis	Damselfish	(García-Rubies and Macpherson 1995)
Scorpaenidae	**Rockfish/Scorpionfish**	
Scorpaena maderensis	Madeira rockfish	(Frau et al. 2003)
Serranidae	**Seabasses**	
Serranus cabrilla	Comber	(Guidetti 2000)
Serranus scriba	Painted comber	(Guidetti 2000)
Sparidae	**Porgies**	
Diplodus annularis	Annular seabream	(Frau et al. 2003)
Diplodus puntazzo	Sharpsnout seabream	(García-Rubies and Macpherson 1995; Harmelin-Vivien et al. 1995)
Diplodus sargus	White seabream	(Guidetti 2000)
Diplodus vulgaris	Common two-banded seabream	(García-Rubies and Macpherson 1995; Harmelin-Vivien et al. 1995)
Oblada melanura	Saddled seabream	(García-Rubies and Macpherson 1995; Harmelin-Vivien et al. 1995)
Sarpa salpa	Salema	(Harmelin-Vivien et al. 1995)
Tripterygiidae	**Threefin blennies**	
Tripterygion delaisi	Black-faced blenny	(Guidetti 2000)
Tripterygion tripteronotus	no common name	(Frau et al. 2003)

Table 4-3. Percentage distribution of sparid juveniles per microhabitat (0 to 15 m water depth) in the Mediterranean Sea. Total percentage per size class is greater than 100% since juveniles may exist in several of the microhabitats listed. cm = centimeter, N = sample size, TL = total length (Harmelin-Vivien et al. 1995).

Microhabitat Classification	Size Classes		
	1-2 cm TL	>2-4 cm TL	>4-6 cm TL
	N = 2,178	N = 2,235	N = 608
Horizontal rocks and algae	0.8	9.9	6.4
Sloping rocks and algae	7.8	29.6	28.8
Boulders and algae	66.8	62.9	56.9
Pebbles and algae	21.5	40.9	30.1
Pebbles	14.9	11.2	6.4
Gravel	21.4	3.2	1.3
Sand	20.1	3.9	8.7
Mud	0	<0.1	1.5
Posidonia seagrass beds	0.5	<0.1	0.2

The Ugento seamounts, located between Santa Maria di Leuca and Gallipoli, range in depth from 40 to 80 m and are mainly colonized by zoantharians, gorgonians, madreporarians, bryozoans, and mollusks as well as fish and cephalopods of commercial interest (D'Onghia et al. 2006). Common also in this region are photophilic algae such as chlorophyceae and calcarious rhodophyceae (D'Onghia et al. 2006).

Deeper rocky bottom communities in the Mediterranean Sea are largely dominated by echnioderms (Massutí and Reñones 2005) and by algae that are adapted to low light levels such as encrusting coralline algae (Cebrián and Ballesteros 2004), *Sargassum acinarium* and other brown algae (Cocito et al. 2000). The accretion of calcareous encrusting algae in dimly lit environments develop coralligenous substrates (coralligenous bioherms) that are typical of Mediterranean Sea circalittoral rocky bottoms (Cebrián and Ballesteros 2004; Ballesteros 2006). Coralligenous substrates form mainly on horizontal substrates, vertical walls, at the base of walls, in deep channels, on overhangs, and in caves (Ballesteros 2006). Coralligenous substrates are common around the Mediterranean coasts (Israel and Lebanon may be exceptions) in water depths ranging from 10 to 130 m, depending on water clarity (Ardizzone 2006; Ballesteros 2006). A combination of biotic and abiotic factors such as light, sedimentation, and biological interactions, affect the distribution of coralligenous bioherms (Ardizzone 2006). Many species of suspension feeders grow on the coralligenous banks and their abundances are related to depth, habitat (suspension feeders prefer crevices, boulder zones, and north-facing slopes), currents, and available food (particulate organic matter; Cebrián and Ballesteros 2004). Corallingenous bioherms are also inhabited by species of high commercial value including fishes (i.e., seabream [*Diplodus*], seabass [*Epinephelus* and *Serranus*]), large crustaceans, and red coral (*Corallium rubrum*; Ardizzone 2006). Other characteristic species include algae, serpulids, bryozoans, sponges, crustaceans, and pelecypods (Bellan-Santini 1985; Ballesteros 2006). Coralligenous communities support high species diversity in the Mediterranean Sea, with approximately 1,666 species of invertebrates, macroalgae, and fish (Ballesteros 2006). These communities are important habitats for some endangered Mediterranean Sea species, although none is exclusive to this habitat (Ballesteros 2006). Major risks to these habitats include sedimentation, trawling fisheries, waster water effluent, diver activity, invasive alien species, and global warming that cause large-scale events such as mass mortalities (Ardizzone 2006; Ballesteros 2006). Some data regarding the location of rocky reefs in the eastern Mediterranean Sea is mapped in **Figure 4-3**. No other information or data were found regarding rocky reefs in the eastern Mediterranean Sea.

4.3.4 Shallow-Water Corals

Shallow-water corals of the eastern Mediterranean Sea are represented by scleractinians (class Anthozoa, subclass Hexacorallia, order Scleractinia) and octocorals (class Anthozoa, subclass Octocorallia, orders Gorgonacea and Alcyonacea). Deep-sea corals are discussed in a separate section (refer to **Section 4.3.5**). Areas that support shallow water corals in the eastern Mediterranean Sea are found on the continental shelf (shoreline to approximately 150 m water depth).

Shallow-water corals of the eastern Mediterranean Sea are typically found on hard substrates (vertical walls, overhangs, and caves) which mainly include rocky and coralligenous substrates (coralligenous bioherms; Bellan-Santini 1985; Ballesteros 2006). Coralligenous substrates can support a highly diverse assemblage of sessile and motile organisms (1,666 species, 43 of which are anthozoans) including scleractinians and octocorals. The assemblage of organisms (animals and plants) that coralligenous substrates support varies depending on nutrient levels and currents. The eastern Mediterranean Sea is generally oligotrophic (Fredj and Laubier 1985). In nutrient-poor areas, dominant suspension-feeders of coralligenous bioherms include sponges, bryozoans, and scleractinians (Ballesteros 2006).

Shallow-Water Corals of the Eastern Mediterranean Study Area—Main areas of the eastern Mediterranean Sea that potentially support shallow corals in the Study Area (as opposed to deep-sea corals) include an 4,987 km^2 area in the Strait of Sicily (within the 150 m isobath) and a 4,225 km^2 area contained between Malta and the southern end of Sicily (within the 150 m isobath). Two other shelf areas of the eastern Mediterranean Study Area that probably support corals but that are not discussed here include an area off the Gaza Strip (depth range 20 to 150 m) and another along the Egyptian coastline (depth range 70 to 150 m). Areas of the Aegean and Adriatic Seas that support corals are not discussed here since they are outside of the Study Area.

Within the 50 to 160 m depth range, the Study Area in the eastern Mediterranean Sea may include up to 25 endemic scleractinian coral species (Zibrowius 1980). There are 13 endemic scleractinian corals known throughout the eastern Mediterranean Sea (Strait of Sicily, Adriatic Sea and east of 21° meridian; Zibrowius 1980). Scleractinians that are common in the eastern Mediterranean Sea are *Madracis pharensis*, *Cladocora caespitosa*, *Madrepora oculata*, *Caryophyllia smithii*, *Caryophyllia inornata*, *Paracyathus pulchellus*, *Polycyathus muellerae*, *Hoplangia durotrix*, *Lophelia pertusa*, *Phyllangia mouchezii*, *Guynia annulata*, *Balanophyllia europaea*, and *Leptopsammia pruvoti* (Zibrowius 1980). Zibrowius (1980) reported 22 endemic scleractinians for the Strait of Sicily and three additional scleractinians (*Caryophyllia calveri*, *Dendrophyllia cornigera*, and *Balanophyllia regia*) east of the 21° meridian.

The coral *Madracis pharensis* is particularly common on coralligenous bioherms in the eastern Mediterranean Sea in the Aegean and Adriatic seas (Ballesteros 2006). Within the eastern Mediterranean Sea, *Cladocora caespitosa*, a main endemic Mediterranean Sea scleractinian and hermatypic coral is found in water depths of up to 50 m (Zibrowius 1980; Morri et al. 1994; Peirano et al. 1997; Rodolfo-Metalpa et al. 2006). It grows on natural and artificial substrates. It is known in the Gulf of Gabes, off Malta, in the Ionian, Adriatic and Aegean Seas, south of Crete, Israel, and Egypt (Zibrowius 1980; Peirano et al. 1997). It forms coral beds (banks) in the Adriatic Sea and the southeastern Mediterranean Sea (Gulf of Atalanta, Levantine Sea; Zibrowius 1980; Schuhmacher and Zibrowius 1985).

The scleractinian *Caryophyllia smithii* is widespread on soft bottoms typically found within the 40 to 200 m depth range (Zibrowius 1980). A species that is typical of caves, overhangs, and crevices of coralligenous bioherms is *Caryophyllia inornata*. Live specimens of this species were found in water depths reaching 100 m. Other scleractinians typical of caves and overhangs are *Paracyathus pulchellus* and *Hoplangia durotrix.* The latter is also common on coralligenous bioherms. Live specimens of *P. pulchellus* were found down to a depth of 200 m and those of *H. durotrix* down to 150 m.

Overhangs, walls, and caves are also populated by *Phyllangia mouchezii* which is typically found in relatively shallow water (no more than 55 m water depth) but may occur in a 100 m water depth. The zooxanthellate coral *Balanophyllia europaea* is light-dependant and does not occur in caves. Rather it is

found in shallow sunlit areas and on coralligenous substrates in a water depth not exceeding 50 m. Caves, overhangs, dimly lit walls, and coralligenous bioherms are populated by *Leptopsammia pruvoti* down to a water depth of approximately 150 m (Zibrowius 1980).

Starting in the early 1980s, *Oculina patagonica*, an invasive scleractinian originating from the southwest Atlantic Ocean, began to occur in shallow waters (up to 30 m water depth) of the eastern Mediterranean Sea off Egypt, Lebanon, and Israel (Fine et al. 2001).

Condition of Shallow-Water Corals of the Eastern Mediterranean Sea—In contrast with the western Mediterranean Sea, scleractinians of the eastern Mediterranean Sea and not gorgonians died as a result of the thermal stress in the upper water column that occurred in 1999 (Cerrano et al. 2000). Other records of the condition of corals in the eastern Mediterranean Sea include the recurrent bleaching of *Oculina patagonica* that typically occurs during the summer as documented off Israel (Rosenberg and Falkovitz 2004). The bleaching of *O. patagonica* coincides with warm seawater temperature but is caused by a bacterial infection or *Vibrio shiloi* (Rosenberg and Falkovitz 2004).

In addition to widespread mortality events affecting coral populations of the Mediterranean Sea, the overharvesting of red coral has had substantial long-term impacts in the Mediterranean Sea and particularly in the western basin (Santangelo et al. 2003; Ballesteros 2006). Overharvested populations of the slow growing red coral may take decades to recover (Tsounis et al. 2006). Trawling causes the most severe impacts to coralligenous bioherms and associated species by way of physical impacts, increased sedimentation, and increased turbidity (Ballesteros 2006). Traditional and recreational fishing target red coral and vulnerable fish species (e.g., grouper) on coralligenous bioherms (Ballesteros 2006). Other sources of impact on corals include the overgrowth and competition by invasive algal species on coralligenous bioherms. The list of invasive algae on coralligenous bioherms in the Mediterranean Sea included pantropical red seaweed (*Womersleyella setacea*), red algae (*Acrothamnion preissii*), green algae (*Caulerpa taxifolia*), red algae (*Asparagopsis taxiformis*), and red algae (*Lophocladia lallemandii*; Ballesteros 2006).

4.3.5 Deep-Sea Corals

True deep-sea coral communities live in complete darkness, in temperatures as low as 4°C and in waters as deep as 6,000 m; therefore, they are also known as “cold-water coral reefs” (Freiwald et al. 2004).[9] Deep-sea coral genera exist, however, within a fairly broad range of environmental conditions: 4° to 13°C, 32 to 39 psu, and as shallow as 13 m (Hain and Corcoran 2004; Álvarez-Pérez et al. 2005). True deep-sea corals lack the symbiotic zooxanthellae typically found in tropical reef-building corals and do not benefit from a carbon supply provided by symbiotic algae. Rather deep-sea corals survive solely on suspension-feeding. The biological diversity of deep-sea corals communities can be high; from an economic perspective, this diversity creates valuable habitat for several commercially fished species (Witherell et al. 2000; Gass 2003).

Deep-sea coral communities usually consist of sessile stony corals (order Scleractinia), soft corals (subclass Octocorallia), black corals (order Antipatharia), and lace corals (order Stylasterina; Freiwald et al. 2004; Hain and Corcoran 2004; Roberts and Hirshfield 2004). These corals can build very large 3D structures in deep-sea environments that are comparable in size and complexity with coral reefs that occur in shallow tropical waters (Freiwald et al. 2004). Deep-sea coral assemblages can provide habitat to sessile and motile species including sponges, polychaetes (or bristle worms), crustaceans (crabs and lobsters), mollusks (clams, snails, octopuses), echinoderms (starfish, sea urchins, brittle stars, feather stars), bryozoans (sea moss), and fish (Freiwald et al. 2004). Much like their shallow-water counterparts, deep-sea corals are fragile and slow growing: thus, they are vulnerable to human-induced physical impacts (Andrews et al. 2002; Roberts and Hirshfield 2003; Freiwald et al. 2004; Roberts and Hirshfield 2004).

Trawls and heavy fishing gear used by commercial fishing have caused severe damages to deep-sea coral communities in many areas of the world (Freese et al. 1999; Roberts and Hirshfield 2004). Deep-sea coral communities are also susceptible to physical impacts caused by oil- and gas-related activities,

cable laying, seabed aggregate extraction, shipping activities, disposal of waste in deep waters, coral exploitation, mineral exploration, and increased atmospheric carbon dioxide (CO_2; Gass 2003; Freiwald et al. 2004; Roberts and Hirshfield 2004). It may take decades to centuries for physically damaged deep-sea coral communities to recover (Freiwald et al. 2004; Roberts and Hirshfield 2004). The recovery of the deep-sea corals is particularly slow not only because of slow growth rates but also because larvae production is positively related to the size of the parent coral colony. Further, some damaged colonies will first devote energy to making repairs before sexual reproduction takes place (Andrews et al. 2002).

Mediterranean Sea Deep-Sea Corals—Deep-sea scleractinian species in the Mediterranean Sea occur from 39 to 2,500 m (De Mol et al. 2005). They are found on soft and hard substrates (cliffs, rocks), coarse-grained calcareous sediments, loose or cemented remains of coral skeletons (carbonate substrates), deep-sea subfossilized giant oysters, diagenized sponges, mound structures, canyons, escarpments, seamounts, and artificial substrates (submarine cables; Fredj and Laubier 1985; Tursi et al. 2004; Álvarez-Pérez et al. 2005; Taviani et al. 2005a; Zibrowius and Taviani 2005). Deep-sea corals are known in more than 20 general locations of the Mediterranean Sea, few of which are in eastern Mediterranean Sea (**Figure 4-2**; WWF/IUCN 2004).

While deep-sea corals may form large structures in the Atlantic or Pacific oceans, colonial deep-sea corals of the Mediterranean Sea typically do not form large bioherms (H. Zibrowius, Centre d'Océanologie de Marseille, pers. comm. 5 September 2006). Coral bioherms known in the Mediterranean Sea include those mapped in the northeast Tyrrhenian Sea (Gasperini et al. 2005) and those of the Ionian Sea located off Santa Maria di Leuca, Italy (Taviani et al. 2005b). These mounds measured up to 3 to 4 m in height and tens of meters wide.

There are few endemic Mediterranean Sea deep-sea corals and relatively few deep-sea coral species overall compared to the Atlantic Ocean (Fredj and Laubier 1985). Of the 16 deep-sea coral species in the Mediterranean Sea, three are dominant: *Lophelia pertusa*, *Madrepora oculata*, and *Desmophyllum dianthus* (De Mol et al. 2005; Taviani et al. 2005a). There are five species of deep-sea gorgonians that occur below 200 m, the most common of which is *Isidella elongata* (Fredj and Laubier 1985). Deep-sea coral diversity is greatest in the Strait of Gibraltar and decreases from west to east (De Mol et al. 2005). While these corals are typical of the deep-sea, they may occur in water depths as shallow as 30 m in the Mediterranean Sea (Álvarez-Pérez et al. 2005).

In the deep-sea, *Lophelia pertusa* and *Madrepora oculata* can grow on each other to form 3D structures to which the solitary *Desmophyllum dianthus* will associate (De Mol et al. 2005; Gasperini et al. 2005; Taviani et al. 2005a; D'Onghia et al. 2006). These structures (frameworks) provide habitat for other invertebrates and fishes (**Table 4-4**; Rogers 1999; Maynou and Cartes 2006). Further, deep-sea coral habitat created by the gorgonian *Isidella elongata* (400 to 800 m depth range) supports substantial diversity and abundance of crustacean decapods and fishes (Maynou and Cartes 2006).

Table 4-4. Invertebrates and fishes (recorded in the Ionian Sea) that can be found associated with the 3D habitat formed by *Lophelia pertusa*, *Madrepora oculata*, and *Desmophyllum dianthus* (Tursi et al. 2004; Longo et al. 2005; Zibrowius and Taviani 2005; Maynou and Cartes 2006).

Invertebrates and Fish	Species
Decapod crustaceans	Norway lobster (*Nephrops norvegicus*)
	Deepwater rose shrimp (*Parapenaeus longirostris*)
	Red shrimp (*Aristeus antennatus*)
Sponges	*Poecillastra compressa*
	Cliona levispira
	Sceptrella insignis
	Desmacella inornata
	Stylocordyla pellita
	Vulcanella (vulcanella) gracilis
	Siphonidium ramosum
Molluscs	*Emarginula adriatica*
	Asperarca nodulosa
	Bathyarca philippiana
	Delectopecten vitreus
	Spondylus gussonii
Polychaete	*Eunice norvegica*
Soft coral	*Scleranthelia musiva*
Gorgonians	*Acanthogorgia hirsuta*
	Callogorgia verticillata
	Dendrobrachia fallax
	Placogorgia sp.
	Smooth black coral (*Leiopathes glaberrima*)
Holothurians	Sea cucumber (*Psolidium complanatum*)
	Sea cucumber (*Stichopus regalis*)
	Pencil urchin (*Cidaris cidaris*)
Fishes	Spiny Eel (*Notacanthus bonapartei*)
	Conger Eel (*Conger conger*)
	Mediterranean Spider Fish (*Bathypterois dubius*)
	Mediterranean Codling (*Lepidion lepidion*)
	Common Mora (*Mora moro*)
	Greater Forkbeard (*Phycis blennoides*)
	Silver Rattail (*Hymenocephalus italicus*)
	Bluntsnout Grenadier (*Nezumia sclerorhynchus*)
	Mediterranean Slimefish
	Blackbelly Rosefish (*Helicolenus dactylopterus*)

Atlantic-type coral taxa (including *Oculina*, *Dendrophyllia*) colonized the Mediterranean Sea deep-sea starting in the Middle Miocene (approximately 14 million years before present; Taviani et al. 2005a). During the late Miocene Messinian crisis the connection with the Atlantic Ocean was closed and the Mediterranean Basin probably desiccated to the point of driving the deep-sea biota to extinction (Bouchet and Taviani 1992). Extant dominant coral genera (*Lophelia*, *Madrepora*, and *Desmophyllum)* date back to the Pliocene-Early Pleistocene (approximately 3.2 million years before present; Bouchet and Taviani 1992; Taviani et al. 2005a) when marine species recolonized the Mediterranean Sea as a result of the

opening of Atlantic Ocean-Mediterranean Sea gateway (Bianchi and Morri 2000). The composition of deep-sea corals evolved since following climatic changes from tropical-subtropical to temperate conditions (Bianchi and Morri 2000). Extant deep-sea coral species date back to the glacial Pleistocene upper series (Zibrowius 1980). The deep-sea fauna was more diverse and abundant during the last glacial period and at the onset of deglaciation (15,000 to 30,000 yrs before present) than today (Delibrias and Taviani 1985). The glacial deep-sea corals that once abounded in the Mediterranean Sea declined abruptly at the onset of post-glacial environmental conditions when a substantial increase in seawater temperature took place (Delibrias and Taviani 1985; Taviani et al. 2005a). This temperature increase was followed by a decrease in sea surface productivity and a shortage of food supply to the deep sea which probably caused starvation of corals; altered respiration and reproduction, and drove deep-sea corals to their decline (Delibrias and Taviani 1985).

Extant deep-sea coral species of the Mediterranean Sea have a strong Atlantic Ocean affinity and yet they exist in fairly extreme hydrological conditions compared to their Atlantic Ocean counterparts (Delibrias and Taviani 1985; Fredj and Laubier 1985). The Mediterranean Sea has a negative hydrological balance (evaporation greater than freshwater input), the deficit of which is compensated by the inflow of surface Atlantic Ocean water (36 psu) through the Strait of Gibraltar (Fredj and Laubier 1985). As a consequence, the Mediterranean Sea acts as a concentration basin. Mean salinity in the western Mediterranean Sea deep sea (below 200 m) ranges from 38 to 38.6 psu and temperature ranges 12.8° to 13.0°C. In the eastern Mediterranean Sea, salinity of the deep sea (below 400 m) ranges from 38.7 to 39.1 psu and temperature ranges from 13.5° to 14.0°C (Bouchet and Taviani 1992; Manca et al. 2004). Further, overall sedimentation in the Mediterranean Sea deep sea is similar to tropical Atlantic Ocean characteristics: limited terrigenous input, low concentrations of suspended matter, and low planktonic productivity (Fredj and Laubier 1985). Terrigenous input is high, however, close to the mouth of River Rhône in the western Mediterranean Sea and the Nile in the eastern Mediterranean Sea (Fredj and Laubier 1985).

In the nearby Atlantic Ocean, the same deep-sea corals flourish in water that is less than 7°C and where salinity ranges from 34 to 35 psu (Zibrowius 1980; Pickard and Emery 1982). The high salinity and temperature of the Mediterranean Sea deep-sea is thought to act as a barrier to the colonization of deep-sea coral spat dispersed from the Atlantic Ocean (Bouchet and Taviani 1992). This barrier is probably the cause of the overall low deep-sea biodiversity of the Mediterranean Sea compared to other oceans (Fredj and Laubier 1985; Bouchet and Taviani 1992). The few species that do occur in the Mediterranean deep-sea occur in low densities (Bouchet and Taviani 1992). Further, in terms of deep-sea coral diversity and density, the eastern basin is even more impoverished than the western basin (Bouchet and Taviani 1992).

The limited replenishment potential of deep-sea corals from the Atlantic Ocean to the Mediterranean Sea suggests that human disturbances have the potential of increasing the level and rate of the decline of deep-sea coral populations in the Mediterranean Sea. Human disturbances actually or potentially affecting deep-sea coral populations include climate change, physically destructive fishing techniques (dredges and trawl nets), and the introduction of invasive species (Bianchi and Morri 2000; Maynou and Cartes 2006). Increased warming of deep water in the Mediterranean Sea as a consequence of climate change may compromise the survival, reproduction, dispersal, and recruitment of existing deep-sea corals (Bianchi and Morri 2000).

Deep-Sea Corals of the Eastern Mediterranean Study Area—Deep-sea benthic communities of the eastern Mediterranean Study Area are known in the Strait of Sicily, Adriatic Sea, Ionian Sea, Levantine Sea, and Aegean Sea (**Figure 4-2**; Fredj and Laubier 1985; Tursi et al. 2004; WWF/IUCN 2004; Bromley 2005; Taviani et al. 2005a; Zibrowius and Taviani 2005). Typical deep-sea coral genera of the eastern Mediterranean Sea include *Lophelia*, *Madrepora*, and *Desmophyllum* (Taviani et al. 2005a). *Lophelia pertusa* was documented on Nameless Bank in the Strait of Sicily (267 to 710 m depth range; Zibrowius and Taviani 2005); and in the Ionian Sea (coral mounds of White Coral Bank, off Santa Maria di Leuca, southeastern Italy, 425 to 1,100 m depth range; **Figure 4-2**; Tursi et al. 2004; Taviani et al. 2005b). *Madrepora oculata* is more common than *L. pertusa* within the eastern Mediterranean Sea, and occurs in the Aegean Sea and the Ionian Sea (coral mounds of White Coral Bank, Santa Maria di Leuca, 425 to

1,100 m depth range; **Figure 4-2**; Tursi et al. 2004; Taviani et al. 2005a; Taviani et al. 2005b). The White Coral Bank in the Ionian Sea is made of fossil and live *Lophelia* and *Madrepora* (Longo et al. 2005). The solitary coral *Desmophyllum dianthus* is more common that either *L. pertusa* or *M. oculata* and occurs throughout the eastern Mediterranean Sea with the exception of the Adriatic Sea. It was found within a 200 to 1,200 m water depth range in the Ionian Sea off Santa Maria di Leuca, southeastern Italy growing on *L. pertusa* and *M. oculata* (Tursi et al. 2004; Taviani et al. 2005a; D'Onghia et al. 2006); in the Aegean Sea; and on the Eratosthenes Seamount south of Cyprus (1,200 m water depth; **Figure 4-3**). Other live scleractinians documented in the eastern Mediterranean Sea include *Stenocyathus vermiformis* (worm coral) and *Thalamophyllia gasti* found on Nameless Bank in the Strait of Sicily (267 to 710 m depth range; Zibrowius and Taviani 2005). Worm corals were also found off Santa Maria di Leuca growing on *L. pertusa* and *M. oculata* (Tursi et al. 2004; D'Onghia et al. 2006).

4.3.6 Chemosynthetic Communities

In light-dependant marine ecosystems, the primary producers (e.g., phytoplankton and seagrasses) produce energy through photosynthesis (a photosynthetic ecosystem). In marine environments rich in methane (CH_4) and sulfides, chemosynthetic bacteria, sulfur-oxidizing bacteria, methane-oxidizing bacteria, and sulfide-reducing bacteria, create the energy that can be used by the organisms in the environment.[2] Chemosynthetic communities are a significant source of biological productivity on the deep-seafloor (**Figure 4-4**). In some locations, vast fields of hydrothermal vents can support benthic communities (Hessler and Lonsdale 1991; Hashimoto et al. 1995; Galkin 1997; Smith et al. 2003). In other locations, gas hydrates in the sediments support extensive chemosynthetic communities (Fisher et al. 2000; Lanoil et al. 2001; Reed et al. 2002).

Chemosynthetic habitats are formed by a variety of geological and biological processes on continental margins, and despite their location in the deep sea, have high biomasses maintained by chemosynthetic bacterial production (Fujikura et al. 2002; Smith et al. 2003) Natural whale falls, hydrothermal vents and seeps, and wood falls provide specific habitat duration and each of these chemosynthetic habitats appears to foster a characteristic fauna (Airamé et al. 2003). All chemosynthetic systems depend on the primary productivity of chemolithoautotrophic bacteria to survive (Nybakken 2001). Of the benthic fauna associated with chemosynthetic ecosystems, some house these symbiotic chemosynthetic bacteria inside their bodies to obtain essential nutrients (Anderson et al. 1993).

In the Mediterranean Sea, chemosynthetic environments (e.g., hydrothermal vents, cold seeps, mud volcanoes, gas hydrates, DHABs, whale falls) are patchily distributed on the ocean floor and can be separated by distances of hundreds to thousands of kilometers (Briand 2003). The Mediterranean Ridge is an accretionary prism that was formed by the subduction of the African plate. The conditions formed by the Mediterranean Ridge are conducive to the formation of chemosynthetic habitats. The occurrence of these chemosynthetic habitats (e.g., mud volcanoes, brine pools) along the Mediterranean Ridge are similar to other chemosynthetic ecosystems in the world's oceans such as the Barbados Ridge complex and the Gulf of Mexico continental slope (Metaxas 2003).

4.3.6.1 Hydrothermal Vents

Hydrothermal vent fluids are rich in chemicals as the heated seawater reacts with the molten rock, causing metals and other minerals to dissolve into solution. The fluids are typically poor in oxygen content and contain toxic reduced chemicals including H_2S, heavy metals, and metal sulfides, which include iron, copper, calcium, silicon, and zinc, as well as metalloids (McMullin et al. 2000; Rathgeber et al. 2002). As the hot hydrothermal fluids come in contact with the much cooler seawater overlying the vent, heavy metals precipitate out and accumulate, forming chimneys and mounds. In complete darkness, high ambient pressure, and extreme thermal and chemical conditions of the deep sea, animals are able to adapt and colonize these sites to form luxuriant chemosynthetic communities. Chemosynthetic bacteria use the reduced chemicals of the hydrothermal fluid (primarily H_2S) as an energy source. Because vent water is anoxic, organisms that require both oxygen and sulfide survive in the narrow area where vent water and ambient water interact (Nybakken 2001).

In 1977, the discovery of hydrothermal vents, profoundly impacted the conventional wisdom associated with structure and function of marine biological communities (Metaxas 2003). Macrofaunal communities associated with chemosynthetic environments are typically characterized by high biomass and low diversity. Fauna can either consume or form symbiotic relationships with the chemosynthetic bacteria (Wheat et al. 2000; Nybakken 2001). In both cases, these animals use numerous morphological, physiological, and behavioral adaptations to flourish in this extreme deep-sea environment. Since, 1979, some 500 new species have been found associated with vent systems (Wheat et al. 2000). In addition, hydrothermal vents sustain a variety of microbial habitats including one within the subseafloor within which warm water vents form cracks in the seafloor. Such venting brings these microorganisms to the seafloor surface (Mehta et al. 2003). Hydrothermal vents have a lifespan of decades. Some inactive vent systems have been observed with the remains of vent macrofauna communities; this suggests that vent organisms have life spans that are also in tens of years (Nybakken 2001).

Hydrothermal vents in the Mediterranean Sea (**Figure 4-4**) are a result of the collision of the African and European plates resulting in the formation of the Mediterranean Ridge, deep basins, and active volcanic arcs. The hydrothermal vents of the Mediterranean Sea occur in shallow waters (<100 m) and are associated with volcanic arcs (WWF/IUCN 2004). Most studies have focused on the vents along the Calabrian and Hellenic Volcanic arcs and fewer studies have focused along the Turkish coast and the crustal extension areas in the Tyrrhenian and Aegean Seas (Dando et al. 1999). Unlike cold seeps, which are well represented along the Mediterranean Ridge, very few hydrothermal vents have been observed in the deeper waters of the Mediterranean Sea (WWF/IUCN 2004). The main difference between deep-sea and shallow-water hydrothermal vents is the occurrence of photosynthetic primary production. Also, the biota that inhabit the shallow-water Mediterranean Sea hydrothermal vents are not endemic to these habitats; they represent the more tolerant fauna of the region (Metaxas 2003). The hydrothermal vents associated with volcanic arcs release large volumes of gas and since most of the vents in the Mediterranean Sea occur in shallow areas, the majority of the outlets are of the gaso-hydrothermal type emitting large volumes of CO_2 (Dando et al. 1999). They also emit heat and metals into the coastal marine ecosystems (WWF/IUCN 2004).

The biotas in the area of shallow Mediterranean Sea hydrothermal vents are characterized by filter-feeders and surface deposit-feeders (Dando et al. 1999). The meiofauna have a reduced diversity, the epifauna (thermophilic species) have a high diversity, and there are generally large numbers of prokaryotes (especially Crenarchaeota). Mediterranean Sea vents support large numbers of Crenarchaeota prokaryotes (sulfur-oxidizers) that are similar to those found at mid-ocean ridge vents and elsewhere. These prokaryotes have potential for biotechnological applications, especially for producing enzymes which degrade biopolymers under conditions in which normal enzymes are inactivated. Organisms that gain nutriment from these symbiotic, sulfur-oxidizing bacteria (e.g., solemyids, lucinid and thyasirid bivalves, and desmodorid nematodes) normally inhabit reducing marine sediments. These organisms seem to be unable to tolerate the prevailing higher temperatures, salinities, sulfide, and metal concentrations around the vents. Some opportunistic species have a degree of sulfide and temperature tolerance; these species, such as the polychaete, *Capitella capitata* (Fabricius), and nematode, *Oncholaimus campyloceroides*, colonize vent vicinities in large numbers. Because most of the hydrothermal vents in the Mediterranean Sea are shallow, they have potential for geothermal heating and power, tourism, pollution control, and biotechnological applications (Dando et al. 1999).

In the eastern Mediterranean Sea, the Hellenic Trench extends from western Greece to southern Turkey and provides several chemosynthetic habitats including the DHABs of Bannock, Tyro, and Strabo basins south of Crete and seamounts with active hydrothermal vents (Dando et al. 1999). Off of Milos Island, there are shallow water hydrothermal vents (44 m water depth) that support extensive white flocculent bacterial mats (Desbruyères 2003). In June 1996, studies were conducted on the shallow hydrothermal vents off Palaeochori Bay. The biotas associated with these vents are extremely diverse and included 83 algae and 212 epifaunal species. No vent-obligate macro-epibenthic species were found but most were warm-water species (Dando et al. 1999; De Biasi et al. 2004). The most common macrofauna found at the vent outlets and living on top of the brine seeps were nassariid gastropods, *Cyclope neritea* and *Nassarius mutabilis*. Near the Milos vent fields, the echiuran, *Bonellia cf. viridis*, appeared to feed on the bacterial mats; this organism is normally found on hard bottom habitats. Although out of the Study Area,

the volcanic arc in the Aegean Sea is home to major hydrothermal vent fields at Euboea, Methana and Sousaki, Milos, Santorini, Kos and Yali, and Nisiros (Dando et al. 1999).

4.3.6.2 Cold Seeps

A cold seep (sometimes referred to as a cold vent) is a region of the seafloor that releases H_2S, CH_4, and other hydrocarbon-rich fluids (Airamé et al. 2003). Cold seep communities depend upon chemolithoautotrophic production associated with the emission of reducing chemicals from "cold" hypersaline brines or other hydrocarbon seeps such as methane hydrates (Nybakken 2001). Chemolithoautotrophic bacteria oxidize the reduced chemicals to form organic matter from CO_2. Typically, cold seeps originate from relatively young sediments and are common along basin margins; however, in recent years many seep communities have been reported in tectonically passive margins, active regions of plate collision, and along marginal basins (Hashimoto et al. 1989; Kvenvolden 1993).

Sediments containing hydrocarbon seeps are often more productive than the surrounding sediments and seepage into surrounding waters has a profound effect on microbial populations and productivity; increased production is likely due to the increased concentration of sulfides as well as the high alkalinity in the sediments (Montagna et al. 1986). For example, hydrocarbon-degrading microbes often comprise a large percentage of the biota associated with hydrocarbon seeps. These bacteria derive energy from the inorganic chemical compounds that is released (i.e., via free-living bacteria, methane-oxidizing archaea, sulfate reducing bacteria, and a consortia of these metabolic types; Airamé et al. 2003). Recently, high rates of chemosynthesis has been documented from the sediments at CH_4 seeps (Levin and Michener 2002).

Chemosynthetic communities associated with cold seeps display an astonishing assemblage of macrofauna forming a unique association for the deep sea (Sibuet and Olu 1998). These macrofauna obtain chemosynthetically fixed organic matter by (1) translocation from sulfide- or methane-oxidizing symbionts, (2) feeding on free-living chemoautotrophic bacteria, or (3) consuming another animal that obtains nutrition through (1) or (2) (Levin and Michener 2002). The chemical makeup of the fluids and depth governs the faunal composition, abundance, and diversity of chemosynthetic communities (Airamé et al. 2003). The vesicomyid clam, *Calyptogena kilmeri*, is most common in areas characterized by high sulfide concentrations. In contrast, at the edge of seeps where sulfide levels are lower, *Calyptogena pacifica* is abundant. In cold seeps rich in CH_4 such as brine pools or methane hydrates, mussels (*Bathymodiolus* spp.) are the dominant macrofauna. These mussels have a methane-based symbiosis where intracellular bacteria oxidize the CH_4 and provide energy for the mussels and the bacteria (Nybakken 2001). Various species are attracted to the biological activity around cold seeps (Airamé et al. 2003).

Of the 211 species of macrofauna known from seeps at present, most are endemic and only 13 species are shared between hydrothermal vents and cold seeps (Sibuet and Olu 1998). Diversity at cold seeps is generally higher than at hydrothermal vents. This is possibly due to the fact that hydrothermal vent systems depend primarily on the utilization of sulfides for energy whereas cold seep systems can utilize sulfides and/or CH_4 (Nybakken 2001). In addition, seeps are stable for a much longer period of time than hydrothermal vents. Cold seeps also have a greater depth distribution than hydrothermal vents, displaying a decrease in species richness with depth (Nybakken 2001).

In the Mediterranean Sea, mud volcanoes are one of the geological features that favor the formation of cold seeps rich in CH_4 (or methane hydrates) that supports chemosynthetic-based communities. These cold seeps are discussed in the following mud volcano **Section 4.3.6.5**. With regard to cold-seeps, CH_4 is the most common fluid constituent; *Beggiatoa*- or *Thioploca*-type bacteria have been found utilizing the anaerobic oxidation of CH_4 at methane-seeps off Pakistan (Peckmann et al. 2004).

Although exploration of cold seeps in the eastern Mediterranean Sea is still in its infancy, several cold-seep communities have been found south of Crete and Turkey, on mud volcanoes, or along faults and associated with high flux of CH_4 (**Figure 4-4**; Briand 2003). Initially, chemosynthetic communities associated with cold seeps in the Mediterranean Sea were discovered on the Napoli mud volcano (Olimpi

mud volcano field) and more recently in the Anaximander Mountain mud volcano field (Corselli and Basso 1996). At another locality, north of Egypt near the Nile delta (close to the Gaza Strip), cold seeps were observed on the continental slope and rise in depths of 500 to 800 m (WWF/IUCN 2004). The benthic communities that surrounded the seeps were dominated by small bivalves (Lucinidae, Vesicomyidae, Mytilidae, and Thyasiridae), pogonophorans (*Lamellibrachia* sp.), a sponge (*Rhizaxinella pyrifera*), polychaetes, galatheid crabs (*Munidopsis marionis* and *Munidopsis acutispina*), a large crab (*Chaceon mediterraneus*) and sea urchins (*Echinus* spp.; Briand 2003). These seeps are similar to those in the Gulf of Mexico in that they contain diverse carbonate forms, including cemented sediment, thick slabs, mounds, and hard "chimney-like" build-ups (Coleman and Ballard 2001).

4.3.6.3 Gas Hydrates

Gas hydrates, also called gas clathrates, are naturally occurring crystalline solids that are comprised of water molecules organized in a rigid polyhedral cage structure; each cage contains a molecule of natural gas, predominantly methane (Kvenvolden 1993; Gornitz and Fung 1994). The gas associated with the hydrates can be CO_2, H_2S, CH_4, or other hydrocarbons; in addition, a hydrate can either be biogenically derived or thermogenically produced (Schmidt 2004). Methane, the most common gas associated with hydrates, accounts for more than 99% of deep ocean hydrates (Schmidt 2004). Gas hydrates are capable of cementing loose sediments into a surface layer several hundred meters thick (Masutani and Coffin 2001). Thus, gas hydrates can alter (1) physical properties of sediments, such as shear strength, porosity, and permeability, (2) geophysical properties, such as acoustic velocity and resistivity, and (3) geochemical properties, such as fluid composition and movement (Kvenvolden 1993).

Gas hydrates occur worldwide on continental margins and have been identified on 10 to 30% of the world's continental shelves (Hovland et al. 1993; Heeschen et al. 2005). Fundamentally gas hydrates are known to occur in polar and deep oceanic regions because of the pressure-temperature and gas volume requirements for formation. In the deep ocean, although not thoroughly explored, gas hydrates are found in the sediments of the continental slope where cold bottom water is present (Kvenvolden 1993). The most obvious gas hydrates in the Mediterranean Sea are those associated with mud volcanoes. Mud volcanoes are a prime location for gas hydrates due to their high CH_4 content and the appropriate pressure and temperature conditions (Aloisi et al. 2000).

4.3.6.4 Whale Falls

The chemosynthetic communities associated with whale falls are probably the least known of the chemosynthetic ecosystems. Studies of whale falls has revealed that chemolithoautotrophic bacteria reside in, on, and around whale falls. Sulfide diffuses out of the bone and provides the energy source for the chemolithoautotrophic bacteria (Nybakken 2001). Whale carcasses on the seafloor support a high abundance of organisms commonly found near seeps, vents, and other deep-sea hard substrates (Baco and Smith 2003; Smith et al. 2003). It has been estimated that at any given time there may be in excess of 500,000 sulfide-rich whale skeletons on the deep-sea floor (Smith and Baco 2003; Smith et al. 2003). Whale falls promote high species diversity by providing hard substrates for settling, organic enrichment, and free sulfides on a typically organic-poor, sediment covered sea floor (Bennett et al. 1994; Butman et al. 1995; Smith and Baco 2003; Smith et al. 2003); these whale falls can support productive communities of chemosynthetic organisms for decades. The falls of large whales (27 to 145 metric tons [mt] adult body weight) yield massive pulses of labile organic matter to the deep-sea floor (Smith and Baco 2003).

4.3.6.5 Mud Volcanoes

Mud volcanoes are conical or volcano-like shaped surface expressions of mud extrusions that are formed when rapidly advecting, over-pressured, mud- and methane-charged pore fluids reach the seafloor (Aloisi et al. 2000). Mud volcanoes are invariably associated with fracture lines and faults in the oceanic crust and with the release of CH_4 gas. The mud of the volcanoes is a slurry of mud, saline water, and methane gas bubbles; thus, it is a reasonable conclusion that the presence of CH_4 gas in the subsurface is an essential feature of the mud volcanoes (WWF/IUCN 2004). Methane is also fundamental to a variety of physical, chemical, and biological processes associated with other areas of seafloor hydrocarbon gas

seepage known as cold seeps. In addition, given appropriate pressure and temperature conditions, mud volcanoes are a prime location for gas hydrates due to their high CH_4 content (Aloisi et al. 2000). Thereby, for the scope of this document; mud volcanoes are considered chemosynthetic habitats. From west to east, mud volcanoes have been documented at several localities along the Mediterranean Ridge: Cobblestone area 3, Pan di Zucchero area, Prometheus-2 area, the Olimpi area, and the Anaximander Mountain area (Corselli and Basso 1996).

In the eastern Mediterranean Sea, the tectonic collision between Africa and Eurasia caused the formation of more than 200 mud volcanoes along the crest of the Mediterranean Ridge (Charlou et al. 2003). There are two main mud volcano fields along the Mediterranean Ridge of the eastern Mediterranean Sea; the Olimpi mud volcano area (south of Crete), between 1,700 and 2,000 m water depths, and in the Anaximander mountain area (southwestern Turkey), between 600 and 2,000 m water depths (Aloisi et al. 2000). In the 2,330 km^2 area of the Olimpi mud volcano field, bathymetric and sidescan sonar data show more than 30 mud volcanoes (Charlou et al. 2003).

In 1998, the Dutch-French MEDINAUT diving expedition was conducted to study both the Olimpi and Anaximander mud volcano fields. The expedition explored the Napoli, Milano, Maidstone, and Moscow mud volcanoes from the Olimpi mud volcano field and the Amsterdam, Kazan, and Kula mud volcanoes from the Anaximander Mountains mud volcano field (Charlou et al. 2003). An upward flow of CH_4 was recorded at concentrations as high as 13 milliliters per liter (ml/l) indicating intense degassing related to fluid circulation in sediments (Desbruyères 2003). This CH_4 is formed either through biological process or from thermogenic gas from hydrocarbon deposits (Olu-Le Roy et al. 2004). These mud volcanoes are important sites of extensive CH_4 fluxes that are probably related to widespread occurrences of gas hydrates (Charlou et al. 2003). An extensive field of gas hydrate was sampled from both the Amsterdam and the Kula mud volcanoes (Olu-Le Roy et al. 2004). Chemosynthetic communities were found to be dominated by small sized bivalves belonging to four families (Lucinidae, Vesicomyidae, Mytilidae and Thyasiridae) and pogonophorans (Annelida, Siboglinidae, and Lamellibrachia; Desbruyères 2003; Fiala-Médioni 2003). These dense populations of chemosynthetic communities occur on mud volcanoes throughout both the Olimpi and Anaximander areas; however, living samples were mainly obtained from the Anaximender field at the top of the mud volcanoes, Amsterdam at 2,032 m depth, and Kazan at 1,707 m depth (Fiala-Médioni 2003). The coverage of bivalves was higher in the Anaximander Mountain area (Amsterdam and Kazan mud volcanoes) than in the Olimpi area (Napoli mud volcano); the percent cover of bivalves in the active areas of Amsterdam was 20.8%, Kazan was 38.6%, and Napoli was 10.5%. At least 25 species were collected form the mud volcanoes during the MEDINAUT cruise (Olu-Le Roy et al. 2004).

4.3.6.6 Deep Hypersaline Anoxic Basins

Deep Hypersaline Anoxic Basins (DHABs) are extreme habitats that form in tectonically active zones in the deep-sea that are characterized by oxygen depletion, salinity above 30%, absence of light, variable pH values and ionic composition, and elevated CH_4 and H_2S concentrations (De Lange et al. 1990; Lampadariou et al. 2003). This habitat sustains chemosynthetically based communities similar to that of seeps and vents incorporating meiofaunal benthic components, as well as diverse communities of protozoans and metazoans (Lampadariou et al. 2003). These habitats are common in the eastern Mediterranean Sea and host a unique environment that ranges among the more extreme ever described (**Figure 4-4**; WWF/IUCN 2004). There are five DHABs in the Mediterranean Sea, all below the depth of 3,300 m and with surface's that range from 5 to 20 km^2: Bannock, Urania, Discovery, L'Atalante, and Tyro basins (Lampadariou et al. 2003). The composition of these basins is fairly constant and the sharp density difference between the brine/seawater interface forms a very stable physical configuration that acts as a barrier to the exchange between seawater and brine (De Lange et al. 1990; Briand 2003). This interface also operates as a barrier to particles (e.g., organic matter and pollutants) that settle through the water column (Lampadariou et al. 2003). Each of the five DHABs is unique. For instance, the Urania basin has the highest concentration of sulfide among all of the earth's aquatic environments and has a mean temperature of 45ºC at the brine/sediment interface; the Discovery basin has hydrocarbon seeps (Lampadariou et al. 2003).

DHABs harbor unique faunal communities; the presence of a fauna living in these extreme environments, particularly metazoans, is unexpected and implies that adaptations exist that provide a long-term tolerance to anoxic conditions and high ionic concentrations. Although, very little is known concerning the biological assemblages that characterize DHABs (Briand 2003), preliminary studies suggest that DHABs typically support protistan and meiofaunal (e.g., nematodes, copepods, and foraminifera) communities that benefit from the symbiotic relationships with chemosynthetic prokaryotes (WWF/IUCN 2004). Many of the species found in DHABs are thought to be new for science (Lampadariou et al. 2003). The faunal components of each basin is detailed by Lampadariou et al. (2003):

- Discovery–Meiofauna comprised 75% of the total fauna and was dominated by copepods and foraminifera (mostly planktonic species). Juvenile bivalves, nematodes, and crustaceans were also found in significant abundance.

- L'Atalante–Similar to the Discovery basin, this basin was characterized by various meiofauna: nematodes, foraminifera, copepods, and juvenile mollusks (unidentified bivalves and gastropods).

- Urania–The faunal community was dominated (61.5%) by juvenile bivalves (unidentified species). In addition, in order of abundance, copepods, foraminifera, and other crustaceans occurred.

- Bannock–Two sites were sampled in this basin; at one of the sites, juvenile gastropods (unidentified species) were the most abundant fauna (45%) followed by bivalves, nematodes, and planktonic copepods and foraminifera. At the other site, meiofauna dominated the fauna and was comprised of various nematodes, foraminifera, crustaceans, and juvenile mollusks.

- Tyro–Currently, there are no studies that document the faunal assemblages of the Tyro Basin.

In addition to basins, brines are known to occur as lakes along with the Mediterranean Ridge; furthermore, the occurrence of brines in association with mud volcanoes is an important new observation. As a part of the Dutch–French MEDINAUT diving expedition in 1998, brine accumulations were found along a fracture zone between the Maidstone and Moscow mud volcanoes in the Olimpi area. The Nadir brine lake, 250 m in diameter and 15 m in depth, is located along the deep fault outside of the mud volcanoes and the Napoli brines are comprised of two shallow brine pools. Both the Nadir and the Napoli brines exhibit mineral and gas composition and variable chlorinity (Charlou et al. 2003).

4.4 ARTIFICIAL HABITATS

Artificial substrates provide a substrate upon which a marine community can develop as well as offer substantial protection from predators, increased protection from predators, enhanced feeding opportunities, and onshore transport to habitats suitable for settlement (Fager 1971; Reñones et al. 1998; Deudero et al. 1999; Dempster 2004, 2005).

Artificial habitats are widespread throughout the world's oceans and have natural or artificial origins and can be either moored or drifting (Dempster 2004, 2005). When solid, hard objects with numerous and varied surfaces are introduced to the seafloor, epibenthic organisms settle and colonize the area (Bohnsack et al. 1991). The initial colonization of artificial habitats works to build communities that increase marine production as additional epibenthic organisms settle and provide a biotope suitable for larger motile organisms (Fager 1971; Bohnsack et al. 1991). Additionally, floating structures may serve as meeting points that fish use to increase the encounter rate between isolated individuals or small schools or other schools in order to create bigger schools that offer higher survival opportunities (Deudero et al. 1999; Dempster 2004).

Artificial structures are often important locations for human activities including commerce, navigation, aquaculture, and recreation (Ritter et al. 1999). Fishermen often target these artificial habitats as they tend to provide food, shelter, and nurseries for a variety of demersal and pelagic fishes (including sport fishes) and many invertebrates (Ambrose and Swarbrick 1989; DeMartini et al. 1994). More than 300 species of fish in 96 families have been observed in association with floating structures worldwide

(Dempster 2004, 2005). Debates continue whether artificial substrates enhance areas or instead, degrade areas by detracting fish from their natural surroundings. In the Mediterranean Sea, studies have suggested that artificial substrates change distribution patterns of locally abundant fish species rather than increase species diversity (Bacchiocchi and Airoldi 2003).

Artificial reefs, FADs, buoys and moorings, offshore platforms, sea-cage farms, and shipwrecks in the eastern Mediterranean Sea are mapped in **Figure 4-5** and discussed below.

4.4.1 Artificial Reefs

An artificial reef consists of one or more submerged structures of natural or man-made origin purposefully deployed on the seabed to influence the physical, biological, or socioeconomic processes related to living marine resources (Baine 2001). Artificial reefs are defined both physically by the design and arrangement of materials used in construction and functionally according to their purpose (Seaman and Jensen 2000). A large number of items are used for the creation of artificial reefs including natural objects such as wood (weighted tree trunks) and shells, quarry rock, or man-made objects like vehicles (e.g., automobile bodies and railroad cars), aircraft, ships and boats, home appliances, discarded construction materials (e.g., concrete culverts), tires, oil/gas platforms, ash byproducts (from solid municipal incineration and coal/oil combustion), and prefabricated concrete structures (Kress et al. 1993; ARS 1997; Reñones et al. 1998; Dempster 2005).

Worldwide, artificial reefs are deployed into the marine environment to: (1) enhance commercial fishery production/harvest; (2) enhance recreational activities (e.g., fishing, Self Contained Underwater Breathing Apparatus [SCUBA] diving, and tourism); (3) restore/enhance water and habitat quality; (4) provide habitat protection and aquaculture production sites; and (5) control fish mortality (Seaman and Jensen 2000; Bacchiocchi and Airoldi 2003). In the Mediterranean Sea, artificial reefs have been deployed as a tool for managing littoral areas, as a solution to overexploitation of nearshore fishery resources, as a preventative measure against illegal trawling, and as a means to increase production in areas with limited habitat and/or food resources (Coll et al. 1998; Reñones et al. 1998).

Within two years of deploying cement blocks off Formantera Island (Balearic Islands) in the western Mediterranean Sea, almost all marine life (38 species in 14 families) from the surrounding area had colonized this artificial reef (Coll et al. 1998; Reñones et al. 1998). The benthic community at this artificial reef consisted of algae, sponges, hydrozoans, polychaetes, bryozoans, tunicates, mollusks, and echinoderms (Reñones et al. 1998). The fish assemblage was dominated by those species that lived in proximity to the artificial reef (e.g., Labridae - wrasses) and by small, demersal species living on the blocks (Reñones et al. 1998). Furthermore, the primary factor in determining the specific composition of fish assemblages was the original substrate where artificial reefs were deployed (Coll et al. 1998).

A unique artificial substrate off the coast of Israel was created when 500,000 tons per yr (t/yr) of coal fly ash was dumped over a period of two years at a location 70 km offshore from the Hadera power station in a water depth of 1,400 m (**Figure 4-5**; Kress et al. 1993). Coal fly ash is a by-product from coal fired power stations and is used in the manufacturing of cement, building blocks, and in road construction (Kress et al. 1993). Excess amounts were transported to the disposal site where the coal fly ash created a rocky substrate with aggregates ranging in size from a few millimeters to boulder size (Kress et al. 1993). Benthic surveys conducted at the location revealed an adverse affect on the marine life (Kress et al. 1993).

Off Malta, local divers associations intentionally sunk six defunct vessels for the purposes of recreational diving. Most of these artificial reefs have attracted a variety of fish species and have been colonized by benthic species (Briand 1999). No other information or data were found regarding artificial reefs in the eastern Mediterranean Sea.

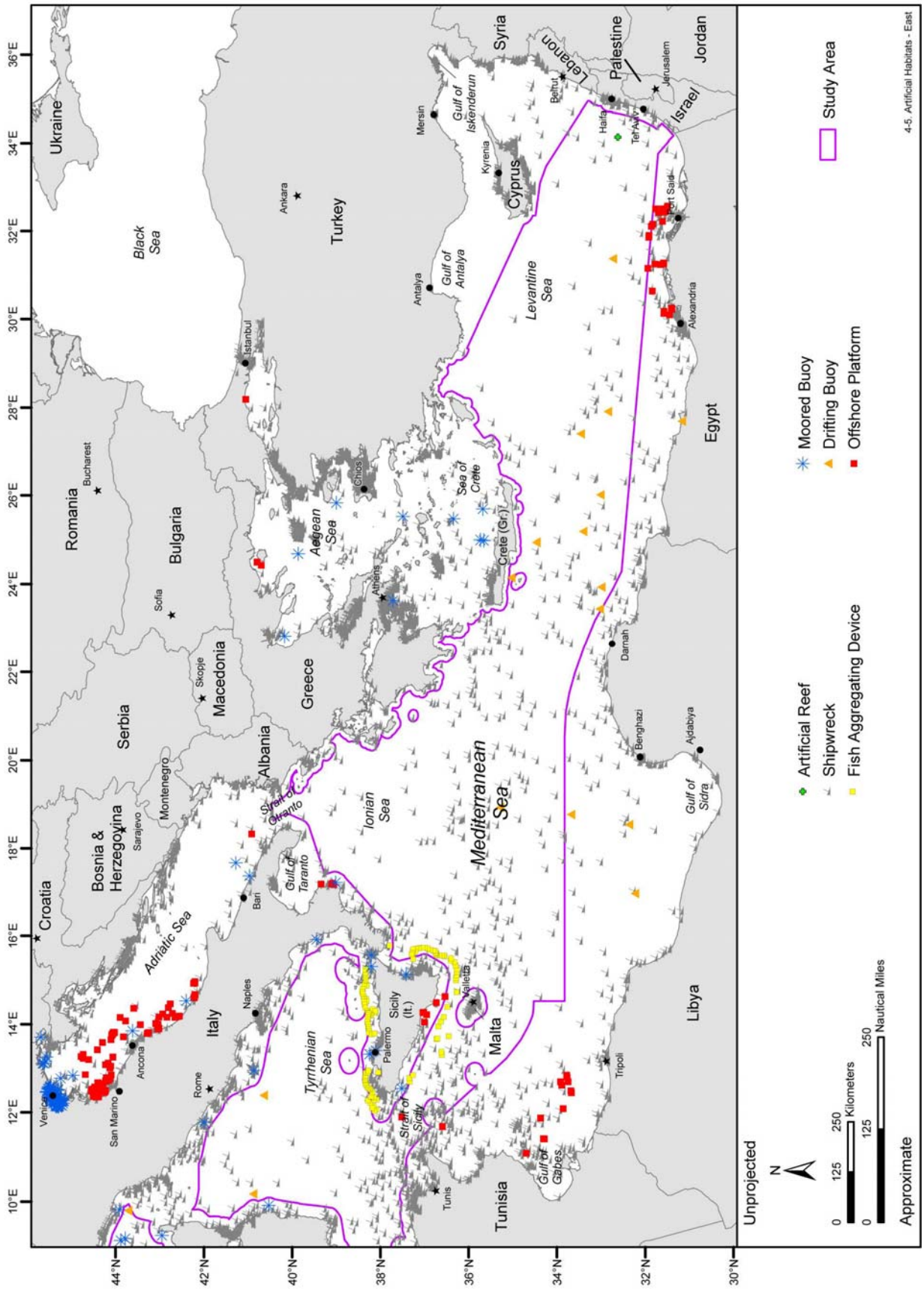


Figure 4-5. Artificial substrates located in the eastern Mediterranean Sea, including artificial reefs, shipwrecks, fish aggregating devices, moored buoys, drifting buoys, and offshore platforms. Source data: Kress et al. (1993), Relini et al. (2000), Veridian Corporation (2001), Legrand et al. (2003), IHS (2006), EDIOS[4], MFS[5], IFM-GEOMAR[6], and Poseidon-NCMR[7].

4.4.2 Fish Aggregating Devices

In addition to artificial structures intentionally or accidentally placed on the seafloor, FADs are suspended in the water column and anchored on the seafloor to attract fish (Dempster 2005). FADs are used extensively in the Mediterranean Sea for recreational, small-scale artisanal, and large-scale commercial fisheries (Massutí et al. 1999; Dempster 2005). In the Mediterranean Sea, artisanal fishers have used FADs for thousands of years, dating back to 200 Anno Domini (AD) when the Roman author Oppian described the use of FADs to catch dolphinfish (Dempster 2004). Designs of FADs vary widely from large, heavy, and expensive to small, light, and inexpensive with the type used depending upon expense and longevity rather than efficiency of attracting fish (Dempster 2004).

In the Mediterranean Sea, light FADs are constructed using cork floats and palm fronds to capture young dolphinfish (*Coryphaena hippurus*) in the 'kannizzati' fishery on Malta, the 'capcer' fishery on Majorca, and the 'cannizzi' fishery on Sicily (D'Anna et al. 1999; Relini et al. 2000; Dempster 2004). Artisanal fishers in Majorca Island deploy 74 FADs for the dolphinfish fishery (Morales-Nin et al. 2005). FADs ("capcers") are inexpensive (30 to 60 USD per FAD) and consist of a float with some palm branches tied on top to ease relocation as well as branches tied below to increase surface area (Morales-Nin et al. 2005).

Worldwide, purse seine fisheries use bamboo rafts approximately 3 by 1.5 m for use as FADs, with some vessels continuously using more than 100 such FADs year-round (Dempster 2004). Equipped with radiolocation beacons or satellite buoys and even sometimes remote fish detection devices, these FADs serve to boost the fishing effort of the fleet (Dempster 2004).

Numerous biological and physical factors, acting over different temporal and spatial scales, influence assemblages of fish at FADs (Massutí et al. 1999; Dempster 2004). Most fish are attracted to FADs during specific life-history stages (e.g., spawning periods or juvenile phases) or on a seasonal basis driven by oceanographic conditions (e.g., currents or SST; D'Anna et al. 1999; Deudero et al. 1999; Dempster 2005). Residence times are variable and range from short periods limited to days or longer periods of weeks to months (Dempster 2004).

The justifications used for FAD deployment have been to: (1) shift fishing pressure towards pelagic fish in regions where demersal fish were scarce due to fishing pressure; (2) diversify regional or national fishing activity; (3) facilitate greater recruitment to an area; and (4) increase and sustain fish diversity in an area (Kingsford 1999; Dempster 2004); however, the use of FADs has increased dramatically over the past decade, resulting in stock exploitation (Dempster 2004). Fishing at FADs has ultimately modified the size structure, sex ratio, diet, and distribution of some fish species (e.g., tuna) in the Mediterranean Sea (Kingsford 1999; Dempster 2004). Additionally, these structure alter pelagic habitat, which may produce ecological changes such as modifications in migration pathways or changes in growth and predation rates (Kingsford 1999; Dempster 2004). The sharp increase in the number of FAD deployments may therefore have significant effects upon the pelagic ecosystem and should be investigated further (Dempster 2004).

Numerous FADs are located around Sicily, Italy, several of which are within the eastern Mediterranean Study Area (**Figure 4-5**; Legrand et al. 2003). The GFCM implemented a seasonal ban on the use of FADs in the dolphinfish fishery from 1 January to 14 August.[3]

4.4.3 Buoys and Moorings

Navigational, meteorological, and oceanographic buoys suspended in the water column potentially function like artificial habitats. A buoy is a floating platform used for navigational purposes or supporting scientific instruments that measure environmental conditions. Pelagic nekton use these artificial islands for shelter, as a reference point during large displacements, and as a moving pelagic association (Relini et al. 2000). Furthermore, buoys, similar to other offshore structures, provide a valuable tool for studying poorly-known species or life phases that are difficult to sample using more conventional methods (Deudero et al. 1999; Kingsford 1999; Relini et al. 2000).

Moored buoys are for the most part in the western Mediterranean Study Area. The moored buoy that is closest to the eastern Mediterranean Study Area is located in the Strait of Sicily (**Figure 4-5**). The moored buoys found in the Mediterranean Sea include accelerometer buoys, acoustic current meters, multi-parameter environmental monitoring probes, scalar and directional wave buoys, meteorological data loggers, and tide gauges.[4,5,6,7]

4.4.4 Offshore Platforms

In some areas of the Mediterranean Sea, offshore platforms may provide the only hard bottom habitat and serve as artificial reefs, attracting aggregations of fish species and resulting in increased diversity (Fabi et al. 2004). Both the depth of the rig and distance from shore contribute to fish abundances; platforms furthest offshore and in deepest water reflected greater and faster aggregation effects (Fabi et al. 2004). Offshore platforms extend throughout the entire water column, offering habitat to marine life in all water layers from the bottom to the surface (Fabi et al. 2004). The orientation, higher prey availability, and shelter may be some of the factors causing the higher occurrence of fish and invertebrates around these structures (Fabi et al. 2004). A study conducted in the Adriatic Sea found higher species richness, diversity, and catch rates at offshore platforms than from the surrounding area (Fabi et al. 2004). Moreover, offshore platforms also create unique ecosystems that are otherwise absent in the natural habitat. For example, scorpaenids (rockfishes/scorpionfishes) were attracted to large shell mounds formed by mussels falling from the platform to the sea floor (Fabi et al. 2004).

Overall, little data exist on fish and invertebrate assemblages at oil and gas platforms in the Mediterranean Sea (Fabi et al. 2004). Because fishing is prohibited within 0.5 km radius of offshore platforms in the Mediterranean Sea, these artificial reefs may represent small protected areas where various marine life may experience greater survival opportunities (Fabi et al. 2004). On the other hand, offshore platforms may have a significant impact on pelagic fish stocks in specific areas because they may potentially modify the following: residence times for fish in a given area, feeding ecology, migratory pathways of pelagic fish, and susceptibility to fishing (Dempster 2004). Platforms typically remain in place long after the oil or gas reserves are exhausted (Crema et al. 2001). In summary, their short-term and long-term ecological effects require more investigation.

An offshore platform is located in the Strait of Sicily in the Study Area between Sicily and Tunisia (IHS Energy 2006). Five offshore platforms are located on the southeast coast of Sicily. Only one is in the Study Area and is located in the Strait of Sicily; 29.8 NM offshore of the southwest coast of Sicily and 50 NM offshore of Cape Bon, Tunisia. Over 20 offshore platforms are located off of Egypt between Alexandria and Port Said. Four of these platforms are within the Study Area ranging in distance from 20.2 to 28.2 NM from the shore (**Figure 4-5**). Numerous platforms are present in the Adriatic Sea and in the Gulf of Gabes, Tunisia but are not within the Study Area (IHS Energy 2006).

4.4.5 Sea-Cage Farms

Sea-cage farms produce both positive (substantial spatial and temporal protection from fishing) and negative (increased susceptibility to parasites and disease) effects on wild fish (Dempster 2004). The ecological effects of these structures have been traditionally thought of as localized because of the focus of impact studies on the benthos (Dempster 2004); however, the potential impacts on pelagic fish species that closely associate with these artificial substrates have not been considered (Dempster 2004). Furthermore, although sea-cage farms provide habitat to a wide variety of marine life (e.g., 104 families of macroinvertebrates in 10 phyla), these structures have caused an overall reduction in biodiversity (Maldonado et al. 2005).

Over 500 coastal sea-cage fish farms exist in the Mediterranean Sea (Dempster 2004). The majority of these artificial substrates are located in the eastern Mediterranean Sea since fish farming has traditionally been dominated by Egypt, Greece, and Turkey (Maldonado et al. 2005). Most of the sea-cage farms are located in shallow, sheltered sites and semi-enclosed bays (Maldonado et al. 2005). More recently however, fish farms have been installed on relatively deep bottoms and exposed sites, especially in the western Mediterranean Sea (Maldonado et al. 2005). Sea-cage farms were moved from inshore and

sheltered sites to offshore sites based on the assumption that enhanced water renewal in cages provides improved aquaculture conditions (Maldonado et al. 2005). In addition to increased fish production, enhanced water renewal may also result in less environmental impact than is found in sea-cage farms in bays or sheltered sites (Maldonado et al. 2005). No data are available for sea-cage farms located in the Study Area of the eastern Mediterranean Sea.

4.4.6 Shipwrecks

Approximately 12,165 shipwrecks exist in the Mediterranean Sea, of which 285 are in the eastern Mediterranean Sea Study Area (Briand 1999; Veridian Corporation 2001). The Strait of Sicily, the area east of Malta, and the area west of Crete, Greece have abundant shipwrecks that are in the Study Area (Briand 1999). These wrecks range from the classical/pre-classical age to the present, including many warships, submarines, and aircraft from the first and second world wars.[8]

4.5 WEBSITES ACCESSED

[1] WWF Meaderranean Sea- A global 200 ecoregion. http://www.panda.org/about_wwf/where_we_work/ecoregions/mediterranean_sea.cfm.

[2] Province of British Columbia. Accessed 13 September 2005. http://srmwww.gov.bc.ca/dss/coastal/download.html.

[3] European Commission. Accessed 26 January 2006. http://ec.europa.eu/fisheries/press_corner_press_releases_com06_05_en.htm.

[4] European Directory of the Initial Ocean-observing System (EDIOS). Accessed 1 September 2006. http://doga.ogs.trieste.it/edios.data.htm.

[5] Mediterranean Forecasting Systems (MFS) Toward Environmental Predictions. Accessed 7 September 2006. http://poseidon.ogs.trieste.it/WP4/table_out.html

[6] Leibniz Institute of Marine Sciences at the University of Kiel (IFM-GEOMAR). Accessed 7 September 2006. http://www.ifm.uni-kiel.de/fb/fb1/po2/research/mfstep/ifm02_WesternMed.html.

[7] Poseidon National Center for Marine Research (NCMR). Accessed 7 September 2006. http://www.poseidon.ncmr.gr/M3A/.

[8] Abysso-Wrecks in Mediterranean. Accessed 21 December 2006. http://www.sportesport.it/wrecks.htm.

[9] CoRIS. Deep water corals. Accessed 11 August 2005. http://www.coris.noaa.gov/about/deep/deep.html.

[10] UNEP-WCMC (United Nations Environment Programme-World Conservation Monitoring Centre). 2005. UNEP World Conservation Monitoring Centre. Accessed 15 March 2005. http://www.unep-wcmc.org/logos.shtm.

[11] Interridge. 1999. An initiative for international cooperation in ridge-crest studies. Hydrothermal vent database. Accessed 3 January 2006. http://interridge.org.

4.6 LITERATURE CITED

Airamé, S., S. Gaines, and C. Caldow. 2003. Ecological linkages: Marine and estuarine ecosystems of central and northern California. Silver Spring, Maryland: National Ocean Service.

Aloisi, G., C. Pierre, J.-M. Rouchy, J.-P. Foucher, J. Woodside, and MEDINAUT Scientific Party. 2000. Methane-related authigenic carbonates of eastern Mediterranean Sea mud volcanoes and their possible relation to gas hydrate destabilisation. Earth and Planetary Science Letters 184:321-338.

Álvarez-Pérez, G., P. Busquets, B. De Mol, N.G. Sandoval, M. Canals, and J.L. Casamor. 2005. Deep-water coral occurrences in the Strait of Gibraltar. Pages 207-221 in Freiwald, A. and J.M. Roberts, eds. Cold-water corals and ecosystems. Berlin, Germany: Springer-Verlag.

Ambrose, R.F. and S.L. Swarbrick. 1989. Comparison of fish assemblages on artificial and natural reefs off the coast of southern California. Bulletin of Marine Science 44(2):718-733.

Anderson, J.W., D.J. Reish, R.B. Spies, M.E. Brady, and E.W. Segelhorst. 1993. Human impacts. Pages 682-766 in Dailey, M.D., D.J. Reish, and J.W. Anderson, eds. Ecology of the Southern California Bight. Berkeley, California: University of California Press.

Andrews, A.H., E.E. Cordes, M.M. Mahoney, K. Munk, K.H. Coale, G.M. Cailliet, and J. Heifetz. 2002. Age, growth and radiometric age validation of a deep-sea, habitat-forming gorgonian (*Primnoa resedaeformis*) from the Gulf of Alaska. Hydrobiologia 471:101-110.

Ardizzone, G.D. 2006. An introduction to sensitive and essential fish habitats identification and protection in the Mediterranean Sea. Rome, Italy and Brussels, Belgium: Scientific Technical and Economic Commitee for Fisheries.

ARS (Artificial Reef Subcommittee). 1997. Guidelines for marine artificial reef materials. FWS Grant Agreement No. GS-96. Ocean Springs, Mississippi: Gulf States Marine Fisheries Commission.

Bacchiocchi, F. and L. Airoldi. 2003. Distribution and dynamics of epibiota on hard structures for coastal protection. Estuarine, Coastal and Shelf Science 56:1157-1166.

Baco, A.R. and C.R. Smith. 2003. High species richness in deep-sea chemoautotrophic whale skeleton communities. Marine Ecology Progress Series 260:109-114.

Baine, M. 2001. Artificial reefs: A review of their design, application, management and performance. Ocean & Coastal Management 44:241-259.

Ballesteros, E. 2006. Mediterranean coralligenous assemblages: A synthesis of present knowledge. Oceanography and Marine Biology: An Annual Review 44:123-195

Basso, D. 1998. Deep rhodolith distribution in the Pontain Islands, Italy: A model for the paleoecology of a temperate sea. Palaeogeography, Palaeoclimatology, Palaeoecology 137:173-187.

Basso, D., J. Thomson, and C. Corselli. 2004. Indications of low macrobenthic activity in the deep sediments of the eastern Mediterranean Sea. Scientia Marina 68(Supplement 3):53-62.

Beaulieu, S.E. 2001a. Colonization of habitat islands in the deep sea: Recruitment to glass sponge stalks. Deep-Sea Research I 48:1121-1137.

Beaulieu, S.E. 2001b. Life on glass houses: Sponge stalk communities in the deep sea. Marine Biology 138:803-817.

Bellan-Santini, D. 1985. The Mediterranean benthos: Reflections and problems raised by a classification of the benthic assemblages. Pages 19-48 in Moraitou-Apostolopoulou, M. and V. Kiortsis, eds. Mediterranean marine ecosystems. New York, New York: Plenum Press.

Bellan, G. 1985. Effects of pollution and man-made modifications on marine benthic communities in the Mediterranean: A review. Pages 163-194 in Moraitou-Apostolopoulou, M. and V. Kiortsis, eds. Mediterranean marine ecosystems. New York, New York: Plenum Press.

Bennett, B.A., C.R. Smith, B. Glaser, and H.L. Maybaum. 1994. Faunal community structure of a chemoautotrophic assemblage on whale bones in the deep northeast Pacific Ocean. Marine Ecology Progress Series 108:205-223.

Bethoux, J.P. and G. Copin-Montegut. 1986. Biological fixation of atmospheric nitrogen in the Mediterranean Sea. Limnology and Oceanography 31(6):1353-1358.

Bianchi, C.N. and C. Morri. 2000. Marine biodiversity of the Mediterranean Sea: Situation, problems and prospects for future research. Marine Pollution Bulletin 40(5):367-376.

BIOMAËRL team. 2003. Conservation and management of northeast Atlantic and Mediterranean maërl beds. Aquatic Conservation: Marine and Freshwater Ecosystems 13:S65-S76.

Bohnsack, J.A., D.L. Johnson, and R.F. Ambrose. 1991. Ecology of artificial reef habitats and fishes. Pages 61-107 in Seaman, W., Jr. and L.M. Sprague, eds. Artificial habitats for marine and freshwater fisheries. San Diego, California: Academic Press.

Bordehore, C., R. Riosmena-Rodríguez, and A. Ramos-Esplá. 2000a. Maërl-forming species in Alicante province (SE Spain): A taxonomic analysis. Pages 101-104 in Regional Activity Centre for Specially Protected Areas (RAC/SPA), ed. Proceedings, First Mediterranean Symposium on Marine Vegetation. 3-4 October 2000. Ajaccio, Corsica.

Bordehore, C., J.A. Borg, E. Lanfranco, A. Ramos-Esplá, M. Rizzo, and P.J. Schembri. 2000b. Trawling as a major threat to Mediterranean maërl beds. Pages 105-108 in Regional Activity Centre for Specially Protected Areas (RAC/SPA), ed. Proceedings, First Mediterranean Symposium on Marine Vegetation. 3-4 October 2000. Ajaccio, Corsica.

Borum, J. and T.M. Greve. 2004. The four European seagrass species. Pages 1-7 in Borum, J., C.M. Duarte, D. Krause-Jensen, and T.M. Greve, eds. European seagrasses: An introduction to monitoring and management. Copenhagen, Denmark: EU project Monitoring and Managing of European Seagrasses (M&MS).

Borum, J., C.M. Duarte, D. Krause-Jensen, and T.M. Greve, eds. 2004. European seagrasses: An introduction to monitoring and management. Copenhagen, Denmark: EU project Monitoring and Managing of European Seagrasses (M&MS).

Bouchet, P. and M. Taviani. 1992. The Mediterranean deep-sea fauna: Pseudopopulations of Atlantic species? Deep-Sea Research 39(2):169-184.

Briand, F., ed. 1999. Scientific design and monitoring of Mediterranean marine protected areas. CIESM Workshop Series No. 8. 23-26 October 1999. Porto Cesareo, Italy.Monaco: CIESM.

Briand, F., ed. 2003. Mare incognitum? Exploring Mediterranean deep-sea biology. CIESM Workshop Monographs 23:1-128.

Bromley, R.G. 2005. Preliminary study of bioerosion in the deep-water coral *Lophelia*, Pleistocene, Rhodes, Greece. Pages 895-914 in Freiwald, A. and J.M. Roberts, eds. Cold-water corals and ecosystems. Berlin, Germany: Springer-Verlag.

Brouns, J.J.W.M. and F.M.L. Heijs. 1986. Production and biomass of the seagrass *Enhalus acoroides* (L.f.) Royle and its epiphytes. Aquatic Botany 25:21-45.

Butman, C.A., J.T. Carlton, and S.R. Palumbi. 1995. Whaling effects on deep-sea biodiversity. Conservation Biology 9(2):462-464.

CalEPPC (California Exotic Pest Plant Council). 1999. The CalEPPC list: Exotic pest plants of greatest ecological concern in California: October, 1999.

Cebrián, E. and E. Ballesteros. 2004. Zonation patterns of benthic communities in an upwelling area from the western Mediterranean (La Herradura, Alboran Sea). Scientia Marina 68(1):69-84.

Cerrano, C., G. Bavestrello, C. Nike Bianchi, R. Cattaneo-vietti, S. Bava, C. Morganti, C. Morri, P. Picco, G. Sara, S. Schiaparelli, A. Siccardi, and F. Sponga. 2000. A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. Ecology Letters 3:284-293.

Charlou, J.L., J.P. Donval, T. Zitter, N. Roy, P. Jean-Baptiste, J.P. Foucher, J. Woodside, and MEDINAUT Scientific Party. 2003. Evidence of methane venting and geochemistry of brines on mud volcanoes of the eastern Mediterranean Sea. Deep-Sea Research I 50:941-958.

Cinelli, G. 1985. On the biogeography of the benthic algae of the Mediterranean. Pages 49-56 in Moraitou-Apostolopoulou, M. and V. Kiortsis, eds. Mediterranean marine ecosystems. New York, New York: Plenum Press.

Cocito, S., C.N. Bianchi, C. Morri, and A. Peirano. 2000. First survey of sessile communities on subtidal rocks in an area with hydrothermal vents: Milos Island, Aegean Sea. Hydrobiologia 426:113-121.

Coleman, D.F. and R.D. Ballard. 2001. A highly concentrated region of cold hydrocarbon seeps in the southeastern Mediterranean Sea. Geo-Marine Letters 21:162-167.

Coll, J., J. Moranta, O. Reñones, A. García-Rubies, and I. Moreno. 1998. Influence of substrate and deployment time on fish assemblages on an artificial reef at Formentera Island (Balearic Islands, western Mediterranean). Hydrobiologia 385:139-152.

Corselli, C. and D. Basso. 1996. First evidence of benthic communities based on chemosynthesis on the Napoli mud volcano (eastern Mediterranean). Marine Geology 132:227-239.

Crema, R., D. Prevedelli, and A. Castelli. 2001. Effect of submerged structures on the diversity of macrozoobenthos in the northern Adriatic Sea. Pages 367-374 in Faranda, F.M., L. Guglielmo, and G. Spezie, eds. Mediterranean ecosystems: Structures and processes. Milano, Italy: Springer-Verlag Italia.

Cunha, A.H., C.M. Duarte, and D. Krause-Jensen. 2004. How long time does it take to recolonize seagrass beds? Pages 72-76 in Borum, J., C.M. Duarte, D. Krause-Jensen, and T.M. Greve, eds. European seagrasses: An introduction to monitoring and management. Copenhagen, Denmark: EU project Monitoring and Managing of European Seagrasses (M&MS).

Cunha, M.R. and G.D.F. Wilson. 2003. Haplomunnidae (Crustacea: Isopoda) reviewed, with a description of an intact specimen of *Thylakogaster* Wilson & Hessler, 1974. Zootaxa 326:1-16.

D'Anna, G., F. Badalamenti, and S. Riggio. 1999. Traditional and experimental floating fish aggregating devices in the Gulf of Castellammare (NW Sicily): Results from catches and visual observations. Scientia Marina 63(3-4):209-218.

D'Onghia, G., P. Maiorano, L. Sion, R. Carlucci, F. Mastrototaro, F. Capezzuto, G. Costantino, and A. Tursi. 2006. Sensitive and essential fish habitats in the North-Western Ionian Sea: Problems and perspectives for fishery management. Pages 181-202 in STECF (Scientific Technical and Economic Committee for Fisheries), ed. Sensitive and essential fish habitats in the Mediterranean

Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

Dando, P.R., D. Stüben, and S.P. Varnavas. 1999. Hydrothermalism in the Mediterranean Sea. Progress in Oceanography 44:333-367.

Danovaro, R., A. Dinet, G. Duineveld, and A. Tselepides. 1999. Benthic response to particulate fluxes in different trophic environments: A comparison between the Gulf of Lions--Catalan Sea (western-Mediterranean) and the Cretan Sea (eastern-Mediterranean). Progress in Oceanography 44:287-312.

De Biasi, A.M., S. Aliani, S. Cocito, P.R. Dando, A. Logan, C. Morri, M. Pansini, A. Peirano, G. Sartoni, and C.N. Bianchi. 2004. The marine biota of shallow-water hydrothermal vents at Milos, Aegean Sea. Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee Monaco 37:510.

De Lange, G.J., J.J. Middelburg, C.H. Van der Weijden, G. Catalano, G.W. Luther III, D.J. Hydes, J.R.W. Woittiez, and G.P. Klinkhammer. 1990. Composition of anoxic hypersaline brines in the Tyro and Bannock Basins, eastern Mediterranean. Marine Chemistry 31:63-88.

De Mol, B., M. Taviani, M. Canals, A. Remia, G. Alverez, P. Busquets, N. Teixido, and J.M. Gilli. 2005. Environmental and spatial distribution of Mediterranean cold-water corals. Page 179 in Abstracts, Third International Symposium on Deep-Sea Corals. 28 November-2 December 2005. Miami, Florida: .

Delibrias, G. and M. Taviani. 1985. Dating the death of Mediterranean deep-sea scleractinian corals. Marine Geology 62:175-180.

DeMartini, E.E., A.M. Barnett, T.D. Johnson, and R.F. Ambrose. 1994. Growth and production estimates for biomass-dominant fishes on a southern California artificial reef. Bulletin of Marine Science 55(2-3):484-500.

Dempster, T. 2004. Biology of fish associated with moored fish aggregation devices (FADs): Implications for the development of a FAD fishery in New South Wales, Australia. Fisheries Research 68(1-3):189-201.

Dempster, T. 2005. Temporal variability of pelagic fish assemblages around fish aggregation devices: Biological and physical influences. Journal of Fish Biology 66:1237-1260.

den Hartog, C. 1970. The seagrasses of the world. Amsterdam, The Netherlands: North-Holland Publishers.

Desbruyères, D. 2003. Chemosynthesis-based ecosystems in the deep Atlantic -- What we do know and we don't. CIESM Workshop Monographs 23:73-76.

Deudero, S., P. Merella, B. Morales-Nin, E. Massutí, and F. Alemany. 1999. Fish communities associated with FADs. Scientia Marina 63(3-4):199-207.

Duarte, C.M. 1991. Seagrass depth limits. Aquatic Botany 40:363-377.

Duarte, C.M. 2002. The future of seagrass meadows. Environmental Conservation 29(2):192-206.

Duarte, C.M. and C.L. Chiscano. 1999. Seagrass biomass and production: A reassessment. Aquatic Botany 65:159-174.

Duarte, C.M., N. Marbà, and R. Santos. 2004. What may cause loss of seagrasses? Pages 24-32 in Borum, J., C.M. Duarte, D. Krause-Jensen, and T.M. Greve, eds. European seagrasses: An introduction to monitoring and management. Copenhagen, Denmark: EU project Monitoring and Managing of European Seagrasses (M&MS).

Dyer, K.R. and D.A. Huntley. 1999. The origin, classification and modelling of sand banks and ridges. Continental Shelf Research 19:1285-1330.

Emig, C.C. and P. Geistdoerfer. 2004. The Mediterranean deep-sea fauna: Historical evolution, bathymetric variations and geographical changes. Carnets de Géologie / Notebooks on Geology, Maintenon. Article 2004/01 (CG2004_A01_CCE-PG).

Fabi, G., F. Grati, M. Puletti, and G. Scarcella. 2004. Effects on fish community induced by installation of two gas platforms in the Adriatic Sea. Marine Ecology Progress Series 273:187-197.

Fager, E.W. 1971. Pattern in the development of a marine community. Limnology and Oceanography 16(2):241-253.

Fiala-Médioni, A. 2003. Sources of energy for deep-sea benthos in Mediterranean mud volcanoes. CIESM Workshop Monographs 23:77-80.

Fine, M., H. Zibrowius, and Y. Loya. 2001. *Oculina patagonica:* A non-lessepsian scleractinian coral invading the Mediterranean Sea. Marine Biology 138:1195-1203.

Fisher, C.R., I.R. MacDonald, R. Sassen, C.M. Young, S.A. Macko, S. Hourdez, R.S. Carney, S. Joye, and E. McMullin. 2000. Methane ice worms: *Hesiocaeca methanicola* colonizing fossil fuel reserves. Naturwissenschaften 87:184-187.

Flagella, M.M. and A.A. Abdulla. 2005. Ship ballast water as a main vector of marine introductions in the Mediterranean Sea. WMU Journal of Maritime Affairs 4(1):95-104.

Foster, M.S. 2001. Rhodoliths: Between rocks and soft places. Journal of Phycology 37:659-667.

Frau, A., S. Deudero, S. Cerdeño, and L. Alou. 2003. No habitat preference in mixed meadows and rocky bottoms for Mediterranean Labridae and Sparidae fish species. Boletín del Instituto Español de Oceanografía 19(1-4):483-491.

Fredj, G. and L. Laubier. 1985. The deep Mediterranean benthos. Pages 109-145 in Moraitou-Apostolopoulou, M. and V. Kiortsis, eds. Mediterranean marine ecosystems. New York, New York: Plenum Press.

Freese, L., P.J. Auster, J. Heifetz, and B.L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. Marine Ecology Progress Series 182:119-126.

Freiwald, A., J.H. Fosså, T. Koslow, and J.M. Roberts. 2004. Cold-water coral reefs: Out of sight-no longer out of mind. Cambridge, United Kingdom: UNEP-WCMC.

Fujikura, K., Y. Fujiwara, S. Kojima, and T. Okutani. 2002. Micro-scale distribution of mollusks occurring in deep-sea chemosynthesis-based communities in the Japan Trench. VENUS 60(4):225-236.

Gacia, E. and C.M. Duarte. 2001. Sediment retention by a Mediterranean *Posidonia oceanica* meadow: The balance between deposition and resuspension. Estuarine, Coastal and Shelf Science 52:505-514.

Galil, B.S. 2004. The limit of the sea: The bathyal fauna of the Levantine Sea. Scientia Marina 68(Supplement 3):63-72.

Galkin, S.V. 1997. Megafauna associated with hydrothermal vents in the Manus Back-Arc Basin (Bismark Sea). Marine Geology 142:197-206.

Gambi, C. and R. Danovaro. 2006. A multiple-scale analysis of metazoan meiofaunal distribution in the deep Mediterranean Sea. Deep-Sea Research I 53:1117-1134.

García-Charton, J.A., Á. Pérez-Ruzafa, P. Sánchez-Jerez, J.T. Bayle-Sempere, O. Reñones, and D. Moreno. 2004. Multi-scale spatial heterogeneity, habitat structure, and the effect of marine reserves on western Mediterranean rocky reef fish assemblages. Marine Biology 144:161-182.

García-Rubies, A. and E. Macpherson. 1995. Substrate use and temporal pattern of recruitment in juvenile fishes of the Mediterranean littoral. Marine Biology 124:35-42.

Gasperini, L., M. Taviani, A. Remia, and G. Bortoluzzi. 2005. Acoustic facies analysis of late Quaternary deep-water coral mounds in the Tyrrhenian Sea. Page 172 in University of Florida/IFAS, ed. Third International Symposium on Deep-Sea Corals Science and Management: Program and abstract book. 28 November - 2 December 2005. University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, Florida.

Gass, S.E. 2003. Conservation of deep-sea corals in Atlantic Canada. World Wildlife Fund-Canada.

Gornitz, V. and I. Fung. 1994. Potential distribution of methane hydrates in the world's oceans. Global Biogeochemical Cycles 8(3):335-347.

Guidetti, P. 2000. Differences among fish assemblages associated with nearshore *Posidonia oceanica* seagrass beds, rocky-algal reefs and unvegetated sand habitats in the Adriatic Sea. Estuarine, Coastal and Shelf Science 50:515-529.

Guidetti, P. 2004. Consumers of sea urchins, *Paracentrotus lividus* and *Arbacia lixula*, in shallow Mediterranean rocky reefs. Helgol Marine Research 58:110-116.

Hain, S. and E. Corcoran, eds. 2004. The status of the cold-water coral reefs of the world. Pages 115-135 in Wilkinson, C., ed. Status of coral reefs of the world: 2004. Volume 1. Townsville, Australia: Australian Institute of Marine Science.

Harmelin-Vivien, M.L., J.G. Harmelin, and V. Leboulleux. 1995. Microhabitat requirements for settlement of juvenile sparid fishes on Mediterranean rocky shores. Hydrobiologia 300/301:309-320.

Hashimoto, J., S. Ohta, K. Fujikura, and T. Miura. 1995. Microdistribution pattern and biogeography of the hydrothermal vent communities of the Minami-Ensei Knoll in the Mid-Okinawa Trough, Western Pacific. Deep-Sea Research I 42(4):577-598.

Hashimoto, J., S. Ohta, T. Tanaka, H. Hotta, S. Matsuzawa, and H. Sakai. 1989. Deep-sea communities dominated by the giant clam, *Calyptogena soyoae*, along the slope foot of Hatsushima Island, Sagami Bay, central Japan. Palaeogeography, Palaeoclimatology, Palaeoecology 71:179-192.

Heeschen, K.U., R.W. Collier, M.A. de Angelis, E. Suess, G. Rehder, P. Linke, and G.P. Klinkhammer. 2005. Methane sources, distributions, and fluxes from cold vent sites at Hydrate Ridge, Cascadia Margin. Global Biogeochemical Cycles 19, GB2016, doi:10.1029/2004GB002266.

Hemminga, M.A. and C.M. Duarte. 2000. Seagrass ecology. Cambridge, United Kingdom: Cambridge University Press.

Hessler, R.R. and P.F. Lonsdale. 1991. Biogeography of Mariana Trough hydrothermal vent communities. Deep-Sea Research 38(2):185-199.

Hovland, M., A.G. Judd, and R.A. Burke, Jr. 1993. The global flux of methane from shallow submarine sediments. Chemosphere 26(1-4):559-578.

IHS Energy. 2006. GIS shapefiles depicting oil platforms in the Mediterranean Sea. Received 20 September 2006 from Mr. Kelly Smith, Senior Account Executive, Energy Segment. Dallas, Texas: IHS Energy.

Kallianiotis, A., K. Sophronidis, P. Vidoris, and A. Tselepides. 2000. Demersal fish and megafaunal assemblages on the Cretan continental shelf and slope (NE Mediterranean): Seasonal variation in species density, biomass and diversity. Progress in Oceanography 46:429-455.

Karakassis, I. and A. Eleftheriou. 1997. The continental shelf of Crete: Structure of macrobenthic communities. Marine Ecology Progress Series 160:185-196.

Kennett, J.P. 1982. Marine geology. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Kingsford, M.J. 1999. Fish attraction devices (FADs) and experimental designs. Scientia Marina 63(3-4):181-190.

Koch, E.W. 2001. Beyond light: Physical, geological, and geochemical parameters as possible submersed aquatic vegetation habitat requirements. Estuaries 24(1):1-17.

Krause-Jensen, D., E.D. Almela, A.H. Cunha, and T.M. Greve. 2004. Have seagrass distribution and abundance changed? Pages 33-40 in Borum, J., C.M. Duarte, D. Krause-Jensen, and T.M. Greve, eds. European seagrasses: An introduction to monitoring and management. Copenhagen, Denmark: EU project Monitoring and Managing of European Seagrasses (M&MS).

Kress, N., A. Golik, B. Galil, and M.D. Krom. 1993. Monitoring the disposal of coal fly ash at a deep water site in the eastern Mediterranean Sea. Marine Pollution Bulletin 26(8):447-456.

Kvenvolden, K.A. 1993. Gas hydrates--Geological perspective and global change. Reviews of Geophysics 31(2):173-187.

Lampadariou, N., E. Hatziyanni, and A. Tselepides. 2003. Community structure of meiofauna and macrofauna in Mediterranean deep-hyper-saline anoxic basins. CIESM Workshop Monographs 23:55-60.

Lanoil, B.D., R. Sassen, M.T. La Duc, S.T. Sweet, and K.H. Nealson. 2001. *Bacteria* and *Archaea* physically associated with Gulf of Mexico gas hydrates. Applied and Environmental Microbiology 67(11):5143-5153.

Legrand, J., M. Alfonso, R. Bozzano, G. Goasguen, H. Lindh, A. Ribotti, I. Rodrigues, and C. Tziavos. 2003. Monitoring the marine environment operational practices in Europe. Pages 304-310 in Building the European Capacity in Operational Oceanography - Proceedings of the Third International Conference on EuroGOOS, Athens, Greece, 2-6 December 2002.

Levin, L.A. and R.H. Michener. 2002. Isotopic evidence for chemosynthesis-based nutrition of macrobenthos: The lightness of being at Pacific methane seeps. Limnology and Oceanography 47(5):1336-1345.

Lloret, J. and S. Planes. 2003. Condition, feeding and reproductive potential of white seabream *Diplodus sargus* as indicators of habitat quality and the effect of reserve protection in the northwestern Mediterranean. Marine Ecology Progress Series 248:197-208.

Longo, C., F. Mastrototaro, and G. Corriero. 2005. Sponge fauna associated with a Mediterranean deep-sea coral bank. Journal of the Marine Biological Association of the United Kingdom 85:1341-1352.

Maldonado, M., M.C. Carmona, Y. Echeverría, and A. Riesgo. 2005. The environmental impact of Mediterranean cage fish farms at semi-exposed locations: Does it need a re-assessment? Helgol Marine Research 59:121-135.

Manca, B., M. Burca, A. Giorgetti, C. Coatanoan, M.-J. Garcia, and A. Iona. 2004. Physical and biochemical averaged vertical profiles in the Mediterranean regions: An important tool to trace the climatology of water masses and to validate incoming data from operational oceanography. Journal of Marine Systems 48:83-116.

Massutí, E. and O. Reñones. 2005. Demersal resource assemblages in the trawl fishing grounds off the Balearic Islands (western Mediterranean). Scientia Marina 69(1):167-181.

Massutí, E., B. Morales-Nin, and S. Deudero. 1999. Fish fauna associated with floating objects sampled by experimental and commercial purse nets. Scientia Marina 63(3-4):219-227.

Masutani, S.M. and R.B. Coffin. 2001. Fiery ice from the seas: The first workshop of the international committee on methane hydrates, 7-9 March 2001, Honolulu, Hawaii. Final Report. NRL Technical Report NRL/MR/6110--02-8646. National Energy Technology Laboratory, U.S. Department of Energy. 36 pp.

Maynou, F. and J. Cartes. 2006. Fish and invertebrate assemblages from *Isidella elongata* facies in the western Mediterranean. Pages 289-307 in Sensitive and essential fish habitats in the Mediterranean. Barcelona, Spain: Institut de Ciències del Mar (CSIC).

McMullin, E.R., D.C. Bergquist, and C.R. Fisher. 2000. Metazoans in extreme environments: Adaptations of hydrothermal vent and hydrocarbon seep fauna. Gravitational and Space Biology Bulletin 13(2):13-23.

Mehta, M.P., D.A. Butterfield, and J.A. Baross. 2003. Phylogenetic diversity of nitrogenase (*nifH*) genes in deep-sea and hydrothermal vent environments of the Juan de Fuca Ridge. Applied and Environmental Microbiology 69(2):960-970.

Metaxas, A. 2003. Current challenges in the study of biological communities at deep-sea hydrothermal vents. CIESM Workshop Monographs 23:67-72.

Mifsud, C. 2000. Malta country report: Marine vegetation. Pages 159-162 in Regional Activity Centre for Specially Protected Areas (RAC/SPA), ed. Proceedings, First Mediterranean Symposium on Marine Vegetation. 3-4 October 2000. Ajaccio, Corsica.

Montagna, P.A., J.E. Bauer, M.C. Prieto, D. Hardin, and R.B. Spies. 1986. Benthic metabolism in a natural coastal petroleum seep. Marine Ecology Progress Series 34:31-40.

Morales-Nin, B., M. Linde, and M. Valls. 2005. The dolphinfish fishery in Majorca Island. Report 2004. Illes Balears, Spain: IMEDEA.

Morri, C., A. Peirano, C.N. Bianchi, and M. Sassarini. 1994. Present-day bioconstructions of the hard coral, *Cladocora caespitosa* (L.) (Anthozoa, Scleractinia), in the eastern Ligurian Sea (NW Mediterranean). Biologia Marina Mediterranea 1(1):371-372.

Nybakken, J.W. 2001. Marine biology: An ecological approach. 5th ed. Menlo Park, California: Addison Wesley Educational Publishers, Inc.

O'Dor, R.K. 2003. The unknown ocean: The baseline report of the census of marine life research program. Washington, D.C.: Consortium for Oceanographic Research and Education. 28 pp.

Olesen, B., S. Enríquez, C.M. Duarte, and K. Sand-Jensen. 2002. Depth-acclimation of photosynthesis, morphology and demography of *Posidonia oceanica* and *Cymodocea nodosa* in the Spanish Mediterranean Sea. Marine Ecology Progress Series 236:89-97.

Olu-Le Roy, K., M. Sibuet, A. Fiala-Médioni, S. Gofas, C. Salas, A. Mariotti, J.-P. Foucher, and J. Woodside. 2004. Cold seep communities in the deep eastern Mediterranean Sea: Composition, symbiosis and spatial distribution on mud volcanoes. Deep-Sea Research I 51:1915-1936.

Panayotidis, P. and P. Drakopoulou. 2000. The Mediterranean phytobenthos in the frame of Natura-2000 project. Pages 173-176 in Regional Activity Centre for Specially Protected Areas (RAC/SPA), ed. Proceedings, First Mediterranean Symposium on Marine Vegetation. 3-4 October 2000. Ajaccio, Corsica.

Pasqualini, V., C. Pergent-Martini, and G. Pergent. 1998a. Use of remote sensing for the characterization of the Mediterranean coastal environment -- The case of *Posidonia oceanica*. Journal of Coastal Conservation 4:59-66.

Pasqualini, V., C. Pergent-Martini, P. Clabaut, and G. Pergent. 1998b. Mapping of *Posidonia oceanica* using aerial photographs and side scan sonar: Application off the Island of Corsica (France). Estuarine, Coastal and Shelf Science 47:359-367.

Peckmann, J., V. Thiel, J. Reitner, M. Taviani, P. Aharon, and W. Michaelis. 2004. A microbial mat of a large sulfur bacterium preserved in a Miocene methane-seep limestone. Geomicrobiology Journal 21:247-255.

Peirano, A., C. Morri, G. Mastronuzzi, and C. Nike Bianchi. 1997. The coral *Cladocora caespitosa* (Anthozoa, Scleractinia) as a bioherm builder in the Mediterranean Sea. Memorie Descrittive Carta Geologica d'Italia 52:59-74.

Pergent-Martini, C., V. Rico-Raimondino, and G. Pergent. 1994. Primary production of *Posidonia oceanica* in the Mediterranean Basin. Marine Biology 120:9-15.

Pergent, G. 1990. Lepidochronological analysis of the seagrass *Posidonia oceanica* (L.) Delile: A standardized approach. Aquatic Botany 37:39-54.

Pergent, G., J. Romero, C. Pergent-Martini, M.-A. Mateo, and C.-F. Boudouresque. 1994. Primary production, stocks and fluxes in the Mediterranean seagrass *Posidonia oceanica*. Marine Ecology Progress Series 106:139-146.

Phillips, R.C. and E.G. Meñez. 1988. Seagrasses. Smithsonian Contributions to the Marine Sciences 34:1-104.

Pickard, G.L. and W.J. Emery. 1982. Descriptive physical oceanography: An introduction. 4th ed. Oxford, United Kingdom: Pergamon Press.

Procaccini, G., M.C. Buia, M.C. Gambi, M. Perez, G. Pergent, C. Pergent-Martini, and J. Romero. 2003. The seagrasses of the western Mediterranean. Pages 48-58 in Green, E.P. and F.T. Short, eds. World atlas of seagrasses. Berkeley, California: UNEP World Conservation Monitoring Centre by the University of California Press.

Rathgeber, C., N. Yurkova, E. Stackebrandt, J.T. Beatty, and V. Yurkov. 2002. Isolation of tellurite- and selenite-resistant bacteria from hydrothermal vents of the Juan de Fuca Ridge in the Pacific Ocean. Applied and Environmental Microbiology 68(9):4613-4622.

Reed, D.W., Y. Fujita, M.E. Delwiche, D.B. Blackwelder, P.P. Sheridan, T. Uchida, and F.S. Colwell. 2002. Microbial communities from methane hydrate-bearing deep marine sediments in a forearc basin. Applied and Environmental Microbiology 68(8):3759-3770.

Relini, G., M. Relini, and M. Montanari. 2000. An offshore buoy as a small artificial island and a fish-aggregating device (FAD) in the Mediterranean. Hydrobiologia 440:65-80.

Reñones, O., J. Moranta, J. Coll, and I. Moreno. 1998. Fish assemblages of an artificial reef in *Posidonia oceanica* (L.) Delile, 1813 meadow off the southern Balearic Islands (western Mediterranean). Boletín del Instituto Español de Oceanografía 14(1-2):57-68.

Ritter, R.A., H.D. Berry, B.E. Bookheim, and A.T. Sewell. 1999. Puget Sound habitat inventory 1996: Vegetation and shoreline characteristics classification methods. Washington State Department of Natural Resources, Aquatic Resources Division.

Roberts, J.M. and A. Freiwald. 2005. Integrated European research into cold-water coral reefs. Journal of Marine Education 21(4):41-45.

Roberts, S. and M. Hirshfield. 2003. Deep sea corals: Out of sight, but no longer out of mind. Washington, D.C.: Oceana.

Roberts, S. and M. Hirshfield. 2004. Deep-sea corals: Out of sight, but no longer out of mind. Frontiers in Ecology and the Environment 2(3):123-130.

Rodolfo-Metalpa, R., C. Richard, D. Allemand, C.N. Bianchi, C. Morri, and C. Ferrier-Pagès. 2006. Response of zooxanthellae in symbiosis with the Mediterranean corals *Cladocora caespitosa* and *Oculina patagonica* to elevated temperatures. Marine Biology 150(1):45-55.

Rogers, A.D. 1999. The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. International Review of Hydrobiology 84(4):315-406.

Rosenberg, E. and L. Falkovitz. 2004. The *Vibrio Shiloi/Oculina Patagonica* model system of coral bleaching. Annual Review of Microbiology 58:143-159.

Ruitton, S., P. Francour, and C.F. Boudouresque. 2000. Relationships between algae, benthic herbivorous invertebrates and fishes in rocky sublittoral communities of a temperate sea (Mediterranean). Estuarine, Coastal and Shelf Science 50:217-230.

Sala, E. 2004. The past and present topology and structure of Mediterranean subtidal rocky-shore food webs. Ecosystems 7:333-340.

Santangelo, G., E. Carletti, E. Maggi, and L. Bramanti. 2003. Reproduction and population sexual structure of the overexploited Mediterranean red coral *Corallium rubrum*. Marine Ecology Progress Series 248:99-108.

Sardà, F., A. Calafat, M.M. Flexas, A. Tselepides, M. Canals, M. Espino, and A. Tursi. 2004. An introduction to Mediterranean deep-sea biology. Scientia Marina 68(Supplement 3):7-38.

Schmidt, K. 2004. Gas hydrate and methane plumes at Hydrate Ridge. Pages 1-13 in Monterey Bay Aquarium Research Institute (MBARI) Internship Symposium Pacific Forum.

Schuhmacher, H. and H. Zibrowius. 1985. What is hermatypic? A redefinition of ecological groups in corals and other organisms. Coral Reefs 4:1-9.

Seaman, W., Jr. and A.C. Jensen. 2000. Purposes and practices of artificial reef evaluation. Pages 1-19 in Seaman, W., Jr., ed. Artificial reef evaluation with application to natural marine habitats. New York, New York: CRC Press.

Sibuet, M. and K. Olu. 1998. Biogeography, biodiversity and fluid dependence of deep-sea cold-seep communities at active and passive margins. Deep-Sea Research II 45:517-567.

Smith, C.R. 1991. The bottom of the sea. Science 251(4993):576-577.

Smith, C.R. and A.R. Baco. 2003. Ecology of whale falls at the deep-sea floor. Oceanography and Marine Biology: An Annual Review 41:311-354.

Smith, C.R., A.R. Baco, A. Hannides, and D. Ruplinger. 2003. Chemosynthetic habitats on the California slope: Whale-, wood- and kelp-falls compared to vents and seeps. Page 1 in Biogeography and Biodiversity of Chemosynthetic Ecosystems: Planning for the Future, UNESS Workshop, Southampton, 16-18 June 2003.

Steller, D.L. and M.S. Foster. 1995. Environmental factors influencing distribution and morphology of rhodoliths in Bahía Concepción, B.C.S., México. Journal of Experimental Marine Biology and Ecology 194:201-212.

Stora, G., M. Bourcier, A. Arnoux, M. Gerino, J. Le Campion, F. Gilbert, and J.P. Durbec. 1999. The deep-sea macrobenthos on the continental slope of the northwestern Mediterranean Sea: A quantitative approach. Deep-Sea Research I 46:1339-1368.

Taviani, M., A. Freiwald, and H. Zibrowius. 2005a. Deep coral growth in the Mediterranean Sea: An overview. Pages 137-156 in Freiwald, A. and J.M. Roberts, eds. Cold-water corals and ecosystems. Berlin, Germany: Springer-Verlag.

Taviani, M., A. Remia, C. Corselli, A. Freiwald, E. Malinverno, F. Mastrototaro, A. Savini, and A. Tursi. 2005b. First geo-marine survey of living cold-water *Lophelia* reefs in the Ionian Sea (Mediterranean basin). Facies 50:409-417.

Terrados, J., C.M. Duarte, L. Kamp-Nielson, N.S.R. Agawin, E. Gacia, D. Lacap, M.D. Fortes, J. Borum, M. Lubanski, and T. Greve. 1999. Are seagrass growth and survival constrained by the reducing conditions of the sediment? Aquatic Botany 65:175-197.

Thayer, G.W., K.A. Bjorndal, J.C. Ogden, S.L. Williams, and J.C. Zieman. 1984. Role of larger herbivores in seagrass communities. Estuaries 7(4A):351-376.

Torcu, H. and S. Mater. 2000. Lessepsian fishes spreading along the coasts of the Mediterranean and the southern Aegean Sea of Turkey. Turkish Journal of Zoology 24:139-148.

Tselepides, A. and N. Lampadariou. 2004. Deep-sea meiofaunal community structure in the Eastern Mediterranean: Are trenches benthic hotspots? Deep-Sea Research I 51:833-847.

Tselepides, A., N. Lampadariou, and E. Hatziyanni. 2004. Distribution of meiobenthos at bathyal depths in the Mediterranean Sea. A comparison between sites of contrasting productivity. Scientia Marina 68(Supplement 3):39-51.

Tselepides, A., K.-N. Papadopoulou, D. Podaras, W. Plaiti, and D. Koutsoubas. 2000. Macrobenthic community structure over the continental margin of Crete (South Aegean Sea, NE Mediterranean). Progress in Oceanography 46:401-428.

Tsounis, G., S. Rossi, J.-M. Gili, and W. Arntz. 2006. Population structure of an exploited benthic cnidarian: The case study of red coral (*Corallium rubrum* L.). Marine Biology 149:1059-1070.

Tursi, A., F. Mastrototaro, A. Matarrese, P. Maiorano, and G. D'Onghia. 2004. Biodiversity of the white coral reefs in the Ionian Sea (central Mediterranean). Chemistry and Ecology 20(Supplement 1):S107-S116.

Vanney, J.-R. and M. Gennesseaux. 1985. Mediterranean seafloor features: Overview and assessment. Pages 3-32 in Stanley, D.J. and F.-C. Wezel, eds. Geological evolution of the Mediterranean Basin. New York, New York: Springer-Verlag.

Veridian Corporation. 2001. The global maritime wrecks database. [CD-ROM]. Falls Church, Virginia: General Dynamics Corporation.

Virgilio, M., L. Airoldi, and M. Abbiati. 2006. Spatial and temporal variations of assemblages in a Mediterreanean coralligenous reef and relationships with surface orientation. Coral Reefs 25:265-272.

Wheat, C.G., H.W. Jannasch, J.N. Plant, C.L. Moyer, F.J. Sansone, and G.M. McMurtry. 2000. Continuous sampling of hydrothermal fluids from Loihi Seamount after the 1996 event. Journal of Geophysical Research 105(B8):19353-19367.

Wilson, G.D. 1976. The systematics and evolution of *Haplomunna* and its relatives (Isopoda, Haplomunnidae, new family). Journal of Natural History 10:569-580.

Witherell, D., C. Pautzke, and D. Fluharty. 2000. An ecosystem-based approach for Alaska groundfish fisheries. ICES Journal of Marine Science 57:771-777.

WWF/IUCN (World Wildlife Fund/International Union for Nature and Natural Resources). 2004. The Mediterranean deep-sea ecosystems: An overview of their diversity, structure, functioning and anthropogenic impacts, with a proposal for conservation. Rome, Italy and Málaga, Spain: WWF/IUCN (World Wildlife Fund/International Union for Nature and Natural Resources).

Zibrowius, H. 1980. Les scléractiniaires de la Méditerranée et de l'Atlantique nord-oriental. Mémoires de l'Institut Océanographique, Monaco 11:1-284.

Zibrowius, H. and M. Taviani. 2005. Remarkable sessile fauna associated with deep coral and other calcareous substrates in the Strait of Sicily, Mediterranean Sea. Pages 807-819 in Freiwald, A. and J.M. Roberts, eds. Cold-water corals and ecosystems. Berlin, Germany: Springer-Verlag.

This page intentionally left blank

5.0 FISH AND FISHERIES

5.1 FISH/INVERTEBRATES

The Mediterranean Sea is an oligotrophic (low productive) sea consisting of various marine fishes and invertebrates, yet supporting a sizeable and very valuable fisheries (Bakun and Agostini 2001; Zenetos et al. 2002). At least 664 species belonging to 156 families of marine fishes have been reported from the Mediterranean Sea encompassing the following habitats: littoral: (epipelagic/benthic), continental shelf (0 to 200 m: demersal/pelagic), continental slope (200 to 1,000 m: demersal, oceanic, and mesopelagic), and offshore (>1,000 m: oceanic, mesopelagic, and bathypelagic) (Quignard and Tomasini 2000). Bony fishes (Osteichthyes) dominate the number of species (575) in the Mediterranean Sea with less than 14% of species being cartilaginous fishes (Chondrichtyes: 86 species) and jawless (Cyclostomes: 3 species) (Bertrand et al. 2000; Quignard and Tomasini 2000). Approximately 74% of the fishes are demersal, while 26% are pelagic (WWF/IUCN 2004). Of the 156 families represented, 67% have more than one species in the family (maximum of three), while 46% are monospecific. Gobies (Gobiidae) are numerically dominant followed respectively by blennies (Blenniidae), wrasses (Labridae), and seabreams (Sparidae) (Quignard and Tomasini 2000). The benthic invertebrate fauna in the Mediterranean Sea consists of more than 6,698 species in the Mediterranean Sea. Within the eastern Mediterranean Study Area, 35% (2,119 species) occur in the Ionian Sea and 28% (1,658 species) in the Levantine Sea. Of the total 6,698 species, more than 74% (4,935 species) are dominated by three major groups (annelids, mollusks, and arthropods) (Zenetos et al. 2002; Zenetos et al. 2003). Arthropods (crabs, shrimp, lobsters) and mollusks (octopus, squids) comprise the dominant shellfish population on the continental shelf and slope bottom communities (Rufino et al. 2006).

The fauna of the Mediterranean Sea is characterized by a high level of biodiversity (i.e., 100 of 300 littoral species dwell at depths less than 50 m) (Tudela and Sacchi 2003; Macpherson and Raventos 2006). Some species are endemic to the area, some have a wider geographical distribution and others recently immigrated into Mediterranean waters (Biagi et al. 2002). Both the Strait of Gibraltar and its west-to-east current in the western Mediterranean Sea and the Suez Canal in the eastern Mediterranean Sea are contributing factors in enriching the overall fish biodiversity (Quignard and Tomasini 2000). Mediterranean demersal assemblages are characterized by high biodiversity either of vertebrate (fish) or invertebrate (cephalopods, decapod crustaceans, macro-epibenthos) organisms (Bianchi and Morri 2000; Colloca et al. 2003). Fishes in the eastern Mediterranean Study Area are generally characterized by a lower species richness (e.g., southern Italian coast (south Sicily): 410 species, southern Adriatic Sea: 275 species, Ionian Sea: 129 species, Crete: 130 species, and Levantine Sea without the Red Sea: 350 species and with the Red Sea: 405 species) as well as a lower rate of endemism (Gulf of Gabes and Eygpt: 3% and Levantine Sea without the Red Sea: 9% and with the Red Sea: 8%) (Quignard and Tomasini 2000). In the Mediterranean Sea as a whole, about 68% of the endemic fish species are benthic, 29% are nektonic, and 3% are pelagic (Quignard and Tomasini 2000). Of the endemic benthic species, approximately 25.4% inhabit hard bottoms, 21.5% hard/soft bottoms, and 52.6% soft bottoms (mud and sand) (WWF/IUCN 2004). This highly diversified fish population also produces smaller individuals (Mediterranean nanism due to a combination of factors of disparate origin: limited resources, elevated temperature, and latitudinal gradients/ecological factors that affect size) (Moranta et al. 2003) which have a short average life span, resulting in a rapid renewal of resources (Zenetos et al. 2003). Within the invertebrate fauna community, epibenthic crustaceans exhibit high species richness, especially decapod crustaceans (Abelló et al. 2002). Both fish and invertebrate fauna distributions are not homogeneous: there are twice as many species in the western basin than the eastern basin (Garibaldi and Caddy 1998).

5.1.1 Distribution

The biota of the Mediterranean Sea consists of a mixture of boreal, subtropical (Indo-Pacific species), and Ponto-Caspic species (Andaloro and Azzurro 2004). In the eastern Mediterranean Study Area, the biota is derived not only from the Atlanto-Mediterranean species but also from the ongoing Lessepsian (Erythrean intrusion) migration of Suez Canal tropical forms (Por 1978; Golani 1998; Galil and Zenetos 2002) with the Strait of Sicily acting as a crossroad between the Atlanto-Mediterranean (boreal) and Indo-Pacific (subtropical) fauna (Briggs 1974; Andaloro and Azzurro 2004; Bianchi 2007). Nearshore areas

(e.g., Nile delta, Suez Canal, Gulfs of Gabes, Tunis, Gela, Taranto, and Messiniakos, and Islands of Malta, Crete, and Cyprus) consists of various habitats. These habitats include brackish water, shallow coastal lagoons (e.g., Biban, Messolongui-Etoliko, etc.) and/or gulfs, mixed meadows (rocky reefs and Neptune grass, *Posidonia oceanica* beds), rocky (hard: coralligenous) bottoms, and maërl beds. All these nearshore areas serve as important spawning, recruitment, and nursery grounds, refuge zones, and feeding areas for different lifestages of various demersal and pelagic species (Tortonese 1985; Halim et al. 1995; Katselis et al. 2003; Pérez-Ruzafa et al. 2004; Ruso and Bayle-Sempere 2006; Pérez-Ruzafa et al. 2007).

Within the eastern Mediterranean Study Area, the continental shelf and slope support a population of small to large pelagic species and a demersal assemblage consisting of fish, elasmobranches, crustaceans, and cephalopods (Kallianiotis et al. 2000; D'Onghia et al. 2003b; Labropoulou and Papaconstantinou 2004; Mytilineou et al. 2005). The demersal megafaunal assemblage is distributed on the coastal shelf, middle shelf, deeper shelf/slope edge, shallow upper-slope, and deeper shallow-slope in the eastern Mediterranean Study Area (Kallianiotis et al. 2000; Maravelias and Papaconstantinou 2006). Mostly fish and large decapod crustaceans are the dominant megafauna with the decapod crustaceans constituting an important part of the total biomass along the continental shelf and slope, especially in the middle and lower portions of the slope (Company et al. 2004). These demersal assemblages are strongly oriented along a bathymetric gradient on the continental shelf and upper and lower slope (Ungaro et al. 1999; Kallianiotis et al. 2000; Labropoulou and Papaconstantinou 2000; Garofalo et al. 2007). Fishes exhibit a transitional zone between the lower/middle slope and decapod crustaceans between the upper/middle slope (Tserpes et al. 1999; Ungaro et al. 1999; Tserpes and Peristeraki 2002; Politou et al. 2003; Kallianiotis et al. 2004). Transitional zones separating faunal assemblages have also been reported in other marine communities: North Atlantic Ocean (Hecker 1990), Azores Archipelago (Menezes et al. 2006), and western Mediterranean Sea (Quetglas et al. 2000). In addition, diel variations have been reported on the shelf break with demersal fish and cephalopods abundant during the day and nektobenthic fish and crustaceans at night (Carpentieri et al. 2005). Throughout the Mediterranean Sea, no predominant fish family exists throughout the entire depth range of the slope assemblages. Dominant families include Gadidae (cods, codfishes, and true cods) and Scyliorinidae (cat sharks) in the upper slope assemblages, Moridae (codlings and deepsea codfishes) and Aleopocephalidae (slickheads) on the middle slope, and Aleopocephalidae on the lower slope (Moranta et al. 2003).

The Mediterranean bathyal assemblage (e.g., fish, decapod crustaceans, etc.) are impoverished in numbers of faunistic species (very low degree of endemism and low diversity; (Bouchet and Taviani 1992); with an abundance well below the fauna of the northeast Atlantic Ocean (Pérès 1985) that generally declines with depth (WWF/IUCN 2004). In the eastern Mediterranean Study Area, the dominant megafaunal components were represented by a deepwater ichthyofaunal assemblage (circa [ca.] 45 species of which seven species were chondrichthyes) (Jones et al. 2003; D'Onghia et al. 2004; Madurell et al. 2004; WWF/IUCN 2004) and decapod crustaceans (ca. 33 species) (Company et al. 2004; Galil 2004; Sardà et al. 2004b; Ungaro et al. 2005). Both the Scyliorhinidae and Squalidae (dogfish sharks) families represented about 74 and 24% respectively of the chondrichthyes (Sion et al. 2004).

Faunal assemblages collected in the eastern Mediterranean Study Area from the Amendolara seamount, western side of Taranto Gulf, consisted of a highly diversified fish (common dentex: *Dentex dentex*, grouper, seabream, anglerfish: *Lophius piscatorius*, and mullet), cephalopod, and crustacean (lobster) community (D'Onghia et al. 2006). The Eratosthenes seamount, south of Cyprus, supports a crustacean community (red shrimp: *Aristeus antennatus*, giant red shrimp: *Aristaeomorpha foliacea*, and deepwater rose shrimp: *Parapenaeus longirostris*) (WWF/IUCN 2004).

Offshore areas are inhabited by pelagic nekton such as tunas, billfish, swordfish (*Xiphias gladius*), and sharks throughout the year (Di Natale 2006). Various offshore areas in the eastern Mediterranean Study Area provide the principal spawning/feeding habitat for many of these species, particularly the tunas (Di Natale 2006). These nektonic species' distributions are generally correlated with oceanographic (e.g., surface fronts, meso-eddies, Pelops, Rhodes, Asia minor, Mersa-Matruth, and Shikmona gyres, mid-Mediterranean jet water masses, meandering currents, Atlantic-Ionian, western-Ionian coastal, and

western-Cretan coastal currents, etc.) and climatic factors (e.g., high/low NAO index, higher temperatures and humidity) (EEA 1999; Dulčić and Grbec 2000; Bombace 2001; Karakulak 2004; Oray and Karakulak 2005; Royer et al. 2005; STECF 2006).

5.1.2 Spawning

The eastern Mediterranean Study Area is an important spawning area for many of the pelagic and demersal fauna supporting a diverse array of larval species influenced by bathymetric (i.e., shelf, slope), hydrographical (e.g., river runoff: Nile), currents (e.g., AIS, etc.), and meteorological conditions (i.e., wind mixing) (Sabatés and Olivar 1996; Somarakis et al. 2000; Caragitsou et al. 2001; Giordano et al. 2001; Somarakis and Maraveya 2001; Agostini and Bakun 2002; Somarakis et al. 2002; Cuttitta et al. 2004; Koutrakis et al. 2004; Somarakis et al. 2004; Arigo et al. 2005; Rollandi et al. 2005; Zarrad et al. 2006).

Within the eastern Mediterranean Study Area, various major spawning/nursery areas have been documented for small pelagics, large/medium pelagics, and demersal species. For small pelagics (e.g., European anchovy, *Engraulis encrasicolus*), major spawning areas include continental shelf in the Strait of Sicily, Aegean Sea and nearby coast of Turkey, southwestern Adriatic Sea as well as the northeastern Aegean Sea continental shelf. Spawning areas for the European sardine (*Sardina pilchardus*) are small-sized semi-enclosed gulfs and bays in the Hellenic seas (central Aegean and Ionian) (Ganias et al. 2001; Quintanilla and García 2001a, 2001b; Agostini and Bakun 2002; Patti et al. 2004; Somarakis et al. 2004; Basilone et al. 2006; Cuttitta et al. 2006; Somarakis et al. 2006b; Somarakis et al. 2006a; STECF 2006). Other spawning regions/nursery areas adjacent to the eastern Mediterranean Study Area for these and other small pelagics are river mouths/lagoons along the Turkish Aegean and Levantine coasts and in Lebanese coastal waters and the Gulf of Tunis (STECF 2006; Zarrad et al. 2006; Bariche et al. 2007).

For large pelagics, major spawning areas for the bluefin tuna (*Thunnus thynnus*) in the eastern Mediterranean Study Area are located in the central Mediterranean Sea southwest of Malta, eastern Mediterranean Sea in the south Aegean Sea to the area north of Cyprus, and in the Levantine Sea, particularly the area between Anamur and Mersin. Major juvenile areas occur over the continental shelf along the coasts of Croatia, south Adriatic Sea, western Ionian Sea, a few areas in the Aegean Sea, and in the Levatinine Sea (between Anamur and Mersin; **Figure 5-1**) (Karakulak 2004; Karakulak et al. 2004; Oray and Karakulak 2005; Di Natale 2006; STECF 2006).

Major spawning areas for the albacore tuna (*T. alalunga*) are in the Strait of Messina, Ionian Sea, southern Adriatic Sea, small area off the Cirenaica coast, and along the south Turkish coast in the area between Anamur and Mersin in the Levantine Sea. Major juvenile areas occur in the western Ionian Sea and in the southern area of Apulia (western Ionian and south Adriatic seas; **Figure 5-2**) (Karakulak 2004; Karakulak et al. 2004; Oray and Karakulak 2005; Di Natale 2006; STECF 2006).

The swordfish's major spawning areas are situated in the Strait of Messina and the surrounding western Ionian Sea, Strait of Sicily and the central Mediterranean Sea between Malta and the Pelagis isles, southern Adriatic Sea, eastern Ionian Sea, Aegean Sea, and around the isles of Crete and Cyprus. Major juvenile areas are concentrated close to the coast or off-shore along the entire Sicilian coasts including the small isles, area around Malta, Ionian coasts, Aegean coasts, eastern Mediterranean Sea particularly along the Turkish coast and around Crete and Cyprus, and the Mediterranean coast of Morocco (**Figure 5-3**) (Karakulak 2004; Karakulak et al. 2004; Oray and Karakulak 2005; Di Natale 2006; STECF 2006).

For some medium pelagics such as the bullet tuna (*Auxis rochei rochei*) and Atlantic black skipjack (*Euthynnus alletteratus*) major spawning occurs along the coast of Turkey in the northern Levantine Sea. Major spawning/nursery areas for the Atlantic bonito (*Sarda sarda*) are close to the Strait of Messina and south-east Sicily, southern Adriatic Sea, and in Turkish waters either along the Mediterranean coast or in the Black Sea (Oray and Karakulak 2005; Orsi Relini et al. 2005; Di Natale 2006; STECF 2006).

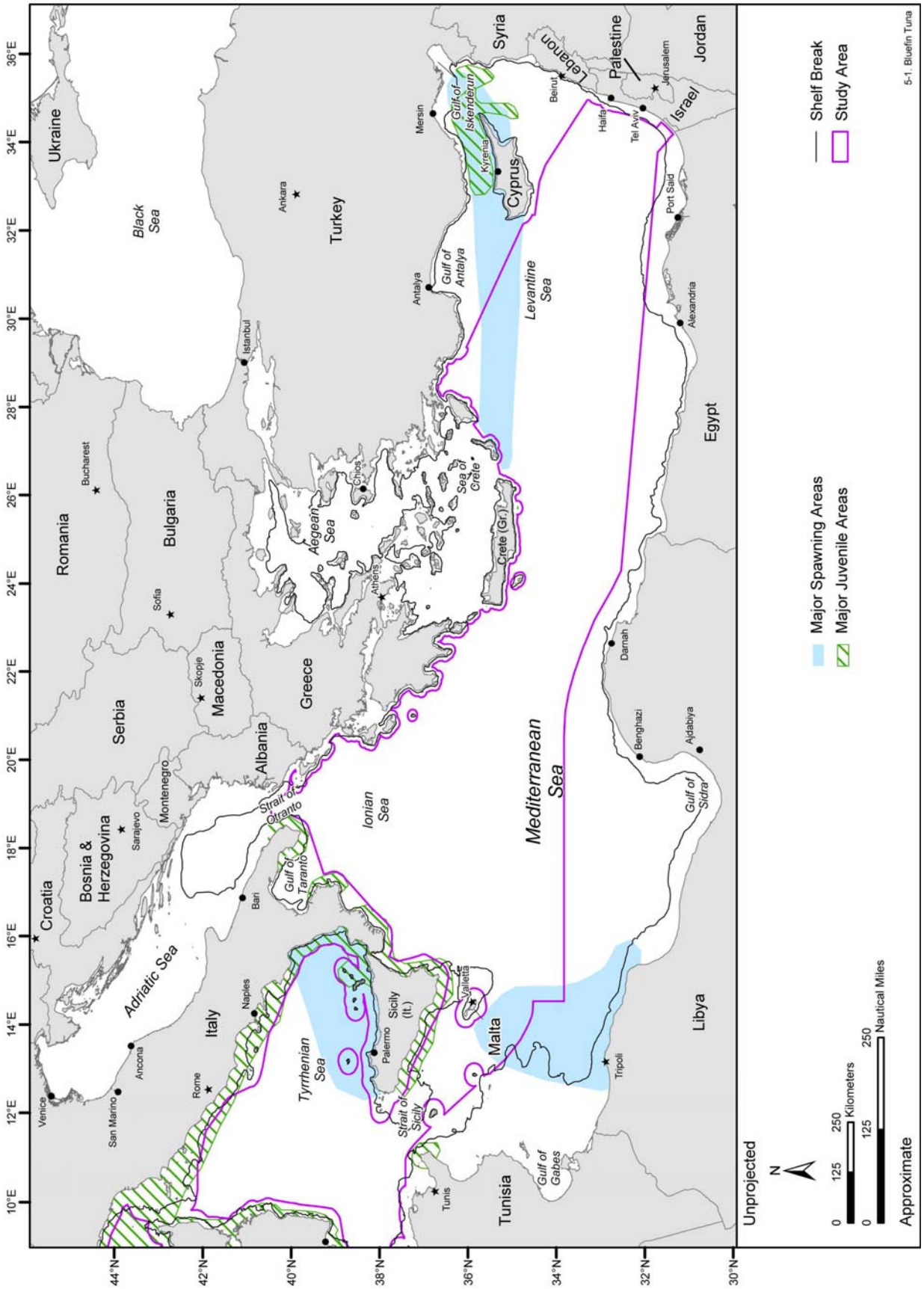


Figure 5-1. Major spawning and juvenile areas of the bluefin tuna in the eastern Mediterranean Study Area. Source map (scanned): STECF (2006).

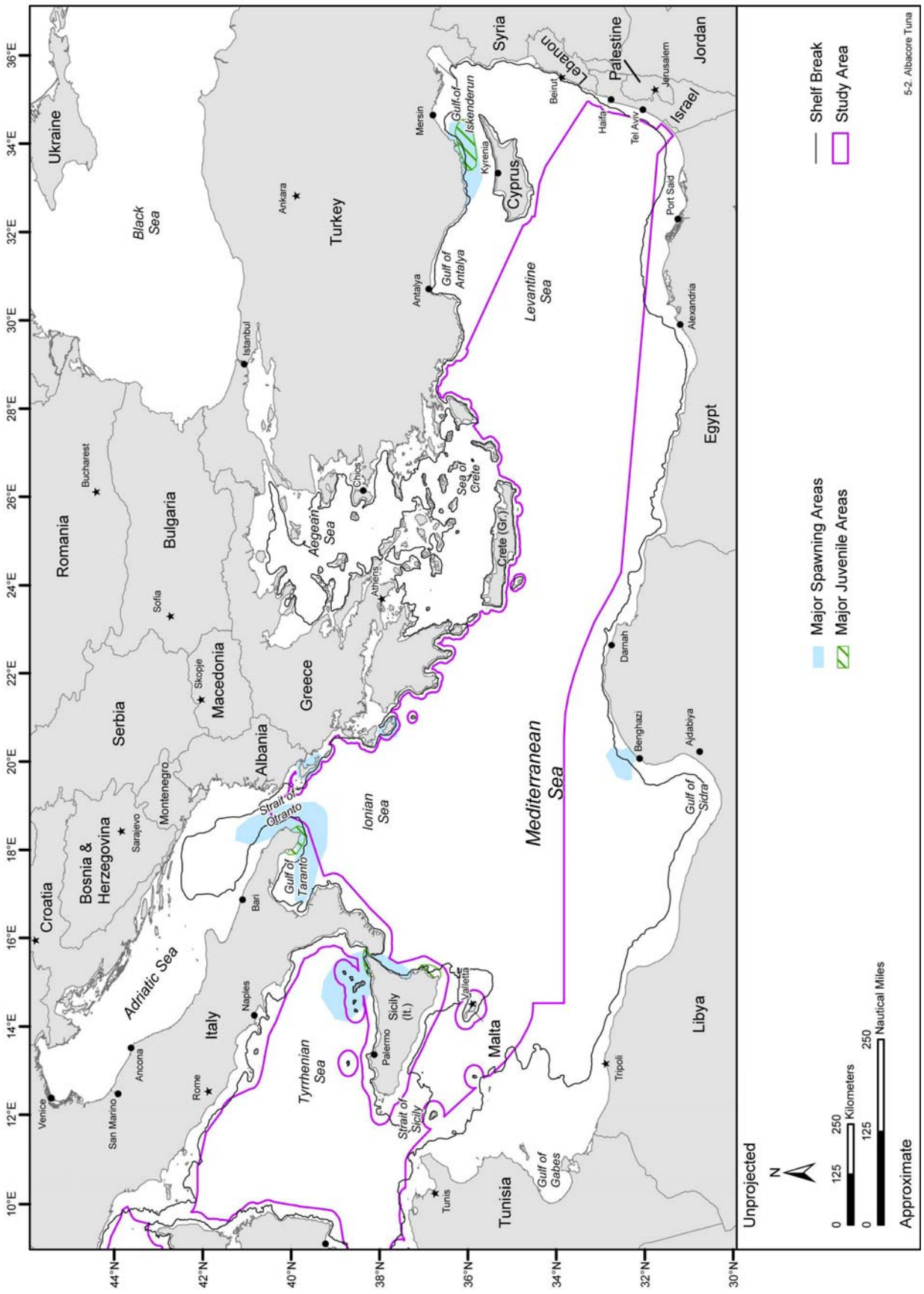


Figure 5-2. Major spawning and juvenile areas of the albacore tuna in the eastern Mediterranean Study Area. Source map (scanned): STECF (2006).

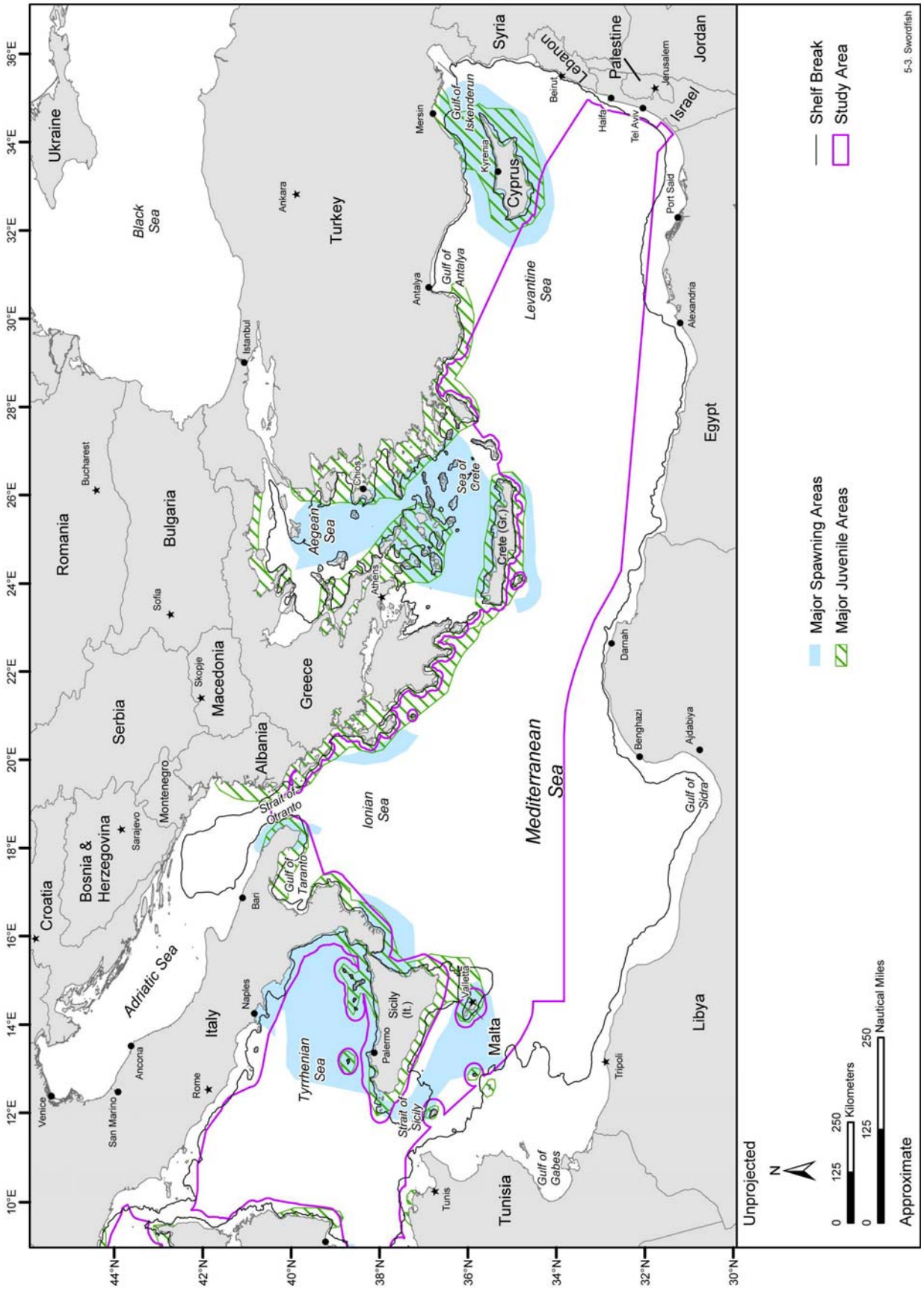


Figure 5-3. Major spawning and juvenile areas of the swordfish in the eastern Mediterranean Study Area. Source map (scanned): STECF (2006).

For demersal species, major spawning/nursery areas in the eastern Mediterranean Study Area encompass the continental shelf/upper slope for various species. The European hake's (*Merluccius merluccius*) major spawning areas are located on Adventure Bank in the Strait of Sicily, along the Apulia and Calabria coasts (Gulf of Squillace) in the northwestern Ionian Sea, and in the Hellenic Seas. Major nursery areas are situated along the eastern side of Adventure and Malta Banks in the Strait of Sicily, in the Otranto Channel, on the west side of the Gulf of Taranto, along the Calabria coasts close to Roccella Jonica Bank, on the west coast of Greece (i.e., Patraikos Gulf), and in the Aegean Sea (Papaconstantinou and Stergiou 1995; STECF 2002a; STECF 2002b; Fiorentino et al. 2003; Fiorentino et al. 2004; Abella et al. 2006; D'Onghia et al. 2006; Fiorentino et al. 2006; Politou et al. 2006; STECF 2006).

Major spawning areas for the red mullet (*Mullus barbatus barbatus*) include Adventure and Malta banks in the Strait of Sicily, Otranto Channel, western side of the Gulf of Taranto, and southern coasts of Calabria in the Ionian Sea. Major nursery areas are located along the southern coast of Sicily, south of Otranto Channel, and along the southernmost Calabria coast. The deepwater rose shrimp's major spawning areas are situated in Otranto Channel, Gulf of Taranto and Gulf of Corigliano as well as Calabria (Roccella Jonica Bank) and in the southernmost Sicily coast, barely south of Siracusa. Major nursery areas are concentrated along the Apulia coast (Otranto Channel and offshore from Torre Ovo) and Calabria (Gulfs of Taranto and Corigliano and Roccella Jonica Bank) and in the Strait of Sicily (eastern side of Malta Bank and off Cape Rossello) (STECF 2002a; Fiorentino et al. 2004; D'Onghia et al. 2006; STECF 2006).

A major nursery area has also been identified for whiting (*Merlangius merlangus*) and Norway lobster (*Nephrops norvegicus*) in the northwestern Ionian Sea (Gulf of Squillace/Apulia sector, abeam of Gallipoli). Major spawning areas for greater forkbeard (*Phycis blennoides*) exists along the Apulia (off Gallipoli and Capo Santa Maria di Leuca) and Calabria (Gulf of Squillace) coasts with major nursery areas along the western and eastern sides of Adventure Bank in the Strait of Sicily (STECF 2002a; STECF 2002b; Fiorentino et al. 2004; STECF 2006).

In addition, major spawning/nursery areas occur on the continental slope for red and giant red shrimps in the Strait of Sicily (off the western side Adventure Bank and between Adventure and Malta banks and between Maltese and Pelagian islands), northwestern Ionian Sea (off Gallipoli and Capo Santa Maria di Leuca), and in the Greek Ionian Sea. Major nursery areas for both species can be found in the Strait of Sicily and in both sectors of the northwestern Ionian Sea (offshore Capo Santa Maria di Leuca, Gallipoli and Torre Ovo along the Apulia coast and in the Roccella bank in Calabria) (STECF 2002b; Papaconstantinou and Kapiris 2003; Politou et al. 2004; Sardà et al. 2004a; D'Onghia et al. 2005; Mytilineou et al. 2006; STECF 2006).

Nursery areas have also been documented for some of the more common by-catch elasmobranches such as the thornback ray (*Raja clavata*) on the continental shelf in the eastern Ionian Sea (Serena et al. 2006b). In addition, other spawning regions/nursery areas adjacent to the eastern Mediterranean Study Area have been identified for demersal species (i.e., red mullet) on the Goksu River, Turkey in the northeastern Levantine Sea (Gucu 2006).

5.1.3 Fisheries

In the Mediterranean Sea, most of the fishery resources are carried along the continental shelf encompassing an area of 750,000 km^2 from the surface waters down to 200 m depth with an average width of 9 NM. Important marine species include demersals with more 100 species (e.g., European hake, red mullet.) representing 55% of the total catch and small (41%) and large (4%) pelagics consisting of 45% of the total but with much lower number of species (e.g., European sardine, European anchovy, bluefin tuna, albacore, and swordfish) (Lleonart and Recasens 1996; Tudela and Sacchi 2003). Although no elasmobranch-directed fishery occurs in the Mediterranean Sea, various demersal sharks (blackmouth catshark: *Galeus melastomus*, velvet belly: *Etmopterus spinax*, small-spotted dogfish: *Scyliorhinus canicula*), and rays (thornback, brown: *Raja miraletus*, and speckled: *R. polystigma*) are taken as bycatch in the bottom trawl fishery (Carbonell et al. 2003; Ferretti et al. 2005; Serena et al. 2006a). At least 10

species of pelagic sharks (**Table 5-1**) are taken as bycatch in the swordfish and tuna fisheries (Megalofonou et al. 2005; Serena 2005; Piovano 2007).

Table 5-1. Sharks incidentally taken as bycatch in swordfish and tuna fisheries operating in the Mediterranean Sea.

Common Name	Scientific Name
Blue Shark	*Prionace glauca*
Shortfin Mako	*Isurus oxyrinchus*
Common Thresher	*Alopias vulpinus*
Bigeye Thresher	*Alopias supercilliosus*
Porbeagle	*Lamna nasus*
Tope	*Galeorhinus galeus*
Sandbar Shark	*Carcharhinus plumbeus*
Basking Shark	*Cetorhinus maximus*
Bluntnose Sixgill	*Hexanchus griseus*
Smooth Hammerhead	*Sphyrna zygaena*

Source: (Megalofonou et al. 2005; Serena 2005; Piovano 2007)

Approximately 59% of the total fisheries catch is produced by EU Mediterranean countries (e.g., Spain, France, Italy, and Greece) in the Mediterranean Sea (Tudela and Sacchi 2003). For a more in-depth discussion of the fisheries within the eastern Mediterranean Study Area, please refer to **Section 5.3**.

Some regions within the eastern Mediterranean Study Area support a high fisheries production of commercially important species due to a number of environmental features. These features include: wider shelf (i.e., Strait of Sicily: Adventure and Maltese banks), strong vertical mixing in the winter and coastal upwelling/downwelling areas related to strong wind conditions (Strait of Sicily, Gulf of Sidra and Gulf of Gabes along eastern coast of Libya and Tunisia, respectively, west coast of Greece in eastern Ionian Sea: Antikithira Strait, southern coast of Turkey, south coast of the Levantine Sea, and western or southern/northern or eastern sides of major islands: Crete), presence of submarine canyons (Sicilian coast: Strait of Sicily; Bradano, Caulonia, and Roccella Jonica canyons along Calabria coast, and Gulf of Taranto: northwestern Ionian Sea), existence of a temporal thermocline, shelf-slope currents, and river discharges (e.g., Nile riverine delta) (Halim et al. 1995; Bakun and Agostini 2001; Agostini and Bakun 2002; Valavanis et al. 2002; Sardà et al. 2004b; D'Onghia et al. 2006; STECF 2006).

5.2 HABITATS

Habitat consists of a geographic area and the characteristics of the area where species may be found during any life stage. Habitat characteristics include geomorphological, physical, biological, and chemical parameters. Interactions between the above environmental parameters influence habitat and determine the biological niche of a species. Habitat parameters affecting fish distribution throughout the Mediterranean Sea include both physical and biological variables. Physical variables include depth (main structural force, and temperature, salinity, light, oxygen concentration) and sediments (which vary according to depth). Biological variables include competitors, predators, and facilitators (Colloca et al. 2003). Habitat types in the Mediterranean Sea are represented by one zoogeographic province: Lustanian consisting of three separate areas – western Mediterranean Sea, Adriatic-Ionian seas, and Aegean-Levantine seas (Spalding et al. 2006). The Adriatic-Ionian and Aegean-Levantine seas areas are represented by the following habitat types on the continental shelf/slope and in the bathyal/abyssal portion within the eastern Mediterranean Study Area (Bellan-Santini 1985; Kallianiotis et al. 2000; Colloca et al. 2004b; Tursi et al. 2004; Akin et al. 2005; Tudela 2005; D'Onghia et al. 2006; STECF 2006). Fish and invertebrate species representative of these habitats are presented in **Table 5-2.**

Table 5-2. Fish and invertebrate species found in the continental shelf/slope and bathyal/abyssal habitats within the Mediterranean Sea.

Location	Species
Continental Shelf/Slope	
Coastal lagoons and estuaries	European eel (*Anguilla anguilla*), European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*), flathead mullet (*Mugil cephalus*), thinlip mullet (*Liza ramado*), golden grey mullet (*Liza aurata*), leaping mullet (*Liza sapiens*), and thicklip grey mullet (*Chelon labrosus*)
Seagrass meadows and eel grass beds	Brown wrasse (*Labrus merula*), annular seabream (*Diplodus annularis*), common two-banded seabream (*Diplodus vulgaris*), salema (*Sarpa salpa*), bogue (*Boops boops*), axillary seabream (*Pagellus acarne*); red mullet (*Mullus barbatus barbatus*), moray eel (*Muraena helena*), conger eel (*Conger conger*); common spiny lobster (*Palinurus elephas*), octopus (*Octopus vulgaris*), and comber (*Serranus cabrilla*)
Corallingenous bottoms	Saddled seabream (*Oblada melanura*), annular seabream (*Diplodus annularis*), common two-banded seabream (*Diplodus vulgaris*), dusky grouper (*Epinephelus marginatus*), and comber (*Serranus cabrilla*)
Maërl bottoms	Small red scorpionfish (*Scorpaena notata*), largescaled scorpionfish (*Scorpaena scrofa*), rock gurnard (*Trigloporus lastoviza*), piper gurnard (*Trigla lyra*), and common pandora (*Pagellus erythrinus*)
Facies: shelf break or canyon heads	European hake (*Merluccius merluccius*), poor cod (*Trisopterus minutus*), red mullet (*Mullus barbatus barbatus*), Argentine (*Argentina sphyraena*), southern shortfin squid (*Illex coindetti*), and deepwater rose shrimp (*Parapenaeus longirostis*)
Facies: intermediate part of continental slope	Red shrimp (*Aristeus antennatus*) and giant red shrimp (*Aristaeomorpha foliacea*)
Bathyal/Abyssal	
Facies: shallower part of bathyal area	Norway lobster (*Nephrops norvegicus*), white horned octopus (*Eledone cirrhosa*), southern shortfin squid (*Illex coindetti*), and lesser flying squid (*Todarodes eblanae*)
Submarine canyons	Greater forkbeard (*Phycis blennoides*), rockfish (*Helicolenus dactylopterus*), tonguesole (*Symphurus nigrescens*), red shrimp (*Aristeus antennatus*) and giant red shrimp (*Aristaeomorpha foliacea*)
Seamounts	Common dentex (*Dentex dentex*), anglerfish (*Lophius piscatorius*), red shrimp (*Aristeus antennatus*), giant red shrimp (*Aristaeomorpha foliacea*), and deepwater rose shrimp (*Parapenaeus longirostis*)
White coral biocenosis	European hake (*Merluccius merluccius*), greater forkbeard (*Phycis blennoides*), rockfish (*Helicolenus dactylopterus*), red shrimp (*Aristeus antennatus*), giant red shrimp (*Aristaeomorpha foliacea*), deepwater rose shrimp (*Parapenaeus longirostis*), and Norway lobster (*Nephrops norvegicus*)
Offshore water column	Swordfish (*Xiphias gladius*) and Mediterranean spearfish (*Tetrapturus belone*)

Source: (Bellan-Santini 1985; Kallianiotis et al. 2000; Colloca et al. 2004b; Tursi et al. 2004; Akin et al. 2005; Tudela 2005; D'Onghia et al. 2006; STECF 2006)

Continental Shelf/Slope Habitats

- Coastal lagoons/estuaries: typical habitat of flat coastal areas which are highly productive in nutrients and are important feeding/nursery grounds for many marine juvenile fish species shellfish; birds; and marine mammals).
- Seagrass meadows (*Posidonia oceanica*) and eelgrass beds (*Cymodocea nodosa*): host high number of species characteristic of both soft/hard bottoms (e.g., fish: wrasses, seabreams, red mullet, and eels; crustaceans [lobsters], and cephalopods [octopus]); recruitment area for pelagic species (i.e., horse and jack mackerels: *Trachurus* spp.) and deeper fish species (seabreams).
- Corallingenous bottoms: characterized by relatively dim light and vegetal dominance of Phaeophycees, calcareous Rhodophytes, and algae with soft thalli; covers rocky substrates with many large erect invertebrates (gorgonians, alcyonarians, sponges, bryozoans) or horizontal surfaces of soft bottoms covered with encrusting Corallinaceae and Peyssonneliaceae with algae; inhabited by species of high commercial value including fishes, large crustaceans, and red coral (*Corallium rubrum*).
- Maërl bottoms: diverse community consisting of detritic bottom associated with laminar and irregular bottom currents dominated by vegetals (marine seagrass meadows and Laminariales forests) representing an important area of growth and stay of economically interesting species of benthopelagic species, mainly juvenile fishes, crustaceans (lobster), and cephalopods (octopus).
- Facies: complex demersal community with detritic sediments either on shelf break or canyon head areas under bottom currents that serve as important nursery areas (e.g., European hake) and are characterized by the echinoderm crinoid: *Leptometra phalangium*, polychaetes, alcyonarians, fishes, cephalopods (squids), and crustaceans (deepwater shrimps).
- Facies: on intermediate part of the continental slope with superficial soft muds characterized by the gorgonian (*Isdella elongata*) with large decapod crustaceans (shrimps) utilizing area as a recruitment/nursery.

Bathyal/Abyssal Habitats

- Facies: shallower part of the bathyal area on steep, soft muddy bottoms with fluid superficial layer characterized by the anthozoan (*Funiculina quadrangularis*) and mollusks providing habitats for various commercial crustaceans (lobster) and cephalopods (octopus and squid).
- Submarine canyons: geological structures of the bathyal region representing a physical discontinuity of the continental slope that supports high macro- and meio-faunal biomass concentrations of commercial crustaceans (red shrimp); plays a role in larval drift and juvenile recruitment; and is a hot spot of species diversity and endemism.
- Seamounts: areas of topographic elevation above the surrounding seafloor that show high biodiversity, high rate of endemism, provide refuge for complex benthic communities, or are habitats for many commercial fish and shrimp species.
- White coral biocenosis: hard bottom deep-water communities dominated by two colonial scleractinians (*Lophelia pertusa* and *Madrepora oculata*); along with the two solitary corals, *Desmophyllum cristagalli* and *Stenocyathus vermiformis,* are considered biodiversity hotspot that increase fish and crustacean {shrimp/lobster) density.
- Offshore water column: pelagic zone which is a critical migratory pathway and home to large pelagic species including many species of the family Scombridae (tunas) , Xiphidae (swordfish), and Istiophoridae (billfish) fishes that are influenced by oceanographic features (e.g., temperature range, salinity, oxygen levels, currents, fronts, and shelf edges).

5.3 FISHERIES RESOURCES

5.3.1 Introduction

Fishery resources in the Mediterranean Sea are unique to other fishing regions primarily due to a high numbered atomized fleet composed of relatively small vessels (e.g., artisanal) with low tonnage, lack of large industrial fishing, multiple landing points (e.g., isolated ports, shelters, and beaches), diversified

fishing gears, multi-species catches, low catch per unit effort (CPUE), and a commercialized fresh fish market with little processing and high prices (Lleonart and Maynou 2003). Mediterranean fisheries include demersal fisheries and small pelagic, large pelagic, and artisanal fisheries. Other fisheries components, such as aquaculture, are rapidly developing in several Mediterranean countries (STECF 2005) along with tuna ranching (farming) (Greenpeace International n.d.).

Demersal species which are targeted generally have the greatest commercial interest and include the European hake, whiting, deepwater rose or red shrimp, Norway lobster, red mullets, octopuses, and sole (*Solea vulgaris*). In addition to these species, more than 100 demersal species have commercial value, although none of them account to more than 3% of the total catch (Abelló et al. 2002). The main contributors of small pelagics fisheries landings include the European anchovy, European pilchard/sardine, European sprat (*Sprattus sprattus sprattus*), and Madeiran sardinella (*Sardinella maderensis*). European sprat and anchovy are the main species in the eastern Mediterranean Sea while sardinella is the main species in the southern Mediterranean Sea (Lleonart and Maynou 2003). Targeted large pelagic species are represented by bluefin tuna, swordfish, and albacore as well as other tuna-like species such as Atlantic black skipjack, bullet and hazard (*Auxis thazard*) tunas, and Atlantic bonito (STECF 2005).

Artisanal or small-scale fisheries target a high number of species (89) dominated by Sparidae (seabreams: 31%), followed by Serranidae (seabasses: 6.3%), Scombridae (mackerels/tunas: 5.9%), Carangidae (jacks: 5.8%), Mullidae (goatfishes: 5.4%), Sepiidae (true cuttlefish: 4.9%), Scorpaenidae (rockfishes: 4.6%), etc. that are collected in the demersal and small pelagic fisheries (Coppola 2004; STECF 2005). Marine aquaculture utilizes important economic species like the Mediterranean mussel (*Mytilus galloprovincialis*), European seabass (*Dicentrarchus labrax*,), gilthead seabream (*Sparus aurata*), flathead mullet (*Mugil cephalus*), as well as the bivalves (e.g., oysters: *Ostrea edulis* and *Crassostrea gigas*, Japanese littleneck clam, *Venerupis philippinarum*, and Manila clam, *Ruditapes philippinarum*) (IUCN 2000; Greenpeace International 2006).

Tuna ranching or capture–based aquaculture (CBA) is the capture, transport, and fattening of bluefin tuna in cages. Industrial purse seiners and tugboats with the latest generation sonar/radar technology from the following countries: France (31), Spain (6), Tunisia (29), Libya (17), Italy (45), Croatia (31), Greece (17), and Turkey (68) sweep the new bluefin tuna fishing grounds off Algeria, Libya, Cyprus, Syria, and Egypt, assisted by a flotilla of aircraft (i.e., Cessna Skymaster and Partenavia P-68) and helicopters (**Figure 5-4)** (Greenpeace International 2006; WWF 2006). Tugboats tow the captured tuna in cages at a speed of 1.2 knots to various tuna ranches. These tuna ranches are located close to shore (about 1 km from the coast) in the following countries: Spain (13), France (2), Italy (6) Malta (7), Croatia (7), Greece (2), Turkey (7), Cyprus (2), Libya (3), and Tunisia (4) (Katavic et al. 2003; Peric 2003; WWF 2006). The tuna are fatten in floating, moored, circular cages with small pelagics (herring [Clupeidae], European pilchard, and round sardinella [*Sardinella aurita*]) at depths between 38 and 55 m for six to seven months before being slaughtered and sold (Caill-Milly et al. 2003). Tuna ranching (or CBA) is a highly profitable activity directed towards the Japanese market and European Asiatic communities (Caill-Milly et al. 2003; Katavic et al. 2003; Greenpeace International n.d.).

5.3.1.1 Fisheries Management

Formal and coordinated fishery management measures are largely absent in most Mediterranean countries (Lleonart 2005). The isolated fleets along with the huge number of landing points, multi-species catches, and lack of a large industrial fishery makes it difficult and expensive to obtain data for stock assessments (Lleonart 2005). The majority of stocks in the Mediterranean Sea are not shared between countries and therefore there is no reason to assess the resources or implement management criteria (Lleonart 2005). For a current list of shared stocks by two or more countries, please refer to FAO-GFMC (2006).

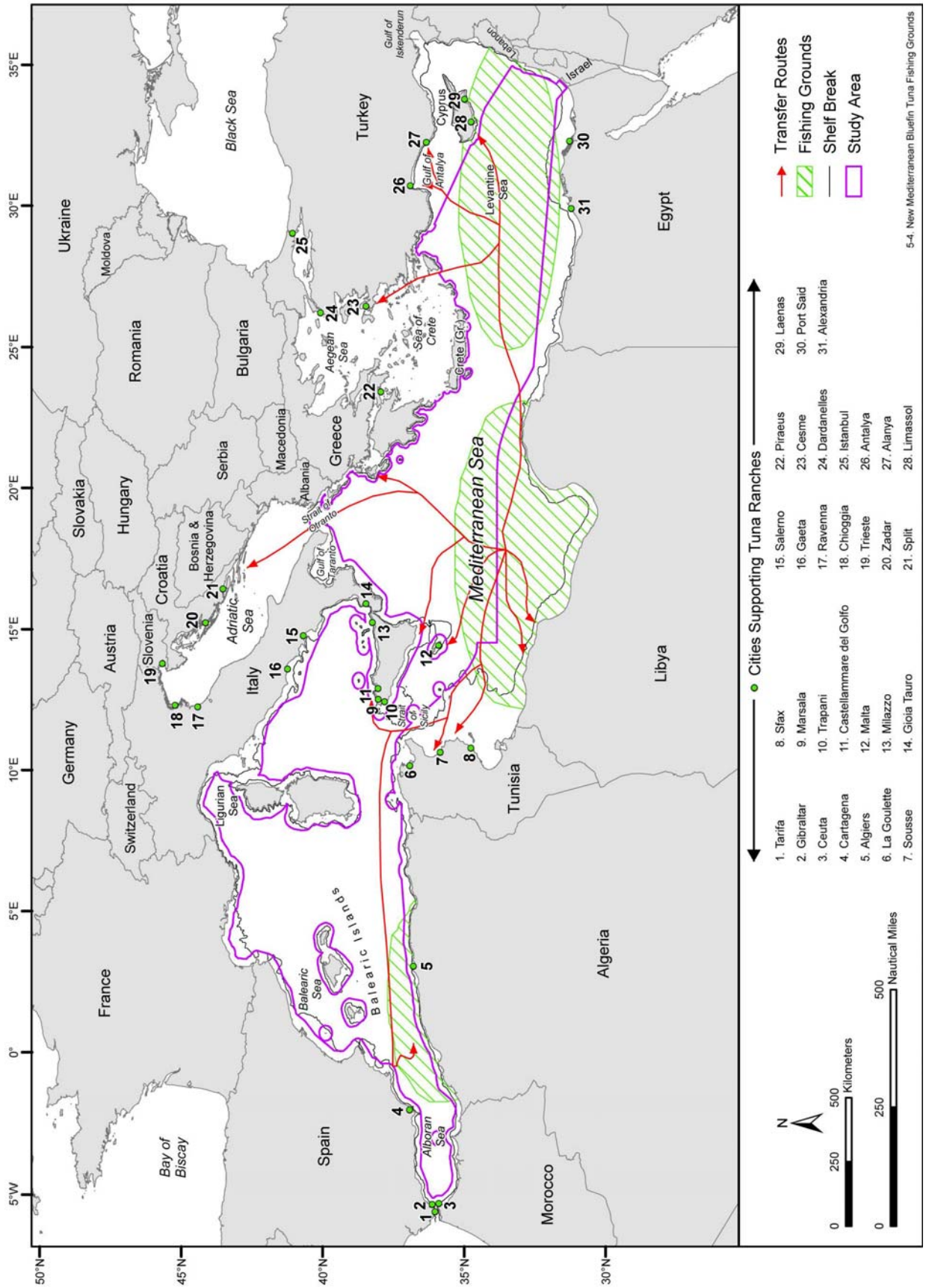


Figure 5-4. New Mediterranean bluefin tuna fishing grounds and routes of live transferred bluefin tuna to offshore tuna ranches. Map adapted from: WWF (2006).

Within the EU Mediterranean countries, fishery management was originally under national jurisdiction (STECF 2005). This national management regime was supplemented by EU regulations and was revised by the GFCM-SAC (Lleonart 2005). The GFCM is the responsible organization for Mediterranean fisheries (IUCN 2000). Its purpose is to promote the development, conservation, rational management, and best utilization of living marine resources occurring in the Mediterranean Sea, Black Sea and connecting waters, in both areas under national jurisdiction and on the high seas (Oliver 2002; Cacuad 2003). Currently, the GFMC is in the process of changing the form of most of its management advice from stock-oriented to fisheries-oriented.

The management of the Mediterranean fisheries is primarily based on effort control (e.g., limiting number of fishing licenses and days at sea) and minimum catching or landing size (range of 9 to 30 cm depending on commercial species) as well as fishing capacity (Lleonart and Maynou 2003; Cacaud 2005; STECF 2005). Effort control is a measure of the activity of the fishing fleet used in one of two different contexts: as a measure proportional to fishing mortality or to the variable costs of the fishing vessels (Oliver 2002). Controlling and monitoring fishing capacity is accomplished by establishing an authorization scheme prior to the construction, importation, modification or transformation of any fishing vessel, prohibiting the issue of fishing licenses to certain categories of vessels, restricting license transfer, and on the vessel's replacement (Cacaud 2005). Fisheries management is also achieved by subsidiary measures such as closed areas/seasons and gear restrictions to keep fishing effort under control and to create more rational exploitation patterns (Cacaud 2005).

Total allowable catches (TACs) and quotas for demersal and small pelagic fisheries are not implemented due to the wide variety of species characterizing these fisheries. Other implemented technical measures (e.g., minimum landing size and mesh sizes) are usually weaker and are not always enforced (Lleonart and Maynou 2003; Cacaud 2005). Large pelagics are currently restricted to internationally agreed TACs for bluefin tunas under the responsibility of ICCAT (STECF 2005). The ICCAT is responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas, such as the Mediterranean Sea (Oliver 2002). In 1995, the GFCM adopted management measures on bluefin fisheries from the ICCAT to apply to all member countries of the GFCM for both bluefin tuna and swordfish (Cacuad 2003). On 16 January 2007, GFMC signed off on the following new rules for tuna fishing in the Mediterranean Sea. These measures include a 15-yr recovery plan (2007 through 2022), six month off season for specific types of vessels, bans the use of aircraft in spotting tuna, forbids the capture of tuna under 30 kg, allows tuna to be offloaded at designated ports, and obliges countries to place observers on fishing boats to monitor adherence to regulations.[1]

The analysis of national fisheries legislation shows that all countries bordering the Mediterranean Sea have adopted some measures to manage fishing activities that are primarily directed at protecting and conserving fishery resources (Oliver 2002). These measures include licensing of fishing vessels and regulating the characteristics of fishing gear and conditions of their use (Oliver 2002). Other important measures, such as catch reporting, protection of protected species and/or immature commercial species, reducing the impact of ghost fishing (lost gear: mainly gill nets or traps either accidentally or deliberately which continues to catch fish for a certain amount of time thereafter or traps) on fishery resources, or specific provisions for the creation of MPAs are either lacking or very inconsistent (Oliver 2002).

Stock assessment for most of the species (e.g., demersal and small pelagics) are under the responsibility of the GFMC-SAC, whereas the large pelagics are under the ICCAT-Standing Committee on Research and Statistics (SCRS) (STECF 2005). Some of the main management measures adopted within the Regional Fisheries Management Organization (RFMO), such as GFCM, include the following:

- Demersal Fisheries—controls (and often reduces) fishing effort together with other technical measures such as minimum mesh size, minimum landing, minimum distance from the shore and/or minimum depth as well as the development of fishing license schemes to control/monitor fleets
- Small Pelagics—reduces fishing mortality including setting minimum size at landing, minimum distance from the shore and/or minimum depth, minimum size mesh, and maximum length of purse seine gear

- Large Pelagics—includes quotas, seasonal/area closures, prohibits use of tuna-spotting aircrafts in June, and size limits
- Artisanal Fisheries—management measures are non-existent due to its complexity (e.g., allocations of effort to fishing gear or targeted species and poor, sporadic, and geographically restricted available data on catch, size composition, discards)
- Aquaculture—some countries have legislation in place or utilize other activities (specific coastal zone plans) to reduce the impact on the ecosystem while other countries remain unregulated causing major conflicts with tourism, conservation projects, and uncontrolled effluents and run-off

In addition, there are a few FAO co-operation programs (COPEMED, ADRIAMED, and MEDSUDMED) that exist in the western and central Mediterranean areas. Their aim is to enhance cooperation to develop common fisheries management policies, introduce common systems for data collection on landings, and develop fishery activities (i.e., artisanal fisheries) and aquaculture in developing countries (IUCN 2000).

For management purposes, the GFCM divided the Mediterranean Sea (FAO Area 37) into 30 GSAs for the demersal and small pelagics, while retaining all of FAO Area 37 as a management unit for the large pelagics (**Figure 5-5**). Each GSA was subdivided into the continental shelf, continental slope, and deep water (GFCM-SAC 2001; FAO-GFCM 2006). Based on stock assessment and conservation, the following 42 fish/invertebrate species have been prioritized by GFCM in the Mediterranean Sea and are presented in **Table 5-3** (Oliver 2002; FAO-GFCM 2006).

5.3.1.2 Subsidiary Measures

Subsidiary measures are traditional conservation and management measures adopted by Mediterranean coastal states (e.g., Spain, France, Italy, Greece) for managing fishing effort and capacity (Cacaud 2005). These measures include closed seasons, fishing methods and gears, prohibited fishing areas, fishing zones, and fish reserves (Coffey 2001; Cacaud 2005). Closed seasons or temporary suspension of fishing operations are designed to reduce pressure on individual fish stocks by curtailing fishing activities to allow sufficient time for major commercial species to mature and reproduce (Cacaud 2005). Restrictions on certain fishing methods (e.g., toxic/soporific/corrosive substances, explosives, electrical devices or percussive instruments, etc.) to prohibiting fishing gears (e.g., mesh size, length) and their uses are measures to prevent the use of destructive methodologies or gears on fishing habitats. These restrictions encompass areas (e.g., using bottom trawls, seines, and similar net above *Posidonia oceanica* beds or within 3 NM of the shoreline or 50 m isobath; curtailing St. Andrew Cross to harvest red coral on rocky bottoms), times (e.g., prohibiting bluefin tuna purse seining in August each year), and landings (minimum size/weight) (Coffey 2001; Cacuad 2003; Tudela 2004; Cacaud 2005). Conversely, prohibited fishing areas are closed to fishing operations and/or to prohibit the use of a specific gear(s)/method(s) in a specified area(s) or at certain depths, whereas established fishing zones allow only certain types of fishing activities by specified categories of vessels (Cacaud 2005). Fish reserves are created to rebuild the diversity of exploited fishery resources and protect spawning grounds or sensitive marine ecosystems by banning fishing or subjecting fishing operations to strict conditions (Tudela 2004).

In 2006, the GFCM banned bottom trawling in three areas which are home to three deep-sea sensitive habitats: (1) off the coast of Egypt (GSA 26: chemosynthesis-based community associated to cold seeps near the Nile delta), (2) Italy (GSA 19: *Lophelia* reef off Capo Santa Maria di Leuca in the Northwestern Ionian Sea), and (3) Cyprus (GSA 26: Erastosthenes Seamount in the Levantine Sea) (Tudela 2005': European Commission[2]). In 2003, the European Community (EC) adopted a resolution to prohibit the practice of shark fining to all types of fishing in EC waters and non-EC waters (COM 2005).

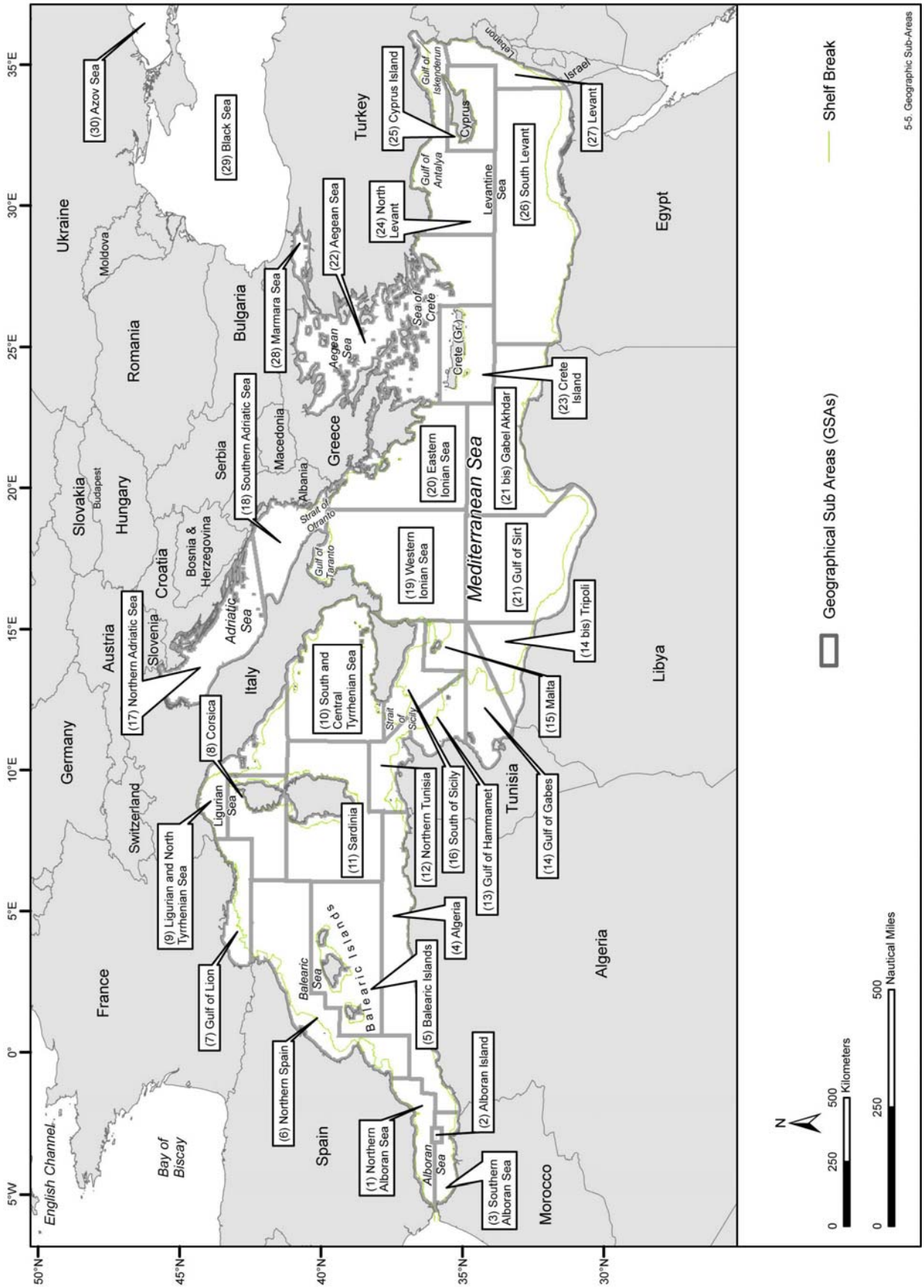


Figure 5-5. Geographical Sub-areas (GSAs) within the Food and Agriculture Organization (FAO) Area 37. Source map (scanned): FAO-GFCM (2006).

Table 5-3. Prioritized commercial fish and invertebrate species in the Mediterranean Sea.

Demersal Species	
European hake (*Merluccius merluccius*)	Blackbellied angler (*Lophius budegassa*)
Whiting (*Merlangius merlangus*)	Anglerfish (*Lophius piscatorius*)
Red mullet (*Mullus barbatus barbatus*)	Common sole (*Solea vulgaris*)
Striped red mullet (*Mullus surmuletus*)	Common cuttlefish (*Sepia officinalis*)
Norway lobster (*Nephrops norvegicus*)	Common spiny lobster (*Palinurus erythrinus*)
White horned octopus (*Eledone cirrhosa*)	Pink spiny lobster (*Palinurus elephas*)
Red shrimp (*Aristeus antennatus*)	Musky octopus (*Eledone moschata*)
Giant red shrimp (*Aristaeomorpha foliacea*)	European squid (*Loligo vulgaris*)
Deepwater rose shrimp (*Parapenaeus longirostris*)	European eel (*Anguilla anguilla*)
Common pandora (*Pagellus erythrinus*)	Blackspot seabream (*Pagellus bogaraveo*)
Bogue (*Boops boops*)	Black sturgeon (*Acipenser gueldenstaedtii*)
Sturgeon (*Acipenser sturio*)	Starry sturgeon (*Acipenser stellatus*)
Turbot (*Psetta maxima*)	Beluga (*Huso huso*)
Small Pelagic Species	
European anchovy (*Engraulis encrasicolus*)	Round sardinella (*Sardinella aurita*)
European pilchard/sardine (*Sardina pilchardus*)	Blue whiting (*Micromesistius poutassou*)
European sprat (*Sprattus sprattus sprattus*)	Atlantic mackerel (*Scomber somber*)
Mediterranean horse mackerel (*Trachurus mediterraneus*)	Atlantic horse mackerel (*Trachurus trachurus*)
Large Pelagic Species	
Bluefin tuna *(Thunnus thynnus)*	Blue shark *(Prionace glauca)*
Albacore tuna *(Thunnus alalunga)*	Shortfin mako *(Isurus oxyrinchus)*
Swordfish (*Xiphias gladius*)	Porbeagle (*Lamna nasus*)
Common dolphinfish (*Coryphaena hippurus*)	Bluefish (*Pomatomus saltatrix*)

Source: (Oliver 2002; FAO-GFCM 2006)

Currently, various prioritized commercial fish/invertebrate fisheries resources within the eastern Mediterranean Study Area are experiencing changes in stocks such as large inter-annual fluctuations in the European sardine/anchovy in Strait of Sicily, high exploitation rate in swordfish, and overexploitation in European hake and European sardine in the Gulf of Saronikos and the Adriatic Sea, respectively, continued decline in the mullet (*Mullus* spp.), bogue (*Boops boops*), common pandora (*Pagellus erythrinus*), and picarel (*Spicara smaris*) fisheries around Cyprus (GFCM 2005; STECF 2005; FAO-GFCM 2006; Maguire et al. 2006). Existing protection measures (e.g., fishing bans, MPAs, general ecosystem approach) adopted in the last decades resulted in no clear evidence of a measurable reduction in fishing mortality or stock recovery. In order to provide protection and improve the status of exploited fishery stocks, the STECF met in Rome, Italy in March 2006 to identify and map marine sensitive habitats (SH) and EFH in the Mediterranean Sea (e.g., eastern Mediterranean Study Area pilot sites: north Aegean continental shelf, Cyclades Plateau, Cretan continental shelf, and Ionian Sea) crucial for the conservation of the priority commercial fish and shellfish resources. These pilot sites support a high fisheries production, are influenced by certain productive ocean processes, and characterized by important sediment and associated biological assemblages functioning as nursery, spawning, and recruitment areas (STECF 2006; European Commission[3]).

For the purpose of identifying SH and EFH in the Mediterranean Sea, STECF has adopted the following definitions based on SH and EFH measures taken elsewhere (i.e., U.S. and ICES areas). Sensitive habitats are widespread fragile benthic habitats that are recognized internationally as ecologically important insupporting assemblages of commercial and non-commercial fish species that may require special protection on the continental shelf (e.g., *Posidonia oceanica* beds, corallingenous and maërl bottoms, coastal lagoons, and *Leptometra phalangium* bottoms) and continental slope (e.g., facies with *Funiculina quadrangularis* and *Isidella elongata*, submarine canyons, and white coral biocenosis).

Essential fish habitat is a habitat identified as essential to the ecological and biological requirements for critical life history stages (i.e., nursery grounds and spawning areas) of exploited commercial demersal/pelagic fish and shellfish species which may require special protection to improve stock status and long term sustainability. Essential fish habitat identification will involve selecting priority species based on stock status and overall ranked value of commercial landings for each Mediterranean GSA independent of fleet segment or fishery type. Closed or restricted areas and seasons will be the main measures to protect EFH (Ardizzone 2006; STECF 2006). Current time frame for the proposed time-series maps and demonstration to designation EFH is January 2008.[3]

5.3.1.3 Fishing Gears

Mediterranean fisheries are notable for the large number and variety of commercially important species caught and the range of fishing methods employed inshore and offshore (Stewart et al. 2002). Fishery gears utilized in the Mediterranean inshore and offshore habitats consists of towed gears (bottom and pelagic trawling, dredges, and fixed open trawls), purse seines, fixed and drifting gear (trammel nets, gillnets, longline and handline, combined bottom set nets, and traps/pots), special fisheries (e.g., beach seine, Danish seine, surface gillnet, manual seine, boat seine), as well as other gears such as fyke net, harpoons, and jiggling hooks (STECF 2004). Most of these other gears have individual features due to local tradition or fishermen's experiences (STECF 2004).

Selectivity depends both on technical characteristics of the gear and on fishing practices and may vary from country to country (STECF 2004). Some of the above fisheries gear may be used interchangeably between the various fisheries: demersals, small pelagics, large pelagics, and artisanal (STECF 2005). Below is list of the common fishing gear types utilized by the various fisheries in the eastern Mediterranean Study Area:

- Bottom trawls—sock-shaped nets having a wide mouth, which tapers into a narrow tail, called a codend with a mesh size of 40 mm; consists of two main types of otter trawls: (1) two-panel/face trawls with vertical opening of 2 to 5 m designed for capture of benthic animals living close to the bottom; and (2) four-panel/faces trawls with a vertical opening of 10 m for catching mid-water/pelagic species
- Pelagic trawls—sock-shaped nets having a wide mouth, which tapers into a narrow tail, called a codend with a mesh size of 20 mm; net is rigged with four doors: two at the wings of the lower panel and two fixed to the extremities of the upper panel wings for mid-water operation to capture small pelagic species
- Purse seines—long panels of netting used to encircle a school of fish at the surface, while the bottom of the net is cinched closed; depending on its size this net has the advantage of targeting recognized schools of species: small or large pelagics
- Trammel nets—consists of both inner and outer nets of varying mesh sizes depending on the target species and depth
- Gill nets—anchored to the seafloor and may be fished on the ocean bottom or floating above the anchors; mesh size and length vary depending upon the demersal species
- Surface gillnets—gillnets attached to the stern of a fishing boat and allowed to drift below the ocean surface; used to collect several pelagic species
- Longlines—deployed horizontally to which gangions and hooks or pots are attached; can be stationary, anchored, or buoyed lines that may be hauled manually, electrically, or hydraulically; may be drifting, handline, or on the bottom; used to collect large pelagics, demersal, and bentho-pelagic species
- Traps—constructed of cane, wicker, or plastic with a steel frame; utilized in shallow or deep water to capture benthic invertebrates
- FADs—float comprised of material ranging from plastic bottles to a group of tires with some palm grounds or bush branches tied on and below the waterline to help identify its location and to increase their surface, respectively; surface material floats centimeters below the surface with the entire structure moored using a lime stone (pedral) and/or one or more large stones/blocks for anchorage

5.3.1.4 Fishing Fleets

Three different types of fishing fleets are in the Mediterranean Sea: artisanal, industrial, and semi-industrial (Lleonart and Maynou 2003). An artisanal fleet is used to describe a low-capital business venture where the fisherman is the owner of the vessel. Artisanal fishing is often associated with coastal fishing (i.e., fisheries located on the continental shelf [0 to 200 m]) where exploitation areas can be reached within a few hours from ports or beaches (Lleonart and Maynou 2003). This type of fisheries employs a large workforce at sea and ashore. Both target demersal and small pelagic resources using diverse fishing gears. Gillnets/entangling nets (54%) and hooks/lines (32.8%) are the dominant gear type. The artisanal fisheries has a large fleet, mostly of low tonnage consisting of small vessels (operating inshore) and large vessels (exploiting offshore stocks), based in a multitude of ports and shelters (Colloca et al. 2004a); (Coppola 2004). This fishery remains an important revenue for the local communities by playing a relevant role at the local level for tourism by virtue of its cultural traditions (Colloca et al. 2004a).

Industrial fleets involve major investments by companies or financial groups (Lleonart and Maynou 2003). These fleets are mainly represented by a variety of medium-scale and pelagic longline fleets operating in Mediterranean waters. They range from Mediterranean border country fleets to large industrial fleets from non-Mediterranean countries (e.g., Japan, Tawian, Province of China, and Republic of Korea), to vessels flying a flag of convenience (FoC), or even unflagged “pirate” or “illegal, unreported and unregulated (IUU) fishing” vessels (Oliver 2002; Miyabe 2003; Tudela 2004; Takase 2005). The IUU fishing is not confined to non-Mediterranean vessels but may also involve vessels flagged to Mediterranean countries (e.g., France, Libya) (Oliver 2002; WWF 2006). Currently, only Spain is the only Mediterranean country that has adopted a National Plan of Action to combat the problem of IUU fishing (Greenpeace International 2006); however, in 2006, GFMC approved further measures to combat IUU as described in Swan (Swan 2005).

There is also an intermediate group between the artisanal fleet and the industrial fleet (the so-called semi-industrial fleet) which is closer to the artisanal scheme. This fleet is mainly composed of trawlers, purse seiners, and some longliners (Lleonart and Maynou 2003) that spend two to three days offshore, but only within a few hours from the port (Sbrana et al. 2006).

The EU Mediterranean fleet comprises 40,976 vessels, with 12,346 (about 30%) vessels below 6 m overall length. This is likely to be an underestimate since, in some countries, fishing vessels less than 5 m overall length are not included in the fishing vessel register (STECF 2005). The exact total number of fishing boats which may be operating across the Mediterranean Sea has been estimated at approximately 100,000 (Oliver 2002) of which 85% are small inshore boats, 14% trawlers and purse seiners, and 1% allocated to various activities (Tudela and Sacchi 2003). Trawler and towed gears clearly predominate given the volume and value of their catches; however, purse seiners and artisanal (small-scale) fleets also constitute an important element of the Mediterranean fisheries (Oliver 2002).

5.3.2 Commercial Fisheries

Two of the four EU member states bordering the Mediterranean Sea (Italy and Greece) account for the majority of commercial fisheries operating in eastern Mediterranean Study Area. Most of the commercial fisheries occur along the narrow continental shelf and in the territorial waters off these two EU members’ countries. Both Mediterranean (EU members) and non-Mediterranean states also conduct high sea fisheries, targeting bluefin tuna and swordfish. Fishing fleets, excluding the pelagic fisheries, are dominated by small multi-purpose vessels (MPVs) conducting different fisheries concentrated within a large number of both small and larger fishing ports along the coastline (Coffey 2001). The following sections describe the various fishing practices encountered within the GSAs of the EU member states of Italy, Greece, Malta, and Cyprus and non-EU member states (Turkey, Egypt, Tunisia, etc.) in the eastern Mediterranean Study Area.

5.3.2.1 Italy

The Italian Mediterranean fishery is a multi-gear, multi-species fishery with a highly heterogeneous fleet widely dispersed along the coast. The bulk of the commercial fishery fleet (72%) consists of artisanal vessels that deploy various fixed gear (e.g., trammel nets, combined trammel-gillnets, gillnets, longlines, traps) on the continental shelf, generally down to 100 m and within 6 NM of the coast. The majority of the artisanal fleet is concentrated in south Italy (Sicily, Campania, Puglia, and Calabria). Artisanal vessels target a wide number of species, both pelagic and demersal. In addition, the semi-industrial sector involves MPVs, bottom trawlers, hydraulic dredges, and purse seiners generally operating within 20 NM of the coastline on the shelf and upper slope. The main target species for semi-industrial sectors vary according to fleet segment (e.g., bottom trawlers: demersal fish, crustaceans, cephalopods; dredges: clams, purse seiners: small pelagics) (FAO Marine Resources Service 2005). Along the southern Sicilian coastline from the Strait of Sicily to the Adriatic Sea, bottom trawling, surface drifting longline, and FADs are utilized by the fishers within the eastern Mediterranean Study Area and described in the GSAs in the following sections.

Strait of Sicily (GSA 16)/Western Ionian Sea (GSA 19)

The Italian bottom trawlers possess multiple licenses using different fishing gears. Traditional or Mediterranean bottom trawl, also known as tartana, coccia, or rizza (depending on the area), is the most widely used trawl in Italy for fishing high-quality bottom species. Depending on their vertical opening, these bottom trawls may be classified into three groups: (1) fixed open trawls (e.g., “rapido” or beam trawl) with 30 m opening; (2) low-opening trawls (e.g., panel trawl) not exceeding 1 m in height; and (3) high (wide)-opening trawls, exceeding 2 m. For all these bottom trawls, mesh size may not be less than 40 mm for any netting in the bottom trawl. Within the Strait of Sicily, the bottom trawl fishery utilizes two different net types: banco (shallow waters) on the continental shelf and fondale (deep waters) on the deeper areas off the continental shelf. The short distant trawling operates closer to the Sicilian coast and encompasses the whole fleet from Sciacca, Port Empedocle, Licata, Gela, Scoglitti, and Pozzallo, and approximately 25% of Mazara del Vallo trawlers. This fishery is typical of the mixed species fisheries in the Mediterranean Sea. The remainder of the Mazara del Vallo trawlers (75%) conduct the distant water trawling operating in a wider area (STECF 2002b; Ragonese et al. 2004; STECF 2004; Gristina et al. 2006). These fishing fleets, along with trawlers from Tunisia, Malta, and Libya, fish the area between Sicily and Tunisia and in the western Ionian Sea (Oceana 2004). A breakdown of the number of fishing vessels, location of fishing grounds, fishing depth, fishing season, and fishing closures as well as targeted species for bottom trawling within GSA 16 can be found in **Table 5-4**.

Within the eastern Mediterranean Study Area, the Sicilian surface drifting longline fleet based mostly in Sicily, Puglia, Sardinia, Campania, and Liguria, conducts its activity either in coastal or offshore waters in the Tyrrhenian Sea, Channel of Sardinia, Strait of Sicily, western Ionian Sea, Gulf of Taranto, and the south Adriatic and Aegean seas (Tudela and Sacchi 2003; Tudela 2004; Piovano 2007). This fishing fleet is not defined for large pelagic species because some vessels have a specific license for drifting longlines while most vessels have a multi-gear license, without a clear distinction of the main gear. This fishery has approximately 1,200 vessels of various sizes (5 to over 30 m), and targets swordfish, albacore, and bluefin tuna. The swordfish fishery is year round and uses the fishing grounds in the Tyrrhenian Sea, Channel of Sardinia, Strait of Sicily, along the Ionian coast, in the southern Mediterranean Sea close to Crete, and along the northern African coast. Albacore fishing began in the summer in the Ionian Sea and in new fishing grounds in the southern Mediterranean Sea. The bluefin tuna fishery is conducted mostly by the fleet based in the Strait of Sicily and in the area between Malta and the Gulf of Sirte, with minor areas in the Ionian Sea from February to July (Di Natale and Notarbartolo-di-Sciara 1994; STECF 2002a; STECF 2004).

Table 5-4. Fisheries in the Strait of Sicily (GSA 16).

Fishing Equipment	Inshore Trawling (Traditional Banco Net)	Distant Trawling (Traditional Fondale Net)
Fishing Vessels	240	115
Fishing Grounds	Continental shelf	Deepwater and in GSAs 12, 13. 14, 15, and 21
Fishing Depth	Unknown	200-750 m
Fishing Season	180 days per year	Varies from all year to specific seasons such as autumn or winter-spring
Fishing Closures	Within 3 NM off the coast where seabed is more than 50 m in depth	None
Target Species		
European hake	X	X
Striped red mullet	X	X
Mullus spp.	X	
Pagellus spp.	X	
Atlantic stargazer	X	
Trachinus spp.	X	
Lophius spp.	X	
John Dory	X	
Greater forkbeard		X
Common pandora		X
Blackmouth catshark		X
Velvet belly lantern shark		X
Raja spp.	X	
Common cuttlefish	X	
Lesser flying squid	X	
Southern shortfin squid	X	
Flying squid		X
Eledone spp.	X	
Octopus	X	
Norway lobster	X	X
Deepwater rose shrimp	X	X
Giant red shrimp		X
Red shrimp		X

Source: (STECF 2002a; STECF 2004)

FADs or cannizzi along with purse seines are deployed for fishing dolphinfish (*Coryphaena hippurus*) along the southern (Strait of Sicily) and eastern (Ionian Sea) coast of Sicily. Within the eastern Mediterranean Study Area, FADs stretch for 21.6 NM along the southern coast (Selinunte to Licata) with each of the 12 vessels placing 10 to 50 FADs spaced approximately 300 m apart. In the Ionian Sea (Porto Palo di Capo Passero to Augusta), each of the 51 vessels place 60 to 100 FADs with approximately 800 m distance between each FAD and at average depths of 1,500 m (Potoschi et al. 1999). This fishery occurs from early September to December in the Strait of Sicily and from early August to December in the Ionian Sea (Cannizzaro et al. 1999; Potoschi et al. 1999). In order to reduce catches of juvenile dolphinfish and improve the sustainability of the stock, a seasonal ban between January 1 and August 14 on the use of FADS was adopted by the GFMC in January 2006.[2]

5.3.2.2 Malta (GSA 16)

Malta has a typical, artisanal Mediterranean fishery, which is not species selective, but a multi-species and multi-gear fisheries with fisherman switching from one gear to another several times throughout the year (Camilleri 2005). Fishing methods include bottom trawls, lampara purse seines, deep-sea and inshore longlines, FADs, trammel nets, drift nets, and traps (de Leiva et al. n.d.). The main gear utilized by the Maltese fishing fleet are various forms of hook-and-line (over 60%) although different types of gillnets and entangling nets are also popular (20%) (FAO 2005b).The Maltese fishing fleet has 2,252 boats (registered in 2004) comprised of two distinct types of vessels: traditional (used for small-scale or coastal artisanal fisheries) and MPVs (used for high seas fisheries). The MPVs forms more than 35% of the Maltese fleet, while 65% are traditional vessels (FAO 2005b). Over 65% of annual landings originates from the tuna and dolphinfish fisheries with trawling, bottom longlining, and swordfish fish longlining having similar landings and value (FAO 2005b). Within the eastern Mediterranean Study Area, drifting surface longline, lampara purse seining, and bottom trawling are utilized by the fishers for large pelagics, small pelagics, and demersals and are described in the following paragraphs.

Within the eastern Mediterranean Study Area, drifting surface longline is conducted for bluefin tuna and swordfish fisheries. Fishing for bluefin tuna is undertaken by 58 MPVs in an area that covers approximately 5,000 km^2. Distances from shore are 30 to 50 NM to the west, south, and southeast of the Maltese Islands between the 35th and 36th parallels. This fisheries runs from May through July mainly in the southwest area of the region and further to the east according to the natural movement of the bluefin tuna (Farrugia 2003). Swordfish are targeted throughout the year with the peak period occurring from late June to August. During the peak period, approximately 50 to 60 boats target swordfish 50 NM to the south of the Maltese Islands. During the autumn and early winter months, swordfish fishing is also undertaken within a 17.4 NM wide corridor which is bounded on each side by the following coordinates: south-southeast latitude 35°41’30” longitude 14°37’00” and southeast latitude 35°47’24”/longitude 14°45’12” (Di Natale and Notarbartolo-di-Sciara 1994; de Leiva et al. n.d.).

Lampara fishing occurs along the entire north side of Malta but the main zone is around a shallow area covering 12 km^2, known as Hurd Bank, which is located east of Malta and is situated in the middle of the eastern Mediterranean Study Area’s boundary of 12 NM. Six purse seiners target chub mackerel (*Scomber japonicus*) year round except for the period from September to December when these vessels target the dolphinfish (Department of Fisheries and Aquaculture Malta 2001; de Leiva et al. n.d.). In addition, bottom trawling is also conducted using otter trawls on and around Hurd Bank at depths between 100 and 200 m at night for red mullet, comber (*Serranus* spp.), pandora (*Pagellus* spp.), squid, cuttlefish (*Sepia officinalis*), and weaver (*Trachinus* spp.) (de Leiva et al. n.d.). The remainder of offshore fisheries takes place along the coast or within the 12 NM boundary (i.e., bottom trawling for king prawns: 8 NM northwest of Gozo, setting of FADs (kannizzai floats) for dolphinfish around the island: 7 NM offshore) (Vella 1999; Cabanelas 2004; de Leiva et al. n.d.).

5.3.2.3 Greece

Fisheries in Greek waters target multispecies, the majority of which are demersal and pelagic fish stocks. The fishing fleet has 19,504 vessels (registered in 2002) and operates in the Hellenic seas (Ionian, Aegean, and Crete) (Anonymous n.d.-b). Fisheries gear include: trawlers in open-sea waters, purse seiners in open-sea and coastal waters, mixed vessels in waters both as trawlers (mainly in the wintertime) and as purse seiners (mainly in the summertime), beach seiners along the coast, and other coastal boats (e.g., small ring netters, drifters, liners) along the coast (Stergiou et al. 1997; Stergiou and Koulouris 2000). Four basic types of fisheries are undertaken in the Hellenic Seas: bottom trawl, purse seine, large pelagics, and small-scale. Since the continental shelf is generally narrow, except in the Aegean Sea, bottom trawl fishing grounds are relatively restricted to European hake, red mullets, shrimp, lobster, and cephalopods. Pelagic trawling is banned and fixed opening trawls are not practiced in the Greek seas (STECF 2004). Purse seining is divided into two categories: those operating at night and those operating during the day. Small pelagic species targeted during nighttime operations are anchovy, sardine, chub mackerel, bogue, and horse mackerels. Daytime operations target migratory species (e.g., Atlantic bonito, jacks: *Caranx* spp., greater amberjack: *Seriola dumerili*, meager: *Argyrosomus regius*).

This fishery is prohibited during July through August. About 50 to 60% of the total domestic fisheries production consists of these small pelagics (STECF 2004). The large pelagic fishery is controlled through a special license system, and for the swordfish, is closed by law from October 1 through January 31. The fishing fleets exploit bluefin tuna, swordfish, and albacore mainly in the Aegean, Ionian, and Cretan seas but seasonally extend their activities into the Levantine basin (STECF 2004). The small-scale fisheries sector is the largest, using of 19,052 vessels. This fisheries accounts for greater than 90% of the total number of fishing boats, greater than 65% of the total number of fishers, and greater than 50% of the total wholesale value of the fish catch (Stergiou et al. 1997). Nets (95%) and bottom longlines (86%) are the two main fishing gears followed by beach seines and surface longlines (Tzanatos et al. 2005). Targeted species include the red mullet, striped red mullet (*Mullus surmuletus*), common two-banded seabream (*Diplodus vulgaris*), common pandora, and seabream (*Diplodus* spp.). This fisheries is conducted year round (winter: 13 days per month, spring/autumn: 18 days per month, and summer: 20 days per month) (Tzanatos et al. 2005). Within the eastern Ionian and Cretan seas, bottom trawling, bottom and surface drifting longline, and special gill net fisheries are utilized by the fishers within the eastern Mediterranean Study Area and are described in the GSAs in the following section.

Eastern Ionian Sea (GSA 20) and Cretan Sea (GSA 23)

The open sea fishery in the eastern Ionian Sea is mainly concentrated in the port of Patras with a total of 36 trawlers operating on the continental shelf/slope at depths of less than 150 m to greater than 300 m. Traditional Mediterranean bottom trawls are utilized with a minimum mesh size for the codend of 40 mm. Targeted species include Atlantic horse mackerel (*Trachurus trachurus*), European hake, silver scabbardfish (*Lepidopus caudatus*), red mullet, picarel, common European cuttlefish, and deep-sea shrimps (red, giant red, and deepwater rose) (Valavanis et al. 2002; Lefkaditou et al. 2003; STECF 2004). Deepwater shrimp fishing occurs at depths of 400 to 500 m between Kerkira Island and the Gulf of Messiniakos (D'Onghia et al. 2003a; D'Onghia et al. 2005; Mytilineou et al. 2006). Each year, bottom trawl fishing is closed in the entire Greek territory from 6 June until 30 September. In addition, in some closed gulfs that have been characterized as sensitive, bottom trawling is either prohibited year round (i.e., Amvarakikos Gulf) or opens two months later (i.e., Patraikos and Korinthiakos Gulfs: 1 December instead of 1 October). The prohibited fishing zone for trawlers was extended to 3 NM or to 50 m depth (STECF 2004). There is almost no bottom trawl fishing activity along the southern coast of Crete due to its very narrow continental shelf (STECF 2004).

Within eastern Mediterranean Study Area, bottom and drifting surface longlines are used in the demersal and large pelagic fisheries. The bottom longline is mainly deployed on rocky bottoms offshore of the Ionian coast at depths of 150 to 500 m. This fishery targets European hake, blackspot seabream (*Pagellus bogaraveo*), and large sparids (STECF 2002a, 2004). Drifting surface longlines are used for large, migratory pelagics such as swordfish, bluefin tuna, and albacore. The swordfish fishing season lasts from February to the end of September. A closed season exists from October to January, with the aim of protecting juveniles. Approximately 120 vessels are involved in the fishery with several additional boats entering the fishing during the summer months (GFCM-SAC 2004). Swordfish composes the bulk of large pelagic catches in the Greek seas (Stergiou et al. 2003). The longliners are based in Crete and the Dodecanese Islands, because they fish in waters farther from port, ranging from the southern Ionian Sea to as far as Cyprus in the Levantine Sea (Ward and Elscot 2000). The bluefin tuna fishery lasts from September to April. This fishing fleet has approximately 200 vessels with efforts concentrated in the Aegean and Cretan seas. Approximately 16% (32 vessels) use the drifting surface longline in the Ionian Sea (STECF 2002a; GFCM-SAC 2004). The traditional albacore tuna fisheries, using troll-lines and longlines, occurs outside of the eastern Mediterranean Study Area in the north and central Aegean Sea during the autumn months (GFCM-SAC 2004). In addition, a special fisheries deploys gill nets with a mesh size of 80 to 90 mm that are used for the blackspot seabream fishery in the Ionian Sea. This fishery is carried out year round at depths from 300 to 600 m on rocky banks (STECF 2002b; STECF 2004).

5.3.2.4 North Levant (GSA 24) and Cyprus (GSA 25)

Fishing operations in Turkish waters is mostly coastal and consists of both small-scale (trammel nets and longline) and large-scale (trawlers, purse seiners, and beach seniers). Of the 16,213 vessels registered in

Turkish waters, approximately 13.8% (2,240 vessels) operate in the Mediterranean Sea. By law, trawlers are not allowed in bays or within 3 NM of the coastline. Both trawlers and purse seiners are banned from fishing between May and September (Anonymous n.d.-a). Currently, Turkish purse seiners target bluefin tuna and swordfish north of the eastern Mediterranean Study Area. These fisheries are conducted year round in the Gulf of Anatalya (south of Turkey) between the Anatolian Peninsula and North Cyprus close to the coast line as well as 30 to 40 NM offshore (Karakulak 2004; Oray and Karakulak 2004).

The Cyprus fisheries fleet is comprised of 500 inshore and 22 trawling boats and 38 MPVs. The main resources exploited by Cyprus are demersals and large pelagics (FAO 2005a). The demersal species are taken by the inshore and trawl fisheries (in national and international waters) and include picarel, bogue, red and striped red mullets, octopus, and mollusks. In the trawl fishery, mesh size is 40 mm, minimum depth is 50 m, towing beyond 1,000 m is forbidden by GFCM, and the fishing season lasts from 7 November to 31 May (FAO 2005a). Large pelagic species are targeted by the multipurpose fishery in national and international waters that use nets and bottom and surface longlines (FAO 2005a). Cypriot fishers initially targeted their coastal waters along the southern, western, and northwestern coastlines, although there are only limited productive fishing grounds within these areas. Within the eastern Mediterranean Study Area, Cyprus' MPVs are active between Syria and Egypt (Ward and Elscot 2000). In addition, distant-water trawlers from Cyprus, Turkey, Libya, Syria, Israel, and Egypt fish in the Levantine Sea (Oceana 2004).

5.3.2.5 Gulf of Hammamet (GSA 13), Gulf of Gabes (GSA 14), Tripoli (GSA 14bis), Gulf of Sirt (GSA 21), Gabel Akhdar (GSA 21bis), South Levant (GSA 26), and Levant (GSA 27)

The overall fish productivity of the Arab countries bordering the southern portion of the eastern Mediterranean Study Area are generally considered medium to poor (Feidi 1998). Within the central portion of the eastern Mediterranean Study Area, while rich in demersal and small pelagic species, suffers from overfishing (i.e., Gulf of Gabes in Tunisia), while other waters bordering Libya are underexploited. The Levantine Sea has the lowest amount of fish productivity and is targeted by much smaller boats than encountered in the central portion (Feidi 1998).

The fisheries in these GSAs are heterogenous, ranging from those based on the relatively abundant resources (Egypt), often exploited by fleets of large industrial vessels, to fisheries based on relatively poor resources (Tunisia, Libya, Syria) and often exploited by individuals with low cost vessels and simple gear, working from nearshore environments (Malvarosa 2002). These fisheries may be classified into two broad categories: high seas and coastal based on vessel size, gear types, and targeted species (Feidi 1998). High seas fisheries are characterized by large mechanized fleets with vessels equipped with freezing, storage, and other facilities for operations of up to three months at sea. Operating beyond the 20 NM fishing zone, these fleets are largely from Egypt, Libya, Syria, and Israel but also include vessels from EU members operating under licenses or joint ventures. This type fishery is an export-oriented (i.e., Japan) sub-sector of high-value species, such as cephalopods (common European cuttlefish, octopus, and squid), crustaceans (shrimp), and large pelagics (swordfish and bluefin tuna) (Feidi 1998). Closed season for trawling is from 1 April to 15 May in Egypt and 20 June to 5 August in Israel (Ardizzone 2006).

Within the coastal fisheries, two sub-groups are considered: intermediate and small scale (artisanal). Intermediate fisheries are characterized by vessels 25 m or less in length, operating up to 20 NM off shore, and targeting pelagic species, sardines, anchovies, and mackerels for utilization in the fish processing industry (canning, fish meal, and fish oil: 15 to 20%). The small scale fisheries consist of small motorized boats, ranging in size from 5 to 6 m equipped with various kinds of traditional fishing gear. This fishery is scattered along the coastlines targeting nearshore demersal species (i.e., crustaceans: shrimps) providing subsistence fishing (80 to 85%) for local markets, families, and clans (Feidi 1998).

5.3.3 Recreational Fisheries

In the European Mediterranean region, recreational fishing has been a traditional leisure activity which is becoming more significant, emerging as a new alternative for tourism and commercial fishing (Franquesa et al. n.d.). Recreational fishing activities take place in the EC waters. These activities are regulated by

individual EU members states and occurs within the 12 NM limit (Cacaud 2005). This fishery is particularly important in the Mediterranean Sea, representing more than 10% of the total fishing production (Morales-Nin et al. 2005). It is also one of the most frequent leisure activities in coastal zones. The majority of recreational fishing occurs outside of the eastern Mediterranean Study Area from 1.0 to 3.5 NM offshore and at depths ranging from 20 to 144 m, depending on the vessel type (Morales-Nin et al. 2005).

5.4 WEBSITES ACCESSED

[1] FAO (Food and Agriculture Organization of the United Nations). Accessed 3 March 2007. http://www.fao.org/newsroom/en/news/2007/1000479/index/html.

[2] European Commission. Accessed 26 January 2006. http://ec.europa.eu/fisheries/press_corner_press_releases/com06_05_en.htm.

[3] European Commission. Accessed 11 September 2006. http://ec.europa.eu/research/fp6/ssp/enviefh_en.htm.

5.5 LITERATURE CITED

Abella, A., F. Fiorentino, A. Mannini, and L. Orsi Relini. 2006. Importance of environmental factors in recruitment process and spatial location of nurseries for Central Mediterranean European hake. Pages 27-28 in Abstracts, IDEA Workshop: Wrapping up of the IDEA Project International Workshop on Environment, Demersal Resources and Fisheries. 10-12 May 2006. Palma de Mallorca, Spain.

Abelló, P., A. Carbonell, and P. Torres. 2002. Biogeography of epibenthic crustaceans on the shelf and upper slope off the Iberian Peninsula Mediterranean coasts: Implications for the establishment of natural management areas. Scientia Marina 66(Supplement 2):183-198.

Agostini, V.N. and A. Bakun. 2002. 'Ocean triads' in the Mediterranean Sea: Physical mechanisms potentially structuring reproductive habitat suitability (with example application to European anchovy, *Engraulis encrasicolus*). Fisheries Oceanography 11(3):129-142.

Akin, S., E. Buhan, K.O. Winemiller, and H. Yilmaz. 2005. Fish assemblage structure of Koycegiz Lagoon--Estuary, Turkey: Spatial and temporal distribution patterns in relation to environmental variation. Estuarine, Coastal and Shelf Science 64:671-684.

Andaloro, F. and E. Azzurro. 2004. The Sicily Channel, a crossroad between Atlantic and Indo-Pacific worlds. Presentation at Thirteenth International Conference on Aquatic Invasive Species, 20-24 September 2004. Ennis, Ireland.

Anonymous. n.d.-a. Country note on national fisheries management systems – Turkey.

Anonymous. n.d.-b. Country note on national fisheries management systems – Greece.

Ardizzone, G.D. 2006. An introduction to sensitive and essential fish habitats identification and protection in the Mediterranean Sea. Rome, Italy and Brussels, Belgium: Scientific Technical and Economic Commitee for Fisheries.

Arigo, G.A., A. Cuttitta, A. Bonanno, A.M. Di Nieri, B. Patti, L. Rollandi, and S. Mazzola. 2005. Abundance, geographical, and length distribution of mesopelagic fish larvae as a response to the hydrological condition of the Strait of Sicily. Page 29 in Abstracts, Twenty-ninth Annual Larval Fish Conference. 11 - 14 July 2005. Barcelona, Spain.

Bakun, A. and V.N. Agostini. 2001. Seasonal patterns of wind-induced upwelling/downwelling in the Mediterranean Sea. Scientia Marina 65(3):243-257.

Bariche, M., R. Sadek, M.S. Al-Zein, and M. El-Fadel. 2007. Diversity of juvenile fish assemblages in the pelagic waters of Lebanon (eastern Mediterranean). Hydrobiologia 580:109–115.

Basilone, G., C. Guisande, B. Patti, S. Mazzola, A. Cuttitta, A. Bonanno, A.R. Vergara, and I. Maneiro. 2006. Effect of habitat conditions on reproduction of the European anchovy (*Engraulis encrasicolus*) in the Strait of Sicliy. Fisheries Oceanography 15(4):271-280.

Bellan-Santini, D. 1985. The Mediterranean benthos: Reflections and problems raised by a classification of the benthic assemblages. Pages 19-48 in Moraitou-Apostolopoulou, M. and V. Kiortsis, eds. Mediterranean marine ecosystems. New York, New York: Plenum Press.

Bertrand, J., L. Gil de Sola, C. Papakonstantinou, G. Relini, and A. Souplet. 2000. Contribution on the distribution of elasmobranchs in the Mediterranean (from the Medits surveys). Biologia Marina Mediterranea 7(1):385-399.

Biagi, F., P. Sartor, G.D. Ardizzone, P. Belcari, A. Belluscio, and F. Serena. 2002. Analysis of demersal assemblages off the Tuscany and Latium coasts (north-western Mediterranean). Scientia Marina 66(Supplement 2):233-242.

Bianchi, C.N. 2007. Biodiversity issues for the forthcoming tropical Mediterranean Sea. Hydrobiologia 580:7-21.

Bianchi, C.N. and C. Morri. 2000. Marine biodiversity of the Mediterranean Sea: Situation, problems and prospects for future research. Marine Pollution Bulletin 40(5):367-376.

Bombace, G. 2001. Influence of climatic changes on stocks, fish species and marine ecosystems in the Mediterranean Sea. Archo Oceanography Limnology 22:67-72.

Bouchet, P. and M. Taviani. 1992. The Mediterranean deep-sea fauna: Pseudopopulations of Atlantic species? Deep-Sea Research 39(2):169-184.

Briggs, J.C. 1974. Marine zoogeography. New York, New York: McGraw-Hill Book Company.

Cabanelas, A.M. 2004. Pilot study on dolphin fish 2004: Final progress report. Fort San Lucjan, MarsaXlokk, Malta: Malta Centre for Fisheries Sciences.

Cacaud, P. 2005. Fisheries laws and regulations in the Mediterranean: A comparative study. Studies and Reviews. General Fisheries Commission for the Mediterranean No. 75. Rome, Italy: Food and Agriculture Organization of the United Nations.

Cacuad, P. 2003. Legal analysis of the measures adopted by Mediterranean coastal states to minimize the impact of fishing activities on marine ecosystems and non-target species. Tunis, Tunisia: Regional Activity Centre for Specially Protected Areas.

Caill-Milly, N., M. Suquet, G. Diez, and H. Arrizabalaga. 2003. Fattening of bluefin tuna (*Thunnus thynnus*) caught by the French and Spanish bait boats in the Bay of Biscay. Cahiers Options Mediterraneennes 60:41-43.

Camilleri, M. 2005. Evaluation of the activity of the Maltese small-scale fishing fleet. Pages 242-249 in Shotton, R., ed. Report on Deep Sea 2003: Conference on the Goverance and Management of Deep-sea Fisheries,1-5 December 2003, Queenstown, New Zealand. Part 1: Conference reports. FAO Fisheries Proceedings 3/1. Rome, Italy: Food and Agriculture Organization of the United Nations.

Cannizzaro, L., F. D'Andrea, A. Potoschi, and M. Scalisi. 1999. Economic aspects of fishing of dolphinfish in Sicily. Scientia Marina 63(3-4):459-464.

Caragitsou, E., A. Siapatis, and A. Anastasopoulou. 2001. Seasonal structure of fish larvae assemblages in the Pagasitikos gulf (Greece). Rapports Commission Internationale de le Mer Mediterranean 36:250.

Carbonell, A., F. Alemany, P. Merella, A. Quetglas, and E. Román. 2003. The by-catch of sharks in the western Mediterranean (Balearic Islands) trawl fishery. Fisheries Research 61:7-18.

Carpentieri, P., F. Colloca, and G.D. Ardizzone. 2005. Day--night variations in the demersal nekton assemblage on the Mediterranean shelf-break. Estuarine, Coastal and Shelf Science 63:577-588.

Coffey, C. 2001. Mediterranean issues: Towards effective fisheries management. Prepared for the Joint Nature Conservation Committee,. Peterborough, United Kingdom.

Colloca, F., M. Cardinale, A. Belluscio, and G. Ardizzone. 2003. Pattern of distribution and diversity of demersal assemblages in the central Mediterranean Sea. Estuarine, Coastal and Shelf Science 56:469-480.

Colloca, F., V. Crespi, S. Cerasi, and S.R. Coppola. 2004a. Structure and evolution of the artisanal fishery in a southern Italian coastal area. Fisheries Research 69:359-369.

Colloca, F., P. Carpentieri, E. Balestri, and G.D. Ardizzone. 2004b. A critical habitat for Mediterranean fish resources: Shelf-break areas with *Leptometra phalangium* (Echinodermata: Crinoidea). Marine Biology 145:1129-1142.

Company, J.B., P. Maiorano, A. Tselepides, C.-Y. Politou, W. Plaity, G. Rotllant, and F. Sardà. 2004. Deep-sea decapod crustaceans in the western and central Mediterranean Sea: Preliminiary aspects of species distribution, biomass and population structure. Scientia Marina 68(Supplement 3):73-86.

Coppola, S.R. 2004. Inventory of artisanal fishery communities in the western-central Mediterranean. Studies and Reviews. General Fisheries Commission for the Mediterranean No.77. Rome, Italy: Food and Agriculture Organization of the United Nations.

Cuttitta, A., C. Guisande, I. Riveiro, I. Maneiro, B. Patti, A.R. Vergara, G. Basilone, A. Bonanno, and S. Mazzola. 2006. Factors structuring reproductive habitat suitability of *Engraulis encrasicolus* in the south coast of Sicily. Journal of Fish Biology 68:264-275.

Cuttitta, A., A. Arigo, G. Basilone, A. Bonanno, G. Buscaino, L. Rollandi, J. Garcia Lafuente, A. Garcia, S. Mazzola, and B. Patti. 2004. Mesopelagic fish larvae species in the Strait of Sicily and their relationships to main oceanographic events. Hydrobiologia 527:177-182.

D'Onghia, G., R. Carlucci, P. Maiorano, and M. Panza. 2003a. Discards from deep-water bottom trawling in the Eastern-Central Mediterranean Sea and effects of mesh size changes. Journal of the Northwest Atlantic Fisheries Science 31:245-261.

D'Onghia, G., F. Mastrototaro, A. Matarrese, C.-Y. Politou, and C. Mytelineou. 2003b. Biodiversity of the upper slope demersal community in the Eastern Mediterranean: Preliminary comparison between two areas with and without trawl fishing. Journal of the Northwest Atlantic Fisheries Science 31:263-273.

D'Onghia, G., C.-Y. Politou, A. Bozzano, D. Lloris, G. Rotllant, L. Sion, and F. Mastrototaro. 2004. Deep-water fish assemblages in the Mediterranean Sea. Scientia Marina 68(Supplement 3):87-99.

D'Onghia, G., F. Capezzuto, C. Mytilineou, P. Maiorano, K. Kapiris, R. Carlucci, L. Sion, and A. Tursi. 2005. Comparison of the population structure and dynamics of *Aristeus antennatus* (Risso, 1816) between exploited and unexploited areas in the Mediterranean Sea. Fisheries Research 76:22-38.

D'Onghia, G., P. Maiorano, L. Sion, R. Carlucci, F. Mastrototaro, F. Capezzuto, G. Costantino, and A. Tursi. 2006. Sensitive and essential fish habitats in the North-Western Ionian Sea: Problems and perspectives for fishery management. Pages 181-202 in STECF (Scientific Technical and Economic Committee for Fisheries), ed. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

de Leiva, I., C. Busuttil, M. Darmanin, and M. Camilleri. n.d. Artisanal fisheries in the western Mediterranean: Malta fisheries. Malta: Department of Fisheries and Aquaculture.

Department of Fisheries and Aquaculture Malta. 2001. A study to establish that the shelf of the Maltese Islands is a distinct management unit.

Di Natale, A. 2006. Sensitive and essential areas for large pelagic species in the Mediterranean Sea. Pages 165-180 in STECF (Scientific Technical and Economic Committee for Fisheries), ed. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

Di Natale, A. and G. Notarbartolo-di-Sciara. 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean Sea and of the cetacean bycatch. Reports of the International Whaling Commission (Special Issue 15):189-202.

Dulčić, J. and B. Grbec. 2000. Climate change and Adriatic ichthyofauna. Fisheries Oceanography 9(2):187-191.

EEA (European Environment Agency). 1999. State and pressures of the marine and coastal Mediterranean environment. Environmental Issues Series Number 5. Copenhagen, Denmark: European Environment Agency.

FAO-GFCM (Food and Agriculture Organization-General Fisheries Commission for the Mediterranean). 2006. Report of the ninth session of the Scientific Advisory Committee. Rome, 24-27 October 2006. FAO Fisheries Report No. 814. Rome, Italy: Food and Agriculture Organization.

FAO (Food and Agriculture Organization of the United Nations). 2005a. Fishery country profile - The Republic of Cyprus. Rome, Italy: Food and Agriculture Organization of the United Nations.

FAO (Food and Agriculture Organization of the United Nations). 2005b. Fishery country profile - The Republic of Malta. Rome, Italy: Food and Agriculture Organization.

FAO Marine Resources Service. 2005. Review of the state of world marine fishery resources. FAO Fisheries Technical Paper No. 547. Rome, Italy: Food and Agriculture Organization of the United Nations.

Farrugia, A.F. 2003. Description of the Maltese longline fishery targeting bluefin tuna (*Thynnus thunnus* L.) in the Mediterranean Sea. Collective Volume of Scientific Papers, International Commission for the Conservation of Atlantic Tunas 55(3):1148-1156.

Feidi, I.H. 1998. Fisheries development in the Arab world. Bulletin of the Yale School of Forestry and Environmental Studies 103:388-406.

Ferretti, F., R.A. Meyers, P. Sartor, and F. Serena. 2005. Long term dynamics of chondrichthyan fish community in the upper Tyrrhenian Sea. ICES CM 2005/N:25. 2005 ICES Annual Science Conference: Theme Session on Elasmobranch Fisheries Science. 20-24 September 2005. Aberdeen, Scotland.

Fiorentino, F., G. Garofalo, M. Gristina, S. Gancitano, and G. Norrito. 2004. Some relevant information on the spatial distribution of demersal resources, benthic biocoenoses and fishing pressure in the Strait of Sicily. Pages 50-66 in MedSudMed, ed. Report of the expert consultation on the spatial distribution of demersal resources in the Straits of Sicily and the influence of environmental factors and fishery characteristics. MedSudMed Technical Documents No. 2.

Fiorentino, F., G. Garofalo, A. De Santi, G. Bono, G.B. Giusto, and G. Norrito. 2003. Spatio-temporal distribution of recruits (0 group) of *Merluccius merluccius* and *Phycis blennoides* (Pisces, Gadiformes) in the Strait of Sicily (central Mediterranean). Hydrobiologia 503:223-236.

Fiorentino, F., G. Garofalo, T. Fortibuoni, T. Bahri, M. Camilleri, A. Drago, M. Gristina, and F. Massa. 2006. Delineating habitats used by different life phases of hake in the Strait of Sicily. Pages 203-234 in STECF (Scientific Technical and Economic Committee for Fisheries), ed. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

Franquesa, R., A. Gordoa, T. Mina, S. Nuss, and J.R. Borrego. n.d. The recreational fishing in the Central and Western European Mediterranean frame. Report of the Sixteenth Annual Conference of the European Association of Fisheries Economists. Rome, Italy. 5–7 April 2004. FAO Fisheries Report 739:1-15.

Galil, B.S. 2004. The limit of the sea: The bathyal fauna of the Levantine Sea. Scientia Marina 68(Supplement 3):63-72.

Galil, B.S. and A. Zenetos. 2002. A sea change – Exotics in the eastern Mediterranean. Pages 1-19 in Leppäkoski, E., ed. Invasive aquatic species of Europe: Distribution, impacts and management. Dordrecht, The Netherlands: Kluwer Academic.

Ganias, K., S. Somarakis, E. Caragitsou, C. Koutsikopoulos, A. Machias, and A. Theodorou. 2001. Differential egg production of sardine off the central Hellenic coasts in December 1999. Rapports Commission Internationale de la Mer Mediterranean 36:268.

Garibaldi, L. and J.F. Caddy. 1998. Biogeographic characterization of Mediterranean and Black Seas faunal provinces using GIS procedures. Ocean & Coastal Management 39:211-227.

Garofalo, G., F. Fiorentino, M. Gristina, S. Cusumano, and G. Sinacori. 2007. Stability of spatial pattern of fish species diversity in the Strait of Sicily (central Mediterranean). Hydrobiologia 580:117-124.

GFCM-SAC (General Fisheries Commission for the Mediterranean-Scientific Advisory Committee). 2001. Working group on management units definition and limits. 23-25 January 2001. Alicante, Spain.

GFCM-SAC (General Fisheries Commission for the Mediterranean-Scientific Advisory Committee). 2004. Report of the Seventh *Ad Hoc* Joint GFCM-ICCAT Meeting on Stocks of Large Pelagic Fishes in the Mediterranean, 19-22 October 2004. Rome, Italy.

GFCM (General Fisheries Commission for the Mediterranean). 2005. Report of the meeting on the Seventh SAC Sub-Committee on Stock Assessment (SCSA). Rome, Italy, 26-30 September, 2005. Rome, Italy: Food and Agriculture Organization of the United Nations.

Giordano, D., A. Cubeta, A. Granata, S. Greco, and L. Guglielmo. 2001. Preliminary data on mesopelagic ichthyoplankton in the Jonian Sea (Eastern Mediterranean). Rapports Commission Internationale de la Mer Mediterranean 36:270.

Golani, D. 1998. Impact of Red Sea fish migrants through the Suez Canal on the aquatic environment of the Eastern Mediterranean. Bulletin Series Yale School of Forestry and Environmental Studies 103:375-387.

Greenpeace International. 2006. Marine reserves for the Mediterranean Sea. Amsterdam, Netherlands: Greenpeace International.

Greenpeace International. n.d. Where have all the tuna gone? How tuna ranching and pirate fishing are wiping out bluefin tuna in the Mediterranean Sea. Amsterdam, Netherlands: Greenpeace International.

Gristina, M., T. Bahri, F. Fiorentino, and G. Garofalo. 2006. Comparison of demersal fish assemblages in three areas of the Strait of Sicily under different trawling pressure. Fisheries Research 81:60-71.

Gucu, A.C. 2006. Essential fish habitats in the NE Levant Sea. Pages 251-270 in STECF (Scientific Technical and Economic Committee for Fisheries), ed. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

Halim, Y., S.A. Morcos, S. Rizkalla, and M.K. El-Sayed. 1995. The impact of the Nile and the Suez Canal on the living marine resources of the Egyptian Mediterranean waters (1958-1986). Pages 19-58 in Food and Agriculture Organization, ed. Effects of riverine inputs on coastal ecosystems and fisheries resources. FAO Fisheries Technical Paper 349. Rome, Italy: Food and Agriculture Organization.

Hecker, B. 1990. Variation in megafaunal assemblages on the continental margin south of New England. Deep-Sea Research 37(1):37-57.

IUCN (International Union for the Conservation of Nature and Natural Resources). 2000. The management of the Mediterranean and Black Sea fisheries. Prepared by the IUCN SSC European Sustainable Use Specialist Group, Fisheries Working Group, Gland, Switzerland.

Jones, E.G., A. Tselepides, P.M. Bagley, M.A. Collins, and I.G. Priede. 2003. Bathymetric distribution of some benthic and benthopelagic species attracted to baited cameras and traps in the deep eastern Mediterranean. Marine Ecology Progress Series 251:75-86.

Kallianiotis, A., P. Vidoris, and G. Sylaios. 2004. Fish species assemblages and geographical sub-areas in the North Aegean Sea, Greece. Fisheries Research 68:171-187.

Kallianiotis, A., K. Sophronidis, P. Vidoris, and A. Tselepides. 2000. Demersal fish and megafaunal assemblages on the Cretan continental shelf and slope (NE Mediterranean): Seasonal variation in species density, biomass and diversity. Progress in Oceanography 46:429-455.

Karakulak, F.S. 2004. Catch and effort of the bluefin tuna purse-seine fishery in Turkish waters. Fisheries Research 68:361-366.

Karakulak, S., I. Oray, A. Corriero, M. Deflorio, N. Santamaria, S. Desantis, and G. De Metrio. 2004. Evidence of a spawning area for the bluefin tuna (*Thunnus thynnus* L.) in the eastern Mediterranean. Journal of Applied Ichthyology 20:318-320.

Katavic, I., V. Ticina, and V. Franicevic. 2003. Bluefin tuna (*Thunnus thynnus* L.) farming on the Croatian coast of the Adriatic Sea - Present stage and future plans. Cahiers Options Mediterraneennes 60:101-106.

Katselis, G., C. Koutsikopoulos, E. Dimitriou, and Y. Rogdakis. 2003. Spatial patterns and temporal trends in the fishery landings of the Messolonghi-Etoliko lagoon system (western Greek coast). Scientia Marina 67(4):501-511.

Koutrakis, E.T., A.A. Kallianiotis, and A.C. Tsikliras. 2004. Temporal patterns of larval fish distribution and abundance in a coastal area of northern Greece. Scientia Marina 68(4):585-595.

Labropoulou, M. and C. Papaconstantinou. 2000. Community structure of deep-sea demersal fish in the North Aegean Sea (northeastern Mediterranean). Hydrobiologia 440:281-296.

Labropoulou, M. and C. Papaconstantinou. 2004. Community structure and diversity of demersal fish assemblages: The role of fishery. Scientia Marina 68(Supplement 1):215-226.

Lefkaditou, E., C. Mytilineou, P. Maiorano, and G. D'Onghia. 2003. Cephalopod species captured by deep-water exploratory trawling in the Northeastern Ionian Sea. Journal of the Northwest Atlantic Fisheries Science 31:431-440.

Lleonart, J. 2005. Mediterranean and Black Sea, FAO statistical area 37. Pages 49-64 in FAO Marine Resources Service, ed. Review of the state of world marine fishery resources. FAO Fisheries Technical Paper No. 547. Rome, Italy: Food and Agriculture Organization of the United Nations.

Lleonart, J. and L. Recasens. 1996. Fisheries and the environment in the Mediterranean Sea. Pages 5-18 in Caddy, J.F., ed. Resource and environmental issues relevant to Mediterranean fisheries management. Studies and Reviews. General Fisheries Commission for the Mediterranean No.66. Rome, Italy: Food and Agriculture Organization of the United Nations.

Lleonart, J. and F. Maynou. 2003. Fish stock assessments in the Mediterranean: State of the art. Scientia Marina 67(Supplement 1):37-49.

Macpherson, E. and N. Raventos. 2006. Relationship between pelagic larval duration and geographic distribution of Mediterranean littoral fishes. Marine Ecology Progress Series 327:257-265.

Madurell, T., J.E. Cartes, and M. Labropoulou. 2004. Changes in the structure of fish assemblages in a bathyal site of the Ionian Sea (eastern Mediterranean). Fisheries Research 66:245-260.

Maguire, J.-J., M. Sissenwine, J. Csirke, R. Grainger, and S. Garcia. 2006. The state of world highly migratory, straddling and other high seas fishery resources and associated species. FAO Fisheries Technical Paper No. 495. Rome, Italy: Food and Agriculture Organization of the United Nations.

Malvarosa, L. 2002. The fish trade of North African Mediterranean countries: Intra-regional trade and import-export with the European Union. FAO Fisheries Circular No. 978. Rome, Italy: Food and Agriculture Organization of the United Nations.

Maravelias, C.D. and C. Papaconstantinou. 2006. Geographic, seasonal and bathymetric distribution of demersal fish species in the eastern Mediterranean Journal of Applied Ichthyology 22:35-42.

Megalofonou, P., C. Yannopoulos, D. Damalas, G. De Metrio, M. Deflorio, J.M. de la Serna, and D. Macias. 2005. Incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea. Fishery Bulletin 103:620-634.

Menezes, G.M., M.F. Sigler, H.M. Silva, and M.R. Pinho. 2006. Structure and zonation of demersal fish assemblages off the Azores Archipelago (mid-Atlantic). Marine Ecology Progress Series 324:241-260.

Miyabe, N. 2003. Description of the Japanese longline fishery and its fishery statistics in the Mediterranean Sea during the recent years. Collective Volume of Scientific Papers, International Commission for the Conservation of Atlantic Tunas 55(1):131-137.

Morales-Nin, B., J. Moranta, C. García, M.P. Tugores, A.M. Grau, F. Riera, and M. Cerdà. 2005. The recreational fishery off Majorca Island (western Mediterranean): Some implications for coastal resource management. ICES Journal of Marine Science 62:727-739.

Moranta, J., J.D.M. Gordon, E. Massutí, S.C. Swan, C. Stefanescu, B. Morales-Nin, and N.R. Merret. 2003. Differences in biomass composition and size-related structure between Mediterranean and Atlantic deep-sea fish assemblages. CIESM Workshop Series 23:35-42.

Mytilineou, C., C.-Y. Politou, C. Papaconstantinou, S. Kavadas, G. D'Onghia, and L. Sion. 2005. Deep-water fish fauna in the Eastern Ionian Sea. Belgian Journal of Science 135(2):229-233.

Mytilineou, C., S. Kavadas, C.-Y. Politou, K. Kapiris, A. Tursi, and P. Maiorano. 2006. Catch composition on red shrimps' (*Aristaeomorpha foliacea* and *Aristeus antennatus*) grounds in the Eastern Ionian Sea. Hydrobiologia 557:155-160.

Oceana. 2004. European trawlers are destroying the oceans. Madrid, Spain: Oceana.

Oliver, P. 2002. Part III: Mediterranean fisheries. Pages 151-215 in Chioccioli, E., M. Allaya, N. Akesbi, M. Allaya, S. Bedrani, R. Capone, J.M.G. Alvarez-Coque, G. Malorgio, G. Miclet, P. Oliver, and A. Simantov, eds. Development and agri-food policies in the Mediterranean region: Annual report 2002. Paris, France: Centre International de Hautes Études Agronomiques Méditerranéennes.

Oray, I.K. and F.S. Karakulak. 2004. Short description of the Turkish bluefin tuna (*Thunnus thynnus*) fishery in 2003. Collective Volume of Scientific Papers, International Commission for the Conservation of Atlantic Tunas 56(3):1153-1157.

Oray, I.K. and F.S. Karakulak. 2005. Further evidence of spawning of bluefin tuna (*Thunnus thynnus* L., 1758) and the tuna species (*Auxis rochei* Ris., 1810, *Euthynnus alletteratus* Raf., 1810) in the eastern Mediterranean Sea: Preliminary results of TUNALEV larval survey in 2004. Journal of Applied Ichthyology 21:236-240.

Orsi Relini, L., F. Garibaldi, C. Cima, G. Palandri, L. Lanteri, and M. Relini. 2005. Biology of Atlantic bonito, *Sarda sarda* (Bloch, 1793), in the Western and Central Mediterranean: A summary concerning a possible stock unit. Collective Volume of Scientific Papers, International Commission for the Conservation of Atlantic Tunas 58(2):575-588.

Papaconstantinou, C. and K.I. Stergiou. 1995. Biology and fisheries of eastern Mediterranean hake (*M. merluccius*). Pages 149-180 in Alheit, J. and T.J. Pitcher, eds. Hake: Biology, fisheries and markets. London, England: Chapman & Hall.

Papaconstantinou, C. and K. Kapiris. 2003. The biology of the giant red shrimp (*Aristaeomorpha foliacea*) at an unexploited fishing ground in the Greek Ionian Sea. Fisheries Research 62:37-51.

Patti, B., A. Cuttitta, A. Bonanno, G. Basilone, G. Buscaino, C. Patti, J.G. Lafuente, A. García, and S. Mazzola. 2004. Coupling between the hydrographic circulation in the Strait of Sicily and the

reproductive strategy of the European anchovy *Engraulis encrasicolus*: Effects on distribution of spawning grounds. Pages 19-27 in MedSudMed, ed. Report of the expert consultation on small pelagic fishes: Stock identification and oceanographic processes influencing their abundance and distribution. MedSudMed Technical Documents No. 5.

Pérès, J.M. 1985. History of the Mediterranean biota and the colonization of the depths. Pages 198-232 in Margalef, R., ed. Key environments: Western Mediterranean. Oxford, United Kingdom: Pergamon Press.

Pérez-Ruzafa, A., M. Carmen Mompeán, and C. Marcos. 2007. Hydrographic, geomorphologic and fish assemblage relationships in coastal lagoons. Hydrobiologia 577:107-125.

Pérez-Ruzafa, A., J.I. Quispe-Becerra, J.A. García-Charton, and C. Marcos. 2004. Composition, structure and distribution of the ichthyoplankton in a Mediterranean coastal lagoon. Journal of Fish Biology 64:202-218.

Peric, Z. 2003. Malta national programme towards farming of the bluefin tuna - Present and future. Cahiers Options Mediterraneennes 60:167.

Piovano, S. 2007. Italy Mediterranean industrial pelagic longline swordfish fishery: Industry practices and attitudes towards shark depredation and bycatch. Pages 100-110 in Gilman, E., S. Clarke, N. Brothers, J. Alfaro-Shigueto, J. Mandelman, J. Mangel, S. Petersen, S. Piovano, N. Thomson, P. Dalzell, M. Goren, and T. Werner, eds. Shark depredation and unwanted bycatch in pelagic longline fisheries: Industry practices and attitudes, and shark avoidance strategies. Honolulu, Hawaii: Western Pacific Regional Fishery Management Council.

Politou, C.-Y., K. Kapiris, P. Maiorano, F. Capezzuto, and J. Dokos. 2004. Deep-sea Mediterranean biology: The case of *Aristaeomorpha foliacea* (Risso, 1827) (Crustacea: Decapoda: Aristeidae). Scientia Marina 68(Supplement 3):129-139.

Politou, C.-Y., S. Kavadas, C. Mytilineou, A. Tursi, R. Carlucci, and G. Lembo. 2003. Fisheries resources in the deep waters of the eastern Mediterranean (Greek Ionian Sea). Journal of the Northwest Atlantic Fisheries Science 31:35-46.

Politou, C.Y., A. Chilari, J. Dokos, A. Kallianiotis, G. Tserpes, and P. Peristeraki. 2006. Identification of the nurseries of hake and deep-water pink-shrimp in Greek waters using trawl survey data. Pages 341-357 in STECF (Scientific Technical and Economic Committee for Fisheries), ed. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

Por, F.D. 1978. Lessepsian migration: The influx of Red Sea biota into the Mediterranean by way of the Suez Canal. New York, New York: Springer-Verlag Berlin Heidelberg.

Potoschi, A., L. Cannizzaro, A. Milazzo, M. Scalisi, and G. Bono. 1999. Sicilian dolphinfish (*Coryphaena hippurus*) fishery. Scientia Marina 63(3-4):439-445.

Quetglas, A., A. Carbonell, and P. Sánchez. 2000. Demersal continental shelf and upper slope cephalopod assemblages from the Balearic Sea (north-western Mediterranean). Biological aspects of some deep-sea species. Estuarine, Coastal and Shelf Science 50:739-749.

Quignard, J.P. and J.A. Tomasini. 2000. Mediterranean fish biodiversity. Biologia Marina Mediterranea 7(3):1-66.

Quintanilla, L.F. and A. García. 2001a. Methodological, biological and environmental factors affecting the DEPM parameters variability in the Mediterranean anchovy. Rapports Commission Internationale de la Mer Mediterranean 36:311.

Quintanilla, L.F. and A. García. 2001b. Daily egg production method for estimating Sicilian Channel anchovy spawning biomass in 1998 and 1999. Rapports Commission Internationale de la Mer Mediterranean 36:312.

Ragonese, S., M.G. Andreoli, G. Bono, G.B. Giusto, P. Rizzo, and G. Sinacori. 2004. Overview of the available biological information on demersal resources of the Strait of Sicily. Pages 67-74 in MedSudMed, ed. Report of the expert consultation on the spatial distribution of demersal resources in the Straits of Sicily and the influence of environmental factors and fishery characteristics. MedSudMed Technical Documents No. 2.

Rollandi, L., G.A. Arigò, A. Bonanno, G. Buscaino, A.M. Di Nieri, B. Patti, and S. Mazzola. 2005. Bullet and bluefin tuna larvae in the oceanographic scenario observed in the Strait of Sicily during 2003 and 2004 summer scientific survey. Abstracts, Twenty-ninth Annual Larval Fish Conference. 11-14 July 2005. Barcelona, Spain.

Royer, F., J.-M. Fromentin, H. Farrugio, and P. Gaspar. 2005. Determining bluefin tuna habitat through frontal features in the Mediterranean Sea. Collective Volume of Scientific Papers, International Commission for the Conservation of Atlantic Tunas 58(4):1275-1284.

Rufino, M.M., F. Maynou, P. Abelló, and F. Sardá. 2006. Spatial and environmental factors affecting the distribution of the main decapod crustacean prey species in the NW Mediterranean. Hydrobiologia 555:129-141.

Ruso, Y.D.P. and J.T. Bayle-Sempere. 2006. Diel and vertical movements of preflexion fish larvae assemblages associated with *Posidonia oceanica* beds. Scientia Marina 70(3):399-406.

Sabatés, A. and M.P. Olivar. 1996. Variation of larval fish distributions associated with variability in the location of a shelf-slope front. Marine Ecology Progress Series 135:11-20.

Sardà, F., G. D'Onghia, C.Y. Politou, J.B. Company, P. Maiorano, and K. Kapiris. 2004a. Deep-sea distribution, biological and ecological aspects of *Aristeus antennatus* (Risso, 1816) in the western and central Mediterranean Sea. Scientia Marina 68(Supplement 3):117-127.

Sardà, F., A. Calafat, M.M. Flexas, A. Tselepides, M. Canals, M. Espino, and A. Tursi. 2004b. An introduction to Mediterranean deep-sea biology. Scientia Marina 68(Supplement 3):7-38.

Sbrana, M., C. Viva, and P. Belcari. 2006. Fishery of the deep-water rose shrimp *Parapenaeus longirostris* (Lucas, 1846) (Crustacea: Decapoda) in the northern Tyrrhenian Sea (western Mediterranean). Hydrobiologia 557:135-144.

Serena, F. 2005. FAO species identification guide for fishery purposes. Field identification guide to the sharks and rays of the Mediterranean and Black Sea. Rome, Italy: Food and Agriculture Organization of the United Nations.

Serena, F., E. Cecchi, C. Mancusi, and R. Pajetta. 2006a. Contribution to the knowledge of the biology of *Etmopterus spinax* (Linnaeus 1758) (Chondrichthyes, Etmopteridae). Pages 388-394 in Shotton, R., ed. Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries, Queenstown, New Zealand, 1-5 December 2003 and Dunedin, New Zealand, 27-29 November 2003. Part 2: Conference poster papers and workshop papers. FAO Fisheries Proceedings 3/2. Rome, Italy: Food and Agriculture Organization of the United Nations.

Serena, F., A. Abella, R. Baino, C. Mancusi, A. Voliani, and G. Relini. 2006b. Sensitive habitats for elasmobranch fishes in the Italian seas through the analysis of trawl surveys data. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01. Brussels, Belgium: Commission of the European Communities.

Sion, L., A. Bozzano, G. D'Onghia, F. Capezzuto, and M. Panza. 2004. Chondrichthyes species in deep waters of the Mediterranean Sea. Scientia Marina 68(Supplement 3):153-162.

Somarakis, S. and E. Maraveya. 2001. Covariation in mean abundance of larval myctophids and zooplankton biovolumes in the NE Aegean Sea. Rapports Commission Internationale de la Mer Mediterranean 36:325.

Somarakis, S., E. Maraveya, and N. Tsimenides. 2000. Multispecies Ichthyoplankton associations in epipelagic species: Is there any intrinsic adaptive function? Belgium Journal of Zoology 130(Supplement 1):125-129.

Somarakis, S., P. Drakopoulos, and V. Filippou. 2002. Distribution and abundance of larval fish in the northern Aegean Sea—eastern Mediterranean—in relation to early summer oceanographic conditions. Journal of Plankton Research 24(4):339-357.

Somarakis, S., D.E. Tsianis, A. Machias, and K.I. Stergiou. 2006a. An overview of biological data related to anchovy and sardine stocks in Greek waters. Pages 56-64 in Palomares, M.L.D., K.I. Stergiou, and D. Pauly, eds. Fishes in databases and ecosystems. Fisheries Centre Research Reports 14(4).

Somarakis, S., K. Ganias, A. Siapatis, C. Koutsikopoulos, A. Machias, and C. Papaconstantinou. 2006b. Spawning habitat and daily egg production of sardine (*Sardina pilchardus*) in the eastern Mediterranean. Fisheries Oceanography 15(4):281-292.

Somarakis, S., I. Palomera, A. Garcia, L. Quintanilla, C. Koutsikopoulos, A. Uriarte, and L. Motos. 2004. Daily egg production of anchovy in European waters. ICES Journal of Marine Science 61:944-958.

Spalding, M., H. Fox, N. Davidson, Z. Ferdana, M. Finlayson, B. Halpern, M. Jorge, A. Lombana, S. Lourie, K. Martin, E. McManus, J. Molnar, K. Newman, C. Recchia, and J. Robertson. 2006. Global coastal and marine biogeographic regionalization as a support tool for implementation of

CBD programmes of work. COP8 Information Document 34. Montreal, Canada: Convention on Biological Diversity.

STECF (Scientific Technical and Economic Committee for Fisheries). 2002a. Deep-sea fisheries. SEC(2002) 133. Brussels, Belgium: Commission of the European Communities.

STECF (Scientific Technical and Economic Committee for Fisheries). 2002b. Mediterranean fisheries shared stocks. SEC(2002) 1374. Brussels, Belgium: Commission of the European Communities.

STECF (Scientific Technical and Economic Committee for Fisheries). 2004. European Union Mediterranean fisheries and exploited resources. SEC (2004) 772. Brussels, Belgium: Commission of the European Communities.

STECF (Scientific Technical and Economic Committee for Fisheries). 2005. Review of scientific advice for 2005. Report SEC(2005) 266. Brussels, Belgium: Commission of the European Communities.

STECF (Scientific Technical and Economic Committee for Fisheries). 2006. Sensitive and essential fish habitats in the Mediterranean Sea. Proceedings, Sub-group on the Mediterranean Sea, 6-10 March 2005, Rome, Italy. SGMED-06-01.

Stergiou, K.I. and M. Koulouris. 2000. Fishing down the marine food webs in the Hellenic seas. CIESM Workshop Series 12:73-78.

Stergiou, K.I., G. Tserpes, and P. Peristeraki. 2003. Modelling and forecasting monthly swordfish catches in the Eastern Mediterranean. Scientia Marina 67(Supplement 1):283-290.

Stergiou, K.I., E.D. Christou, D. Georgopoulos, A. Zenetos, and C. Souvermezoglou. 1997. The Hellenic seas: Physics, chemistry, biology and fisheries. Oceanography and Marine Biology: An Annual Review 35:415-538.

Stewart, P.A.M., R. Robles, ed., and P. Hernández, ed. 2002. A review of studies of fishing gear selectivity in the Mediterranean. Informes y estudios COPEMED 9:1-56.

Swan, J. 2005. Implementation of the international plan of action to prevent, deter and eliminate illegal, unreported and unregulated fishing: Relationship to, and potential effects on, fisheries management in the Mediterranean. Studies and Reviews. General Fisheries Commission for the Mediterranean No. 76. Rome, Italy: Food and Agriculture Organization of the United Nations.

Takase, M. 2005. Problems of illegal, unreported and unregulated fishing and overcapacity of tuna fishing vessels. Pages 324-331 in Bayliff, W.H., J.I. de Leiva Moreno, and J. Majkowski, eds. Second meeting of the technical advisory committee of the FAO project "Management of tuna fishing capacity: Conservation and socio-economics." 15-18 March 2004. Madrid, Spain. FAO Fisheries Proceedings 2.

Tortonese, E. 1985. Distribution and ecology of endemic elements in the Mediterranean fauna (fishes and echinoderms). Pages 57-83 in Moraitou-Apostolopoulou, M. and V. Kiortsis, eds. Mediterranean marine ecosystems. New York, New York: Plenum Press.

Tserpes, G. and P. Peristeraki. 2002. Trends in the abundance of demersal species in the southern Aegean Sea. Scientia Marina 66(Supplement 2):243-252.

Tserpes, G., P. Peristeraki, G. Potamias, and N. Tsimenides. 1999. Species distribution in the southern Aegean sea based on bottom-trawl surveys. Aquatic Living Resources 12(3):167-175.

Tudela, S. 2004. Ecosystem effects of fishing in the Mediterranean: An analysis of the major threats of fishing gear and practices to biodiversity and marine habitats. Studies and Reviews. General Fisheries Commission for the Mediterranean No. 74. Rome, Italy: Food and Agriculture Organization of the United Nations.

Tudela, S. 2005. Proposal for a representative network of protected deep-sea sensitive habitats in the Mediterranean. Barcelona, Spain: WWF Mediterranean Programme Office.

Tudela, S. and J. Sacchi. 2003. Effects of fishing practices of the Mediterranean sea: Impact on marine sensitive habitats and species, technical solution and recommendations. Tunis, Tunisia: Regional Activity Centre for Specially Protected Areas.

Tursi, A., F. Mastrototaro, A. Matarrese, P. Maiorano, and G. D'Onghia. 2004. Biodiversity of the white coral reefs in the Ionian Sea (central Mediterranean). Chemistry and Ecology 20(Supplement 1):S107-S116.

Tzanatos, E., E. Dimitriou, G. Katselis, M. Georgiadis, and C. Koutsikopoulos. 2005. Composition, temporal dynamics and regional characteristics of small-scale fisheries in Greece. Fisheries Research 73:147-158.

Ungaro, N., C.A. Marano, L. Ceriola, and M. Martino. 2005. Distribution of demersal crustaceans in the southern Adriatic Sea. Acta Adriatica 46(1):27-40.

Ungaro, N., C.A. Marano, R. Marsan, M. Martino, M.C. Marzano, G. Strippoli, and A. Vlora. 1999. Analysis of demersal species assemblages from trawl surveys in the South Adriatic sea. Aquatic Living Resources 12(3):177-185.

Valavanis, V.D., S. Georgakarakos, D. Koutsoubas, C. Arvanitidis, and J. Haralabous. 2002. Development of a marine information system for cephalopod fisheries in Eastern Mediterranean. Bulletin of Marine Science 71(2):867-882.

Vella, A. 1999. Dolphinfish fishery around the Maltese Islands. Scientia Marina 63(3-4):465-467.

Ward, P. and S. Elscot. 2000. Broadbill swordfish: Status of world fisheries. Canberra, Australia: Bureau of Rural Science.

WWF (World Wildlife Fund). 2006. The plunder of bluefin tuna in the Mediterranean and East Atlantic in 2004 and 2005: Uncovering the real story. Rome, Italy: WWF.

WWF/IUCN (World Wildlife Fund/International Union for Nature and Natural Resources). 2004. The Mediterranean deep-sea ecosystems: An overview of their diversity, structure, functioning and anthropogenic impacts, with a proposal for conservation. Rome, Italy and Málaga, Spain: WWF/IUCN (World Wildlife Fund/International Union for Nature and Natural Resources).

Zarrad, R., H. Missaoui, F. Alemany, R.M. Salah, A. García, M. Ridha, J. Othman, and E.A. Amor. 2006. Spawning areas and larval distributions of anchovy *Engraulis encrasicolus* in relation to envrionmental conditions in the Gulf of Tunis (Central Mediterranean Sea). Scientia Marina 70S2:137-146.

Zenetos, A., V. Todorova, and B. Alexandria. 2003. Marine biodiversity changes in the Mediterranean and Black Sea regions. Abstracts, International Conference on the Sustainable Development of the Mediterranean and Black Sea Environment. 28 May - 1 June 2003. Thessaloniki, Greece.

Zenetos, A., I. Siokou-Frangou, O. Gotsis-Skretas, National Centre for Marine Research Greece, and S. Groom. 2002. Europe's biodiversity- biogeographical regions and seas: Seas around Europe the Mediterranean Sea- blue oxygen-rich, nutrient-poor waters. Copenhagen, Denmark: European Environment Agency.

This page intentionally left blank

6.0 ADDITIONAL CONSIDERATIONS

6.1 MARITIME BOUNDARIES

Maritime boundaries are critical elements that affect the planning of activities in the marine environment[1]. They delimit the extent of a nation's sovereignty, exclusive rights, jurisdiction, and control over the ocean areas off its coast. Maritime boundaries may include (if claimed) a 12 or 6 NM territorial sea, an 18 to 24 NM contiguous zone, an exclusive fishing zone (EFZ), a 200 NM exclusive economic zone (EEZ), and a nation's continental shelf (**Figure 6-1**; **Table 6-1**). Since maritime boundaries are delimited, rather than demarcated, there is generally no physical evidence of the boundary. As a result, there can often be confusion, disagreement, and conflicting versions of marine boundaries between distinct nations and/or territories[2].

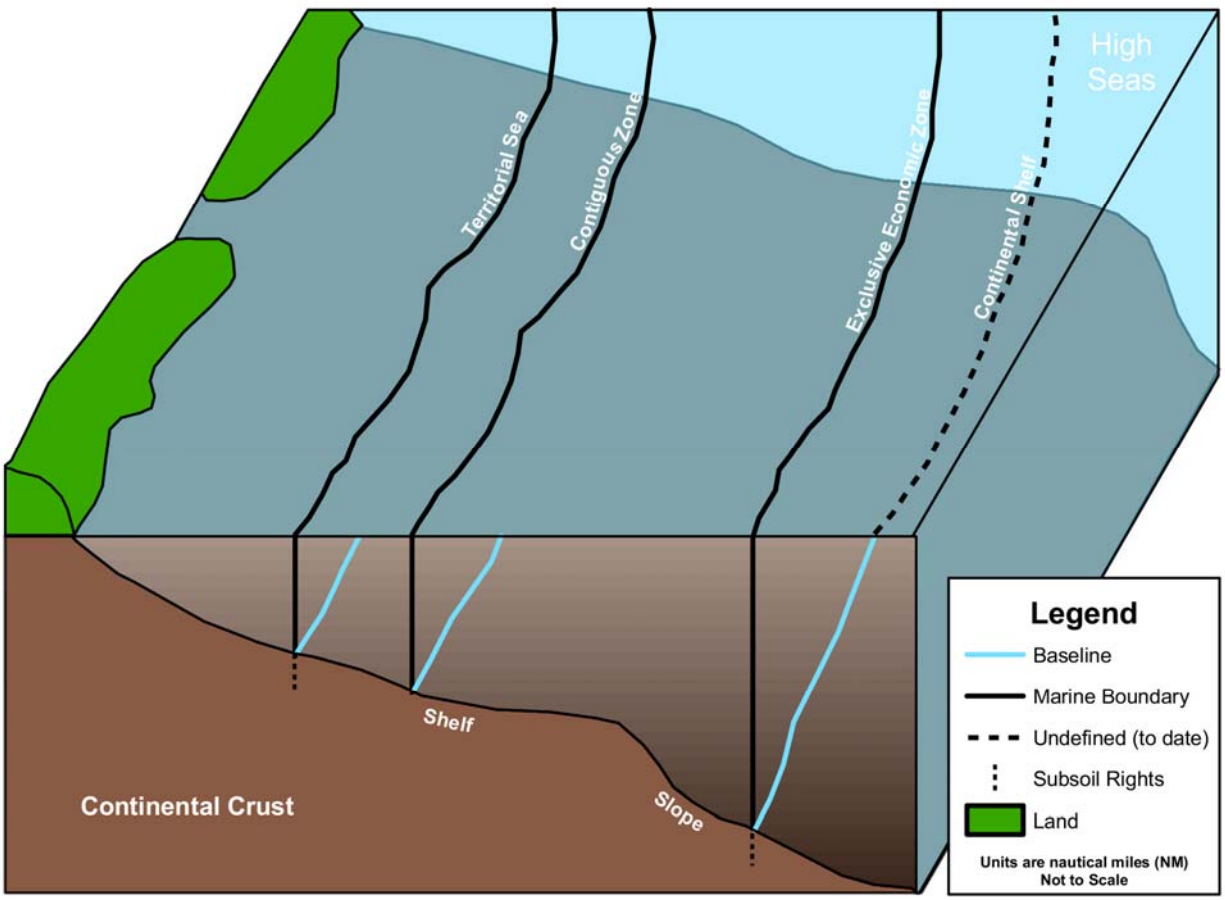


Figure 6-1. A generalized 3D depiction of maritime boundaries, including territorial sea, contiguous zone, exclusive fishing zone, EEZ, and continental shelf. The baseline is defined as the mean low water/tide line along the coast or a straight line drawn across coastal bays or other inlets. Map adapted from: NOAA[2].

Table 6-1. The maritime boundaries of the Mediterranean Sea and their seaward and jurisdictional extents.

Maritime Boundary	Seaward Extent	Jurisdictional Extent
Territorial Waters	12 or 6 NM from baseline	Claim of jurisdiction over the air, sea, and seabed
Contiguous Zone	24 NM from baseline	Power to prevent and punish for infringement of fiscal, customs, immigration, and sanitary laws
Exclusive Fishing Zone	Variable, up to 200 NM from baseline	Claim of jurisdiction over living resources
Exclusive Economic Zone	200 NM from baseline	Sovereign rights over all natural resources and jurisdiction to protect the marine environment

Source: DOALOS[3]

The Mediterranean Sea is surrounded by 22 States (two of which are island States [Malta and Cyprus]) that have the responsibility of managing and conserving the numerous proffered marine resources. The Mediterranean Sea occupies approximately 2.5 million km and harbors 7% of the known world marine fauna and 18% of the known world marine flora.[13] **Figure 6-2** depicts the maritime boundaries of the Mediterranean States in the eastern Mediterranean Sea (GDAIS 2004; Alsied 2006). Currently, the coastal states generally restrain their right to national jurisdiction over waters in the Mediterranean Sea (**Table 6-2**). Most states have established territorial waters; however, for geographic, economic, and political reasons, few have claimed an EEZ or an EFZ. Those States that have declared an EFZ do so to protect fish resources; although EFZ legislation is not included in the international law of the UNCLOS. The UNCLOS Treaty, created in 1982, provides a general framework governing the establishment and delimitation of maritime zones. It recognizes the right of coastal nations to delimit the international maritime sovereignties as 12 or 6 NM for territorial seas, 18 to 24 NM for a contiguous zone, and 200 NM for an EEZ (54 FR 777; **Figure 6-1**; **Table 6-1**); however, according to international law, states that choose to claim an EEZ that overlaps must negotiate the maritime boundary delimitation to achieve an equitable solution. After a certain period of time, if there is no agreement, the states will have their case decided according to the UNCLOS. For example, in 2003, the boundary line between Cyprus's and Egypt's EEZ was established as the median line that is equidistant from the nearest point on the baseline of each state. Therefore, there is a large area of unclaimed waters (high-seas) in the Mediterranean Sea that requires increased levels of cooperation between the states to ensure sustainability of the marine resources (Cacaud 2005). Article 123 of UNCLOS prescribes the coordination of management, conservation, exploration and exploitation of the living resources of the sea, and implementation of their rights and duties with respect to the protection and preservation of the marine environment. In accordance with the UNCLOS, the Mediterranean States have demonstrated a high-level of co-operation and have adopted legislation to prevent, reduce, and control the pollution of the marine environment. For example, in 1995, a protocol was developed to conserve biological diversity through the designation of specially protected areas; this protocol applies to all the waters in the Mediterranean Sea irrespective of their legal status; "internal waters, historical bays, territorial seas, continental shelf, exclusive economic zone, exclusive fishery zone, fishery protection zone, high seas" status (Alsied 2006).

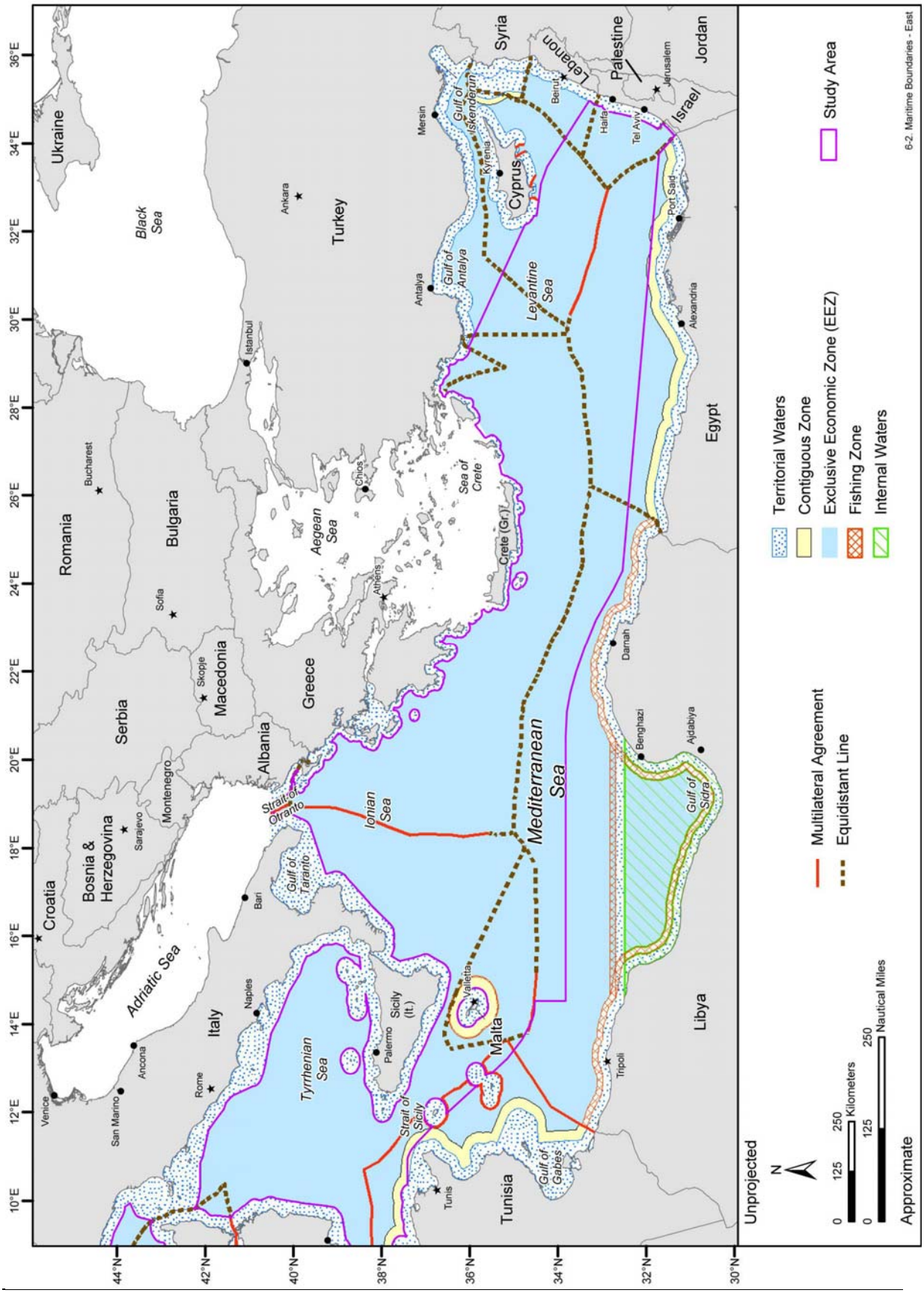


Figure 6-2. Maritime boundaries in the eastern Mediterranean Study Area and vicinity. If claimed, the territorial waters, contiguous zone, exclusive fishing zone, and EEZ are each measured outward from the baseline (usually mean low-tide line) along the shore and extend out the entire length unless there is an agreed upon equidistant line or multilateral agreement. Source data: GDAIS (2004). Map adapted from: Alsied (2006).

Table 6-2. Claims to maritime jurisdiction by the states bordering the eastern Mediterranean Sea (Cacaud 2005).[6]

State	Territorial Sea (NM)	Contiguous Zone (NM)	EFZ (NM)	Continental Shelf: outer limit	EEZ (shelf) km^2	EEZ (NM)
Albania	12	—	—	Depth 200 m or exploitability	13,691 (6,979)	—
Bosnia and Herzegovina	No data	No data	No data	No data	50 (50)	No data
Croatia	12	—	—	Depth 200 m or exploitability	59,032 (50,277)	—
Cyprus	12	—	—	Depth 200 m or exploitability	98,707 (4,042)	—
Egypt	12	24	—	Depth 200 m or exploitability	263,451 (61,591)	200
Greece[1]	6	—	—	Depth 200 m or exploitability	505,572 (81,451)	—
Israel	12	—	—	Depth of exploitability	26,352 (3,745)	—
Italy	12	—	—	Depth 200 m or exploitability	541,915 (116, 834)	—
Lebanon	12	—	—	—	19,516 (1,067)	—
Libya[2]	12	—	No data	—	351,589 (64,763)	—
Malta	12	24	25	Depth 200 m or exploitability	54,823 (5,301)	—
Serbia and Montenegro	12	—	—	del	7,745 (3,896)	—
Slovenia	—	—	—	—	220 (220)	—
Syria	35	41	—	Depth 200 m or exploitability	110,503 (1,085)	—
Tunisia[3]	12	24	Up to 50 m isobath off the Gulf of Gabès	No data	101,857 (67,126)	—
Turkey	6 (in the Aegean Sea), 12 (in Black Sea and Mediterranean Sea)	—	—	No data	92,599 (38,015)	200 (in Black Sea only: to the maritime boundary agreed upon with the former USSR)

del = Up to delimitation with neighboring states

[1] The extent of the territorial sea is fixed at 10 NM for the purpose of regulating civil aviation.

[2] Gulf of Sidra closing line - 32° 30'N

[3] Territorial waters extend up to the 50 m isobath off the Gulf of Gabès

6.1.1 Territorial Seas

Most Mediterranean States have established a 12-mile (mi) territorial sea (**Figure 6-2**). A few countries still adopt narrower limits, namely Greece and Turkey; they have established a 6-mi territorial jurisdiction in the Aegean Sea. Syria claims a 35-mi territorial sea that does not fit with international law; however, it is unclear whether or not there is enforcement beyond 12 mi. Of importance for the Mediterranean Study Area, treaties for the delimitation of territorial seas have been signed between France and Italy on 28 November 1986 regarding the Strait of Bonifacio (between Corsica and Sardinia) and between Italy and Yugoslavia on 10 November 1975 regarding the Gulf of Trieste (Cacaud 2005).

6.1.2 Exclusive Economic Zone

Only three Mediterranean States have taken steps to establish a 200 NM EEZ within the Mediterranean Sea (**Figure 6-2**). Most of the Mediterranean States are reluctant to proclaim an EEZ because of the difficultly associated with the delimitation of the relatively narrow Mediterranean Sea. In the cases where a nation's EEZ overlaps with that of one or more countries, the international maritime boundaries must be agreed upon by each country to resolve the overlapping claim with a "median line", an imaginary line that is equidistant from the baseline of each country. Also there is a desire of most states to preserve the freedom of navigation, mobility, and fishery access; however, legally, there is nothing to prevent Mediterranean States from establishing an EEZ. In 1981, Morocco proclaimed an EEZ in both its Mediterranean and Atlantic waters; however, it is unclear if the EEZ legislation is enforced in its Mediterranean waters. Morocco has not yet negotiated with neighboring states to define its EEZ boundaries in the Mediterranean Sea. In 1983, Egypt proclaimed an EEZ in its Mediterranean Sea and Red Sea waters; however it appears that the proclamation of its EEZ was not followed by implementing legislation. In 1994, Croatia proclaimed an EEZ; however, the enforcement of its EEZ is conditionally governed by the decisions of the Croatian Parliament (Cacaud 2005)

6.1.3 Exclusive Fishing Zones

In the Mediterranean Sea, four countries, namely, Algeria, Malta, Spain, and Tunisia have claimed an EFZ that extends beyond their territorial waters (**Figure 6-2**). In 1994, Algeria claimed an EFZ extending beyond its territorial sea. The exclusive fishing zone encompasses 32 NM beyond the territorial waters from the western maritime border until Ras Ténés, at which point it encompasses 52 NM beyond the territorial waters from Ras Ténés to the eastern maritime border. In 1978, Malta claimed a 25 NM exclusive fishing zone; however, as a result of geographical features, the northern boundary does not extend the full 25 NM. In 1997, Spain claimed a 37 NM (starting from the outer limit of the territorial sea) fisheries protection zone; it is delimited by the median line from the opposite coast of Algeria and Italy and the adjacent coast of France. Spain did not claim a fisheries protection zone in the Alboran Sea. In 1951, Tunisia claimed an EFZ at the 50-m isobath, which can vary from as far away as 75 NM from the Tunisian coast to only 15 NM from the Italian island of Lampedusa.

In the interest of conservation and sustainability of fisheries resources in the Mediterranean Sea, the EU dvocates the declaration of fisheries protection zones of up to 200 NM to control illegal, unreported, and unregulated (IUU) fishing. Recently, France indicated that they were in the process of declaring legislation for a 50 NM fisheries protection zone off its Mediterranean Sea coast (Cacaud 2005).

6.1.4 Continental Shelves

In the Mediterranean Sea, the delimitation of the continental shelf can become very complicated. There are many long-lasting disputes on the delimitation of coastal zones; this can be owing to the geographical problems of islands and the concave/convex configuration of the coastlines. These issues become even more complicated by the fact that there are usually more than two states involved (Cacaud 2005). In general, the delimitation of the continental shelf is defined by 200 m of water depth or by the depth of exploitability.

6.2 MAJOR TRADE ROUTES AND SEAPORTS

The Mediterranean Sea provided some of the most ancient civilizations the necessary resources to flourish. Initially merchants used the sea as a highway for trade from Phoenicia. The Mediterranean Sea region went through several eras of dominance from the Roman and then the Byzantine Empire to the Italian city trading states such as Genoa, Venice, and Barcelona in the 11th and 14th centuries. Later, Mediterranean Sea trade routes passed products between Asia and Europe until the establishment of a route around the Cape of Good Hope (late 15th century). In 1869, with the opening of the Suez Canal, the Mediterranean Sea continued to serve as an important trade route to the East. The Mediterranean Sea is increasingly being used as an important trade route with the development of the northern regions of Africa and the oil fields in the Middle East. During the world wars, the Mediterranean Sea proved to be a dangerous route for attacks on Europe and an important trade link; this led to competition for control over its coasts and islands. The Mediterranean Sea continues to be a region of strategic importance.[4]

Currently, shipping in the Mediterranean Sea includes the transport of passengers (e.g., ferries), general cargoes, livestock, cars, dry and liquid build cargoes, and many other goods, resulting in the co-existence of various types and sizes of vessels (REMPEC 2002).The Mediterranean Sea harbors some of the world's busiest shipping routes with the major importers being Spain, Italy, and Greece. The density of merchant vessels traffic in the Mediterranean Sea is particularly high. It is estimated that the Mediterranean Sea accounts for approximately one third (some 20 to 25% of that is oil traffic) of the world's total merchant shipping, 200,000 merchant vessels of over 100 gross registered tons (GRT) per year, and 305 seaports (one per km of coastline) (Greenpeace International 2006). There are approximately 2,000 merchant vessels of over 100 GRT seaborne at any moment and 250 to 300 of these are oil tankers. In the narrow passages of the Mediterranean Sea through which ships enter and exit, the traffic is particularly congested. The ferry routes are quite extensive and well developed (**Figure 6-3**; GDT and ESRI 2006)[10] and there is a significant amount of information concerning the oil traffic routes (**Figure 6-4**)[11] in the Mediterranean Sea; however, there is a lack of data on the general traffic and trade patterns in the Mediterranean Sea. To accommodate for the lack of information in the maritime transportation industry, the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) plans to identify the principal routes, origins, destinations, and quantities of goods carried or planned to be carried in the Mediterranean Sea (REMPEC 2002). The current state and expected development of maritime traffic within and outside the Mediterranean Sea region suggests the Mediterranean Sea is and shall remain a major route for transportation (REMPEC 2002).

6.2.1 Ports

In 1995, the Mediterranean Sea supported 305 ports located mainly in Italy, Greece, and Spain. There are three categories of Mediterranean Sea ports:

- Multi-purpose ports with a wide range of services;
- Single-user ports and facilities for large organization, government, or private use;
- Small ports, including fishing ports, marinas, and pleasure craft ports (REMPEC 2002).

The major seaports in the Mediterranean Sea (**Figure 6-4**; GDT and ESRI 2006), in order from largest, include: Gioia Tauro, Algeciras, Genoa, Barcelona, and Valencia (Mundy 2001). Gioia Tauro is the largest seaport in the Mediterranean Sea and is ranked sixth in all of Europe. It is the largest seaport in Italy (right before Genoa and La Spezia) in terms of container traffic and handles more than 3,000,000 twenty-foot equivalent units (TEUs; Container capacity is measured in TEUs) and 3,000 ships per year. The Port of Algeciras is the port and harbor of Algeciras, a city in the province of Cádiz. The seaport serves as the main embarkation point between Spain and Tangier and other ports in Morocco as well as the Canary Islands and the Spanish-Moroccan enclaves of Ceuta and Melilla. In 2006, the port managed 73 million tons and is the second largest seaport in the Mediterranean Sea. It is ranked seventh in all of Europe. Some of the numerous seaports in the eastern Mediterranean Sea (**Figure 6-4**) include: Valletta, Malta; Piraeus, Patras, and Volos, Greece; Alanya, Turkey; and Cyprus, Israeli, and Egyptian ports. Piraeus Port is the largest container port in eastern Mediterranean Sea, and Patras Port is the busiest harbor in western Greece and a major transportation link between Greece and Italy.

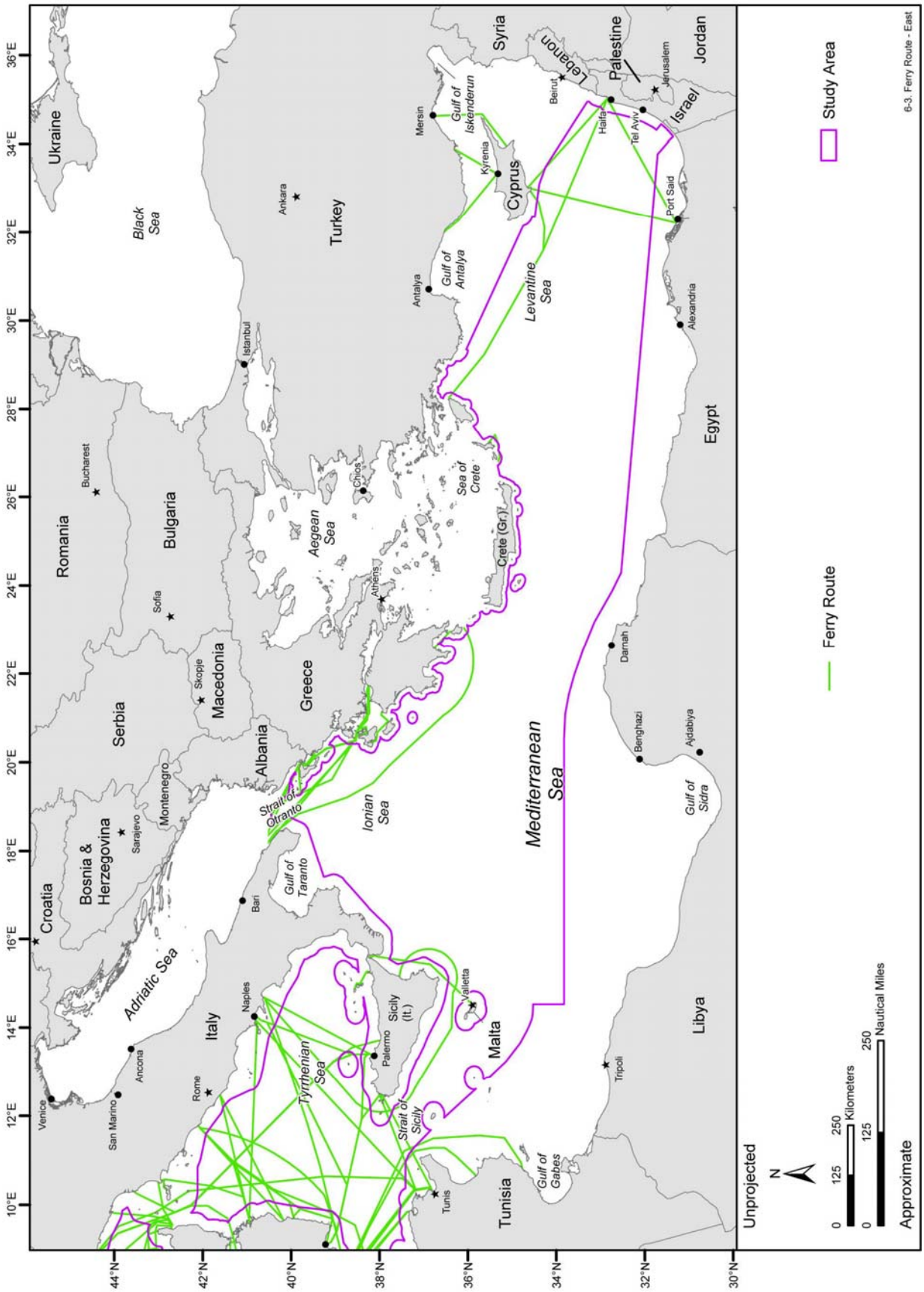


Figure 6-3. Ferry routes of the eastern Mediterranean Study Area and vicinity. Source data: GDT and ESRI (2006) and East Med Ferries[10].

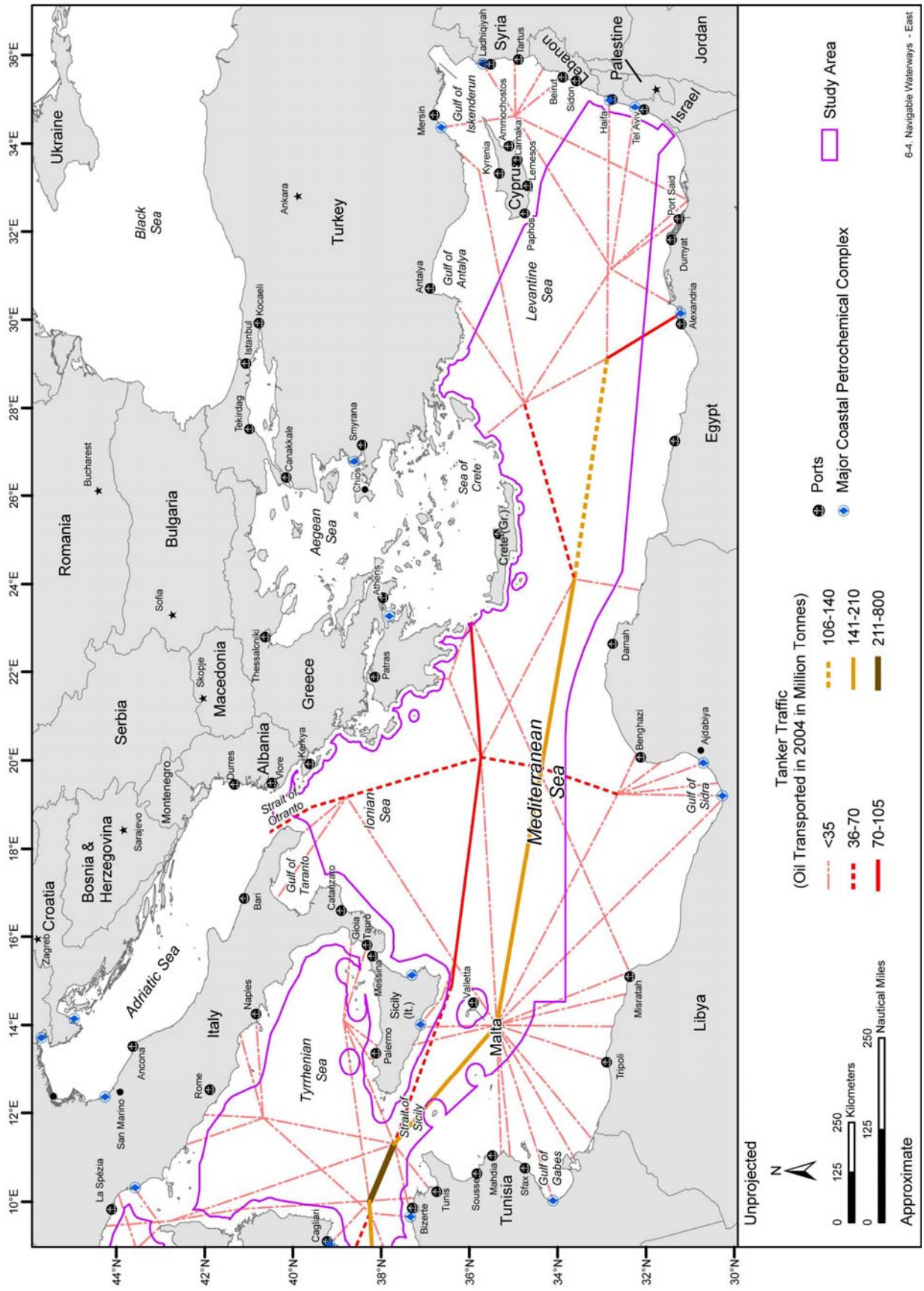


Figure 6-4. Commercially navigable waterways of European oil maritime transport and amount transported as of 2004 in the eastern Mediterranean Study Area and vicinity. Source data: GDT and ESRI (2006). Source maps (scanned): UNEP[11].

6.2.2 Oil Traffic

The Mediterranean Sea region oil industry is highly active because it is the major route for the transport of crude oil from the Middle East, North Africa, and the oil ports of the Black Sea to the major consumption centers of Europe and North America. The largest exporters of oil are Libya, Algeria, Egypt, and Syria and the largest importers of oil are France, Italy, Spain, and Turkey. Generally, tanker traffic flows in the east-west direction and the south-north routes occasionally intersect, join, or branch off from the three principal east-west lanes (**Figure 6-4**). An estimated 90% of the total oil traffic runs between the Suez Canal and Gibraltar and connecting with the Sumed pipeline in Egypt along the way; this route passes between Sicily and Malta and then follows the coasts of Tunisia, Algeria, and Morocco. There are more than 40 oil refineries distributed throughout the Mediterranean Sea with a combined capacity of around 458 million t/yr. Approximately 370 million tons of oil (representing 20% of global oil shipping) is transported through the Mediterranean Sea annually (Greenpeace International 2006).

6.3 MARINE PROTECTED AREAS

An MPA is a widely used term that is used to describe a wide range of marine areas that are under some level of restriction to protect living, non-living, cultural, and/or historic resources (Russ and Alcala 2004). Domestically, MPAs are defined in the EO 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Internationally, the IUCN defines MPA as “any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.” (Kelleher and Kenchington 1992). The intent of MPAs, both internationally and domestically, is to conserve the diversity of life according to the three aspects of biodiversity: ecosystems diversity (habitats and species), species richness, and genetic diversity (Halpern and Warner 2002).

The IUCN is a global network developed to promote the protection and identification of MPAs in order to provide effective management, valuable legislation, and evaluation of MPAs. Although each country establishes specific legislation regarding the management of their protected areas, the success of the conservation objectives and sustainable development is dependent upon local support (Chape et al. 2005). To assist the Mediterranean States in the control of marine pollution, the MAP was adopted by the states at the Barcelona Convention in 1995 (Alsied 2006).

The ecologically vulnerable Mediterranean Sea is characterized by high biodiversity and endemism; however, it has been subjected to growing human pressure that has a direct negative impact on species and their habitats.[7] MPAs serve as an effective conservation tool to protect representative ecosystems of the Mediterranean Sea and the habitats important for threatened or endangered species; therefore, ecosystems are sustained in their biodiversity, renewability, and resource productivity (Agardy 1999; NRC 2000). The Mediterranean States have already established more than 150 of the most successful marine and coastal protected areas in the world (Alsied 2006).

The term MPA has many meanings in any one country or region and can provide a wide range of protection status and benefits. MPAs can be created for many reasons; they can protect a single species, a whole habitat, or an entire ecosystem as well as certain interests, such as small scale or recreational fishing (Greenpeace International 2006). For example there are many related terms such as Particularly Sensitive Sea Areas (PSSAs), “special areas”, Specially Protected Areas of Mediterranean Importance (SPAMIs), Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs), and Areas of Special Scientific Interest (ASSIs) all of which have specific types of restrictions associated with them, as defined by the laws of the state.

Marine Reserves (MRs) are one type of MPA that offers the highest level of protection; they are fully protected from all damaging human activities (Greenpeace International 2006). Marine reserves are closed to all extractive uses including fishing, mining, and disposal activities. Within a MR, there may be specific zones of even stricter restrictions, for example, some areas that are of particular interest scientifically or contain particularly sensitive habitats or species are exempt from any human activities.

Within the Mediterranean Sea, these specific zones can be designated SPAMIs (under the Barcelona Convention), SACs (within the Natura 2000 Habitats Directive), or SPAs (within the Natura 2000 Birds Directive).

Marine reserves have been shown to increase abundance, diversity, and productivity within a habitat/ecosystem as well as among migratory species when spawning and nursery grounds are protected (Greenpeace International 2006). Roberts et al. 2003 have identified a set of criteria to identify priority habitats that are necessary to protect. These are:

- Sites that include vulnerable habitats e.g. seamounts
- Sites that contain vulnerable life history stages e.g. fish spawning and nursery grounds
- Sites capable of supporting exploited species or rare species
- Sites that provide ecological services (Greenpeace International 2006).

6.3.1 Marine Protected Area Designations

Special Protection Area (SPA)—A SPA is designated under the EU as part of a network of protected sites assigned by the Natura 2000. It is an EC directive on the Conservation of Wild Birds (79/409/CEE) that orders the safeguard of the habitats of migratory birds, particularly threatened birds by the Mediterranean States. SPAs can comprise of a conglomeration of one or more SSSI or ASSI.[8]

Special Area of Conservation (SAC)—The EC Habitats Directive (92/43/EEC - Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora) designated 220 habitats and approximately 1,000 species as SAC. Special Areas of Conservation together with SPAs form Natura 2000, a network of protected sites, which, in turn, is a part of a network of Areas of Special Conservation Interest (ASCIs) as per the Berne Convention.[9]

Specially Protected Areas of Mediterranean Importance (SPAMI)—Within Article 8(2) of the 1995 Protocol Concerning Mediterranean SPAs and Biological Diversity in the Mediterranean (which replaced the 1982 Protocol Concerning Mediterranean SPAs), SPAMI are defined as sites "of importance for conserving the components of biological diversity in the Mediterranean; contain ecosystems specific to the Mediterranean area or the habitats of endangered species; are of special interest at the scientific, aesthetic, cultural or educational levels". This Protocol is part of the UNEP's Barcelona Convention of 1976 as part of a program for the protection of the Mediterranean Sea, i.e., the MAP. A List of SPAMI was established and in order to assist in the management, conservation, and protection of these listed habitats and threatened species, the RAC/SPA was established (Scovazzi 2004).

The List of SPAMI sites in the Mediterranean Sea may include areas of importance for the conservation of biological diversity, habitats and ecosystems specific to endangered species, and areas of special interest at the scientific, aesthetic, cultural, or educational levels. Under the legislation for the protection of SPAMI sites, Mediterranean States agree to recognize the particular importance of these sites and to comply with applicable measures and avoid any activity that might be contrary to the objectives for which the SPAMI sites were established (UNEP 1995). The largest SPAMI site is the Pelagos Sanctuary for Mediterranean Marine Mammals or the International Ligurian Sea Cetacean Sanctuary in the western Mediterranean Sea.

6.3.2 International and Regional Initiatives relating to Marine Protected Areas

There are many international organizations and conventions that are dedicated to conservation in the Mediterranean Sea. This section details the most important of those organizations and the implementation of their respective conventions.

United Nations Environment Programme—In 1972, the UNEP began the development of its regional seas programs. In 1978, the UNEP Mediterranean States signed the Barcelona Convention for the protection of the Mediterranean Sea against pollution; the convention calls for the states to take every necessary means to minimize pollution and protect the marine environment (Becker and Choresh 2006). The

Barcelona convention also provided the legal framework for the MAP to assist in the implementation of the convention and associated protocols to enable the states to monitor the sea and identify environmental problems (Becker and Choresh 2006). In addition, the Mediterranean States created a Mediterranean Coordinating Unit in Athens and Regional Activity Centers. Later, in 1983, the Mediterranean SPA Protocol was adopted to assist in the selection, creation and management of marine and coastal protected areas. As of 1995, the SPA Protocol has been signed by 16 of the Mediterranean coastal States (except Syria and Libya) and the EC (Batisse and Jeudy de Grissac 1995).

International Maritime Organization—The MARPOL is the main international convention covering the prevention of pollution by oil, chemicals, harmful substances in packaged form, sewage, and garbage in the marine environment by ships from operational or accidental causes. The MARPOL Convention is a combination of two treaties adopted in 1973 and 1978 by the International Maritime Organization (IMO) and has been updated by amendments through the years (Becker and Choresh 2006).

United Nations Educational, Scientific, and Cultural Organization (UNESCO)—There are two main activities performed by the UNESCO. The first, the World Cultural and Natural Heritage, was adopted in 1972 and has been signed by all Mediterranean States with the exception of Israel. As of 1995, there were four natural/cultural sites on the list. The second, the Man and the Biosphere Program (MAB) was launched in 1971 to provide knowledge, skills, and human values to support harmonious relationships between people and their environment. Under the MAB program, a Biosphere Reserves (BR) is designated to promote conservation with the purpose of sustainable development and scientific research. As of 1995, 11 sites have been accepted as BRs (Batisse and Jeudy de Grissac 1995).

European Union—The EU has prepared directives for the conservation of biodiversity in the Mediterranean Sea; the Union works within the framework of the Charter of Nicosia (or the EuroMediterranean Cooperation concerning the Environment in the Mediterranean Basin) and through the implementation of its Special Action Program for the Mediterranean (MEDSAP). As of 1995, 70 sites have been designated in the Mediterranean Sea (20 for Spain, 7 for France, 33 for Italy and 10 for Greece) (Batisse and Jeudy de Grissac 1995).

Council of Europe—As of 1995, the Council of Europe included Cyprus, France, Greece, Italy, Spain, and Turkey. The Council of Europe works to conserve representative examples of European flora, fauna, and natural areas by designating a network of biogenetic reserves for Mediterranean Sea coastal ecosystems (Batisse and Jeudy de Grissac 1995).

Ramsar Convention—In 1971, the Ramsar Convention was adopted to provide the framework for the international conservation of wetland habitats. The Convention was entered into force in 1975 by placing general obligations on contracting parties (Algeria, Bulgaria, Egypt, France, Greece, Italy, Malta, Morocco, Spain, and Tunisia, as well as the former Union of the Soviet Socialist Republic [USSR] and Yugoslavia) to the conserve wetlands and special obligations for designated wetlands in the “List of Wetlands of International Importance.” As of 1995, there were 61 sites listed for these countries along the coast of the Mediterranean Sea (33 for Italy, 8 for Greece, 7 for Spain, 3 for Bulgaria and Ukraine, 2 for Egypt and Algeria, and 1 for France, Malta, and Tunisia; Batisse and Jeudy de Grissac 1995).

Bonn Convention—The Bonn Convention (Convention on Migratory Species of Wild Animals) promotes international agreements between contracting parties (Egypt, Israel, Italy, Spain, Tunisia, and EC) for the conservation of migratory species. The convention classifies migratory species into four categories according to their migration patterns (Batisse and Jeudy de Grissac 1995).

Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)—The CITES regulates the international trade of endangered species of fauna and flora. The CITES contracting parties includes Algeria, Cyprus, Egypt, France, Israel, Italy, Monaco, Morocco, Spain, and Tunisia (Batisse and Jeudy de Grissac 1995).

European Program for the Mediterranean—The European Program for the Mediterranean (EPM) was developed by the European Investment Bank and the World Bank. In 1990, a second phase, the

Mediterranean Environmental Technical Assistance Program (METAP), was launched to identify investment projects and prepare institutional development activities for environmental management. Specific policy measures were defined in the following priority areas: integrated water resource management, solid and hazardous waste management, prevention and control of marine oil and chemical pollution, and coastal zone management. Within this last priority of coastal zone management, there is a significant biodiversity emphasis wherein Mediterranean States are provided assistance for activities that promote the conservation of protected areas and an organizational network of Mediterranean Marine Protected Areas (MedPAN; Batisse and Jeudy de Grissac 1995).

International Nongovernmental Organizations (NGOs)—There are numerous international NGOs that are very active in the Mediterranean Sea. Some of the international NGOs include the WWF, IUCN, Greenpeace, Friends of the Earth, and the European Environmental Bureau (EEB). A protected areas action plan was developed by the IUCN that includes a section on MPAs in the Mediterranean Sea (Batisse and Jeudy de Grissac 1995).

6.3.3 Marine Protected Areas in the Eastern Mediterranean Study Area

As of 1995, the Ionian Sea had only one MPA (Italy) in the Ionian Basin and there were no protected areas along the North African coast. This region between the Gulf of Gabes (Tunisia) and the Gulf of Sirte (Libya) harbors some of the world's largest seagrass meadows that cover more that 1,500 km^2, constituting one of the most important Mediterranean Sea features. In addition, endemism in this region is high due to the fact that it is far from the influence of the Atlantic Ocean and Red Sea. The Levantine Basin harbors nine MPAs (one in Cyprus, three in Israel, and five in Turkey); the Aegean Sea includes four MPAs (one in Greece and three in Turkey) although they do not protect the nearly 20,000 km of coastline that is one of the most important places for the endangered Mediterranean monk seal; the Adriatic Sea harbors 10 MPAs (two in Italy, two in Slovenia, five in Croatia, and one in Montenegro; Batisse and Jeudy de Grissac 1995).

A current list and map of MPA sites have been compiled for the eastern Mediterranean Sea in **Table 6-3** and **Figure 6-5** (Mabile and Piante 2005); these resources were constructed from two on-line lists of MPAs world-wide and in the Mediterranean Sea, MPA Global[5] and MedPAN[7]. Of the 123 MPAs within the eastern Mediterranean Sea (**Figure 6-5**), none are located within the eastern Mediterranean Study Area.

Table 6-3. Marine protected areas in the eastern Mediterranean Study Area (Mabile and Piante 2005).[5,7]

Site Name	**Marine Area Surface**	Type of Site; ***International Recognition***	**Principal Marine Species**
Cyprus			
Lara Toxeftra	650 ha	Nature Reserve	Sea turtles (*Caretta caretta*, *Chelonia mydas*) and Ghost crab (*Ocypode cursor*)
Larnaca Saltwater Lake	668 ha	Permanent Game Reserve	
Paedagogical Akademi	45 ha	National Forest Park	
Potamos Liopetriou	89 ha	National Forest Park	
Tripylos	823 ha	Nature Reserve	
Croatia			
Limski Zaljev	600 ha	Special Marine Reserve	No information

Brijuni	3,385 ha	National Park	*Pinna nobilis*, *Alcyonium acaule*, *A. brionense*, *Lithophaga lithophaga*, *Jadaranski bračić*, *Jadaranski ciganin*, *Ircinia variabilis*, etc.
Telascica	6,706 ha	Nature Park	Fauna (Porifera, Polyplacophora, Gastropoda, Bivalvia, Echiura, Corallinacea, etc.) Flora (*Goniolithon byssoides*, *Posidonia oceanica*, *Cymodocea nodosa*, etc.)
Kornati	22,380 ha	National Park	*Pinna nobilis*, *Alcyonium acaule*, *A. brionense*, *Lithophaga lithophaga*, *Jadaranski bračić*, *Jadaranski ciganin*, *Ircinia variabilis*, etc.
Malostonski Zalijev	4,821 ha	Special Marine Reserve	No information
Mljet	5,375 ha	National Park	*Cladocora caespitosa*, *Pinna nobilis*, *Lithophaga lithophaga*, *Aurelia* sp., *Tima* sp., *Posidonia oceanica*
Egypt			
Arish-Rafah (El Ahrish El Shamalia) Coastline PA	No information	Protected Area	
Ashtum El Gamil	17,120 ha	Nature Reserve	
El Omayed	70,000 ha	Protected Area	
Lake Burullus	46,000 ha	Protected Area	
Mersa Matrouh	No information	Protected Area	
Zaranik	17,000 ha	Protected Area	
Greece			
Alonissos-Vories Sporades	226,500 ha	National Marine Park	*Delphinus delphis*, *Globicephala melas*, *Monachus monachus*, *Orcinus orca*, *Pseudorca crassidens*, *Stenella coeruleoalba*, *Antipathes* spp., *Corallium rubrum*, *Palinurus elephas*, *Physeter catodon*.
Antimilos Kykladon	795 ha	Game Breeding Station	
Dasi nisou Skiathou Magnisias	1,500 ha	Aesthetic Forest	
Delta Evrou	9,267 ha	Protected Area	
Dias Irakleiou	1,250 ha	Controlled Hunting Area	
Pefkias Xylokastrou Korinthias	27 ha	Aesthetic Forest	
Sapientza Kalamatas	850 ha	Controlled Hunting Area, Natural Monuments and Landmarks	
Sounio	3,500 ha	Core Zone in National Park	
To nisi Piperi stis Voreies Sporades	438 ha	Natural Monuments and Landmarks	

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Greece (*continued*)			
Ypoleima ydrocharous dasous stin Istiaia Evoias	0.8 ha	Natural Monuments and Landmarks	
Zankynthos	8,920 ha	National Marine Park	*Posidonia oceanica*, *Caretta caretta*, *Monachus monachus*
Israël			
Har Hakarmel	10,160 ha	Nature Reserve	
Hof Atlit	43 ha	Nature Reserve	
Hof Hasharon	125 ha	National Park	
Iyye Hof Rosh Ha-niqra	31 ha	Nature Reserve	
Nahal Alexander	374 ha	National Park	
Rosh Hanikra	440 ha	National Park, Nature Reserve	
Taninim river	6 ha	Nature Reserve	
Yam Dor HaBonim	530 ha	Marine Nature Reserve	No information
Yam Evtah	137 ha	Marine Nature Reserve	No information
Yam Gador	84 ha	Marine Nature Reserve	No information
Italy			
Archipelago di La Maddalena	15, 050 ha	National Park; ***Worldwide network of geosites-geoparcs (UNESCO)***	*Posidonia oceanica*, *Gerardia savalia*, *Patella ferruginea*, *Pinna nobilis*, *Lithophyllum byssoides*, *Paramuricea clavata*
Archipelago Toscano	56,770 ha	National Park; ***Biosphere Reserve***	*Posidonia oceanica*, *Pinna nobilis*, *Hippocampus hippocampus*, *Delphinus delphis*, *Physeter macrocephalus*, *Tursiops truncates*, *Corallium rubrum*, *Paracentrotus lividus*, *Scyllarides latus*, *Epinephelus marginatus*, *Thunnus thynnus*, *Acetabularia acetabulum*, *Penicillus capitatus*, *Padina pavonica*, *Actinia equina*, *Eunicella cavolinii*, *Eunicella* sp., *Paramuricea clavata*, *Echinaster sepositus*, *Haliotis tuberculata*, *Octopus vulgaris*, *Patella caerulea*, *Chthamalus stellatus*, *Boops boops*, *Mola mola*, *Mullus surmuletus*, *Sarpa salpa*, *Serranus scriba*, *Sabella spallanzanii*
Area Amantea	7,500 ha	Temporary Fishing Reserve	
Area Tremiti	2,116 ha	Fishing Reserve	

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Italy (*continued*)			
Baia	176 ha	Submerged National Park	
Capo Caccia – Isola Piana	2,631 ha	Marine Protected Area	*Posidonia oceanica, Lithophyllum lichenoides, Centrostephanus longispinus, Lithophaga lithophaga, Pinna nobilis, Hippocampus hippocampus, Stenella coeruleoalba, Tursiops truncatus, Corallium rubrum, Cymodocea nodosa, Acetabularia acetabulum, Cystoseira* sp.*, Peyssonnelia squamaria, Anemonia sulcata, Cerianthus membranaceus, Paramuricea clavata, Brissus unicolor, Echinus melo, Dicentrarchus labrax, Lophius piscatorius, Seriola dumerili, Sparus aurata*
Capo Carbonara	8,598 ha	Marine Protected Area	*Posidonia oceanica, Pinna nobilis, Monachus monachus*, etc.
Capo Gallo	2,173 ha	Natural Marine Protected Area	*Posidonia oceanica, Pinna nobilis, Paramuricea clavata, Gnathophyllum elegans, Scyllarus arctus, Dicentrarchus labrax, Grammonus ater*
Capo Rizzuto	14,720 ha	Marine Protected Area	*Posidonia oceanica, Caretta caretta*, etc.
Castellabate Fishery Reserve (Zona di Tutela) FiR	4,400 ha	Fishing Reserve	
Cinque Terre	4,591 ha	Natural Marine Protected Area	*Pinna nobilis, Homarus gammarus, Palinurus elephas, Scyllarides latus, Scyllarus arctus, Epinephelus marginatus, Polyprion americanus*
Foce del Isonzo	1,154 ha	Nature Reserve	
Gaiola	41 ha	Submerged National Park	
Golfo di Portofino	346 ha	Natural Marine Protected Area	*Corallium rubrum, Epinephelus marginatus, Eunicella* sp., *Paramuricea clavata*
Gulf of Castellammare	20,000 ha	Trawl Ban Area	
Isola Asinara	21,000 ha	National Park / Natural Marine Protected Area ***SCI "Island of Asinara"***	*Posidonia oceanica*, *Laminaria rodriguezii*, *Lithophyllum lichenoides*, *Patella ferruginea*, *Pinna nobilis*, *Caretta caretta*, *Corallium rubrum*
Isola Bergeggi	8 ha	Regional Nature Reserve	
Isola di Budelli	No information	Zona di Tutela Biologica Marina	
Isola di Caprera	1,575 ha	State Nature Reserve	

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Italy (*continued*)			
Isola di Ustica	15,961 ha	Natural Marine Protected Area	*Posidonia oceanica, Astroides calycularis, Pinna nobilis, Euspongia officinalis, Paracentrotus lividus, Palinurus elephas, Epinephelus marginatus, Sciaena umbra, Halimeda tuna, Anemonia sulcata, Octopus vulgaris, Parapandalus narval, Balistes capriscus, Chromis chromis, Coris julis, Mullus surmuletus, Muraena helena, Oblada melanura, Phycis phycis, Scorpaena scrofa*, *Seriola dumerili, Thalassoma pavo*
Isole Ciclopi	623 ha	Marine Protected Area	*Homarus gammarus, Palinurus elephas, Scyllarides latus, Actinia equina, Anemonia viridis,* *Echinaster sepositus, Sphaerechinus granularis, Myriapora truncata, Aporrhais pespelecani, Bolinus brandaris, Bolma rugosa, Discodoris atromaculata, Flabellina affinis, Octopus vulgaris, Patella caerulea, Dardanus arrosor, Ligia italica, Pachygrapsus marmoratus, Hermodice carunculata, Sabella spallanzani*
Isole dello Stagnone di Marsala	2,012 ha	Regional/Provincial Nature Reserve	
Isole di Ventotene e Santo Stefano	2,799 ha	Natural Marine Protected Area	*Calonectris diomedea, Puffinus yelkouan, Falco peregrinus*
Isole Egadi	53,992 ha	Natural Marine Protected Area	*Posidonia oceanica, Astroides calycularis, Pinna nobilis, Caretta caretta, Cystoseira* sp.
Isole Pelagie	3,230 ha	Natural Marine Protected Area; ***Natura 2000 Special Protection Area, Proposed Site of Community Interest***	*Posidonia oceanica, Pinna nobilis, P. rudis* (= *P. pernula*), *Caretta caretta, Balaenoptera physalus, Tursiops truncatus, Cladocora caespitosa, Sphaerechinus granularis, Flabellina affinis*

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Italy (*continued*)			
Isole Tavalora-Punta Coda Cavallo	15,360 ha	Natural Marine Protected Area	*Posidonia oceanica, Goniolithon byssoides, Lithophyllum lichenoides, Aplysina* spp., *Axinella polypoides, Tethya* spp., *Gerardia savalia, Asterina pancerii, Centrostephanus longispinus, Ophidiaster ophidianus, Erosaria spurca, Lithophaga lithophaga, Luria lurida* (= *Cypraea lurida*), *Patella ferruginea, Pinna nobilis, Hippocampus hippocampus, Monachus monachus, Tursiops truncatus, Paracentrotus lividus, Homarus gammarus, Maja squinado, Palinurus elephas, Scyllarides latus, Scyllarus arctus, S. pygmaeus, Epinephelus marginatus, Sciaena umbra, Thunnus thynnus, Cymodocea nodosa, Cladocora caespitosa, Paramuricea clavata*, *Arbaciella elegans, Podarcis tiliguerta ranzii, Eunicella verrucosa*
Isole Tremiti	1,466 ha	Natural Marine Protected Area	*Posidonia oceanica, Astroides calycularis, Pinna nobilis, Hippocampus hippocampus, Corallium rubrum, Palinurus elephas, Epinephelus marginatus, Sciaena umbra, Cystoseira* sp., *Axinella* sp., *Eunicella cavolinii, Parazoanthus axinellae, Antedon mediterranea, Conger conger, Diplodus* sp., *Muraena helena, Polyprion* sp.
Lagoon of Kotichi	800 ha	Other Area	
Laguna di Ponente di Orbetello	9,500 ha	Regional/Provincial Nature Reserve	
Le Montagne delle Felci e dei Porri	1,521 ha	Regional/Provincial Nature Reserve	
Miramare - Golfo di Trieste	120 ha	Marine Protected Area; ***Biosphere Reserve***	*Pinna nobilis, Sciaena umbra, Fucus virsoides, Cladocora caespitosa, Lipophrys adriaticus, Salaria pavo, Platichthys flesus italicus*
Monte di Portofino	4,660 ha	Regional/Provincial Nature Park	
Montecristo	1,039 ha	State Nature Reserve, Fishing Reserve	
Oasi blu di Gianola	5 ha	Public Maritime Domain	
Oasi blu di Monte Orlando	30 ha	Public Maritime Domain	
Oasi blu di Scogli di Isca	6 ha	Public Maritime Domain	
Oasi blu di Villa di Tiberio	10 ha	Public Maritime Domain	

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Italy *(continued)*			
Penisola del Sinis-Isola di Mal di Ventre	24,800 ha	Marine Protected Area, Zona di Tutela Biologica Marina; ***Special Protection Area, Proposed Site of Community Interest, EU Directive 73/409, EU Directive 92/43***	*Posidonia oceanica, Patella ferruginea, Pinna nobilis, Larus audouinii, Corallium rubrum, Paramuricea clavata*
Plemmirio	184,000 ha	Natural Marine Protected Area	
Porto Cesareo	17,156 ha	Natural Marine Protected Area	*Posidonia oceanica, Caretta caretta, Dermochelys coriacea, Umbrina cirrosa, Sciaena corboasprensis, Dentex dentex, Diplodus* sp., *Epinephelus aeneus, E. alexandrinus, E. marginatus, Lithognathus mormyrus , Mullus surmuletus, Pagellus acarne, Puntazzo puntazzo, Scorpaena* sp., *Xyrichtys novacula*
Portoferraio	160 ha	Fishing Reserve	
Portofino	346 ha	Natural Marine Protected Area	
Punta Campanella	1,539 ha	Natural Marine Protected Area	*Posidonia oceanica, Hippocampus hippocampus, Paracentrotus lividus, Actinia equina, Anemonia sulcata, Cribrinopsis crassa, Eunicella cavolinii, E. singularis, Paramuricea clavata, Asterina gibbosa, Coscinasterias tenuispina, Echinaster sepositus, Marthasterias glacialis, Ophioderma longicauda, Psammechinus microtuberculatus, Sphaerechinus granularis, Sertella beaniana, Clanculus corallinus, Haliotis lamellosa, Littorina neritoides, Osilinus turbinata, Patella caerulea, Balanus perforatus, Eriphia verrucosa, Maia verrucosa, Pachygrapsus marmoratus, Hippocampus guttulatus, Halocynthia papillosa*
Sacca di Gorino	479 ha	Regional/Provincial Nature Reserve	
Salina di Margherita di Savoia	3,871 ha	State Nature Reserve	
Salina di Tarquinia	170 ha	State Nature Reserve	
Secche di Tor Paterno	1,387 ha	Marine Protected Area	*Posidonia oceanica, Pinna nobilis, Paramuricea clavata, Epinephelus marginatus*

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Italy *(continued)*			
Tegnùe di Chioggia	2,650 ha	No-Take Zone	
Tomboli di Cecina	465 ha	State Nature Reserve	
Torre Guaceto	2,227 ha	Marine Protected Area	*Posidonia oceanica, Astroides calycularis, Pinna nobilis, Eupongia officinalis, Paracentrotus lividus, Palinurus elephas, Epinephelus marginatus, Sciaena umbra, Halimeda tuna, Anemonia sulcata, Octopus vulgaris, Parapandalus narval, Balistes capriscus, Chromis chromis, Coris julis, Mullus surmuletus, Muraena helena, Oblada melanura, Phycis phycis, Scorpaena* sp., *Seriola dumerili, Thalassoma pavo*
Zingaro	1,600 ha	Regional/Provincial Nature Reserve	
Lebanon			
Palm Island	500 ha	Nature Reserve; ***RAMSAR site***	*Caretta caretta, Monachus monachus, Epinephelus marginatus, Boops boops, Coris julis, Dentex dentex, Diplodus sargus, Diplodus* sp., *D. vulgaris, Mycteroperca rubra, Oblada melanura, Pempheris vanicolensis, Sargocentron rubrum, Serranus cabrilla, S. scriba, Siganus luridus, S. rivulatus, Sparisoma cretense, Stephanolepis diaspros, Symphodus tinca, Thalassoma pavo*
Lybia			
Kouf	35,000 ha	National Park	
Serbia and Montenegro			
Boyana (Bojana) River Delta	20 ha	Nature Reserve	
Kotorsko Risanski Zaliv	2,600 ha	Nature Reserve	
Slovenia			
Cape Madona	13 ha	Natural Monument	*Geodia cydonium, Lithophaga lithophaga, Pholas dactylus, Pinna nobilis, Hippocampus hippocampus, Hippospongia communis, Halimeda* sp., *Cystoseira* sp., *Dictyota* sp., *Padina* sp., *Sargassum* sp., *Cladocora caespitosa, Astraea rugosa, Chromis chromis, Sciaena corboasprensis, Symphodus* sp., *Diplodus sargus, Oblada melanura, Serranus scriba, Protula tubularia, Serpula vermicularis, Spirographis spallanzani*

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Slovenia (*continued*)			
Debeli rtiç	16 ha	Natural Monument	*Pinna nobilis, Paracentrotus lividus, Cymodocea nodosa, Anemonia sulcata, Cerithium vulgatum, Murex truncatus, Mytilus galloprovincialis, Ostrea edulis, Maia verrucosa, Aplysina aerophoba*
Strunjan	90 ha	Nature Reserve	*Zostera noltii, Lithophaga lithophaga, Pinna nobilis, Cymodocea nodosa, Cystoseira* sp., *Cladocora caespitosa, Maia* sp., *Spirographis spallanzani*
Syria			
Fanar Ibn Hani	1,000 ha	Protected Area	*Axinella polypoides, Monachus monachus, Cymodocea nodosa, Caulerpa racemosa* variety (var.) *lamourouxii, Penicillus capitatus, Ircinia* sp., *Cerithium scabridum, Strombus decorus, Diplodus vulgaris, Sargocentron rubrum, Siganus rivulatus*
Om Al Toyour	1,000 ha	Protected Area	*Lithophaga lithophaga, Caretta caretta, Chelonia mydas, Monachus monachus, Tursiops truncatus, Crambe crambe, Ircinia fasciculate, Pinctada radiata, Diplodus* sp., *Sarpa salpa, Siganus luridus, Thalassoma pavo*
Ras El Bassit	3,000 ha	Protected Area	*Axinella polypoides, Caretta caretta, Chelonia mydas, Monachus monachus, Epinephelus marginatus, Halophila stipulacea, Zostera* sp., *Anadyomene* sp., *Penicillus capitatus, Axinella sp., Strombus decorus, Coris julis, Diplodus vulgaris, Sarpa salpa, Serranus scriba*
Sabkhat al Jabboul	320 ha	Protected Area	
Tunisia			
Archipel de La Galite	450 ha	Nature Reserve, Marine and coastal protected area; ***SPAMI***	*Astroides calycularis, Pinna nobilis, Cladocora caespitosa*
Salines de Thyna	860 ha	Wetland Zone of National Importance	
Zembra and Zembretta	4,700 ha	National Park, Marine and coastal protected area; ***SPAMI, Biosphere Reserve***	*Axinella cannabina, Astroides calycularis, Centrostephanus longispinus, Ophidiaster ophidianus, Dendropoma petraeum, Pinna nobilis, Euspongia officinalis, Sciaena umbra, Dentex dentex*
Turkey			
Beydaglari coastal	34,430 ha	National Park	

Table 6-3. Continued.

Site Name	Marine Area Surface	Type of Site; ***International Recognition***	Principal Marine Species
Turkey (*continued*)			
Datça-Bozburun	76,300 ha	Specially Protected Area	*Posidonia oceanica, Zostera marina, Cystoseira amentacea* (including var. *stricta* and var. *spicata*), *Cystoseira mediterranea, Cystoseira spinosa* (including *C. adriatica*), *C. zosteroides, Axinella cannabina, A. polypoides, Astroides calycularis, Centrostephanus longispinus, Charonia tritonis* (= *C. seguenziae*), *Erosaria spurca, Luria lurida* (= *Cypraea lurida*), *Pinna nobilis, Tonna galea, Delphinus delphis, Monachus monachus, Cystoseira* sp., *Ircinia* sp.
Dilek Yarimadisi	10,990 ha	National Park	
Fethiye-Göcak	31,300 ha	Specially Protected Area	
Foca	1,200 ha	Specially Protected Area	
Gelibolu Yarimadisi (Galipoli)	33,000 ha	National Park	
Gokova	27,600 ha	Specially Protected Area	
Göksu Deltasi	11,200 ha	Specially Protected Area	
Kekova	11,500 ha	Specially Protected Area, Nature Protection Area, Archaeological Protection Area	*Posidonia oceanica, Pinna nobilis, Monachus monachus*
Köycegiz-Dalyan	10,200 ha	Specially Protected Area	
Patara	4,200 ha	Specially Protected Area	

* International Recognition designated in bold italic font.

The above **Table 6-3** and **Figure 6-5** are areas that are currently protected; however, the following list and map (**Figure 6-6**) are areas (based on Greenpeace International 2006) that are not necessarily protected areas, but are areas of significant importance based on available information on species and habitats of the eastern Mediterranean Study Area:

- South Messina Strait—The waters of the Strait of Messina support a large upwelling system. Because of this upwelling, it is a highly productive area; it can support sperm and fin whales and is a spawning area for tuna and swordfish. It is also a migratory route for pelagic fish, whales, and dolphins. It contains numerous seamounts and one of the largest seamounts in the Mediterranean Sea, the Marsili Seamount rises 3,000 m from the seabed.

- Strait of Sicily—The Strait of Sicily is a highly productive area and is considered a biodiversity hotspot in the Mediterranean Sea. It is an important area for sperm whales and fin whales, and the great white shark. Habitats include seamounts and deep-sea corals close to Sicily, and turtle nesting beaches, seagrass meadows, and sponge communities along the Tunisian coastline.

- Slope of Malta—The slope of Malta is also an area of high biodiversity and it contains an important area for juvenile anchovy and common dolphins. It is also thought be to a breeding area of great white sharks (*Carcharodon carcharias*).[12] It has been proposed by ACCOBAMS for status as a MPA.

- Medina Ridge—The Medina Ridge contains many important deep-sea habitats including many seamounts, such as the Epicharmos and Archimedes Seamounts.

- Gulf of Sirte—The Gulf of Sirte provides an important habitat as a feeding ground for the northern bluefin tuna. In addition, the coastline provides habitats as turtle nesting beaches and seagrass meadows.

- Libyan head—The coastal area of East Libya contains seagrass meadows that provide important fish nursery areas. Habitats include beaches for turtle nesting, further offshore are seamounts, including the Herodotus Seamount, and cold seeps.

- Strait of Otranto—This area is an important site of deep-sea corals, including the rare white coral, Lophelia. In 2006, it was partially protected by a GFCM ban on trawling and it has been recommended for protection by WWF and IUCN.

- Hellenic trench—The Hellenic Trench contains deep-sea features including the Calypso Deep, the deepest part of the Mediterranean Sea, important habitats such as cold seeps and seamounts, turtle nesting beaches along the Greece coastline(some protected areas), and is an important area for sperm whale and Cuvier's beaked whale. It has been recommended for protection by Pelagos, a marine NGO, and the area south-west of Crete has been recommended as a MPA for sperm whales by ACCOBAMS.

- Olimpi—The Olimpi mud volcano field south of Crete contains important deep-sea features such as mud volcanoes, cold seeps, brine pools, and chemosynthetic communities.

- Central Levantine Sea—The Levantine Sea contains numerous deep-sea habitats including seamounts and cold seeps. It is also an important spawning ground for swordfish, a commercially important species in the Mediterranean Sea.

- Anaximander Mountains—The Anaximander mud volcano area south of Turkey contains important deep-sea features such as seamounts, mud volcanoes, cold seeps, and chemosynthetic communities. In addition, the adjacent coastline is a sea turtle nesting beach.

- Cypriot Channel—The Cypriot Channel between Cyprus and southern Turkey is an important spawning ground for bluefin tuna, frigate tuna, and Atlantic black skipjack and the coastlines of Cyprus and Turkey provide sea turtle nesting beaches for the endangered loggerhead turtle and green turtle.

- Eratosthenes Seamount—South of Cyprus and north of the Nile delta, the Eratosthenes seamount provides habitat for rare coral species such as *Caryophyllia calveri* and *Desmophyllum cristagalli*. It is also an important area for sperm whales, fin whales, and striped and bottlenose dolphins with the nearby coastline of Cyprus supplying a high concentration of turtle nesting beach habitat.

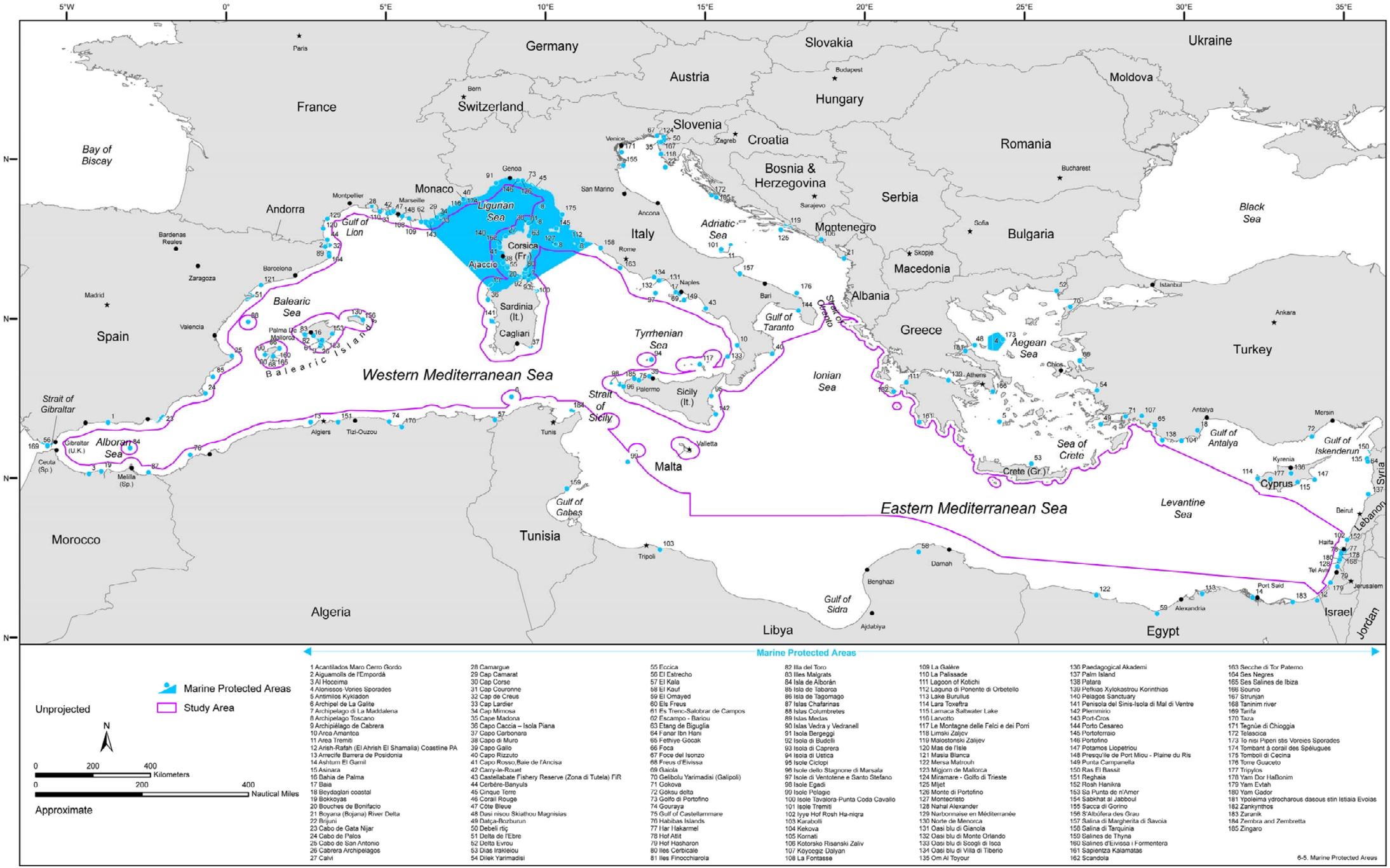


Figure 6-5. Marine protected areas in the eastern Mediterranean Study Area and vicinity. Source data: MPA Global5 and MedPAN7. Source maps (scanned): Mabile and Piante (2005).

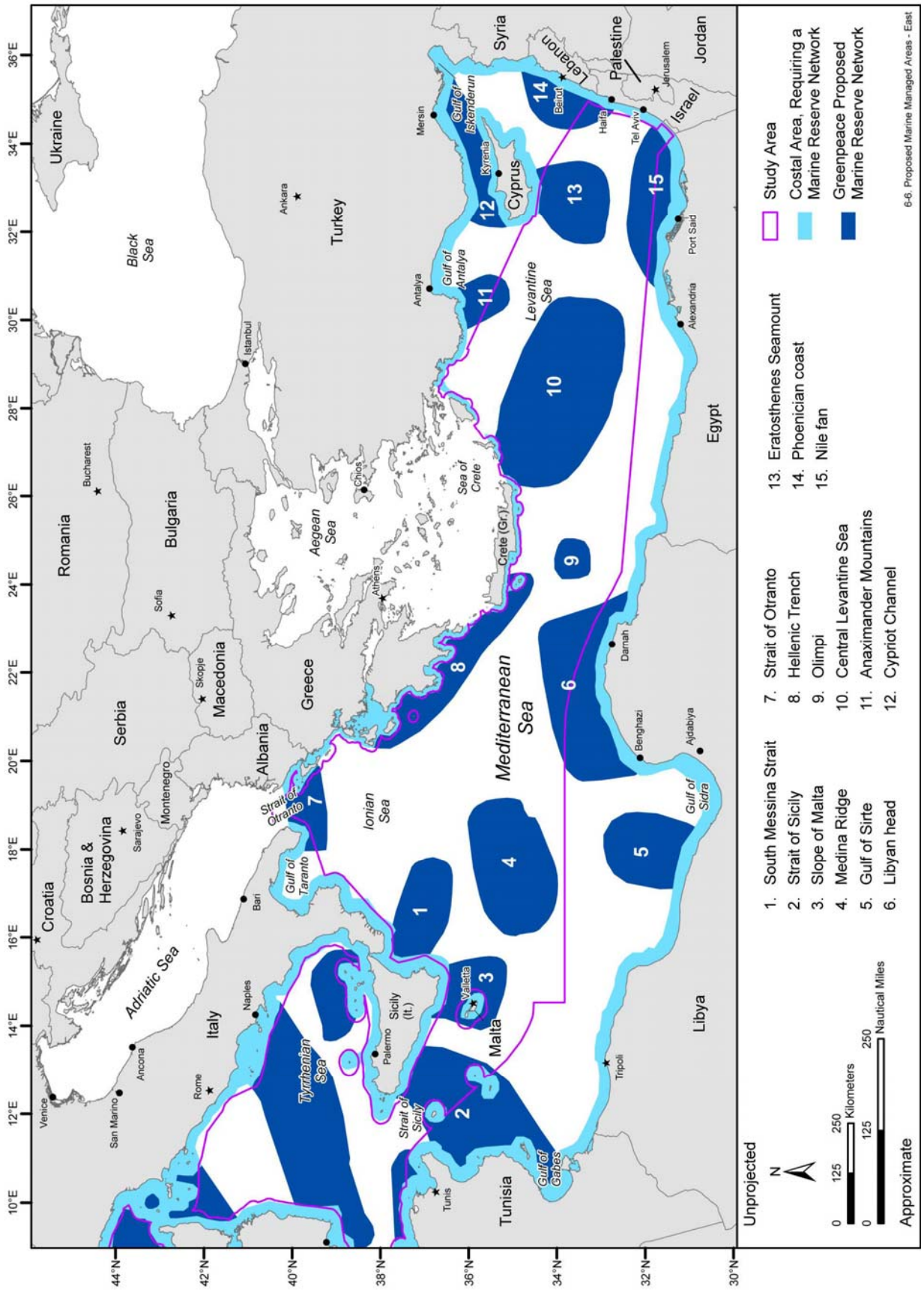


Figure 6-6. Proposed marine protected areas in the eastern Mediterranean Study Area and vicinity. Source maps (scanned): Greenpeace (2006).

- Phoenician coast—The Phoenician coast provides an important migratory route for tuna, a breeding area for loggerhead turtles, green turtles, and sharks (e.g., sand tiger [*Carcharias Taurus,* VU], gulper [*Centrophorus granulosus,* VU], and angel [*Squatina squatina,* CR]) are common in the area. In addition, habitats of hydrothermal vents support their associated chemosynthetic communities along the adjacent coastline.[12]

- Nile fan—The Nile fan is characterized by deep waters that contain submarine canyons and cold seeps that are areas of high biodiversity. The cold seeps emit mud, gas, fluids, and harbor high chemosynthetic community diversity and the area is also an important feeding ground for fish, including tuna. It has been protected by the GFCM by banning trawling (Greenpeace International 2006).

6.4 OIL AND GAS STRUCTURES

The oil platforms that are currently in the eastern Mediterranean Sea are listed in **Table 6-4** and shown in **Figure 4-5**. Some platforms are currently in use while others have been decommissioned. Platforms typically remain in place long after the oil or gas reserves are exhausted (Crema et al. 2001). Oil and natural gas have been found in several sections of the Mediterranean Sea. Offshore platforms can create unique ecosytems that are otherwise absent in the natural habitat. A discussion of oil and gas structures and their role as artificial habitats is available in **Section 4.4.4** of this document. In some areas of the Mediterranean Sea, offshore platforms may provide the only hard-bottom habitat and serve as artificial reefs, attracting aggregations of fish species and resulting in increased diversity (Fabi et al. 2004). Fishing is prohibited within 0.5 km radius of offshore platforms in the Mediterranean Sea, therefore, these artificial reefs may represent small protected areas where various marine life may experience greater survival opportunities (Fabi et al. 2004); however, the short-term and long-term ecological effects that oil platforms have on the Mediterranean Sea ecosystem require more investigation.

The eastern Mediterranean Sea is an important transit route between the Middle East/Russian oil and the consumers of the western European countries/U.S. The major importers of oil in the Mediterranean Sea region are Spain (net oil import 1.5 million barrels per day [bbl/d], 2003), Italy (net oil import 1.71 million bbl/d, 2003) and Greece (net oil import 400,838 bbl/d in 2002; Martini and Patruno 2005). In the eastern Mediterranean Sea, there is an offshore platform located in the Strait of Sicily in the Study Area between Sicily and Tunisia, five off the southeast coast of Sicily, over 20 off of Egypt between Alexandria and Port Said, and numerous platforms are in the Adriatic Sea and in the Gulf of Gabes, Tunisia. There are a total of five platforms located within the Study Area; one is located in the Strait of Sicily, 29.8 NM offshore of the southwest coast of Sicily and 50 NM offshore of Cape Bon, Tunisia, and four are located off of Egypt and range in distance from 20.2 to 28.2 NM from the shore (**Figure 4-5**; IHS Energy 2006).

Table 6-4. Oil platforms in the eastern Mediterranean Sea (IHS Energy 2006).

Platform Name	Status	Structure	Installation Date	Permanent?
Croatia				
Ivana A	In place	Fixed Steel	1986	Y
Ivana B	In place	Fixed Steel	September 2000	N
Ivana C	Planned	Fixed Steel		N
Ivana D	In place	Fixed Steel	2000	N
Ivana E	In place	Fixed Steel	2000	
Ika West A	In place	Fixed Steel	1986	N
Egypt				
Abu Qir West A	In place	Fixed Steel	1993	N
Abu Qir North (NAF) A	In place	Fixed Steel	1986	N
Abu Qir North (NAF) B	In place	Fixed Steel	1993	N

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Egypt (*continued*)				
Nidoco NID-09	In place	Monopod Structure	1997	N
Port Fouad Marine A	In place	Fixed Steel	June 1995	N
Wakar A	In place	Fixed Steel	1996	N
Rosetta 3 A	In place	Fixed Steel	1998	N
Baltim South A	In place	Monopod Structure	February 1997	N
Abu Qir TP	In place	Fixed Steel	1985	Y
Abu Qir A-C	In place	Fixed Steel	1993	N
Abu Qir B-C	In place	Fixed Steel	1993	N
Abu Qir LQ	In place	Fixed Steel	1985	Y
Ha'py A	In place	Fixed Steel		
Karous A	In place	Monopod Structure		
Darfeel (Petrobel) A	In place	Fixed Steel		
Darfeel (Petrobel) D-01	In place	Monopod Structure		
Baltim North BN-1	In place	Fixed Steel		
Baltim East A	In place	Fixed Steel		
Port Fouad Marine SE 2 M-SE 02	In place	Monopod Structure		
Port Fouad Marine M-SW 02	In place	Monopod Structure		
Darfeel (Petrobel) D	In place	Fixed Steel		
Port Fouad Marine RPP	In place	Fixed Steel		
Nouras B-03	In place	Monopod Structure		
Nouras A-01	In place	Monopod Structure		
Barboni B-01	In place	Fixed Steel		
Temsah 4/8	In place	Fixed Steel		
Denise NW-1/3	In place	Fixed Steel		
Akhen A	In place	Fixed Steel		
Nidoco NID-10	In place	Monopod Structure		
Port Fouad Marine SE 1 M-SE 01	In place	Monopod Structure		
Abu Qir A	In place	Fixed Steel	1977	Y
Abu Qir B	In place	Fixed Steel	1983	Y
Greece				
Prinos Alpha	In place	Fixed Steel	July 1979	N
Prinos Beta	In place	Fixed Steel	July 1979	N
Prinos Delta	In place	Fixed Steel	October 1980	Y
Kavala South Kappa	In place	Fixed Steel	1980	Y
Italy				
Rospo Mare RSMA	In place	Fixed Steel	July 1981	Y
Rospo Mare RSMB	In place	Fixed Steel	July 1986	Y
Perla Perla	In place	Fixed Steel	February 1981	N
Nilde FPSO	In place	Buoyant Tower		Y
Vega Vega A	In place	Fixed Steel	November 1986	Y

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Italy (*continued*)				
Prezioso Prezioso	In place	Fixed Steel	1987	N
Ravenna Mare-Punta Marina RM A	In place	Fixed Steel	1967	N
Ravenna Mare-Punta Marina RA 6 bis	In place	Fixed Steel	1963	N
Cesenatico Mare CS 1	Decommissioned	Fixed Steel	1961	N
Cesenatico Mare CS 3	Decommissioned	Fixed Steel	1965	N
Cesenatico Mare CS 4	Decommissioned	Fixed Steel	1965	N
Porto Corsini Mare Est PCE B	In place	Fixed Steel	1968	Y
Porto Corsini Mare Est PC 1 bis	In place	Fixed Steel	1968	N
Porto Corsini Mare Est PC 80	In place	Fixed Steel	1981	Y
Porto Corsini Mare Est PC 80 bis	In place	Fixed Steel	May 1983	N
Porto Corsini Mare Est PC 3	In place	Fixed Steel	1963	N
Porto Corsini Mare Est PC 4	In place	Fixed Steel	1964	N
Porto Corsini Mare Est PC 9	In place	Fixed Steel	1966	N
Porto Corsini Mare Est PC 25 bis	In place	Fixed Steel	1976	N
Porto Corsini Mare Est PC 27	In place	Fixed Steel	1979	N
Porto Corsini Mare Est PC 30	In place	Fixed Steel	1982	N
Porto Corsini Mare Est PCE C	In place	Fixed Steel	1987	N
Ravenna Mare Sud RM Sud 1	In place	Fixed Steel	1963	N
Ravenna Mare Sud RM Sud 5	In place	Fixed Steel	1968	N
Cervia/Arianna Cervia A	In place	Fixed Steel	1971	Y
Cervia/Arianna Cervia B	In place	Fixed Steel	July 1984	N
Porto Corsini Mare Ovest PCW B	In place	Fixed Steel	1968	Y
Porto Corsini Mare Ovest PCW PRO	In place	Fixed Steel	1968	N
Porto Corsini Mare Ovest PCW C	In place	Fixed Steel	1987	N
Amelia Mare A	In place	Fixed Steel	1971	Y
Amelia Mare B	In place	Fixed Steel	February 1991	N
Amelia Mare C	In place	Fixed Steel	April 1991	N

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Italy (continued)				
Porto Garibaldi-Agostino GAR-A	In place	Fixed Steel	1969	N
Porto Garibaldi-Agostino GAR-B	In place	Fixed Steel	1969	N
Diana Diana	In place	Fixed Steel	1971	N
Cervia/Arianna Arianna A	In place	Fixed Steel	July 1984	N
Emilio Emilio 3	In place	Subsea Production		N
Emilio Emilio	In place	Fixed Steel	1989	N
Luna A	In place	Fixed Steel		Y
Luna B	In place	Fixed Steel		N
Antonella Antonella	In place	Fixed Steel	1976	Y
Barbara A	In place	Fixed Steel	September 1978	N
Barbara C	In place	Fixed Steel	1985	Y
Barbara D	In place	Fixed Steel	June 1986	Y
Barbara E	In place	Fixed Steel	1987	Y
Barbara F	In place	Fixed Steel	1988	Y
Emma Ovest Emma W	In place	Fixed Steel	February 1981	N
Fratello Est	In place	Fixed Steel	1979	N
Fratello Cluster	In place	Cluster	1979	N
Armida Armida 1	In place	Fixed Steel	1973	N
Anemone 2	In place	Fixed Steel	1973	N
Anemone 1-3x ("cluster")	In place	Fixed Steel	1979	N
Angela/Angelina Angela 1-2-3-4	In place	Fixed Steel	1975	N
Azalea A	In place	Fixed Steel	1975	N
Azalea B (production)	In place	Fixed Steel	1987	N
Lavinia Lavinia 3	In place	Subsea Production		N
Squalo Centrale Squalo Centrale	In place	Fixed Steel	1979	N
Basil Basil	In place	Fixed Steel	April 1983	N
Clara Ovest A	In place	Fixed Steel	1987	N
Gianna Gianna	In place	Fixed Steel	1989	Y
Flavia Flavia	Decommissioned	Fixed Steel	1980	N
Fulvia Fulvia	In place	Fixed Steel	1981	N
Pennina Pennina	In place	Fixed Steel	July 1986	Y
Antares Antares A	In place	Fixed Steel	February 1985	N
Giovanna Giovanna	In place	Fixed Steel	December 1989	Y
David David	In place	Fixed Steel	1978	N
Mila FPS	In place	Floating		Y
Aquila FPSO Firenze	In place	Float.Prod.Stor.& Off	15 July 1997	Y
Gela Gela 1	In place	Fixed Steel		N

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Italy (continued)				
Gela Gela 2	In place	Fixed Steel		N
Rospo Mare RSMC	In place	Fixed Steel	October 1991	
Ravenna Mare-Punta Marina PM 3	In place	Fixed Steel	1966	N
Cervia/Arianna Cervia C	In place	Fixed Steel	February 1992	Y
Cervia/Arianna Cervia cluster	In place	Fixed Steel	January 1992	N
Amelia Mare D	In place	Fixed Steel	1992	N
Porto Garibaldi-Agostino AGO-A-Cluster	In place	Fixed Steel	1970	N
Porto Garibaldi-Agostino AGO-B	In place	Fixed Steel	1970	N
Porto Garibaldi-Agostino AGO-C	In place	Fixed Steel	1992	N
Porto Garibaldi-Agostino GAR-C	In place	Fixed Steel	March 1992	N
Barbara G	In place	Fixed Steel	1992	Y
Annabella Annabella	In place	Fixed Steel	1991	N
Santo Stefano Mare SSM-8	In place	Fixed Steel		N
Santo Stefano Mare SSM-1	In place	Fixed Steel		N
Santo Stefano Mare SSM-3	In place	Fixed Steel		N
Santo Stefano Mare SSM-101	In place	Fixed Steel		N
Barbara H	In place	Fixed Steel	1992	N
Porto Garibaldi-Agostino AGO-cluster D	In place	Fixed Steel	1993	N
Daria A	In place	Fixed Steel	June 1994	Y
Regina Regina 1	In place	Fixed Steel	1997	N
Bonaccia Bonaccia	In place	Fixed Steel	July 1997	N
Porto Corsini Mare Sud A	In place	Fixed Steel	May 1998	N
Porto Corsini Mare Sud PCM S1	In place	Fixed Steel	May 1998	N
Hera Lacinia-Linda A	In place	Fixed Steel	September 1995	N
Fabrizia Fabrizia	In place	Fixed Steel	1998	
Barbara T	In place	Fixed Steel	1985	N
Daria B	In place	Fixed Steel	August 1995	Y
Anemone B	In place	Fixed Steel	October 1998	N
Brenda Brenda T	In place	Fixed Steel	1987	Y
Azalea B (drilling)	In place	Fixed Steel	1986	

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Italy (continued)				
Barbara Nord-ovest NW	In place	Fixed Steel	1999	
Cervia/Arianna Arianna cluster	In place	Cluster	1992	
Antares Antares 1	In place	Fixed Steel	1982	
Porto Corsini Mare Ovest PCW T	In place	Fixed Steel	1987	
Porto Corsini Mare Est PC 7A	In place	Fixed Steel	1965	
Porto Corsini Mare Est PC 7B	In place	Fixed Steel	1965	
Porto Corsini Mare Est PC 8	In place	Fixed Steel	1966	
Porto Corsini Mare Est PC 10	In place	Fixed Steel	1966	
Porto Corsini Mare Est PC 11	In place	Fixed Steel	1966	
Clara Est Clara Est	In place	Fixed Steel	2000	
Eleonora Eleonora	In place	Fixed Steel	1987	N
Fratello Simonetta 1	In place	Fixed Steel	1997	
Fratello Viviana	In place	Fixed Steel	1998	
Morena Morena 1	In place	Fixed Steel	1996	
Angela/Angelina Angela/Angelina	In place	Fixed Steel	October 1995	Y
Ravenna Mare-Punta Marina RM Quarters	In place	Fixed Steel	1967	
Ravenna Mare-Punta Marina RA 4	In place	Fixed Steel	1960	
Ravenna Mare-Punta Marina RA 5	In place	Fixed Steel	1962	
Ravenna Mare-Punta Marina RA 7	In place	Fixed Steel	1963	
Porto Garibaldi-Agostino GAR-K	In place	Fixed Steel		
Giulia 1 Giulia 1	In place	Fixed Steel	1980	Y
Porto Corsini Mare Est PC 73	In place	Fixed Steel	1996	N
Annalisa Annalisa	In place	Fixed Steel	29 June 1999	
Sarago Mare Sarago Mare	In place	Fixed Steel	September 1982	Y
Porto Corsini Mare Est PCE A	In place	Fixed Steel	1967	N
Porto Corsini Mare Est PC 26	In place	Fixed Steel	1978	N
Porto Corsini Mare Ovest PCW A	In place	Fixed Steel	1968	Y
Porto Garibaldi-Agostino GAR-T	In place	Fixed Steel	1970	N

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Italy (continued)				
Barbara B	In place	Fixed Steel	1983	Y
Armida Armida A	In place	Fixed Steel	1985	N
Fratello Nord	In place	Cluster	1979	N
Brenda Brenda A	In place	Fixed Steel	1987	Y
Ravenna Mare-Punta Marina PM 2	In place	Fixed Steel	1965	N
Porto Garibaldi-Agostino GAR-D	In place	Fixed Steel	March 1993	N
Vega FSO	In place	Float.Stor.& Offload.		N
Santo Stefano Mare SSM-4	In place	Fixed Steel		N
Regina Regina	In place	Fixed Steel	1997	
Calpurnia Calpurnia	In place	Fixed Steel	2000	
Pandora Pandora	In place	Fixed Steel	2001	
Rospo Mare Alba Marina	In place	Float.Stor.& Offload.	1987	Y
Vongola Mare Vongola Mare	In place	Fixed Steel	1984	
Jole Jole	In place	Fixed Steel	2000	
Libya				
Bouri (NC041-B) DP 3	In place	Fixed Steel	June 1987	Y
Bahr Essalam (NC041-C) Sabratha	In place	Fixed Steel		
Al Jurf (137N-B) Farwah	In place	Float.Prod.Stor.& Off		
Bahr Essalam (NC041-C) CWE-01	In place	Subsea Template		
Bahr Essalam (NC041-C) CWE-02	In place	Subsea Template		
Bahr Essalam (NC041-C) CEA-01	In place	Subsea Template		
Bahr Essalam (NC041-C) CEA-02	In place	Subsea Template		
Bouri (NC041-B) DP 4	In place	Fixed Steel	September 1986	Y
Serbia and Montenegro				
unknown	In place	Fixed Steel	1986	N
Tunisia				
Miskar Template A	In place	Subsea Template	May 1993	N
Cercina WHP-A	In place	Fixed Steel	1994	N
Miskar WHP-A	In place	Fixed Steel	November 1994	N
Ashtart ASPT 2	In place	Tripod Structure	December 1975	N
Tazerka SALS & FPSO	In place	Float.Prod.Stor.& Off	1982	N
Ashtart ASPF 3	In place	Fixed Steel	March 1995	N
Ashtart ASPP 1	In place	Fixed Steel	1972	Y

Table 6-4. Continued.

Platform Name	Status	Structure	Installation Date	Permanent?
Tunisia (continued)				
Ashtart ASPF 1	In place	Fixed Steel	October 1973	Y
Ashtart ASPT 1	In place	Tripod Structure	October 1973	N
Ashtart ASPP 2	In place	Fixed Steel	December 1975	Y
Ashtart ASPF 2	In place	Fixed Steel	October 1985	Y
Turkey				
Marmara Kuzey A	In place	Fixed Steel	1997	N

6.5 WEBSITES ACCESSED

[1] GDAIS (General Dynamics Advanced Information Systems). 2003. Global maritime boundaries database. Accessed 17 October 2006. http://www.gd-ais.com/capabilities/offerings/sr/gmbd.htm

[2] NOAA (National Oceanic and Atmospheric Administration). 2006. U.S. Marine Cadastre. Accessed 4 January 2007. http://www.csc.noaa.gov/mbwg/htm/cadastre.htm

[3] DOALOS (Division for Ocean Affairs and the Law of the Sea). 2004. Maritime space: Maritime zones and maritime delimitation. Accessed 17 October 2006. http://www.un.org/Depts/los/LEGISLATIONANDTREATIES/index.htm

[4] Department of Ancient Near Eastern Art. 2000. "Ancient Trade Routes between Europe and Asia". In *Timeline of Art History*. New York: The Metropolitan Museum of Art, 2000–. Accessed 27 March 2007. http://www.metmuseum.org/toah/hd/trade/hd_trade.htm

[5] MPA (Marine Protected Areas) Global. 2006. A database of the world's Marine Protected Areas. Accessed 4 January 2007. http://mpaglobal.org/home.html

[6] CIA (Central Intelligence Agency). 2006. The World Factbook. Field Listing-Maritime claims https://www.cia.gov/cia/publications/factbook/fields/2106.html

[7] MedPAN (Mediterranean Marine Protected Areas). 2007. Accessed 06 February 2007. Marine protected areas in the Mediterranean. http://www.medpan.org/

[8] JNCC (Joint Nature Conservation Committee). 2007. Special Protection Areas (SPAs). Accessed 13 February 2007. http://www.jncc.gov.uk/page-162

[9] JNCC (Joint Nature Conservation Committee). 2007. Special Areas of Conservation (SACs). Accessed 13 February 2007. http://www.jncc.gov.uk/page-23

[10] East Med Ferries. 2007. Accessed 21 February 2007. http://uk.geocities.com/my_ferries/eastmed.html

[11] UNEP (United Nations Environment Programme). 2006. Global Resource Information Database-Europe. Accessed 4 January 2007.http://www.grid.unep.ch/product/map/images/EU_oildischargeb.gif

[12] IUCN (International Union of Conservation of Nature and Natural Resources). 2006. 2006 IUCN Red List of Threatened Species. Accessed 28 February 2007. http://www.iucnredlist.org.

[13] RAC-SPA (Regional Activity Centre for Specially Protected Areas).2007. Biodiversity in the Mediterranean. Accessed 23 March 2007. http://www.rac-spa.org/carasp.php?id_page=42

6.6 LITERATURE CITED

Agardy, T. 1999. Creating havens for marine life. Issues in Science and Technology 16(1):37-44.

Alsied, A.O. 2006. Delimitation of maritime boundaries with special reference to the EEZ and the IMO Conventions Regime: A Libyan case study. New York, New York: United Nations - The Nippon Foundation.

Batisse, M. and A. Jeudy de Grissac. 1995. Marine Region 3: Mediterranean. Pages 77-105 in Kelleher, G., C. Bleakley, and S. Wells, eds. A global representative system of marine protected areas. Volume I. Washington, D.C.: The Great Barrier Reef Marine Park Authority, The World Bank, The World Conservation Union (IUCN).

Becker, N. and Y. Choresh. 2006. Economic aspects of Marine Protected Areas (MPAs). Tunis Cedex, Tunisia: UNEP-MAP RAC\SPA.

Cacaud, P. 2005. Fisheries laws and regulations in the Mediterranean: A comparative study. Studies and Reviews. General Fisheries Commission for the Mediterranean No. 75. Rome, Italy: Food and Agriculture Organization of the United Nations.

Chape, S., J. Harrison, M. Spalding, and I. Lysenko. 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Philosophical Transactions of the Royal Society of London B 360:443-455.

Crema, R., D. Prevedelli, and A. Castelli. 2001. Effect of submerged structures on the diversity of macrozoobenthos in the northern Adriatic Sea. Pages 367-374 in Faranda, F.M., L. Guglielmo, and G. Spezie, eds. Mediterranean ecosystems: Structures and processes. Milano, Italy: Springer-Verlag Italia.

Fabi, G., F. Grati, M. Puletti, and G. Scarcella. 2004. Effects on fish community induced by installation of two gas platforms in the Adriatic Sea. Marine Ecology Progress Series 273:187-197.

GDAIS (General Dynamics Advanced Information Systems). 2004. The global maritime boundaries database: August 2004 Edition. [CD-ROM]. Fairfax, Virginia: General Dynamics Corporation.

GDT (Geographic Data Technology Inc.) and ESRI (Environmental Systems Research Inc.). 2006. ESRI data & maps 2006. [CD-ROM/DVD]. . Redlands, California: Environmental Systems Research, Inc.

Greenpeace International. 2006. Marine reserves for the Mediterranean Sea. Amsterdam, Netherlands: Greenpeace International.

IHS Energy. 2006. GIS shapefiles depicting oil platforms in the Mediterranean Sea. Received 20 September 2006 from Mr. Kelly Smith, Senior Account Executive, Energy Segment. Dallas, Texas: IHS Energy.

Kelleher, G. and R. Kenchington. 1992. Guidelines for establishing marine protected areas. A marine conservation and development report. Gland, Switzerland: IUCN.

Mabile, S. and C. Piante. 2005. Global directory of marine protected areas in the Mediterranean. Paris, France: WWF-France.

Martini, N. and R. Patruno. 2005. Oil pollution risk assessment and preparedness in the East Mediterranean. 2005 International Oil Spill Conference. 15-19 May 2005. Miami, Florida.

NRC (National Research Council). 2000. Marine protected areas: Tools for sustaining ocean ecosystems. Washington, D.C.: National Academy Press.

Regional Marine Pollution Emergency Response Centre (REMPEC). 2002. Protecting the Mediterranean against maritime accidents and illegal discharges from ships.

Scovazzi, T. 2004. Marine protected areas on the high seas: Some legal and policy considerations. International Journal of Marine and Coastal Law 19(1):1-17.

UNEP (United Nations Environment Programme). 1995. Protocol concerning specially protected areas and biological diversity in the Mediterranean (Barcelona, 1995). Tunis, Tunisia: Regional Activity Centre for Specially Protected Areas.

7.0 RECOMMENDATIONS

The following recommendations, conceived by the MRA authors, are designed to improve our understanding of the marine resources in the eastern Mediterranean region. Particular concern is given to those resources that may be potentially affected by Navy operations. Each recommendation is assigned a priority value of 1, 2, or 3; 1 is the highest priority while 3 is the lowest. The priority designations are relative to each other and in no way refer to a recommendation's overall value. The relative cost of each recommendation is labeled as low, moderate, or high. Low-cost recommendations may be completed at a cost of several hundred to a few thousand dollars. Moderate-cost projects could range from thousands to tens of thousands of dollars, while high-cost research initiatives range from tens of thousands to over one hundred thousand dollars. The recommendations below are grouped into those related to the production and evaluation of the MRA and those needed to adequately complete environmental documentation for the eastern Mediterranean Study Area.

7.1 MARINE RESOURCES ASSESSMENTS

- Revise the eastern Mediterranean MRA once every five years. The MRA would need a full revision of the text, data, GIS maps, and other informational components so that newly available data sets and published literature can be incorporated. The Navy needs the best (i.e., most recent, most complete, and most accurate) available information to evaluate future actions and consider adjustments to training exercises or operations in order to mitigate any potential impacts to protected marine resources. Periodic updates would be of moderate cost relative to the initial MRA. Cost: High. Priority: 1.

- Expand the current MRA to include the rest of the Mediterranean Sea including the Adriatic and Aegean seas. Cost: High. Priority: 1.

- Subject the eastern Mediterranean MRA to peer review. Peer-review by regulatory agencies, the general scientific community, and potential government users would increase the effectiveness of this MRA. Biologists from universities and agencies (such as those listed in **Table 7-1**) could evaluate the collection, synthesis, and interpretation of data, including data completeness, and provide suggestions for improvements to the MRA. Cost: Low. Priority: 1.

- Obtain marine mammal and sea turtle data sets for the eastern Mediterranean Study Area that may not have been available for inclusion in this assessment. While all available comprehensive data have been included (**Table A-1**), acquiring the following data sets may ensure more complete data coverage:

  - Marine mammal database. Data are currently being integrated into a Mediterranean-wide public database with resources from CIESM, PELAGOS Cetacean Research Institute, and ACCOBAMS. Data feeding into this resource will not be made available until completion of the integrated database (initial estimated completion date of fall 2007).
    (contact: Giuseppe Notarbartolo di Sciara, Ph.D., ACCOBAMS)
  - Fin whale tagging data. Researchers from Le Centre d'Études Biologiques de Chizé-Centre National de la Recherche Scientifique (CEBC-CNRS), Oregon State University, and other participating organizations tagged 11 fin whales with Argos satellite-monitored radio tags in the Ligurian Sea in August 2003 (Mate and Guinet In prep). The results from this study are not yet published. GMI was unable to obtain tagging data from this study.
    (contact: Bruce Mate, Ph.D., Oregon State University)
  - Sea turtle data. Sighting information for sea turtles collected during aerial surveys conducted by the University of Valencia, Spain off the Mediterranean coastline of Spain from 2000 to 2003 to estimate the abundance and distribution of loggerhead turtles (Gómez de Segura et al. 2003, 2006).
    (contact: Amaia Gómez de Segura, Marine Zoology Unit, Cavanilles Institute of Biodiversity and Evolutionary Biology)

Table 7-1. Suggested expert reviewers for the eastern Mediterranean MRA.

Name	Affiliation	Expertise	Address	Email
Amaia Gómez de Segura	Cavanilles Institute of Biodiversity and Evolutionary Biology	Sea turtles	Marine Zoology Unit, Cavanilles Institute of Biodiversity and Evolutionary Biology P.O. Box 22085 E-46071 Valencia, Spain	amaia.gomez@uv.es
Ana Cañadas, Ph.D.	Alnitak	Cetaceans	Nalón 16. E-28240 Hoyo de Manzanares Madrid, Spain	alnitak.ana@ cetaceos.com
Brendan Godley, Ph.D.	Marine Turtle Research Group, University of Exeter	Sea turtles	Marine Turtle Research Group, Center for Ecology and Conservation University of Exeter Tremough, Cornwall TR3 6PW United Kingdom	bgodley@seaturtle.org
Caterina Fortuna, Ph.D.	ICRAM	Cetaceans	ICRAM Via di Casalotti 300 00166 Rome, Italy	fortuna.cm@tiscalinet.it
Claude Millot	Laboratoire d'Océanographie et de Biogéochimie	Oceanograph y	Laboratoire d'Océanographie et de Biogéochimie Antenne LOB-COB-CNRS BP 330 F-83507 La Seyne sur Mer France	cmillot@ifremer.fr
Costas Papaconstantinou, Ph.D.	Hellenic Centre for Marine Research	Fisheries	Hellenic Centre for Marine Research Institute of Marine Biological Resources 47Km Athinos Souniou Ave. Attica 190 13, Greece	pap@ncmr.gr
Denise Bellan-Santini, Ph.D.	Centre d'Océanologie de Marseille	Habitat	Centre d'Océanologie de Marseille Station Marine d'Endoume Rue de la Batterie des Lions 13007 Marseille France	bellan@com.univ-mrs.fr
Dimitris Margaritoulis, Ph.D.	International Sea Turtle Society/ ARCHELON	Sea turtles	International Sea Turtle Society c/o Archelon P. O. Box 51154, KIFISSIA Attiki GR-14510, Greece	margaritoulis@ archelon.gr
Gaston Fredj	Cimiez le Haut	Habitat	44 D Avenue de la Marne 06100 Nice France	fredj@unice.fr
Giovanni Bearzi, Ph.D.	Tethys Research Institute	Cetaceans	Tethys Research Institute c/o Acquario Civico Viale G.B. Gadio 2, 20121 Milano, Italy	bearzi@inwind.it
Giulia Mo	ICRAM	Pinnipeds	ICRAM Via di Casalotti 300 00166 Rome, Italy	giulia.mo@icram.org
Helmut Zibrowius, Ph.D.	UNIVMED	Corals	Université de la Méditerranée Station Marine d'Endoume Rue Batterie des Lions Via di Casalotti 300 00166 F-13007 Marseille, France	helmut.zibrowius@univ med.fr

Table 7-1. Continued.

Name	Affiliation	Expertise	Address	Email
Luis Cardona, Ph.D.	Department of Animal Biology, University of Barcelona	Sea turtles	Department of Animal Biology, Faculty of Biology University of Barcelona Avda. Diagonal 645, 08028 Barcelona, Spain	cardona@porthos.bio.ub.es
Manel Gazo, Ph.D.	GRUMM	Pinnipeds	Apartado de Correos 94141 Universidad de Barcelona Avinguda Diagonal, 645 08028 Barcelona, Spain	manel@cram.es
Paolo Casale, Ph.D.	WWF Italy	Sea turtles	WWF Italy Via Po 25c Rome, -00198, Italy	p.casale@wwf.it
Scott A. Eckert, Ph.D.	Wider Caribbean Sea Turtle Conservation Network (WIDECAST)/ Duke University	Sea turtles	135 Duke Marine Lab Road Beaufort, North Carolina 28516-9721	seckert@widecast.org
Simone Panigada, Ph.D.	Tethys Research Institute	Cetaceans	Tethys Research Institute Viale G. B. Gadio 2 20121 Milano, Italy	panigada@inwind.it

Acquisition and analysis of existing data is less expensive than physically collecting new marine mammal and sea turtle survey data. The potential contribution of these data sets to our understanding of the distribution of these protected species is high. Cost: Moderate. Priority: 1

7.2 ENVIRONMENTAL DOCUMENTATION

- Support ACCOBAMS basin-wide shipboard marine mammal survey that is anticipated to take place in 2009. Cost: High. Priority: 1.

- Fund dedicated marine mammal and sea turtle aerial and shipboard line-transect surveys and predictive modeling efforts in the Mediterranean Sea, especially in portions of the eastern Mediterranean Study Area in which there have been no dedicated research effort (**Figure 7-1**). While it is essential to continue surveying in previously studied areas to account for seasonal and inter-annual variations in the distribution and abundance of protected species, it is also critical to gather data for areas where survey effort has not taken place (or has occurred at lower levels). By focusing attention on these areas, a more complete picture of marine mammal and sea turtle distribution may emerge. Given the high-profile status of these protected species, it would be beneficial to learn as much as possible about them, especially their distribution. Year-round surveys will aid in determining seasonal and year-round occurrence patterns of these protected species. Surveys should also be focused near Navy high-use areas such as the Pachino Target Range along the south coast of Sicily, Italy and the NAMFI along the northern coast of Crete. Additionally, further funding by the Navy will provide the means to provide greater focus on data collection and thereby greatly improve the ability to estimate species densities within the region. Cost: High. Priority: 1.

- Support onboard specialists to collect marine mammal and sea turtle sightings data during dedicated oceanographic or fisheries surveys within the eastern Mediterranean Study Area. This can be done at a relatively low cost (primarily the salaries of the observers) since the monitoring would occur simultaneously with ongoing cruises. An interagency agreement may facilitate this effort. The cruise tracks of existing surveys are usually predetermined to address concerns of the group conducting the

survey and may not necessarily address those areas of particular concern to the Navy. Nevertheless, existing research cruises are valuable opportunities to collect a suite of data of interest to the Navy (the alternative, dedicated cruises, offer the benefit of controlling survey design and focus, but are very expensive). Cost: Low. Priority: 1.

- Support acoustic surveys for marine mammals either conducted by towing passive acoustic arrays behind research ships or efforts to collect data from underwater listening stations such as the NEMO. Acoustic surveys have been conducted in conjunction with some sighting surveys and are particularly useful for vocal, deep-diving species such as sperm whales, which spend less time at the surface and are often missed during visual sighting surveys. Acoustic equipment and ship costs make this program potentially expensive. Cost: Moderate to High. Priority: 1.

- Support the utilization of satellite-tracking technology to monitor the movements of species of special interest. Several species of endangered marine mammals and sea turtles occur in the eastern Mediterranean Study Area, yet comparatively little is known about their movements. Knowledge of their potential movements would greatly aid our understanding of their behavior and ecology. Given the endangered status of certain whales, sea turtles, and the Mediterranean monk seal, such studies are tremendously important. Of particular interest would be support for continued tagging of fin whales in order to determine their movements into nearby Atlantic waters, such as those conducted already by Drs. Christophe Guinet and Bruce Mate. Satellite-tracking programs are expensive, precluding the study of more than a few individuals. While insights on an individual's behaviors or movements may be gained, questions at the population level may go unanswered. Cost: Moderate. Priority: 2.

- Support genetic studies of both marine mammals and sea turtles occurring in the Mediterranean Sea. Such information is vital for understanding stock structures and origin of individuals (particularly for the loggerhead sea turtle and fin whale) that move into the Mediterranean Sea from the nearby Atlantic Ocean and intermix with Mediterranean individuals. Cost: Moderate to High. Priority: 2.

- Support the marine mammal and sea turtle stranding networks throughout the Mediterranean Sea, particularly with analyses of their collected data. Stranding network data could be utilized to determine the species diversity in the area, collect life history information on diet and reproduction, assist with stock determination, and assess impacts of human activities. Cost: Low. Priority: 3.

- Support efforts to compose a review of the biology and distribution of the Mediterranean monk seal in the Mediterranean Sea and the eastern North Atlantic Ocean. A vast amount of information on Mediterranean monk seals has been collected, but much of this information is scattered among journal articles, conservation plans, sighting/stranding databases, and grey literature. Monk seal experts have recently developed the Monk Seal Fact Files which is a website (http://www.monachus-guardian.org/factfiles/medit11.htm) that contains consolidated information on the biology, behavior, status, and conservation of the Mediterranean monk seal. This website allows researchers and managers to have easy access to historical and current Mediterranean monk seal information. Further support is needed to make sure that the website is kept up-to-date as new literature and information on the species is released. Cost: Low to Moderate. Priority: 2.

- Support the development of photo-identification catalogs for marine mammal species in the Mediterranean Sea. Photographs of individual marine mammals can supplement aerial surveys in the determination of movement patterns and stock structure for those species with photo-identification catalogs. Europhlukes is a multi-species photo-identification project which was initiated in 2002 by the European Commission. The goal of this collaborative project is to develop a European-wide (ranging from the Black Sea to Norway) photo-identification system and database of photos of cetaceans. Europhlukes is currently funded by the European Cetacean Society (contact: Peter Evans, Ph.D.) and ACCOBAMS. Contributions to this initiative would provide the additional support needed to make this a successful project. Cost: Moderate. Priority: 3.

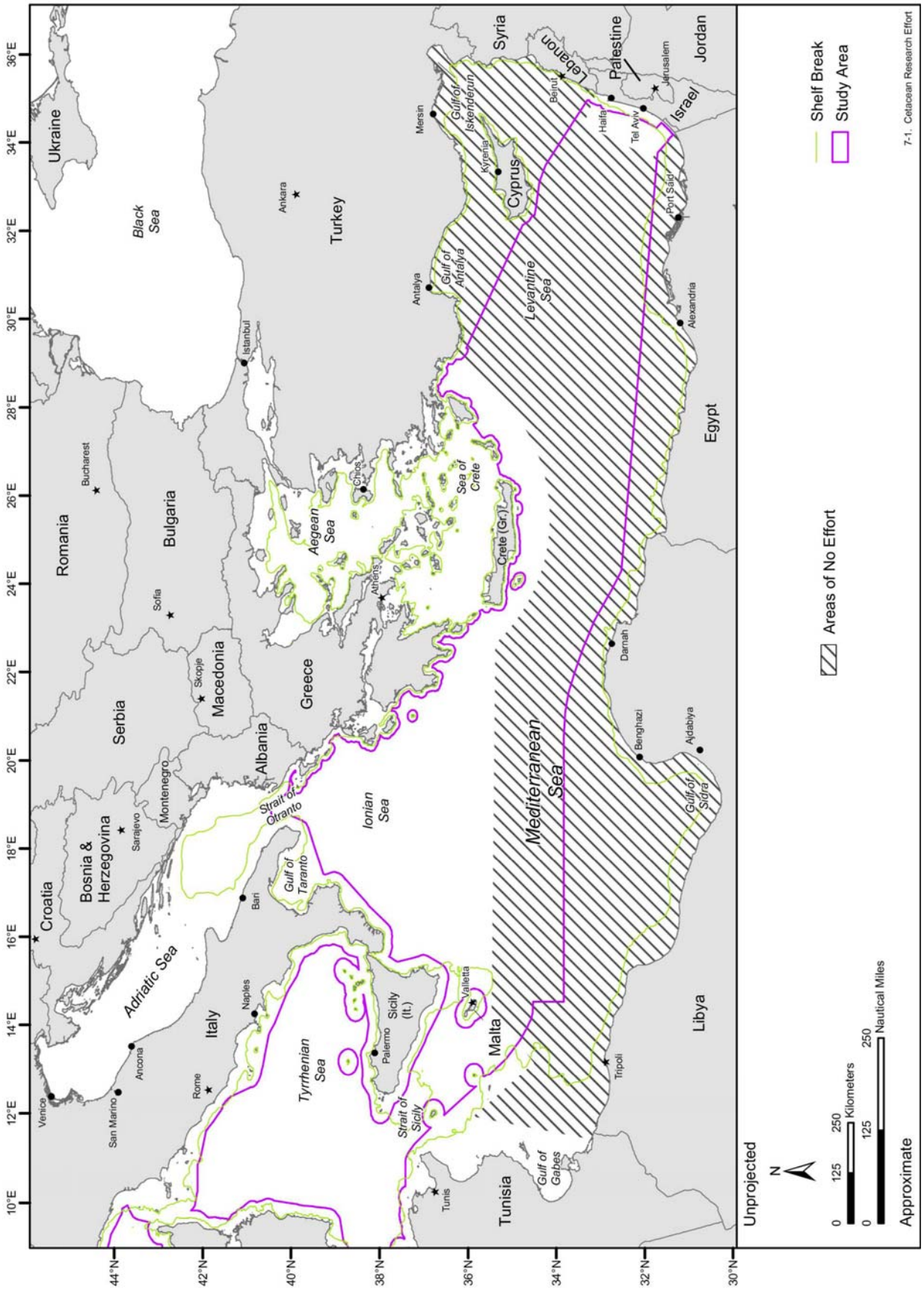


Figure 7-1. Areas in which there have been no dedicated cetacean research efforts within the eastern Mediterranean Sea.

- Conduct small boat-based, SCUBA/snorkel, or land-based surveys for Mediterranean monk seals along the coastline throughout the eastern Mediterranean Sea, particularly in areas where not much information has been collected such as Libya and Tunisia. Monk seal locations can be documented in the water through the use of hand-held waterproof global positioning system (GPS) units. Video cameras can be set up in potential seal caves to record sightings and individually identify seals. Monthly or quarterly surveys could help to elucidate the distribution patterns of monk seals throughout these nearshore areas and also help to determine seasonality. Sea caves and other important Mediterranean monk seal habitats need to be identified in these areas so that appropriate conservation measures can be taken. An inventory of monk seal caves and other breeding/resting areas throughout the entire Mediterranean Sea can be used to develop a network of protected areas specifically for the Mediterranean monk seal. ICRAM, MOm, Archipelgos, Underwater Research Society-Mediterranean Seal Research Group (SAD-AFAG), and other organizations have coordinated research efforts in the eastern Mediterranean Sea. Support of these efforts and more extensive surveys are needed to gain critical information on monk seals in the Mediterranean Sea. Cost: Moderate. Priority: 2.

- Support a survey of the Mediterranean Sea to obtain accurate, high-resolution bathymetry data. High-resolution bathymetry that spans the region will allow for an accurate assessment of shelf bathymetry and hardbottom habitats. Cost: High. Priority: 2.

- Support research to identify the seasonal distribution of essential habitats that affect marine mammals, fisheries, water quality, and shoreline erosion. A significant amount of research is necessary to analyze the present state and sensitivity of these areas and their present locations. Habitat distribution information in the Mediterranean Sea is essential for predicting consequences of habitat destruction/reduction. Conservation plans and the distributions of the following habitats are needed:

  - Seagrass beds. A conglomerate database of the distribution of current seagrass habitats in the Mediterranean Sea is highly needed to support conservation efforts of these important habitats. In addition, potential seagrass mitigation/transplantation sites, as well as distressed areas need to be identified to benefit from restoration activities. Cost: High. Priority: 1.
  - Live/hardbottom communities. There are many live/hardbottom communities whose locations are unknown. Cost: High. Priority: 1.
  - Maërl beds. A significant amount of data has already been collected regarding the importance of maërl bed habitats; however, the distribution of such habitats in the Mediterranean Sea is largely unknown. Fund a survey of maërl bed habitat occurrence as well as a conservation plan to salvage the remaining habitats. Cost: High. Priority: 1.

- Support the mapping and monitoring of live coral communities (corals and associated biota) both on shelf and deep-water environments of the Mediterranean Sea, and the development and update of a database on the locations and status of these coral communities. Cost: High. Priority: 1.

- Support efforts of the STECF which is working towards designating EFH in the eastern Mediterranean Sea. Currently, four coastal marine regions (north Aegean Sea continental shelf, Cyclades Plateau, Cretan continental shelf, and Ionian Sea) are being utilized as pilot-study areas for EFH mapping of coastal spawning species. Efforts are also underway to map offshore spawning species and alternative fishing grounds. This information is also relevant to protect marine species (e.g., marine mammals) that utilize these areas for feeding on these species. The projected date for availability of these products is January 2008. Cost: Low. Priority: 2.

7.3 LITERATURE CITED

Gómez de Segura, A., J. Tomás, S.N. Pedraza, E.A. Crespo, and J.A. Raga. 2003. Preliminary patterns of distribution and abundance of loggerhead sea turtles, *Caretta caretta,* around Columbretes Islands Marine Reserve, Spanish Mediterranean. Marine Biology 143:817-823.

Gómez de Segura, A., J. Tomás, S.N. Pedraza, E.A. Crespo, and J.A. Raga. 2006. Abundance and distribution of the endangered loggerhead turtle in Spanish Mediterranean waters and the conservation implications. Animal Conservation 9:199-206.

Mate, B.R. and C. Guinet. In prep. Movements and surfacing rates of fin whales tagged in the Mediterranean Sea.

This page intentionally left blank

8.0 LIST OF PREPARERS

Name/Title/Affiliation	Education	Project Role
Joel T. Bell Marine Mammal Biologist Naval Facilities Engineering Command, Atlantic Norfolk, Virginia	M.E.M., Coastal Environmental Management Duke University B.S., Marine Science Kutztown University	Navy Technical Representative
Dan L. Wilkinson Vice President, Special Projects Geo-Marine, Inc. Plano, Texas	Ph.D., Botany Texas A&M University M.S., Zoology Stephen F. Austin State University B.S., Biology Central State University	Program Director
Deanna R. Rees Natural Resource Specialist Naval Facilities Engineering Command, Atlantic Norfolk, Virginia	B.S., Wildlife Resources University of Idaho	Navy Technical Representative, Alternate
Jason See Dept. Manager, Marine Sciences Senior Marine Scientist Geo-Marine, Inc. Plano, Texas	Ph.D., Marine Sciences Virginia Institute of Marine Sciences College of William and Mary B.S., Zoology Texas A&M University	Project Manager, Oceanography PI; Technical Review
Chad Burrows Fisheries Biologist Geo-Marine, Inc. Plano, Texas	M.S., Environmental Science Stephen F. Austin State University B.S., Limnology Stephen F. Austin State University	Additional Considerations PI; Fish and Fisheries PI; Species of Concern: Fish; Technical Review
Brian Chastain GIS Analyst Geo-Marine, Inc. Plano, Texas	M.A., Geography Ohio State University B.S., Computer Science Baylor University	GIS Map Production
Ross Crossland GIS Analyst Geo-Marine, Inc. Plano, Texas	B.S., Geography Texas A&M University	GIS Map Production
Ken Deslarzes Senior Marine Ecologist Geo-Marine, Inc. Plano, Texas	Ph.D., Oceanography Texas A&M University Diploma Biology University of Lausanne, Switzerland License of Biology University of Lausanne, Switzerland	Habitats of Concern PI; Technical Review
Dagmar Fertl Senior Marine Mammal Biologist Geo-Marine, Inc. Plano, Texas	M.S., Wildlife and Fisheries Science Texas A&M University B.S., Biology Trinity University	Species of Concern PI, Marine Mammals, and Sea Turtles; Technical Review

LIST OF PREPARERS
(Continued)

Name/Title/Affiliation	Education	Project Role
Peter Gehring GIS Manager Geo-Marine, Inc. Plano, Texas	M.S., Environmental Science Miami University B.S., Zoology/Biochemistry Miami University	GIS Project Oversight and Graphics
Kayla Gibbs Librarian Geo-Marine, Inc. Plano, Texas	B.S., Biology Northern Arizona University	Literature and Library
Joseph Kaskey Senior Environmental Scientist Geo-Marine, Inc. Plano, Texas	M.S., Botany Southern Illinois University B.A., Biological Sciences Southern Illinois University	Fish and Fisheries; Acronyms and Abbreviations; Glossary
Kevin Knight Senior GIS Analyst Geo-Marine, Inc. Plano, Texas	B.S., Geology University of Texas	GIS Data Manager, GIS Documentation PI, and Map Production
Anu Kumar Marine Scientist/ Acoustician Geo-Marine, Inc. Hampton, VA	M.S., Marine Science California State University B.S., Biology-Ecology California State University	Oceanography; Technical Review
Jennifer Laliberté Marine Biologist Geo-Marine, Inc. Plano, Texas	M.E.M., Coastal Environmental Management Duke University B.S., Biology Arizona State University	Technical Review
Juan Levesque Marine Fishery Biologist Geo-Marine, Inc. Plano, Texas	M.S., Marine Biology Nova Southeastern University B.A., Biology University of South Florida	Technical Review
Tamara Lunsman Marine Scientist Geo-Marine, Inc. Plano, Texas	Ph.D., Marine Science University of California B.S., Marine Biology Texas A&M University	Physical Environment; Additional Considerations; Technical Review
Jason Lyon GIS Analyst Geo-Marine, Inc. Plano, Texas	M.P.A., Planning/Emergency Management University of North Texas B.A., Geography/Political Science University of North Texas	GIS Map Production

LIST OF PREPARERS
(Continued)

Name/Title/Affiliation	Education	Project Role
Chandria Moore Administrative Assistant Geo-Marine, Inc. Plano, Texas	Assoc. Degree, Criminal Justice, Almeda University Assoc. Degree, Culinary Arts Hudson County Community College	Literature and Library
Anna Perry Report Production Geo-Marine, Inc. Plano, Texas	M.S., Geology Baylor University B.S., Geology Clemson University	Report Production, Acronyms and Abbreviations
Leslie Whaylen Marine Scientist Geo-Marine, Inc. Plano, Texas	B.S., Marine Biology Texas A&M University at Galveston	Introduction; Habitats of Concern; Technical Review
Amy Whitt Marine Scientist Geo-Marine, Inc. Plano, Texas	M.E.M., Coastal Environmental Management Duke University B.S., Biology Lyon College	Species of Concern: Marine Mammals
Mike Zickel Marine Scientist Geo-Marine, Inc. Hampton, VA	M.S., Marine, Estuarine, Environmental Sciences University of Maryland B.S., Physics College of William and Mary	Oceanography; Technical Review

This page intentionally left blank

9.0 GLOSSARY

Abiotic—nonliving

Abundant—an indication of the plentifulness of a species at a particular place and time; an abundant species is more plentiful than an occasional or rare species

Abyssal plain—flat, sediment-covered part of the ocean floor between the continental slope and the mid-ocean ridge starting at approximately 2,000 to 3,000 m of depth reaching to the deepest point. The abyssal plain is characterized by extremely cold water, no light, and extremely diverse marine inhabitants

Abyssal zone—flat, sediment-covered part of the ocean floor between the continental slope and the mid-ocean ridge starting at approximately 2,000 to 3,000 m of depth reaching to the deepest point. The abyssal zone is characterized by extremely cold water, no light, and extremely diverse marine inhabitants

Abyssopelagic—from 4,000 m down to above the ocean floor; this area is characterized by no light and blind and colorless creatures

Accretionary prism—a wedge-shaped body of faulted and folded material scraped off subducting oceanic crust and added to an island arc or continental margin at a subduction zone

Acoustic thermometry—method for obtaining information about the temperature field in the ocean from precise measurements of the travel time of sound pulses transmitted through the ocean

Active margin—a continental margin that is tectonically deformed as it collides with another tectonic plate. It is the leading edge of a continent as it moves away from an oceanic spreading center

Adult—developmental stage characterized by sexual or physical (full size and strength) maturity

Advection—horizontal movement of water, as in ocean current

Aggregation—group of animals that forms when individuals are attracted to an environmental resource to which each responds independently; the term does not imply any social organization

Aggression—a set of social interactions ranging from threats to open fights, reflecting a conflict of interest over limited resources and having the potential to cause injuries and sometimes death to participants. Generally refers to conflict involving members of the same species by may refer to any interaction of this kind

Agonistic behavior—see aggression

Algae—a number of primarily aquatic, photosynthetic groups (taxa) of plants and plant-like protists ranging in size from single cells to large, multicellular forms (i.e., giant kelp) that have no seeds, roots, stems, flowers or leaf systems

Allochthonous—material that has originated elsewhere, non-native

Alpha male—the dominant male

Amphipod—an order of laterally compressed (shrimp-like) crustaceans with thoracic gills, no carapace, and similar body segments. An important component of zooplankton and benthic invertebrate communities

Anadromous species—referring to the life cycle of fishes, such as salmon, in which adults travel upriver from the sea to breed, usually returning to the area where they were born

Anaerobic—life or biological processes that occur in the absence of oxygen

Anemone—a cnidarian of the class Anthozoa that possess a flexible cylindrical body and a central mouth surrounded by tentacles

Annelid worms—invertebrate animals of the phylum Annelida in which the body is typically made up of a series of rings or segments covered by a soft cuticle and lacking jointed appendages (e.g., marine worms)

Annelids—invertebrate animals of the phylum Annelida in which the body is typically made up of a series of rings or segments covered by a soft cuticle and lacking jointed appendages (e.g., marine worms)

Anomaly—something irregular or abnormal

Anthozoan—a class of the coelentrates in which the medusiod stage is absent and the polyp (hydroid) stage is better developed than in other coelentrates (e.g., sea anemones, corals, alcyonarians, sea fans, sea pens, sea pansies, sea feathers)

Anthropogenic—describing a phenomenon or condition created, directly or indirectly, as a result of human activity

Anticyclonic—clockwise circulation in the Northern Hemisphere and counterclockwise circulation in the Southern Hemisphere; in oceanography, synonymous with warm-core ring

Aquaculture—cultivation of marine or freshwater fish or other aquatic animals or plant species

Archaea—also called Archaeobacteria, a major division of living organisms, are single-celled organisms lacking nuclei and are therefore prokaryotes

Archipelago—group of islands more or less adjacent to each other and arranged in groups covering portions of the sea

Area of primary occurrence—for the MRA, it is the areas and habitats where the marine mammal or sea turtle species is primarily found

Area of rare occurrence—for the MRA, it is the areas and habitats where the marine mammal or sea turtle species is not expected to be found regularly

Area of secondary occurrence—for the MRA, it is the areas and habitats where the marine mammal or sea turtle species may be found, especially during “anomalous” environmental conditions

Arthropods—largest phylum of animals that includes crustaceans; characterized by possession of a segmented body with appendages on each segment

Artificial habitat—a human-made, estuarine/marine habitat (shipwrecks, dedicated artificial reefs: rubble, concrete igloos, trains, tanks, ships, fish aggregating devices [FADs]) created in navigable waters of the U.S. or in waters overlying the continental shelf to attract aquatic life

Artificial reef—a human-made, reef habitat (sunken ships, trains, tanks, concrete igloos, rubble) created in the navigable waters of the U.S. or in waters overlying the continental shelf to attract aquatic life

Artisanal—refers to catch or effort that is neither industrial nor recreational in nature, and which is generated using simple fishing methods

Artisanal fisheries (small-scale fishery)—a small scale, low cost and labor-intensive fishery in which catch is consumed locally

Ascidians—sea squirts; taxonomic class of globular or cylindrical animals that inhabit shallow and deep water, attach themselves to substrates (rocks, pilings, the bottom of ships, and coral reefs), and may be solitary or colonial

Assemblage—the populations of various species from a larger taxon characteristically associated with a particular environment that can be used as an indicator of the environment

Atomized—fragmented

Audiogram—a hearing sensitivity curve drawn as a function of frequency and sound pressure level; describes the hearing ability of an animal

Auditory-evoked potential study—an electrophysiological far-field recording of the auditory nerve and its associated accessory auditory nuclei in response to a sound stimuli

Autochthonous—native or indigenous (opposite of allochthonous), produced within a given habitat, community, or system

Back-arc—referring to the region behind the island arc (the concave side of the arc)

Baleen—the interleaved, hard, fibrous plates made of keratin (protein in fingernails and hair) that hang side by side in rows from the roof of the mouth of mysticete whales; baleen takes the place of teeth and serves to filter the whale's food from the water

Bandwidth—the difference between the highest and lowest frequencies; measured in Hertz (Hz)

Bank—a topographic feature on a continental (or island) shelf and over which the depth of water is relatively shallow (20 to 200 m)

Barnacles—a collective name for various marine crustaceans of the subclass Cirripedia; the adults form a hard outer shell and attach to hard substrates such as rocks and ships, as well as to certain whales

Baseline—the line from which maritime boundaries (EEZ, contiguous zone, territorial waters) are measured; in the U.S., the baseline is the low tide line except at the mouths of inland water bodies (bays) where a closing line (straight line) is drawn

Basking—an activity performed by pinnipeds and sea turtles while on land in which they expose themselves to pleasant warmth

Bathyal—of or relating to the region of the ocean bottom. The bathyal zone begins at the end of the continental slope and reaches to a depth of approximately 2,000 to 3,000 m, where it is continuous with the deeper abyssal zone. The bathyal zone is characterized by extremely cold water, no light, and extremely diverse marine inhabitants

Bathyaldemersal—organisms living at or near the bottom of the sea floor between 200 and 4,000 m

Bathymetry—the topography of the ocean floor; study and mapping of the ocean depths

Bathypelagic—living in depths of the ocean at depths of the ocean at depths between 600 and 3,000 m

Bay—a body of water partly enclosed by land but with a wide outlet to the sea

Beaked whales—members of the family Ziphiidae, includes the genus *Ziphius*, *Mesoplodon*, *Indopacetus*, *Berardius*

Behavioral audiogram—a graphic representation of an animal's auditory threshold that is determined by tests with trained animals; measures the hearing ability of an animal

Benthic—organisms living on or near the ocean floor; the term is used irrespective of whether the sea is shallow or deep

Benthonic—of or relating to or happening on the bottom under a body of water

Benthopelagic—the ecological zone from the seabed to 100 m above the seabed

Benthos—organisms that live in, on, or are attached to the ocean bottom substrate

Bifurcation—refers to the main body of one item splitting into two parts

Biocenosis—a group of interacting organisms that live in a particular habitat and form an ecological community

Bioclastic—composed of broken fragments of organic skeletal material

Biodiversity—variety of living material in terms of genes, species or ecosystems within a given area

Biogenic—originating from living organisms

Biogeographic—relates to large regions with distinct landscapes or seascapes, plants and animals

Bioherm—a limestone structure or build-up produced by biological activity

Biomass—weight of organic matter (organisms or an assemblage of organisms) per unit area

Biome—major regional group of distinctive plant and animal communities well adapted to the region's physical environment

Biotic—pertaining to life or living organisms

Biopolymer—a special class of polymers produced by living organisms (e.g., starch, proteins and peptides, DNA, and RNA)

Bioturbation—the mixing of a sediment by the burrowing, feeding, or other activity of living organisms

Bivalve—group of marine or freshwater bilaterally symmetrical mollusks that consist of a soft body protected by two hinging calcareous shells (e.g., clams, oysters, scallops, mussels); are mostly sedentary filter feeders

Blackfish—a colloquial term adopted from American whalers and sometimes applied to pilot whales and other superficially similar species, including false killer, pygmy killer, and melon-headed whales

Bloom—the usually seasonally dense growth of algae or phytoplankton that is triggered by an increase in the nutrient concentration or increased availability of light

Blowhole—the nostrils or nasal openings on top of the head of a cetacean

Blubber—a specialized layer of fat found between the skin and underlying muscle of many marine mammals; it is used primarily for insulation and energy storage

Boreal—comprising or throughout far northern regions

Bottlenose dolphin—the former common name for *Tursiops truncatus,* now called the common bottlenose dolphin

Brachiopod—also known as lamp shells, they are sessile, two-shelled, marine animals in the phyla Brachiopoda

Brackish—having a salinity between that of fresh and sea water

Brine pools—are large areas of brine on the ocean basin near cold seep vents which release methane into the water; has extremely high salinity as compared to the surrounding ocean, caused by the motion of large salt deposits through salt tectonics

Brittlestar—starfish-like echinoderm belonging to class Ophiuroidea that has five to eight elongate, slender, cylindrical arms distinctly radiating from a flat central disc

Brown algae—division of algae (Phaeophycophyta) consisting of large macroscopic forms occurring widespread in marine habitats attached either to rocks, stones, or coarser algae (kelp); commonly found in relatively shallow water in the intertidal and subtidal zones along the coast, in estuaries, and muddy bottoms of slat marshes

Bryozoans—phylum of small, aquatic colonial animals that are commonly called moss animals; each zooid or animal in the colony has a crown of ciliated tentacles

Bubble netting—a coordinated feeding technique of humpback whales, in which they use bubbles to corral and trap small fish or invertebrates

Bull—a male seal or whale, especially an adult male

Buoy—a bright-colored float attached by rope to the seabed to mark channels in a harbor or underwater hazards

Bycatch—marine species caught along with targeted species in a fishery, but which are not sold or kept for personal use, and includes economic and regulatory discards

Calanoids—most numerous in size and species of planktonic copepods

Calcareous—composed of calcium or calcium carbonate

Caldera—a type of volcanic crater that is extremely large (over one mile in diameter), usually formed by the collapse of a volcanic cone or by a violent volcanic explosion

Calf—a young animal dependent on its mother

Callosity—a patch of thickened, keratinized tissue on the head of a right whale, inhabited by large numbers of whale lice

Calving interval—the period of time from one birth to the next, generally applicable to cetaceans

Calving—the process of giving birth by a whale, dolphin, porpoise, or manatee

Candidate species—a species that is the subject of either a petition to list or status review, and for which the NMFS or USFWS has determined that listing may be or is warranted

Canopy—the cover produced by the intermingling of upper branches of trees in a forest. Analogous cover can be formed by algae and octocorals.

Cape—a darker region on the back of many species of dolphins and small whales, generally with a distinct margin

Capture-based aquaculture (CBA)—practice of collecting "seed" material – from early life stages to adults – from the wild, and its subsequent on-growing in captivity to marketable size, using aquaculture techniques

Carangids—burrowing shrimp

Carapace—the outer covering of the back of a sea turtle, which is bony for all sea turtle species with the exception of the leatherback, which has a leathery covering

Carbon sequestration—processes that removes carbon from the atmosphere

Carnivora—an order of living and extinct mammals that includes such species as pinnipeds and otters

Carnivore—an animal that feeds exclusively on another animal's tissue

Carrion—dead and rotting body of an animal

Carrying capacity—the maximum population of a particular species a particular region can support without hindering future generations' ability to maintain the same population. The carrying capacity of an environment will vary for different species in different habitats, and can change over time due to a species' impact on its environment, as well as other environmental factors

Catch—total number and/or weight of organisms caught by fishing operations

Catch per unit of fishing effort (CPUE)—total catch divided by the total amount of effort used to harvest the catch

Cephalopods—any marine mollusk of the class Cephalopoda, with the mouth and head surrounded by tentacles (squid, octopus, cuttlefish)

Cetaceans—whales, dolphins, and porpoises

Cheloniidae—the family of hard-shelled sea turtles that includes the green turtle, loggerhead turtle, hawksbill turtle, Kemp's ridley turtle, olive ridley turtle, and flatback turtle

Chemoautolithotrophic bacteria—an organism that depends on inorganic chemicals for its energy and principally on carbon dioxide for its carbon. Also called *chemolithotroph* or chemoautotroph

Chemoautotrophic—obtain metabolic energy by the oxidation of inorganic substances, such as sulphur, nitrogen, or iron

Chemosynthesis—the formation of organic compounds from inorganic substances using energy derived from oxidation

Chevron—a V-shaped stripe

Chimeras—a deep-sea cartilaginous fish of the family Chimaeridae having a smooth-skinned tapering body and a whip-like tail

Chlorophyte—green algae

Circalittoral—lower subdivision of the marine sublittoral zone below the infralittoral zone dominated by photophilic algae; sometimes used for the depth zone between 100 and 200 m

Circumglobal—ranging all the way around the world

Circumpolar—ranging all the way around high northern or southern latitudes

Circumtropical—organisms which occur around the tropics of the world (land or sea)

Clan—one or more killer whale pods that share a related dialect; pods within a clan have probably descended from a common ancestral group and therefore are probably more closely related to each other than to pods from other clans

Click—a broad-frequency sound used by toothed whales for echolocation and which may serve a communicative function; usually with peak energy between 10 kHz and 200 kHz

Closed season—a specified period during which the category of fish or marine plants may not be fishes or harvested

Closure—banning of fishing during particular times or seasons (temporal closures) or in particular areas (spatial closures), or a combination of both

Clutch—a total number of eggs from one nesting

Cnidarians—the phylum of animals that includes corals, sea fans, sea anemones, hydroids, and jellyfish; known for the stinging cells on their tentacles; these animals exhibit two body types, polyps (may be attached or planktonic) or medusa, sometimes at different periods of one species development

Coast—the boundary where land and water meet

Coastal area—a geographical area of land and water along the coast, affected by the biological and physical processes of both the terrestrial and marine environments

Coastal water—water that is along, near, or relating to a coast

Cochlea—a spiral bony structure in the inner ear that looks like a snail shell and contains over 10,000 tiny hair cells, which are the receptor organs essential for hearing and that bend in response to sound waves, the bending of the hair cells stimulates nerve cells to send messages to the brain, which the brain interprets as sound

Coda—a patterned series of 3 to 20 clicks lasting about 0.5 to 2.5 seconds, used by sperm whales for communication

Cold-core ring—an eddy or circular current of warm water; in the North Atlantic Ocean, the water in cold-core rings circulates cyclonically (counterclockwise)

Cold seeps—(sometimes called a cold vent) is an area of the ocean floor where hydrogen sulfide, methane and other hydrocarbon-rich fluid seepage occurs. Cold seeps are distinct from hydrothermal vents because the emissions are the same temperature as the surrounding seawater

Cold-stunning—the behavior exhibited by sea turtles in response to cold water temperatures; turtle becomes lethargic and adopts a stunned floating posture

Cold-temperate—a latitudinal zone extending between 45 degrees and 58 degrees in both northern and southern hemispheres

Coelenterate—radially symmetrical animals having sac-like bodies with only one opening and tentacles with stinging structures, such as hydras, jellyfish, sea anemones, corals; occur in polyp and medusa forms

Colonial—nesting in groups or colonies rather than in isolated pairs

Colony—highly integrated group of animals; herein refers specially to birds and land-breeding pinnipeds

Commercial fishing—fishing in which the fish is harvested, either in whole or part, are intended to enter commerce through sale, barter, or trade

Community—killer whales that can be linked together through associations form a community. Although all whales in a community may not have been observed to mix, all can be linked together through intermediate associations

Competitors—simultaneous demand by two or more organisms for limited environmental resources, such nutrients, living space, light

Conspecific—member of the same species, and in many cases, the same age or even sex

Continental margin—the boundary or transition between the continents and the ocean basins that consists of the physiographic provinces of the continental shelf, continental slope, and continental rise

Continental rise—the province of the continental margin with a sloping seabed (1:100-1:700 gradient change) and a generally smooth surface, which lies between the abyssal plains and continental slope

Continental shelf break—the area where the slope of the continental shelf rapidly changes from gently sloping to steeply sloping; where the continental shelf gives way to the continental slope

Continental shelf—the province of the continental margin with a gently seaward-sloping seabed (1:1000 gradient change) extending from the low-tide line of the shoreline to 100 to 200 m water depth where there is a rapid gradient change

Continental slope—the province of the continental margin with a relatively steeply sloping seabed (1:6 to 1:40 gradient change) that begins at the continental shelf break (about 100 to 200 m) and extends down to the continental rise; along many coasts of the world, the slope is furrowed by deep submarine canyons

Contour—a line of connected points of equal value on a surface

Coordinate system—set of numbers used to assign a location in a given reference system (x and y in a planar coordinate system and x, y, and z in a three-dimensional coordinate system); a pair of coordinates represents a location on the earth's surface relative to other locations

Copepods—very small planktonic crustaceans present in a wide variety and great abundance in marine habitats, forming an important basis of ecosystems; they are a major food of many marine animals and are the main link between phytoplankton and higher trophic levels

Coral reef ecosystem (CRE)—those species, interactions, processes, habitats and resources of the water column and substrate located within any waters less than or equal to 50 fathoms (100 meters) in total depth

Coralline algae—family of red algae (Corallinaceae) having bushy or encrusting form and deposits of calcium carbonate either on branches or as crusts; maybe divided into two groups: geniculate (articulated) or nongeniculate (non-articulated)

Crinoids—class of sessile echinoderms commonly called sea lilies and feather stars; these animals have a cup-shaped body that attaches to the substratum by a stalk (sea lilies) and have feathery arms; class Crinoidea of the phylum Echinodermata

Critical endangered (CR) species (IUCN Red List)—a species considered to be facing an extremely high risk of extinction in the wild

Critical habitats—the portion (minimum) of the habitat that is essential for the survival for certain protected (threatened and endangered) species (whales or sea turtles) and may include areas essential for feeding or reproduction by those species

Crustaceans—arthropods that have two pairs of antennae and a hard exoskeleton (shell); lobster, shrimp, and crabs are the most familiar examples

Crustose—having a thin crusty thallus that adheres closely to the surface on which it is growing

Cryptic—hidden; living in holes, caves, burrows

Cyanobacteria—large and varied group of bacteria which possess chlorophyll a and carry out photosynthesis in the presence of light and air, with concomitant production oxygen; formerly regarded as algae and called blue-green algae; may be single-celled or filamentous and may or may not be colonial; many species carry out the fixation of atmospheric nitrogen; widely distributed in marine and freshwater environments in littoral zone on soil, rocks, and plants as epiphytes or symbionts; may produce harmful algal blooms in low-salinity systems with excessive nutrients

Data deficient (DD) species (IUCN Red List)—information is inadequate to make a direct, or indirect, assessment of the species' risk of extinction based on its distribution and/or population status

Decapod—order of freshwater, marine, and terrestrial crustaceans having five pairs of legs on the thorax and a carapace completely covering the throat (e.g., shrimps, crabs, lobsters)

Deep hypersaline anoxic basins (DHABs)—extreme habitats that form in tectonically active zones in the deep sea that are characterized by oxygen depletion, salinity above 30%, the absence of light, variable pH values and ionic composition, and elevated methane and hydrogen sulphide concentrations

Deep-sea fan—a cone-shaped of fan-shaped deposit of land-derived sediment located seaward of large rivers or submarine canyons

Deepwater—the area of the ocean that is past the continental shelf break, deeper than 100 to 200 m of water

Deglaciation—uncovering of glaciated land due to melting or sublimation of the glacier

Delayed implantation—in mammals it is the suspended development of an embryo between shortly after conception and subsequent attachment (implantation) to the uterine wall

Delimitation—fixing a boundary

Delphinid—a small dolphin species belonging to the family Delphinidae

Demersal—species which live on the bottom or directly related to it

Demersal fishery—fishery targeting on demersal species

Demosponges—largest and most complex group of siliceous and horny sponges; includes forms with needle-shaped or four-branched siliceous spicules, which may or may not be sported by spongin

Density—physical property measured by mass per unit volume; in biology, the number of organisms per unit of distance

Depauperate—impoverished

Deposit-feeders—organisms that feed on the particles of matter in the soil, usually the top sediment where it is filled with organisms; is accomplished by either ingesting the soil or by trapping the falling particles

Desertification—degradation of land in arid, semi-arid, and dry sub-humid areas resulting from various factors including climatic variations, but primarily from human activities

Desiccation—removal of water; the process of drying

Desmodorid nematode—one of two orders (Desmodorida) in the phylum Nematoda

Detritus—a mass of dissolved organic waste material from decomposing dead plants or animals

Diagenized (diagenesis)—chemical and physical processes, in particular, compaction and cementation, involved in rock formation after the initial deposition of sediment

Diatoms—microscopic algae (Bacillariophyceae) in which the cell wall (frustule) is composed of silica and consists of two major valves and girdle bands; unicellular, colonial, or filamentous; important components of freshwater and marine habitats as members of both planktonic and benthic communities; comprised of two major types based on symmetry: pennate – bilateral, centric – radial; forms the primary food base for marine ecosystems; may produce harmful algal blooms in marine habitats (domoic acid producing *psuedo-nitzschia*)

Diel—refers to 24-hour activity cycle based on daily periods of light and dark

Diffraction—various phenomena associated with wave propagation, such as the bending, spreading, and interference of waves emerging from an aperture

Digitize—encoding geographic features into a digital geographically referenced form

Dilapidation—falling into decay

Discards—release or return captured organisms to the sea, dead or alive, whether or not such organisms are brought fully on board a fishing vessel

Disparate—fundamentally distinct

Dispersal—spreading of individuals throughout suitable habitat within or outside the population range. In a more restricted sense, the movement of young animals away from their point of origin to locations where they will live at maturity

Display—any behavior that conveys information, usually to members of the same species or to predators; often used during mating or territory defense

Dissipating—to drive away, disperse

Distant-water trawler—also caller a freezer trawler which is fitted with refrigerating equipment, fish freezing equipment, and insulated and refrigerated fish holds

Distinct population segment—a population segment of fish, wildlife, or plants that is “discrete” (i.e., separated from other populations of its species or subspecies) and 'significant' (i.e., essential to the long-term conservation status of its species or subspecies)

Diurnal—active or occurring during daylight hours; having a daily cycle

Diversity—number of species present in a community (species richness), as well as the relative abundance of each species

Dominant species—species most prevalent in a particular community, or at a given period

Dorsal—relating to the upper surface of an animal

Downwelling—downward movement or sinking of surface water towards the ocean bottom; may be caused by convergent currents or density differences

Drift gillnets—gillnets attached to the stern of a fishing boat and allowed to drift below the ocean surface; sharks and swordfish are among some of the targeted species

Drift net—a monofilament gillnet set at or near the surface that stretches up to 60 km or more in length, used passively (drifts) to entangle fish or invertebrates, which also catches a large number of non-target species, including marine mammals and sea turtles

Dunnage—means packing (wood, or nowadays sometimes strong inflatable bags) to prevent damage to ships and cargo

Ebb tide—outgoing or falling tide

Echinoderms—phylum of marine invertebrates having bilateral symmetry in larval forms and usually a five-sided radial symmetry as adults, a calcareous endoskeleton, and a water vascular system (e.g., sea cucumbers, sea urchins)

Echinoid—referring to echinoderms, e.g., sea urchins and sand dollars

Echinoids—group (class) of echinoderms including sea urchins, heart urchins, sand dollars, etc. that are spiny and globular to disc-like in shape

Echiuran—marine worms in the phylum Echiura

Echiurid proboscis—known as spoon worms; are sediment dwellers that extend their proboscis onto the sediment surface

Echiuroids—unsegmented marine worms with one or more pairs of bristles; live in sand or rock crevices intertidally or in shallow water

Echolocation—the production of high-frequency sound waves and reception of echoes to locate objects and investigate the surrounding environment

Ecosystem—a system of ecological relationships in a local environment comprising both organisms and their nonliving environment, intimately linked by a variety of biological, chemical, and physical processes

Eddy—the circular movement of water

Eelgrass—vascular flowering plants of the genus *Zostera* that are adapted to living under water while rooted in shallow sediments of bays and estuaries

El Niño/Southern Oscillation (ENSO)—the climatic phenomenon that causes changes in wind and current patterns (reversal of the Pacific equatorial currents) that leads to changed ocean temperatures and weather patterns over vast distances; leads to the disruption of coastal upwelling and die-offs of plankton, fish, sea birds, and marine mammals

El Niño—wind-driven reversal of the Pacific equatorial currents resulting in the movement of warm water towards the coasts of the Americas, considered a natural cyclical atmospheric/oceanic phenomenon; El Niño is often termed the El Niño/Southern Oscillation, or "ENSO"

Elasmobranch—fishes of the class Chondrichthyes that are characterized by having a cartilaginous skeleton; includes sharks, skates, and rays

Elucidate—to provide clarification, explain

Emigration—a movement out of an area by members of a population

Encrusting—forming or resembling a crust

Endangered (EN) species (IUCN Red List)—a species considered to be facing a very high risk of extinction

Endangered species—any animal or plant species in danger of extinction throughout all or a significant portion of its range; the authority to list a species is shared by the USFWS (plants and animals on land) and NMFS (most marine species) under provisions of the ESA

Endemic—occurring in a specific area

Endemic species—species native and confined to a certain region and having restricted distribution (i.e., a species unique to a place, found naturally nowhere else

Endogenous—originating within or produced by the body

Environmental impact statement (EIS)—a detailed written statement that helps public officials make decisions that are based on understanding of environmental consequences and to take actions that protect, restore, and enhance the environment

Epibenthic—refers to organisms living on the ocean floor

Epicontinental waters—shallow waters which occupy wide portions of continental shelf

Epifauna—animals living on the surface of the ocean floor; any encrusting fauna

Epi-mesopelagic—zone of marine waters between epipelagic and mesopelagic

Epipelagic—the oceanic zone from the surface to 200 m

Epiphyte—a plant growing on another plant for support or anchorage rather than for water supply or nutrients

Epizoically—living on the surface of another organism

Equatorial—of or existing at or near the geographic equator

Erosion—displacement of solids (soil, mud, rock, and other particles) by the agents of ocean currents, wind, water, or ice by downward or down-slope movement in response to gravity or by living organisms

Escarpment—a steep slope or long cliff that results from erosion or faulting and separates two relatively level areas of different elevations

Estuary—area of the mouth of a river where river water meets and mixes with seawater; often an area of high biological productivity and important as nursery areas for many marine species

Euphausiids—known as krill, these are pelagic shrimp-like crustaceans

Euphotic zone—the uppermost area of the ocean (up to 150 m) that is sufficiently illuminated to permit photosynthesis by phytoplankton, algae, and submerged aquatic vegetation

Eurybathic—an organism that can tolerate of a wide range in depth

Eutrophication—the process by which nutrient-rich water promotes a rapid growth of algae and phytoplankton, which reduces the water's dissolved oxygen content

Exogenous—originating or produced outside the body

Extent—coordinate pairs that define the rectangular boundary (xmin, ymin and xmax, ymax) of a data source and in which all the coordinates for that data source fall

Extirpated—species that no longer exists in the wild

Extrapolate—to estimate a value that falls outside a range of known values

Eye patch—the elliptically-shaped white patch located above and behind a killer whale's eye

Facies—general aspect or outward appearance, as of a given growth of flora

Falcate—sickle-shaped and curved (refers to the dorsal fin of some cetaceans)

False crawl—an abandoned sea turtle nesting attempt or simply a U-shaped crawl from the ocean up the beach, and then back to the water

Fathom—a marine unit of measure of water depth equaling 1.83 m

Fauna—animal life of a region

Faunistic—relating to the geographic distribution of animals

Feather star—any of numerous crinoids of the genus *Antcedon* and related genera, having a free-swimming, stalkless adult stage with branched feathery arms

Fecundity—the potential of an organism to produce offspring (measured as a number of gametes)

Filter-feeder—any animal that feeds by filtering suspended particulate organic matter from water

Finning—practice of removing fins and discarding the carcass, usually pertaining to sharks

Fish aggregating device (FAD)—single or multiple floating structures that are connected to the ocean floor by ballast or anchors; used to attract fish

Fishing capacity—maximum amount of fish over a period of time (year, season) that can be produced by a fishing fleet if fully utilized, given the biomass and age structure of the fish stock and the present state of technology

Fishing fleet—aggregation of fishing vessels of a particular country (e.g., European Union fishing fleet) or using a particular gear (purse seine fleet)

Fishing gears—equipment used for (e.g., baitboat, gillnet, handline, harpoon, haul seine, longline, widewater trawl, purse seine, rod-and-reel, trap, and trawler). Each of these gears may have multiple configurations

Fishing zone—a zone of variable width (up to 200 NM) proclaimed by a coastal country around its coast, within which it controls domestic and foreign access to fish resources

Flag of convenience (FoC)—pertains to cases when a boat is registered in a different country than that of ownership, for whatever reasons of convenience

Flank—side of the body; used mainly to refer to the side of the posterior half of the body

Flipper—the flattened forelimb of a marine mammal

Flood tide—incoming or rising tide

Flora—all the plant species of a given area

Flotsam—debris floating on the water surface

Flukes—the horizontally spread tail of a cetacean

Forage—the act of searching for food or provisions

Forage fish—any fish eaten by larger predatory fish, seabirds, or marine mammals, usually swimming in large schools

Foraminiferan—planktonic or benthic protozoan that possesses protective coverings usually composed of calcium carbonate

Forams—single-celled marine microorganisms having a calcareous shell with openings where pseudopods protrude

Front or frontal—see ocean front

Fully exploited—used to qualify a stock which is probably neither being overexploited nor under exploited and is producing, on average, close to its Maximum Sustainable Yield

Fundamental frequency—the lowest frequency of a harmonic series; measured in the Hz (cycles per second)

Fungi—a group of organisms that lack chlorophyll and obtain nutrients from dead or living organisms by breaking them down and then absorbing the substances into their cells

Fusiform—spindle-shaped or torpedo-shaped and tapering at one or both ends

Galatheid crabs—deep sea scavenging crabs found in abundance around hydrothermal vents, cold seeps, and whale falls; in the family Chirostylidae, also known as “pinch-bugs”

Gammarid amphipods—amphipods commonly associated with sediments

Gape—the mouth in cetaceans, usually referring to the junction of upper and lower lips

Gas hydrates—also called gas clathrates, are naturally occurring crystalline solids that are comprised of water molecules organized in a rigid polyhedral cage structure; each cage contains a molecule of natural gas, predominantly methane

Gastropods—class of symmetrical, univalve mollusks that have a true head, an unsegmented body, and a broad, flat foot

Genera—one of taxonomic or scientific classifications of plants and animals

Geographic coordinate system—reference system of latitude and longitude that defines the locations of points on the surface of a sphere or spheroid

Geographic coordinates—location on the earth's surface expressed in degrees of latitude and longitude

Geostrophic current—a current defined by assuming the existence of an exact balance between the horizontal pressure gradient force and the Coriolis force

Gestation—period of development in the uterus from conception until birth (pregnancy)

Gestation period—period of development of an embryo within the uterus of a viviparous animal from conception to birth

Ghost fishing—accidental capture of aquatic organisms by fishing gear (usually gill nets, or traps, pots, etc.) that has been lost or discarded into the sea and which continues to entangle or trap aquatic animals

Gillnet—a type of fishing gear made of rectangular mesh panels that are set more or less vertically in the water so that fish swimming into it are entangled by their gills; they can be set to fish at the surface, midwater, or on the bottom of the water column

Gorgonians—coral of the class Anthozoa, subclass Octocorallia, order Gorgonacea; this order of corals includes sea rods, sea whips, feather plumes, and sea fans

Great whales—typically refers to all the baleen whales plus the sperm whale

Green algae—division of algae (Chlorophyta) consisting of plankton and benthic forms occurring widespread in marine and freshwater habitats; marine species are primarily macroscopic forms frequently attached to moist rocks, woods, pilings, or larger algae or grow on sandy bottoms on shells in quiet estuaries; consist of motile and nonmotile types; may be unicellular, colonial, filamentous, membranous (e.g., sea lettuce), and tubular

Gregarious—used to describe animals that form social groups

Groundfish—group of fishes that spend most of their life on or near the ocean floor (e.g., rockfish, flatfish, roundfish, skates, sharks, chimeras); also known as demersal species

Gyre—circular movement of waters, larger than an eddy; usually applied to oceanic systems

Habitat—the place where an organism is found temporarily or permanently and that provides sustenance, shelter, and space

Habitat preference—the choice by an organism of a particular habitat in preference to others

Hake—any of various marine food fishes of the genus Merluccius and Urophycis, relater to and resembling the cod

Halopyte—a set of closely linked genetic markers present on one chromosome which tend to be inherited together (not easily separable by recombination)

Hard bottom—a substrate formed by the deposition of calcium carbonate by reef building corals and other organisms, bedrock or volcanic rock usually of minimal relief, or rocky outcroppings and talus

Hard bottom community—area of bottom habitat with three-dimensional character providing physically stable shelter and substrate for large populations of sessile or attached invertebrates and fishes

Harpacticoid copepod—very small crustacean with cylindrical body; order Harpacticoida in the class Ostracoda

Harvest—fish killed as a result of encounters with fishing gear

Hatchling—a newly hatched bird, amphibian, fish, or reptile

Haul out—the process by which pinnipeds crawl or pull themselves out of the water onto land

Haulout site—intertidal rock outcrops, sandbars, shoals, mudflats, or sandy beaches where marine animals, such as pinnipeds, periodically and purposefully come ashore

Headlands—parts of the coastline that extend out into the sea

Hectare—a measurement of land area and is equivalent to 0.01 square kilometers

Herbivore—an animal that eats plants as its main source of energy

Herbivorous—feeding on plants; phytophagous; protozoans that feed on bacteria and/or algae

Hermatypic—reef building corals with zooxanthellae

Heterogeneous—having a non-uniform structure or composition

High tide—the highest level to which the tide rises within the daily tidal cycle

Holothurian—also known as sea cucumbers belonging to the Phylum Echinodermata; elongated body and leathery skin; bottom-dwelling

Homogeneous—uniform in structure or composition throughout

Hydrodynamic—pertaining to forces in or motions of liquids

Hydrographic—used with reference to the structure and movement of bodies of water, particularly currents and water masses

Hydrography—the science of measuring and describing the surface waters of the Earth

Hydrophone—transducer for detecting underwater sound pressures; an underwater microphone

Hydrothermal vent—location on the ocean floor in which water percolates down through fractures in recently formed ocean floor, is heated by underlying magma, and surfaces through chimneys. Hydrothermal vents are usually located near the axis of spreading on ocean ridges and rises

Hydrozoans—delicate marine animals usually in clusters or colonies of the phylum Coelenterata; individual polyps are encased in gelatinous cups and often secrete coral as supporting structures; highly branched polyp or hydroid stage of many members is important component of fouling

Hyperiid amphipods—family and suborder of Amphipoda with very large head and eyes, five abdominal segments and seven pairs of thoracic legs

Hypersaline—water with a high concentration of dissolved mineral salts present

Hypoxia—waters with a low oxygen concentration, usually less than 2 parts per million; hypoxic waters are considered oxygen-depleted

Ice scour—long, narrow ditches in a seabed, created by the collision of fast ice and pack ice

Illegal fishing—(1) conducted by national or foreign vessels in waters under the jurisdiction of a State, without the permission of that State, or in contravention of its laws and regulations; (2) conducted by vessels flying the flag of states that are parties to e relevant regional fisheries management organization but operate in contravention of the conservation and management measures adopted by that organization and by which the states are bound, or relevant provisions of the applicable international law; and (3) in violation of national laws or international obligations, including those undertaken by cooperating states to a relevant regional fisheries management organization

Incidental fisheries bycatch—the catch of additional species, such as fishes, turtles, or marine mammals, that are not targeted by a fishery but are harvested in addition to the target or sought after species

Indigenous species—a species native to a place or biota

Indo-Pacific—widespread species with western limit west of the Andamans and eastern limit east of non-marginal areas of the Pacific Plate

Infaunal—invertebrates living in the sediment of the seafloor

Infralittoral—upper subdivision of the marine sublittoral zone, typically dominated by photophilous algae, having a lower limit at the depth at which illumination is at about 1% of the surface level; between low tide and 100 m

Infrasonic—sound at frequencies too low to be audible to humans, generally below 20 Hz

Inshore—lying close to the shore or coast

Insular—geographically isolated; pertaining to an island

International Union for Conservation of Nature (IUCN) Red List—system for classifying species at high risk of extinction, a list of animal species and subspecies thought to be threatened with extinction and those which are known or thought to have become extinct in the wild

Inter-nesting interval—the amount of time between successive sea turtle nesting events during the nesting season

Interpolate—extrapolation to predict values for a parameter between limited data points

Interspecific competition—competition between two or more distinct species

Interstices—a small or narrow space or interval between things or parts

Interstitial—pertaining to, or occurring within, the pore spaces (interstices) between sediment particles

Intertidal—marine or estuarine environment that lies between the area of shore exposed between high and low tide

Irradiance—incident flux of radiant energy per unit area

Irruptive—entering an area where not characteristically seen

Islet—a small island

Isobath—bathymetric contour of equal depth; usually shown as a line linking points of the same depth

Isohaline—contour of equal salinity, usually shown as a line connecting points of the same salinity

Isopods—shrimp-like animals of the order Isopoda that have their body flattened dorso-ventrally

Isopycnal—a surface of constant potential density

Isotherm—contour of equal temperature; usually shown as a line linking points of the same temperature

Jellyfish—any various free-swimming coelenterates having disc or bell-shaped body of jelly-like consistency having long tentacles with nematocysts of the classes Scyphozoa and Hydrozoa of the phylum Cnidaria

Juvenile—mostly similar in form to adult but not yet sexually mature; a smaller replica of the adult

Kelp—usually large blade-shaped or vine-like brown algae of the order Laminariales that typically grows on rock or stony bottoms (i.e., giant kelp, bull kelp, etc.)

Kogia—the genus comprised of the pygmy sperm whale (*Kogia breviceps*) and dwarf sperm whale (*Kogia sima*)

Krill—see euphausiids

La Niña—when ocean temperatures in the eastern equatorial Pacific are unusually cold; it is essentially the opposite of the El Niño phenomenon; La Niña sometimes is referred to as the cold phase of an El Niño Southern Oscillation event (ENSO)

Lactation—secretion or formation of milk by the mammary glands for the purpose of nursing offspring

Lagoon—a shallow stretch of seawater partly or completely separated from the open ocean by an elongated, narrow strip of land such as a reef or barrier island

Lamellibranchs—any of bivalve mollusks of the class Lamellibranchia, including the clams, scallops, and oysters; also called pelecypod

Laminar—smooth, non-turbulent flow

Laminariales—an order of large brown, structurally complicated, often highly differentiated members, common called kelps, of the alga class Phaeophyceae; distinctive feature include a life history in which microscopic, filamentous, dioecious, gametophytes alternate with a massive parenchymatous sporophyte, and a mature sporophyte typically consisting of a holdfast, stipe, and one or more blades

Lampara net—a surrounding net with a central bunt in the form of a spoon and two lateral wings, making it possible to retain the shoal of fish when the two wings are hauled up at the same type. The ring net type is shaped more like a purse seine and most often fitted with bridles to help pull in the leadline. These nets are generally operated by a relatively small simple boat

Langoustine—a large, edible prawn

Larval—young fish between time of hatching and attainment of juvenile characteristics

Least Concern species (IUCN Red List)—a species that does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened status since it is widespread and abundant

Lessepsian migration—migration between the Red Sea and the Mediterranean by way of the Suez Canal

Lithodid crabs—an anomuran crab with a short body and asymmetrical appendages beneath the abdomen which is no longer housed within shells; inhabitant of cold oceans

Littoral—the zone or division of the ocean bottom that lies between the high and low tide lines; intertidal

Live bottom community—a concentration of benthic invertebrates and demersal fishes that is associated with a region of vertical relief and structural complexity that can be organic (e.g., coral skeletons) and inorganic (e.g., rocks) in origin; such oasis-like communities are often surrounded by expanses of bottom with little relief or structure

Longline—a type of fishing gear using a buoyed line onto which are attached numerous branch lines each terminating in a baited hook; longlines may extend for tens of kilometers and are usually left to drift in surface waters or near the seafloor

Lost year—the early juvenile stage (first years of life) of most sea turtle species that is spent far offshore; few turtles are observed during this time

Low tide—the lowest level to which the tide ebbs within the daily tidal cycle

Low-frequency sound—sound having frequencies below 1,000 Hz

Lucinid bivalve—small mollusks with rounded shells; superfamily Lucinacea

Macroalga—classification of multicellular algae consisting of red, green, or brown species that are defined according to the size of the plant where the body of the plant is large enough to be observable to the human eye and project more than one centimeter above the substratum

Macrobenthic—organisms that live on the bottom of a water body (or in the sediment) on the surface of bedforms (e.g. rock, coral or sediment-epibenthos) or within sedimentary deposits (infauna), that are greater than 50 cm in length

Macrofauna—small to moderate sized invertebrates living on and in bottom sediments

Macrofaunal—organisms large than two millimeters

Macroflora—aquatic plants large enough to be seen with the unaided eye. The most common macrophytes are rooted vascular plants that are usually arranged in zones in aquatic ecosystems and restricted by light and sediment deposition along the shoreline

Macrohabitat—specific, recognizable, repeatable structural units of the environment

Macrophyte—macroscopic plant in an aquatic environment

Macroplankton—large planktonic organisms, 2 to 20 cm in size

Macroplanktonic—large planktonic organisms 20 to 200 mm in diameter

Macroscopic algae—large algae, commonly referred to as seaweed

Madreporian—stony coral; scleractinian

Maërl—loose-lying corallines, either living or dead, usually aggregated into sublittoral masses

Map projection—a mathematical formulation that transforms feature locations on the Earth's curved surface (three-dimensional) to a map's flat surface (two dimensions)

Marine managed area (MMA)—any area of the marine environment set aside by federal, state, local, or tribal governments to protect geological, cultural, or recreational resources and which currently may not be protected as marine protected areas; marine managed areas encompass a broader spectrum of management purposes than marine protected areas

Marine protected area (MPA)—a protected marine littoral or sublittoral area, within territorial waters, EEZs or in the high seas, set aside by law or other effective means, together with its overlying water and associated flora, fauna, historical and cultural features. It provides degrees of preservation and protection for important marine biodiversity and resources or a particular habitat (e.g., mangrove or a reef) or species, or sub-population (e.g., spawners or juveniles) depending on the degree of use permitted. MPAs use (for scientific, educational, recreational, extractive, and other purposes including fishing) is strictly regulated and could be prohibited

Masking—obscuring of sounds of interest by interfering sounds, generally at similar frequencies

Matriarch—the eldest female in a matrilineal group, pod, or subpod

Matriline—the basic social unit of resident killer whales, comprised of a mature female and her immediate descendants; descendants may include mature males and mature daughters and their offspring

Matte—coarse; rough; rugose or granular surface

Maturation—process of becoming mature

Maximum sustained (sustainable) yield (MSY)—largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions

Mean—(arithmetic) average

Median—(arithmetic) the middle number in a set of data when it is calculated from lowest to highest; it is an indicator of central location in a dataset

Mediterranean Oscillation (MO)—pressure difference between the areas of the Mid North Atlantic and the Southeast Mediterranean

Medusa—any of numerous usually marine and free-swimming coelenterates that constitute the sexually reproductive forms of hydrozoans and scyphozoans

Megafaunal—large or relatively large animals of a particular region, considered as a group

Meiofaunal—benthic organisms between 0.5 millimeter and 0.62 micrometer in size

Melon—a fatty cushion forming a bulbous “forehead” in toothed whales; may act to focus sound for echolocation

Mesh size—size of holes in fishing net. Minimum mesh sizes are often prescribed by regulations in order to avoid the capture of the young of valuable species before they have reached their optimal size for capture

Mesopelagic—ocean zone of intermediate depths from about 200 to 2,000 m below the surface, where light penetration drops rapidly and ceases

Mesoplodon—a genus of beaked whales, which includes the Blainville’s beaked whale, Ginkgo-toothed beaked whale, Hubbs’ beaked whale, Perrin’s beaked whale, and pygmy beaked whale

Mesoscale—pertaining to atmospheric phenomena having horizontal scales ranging from a few to several hundred kilometers, including thunderstorms, squall lines, fronts, precipitation bands in tropical and extratropical cyclones, and topographically generated weather systems such as mountain waves and seas and land breezes

Metabolism—all biochemical reactions that take place in an organism

Metadata—information about a geographic information system (GIS) shapefile or coverage file that describes the source of the data or information, the creation date, the data format, the projection, the scale, the accuracy, and the reliability of the GIS file with regard to some standard

Metalloids—nonmetallic element that has some of the chemical properties of a metal

Metamorphosis—process of transforming from one body form to another form during development (e.g., tadpole changing to a frog)

Metazoan—an organism composed of many cells

Migration—periodic movement between one habitat and one or more other habitats involving either the entire or significant component of an animal population; this adaptation allows an animal to monopolize areas where favorable environmental conditions exist for feeding, breeding, and/or other phases of the animals' life history

Mimicry—close resemblance of one organism (mimic) to another (model) to deceive a third (operator)

Moderately exploited—exploited with a low fishing effort, believed to have some limited potential for expansion in total production

Mollusk—largely aquatic phylum of bilaterally symmetrical, unsegmented invertebrates consisting of snails, squids, octopuses, clams, and others

Molt—for pinnipeds, this refers to shedding the fur; belugas are the only cetacean known to do this–the top layer of skin is shed all at one time of the year versus other cetaceans which continuously are sloughing skin

Monospecific—genus with only one species

Morphology—the form and structure of an organism considered as a whole; appearance

Mud volcanoes—conical or volcano-like shaped surface expressions of mud extrusions that are formed when rapidly advecting, over-pressured, mud- and methane-charged pore fluids reach the seafloor

Multi-purpose vessels (MPVs)—fishing vessels equipped so that two or more different types of fishing gear can be operated with minor modification to the vessel or her outfit (e.g., seiner-handliner, trawler-purse seiner, trawler-drifter)

Mysids—small shrimp-like crustaceans

Mysticeti—suborder of cetaceans comprised of the baleen whales

Nanism—short stature

Nasal septum—the wall of flexible cartilage dividing the nasal cavity into halves

Nassariid gastropod—*Nassarius* sp(p) in the superfamily Buccinacea; mollusk

Natal—of or associated with the time or place of one's birth

Nautical mile (NM)—a distance unit used in the marine environment that is equal to one minute of latitude or 1.85 km

Near Threatened (NT) species (IUCN Red List)—a species that does not qualify for Critically Endangered, Endangered, or Vulnerable status, but is close to qualifying for or is likely to qualify for one of those categories in the near future

Nearshore—an indefinite zone that extends seaward from the shoreline

Nektobenthic—swimming off the seabed

Nematode—any unsegmented worm of the phylum Nematoda, having an elongated, cylindrical body; a roundworm

Neonate—a newborn

Neritic zone—the shallow portion of pelagic ocean waters; ocean waters that lie over the continental shelf, usually no deeper than 200 m

Neustonic—organisms living on or just under the water surface, often dependent on surface tension for support

Nocturnal—applied to events that occur during nighttime hours

Nongeniculate corallines—range from a few micrometers to several centimeters thick crusts; often very slow growing occurring on rock, coral skeletons, shells, other algae or seagrasses

North Atlantic—the part of the Atlantic Ocean found north of the Equator

North Pacific—the part of the Pacific Ocean found north of the Equator

Northwest Atlantic—the part of the Atlantic Ocean found north of the Equator and west of the mid-ocean ridge (or roughly the area between Iceland and Greenland); synonymous with western North Atlantic Ocean

Not known—not much information is available to make a judgment

Nursery grounds—any area habitually used for the breeding and keeping of fish stocks

Nursery habitat—an environment crucial for the development of early-stage animals; for some sea turtles, this environment is often an open-ocean area characterized by the presence of *Sargassum* rafts and/or ocean current convergence fronts

Occurrence record—a marine mammal or sea turtle sighting (aerial or shipboard survey), stranding, incidental fisheries bycatch, nesting, or tagging data record for which location information is available. An occurrence record, especially sighting occurrence records, may represent the occurrence of one or multiple animals of a particular species; for instance, <u>one</u> occurrence record from a marine mammal sighting survey may indicate that <u>34</u> short-finned pilot whales were observed at a location but this information would be plotted on a MRA map figure as one occurrence record

Ocean front—a boundary between two water or air masses that have different densities; water density differences are caused by differences in temperature or salinity

Oceanography—the scientific study of the oceans, including the chemistry, biology, geology, and physics of the ocean environment

Octave band—the frequency band whose upper limit in Hz is twice the lower limit

Offshore—open ocean waters over the continental slope that are deeper than 200 m; water beyond the continental shelf break

Oligotrophic—water that is lacking in nutrients, which results in low primary production

Omnivore—an animal that feeds on both plant and animal tissue

Ophuiroid—echinoderms known as basket stars or brittle stars that have long, slender, jointed arms distinctly separated from the body

Opportunistic—used to describe organisms that take advantage of all feeding opportunities and do not prey on a few specific items

Optimum sustainable population—with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element

Over-exploitation—rate of exploitation where the resource stock is drawn below the size that, on average, would support the long term maximum potential yield of the fishery

Overexploited (overfished)—abundance of the stock is too low or when biomass has been estimated to be below a limit biological reference point that is used as the threshold that defines overfished conditions

Overfishing/Overfished—fishing at a rate or level that jeopardizes the capacity of a stock or stock complex to produce maximum sustainable yield on a continuing basis

Overwinter—staying the winter in one area

Overwintering—to remain alive through the winter

Pacific Ocean—a major ocean area contained in a basin extending approximately from 70° west longitude (Cape Horn) to 147° east longitude. The separation of the Pacific Ocean from the Atlantic Ocean is a line marking the shortest distance between Cape Horn and the South Shetland Islands. The Pacific and Indian Oceans are separated by a line running through the Malay Peninsula, Sumatra, Java, Timor, Cape Londonderry (Australia), Tasmania, and the 147° east longitude to Antarctica

Pack ice—sea ice, especially that which is unattached to land and usually moving and shift to same extent

Pandalid shrimp—coldwater “true shrimp” are commercially important nearshore and offshore members of the infraorder Caridea

Pantropical—distributed throughout the tropics

Particulate organic matter (POM)—organic matter that is retained on a 0.45 um sieve; consists of living organisms (phytoplankton, bacteria and animals) and detritus (e.g., biogenic material in various stages of decomposition)

Parturition—act of giving birth

Passive margin—the margin of a continent that is not significantly deformed by tectonic processes because it is the trailing edge of a continent. It does not directly collide with other tectonic plates. The Atlantic coast of North America is an example

Pectoral fin—flipper; flattened fore-limb of a cetacean (supported by bone)

Pelage—the fur or hair covering a mammal

Pelagic—open ocean; the primary division or zone in the open ocean that encompasses the entire water column and is subdivided into the neritic (shallow) and oceanic (deep) zones

Pelagic fishery—fishery targeting on pelagic species

Pelecypod—marine or freshwater mollusks having a soft body with plate-like gills within two shells hinged together; living types include oysters, mussels, clams

Perturbation—a small change in a physical system, most often in a physical system at equilibrium that is disturbed from the outside

Phaeophyte—brown algae

Phocids—all of the "true" seals (i.e., "earless" species); from the family Phocidae. Generally used to refer to all recent pinnipeds that are more closely related to Phoca than to otariids or the walrus

Photic zone—the uppermost zone in the water where sunlight permits photosynthesis

Photo-identification—the use of photographs to identify animals individually; for example, dorsal fin shape and markings for dolphins and the underside of flukes for humpback whales

Photolithic—thriving in conditions of full light

Photosynthesis—the autotrophic process in which solar energy is converted into organic matter (cellular energy) by synthesizing water and carbon dioxide with chlorophyll; plants, algae, and phytoplankton synthesize organic compounds via this process

Physiographic—pertaining to geographic features of the earth's surface

Physiography—physical geography of the ocean bottom and continental margins

Phytoplankton—microscopic, photosynthetic plants and plant-like protists (algae) of the epi-pelagic and neritic zones that are the base of offshore food webs on which ultimately most shellfish, fish, birds, and marine mammals depend; drift with currents, but usually have some ability to control their level in the water column

Pinnacles—sharp pyramidal or cone-shaped rock partly or completely covered by water

Pinnipeds—seals, sea lions, fur seals, and walruses

Piscivorous—a carnivorous animal that eats fish

Pixel—a single point in a graphic image; short for picture element

Plankton—organisms (plant or animal) that drift in the water column and cannot propel or move themselves

Plastron—bony shield composing the ventral side of a turtle's shell

Pod—in resident killer whales, a group of maternally related individuals that tend to travel together; in transient killer whales, the term 'group' is used in preference to 'pod' because groups are not necessarily made up of related animals

Pogonophoran—any member of the small phylum Pogonophora; slender tentacled animals having a tube-like outer covering, living on the deep ocean bottom

Point—single x, y coordinate pair that represents a single geographic feature (e.g., sea turtle sighting)

Polyhedral—a three-dimensional geometric figure whose sides are polygons

Polychaete—class of soft-bodied, metamerically segmented coelomate worms that bears bristles and fleshy appendages on most segments; marine; may be free-swimming, errant, burrowing or tube dwelling

Polygon—area represented by a two-dimensional feature

Ponto-Caspian—encompasses the basins of the Black, Azov, and Caspian seas

Population—a group of individuals of the same species occupying the same area

Posterior—situated near or toward the back of an animal's body

Predation—an interspecific interaction where one animal species (predator) feeds on another animal or pant species (prey) while the prey is alive or after killing it. The relationship tends to be positive (increasing) for the predator population and negative (decreasing) for the prey population

Predator—an organism that lives by preying on other organisms

Prey—animal hunted or caught for food

Primary producer—an autotroph or organism able to utilize inorganic sources of carbon and nitrogen as starting materials for biosynthesis; uses either solar or chemical energy

Primary production—organic matter synthesized by organisms from inorganic substances

Priority species—species considered of interest to the General Fisheries Commission of the Mediterranean (GFCM) based on the volume of landings and economic importance of the species

Prohibited species—any species of fish that a vessel is not specifically allocated or authorized to retain, including fish caught or received in excess of any allocation or authorization

Projection—mathematical formula that transforms the three-dimensional real world features and their locations on the Earth's curved surface into a mapped, two-dimensional surface; projections cause distortions in one or more of the following spatial properties: distance, area, shape, and direction

Prokaryote—any cellular organism that has no nuclear membrane, no organelles in the cytoplasm except ribosomes, and has its genetic material in the form of single continuous strands forming coils or loops, characteristic of all organisms in the kingdom Monera (bacteria and blue-green algae)

Protistan—pertaining to the eukaryotic organisms of the kingdom Protista; includes some algae, fungi, and protozoans

Protozoans—any of a large group of single-celled, usually microscopic, eukaryotic organisms, such as amoebas, ciliates, flagellates, and sporozoans

Psycho-acoustic study—a behavior study used to measure the hearing ability of an organism (e.g., operant conditioning where an animal is behaviorally trained using positive reinforcement to respond to sound stimuli)

Pteropods—any of various marine gastropod mollusks of the subclass Opisthobranchia having the anterior lobes of the foot expanded into broad, line, wing-like swimming organs; also called seabutterfly

Pup—a young animal of various species, especially young pinnipeds

Pupping—the process of giving birth by pinnipeds

Pycnocline—a zone of marked water density gradient that is usually associated with depth

Pyrosome—any compound ascidian of the genus *Pyrosoma;* form large hollow cylinders, sometimes two or three feet long, which swim at the surface; are very phosphorescent

Quay—wharf or bank where ships and other vessels are loaded

Range—the maximum extent of geographic area used by a species

Rare—a plant or animal restricted in distribution or number; in the case of sea turtles, rare means that a species occurs, or probably occurs, regularly within the region but in very small numbers; in the case of marine mammals, rare means a species that only occurs in the area sporadically

Recreational fishing—fishing for sport or pleasure

Recruitment—number of fish that first become vulnerable to the fishery each year through growth and/or migration into the fishing area

Red algae—division of algae (Rhodophyta) consisting of large multicellular, structurally complex photosynthetic organisms that grow attached to rocks or other substrates; largely marine; some forms instrumental in formation of coral reefs by precipitating calcium carbonate; form large rocky masses

Redox potential—abbreviation for Reduction-Oxidation Potential. A measurement of the state of oxidation of a system

Regular—in the case of marine mammals, a species that occurs as a regular or normal part of the fauna of the area, regardless of how abundant or common it is

Relief—the inequalities (elevations and depressions) of the sea bottom

Remineralization—release of nutrients and other compounds from dead organic matter chemically bound in soils or sediments through chemical processes

Rhizome—horizontal stem of a plant that often sends out roots and shoots from its nodes

Rhodophyte—red algae

Robust—powerfully built

Rookery—an animal's breeding ground; it is the specific beach on which they nest (turtle) or pup (pinniped)

Rorqual—any of six species of baleen whales (the minke, blue, humpback, fin, Bryde's, or sei whale) belonging to the family Balaenopteridae; characterized by a variable number of pleats that run longitudinally from the chin to near the umbilicus; the pleats expand during feeding to increase the capacity of the mouth

Rostrum—the snout or beak of a cetacean; in fish, a forward projection of the snout

Saddle—a light-colored patch behind the dorsal fin of some cetaceans

Salinity—the concentration of salt in water, measured in practical salinity units (psu)

Salp—any of various free-swimming tunicates of the genus *Salp*, of warm seas, having a translucent, somewhat flattened, keg-like body with an opening at each end

Salt marsh—coastal ecosystem that is inundated by seawater for some period of time; plants in this ecosystem have special adaptations to survive in the presence of high salinities

Sand bank—a patch of sand in water, which creates a shallow area; may serve as a natural habitat for a variety of wading birds

Sandeels—very small silvery eel-like schooling fishes that burrow into sandy beaches, of the genus *Ammodytes*

Sargassum—a genus of brown algae commonly found in temperate and tropical waters

Scalar—the distance between two points in space

Scallop—belong to the family Pectinidae of bivalve mollusks; have a central adductor muscle, shell has characteristic central scar marking its point of attachment; may be attached to a substrate by a structure called a byssus or cemented to their substrate

Scavenger—animals that consume already dead organic life-forms

School—a social group of fish, drawn together by social attraction, whose members are usually of the same species, size, and age; the members of a school move in unison along parallel paths in the same direction

Scleractinian—hard or stony corals (class Anthozoa, subclass Hexacorallia, order Scleractinia) known as true corals that dominate reef ecosystems; they have a compact calcareous skeleton and polyps with no siphonoglyphs (grooves)

Scutes—long, thickened scales that cover underlying bony plates of carapace and plastron of sea turtles that are used for protection

Sea anemones—large, heavy, complex polyps that belong to the cnidarian class Anthozoa

Sea cucumbers—echinoderm having a flexible sausage-shaped body with tentacles surrounding the mouth and tube feet; free-living feeder

Sea lilies—class of sessile echinoderms referred to as crinoids; these animals have a cup-shaped body that attaches to the substratum by a stalk and has feathery arms; filters food particles from the currents flowing past them

Sea mosses—sessile aquatic animal forming moss-like colonies of small polyps each having a curved or circular ridge bearing tentacles; attaches to stones or seaweed; reproduces by budding

Sea stars—one of the class Asteroidea of echinoderms having flat, usually fine-armed body containing embedded calcareous plates bearing spines or tubercles

Sea surface temperatures (SST)—the temperature of the layer of seawater (approximately 0.5 m deep) nearest the atmosphere

Sea urchins—one of the class (Echinoidea) of echinoderms in which the body is covered by hard shell (test) composed of fitted immovable plates with often large and sharp spines that are articulated at bases; may be of various sizes - spherical, depressed spherical, discoid, or round

Sea whips—erect colony of marine animals of the phylum Cnidaria with whip-like branches; skeleton consists of a horny axis, overlaid with small calcareous bodies called spicules

Seagrass—submerged aquatic vegetation that form extensive underwater meadows (or beds) found in shallow-water depths and various temperatures and salinity ranges

Seamount—an undersea mountain rising more than 914 m from the sea floor, but having a summit at least 305 m below sea level (in contrast to an island)

Seasonal closure—banning of fishing activity (in an area or of an entire fishery) for a few weeks or months, to protect juveniles or spawners

Sedentary—organism that spends the majority of its time in one place

Sediment—solid fragmented material, either mineral or organic, that is deposited by ice, water, or air

Sequestration—compound or metabolite is locked away so as to not to be readily available

Serpulid—fan worms or feather-duster worms belonging to the class Polychaeta in the phylum Annelida; calcareous tubes

Sessile—used to describe an animal that is attached to something rather than free moving

Sexual maturity—the state in which an animal is physiologically capable of reproducing

Sexually dimorphic—differences in the appearance of the sexes of a species; size differences are a primary difference where males are generally larger than females; other differences may be in body shape and color

Shallow-water—water that is between the shore and the continental shelf break or shallower than 200 m

Shapefile—vector data storage format used to store the location, shape, and attributes of geographic features; a shapefile must be one and only one of three possible feature classes: lines, points, and polygons

Shared stock—stock fished by two or more countries

Shelf break (continental)—region where the slope of the seabed rapidly changes from gently sloping to steeply sloping and the continental shelf gives way to the continental slope; the world-wide average water depth at which the shelf break is found is 155 m, but on average, the shelf break usually occurs between 100 to 200 m water depth

Shelf break region—the geographic area surrounding the continental shelf break and including both the outer continental shelf and upper continental slope

Siphonophora—marine colonial hydrozoans characterized by the complex organization of components which may be connected by a stem-like region or may be more closely united into a compact organisms; jellyfish

Sipunculan—sipunculid worms or peanut worms; bilaterally symmetrical, unsegmented marine worms in the phylum Sipuncula

Sirenia—the order of marine mammals that consists of manatees and the dugong

Site fidelity—the tendency to return to the same site repeatedly

Soft corals—class of corals (Anthozoa) characterized by having retractable polyps with eight, branching tentacles (i.e., sea anemones); usually attached to rocks

Soft bottom—as substrate comprised of soft sedimentary material such as sand, silt, or mud

Solemyid—awning clams; possess chemosynthetic bacteria in gills; mollusk in the order Solemyoida

Source level—the acoustic pressure that would be measured at a standard distance (usually 1 m) from a point source radiating the same amount of sound as the actual source

Spat—larval stage; spawn

Spawn—the release of eggs and sperm during mating

Spawning grounds—areas where a fish stock or species will move to, to spawn

Species—a population or series of populations of organisms that can interbreed freely with each other but not with members of the other species

Species diversity—the number of different species in a given area

Species of concern—a species about which the NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA

Species richness—total number of different species present in a particular environment. It expresses variety but not relative abundance. Species richness is perhaps the simplest measure of biodiversity

Sponges—any of numerous primitive, chiefly marine animals of the phylum Porifera, characteristically having a porous skeleton composed of fibrous material or siliceous or calcareous spicules and often forming irregularly shaped colonies attached to an underwater surface

Standard deviation (S.D.)—a statistical measure of the amount by which a set of values differs from the arithmetical mean; simply, how widely values are dispersed from the mean

Star fish—any of various marine echinoderms of the class Asteroidea, characteristically having a thick, often spiny body with five arms extending from a central disk; also called sea star

Stenella—in the Pacific, it is the genus of oceanic dolphins consisting of striped, pantropical spotted, and spinner dolphins, which are similar in appearance

Stenellid—refers to dolphins of the genus *Stenella*

Stock—a group of individuals that belong to the same population, that reacts to the exploitation in an homogeneous way, that has a more or less fixed spawning area, spawning season, and migration habits that are similar

Stock structure—the genetic diversity of a stock

Stranding—the act where marine mammals or sea turtles accidentally come ashore, either alive or dead

Strategic stock—any marine mammal stock: (1) from which the level of direct human-caused mortality exceeds the potential biological removal level; (2) which is declining and likely to be listed as threatened under the Endangered Species Act; or (3) which is listed as threatened or endangered under the Endangered Species Act or as depleted under the Marine Mammal Protection Act

Subadult—maturing individuals that are not yet sexually mature

Subarctic—pertaining to regions adjacent to the Arctic Circle

Sublittoral—benthic region extending from mean low waters to a depth of about 200 meters

Submarine canyon—narrow, deep depression or steep-sided valley cut in the continental shelf or slope formed by river of glacial erosion before the shelf was submerged

Submarine fans—are essentially turbidite dumps most typically at the mouths of submarine canyons that feed them

Submarine ridge—a ridge of submarine mountains where two massive tectonic plates are moving apart

Substrata—layer or base on which animal or plant lives

Substrate—the material to which an organism is attached or in which it grows and lives; also, the underlying layer or substance

Subtidal—marine or estuarine environment that lies below mean low-water; always submerged in a tidally-influenced area

Subtropical—the regions lying between the tropical and temperate latitudes

Suction feeding—capture of prey using suction, generally with the tongue employed as a piston to create a vacuum pressure

Suspension feeder—an animal that eats by filtering out tiny particles or organic material suspended in the water

Symbiont—the smaller participant in a symbiotic relationship; living in or on the host

Sympatric—species or subspecies occurring together; having overlapping areas of distribution

Talus—weathered rock which has fallen from and accumulated at the bottom of a cliff

Target species—species of fish or invertebrate specifically sought by a fishery

Taxa (taxon)—a defined unit (e.g., species, genus, or family) in the classification of living organisms

Taxonomy—the study of the rules, principles, and practice of classification, especially of living organisms

Temperate—between subpolar and subtropical regions, where the mean annual temperature ranges between 50°and 55°F (10° to 13°C)

Temporary threshold shift (TTS)—a temporary impairment in hearing ability caused by exposure to strong sounds

Terrigenous—shallow marine sediments consisting of material deriver from the land surface

Territory—an area occupied exclusively by one animal and defended by aggressive behavior or displays

Thermocline—a relatively narrow boundary layer of water where temperature decreases rapidly with depth; little water or solute exchange occurs across the thermocline which is maintained by solar heating of the upper water layers

Thermogenic—causing or pertaining to the production of heat

Thermophilic—thrives at relatively high temperatures

Thermoregulatory—an organism's ability to maintain a specific body temperature regardless of the environmental temperature

Threatened species—any plant or animal species likely to become endangered within the foreseeable future throughout all or a part of its range; the authority to designate a species as threatened is shared by the U.S. Fish and Wildlife Service (terrestrial species, sea turtles on land, manatees) and National Marine Fisheries Service (most marine species) under provisions of the Endangered Species Act

Thyasirid bivalve—bivalve mollusk in the order Veneroida in the class Bivalvia

Tidal bore—a tidal phenomenon in which the leading edge of the incoming tide forms a wave of water that travel up a river against the direction of the current

Tidal flat—a marshy or muddy land area covered and uncovered by the rise and fall of the tide

Topography—physical features of the ocean floor, such as mounds or ridges

Total length—the longest measurable distance from the outermost portion of a fish's snout lengthwise to the outermost portion of the tail fin

Transoceanic—spanning or crossing the ocean

Trawl net—a towed fishing gear or net that consists of a cod-end or bag for collecting the fish or other target species; trawls can be towed at any depth of the water column

Trophic level—a step in the transfer of food or energy within a chain

Tuna farming—involves the collection of wild fish, ranging from small to large specimens, and their rearing in floating cages to increase their fat content for periods spanning from two to six months up to one to two years

Tunicates—any of various chordate marine animals of the subphylum Tunicata or Urochordata having a cylindrical or globular body enclosed in a tough outer covering (i.e., sea squirts and salps)

Tursiops—the genus of bottlenose dolphins comprised of the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)

Underexploited—undeveloped or new fishery, believed to have a significant potential for expansion in total production

Underslung—having lower part projecting beyond the upper

Unregulated fishing—(1) area of application of a relevant regional fisheries management organization that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization and (2) in areas or fish sticks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law

Unreported fishing—(1) have not been reported, or have been misreported, to the relevant national authority, in contravention of national and regulations and (2) undertaken in the area of competence of a relevant regional fisheries management organization which have not been reported or have been misreported, in contravention of the reporting procedures of that organization

Upwelling—movement of dense, cold, nutrient-rich water up from ocean depths to the surface

Uro-genital area—portion of ventral surface around and near the excretory and genital orifices

Vagile—wandering, free motile, mobile

Vagrant—a wanderer, in the same sense of an animal moving outside the usual limits of distribution for its species or population

Vegetal—characteristic of plants

Ventral—relating to the underside (or belly side) of an animal

Vermetid—sessile worm snail in the family Vermetidae in the phylum Mollusca; mollusk

Vertebrates—animals with a backbone

Volcanic arc—chain of volcanic islands or mountains located near the edge of continents that are formed as the result of tectonic plate subduction

Vulnerable (VU) species (IUCN RedList)—a species considered to be facing a high risk of extinction

Warm-core ring—an eddy or circular current of warm water; in the North Atlantic Ocean, the water in warm-core rings circulates anticyclonically (clockwise) and the rings are formed when meanders pinch off the northern side of the warm Gulf Stream

Water column—a vertical column of seawater extending from the surface to the sea bottom

Water mass—a body of water that can be identified by a specific temperature and salinity

Weaning—the end of the lactation period; the process of changing from milk to a solid diet in juvenile mammals

Western North Atlantic—the part of the Atlantic Ocean found north of the Equator and west of the mid-ocean ridge (or roughly the area between Iceland and Greenland); synonymous with Northwest Atlantic Ocean

Wetland—an area inundated by water frequently enough to support vegetation that requires saturated soil conditions for growth and reproduction; generally includes swamps, marshes, springs, seeps, or wet meadows; they can be freshwater or saltwater

Whale fall—term used for a whale carcass that has fallen to the ocean floor

Whale lice—amphipod crustaceans of the family Cyanidae; adapted for living in crevices and other secure places on the skin of cetaceans (for example, gray whales), on which whale lice largely feed

Whistle—a narrow band frequency sound produced by some toothed whales and used for communication; they typically have energy below 20 kHz

Young-of- the-year (YOY)—a juvenile fish less than one year old

Zoantharian—also known as Hexacorallia; subclass of the class Anthozoa within the phylum Cnidaria; includes sea anemones and most existing corals except for soft corals

Zonation—the occurrence of single species or groups of species in recognizable bands that might delineate a range of water depth or a range of height in the intertidal zone

Zoobenthos—animals living in or on the sea bed

Zooplankton—diverse group of non-photosynthesizing organisms that drift freely in the water or its surface; zooplankton are composed of a wide range of invertebrates, including larval forms of fish and shellfish

This page intentionally left blank

APPENDIX A: INTRODUCTION

TABLE OF CONTENTS

Data confidence and Eastern Mediterranean Study Area geographic information system (GIS) maps ..... Appendix A-1

Map projections ..... Appendix A-2

Overview of research efforts that provide occurrence information for marine mammals and sea turtles in the Mediterranean Study Area ..... Appendix A-3

APPENDIX A

LIST OF TABLES

Table	Title
A-1	Inventory of the marine mammal and sea turtle data sources included in the MRA for the eastern Mediterranean Study Area.

Appendix A-1. Data confidence and Eastern Mediterranean Study Area geographic information system (GIS) maps.

The level of data confidence is dependent upon three factors: precision, accuracy, and currency. Each of these three factors are in turn affected by all the variables involved in obtaining data and putting the data into a GIS in order to display the data on a map. Following is a brief description of the three main factors and some of the subsequent variables that figure into overall level of confidence.

- ***Precision***—Refers to whether or not the description of the data is specific or non-specific. It is possible to have data recorded very precisely but with very low accuracy. In other words we may say that 2 + 2 = 5.12546732, where the sum is given very precisely but inaccurately. Global positioning systems (GPS) offer the highest level of precision for recording locations.

- ***Accuracy***—Refers to how well the data reflect reality. There may be 10 sightings of harbor porpoises in an area, but they may actually have been common dolphins. Even if the locations were precisely recorded, the data are still not accurate. Some variables that affect accuracy are who originally recorded the data (source reliability), how many people have processed/altered the data since it originated (number of iterations), and the method used to record the data.

- ***Currency***—Refers to how recently the data were obtained. Because recent developments in equipment and methods have improved precision and accuracy, confidence is higher for data that have been recorded more recently.

Eastern Mediterranean Study Area Map Examples	Description of Map Data	Confidence Level
Bathymetry, Bottom Substrate Sea Surface Temperature, Chlorophyll, Marine Mammal and Sea Turtle Occurrence maps, Maritime Boundaries, Ferry Routes	Data from original/reliable sources. Provided in a digital format with geographic coordinates given. Identified as "*source data*" in map captions.	**High** 37 maps (64% of total number of maps)
Circulation, Marine Protected Areas, Navigable Waterways, Seagrass, Maërl Beds, Rocky reefs, Artificial Substrates	First- or second-hand data sources. Locations obtained through scanning geo-referenced* maps. Identified as "*source map(s) scanned*" in map captions.	**Medium** 14 maps (24% of total number of maps)
Migration maps, Fisheries	First- or second-hand data sources. Locations obtained by digitizing from written descriptions with no coordinate data or by altering and/or interpreting raw data. Identified respectively as "*source information*" or "*map adapted from*" in map captions.	**Low** 7 maps (12% of total number of maps)

* Geo-referenced–Refers to data, maps, and images with points that can be matched to real world coordinates so that the data can be accurately positioned in a GIS.

Appendix A-2. Map projections.

Since understanding the role map projections play in the creation of valid and usable maps is so critical, further explanation of this issue is provided. A geographic reference system (such as latitude and longitude) is based on the angles measured from the earth's center. A planar coordinate system, on the other hand, is based on measurements on the surface of the earth. To meaningfully transfer real world coordinates (in 3D) to planar coordinate (2D), a transformation process has to be applied. This transformation process is called a projection. Such a transformation involves the distortion of one or more of the following elements: shape, area, distance, and/or direction. The user typically dictates the choice of a projection type to ensure the least distortion to one or more of the four elements. Choice of a particular projection is dictated by issues such as the location of the place on Earth, purpose of the project, user constraints, and others.

The length of one degree of longitude will vary depending on what latitude on Earth the measurement is taken. The geographic coordinate system measures the angles of longitude from the center of the Earth and not distance on the Earth's surface. One degree of longitude at the equator measures 111 km versus 0 km at the poles. Using a map projection mitigates this difference or seeming distortion when using geographic coordinates. However, when multiple data sources with multiple projection systems are used, the most flexible system to standardize the disparate data is to keep all data unprojected. Thus, the maps in this MRA are untransformed, meaning they are shown unprojected on the map figures and their associated geographic data are delivered unprojected.

Since the measurement units for unprojected, geographic coordinates are not associated with a standard length, they cannot be used as an accurate measure of distance. Since the maps in the assessment report are in geographic coordinates and the scale information only provides approximate distances, the map figures should not be used for measurement. The map scales and reference datum used on all maps in this MRA are presented in nautical miles.

Appendix A-3. Overview of research efforts that provide occurrence information for marine mammals and sea turtles in the Mediterranean Study Area.

Scientific research in the Mediterranean Sea has a long history, first attributed to the Prince of Monaco's cruises to the Atlantic in 1885. On these cruises, he began to investigate not only the species encountered, but oceanographic parameters, such as local current flow, as well (Albert Prince of Monaco 1898). Since that time a number of governmental and non-governmental agencies have formed in the Mediterranean Sea attempting to conserve and understand the Mediterranean Sea and its inhabitants.

To subjectively determine the areas of occurrence for marine mammals and sea turtles in the Mediterranean Study Area, attempts were made to compile available records from aerial and shipboard survey sightings, strandings, incidental fisheries bycatch, taggings, pinniped haulout sites, and miscellaneous/opportunistic encounters. The following is intended to be a review of the many comprehensive research efforts conducted and/or sponsored by federal, state, and academic institutions in both the U.S. and abroad directed to the marine mammal and sea turtle species in the region. For a variety of reasons, it was not possible to obtain every data source in existence; however, a large number of data sets were collected (**Table A-1**). Comprehensive data sources that were available for inclusion in this MRA are described below. The occurrence polygons were based on both the aerial and shipboard survey (on-effort) data as well as known habitat preferences of individual species in the Mediterranean Sea determined in consultation with regional experts.

Aerial and Shipboard Surveys

Aerial and shipboard surveys constitute a majority of the marine mammal data collected for this MRA. Henwood and Epperly (1999) and Forney (2002) provide brief descriptions of how aerial and shipboard surveys are conducted. Aerial or shipboard observers usually collect line-transect data during daylight hours, weather permitting (e.g., no rain, calm seas). Surveys are conducted along pre-designated transect lines following established sampling methods that allow for abundance estimates in an area of interest. Animal sightings that occur while the observation platform (e.g., ship or plane) is traveling along the transect line and observers are actively searching for animals are noted as "on-effort" sightings and can be included when estimating abundances and/or densities in an area. Any animal sightings that occur while the observation platform is diverted from or in transit to the transect line are recorded as "off-effort" sightings. It should be noted that limited aerial and shipboard surveys have been conducted within the Mediterranean Study Area. In addition, very few offshore surveys have been conducted in the eastern Mediterranean Sea, which likely accounts for the small number of sightings reported for the region. The Mediterranean Study Area has been surveyed much more intensely during the summer (May 29 through November 15) than during the winter (November 16 through May 28).

The typical goal of an aerial survey is to estimate the overall density or abundance of a given marine mammal or sea turtle population. Aerial surveys are appropriate when little is known about the distribution and abundance of a population or species over relatively large areas. Such surveys help identify "hot spots" for future studies. Surveys can then be conducted to monitor trends in seasonal or annual variations in distribution and abundance patterns. Aircraft are also used in fine-scale surveys over a subregion of a study area.

- Between August and October 2003 the **IFAW** conducted a pilot survey aboard the research vessel *Song of the Whale* to develop and test an appropriate survey protocol that could provide adequate 'snap shot' abundance estimates within the Mediterranean Sea. Although the main focus areas of this study were the Ionian Sea and the Sicilian and Malta Channels, data were also collected on passage through the western Mediterranean Sea (Song of the Whale Research Team 2004). Data collected from these pilot studies were requested from the IFAW, but were not received for inclusion in the report.

Table A-1. Inventory of the marine mammal and sea turtle data sources included in the MRA for the eastern Mediterranean Study Area.

Data Source	Record Dates
Strandings	
Strandings of Cuvier's Beaked Whale in the Mediterranean Sea	1803-2003
Centro Studi Cetacei	1986-
Mixed/Miscellaneous Data Sources	
United Kingdom Royal Navy Opportunistic Cetacean Sightings	1947-2003
Published Literature and Reports	
Allen	1908
Pilleri	1970
Marchessaux	1980
Pilleri and Pilleri	1983
Raga et al.	1985
Cagnolaro et al.	1986
Kinzelbach	1986
Pilleri and Pilleri	1987
Hammond and Lockyer	1988
Manzella and Fontaine	1988
Chakroun	1994
Pulcini and Angradi	1994
Margaritoulis et al.	1996
Marini et al.	1996
Kinzelbach	1997
Taskavak et al.	1998
Van Waerebeek et al.	1999
Bearzi	2000
Frantzis et al.	2001
Kerem et al.	2001
Laurent et al.	2001
Affronte et al.	2003
Drouot	2003
Roberts	2003
Drouot et al.	2004
Frantzis et al.	2004
Kerem and Goffman	2004
Ozturk et al.	2004
Saad	2004
Scheinin et al.	2004
Gomercic et al.	2005
Kerem	2005
Podesta et al.	2006

- The **Ocean Alliance** conducted eight research legs based in the Mediterranean Sea between the 20th July and 19th November 2004. The objectives of these research legs were two-fold. 1) To collect biopsy samples, identification photographs, and acoustic recordings from sperm whales (*Physeter macrocephalus*) for toxicological, genetic, fatty acid, isotopic, acoustic, and photo-identification studies and 2) To obtain audible acoustic recordings of beaked whale species for acoustic analysis. In addition to sperm whales, eight additional species were sighted, including sea turtles, cetaceans, and pinnipeds (The Ocean Alliance 2004).

- The **Cetacean Research Group of the University of Thessaly**, the **Zoology and Marine Biology Department of the University of Athens** and **OCEANUS onlus** recruited volunteer assistants for a marine mammal census conducted in the Greek Seas in October 2006. The aim of the survey was to collect visual and acoustic data as well as skin samples for a population genetic structure research and toxicology analysis of marine mammals in the region. While a majority of this cruise took place in

the Aegean Sea, the second leg of the voyage (Crete to Patra) did venture into the eastern Ionian Sea. Attempts to obtain data from Oceanus onlus for this and other research cruises conducted in the Ionian Sea were unsuccessful.

Strandings

Strandings data provide critical information on natural and human-induced mortality of marine mammals as well as information on the health, population dynamics, and life histories of the concerned species (Becker et al. 1994). Stranding networks exist throughout the Mediterranean Sea at the national level. They each vary in the extent of their spatial and temporal coverage, efficiency, and institutional involvement. Many of the national stranding networks involve government agencies and have been in operation for the last 10 yrs. Involved parties include national, regional, or local departments of the environment or fisheries; public and private research institutions (universities, marine institutes, etc.); and NGOs. Organizations in the following countries are currently involved in stranding procedures: Albania, Algeria, Cyprus, Croatia, France, Greece, Israel, Italy, Libya, Malta, Morocco, Spain, Tunisia, and Turkey (UNEP 2004). Other countries in the Mediterranean Sea have not developed stranding networks and do not regularly monitor strandings.

- The **Mediterranean Database of Cetacean Strandings** (**MEDACES**) was established in 2001 under the Barcelona Convention to coordinate cetacean stranding information among regions adjacent to the Mediterranean Sea, Black Sea, and contiguous Atlantic waters as defined in the ACCOBAMS.[1] Management of the database is entrusted to the University of Valencia's Cavanilles Biodiversity Institute (**ICBIBE**), with the financial support of the Spanish Ministry of Environment (**MMA**). The **RAC/SPA** is the depository for the database. The MEDACES aims to standardize stranding data collection and compile and maintain all details of cetacean strandings including an inventory of the samples taken. MEDACES will also incorporate stranding information that has already been published in scientific journals and technical reports. The cetacean stranding data will be organized into a spatially referenced database of public access via the MEDACES website (http://medaces.uv.es/). The database is still in progress; therefore, it could not be included in this MRA.

- The **Centro Studi Cetacei** (**CSC**), a research group of the Italian Society of Natural Sciences, was founded in 1985 and is recognized as a central location for the reporting and recording of strandings of cetaceans along the Italian coastlines. This information on stranded or accidentally captured cetaceans off the coasts of Italy has been collected by the CSC since 1986 as part of the "Stranding Project." Recorded strandings are published in annual reports (e.g., Centro Studi Cetacei 1997, 2000, 2003). "Stranding Project" is the continuation of the "Cetacea Project," initiated by the Institute of Zoology and Comparative Anatomy of the **University of Messina** and the **Civic Museums of Natural History** under the auspice of the **WWF Italia** (Bortolotto et al. 1992). Stranding information is collected by CSC with the help of Harbour Offices and the general public. Data from 1986 to 2002 was obtained from the **Supreme Allied Commander, Atlantic** (**SACLANT**) database; data since 2002 was georeferenced from the annual reports and included in the MRA.

- Strandings have recently been collected and placed into a stranding database for Cuvier's Beaked Whales in the Mediterranean Sea. A list of the strandings can be found in Podesta et al. (2006). These data points were acquired from a variety of sources including the stranding societies of Italy (**CSC**), Greece (**Cetacean Rescue and Rehabilitation Research Society** [**ARION**] and **Delphis Hellenic Cetacean Research and Conservation Society**), and France (**Centre de Recherche sur les Mammifères Marins, La Rochelle** [**CRMM**]). Additionally, stranding information was compiled from scientific literature, personal communications and archives, regional newspapers, and the World Wide Web from the 20 countries that border the Mediterranean Sea. This database also includes bycaught and dead animals found floating in the open sea. The database includes information (when available) about the number of animals, the species, size and sex, the status observed when the animals were found (alive, dead, level of decay), any injuries observed on bodies, the presumed cause of death and the treatment and release condition in cases of animals found alive. Additional information related to the location of biological samples (tissue, skeletons, etc.) and the final

disposition of the bodies is included. All data were georeferenced as in many cases exact latitude and longitude was not known. Information from the database was acquired from Angela D'Amico, Space and Naval Warfare Systems Command (**SPAWAR**) for use in the MRA.

Incidental Fisheries Bycatch

In contrast to commercial fisheries in the U.S., those in the Mediterranean Sea are not currently required to have observers onboard to collect information on incidental bycatch of marine mammals, sea turtles, and seabirds. Although all countries bordering the Mediterranean Sea have adopted measures to manage fishing activities, they either lack or are inconsistent in adopting other important measures such as the protection of protected species. Therefore, information regarding fishery operations and associated bycatch is limited. Most bycatch data from the Mediterranean Sea has been collected by researchers who have collaborative relationships with fishermen who allow observers onboard their vessels. Most of the marine mammal and sea turtle bycatch data used in this MRA came from published literature and reports (see **Table A-1**).

- From October 1999 to December 2000, gillnet fisheries off the northeastern coastline of Sardinia were monitored through weekly interviews with local fishermen (approximately 20% of the gillnet fleet) in a first attempt to analyze the interactions between bottlenose dolphins and gillnet fisheries. Information requested from the fishers included 1) days operating in the fishery, 2) gillnet position at sea (fishing area and depth), 3) days on which damage was caused to the gear by bottlenose dolphins, and 4) bottlenose dolphin mortality (Díaz López 2006). All surveys were conducted within the 12 NM buffer predetermined for this report and thus data were not requested for inclusion.

Mixed/ Miscellaneous Data Sources

- Eighteen dedicated surveys were organized during the summer and autumn months between 1991 and 2002 for sightings of cetaceans in the eastern Ionian Sea, the area southwest of Crete, the Gulf of Corinth, and the Myrtoon Sea (Frantzis et al. 2003). Ferries with standard routes were utilized by researches as platforms of opportunity by Carpentieri et al. (1999) for surveys of the Aegean and Cretan seas. Convential sighting methodology was utilized for most survey areas addressed, with one observer continuously scanning the surface. Only initial sighting positions of each animal were recorded (Frantzis et al. 2003).

- Visual and acoustic studies have been conducting by the **National Centre for Marine Research** southwest of Crete. This research comprises a long-term study of cetaceans, beaked whales and sperm whales in particular (Frantzis et al. 1999). In conjunction with the survey, photo-identification surveys are also conducted onboard the research vessels.

- **Archelon**, **the Sea Turtle Protection Society of Greece** (**STPS**), was established in 1983 with the objectives of studying, protecting and managing sea turtle populations and their habitats (Kasparek 2001). Ongoing projects include the study and protection of nesting activity on all major nesting beaches in Greece (Zakynthos, Kyparissia Bay, Lakonikos Bay, Crete). Lobbying is done both locally and nationally for sea turtle conservation in Greece. Projects are carried out in cooperation with various Ministries and competent authorities, partly with support from the European Commission. Archelon was instrumental in the establishment of the first National Marine Park for sea turtles in the Mediterranean Sea (Zakynthos; Kasparek 2001).

- **Archipelagos**, **Institute of Marine and Environmental Research of the Aegean Sea**, is a Greek non-profit, non-governmental organization dedicated to preserving the natural marine and terrestrial environment of the Aegean Sea. Since 1998, Archipelagos scientists have conducted research in several regions of the Greek seas including the Ionian Sea, Sporades, the central Aegean Sea, Lybian Sea, and the eastern Aegean Sea. Since 2000, Archipelagos has focused its research efforts in the eastern Aegean Sea. Archipelagos has collaborated with universities and research institutes from Greece, U.K., Spain, Portugal, and Turkey as well as scientists from other European countries. Archipelagos research efforts include studies of the ecology of littoral zone ecosystems and surveys

and acoustic monitoring of populations of striped, bottlenose, common, and Risso's dolphins as well as sperm whales and Cuvier's beaked whales. Scientists have also assessed the populations of Mediterranean monk seals via boat-based surveys and the involvement of fishermen in monitoring their populations. Due to the locations of these studies outside of the Study Area, cetacean data was not requested from Archipelagos. Attempts were made to obtain Mediterranean monk seal information; however, the data were not received.

- The **Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare** (**ICRAM**) began a series of activities in the late 1990s and early 2000s to promote an increased knowledge of cetaceans in the Mediterranean Sea (Notarbartolo di Sciara and Bearzi in press). This included an investigation of bottlenose dolphin encounters with local fishing operations off the coast of Sardinia and in the Adriatic Sea (Lauriano et al. 1999; Lauriano et al. 2004), acoustic monitoring in the Pelagos Sanctuary (Clark et al. 2002), and collection of cetacean sightings by the Italian Navy (Nascetti and Notarbartolo di Sciara 1997). Attempts were made to obtain Mediterranean monk seal sightings and haul out information; however, a change in organizational leadership prevented the release of the data for inclusion.

- **Chelon** is a non-governmental organization carrying out marine turtle research projects including the mapping of turtle nesting beaches. Primarily, research has focused in Greece and Turkey; however, work has spanned as far west as Italy (Kasparek 2001; Casale et al. 2003).

- The **Groupe de Recherche sur les Cétacés** (**GREC**) aims to support the acquisition of new knowledge on wild cetaceans, to distribute this knowledge towards the scientific community, and to contribute to the education of the public on the protection of cetaceans in the Mediterranean Sea. Much of this work takes place in the northwestern Mediterranean Sea, although some work has extended eastward into the Ionian and Levantine seas (Gannier 1998, 2005).

- The **Institute of Marine Biology of Crete** (**IMBC**), founded in 1987 as an independent research organization by the Greek Ministry of Industry, Energy, Research and Technology, under the direct supervision of the General Secretariat for Research and Technology, has been widely recognized as one of the leading marine research institutes of the Mediterranean region (Kasparek 2001). IMBC research endeavors have included the mapping of turtle nesting areas (including the marine regions adjacent to them), marine turtle genetics, and turtle-fisheries interactions.

- The **Italian Navy** has aided in increasing the knowledge on the distribution of large cetaceans in the Italian Seas by reporting sightings to ICRAM (Nascetti and Notarbartolo di Sciara 1997), and investigating the possible effect of military sonar on cetaceans (Nascetti et al. 1997). Sighting data from the Italian Navy are included in the SACLANT database obtained and are included in this MRA.

- The objectives of the **Marine Biology Research Centre Tajura, Libya** (**MBRC**) include carrying out field studies, research and training activities in the domain of marine biology, establishing classified reference collections of marine and coastal lagoon fauna and flora, and documenting and publishing results of studies/research works. The MBRC acted as a partner in the national sea turtle nesting surveys carried out 1995, 1997 and 1998 (Kasparek 2001).

- The **Mediterranean Association to Save the Sea Turtles** (**MEDASSET**), founded in 1988, aims to conserve and protect the remaining Mediterranean sea turtle populations and their habitats, through scientific research programs, education, political action, public involvement, campaigns, beach assessments, and through the media (Kasparek 2001). The MEDASSET has forged links with many sea turtle protection organizations. Through its research endeavors, the MEDASSET has surveyed and reported on over 7,500 km. of Mediterranean coastline from Sardinia to Lebanon and from the Ionian Sea to the shores of Egypt and Libya. Politically, the organization has played a significant role in the composition of the legal framework for the protection of sea turtles in the Mediterranean Sea, especially in Greece (Kasparek 2001).

- The **Hellenic Society for the Study and Protection of the Monk Seal** (**MOm**) is a non-profit, non-governmental organization founded in 1988 by a group of biologists at the University of Athens. MOm's aim is to protect and conserve the marine environment and the Mediterranean monk seal. MOm's research projects include studies on monk seal biology, ecology, and behavior and surveys of monk seal haulout sites in various regions of Greece. In 1991, MOm founded the Rescue Network and Information Collection Network to aid in the collection of information on the distribution of the Mediterranean monk seal, the rescue of orphaned and injured seals, and to increase awareness of the local population of seals. Attempts were made to obtain Mediterranean monk seal sightings, strandings, and haulout data, but the data were not received.

- In 1996 a study on bottlenose dolphins around the island of Lampedusa (within the Strait of Sicily) was conducted under the newly formed non-governmental organization **Oceanomare**. Oceanomare is also involved in research on the behavior and ecology of Mediterranean cetaceans, including dolphin interactions with local fisheries. Marina Pulcini, one of the initial founders, has also worked with cetaceans of the Ligurian Sea and the Greek Ionian islands (Notarbartolo di Sciara and Bearzi in press). Data was not requested from Oceanomare.

- The **Underwater Research Society-Mediterranean Seal Research Group** (**SAD-AFAG**) is a Turkish conservation organization that has been working with fishermen since 1991 to protect the Mediterranean monk seal. The SAD-AFAG organized the first Turkish government national committee for monk seals in cooperation with the Turkish Environment Ministry which brought together government officials and academics to develop a strategy to protect Mediterranean monk seals. The SAD-AFAG has also collaborated with WWF to work closely with fishermen to protect monk seal breeding caves and increase fish stocks by creating no-fishing zones and patrolling against illegal fishing activities in the Gulf of Izmir in the Aegean Sea and the Cilician Basin in the eastern Mediterranean Sea. Monk seal information, particularly breeding sites, were requested for inclusion in this MRA but were not available.

- Founded in 1986, the **Tethys Research Institute** (a partner to the **ACCOBAMS**) is a nongovernmental agency specialized in cetacean research. Tethys has generated one of the largest datasets on Mediterranean cetaceans. Tethys was the first research group to propose the creation of the Pelagos Sanctuary (Ligurian Sea), based on extensive information collected in the field (Notarbartolo di Sciara and Bearzi in press). Research by Tethys has contributed greatly to the expanding knowledge of cetaceans in the Mediterranean Sea. Some of the larger research endeavors include the determination that fin whales are endemic in the Mediterranean Sea (Bérubé et al. 1998), and longitudinal studies of dolphins in the Adriatic (Bearzi et al. 1997; Bearzi et al. 1999; Bearzi et al. 2000) and Ionian (Politi et al. 1992) seas. Attempts were made to obtain data from Tethys; however, data are currently being integrated with additional resources from **CIESM**, **Pelagos**, and **ACCOBAMS** into a publicly available database. Data will not be made available until completion of the integrated database (estimated completion date of fall 2007).

- The **United Kingdom Royal Navy** often operates in remote areas. Opportunistic cetacean sightings are collected onboard and maintained in a cetacean sightings database; ensuring that Royal Navy personnel keep watch for cetaceans this helps the Navy comply with current risk mitigation measures. It is also hoped that by collecting data of cetacean sightings the Royal Navy may be able to contribute to a better scientific understanding of cetacean distributions, breeding areas, and migration routes. Data of sightings collected from 1947 through 2003 were obtained from the **OBIS-SEAMAP** with permission from the **U.K. Hydrographic Office**.

- The **University of Rome** has been focusing on cetacean ecology and distribution in the Tyrrhenian Sea and dolphin behavior and ecology of the coast of Sardinia since the early 1990s (Notarbartolo di Sciara and Bearzi in press). In 1996, the leading researchers from these endeavors created the non-governmental organization **Accademia del Leviatano** to continue the work off of the Sardinian coast (e.g., Díaz López 2006). Additional work by this group has been conducted in the eastern Mediterranean Sea, including the Aegean Sea (Carpentieri et al. 1999). Researchers of the University

have also participated in a tagging program of loggerhead sea turtles to track the movements of the species between the eastern and western Mediterranean basins (Argano et al. 1992).

- Over the years, **WWF** has dedicated considerable efforts to the conservation of endangered species and habitats throughout the Mediterranean region (Kasparek 2001). A number of initiatives currently exist that attempt to conserve marine turtles in the Mediterranean basin. The most significant efforts focus primarily on the major nesting sites in Greece and Turkey (see under national WWF organizations). A three-year project which started in 1994 was aimed at helping to eliminate the serious gaps in the existing knowledge about the ecology of marine turtles at sea by utilizing new methods such as genetic markers and mathematical modeling (Kasparek 2001).

Websites Accessed

[1] MEDACES (Mediterranean Database of Cetacean Strandings). http://medaces.uv.es/home_eng.htm. Accessed 28 February 2007.

Literature Cited

Affronte, M., L.A. Stanzani, and G. Stanzani. 2003. First record of a humpback whale, *Megaptera novaeangliae* (Borowski, 1781) from the Adriatic Sea. Annals of Istrian and Mediterranean Studies 13(1):51-54.

Albert Prince of Monaco. 1898. Some results of my researches on oceanography. Nature 58(1496):200-204.

Allen, J.A. 1908. The North Atlantic right whale and its near allies. Bulletin of the American Museum of Natural History 24:277-329.

Argano, R., R. Basso, M. Cocco, and G. Gerosa. 1992. Nuovi dati sugli spostamenti di tartaruga marina comune *(Caretta caretta)* in Mediterraneo (New data on loggerhead (*Caretta caretta*) movements within Mediterranean). Bollettino dei Musei e degli Istituti Biologici dell'Universitá di Genova 56-57:137-163.

Bearzi, G. 2000. First report of a common dolphin (*Delphinus delphis*) death following penetration of a biopsy dart. Journal of Cetacean Research and Management 2(3):217-221.

Bearzi, G., G. Notarbartolo-di-Sciara, and E. Politi. 1997. Social ecology of bottlenose dolphins in the Kvarneric (northern Adriatic Sea). Marine Mammal Science 13(4):650-668.

Bearzi, G., E. Politi, and G. Notarbartolo di Sciara. 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric (northern Adriatic Sea). Marine Mammal Science 15(4):1065-1097.

Bearzi, G., E. Politi, C.M. Fortuna, L. Mel, and G. Notarbartolo di Sciara. 2000. An overview of cetacean sighting data from the northern Adriatic Sea: 1987-1999. European Research on Cetaceans 14:356-361.

Becker, P.R., D. Wilkinson, and T.I. Lillestolen. 1994. Marine Mammal Health and Stranding Response Program: Program development plan. NOAA Technical Memorandum NMFS-OPR-94-2:1-35.

Bérubé, M., A. Aguilar, D. Dendanto, F. Larsen, G. Notarbartolo di Sciara, R. Sears, J. Sigurjónsson, J. Urban-R., and P.J. Palsbøll. 1998. Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus (*Linnaeus 1758): Analysis of mitochondrial and nuclear loci. Molecular Ecology 7:585-599.

Bortolotto, A., L. Casini, and L.A. Stanzani. 1992. Dolphin mortality along the southern Italian coast (June-September 1991). Aquatic Mammals 18(2):56-60.

Cagnolaro, L., B. Cozzi, L. Magnaghi, M. Podestà, R. Poggi, and P. Tangerini. 1986. Su 18 cetacei spiaggiati sulle coste Italiane dal 1981 al 1985. Rilevamento biometrico ed osservazioni neccroscopiche (Regarding 18 cetaceans stranded on the Italian coast from 1981 to 1985. Biometric survey and necropsy observations). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 127(1-2):79-106.

Carpentieri, P., M. Corsini, and L. Marini. 1999. Contribute to the knowledge of the presence and distribution of cetaceans in the Aegean Sea. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 140:65-75.

Casale, P., P. Nicolosi, D. Freggi, M. Turchetto, and R. Argano. 2003. Leatherback turtles (*Dermochelys coriacea*) in Italy and in the Mediterranean Basin. Herpetological Journal 13:135-139.

Centro Studi Cetacei. 1997. Cetacei spiaggiati lungo le coste italiane. XI. Rendiconto 1996 (Cetaceans stranded in Italy. XI. Statement 1996). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 137(I-II):135-147.

Centro Studi Cetacei. 2000. Cetacei spiaggiati lungo le coste italiane. XIII. Rendiconto 1998 (Cetaceans stranded in Italy. XIII. Statement 1998). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 141(I):129-143.

Centro Studi Cetacei. 2003. Cetacei spiaggia ti lungo le coste italiane. XVI. Rendiconto 2001 (Cetaceans stranded in Italy. XVI. Statement 2001). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 144(I):151-166.

Chakroun, F. 1994. Status of cetaceans in Tunisian marine waters. European Research on Cetaceans 8:107.

Clark, C.W., J.F. Borsani, and G. Notarbartolo-di-Sciara. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Marine Mammal Science 18(1):286-295.

Díaz López, B. 2006. Interactions between Mediterranean bottlenose dolphins (*Tursiops truncatus)* and gillnets off Sardinia, Italy. ICES Journal of Marine Science 63:946-951.

Drouot, V. 2003. Ecology of sperm whale (*Physeter macrocephalus*) in the Mediterranean Sea. Ph.D. diss., University of Wales.

Drouot, V., A. Gannier, and J.C. Goold. 2004. Summer social distribution of sperm whales (*Physeter macrocephalus*) in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 84:675-680.

Forney, K.A. 2002. Surveys. Pages 1203-1205 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Frantzis, A., J. Gordon, G. Hassidis, and A. Komnenoy. 2001. The enigma of harbor porpoise presence in the Mediterranean Sea. Marine Mammal Science 17(4):937-944.

Frantzis, A., O. Nikolaou, J.-M. Bompar, and A. Cammedda. 2004. Humpback whale (*Megaptera novaengliae*) occurrence in the Mediterranean Sea. Journal of Cetacean Research and Management 6(1):25-28.

Frantzis, A., R. Swift, D. Gillespie, C. Menhennett, J. Gordon, and S. Gialinakis. 1999. Sperm whale presence off south-west Crete, Greece, Eastern Mediterranean. European Research on Cetaceans 13:214-217.

Frantzis, A., P. Alexiadou, G. Paximadis, E. Politi, A. Gannier, and M. Corsini-Foka. 2003. Current knowledge of the cetacean fauna of the Greek Seas. Journal of Cetacean Research and Management 5(3):219-232.

Gannier, A. 1998. A contribution to the knowledge of the cetological fauna in the waters of western Sardinia. Hystrix 10(2):21-27.

Gannier, A. 2005. Summer distribution and relative abundance of delphinids in the Mediterranean Sea. Revue d'Ecologie: La Terre et la Vie 60:223-238.

Gomercic, M.D., T. Gomercic, D. Huber, and H. Gomercic. 2005. Recent sightings of the monk seal in Croatian areas of the Adriatic. Monachus Guardian 8(2).

Hammond, P.S. and C. Lockyer. 1988. Distribution of killer whales in the eastern North Atlantic. Rit Fiskideildar: Journal of the Marine Research Institute Reykjavik 11:24-41.

Henwood, T.A. and S.P. Epperly. 1999. Aerial surveys in foraging habitats. Pages 65-66 in Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois, and M. Donnelly, eds. Research and management techniques for the conservation of sea turtles. Publication No. 4. Washington, D.C.: IUCN/SSC Marine Turtle Specialist Group.

Kasparek, M. 2001. Organisations and institutions working on marine turtles in the Mediterranean: A preliminary overview. Zoology in the Middle East 24:143-154.

Kerem, D. 2005a. Rough-toothed dolphins "invading" the port of Haifa. FINS (Newsletter of ACCOBAMS) 2(1):19.

Kerem, D. 2005b. Starving fin whale calf dies in Haifa Port. FINS (Newsletter of ACCOBAMS) 2(1):18-19.

Kerem, D. and O. Goffman. 2004. The Israel Marine Mammal Research and Assistance Center (IMMRAC), 2004 update. R.I.M.S. News (Newsletter of the University of Haifa, Leon Recanati Institute for Maritime Studies) 30:25-27.

Kerem, D., O. Goffman, and E. Spanier. 2001. Sighting of a single humpback dolphin (*Sousa* sp.) along the Mediterranean coast of Israel. Marine Mammal Science 17(1):170-171.

Kinzelbach, R. 1986. First record of Risso's dolphin, *Grampidelphis griseus*, in the eastern Mediterranean Sea. Zoology in the Middle East 1:17-19.

Kinzelbach, R. 1997. A record of striped dolphin *Stenella coeruleoalba* (Meyen, 1833) from the Turkish Mediterranean Sea coast. Zoology in the Middle East 15:15-18.

Lauriano, G., C.M. Fortuna, G. Moltedo, and G. Notarbartolo di Sciara. 2004. Interactions between common bottlenose dolphins (*Tursiops truncatus*) and the artisanal fishery in Asinara Island National Park (Sardinia): Assessment of catch damage and economic loss. Journal of Cetacean Research and Management 6(2):165-173.

Lauriano, G., L. Tunesi, G. Notarbartolo di Sciara, E. Salvati, and A. Cardinali. 1999. The role of cetaceans in the zoning proposal of marine protected areas: The case of the Asinara Island MPA. European Research on Cetaceans 13:114-117.

Manzella, S.A. and C.T. Fontaine. 1988. Loggerhead sea turtle travels from Padre Island, Texas to the mouth of the Adriatic Sea. Marine Turtle Newsletter 42:7.

Marchessaux, D. 1980. A review of the current knowledge of the cetaceans in the eastern Mediterranean Sea. Vie Marine 2:59-66.

Margaritoulis, D., D. Karavellas, and C. Irvine. 1996. Predation of adult loggerheads by Mediterranean monk seals. Pages 193-196 in Keinath, J.A., D.E. Barnard, J.A. Musick, and B.A. Bell, eds. Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-387.

Marini, L., C. Consiglio, B. Catalano, T. Valentini, and G. Villetti. 1996. Aerial behavior in fin whales (*Balaenoptera physalus*) in the Mediterranean Sea. Marine Mammal Science 12(3):489-495.

Nascetti, D. and G. Notarbartolo di Sciara. 1997. A fin whale and sperm whale sighting programme undertaken by the Italian Navy in the central Mediterranean Sea. European Research on Cetaceans 10:150-153.

Nascetti, P., A. Perazzi, and O. Hastrup. 1997. An investigation of the interaction between active sonar operations and marine mammals. European Research on Cetaceans 10:61-67.

Notarbartolo di Sciara, G. and G. Bearzi. in press. Research on cetaceans in Italy. Pages 1-18 in Cozzi, B., ed. Marine mammals of the Mediterranean Sea: Natural history, biology, anatomy, pathology, parasitology. Milano, Italy: Massimo Valdina Editore.

Ozturk, A.A., B. Ozturk, and A. Dede. 2004. A fin whale stranding on the Mediterranean coast of Turkey. European Research on Cetaceans 15:341.

Pilleri, G. 1970. Records of cetaceans off the Italian and Dalmatian coasts. Investigations on Cetacea II:21-24.

Pilleri, G. and O. Pilleri. 1983. Sight records of cetaceans in the Mediterranean Sea during 1981-1982. Investigations on Cetacea 15:189-197.

Pilleri, G. and O. Pilleri. 1987. Records of cetaceans in the Mediterranean Sea and North Atlantic Ocean in the period 1982-1986. Investigations on Cetacea XX:267-280.

Podestà, M., A. D'Amico, G. Pavan, A. Drougas, A. Komnenou, and N. Portunato. 2006. A review of Cuvier's beaked whale strandings in the Mediterranean Sea. Journal of Cetacean Research and Management 7(3):251-261.

Politi, E., M. Bearzi, G. Notarbartolo di Sciara, E. Cussino, and G. Gnone. 1992. Distribution and frequency of cetaceans in the waters adjacent to the Greek Ionian Islands. European Research on Cetaceans 6:75-78.

Pulcini, M. and A.M. Angradi. 1994. Observations of Cuvier's beaked whale *Ziphius cavirostris* (Cetacea, Odontoceti) in the Ionian Islands of Greece. European Research on Cetaceans 8:116-119.

Raga, J.A., M.A. Raduán, and C. Blanco. 1985. Contribución al estudio de la distribución de cetáceos en el Mediterráneo y Atlánticó Ibérico (Contribution to the study of distribution of cetaceans in the Mediterranean and Iberian Atlantic waters). Miscellania Zoologica 9:361-366.

Roberts, S.M. 2003. Examination of the stomach contents from a Mediterranean sperm whale found south of Crete, Greece. Journal of the Marine Biological Association of the United Kingdom 83:667-670.

Saad, A. 2004. First record of a humpback whale stranding on the coast of Syria (Eastern Mediterranean). FINS (Newsletter of ACCOBAMS) 1(1):10.

Scheinin, A., D. Kerem, O. Goffman, and E. Spanier. 2004. Rare occurrences of cetaceans along the Isreali Mediterranean coast. FINS (Newsletter of ACCOBAMS) 1(1):10-11.

Song of the Whale Research Team. 2004. Results of 2003 pilot survey and remarks on proposed basin-wide sperm whale survey. Working document MOP 2/Inf 10 presented to the ACCOBAMS Scientific Committee.

Taskavak, E., R.H. Boulon, Jr., and M.K. Atatur. 1998. An unusual stranding of a leatherback turtle in Turkey. Marine Turtle Newsletter 80:13.

The Ocean Alliance. 2004. Voyage of the *Odyssey* (Mediterranean Research Report 20th July to 19th November 2004). Unpublished cruise report. Gibraltar, United Kingdom: Ocean Alliance.

UNEP (United Nations Environment Programme). 2004. Guidelines for the development of national networks of cetacean strandings monitoring. Tunis, Tunisia: Regional Activity Centre for Specially Protected Areas.

Van Waerebeek, K., M. André, M. Sequeira, V. Martín, D. Robineau, A. Collet, V. Papastavrou, and E. Ndiaye. 1999. Spatial and temporal distribution of the minke whale, *Balaenoptera acutorostrata* (Lacépède, 1804), in the southern northeast Atlantic Ocean and the Mediterranean Sea, with reference to stock identity. Journal of Cetacean Research and Management 1(3):223-237.

APPENDIX B: MARINE MAMMALS

LIST OF FIGURES

Figure	Title
B-1	Areas of occurrence for threatened and endangered cetaceans in the eastern Mediterranean Study Area (Summer).
B-2	Areas of occurrence for threatened and endangered cetaceans in the eastern Mediterranean Study Area (Winter).
B-3	Areas of occurrence for the North Atlantic right whale in the eastern Mediterranean Study Area.
B-4	Areas of occurrence for the humpback whale in the eastern Mediterranean Study Area.
B-5	Areas of occurrence for the sei whale in the eastern Mediterranean Study Area.
B-6	Areas of occurrence for the fin whale in the eastern Mediterranean Study Area (Summer).
B-7	Areas of occurrence for the fin whale in the eastern Mediterranean Study Area (Winter).
B-8	Areas of occurrence for the sperm whale in the eastern Mediterranean Study Area.
B-9	Areas of occurrence for the Mediterranean monk seal in the eastern Mediterranean Study Area.
B-10	Areas of occurrence for the common minke whale in the eastern Mediterranean Study Area.
B-11	Areas of occurrence for the dwarf sperm whale in the eastern Mediterranean Study Area.
B-12	Areas of occurrence for the Cuvier's beaked whale in the eastern Mediterranean Study Area.
B-13a	Areas of occurrence for *Mesoplodon* spp. in the eastern Mediterranean Study Area.
B-13b	Areas of occurrence for the northern bottlenose whale in the eastern Mediterranean Study Area.
B-14	Areas of occurrence for the rough-toothed dolphin in the eastern Mediterranean Study Area.
B-15	Areas of occurrence for the common bottlenose dolphin in the eastern Mediterranean Study Area.
B-16	Areas of occurrence for the striped dolphin in the eastern Mediterranean Study Area.
B-17	Areas of occurrence for the short-beaked common dolphin in the eastern Mediterranean Study Area.
B-18	Areas of occurrence for the Indo-Pacific hump-backed dolphin in the eastern Mediterranean Study Area.
B-19	Areas of occurrence for the Risso's dolphin in the eastern Mediterranean Study Area.
B-20	Areas of occurrence for the false killer whale in the eastern Mediterranean Study Area.
B-21	Areas of occurrence for the killer whale in the eastern Mediterranean Study Area.
B-22	Areas of occurrence for the long-finned pilot whale in the eastern Mediterranean Study Area.
B-23	Areas of occurrence for the harbor porpoise in the eastern Mediterranean Study Area.

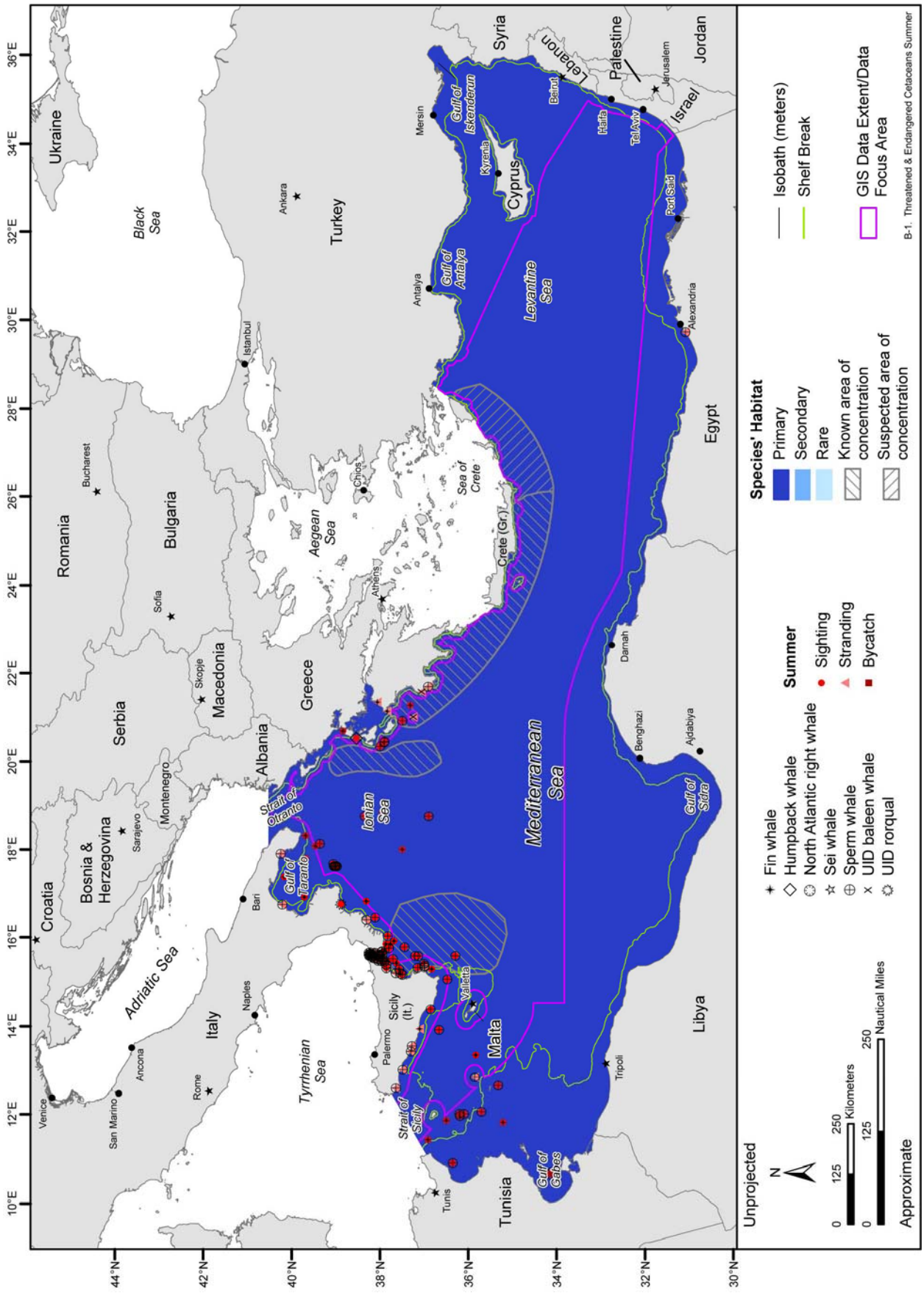


Figure B-1. Areas of occurrence for threatened and endangered cetaceans in the esatern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented for the summer season. The known areas of concentration depicted on the map are based on concentrations of fin and sperm whales only. Source data: refer to Table A-1.

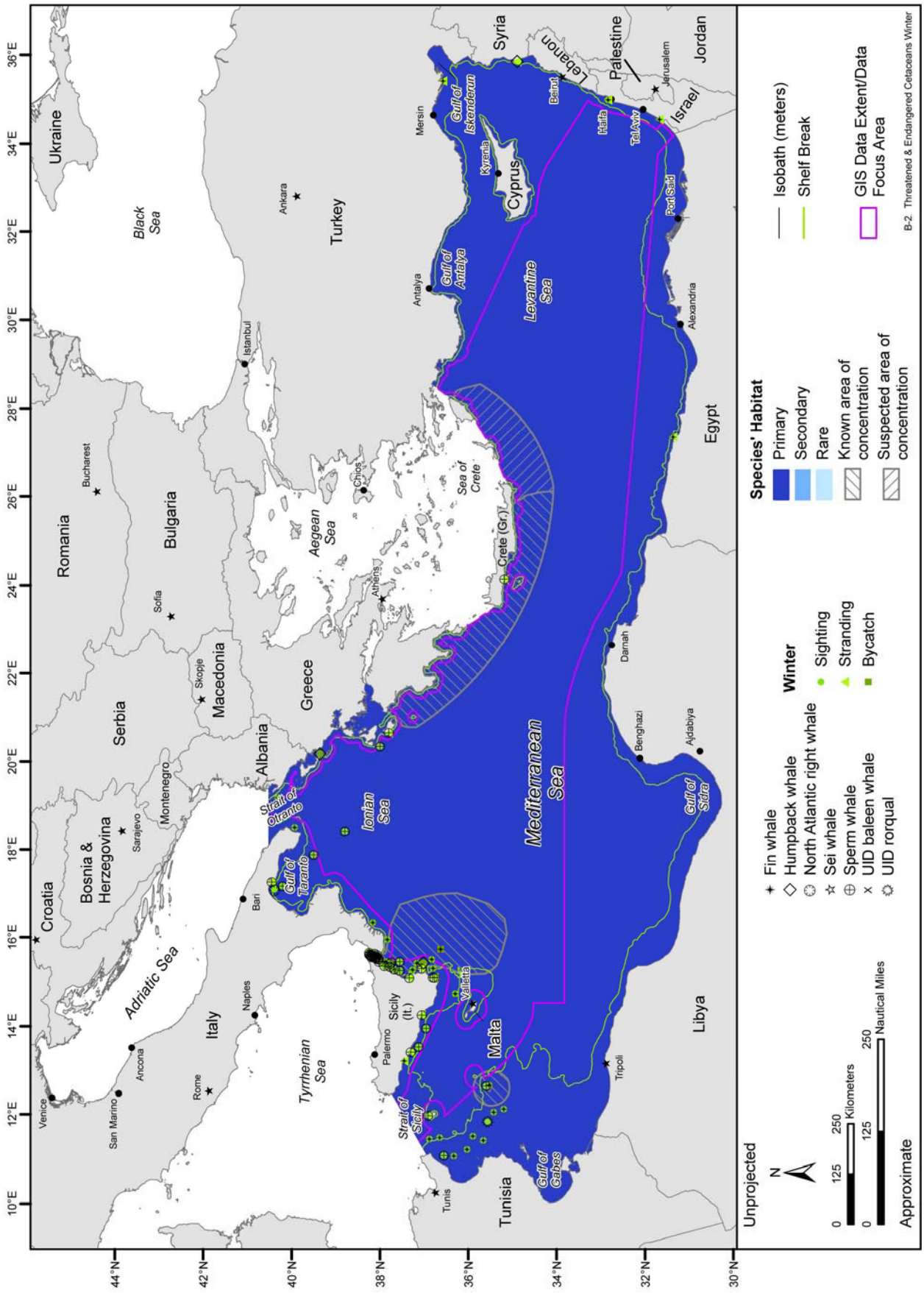


Figure B-2. Areas of occurrence for threatened and endangered cetaceans in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented for the winter season. The known areas of concentration depicted on the map are based on concentrations of fin and sperm whales only. Source data: refer to Table A-1.

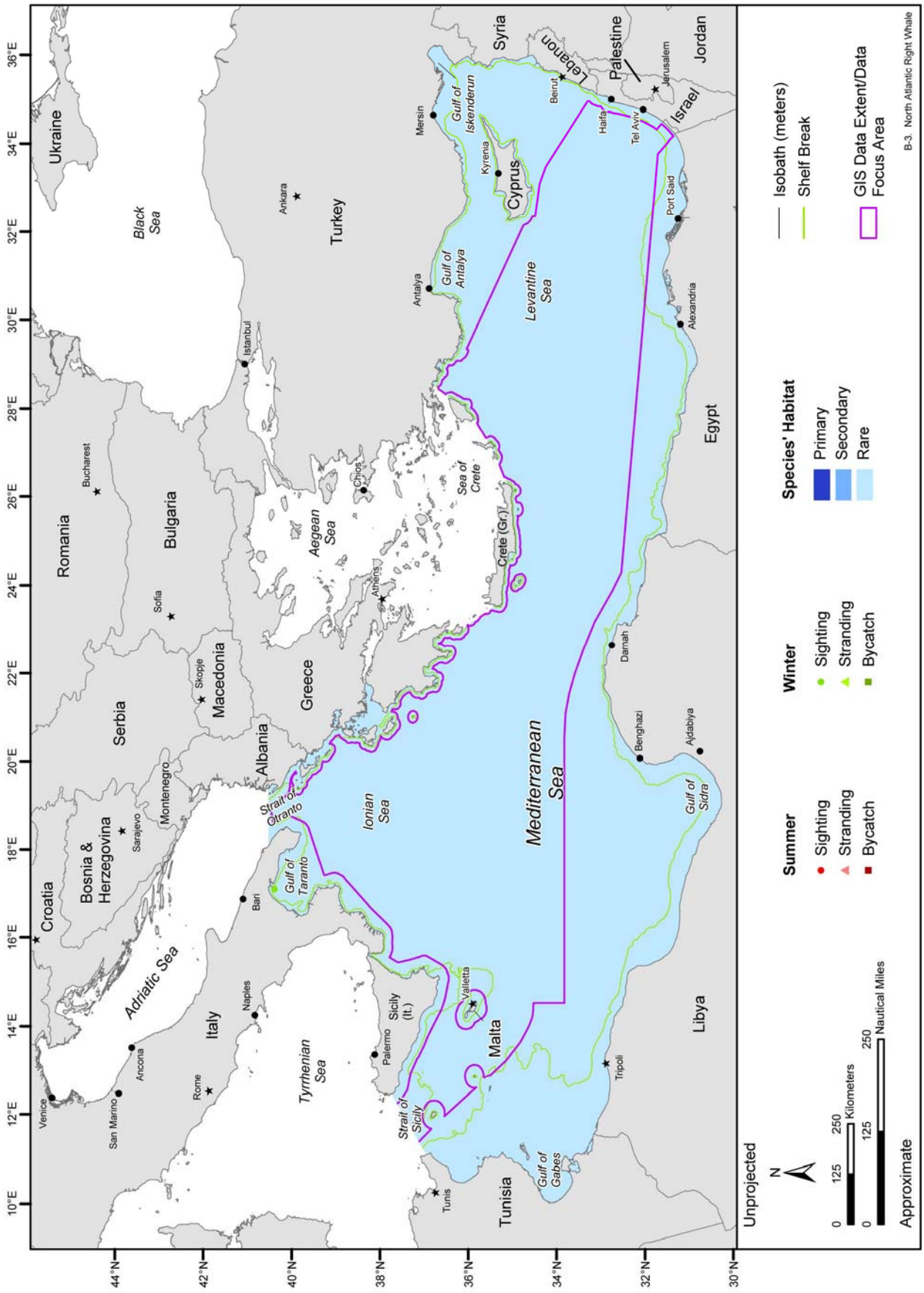


Figure B-3. Areas of occurrence for the North Atlantic right whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

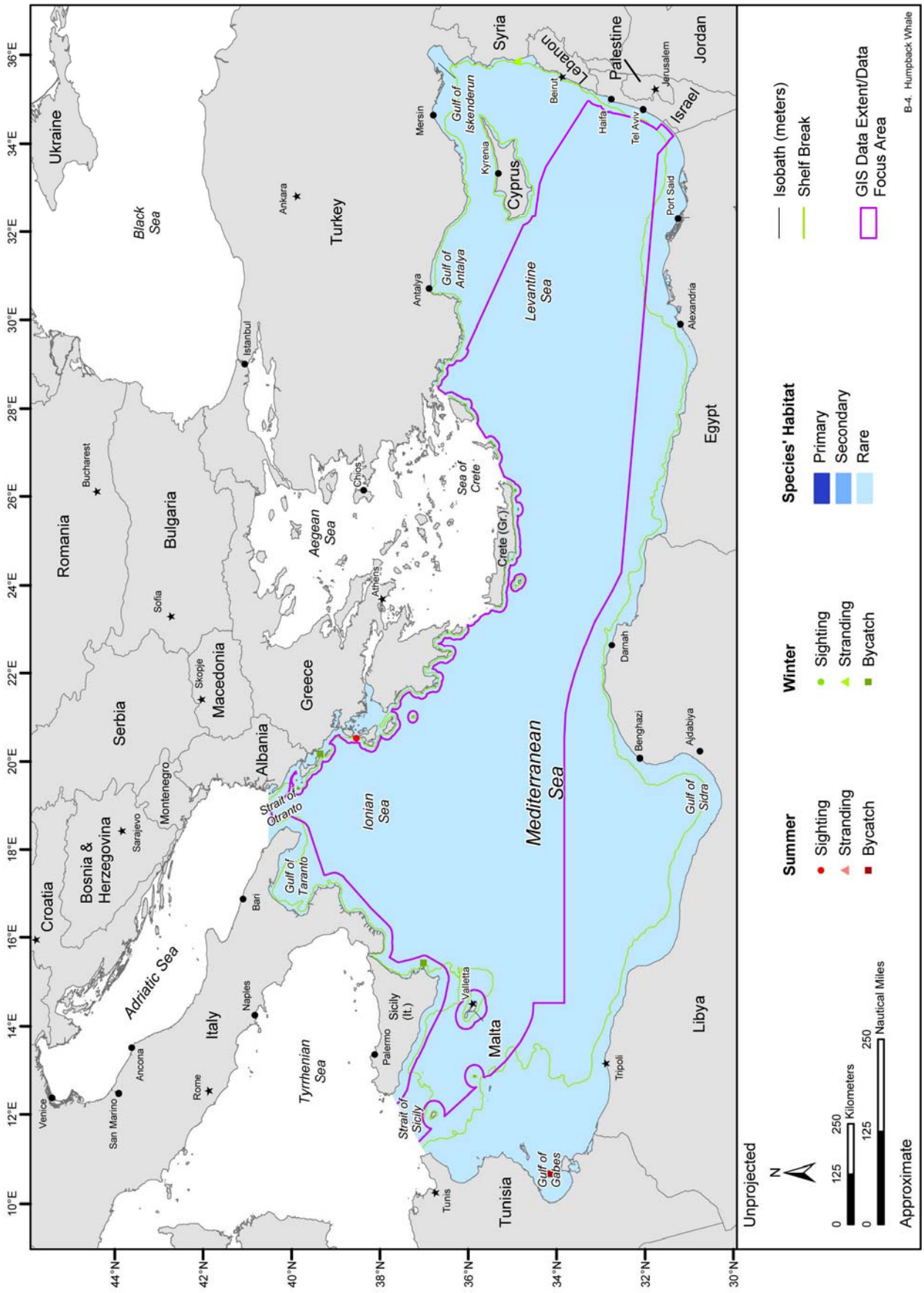


Figure B-4. Areas of occurrence for the humpback whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

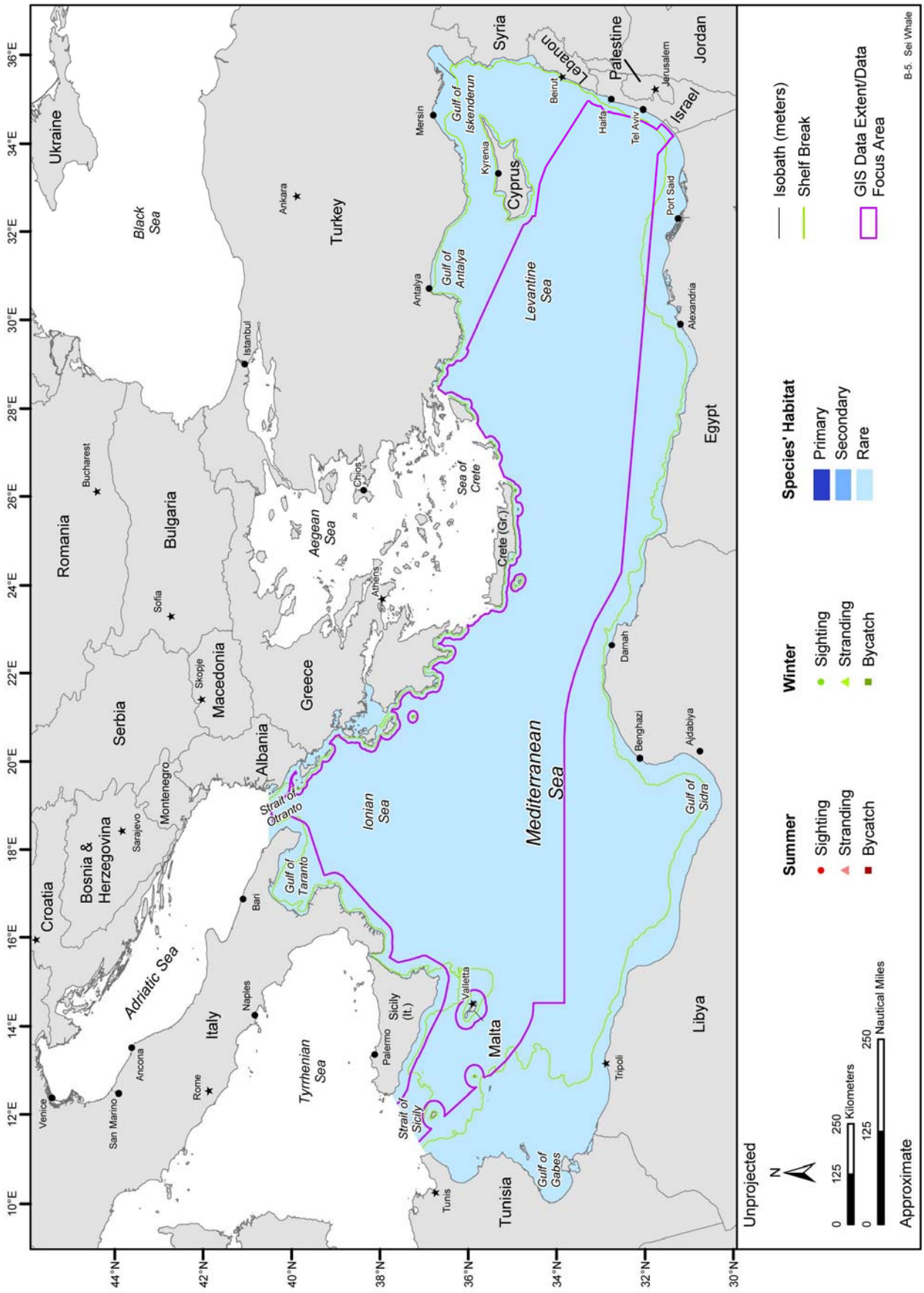


Figure B-5. Areas of occurrence for the sei whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

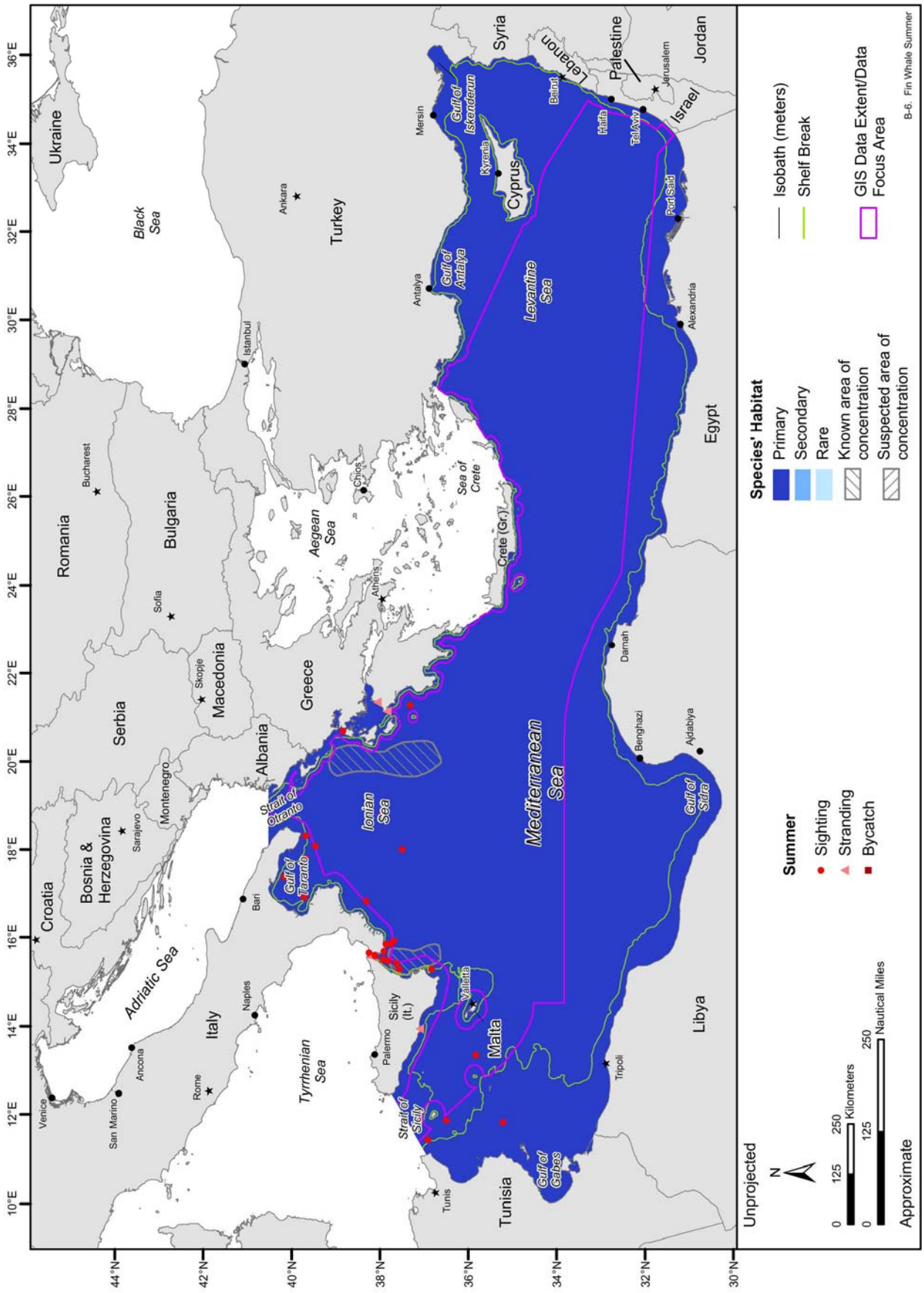


Figure B-6. Areas of occurrence for the fin whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented for the summer season. Known areas of concentration are also depicted. Source data: refer to Table A-1.

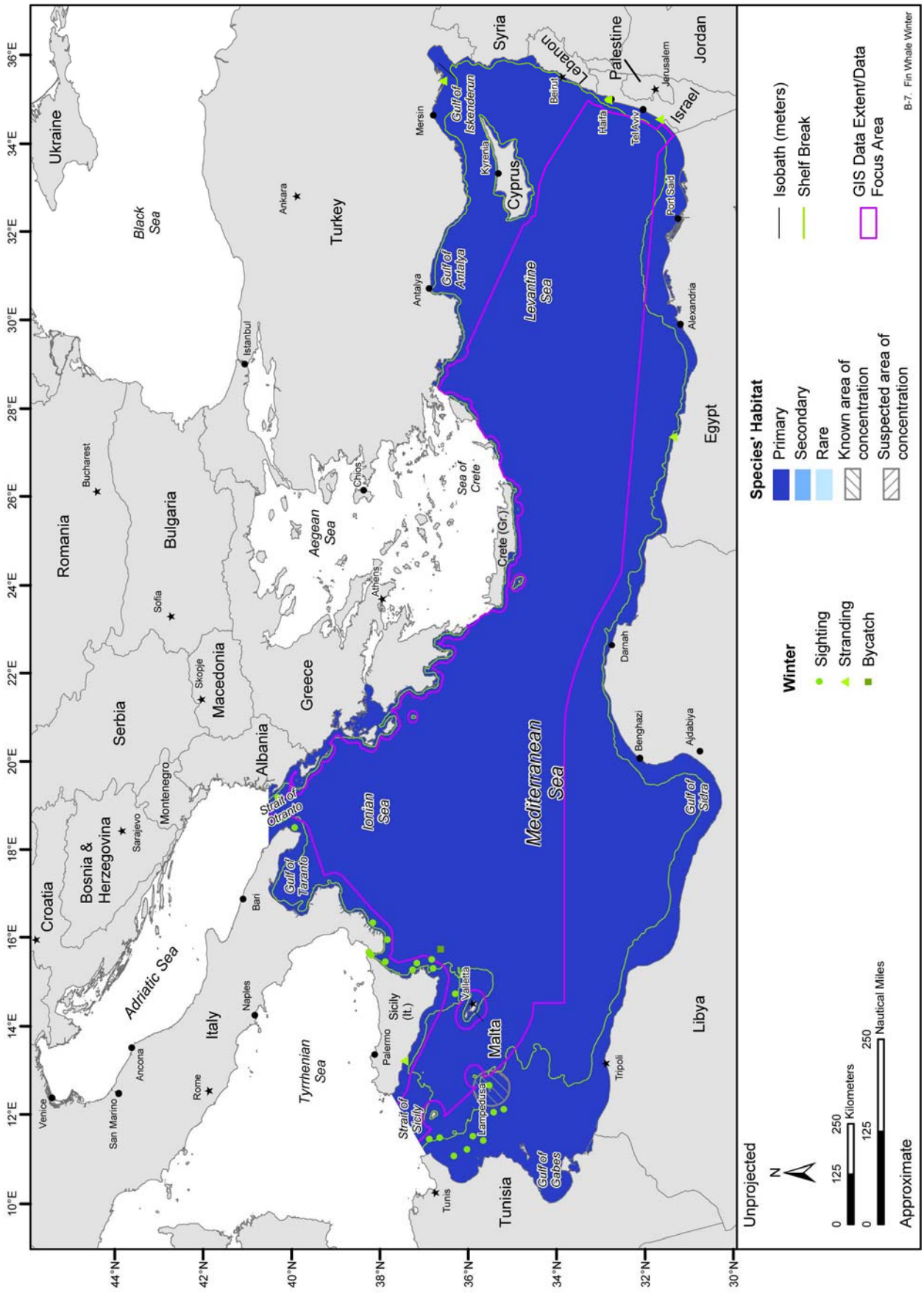


Figure B-7. Areas of occurrence for the fin whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented for the winter season. Known areas of concentration are also depicted. Source data: refer to Table A-1.

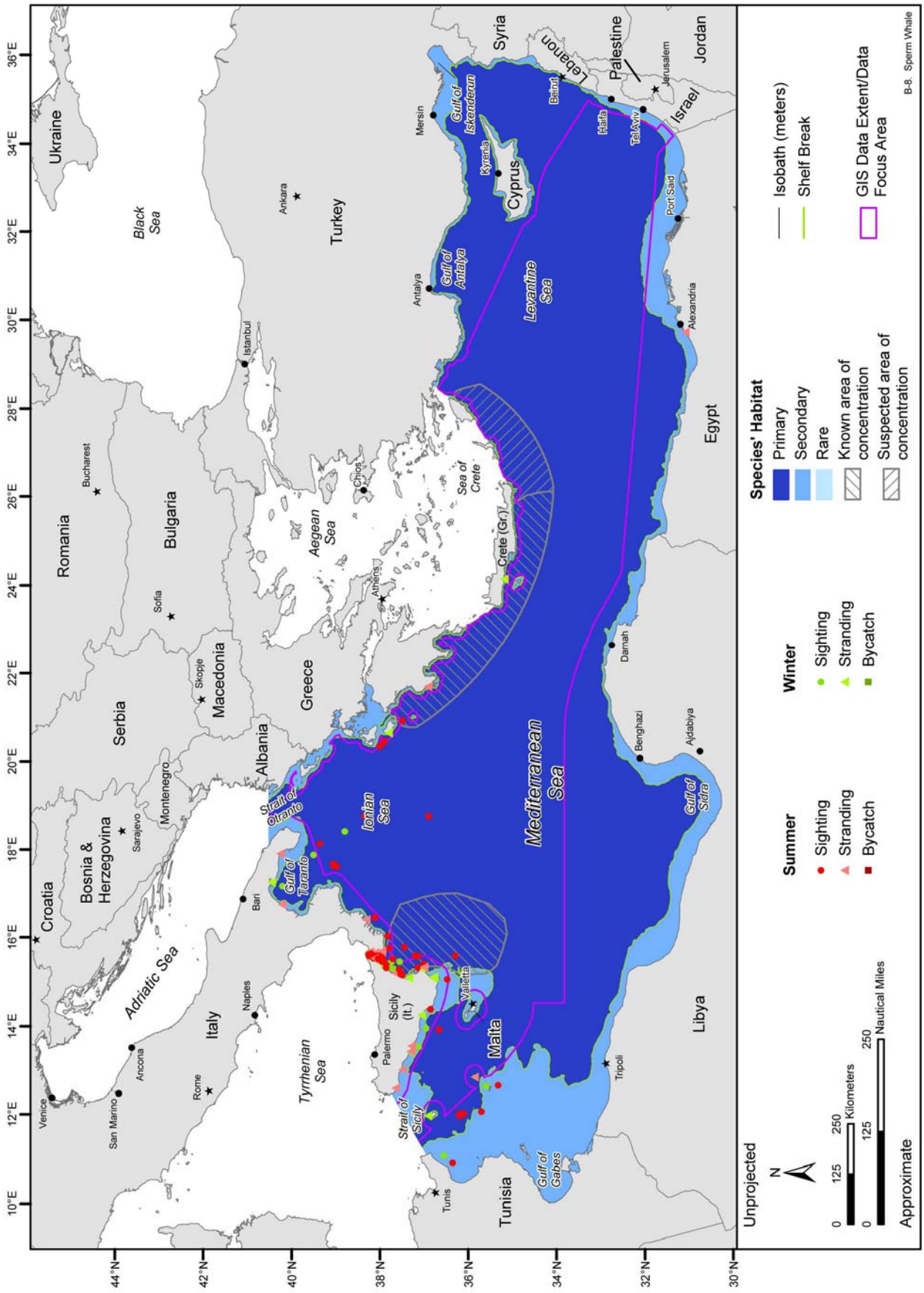


Figure B-8. Areas of occurrence for the sperm whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Known areas of concentration are also depicted. Source data: refer to Table A-1.

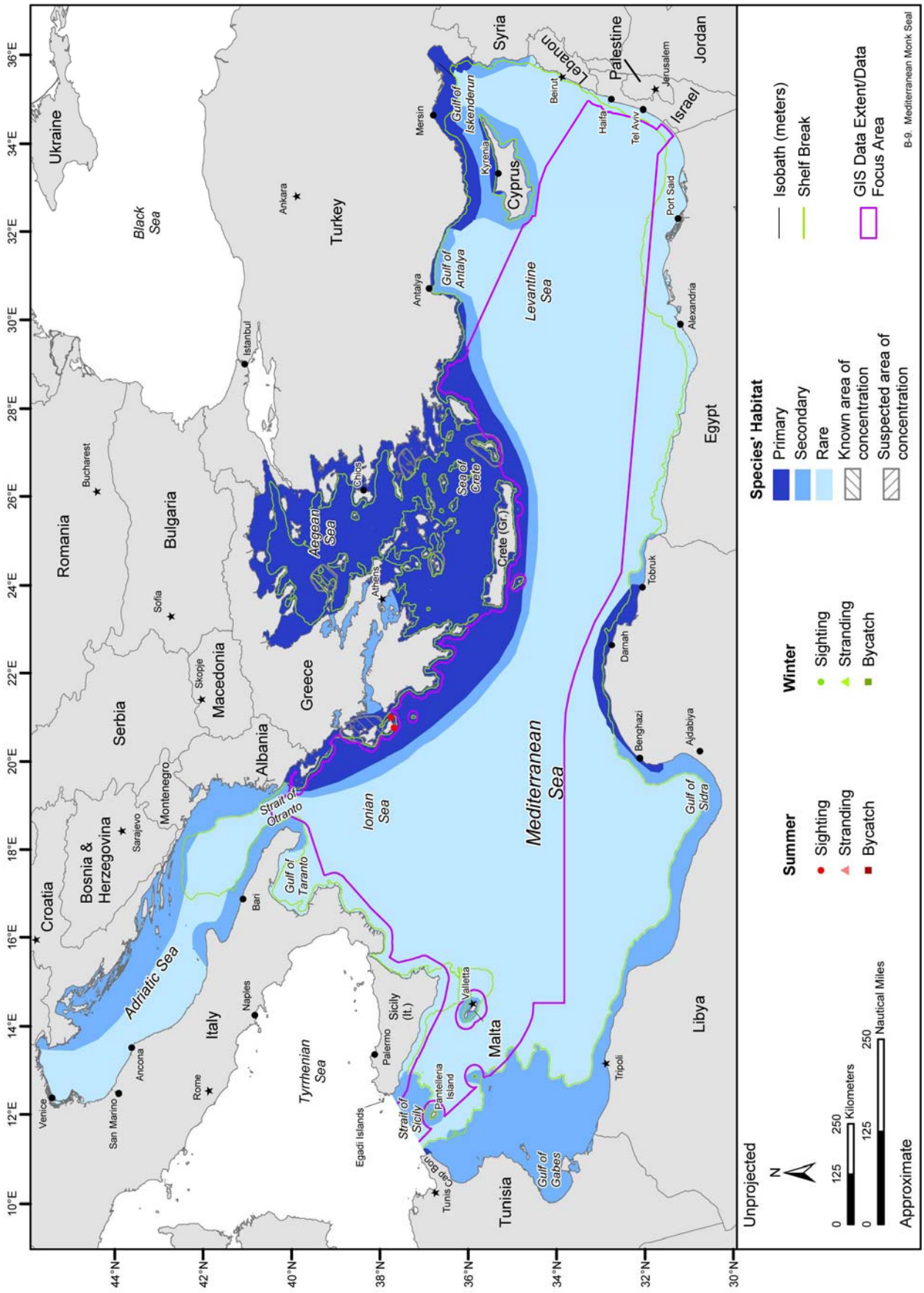


Figure B-9. Areas of occurrence for the Mediterranean monk seal in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Known areas of concentration are also depicted. Source data: refer to Table A-1.

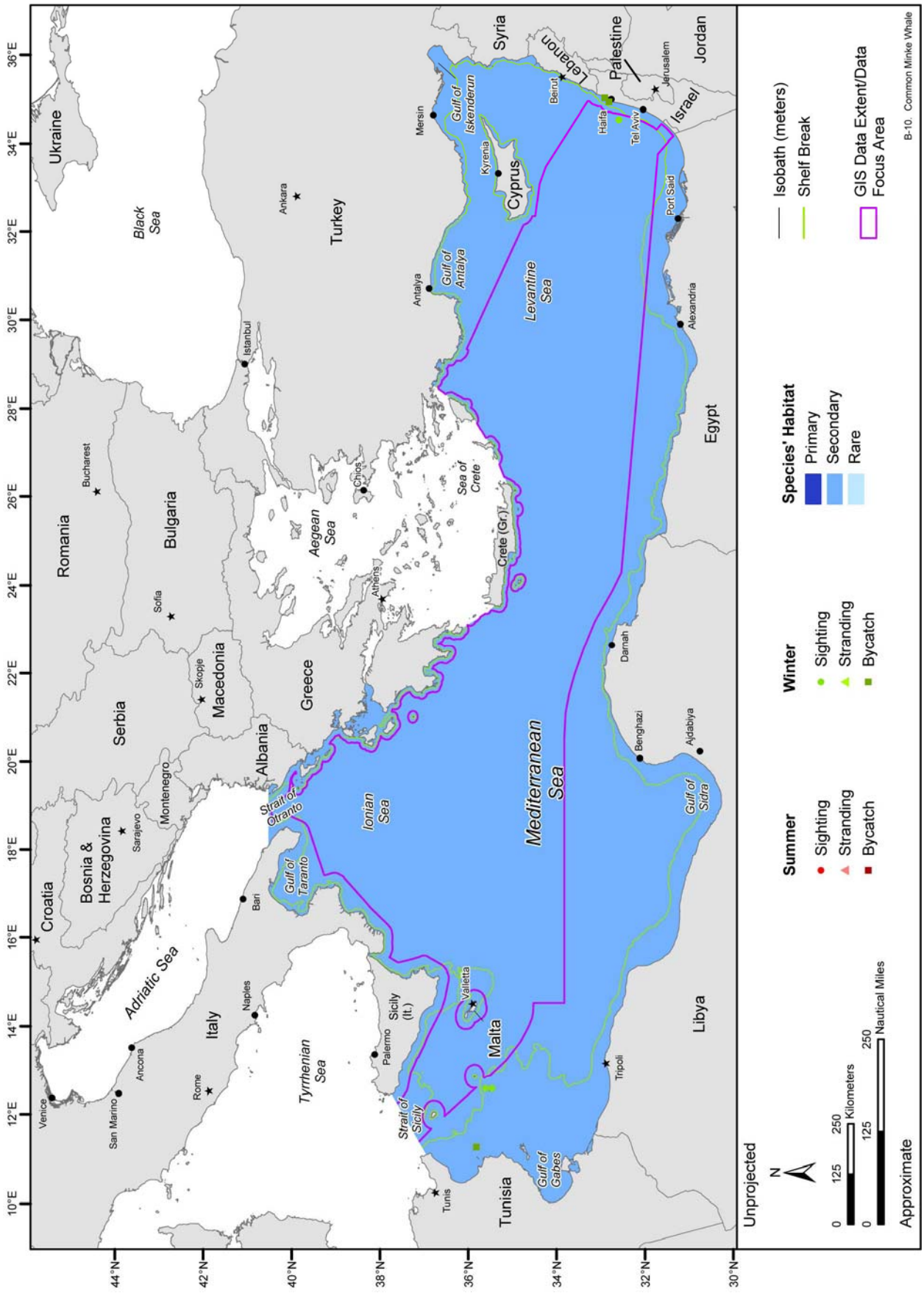


Figure B-10. Areas of occurrence for the common minke whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

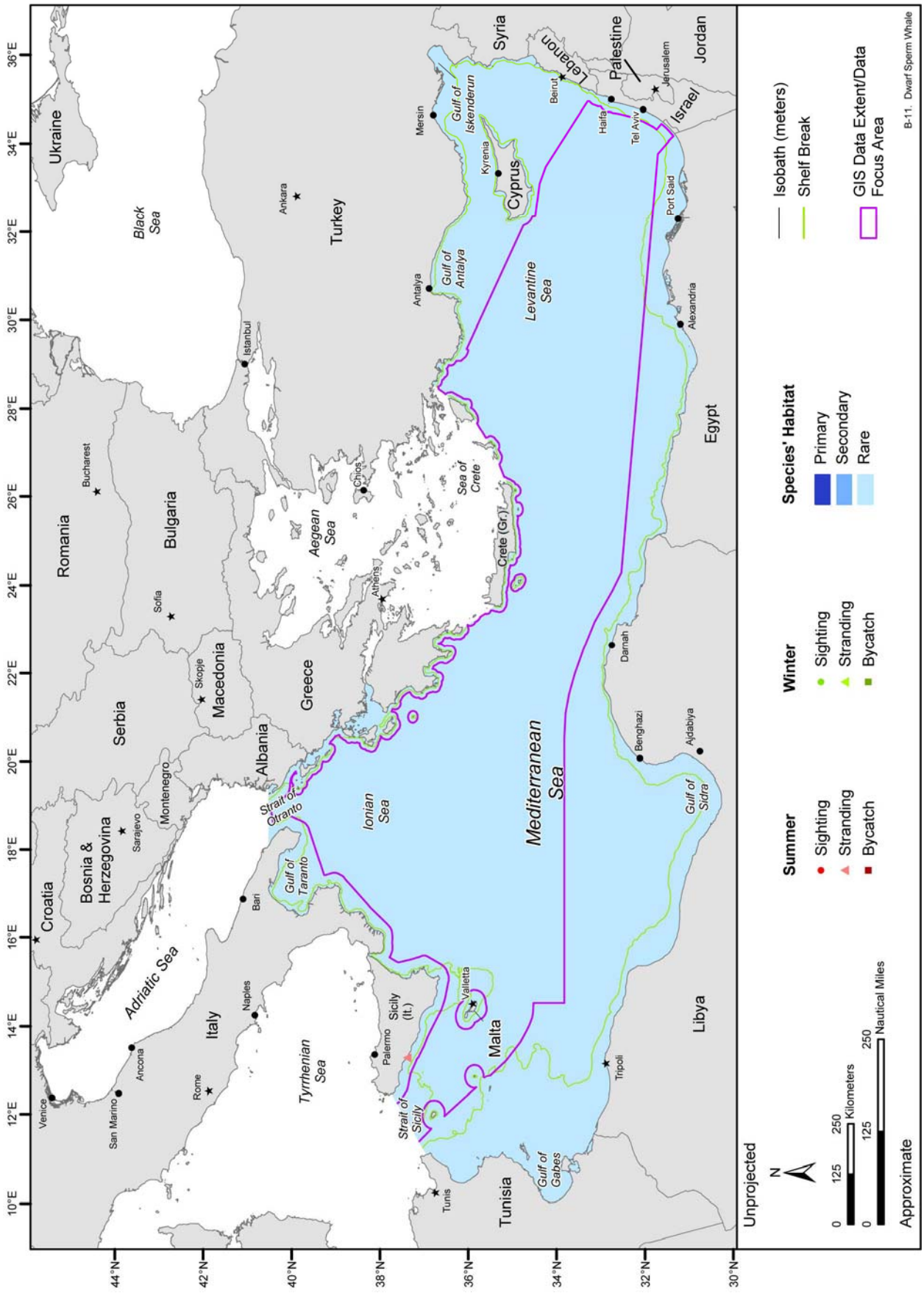


Figure B-11. Areas of occurrence for the dwarf sperm whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

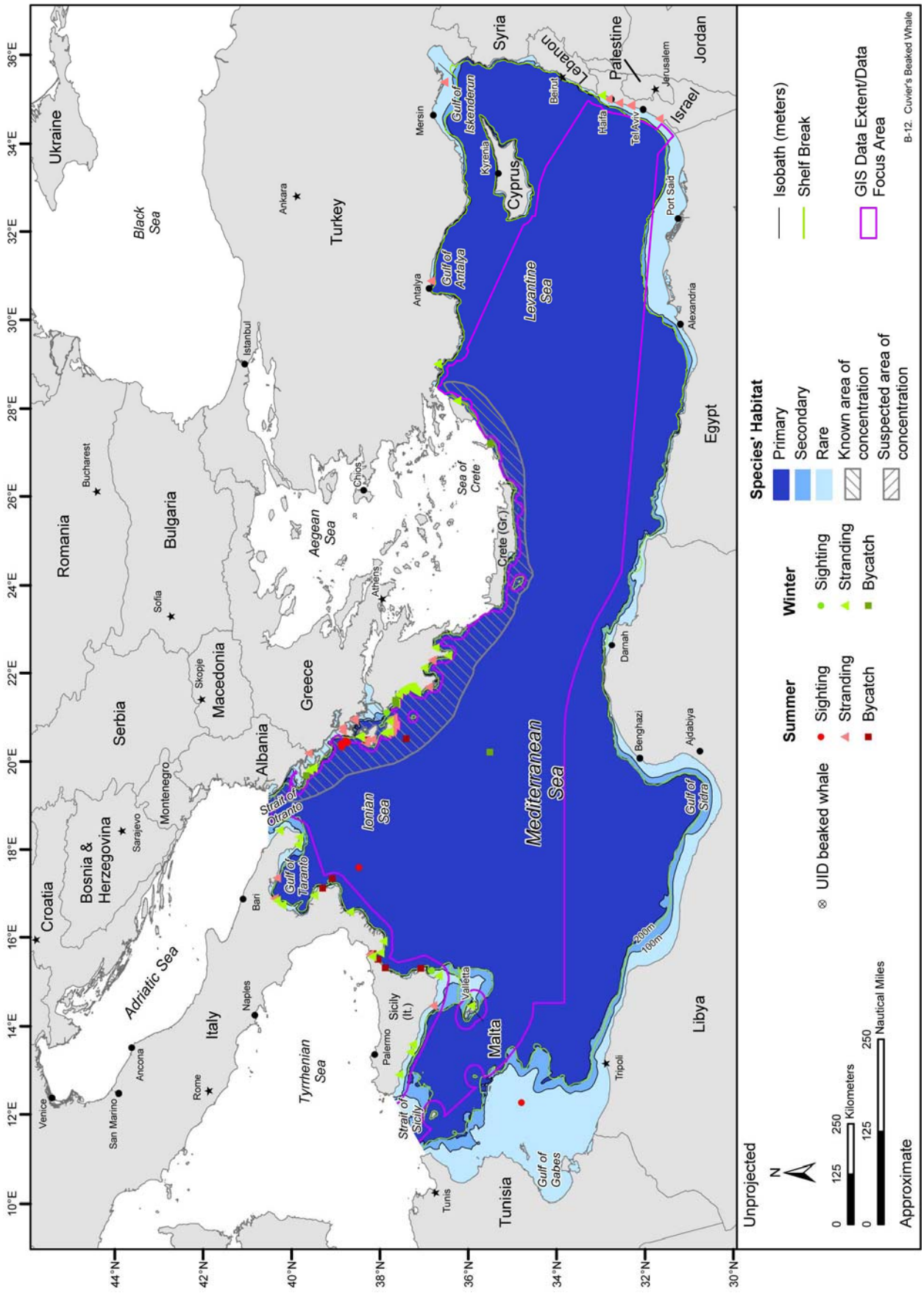


Figure B-12. Areas of occurrence for the Cuvier's beaked whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Known and suspected areas of concentration are also depicted on the map. Source data: refer to Table A-1.

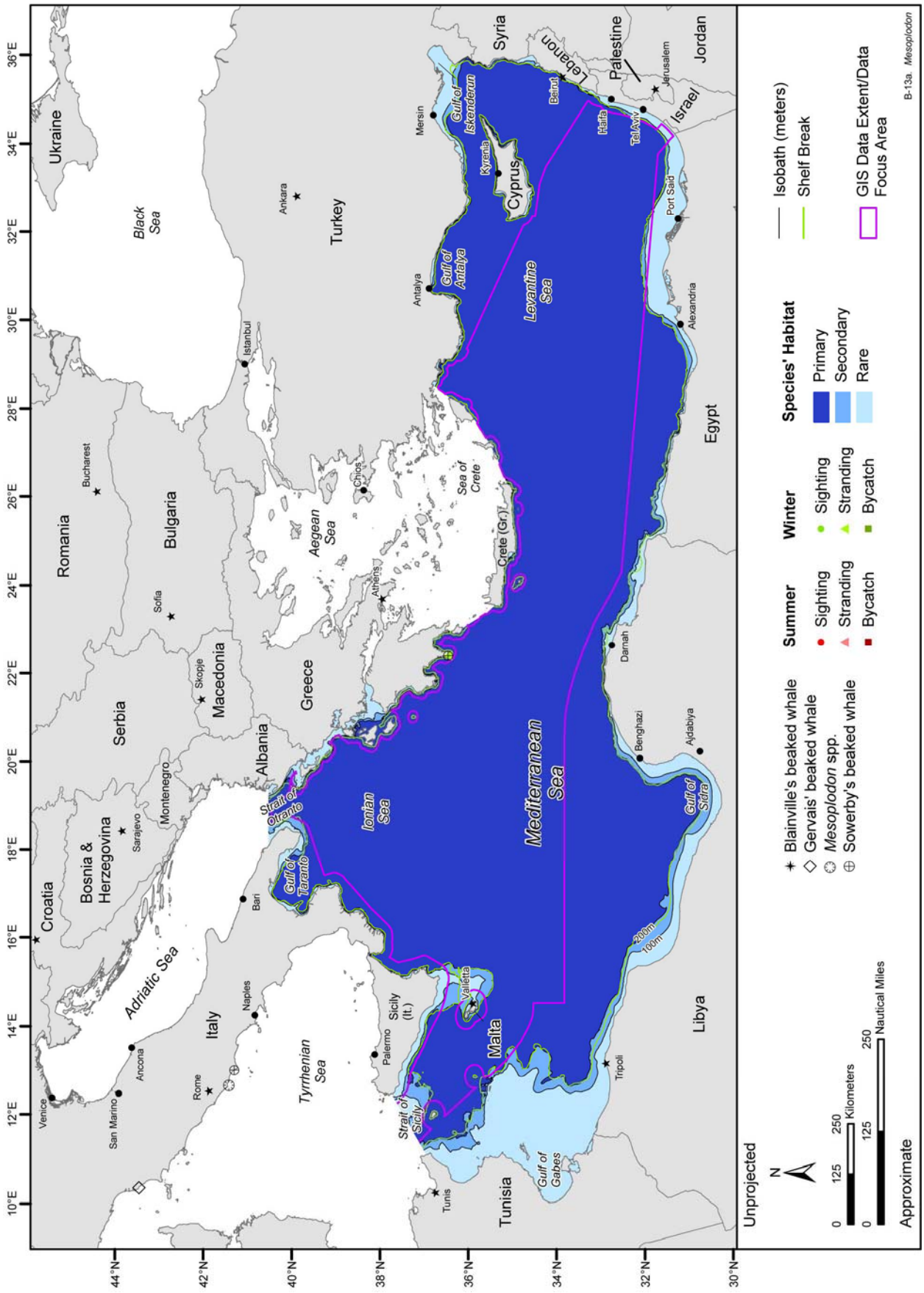


Figure B-13a. Areas of occurrence for Mesoplodon spp. in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

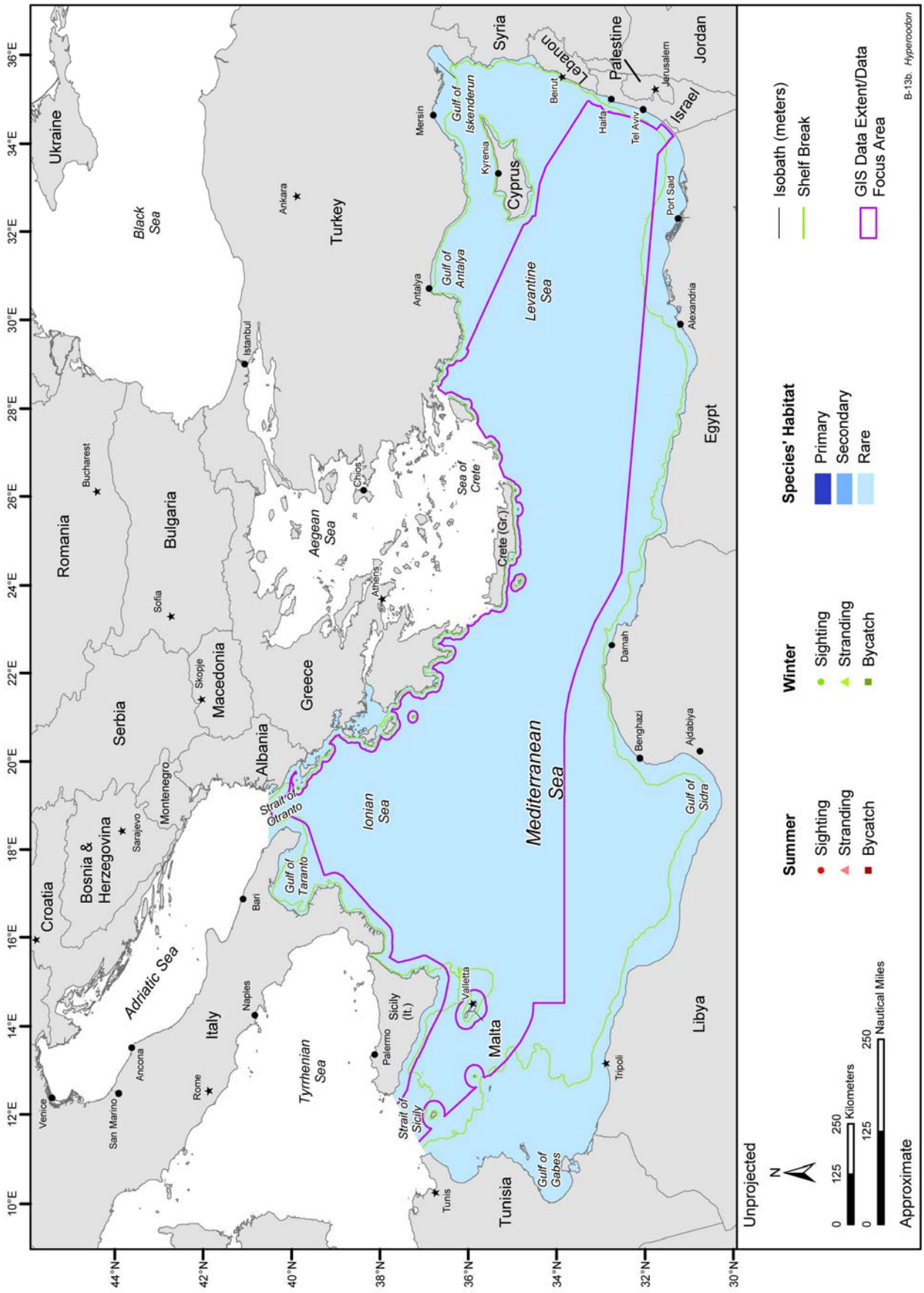


Figure B-13b. Areas of occurrence for the northern bottlenose whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

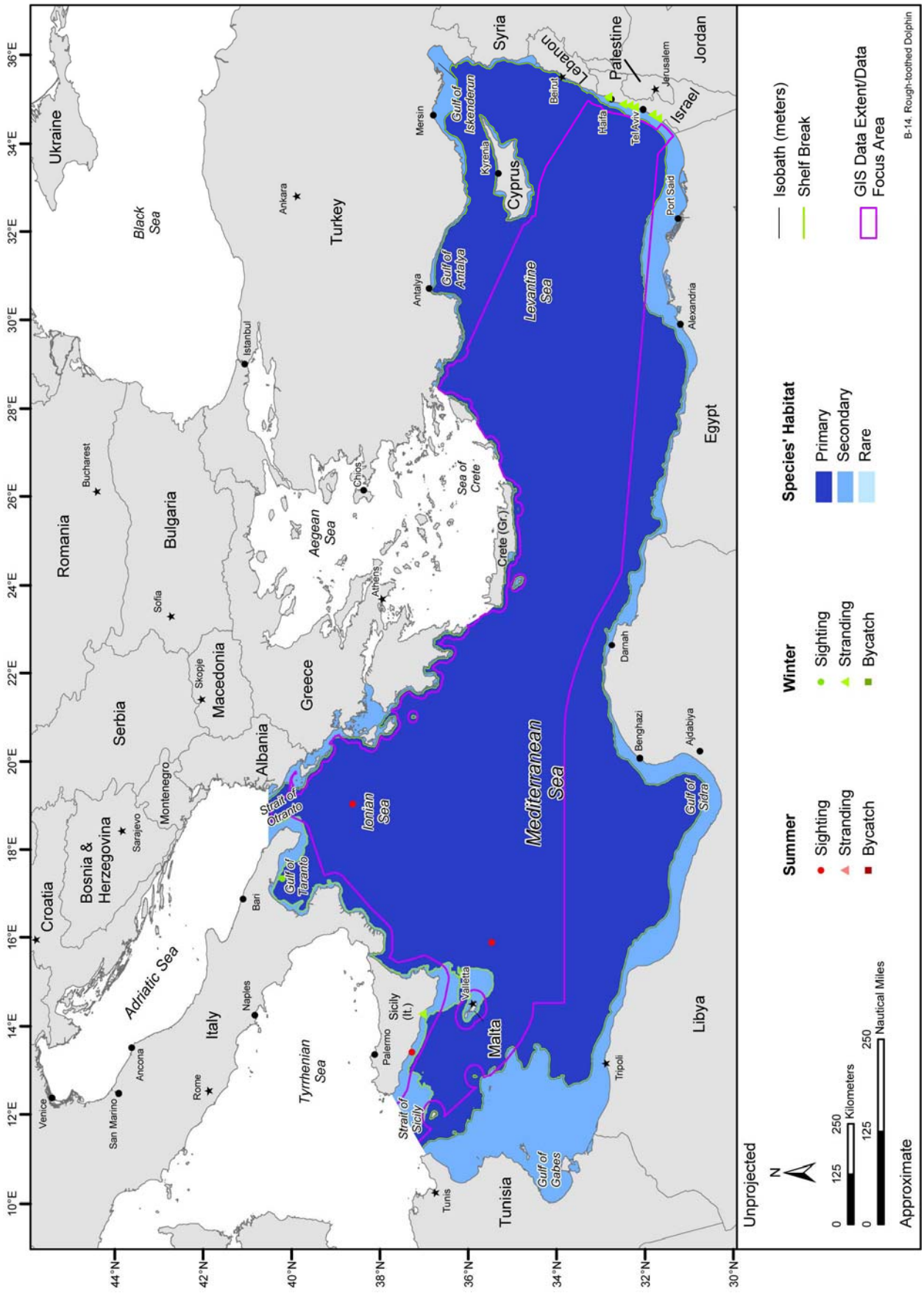


Figure B-14. Areas of occurrence for the rough-toothed dolphin in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

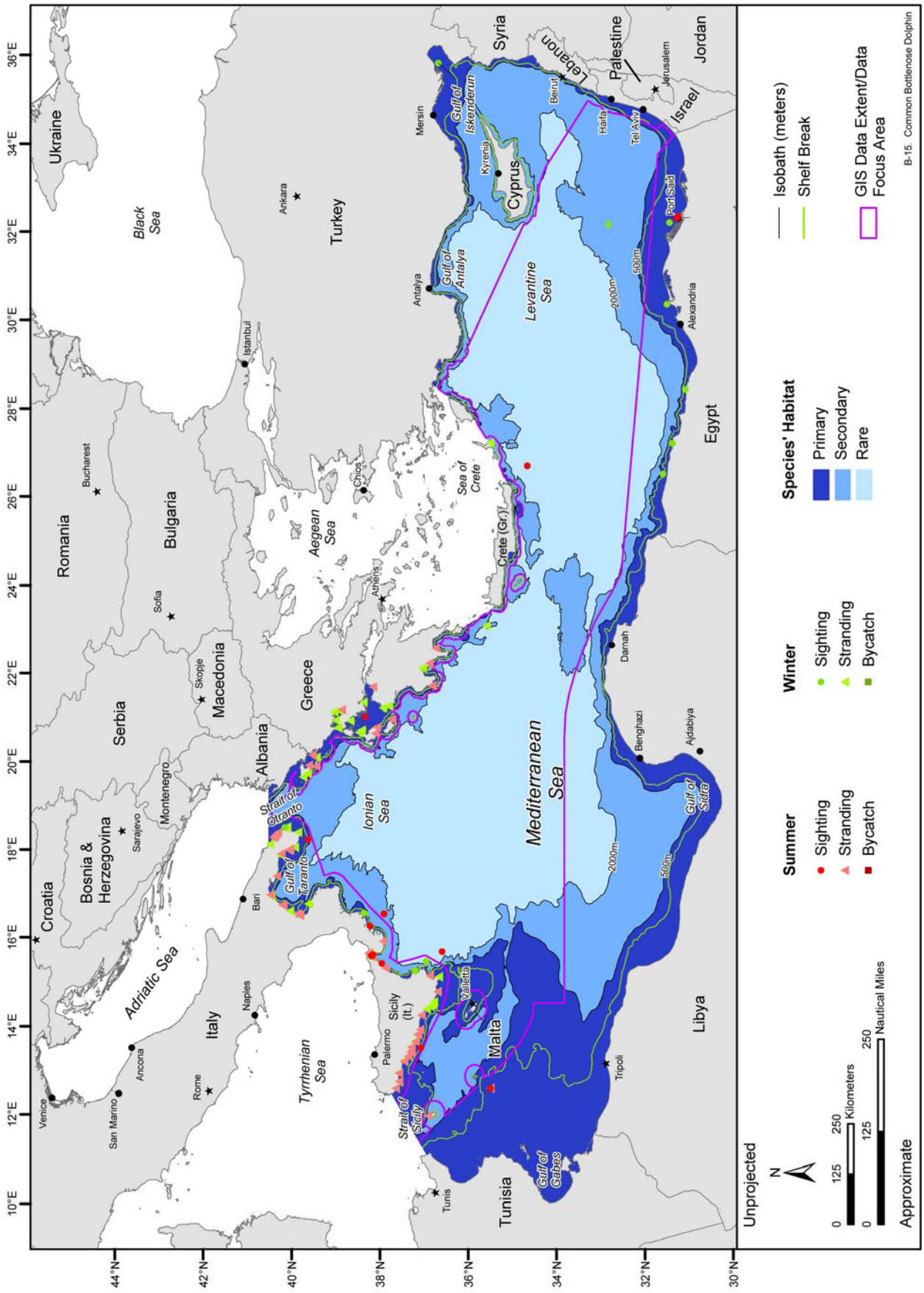


Figure B-15. Areas of occurrence for the common bottlenose dolphin in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

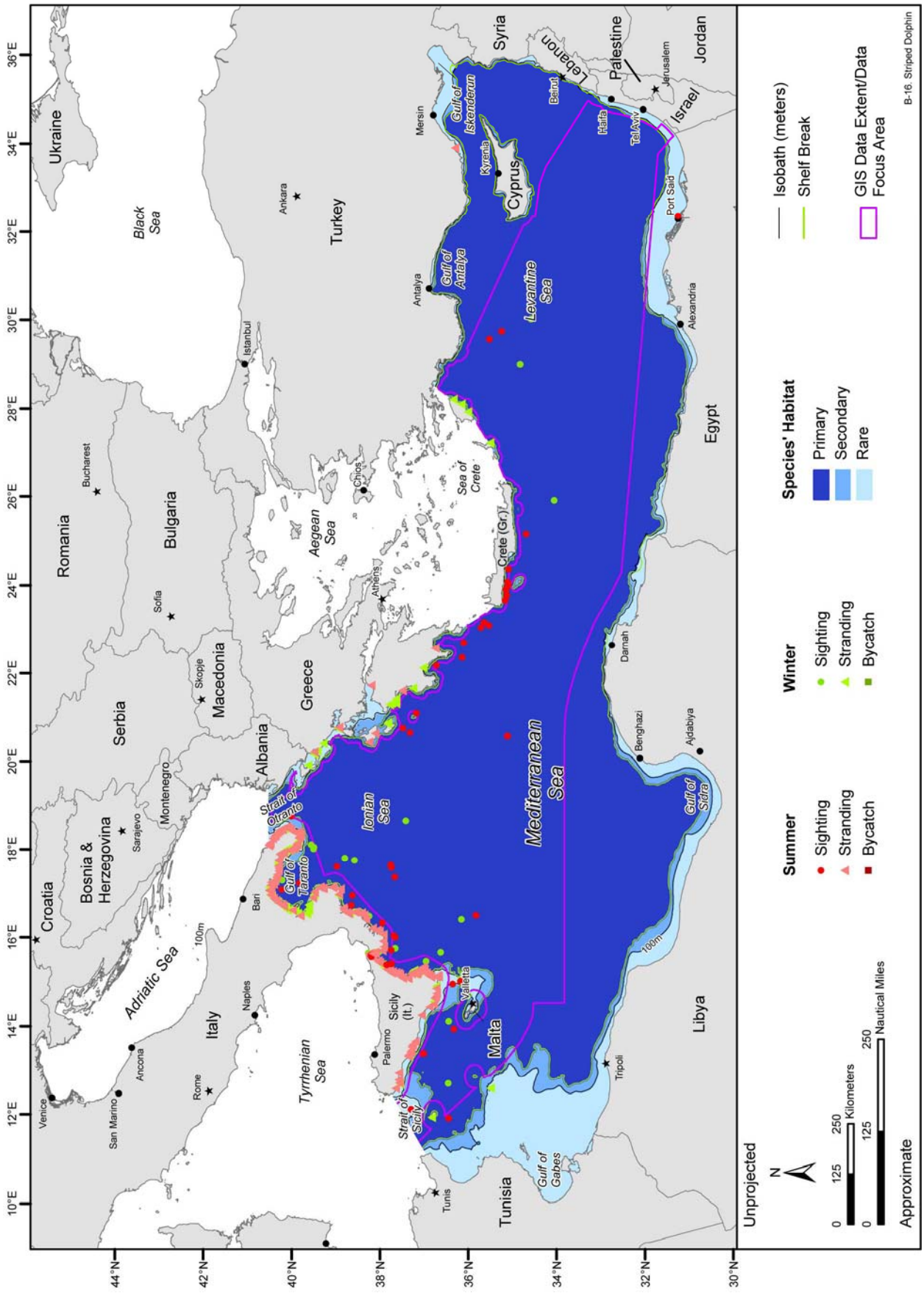


Figure B-16. Areas of occurrence for the striped dolphin in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

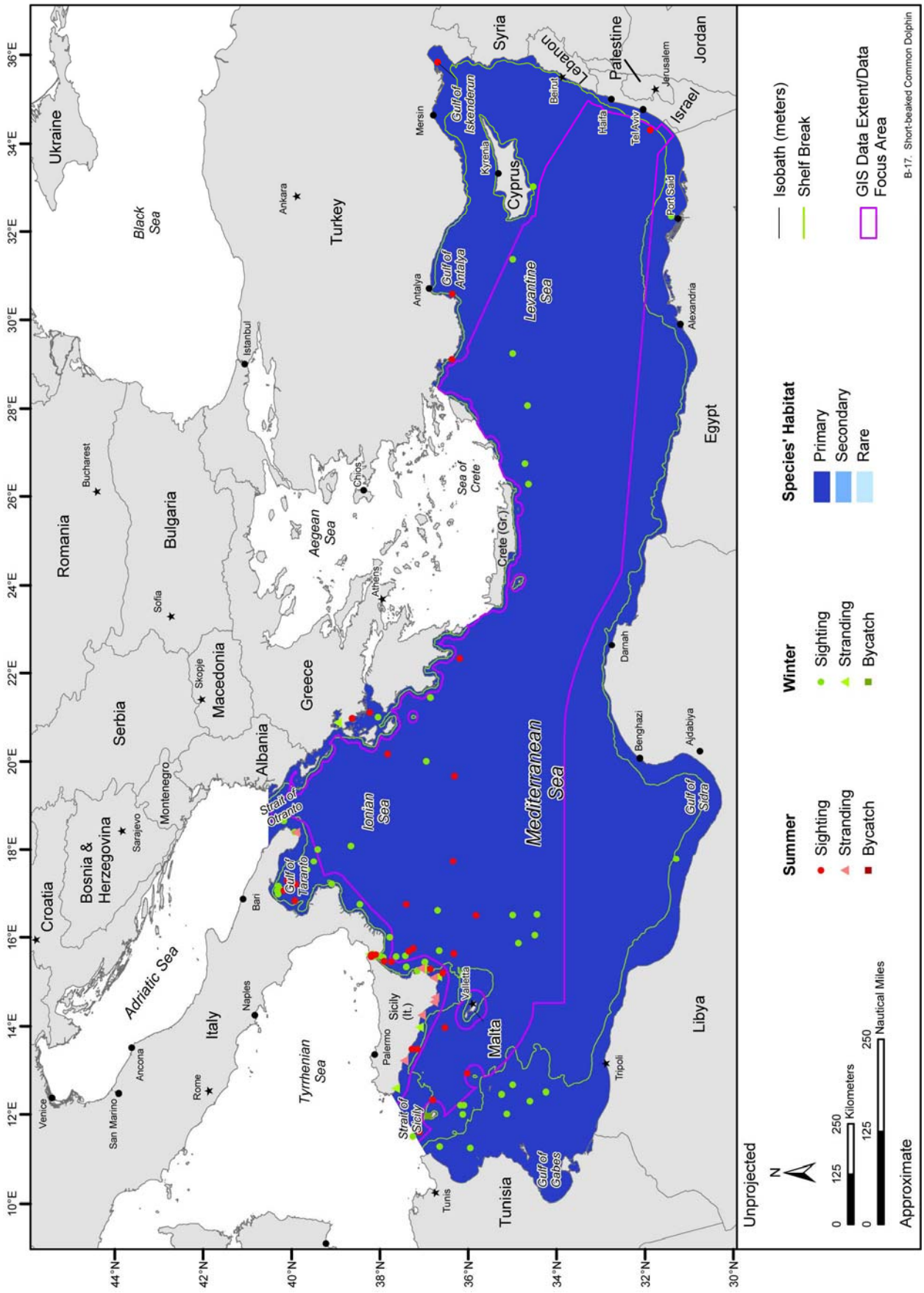


Figure B-17. Areas of occurrence for the short-beaked common dolphin in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

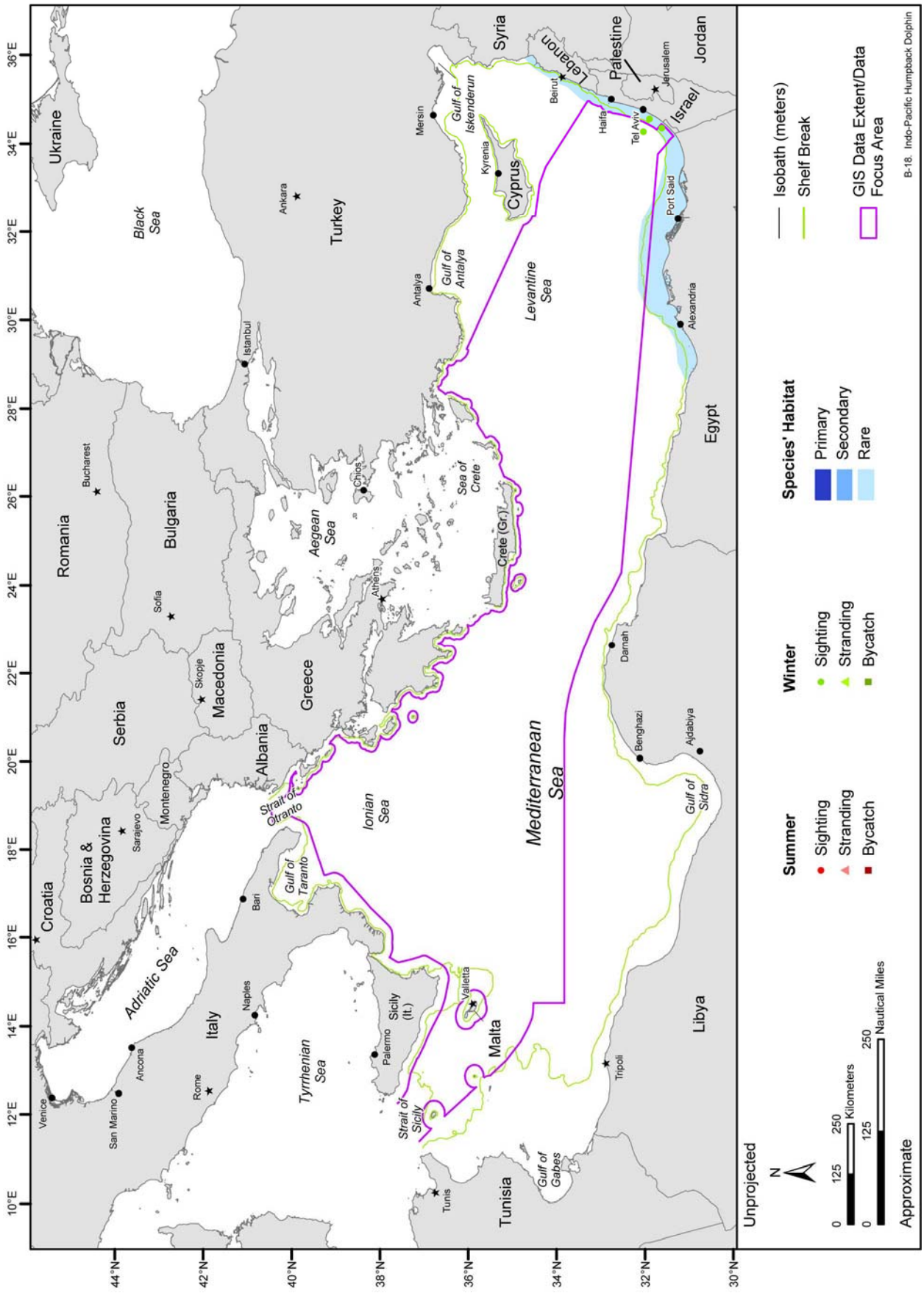


Figure B-18. Areas of occurrence for the Indo-Pacific hump-backed dolphin in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

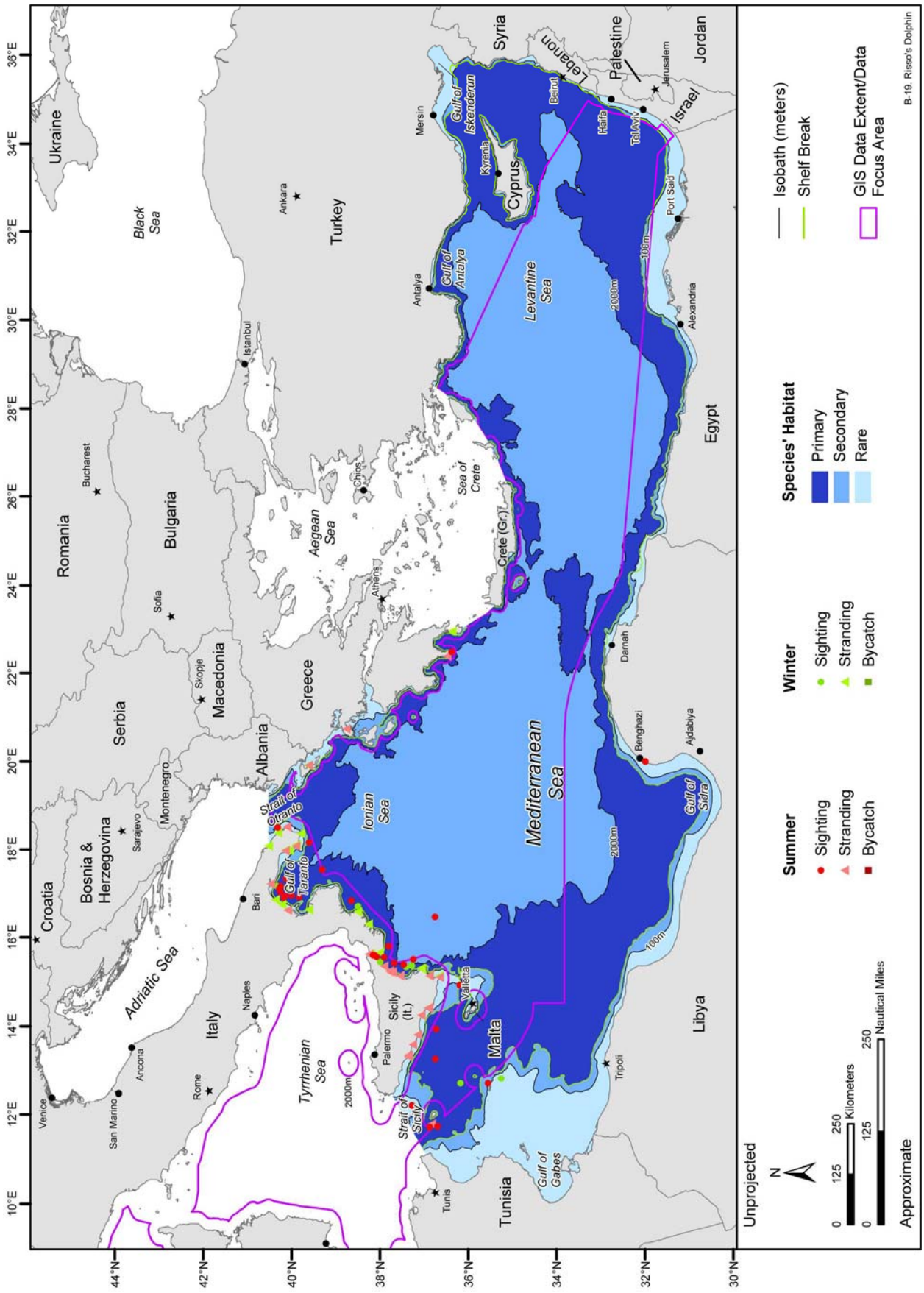


Figure B-19. Areas of occurrence for the Risso's dolphin in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

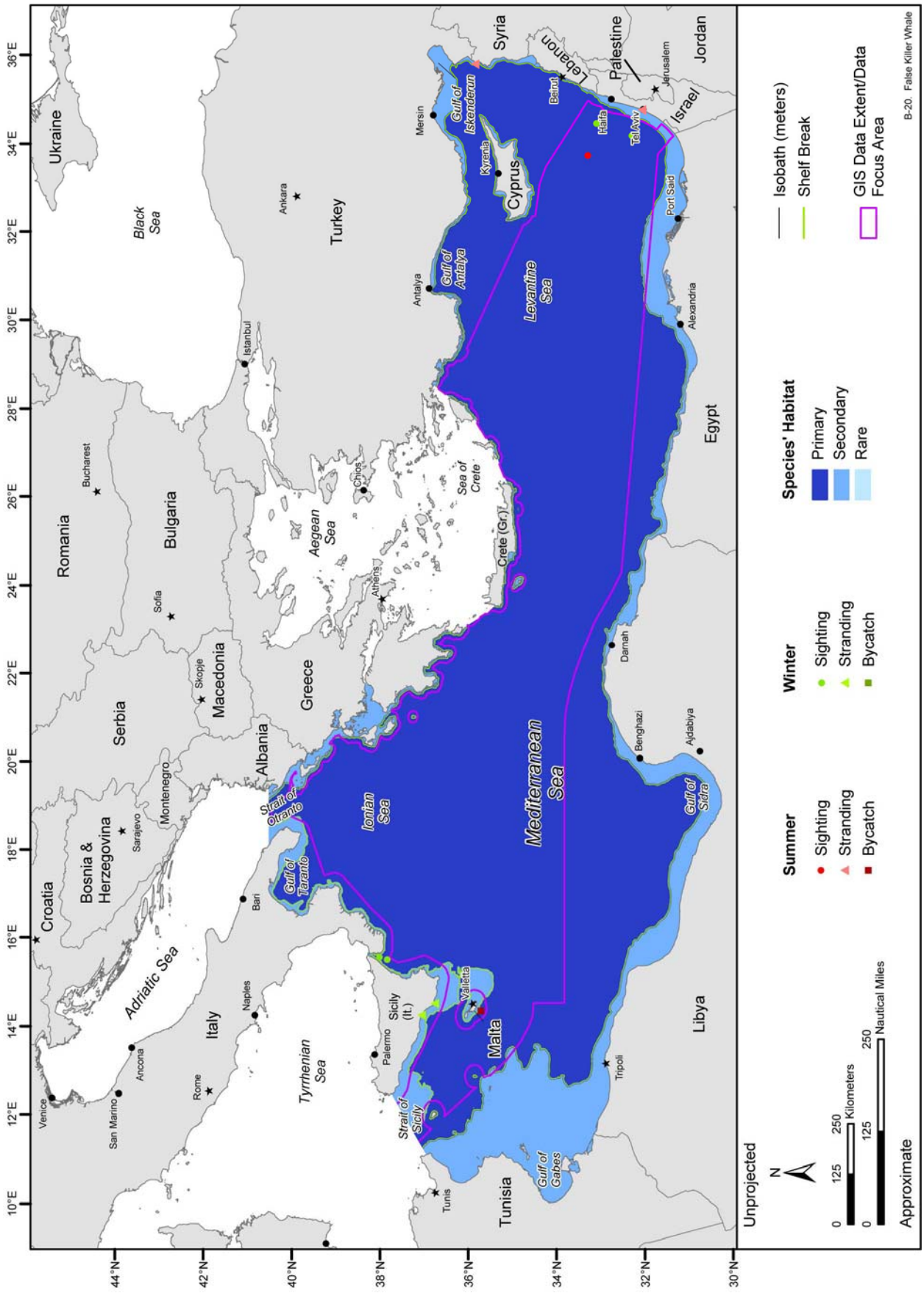


Figure B-20. Areas of occurrence for the false killer whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

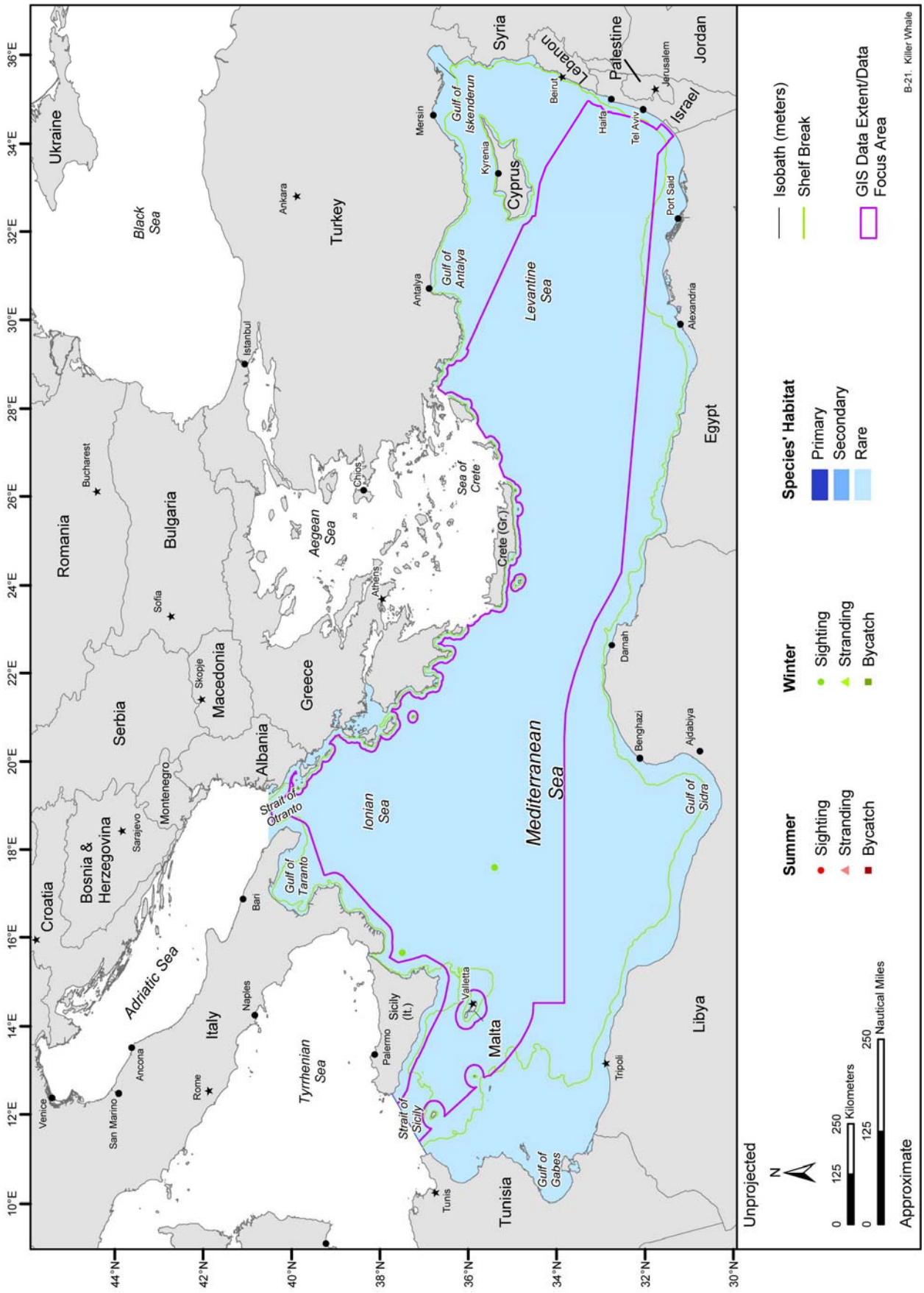


Figure B-21. Areas of occurrence for the killer whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-2.

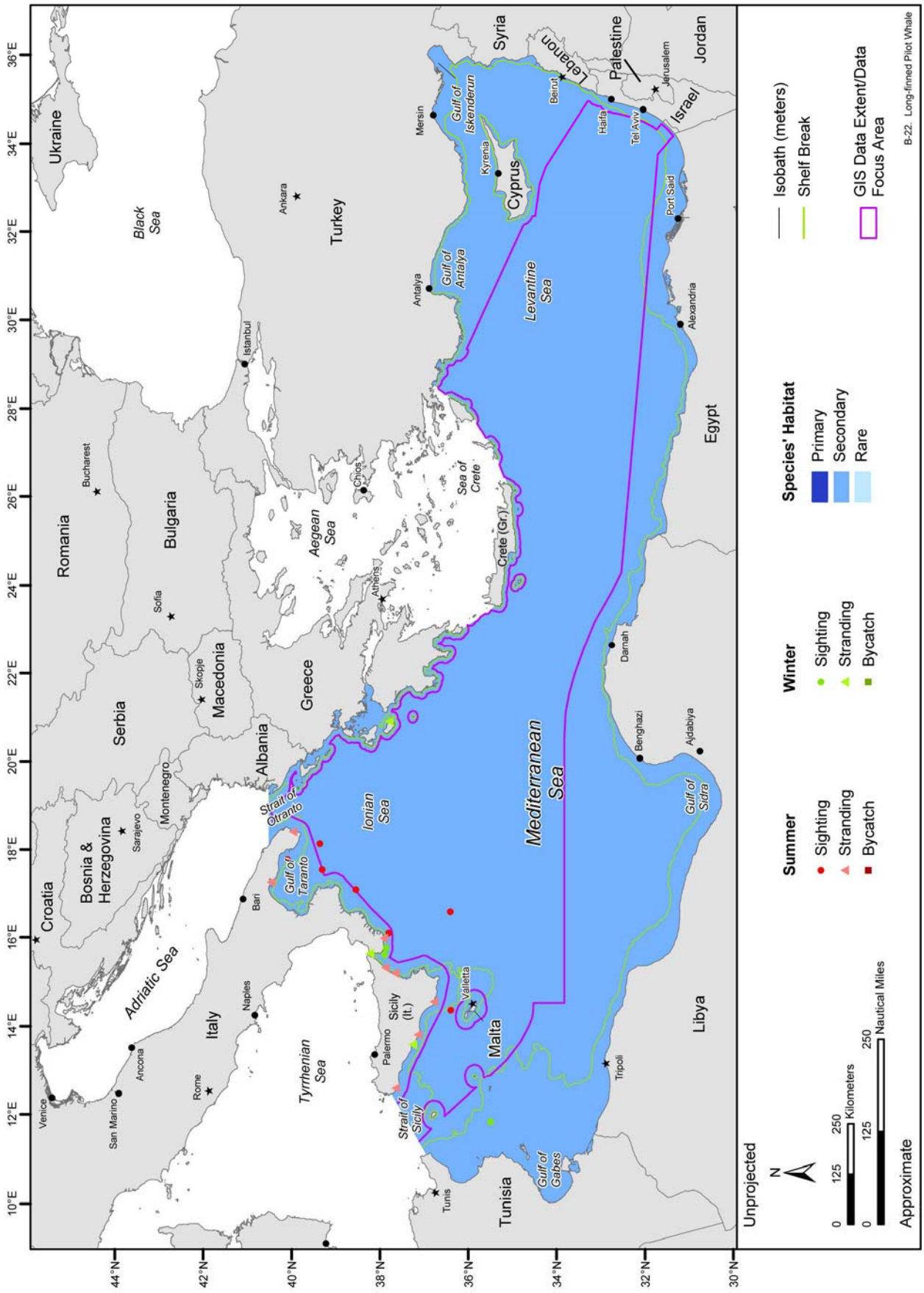


Figure B-22. Areas of occurrence for the long-finned pilot whale in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

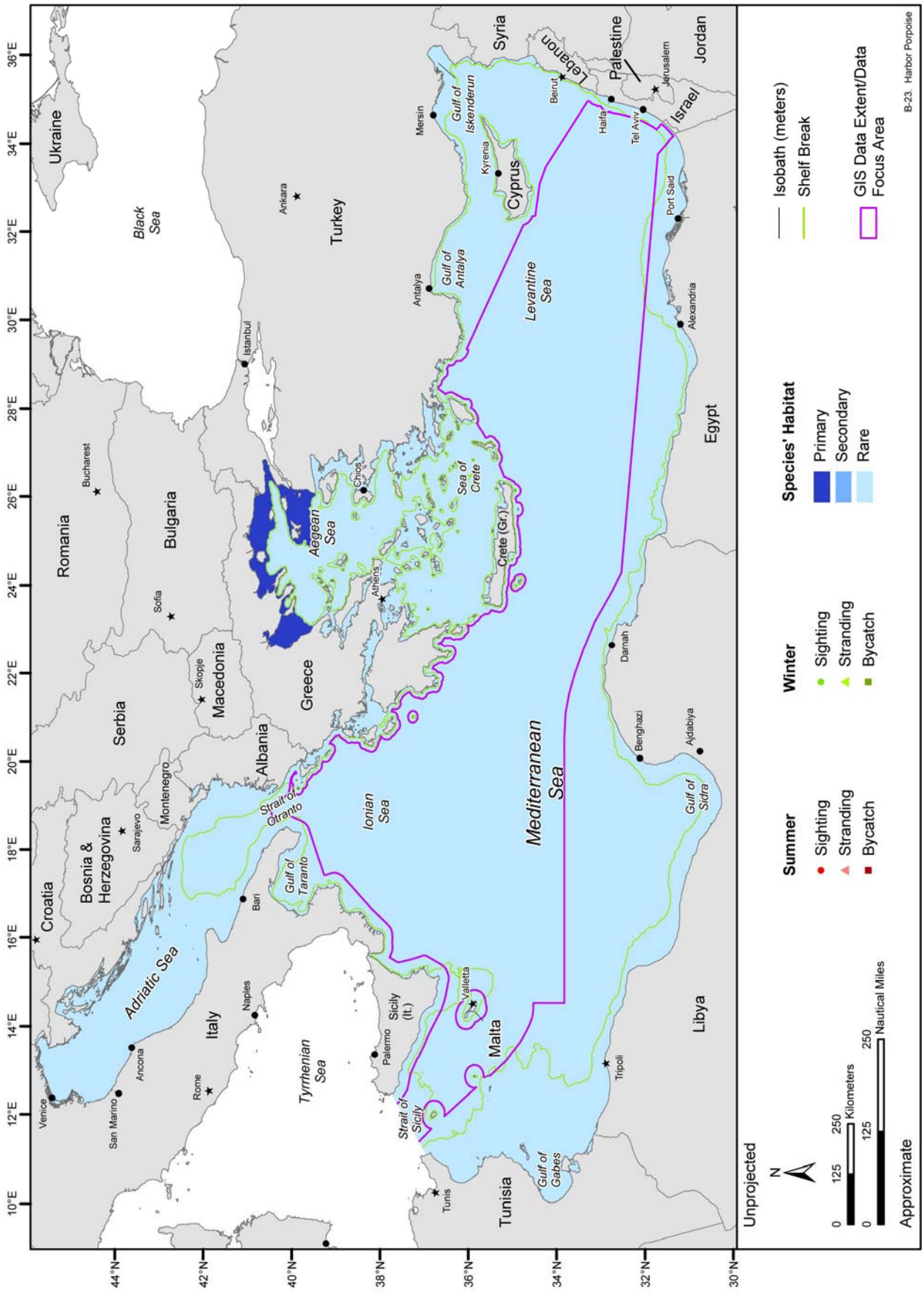


Figure B-23. Areas of occurrence for the harbor porpoise in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

APPENDIX C: SEA TURTLES

LIST OF FIGURES

Figure	Title
C-1	Areas of occurrence for threatened and endangered turtles in the eastern Mediterranean Study Area.
C-2	Areas of occurrence for the leatherback turtle in the eastern Mediterranean Study Area.
C-3	Areas of occurrence for the loggerhead turtle in the eastern Mediterranean Study Area.
C-4	Areas of occurrence for the green turtle in the eastern Mediterranean Study Area.
C-5	Areas of occurrence for the hawksbill turtle in the eastern Mediterranean Study Area.
C-6	Areas of occurrence for the Kemps' ridley turtle in the eastern Mediterranean Study Area.

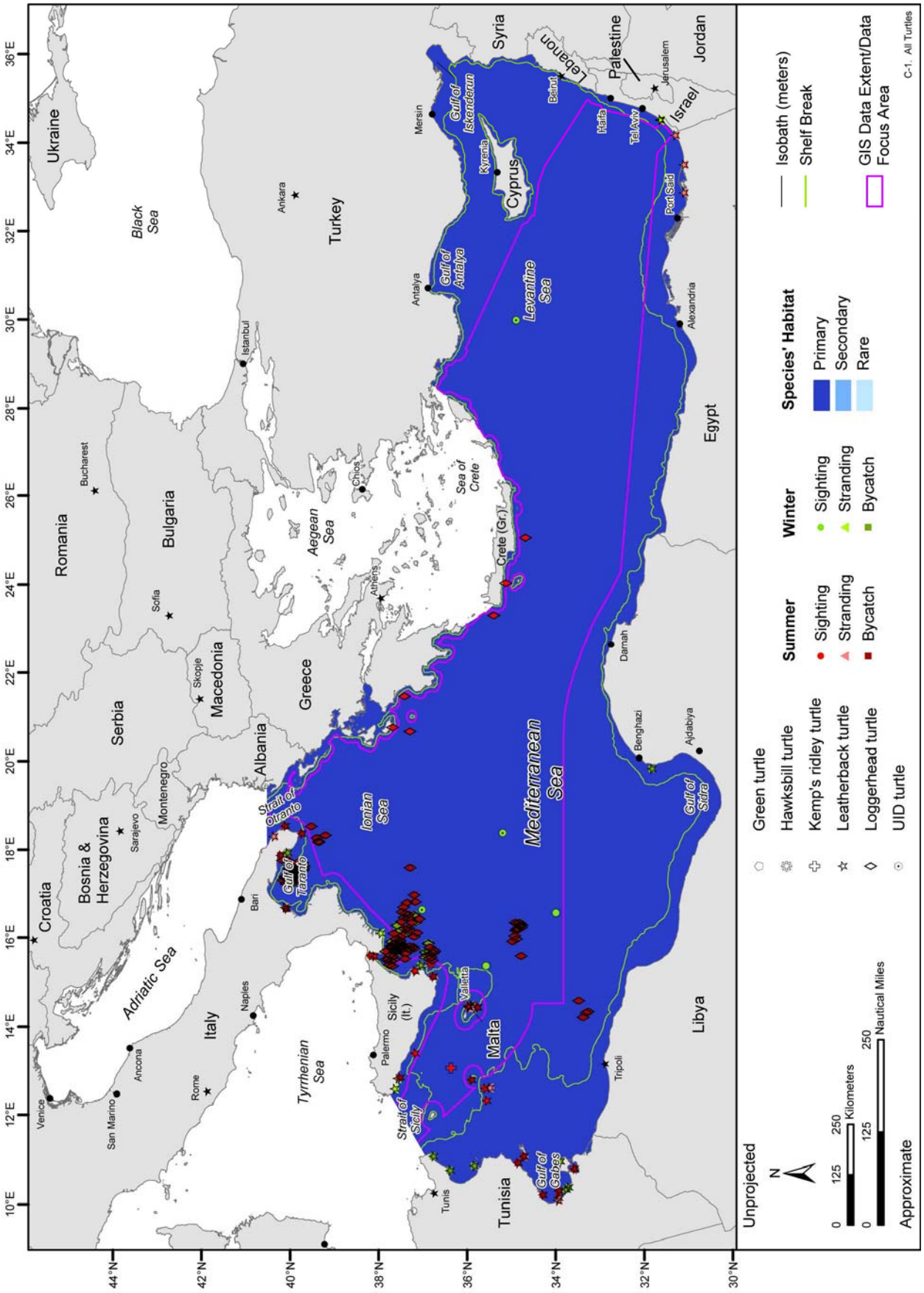


Figure C-1. Areas of occurrence for threatened and endangered turtles in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

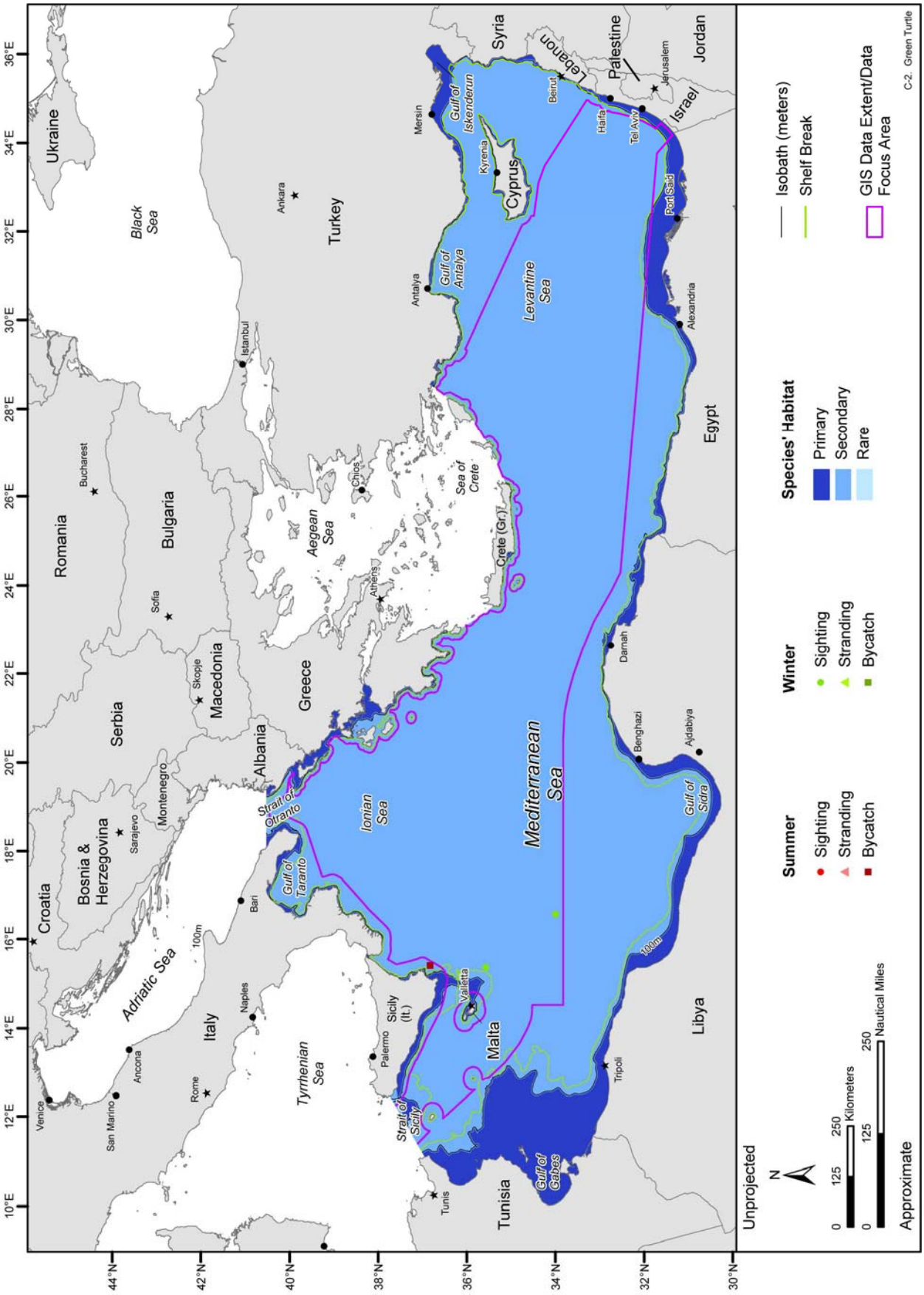


Figure C-2. Areas of occurrence for the leatherback turtle in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

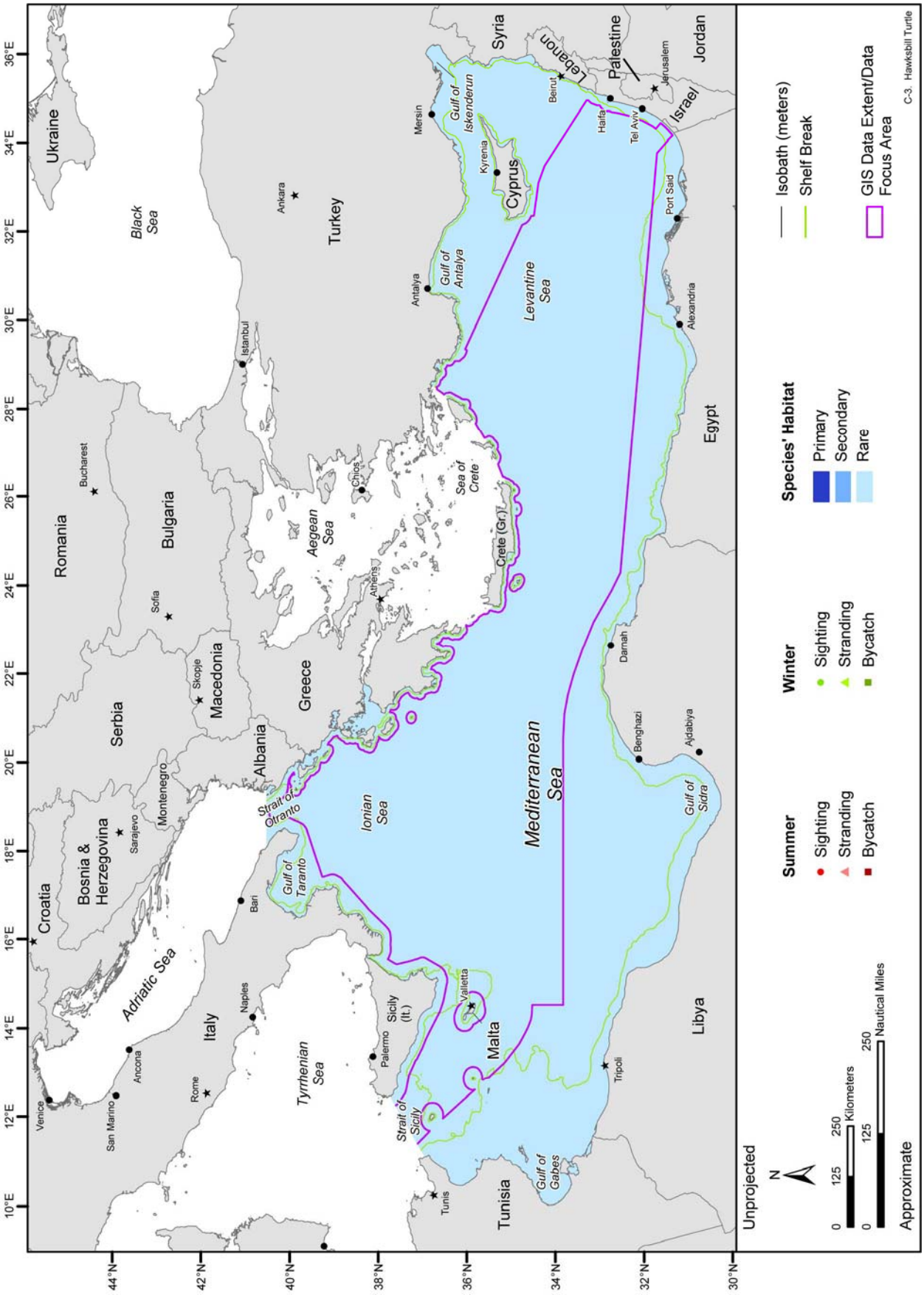


Figure C-3. Areas of occurrence for the loggerhead turtle in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

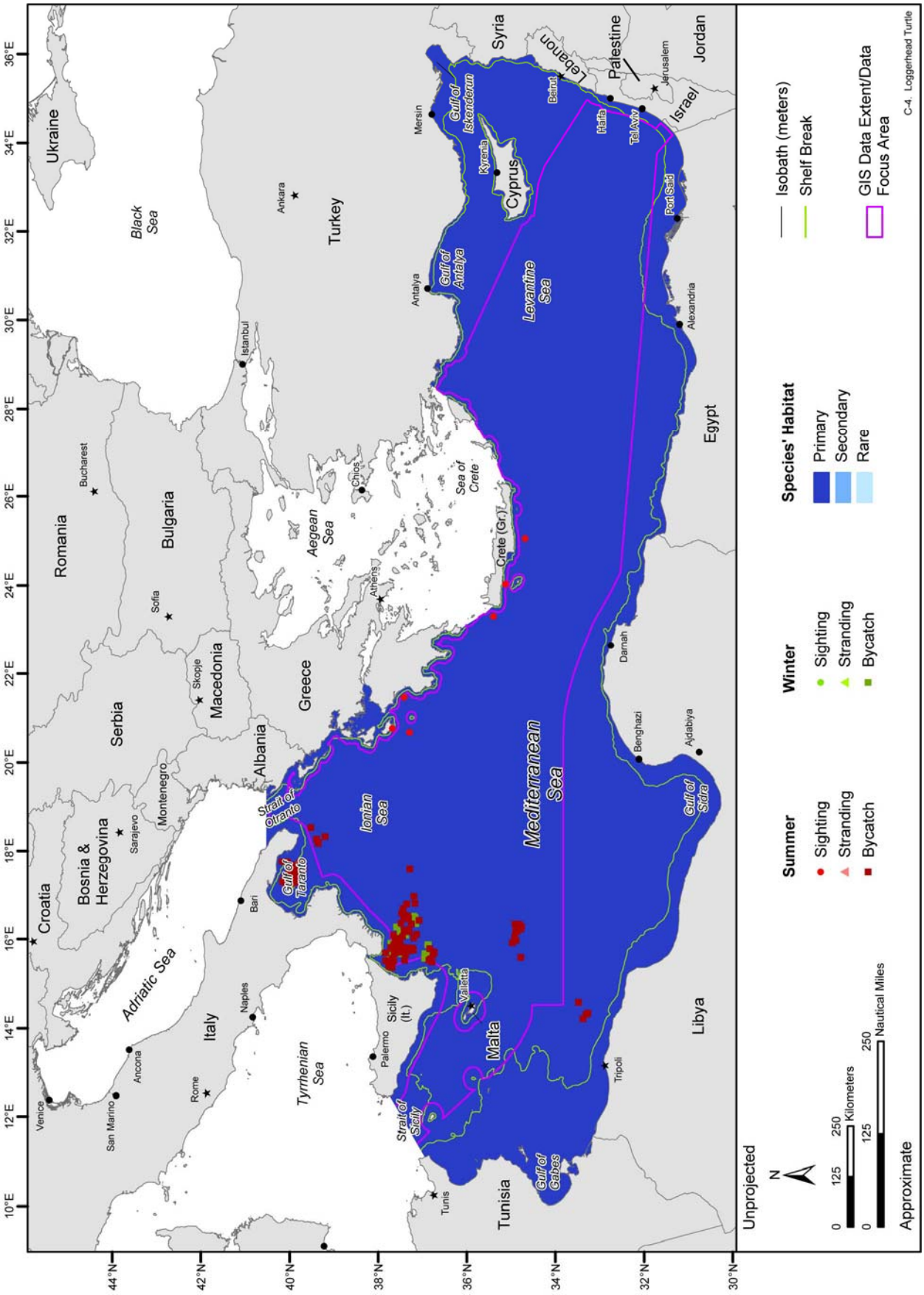


Figure C-4. Areas of occurrence for the green turtle in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

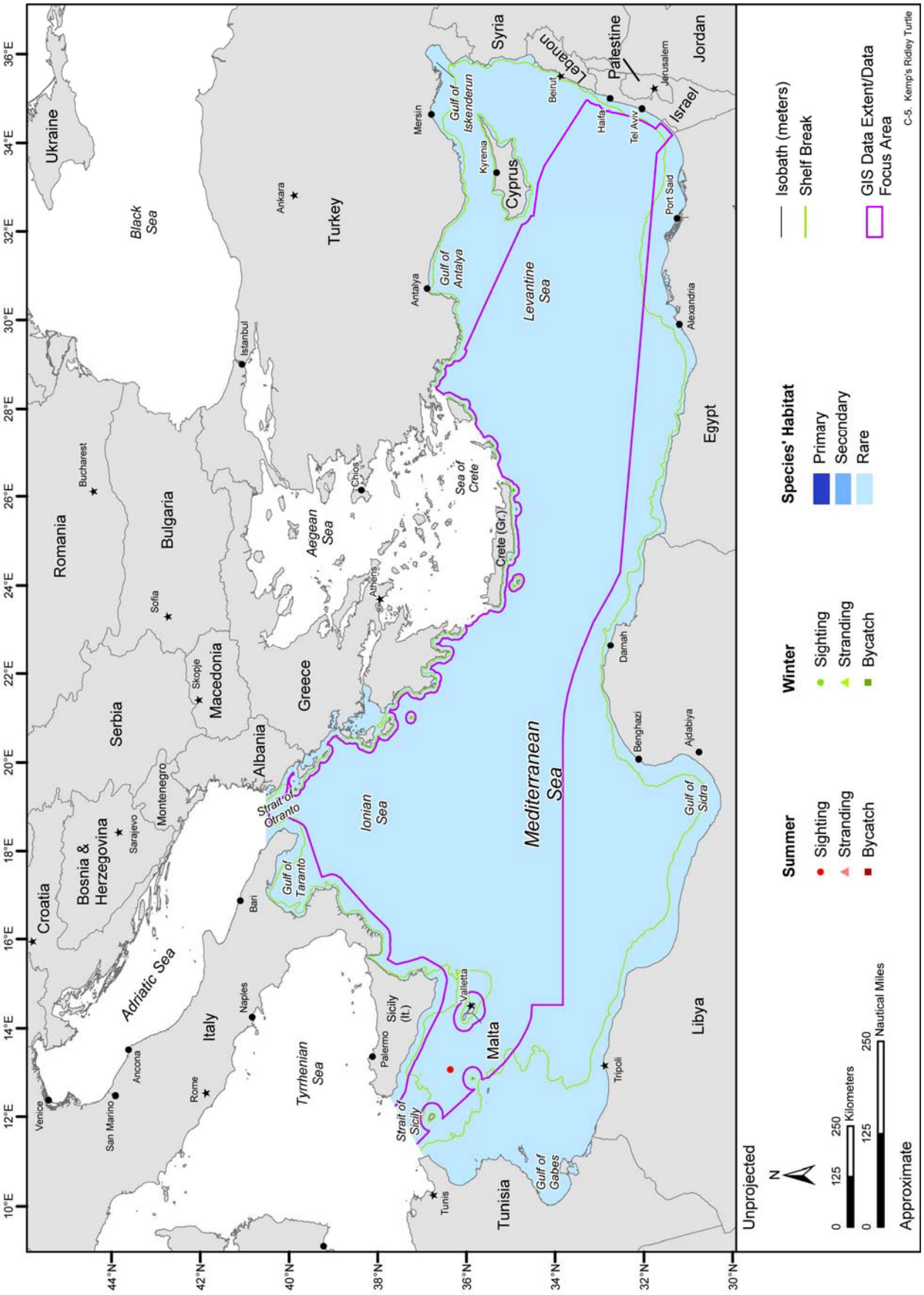


Figure C-5. Areas of occurrence for the hawksbill turtle in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

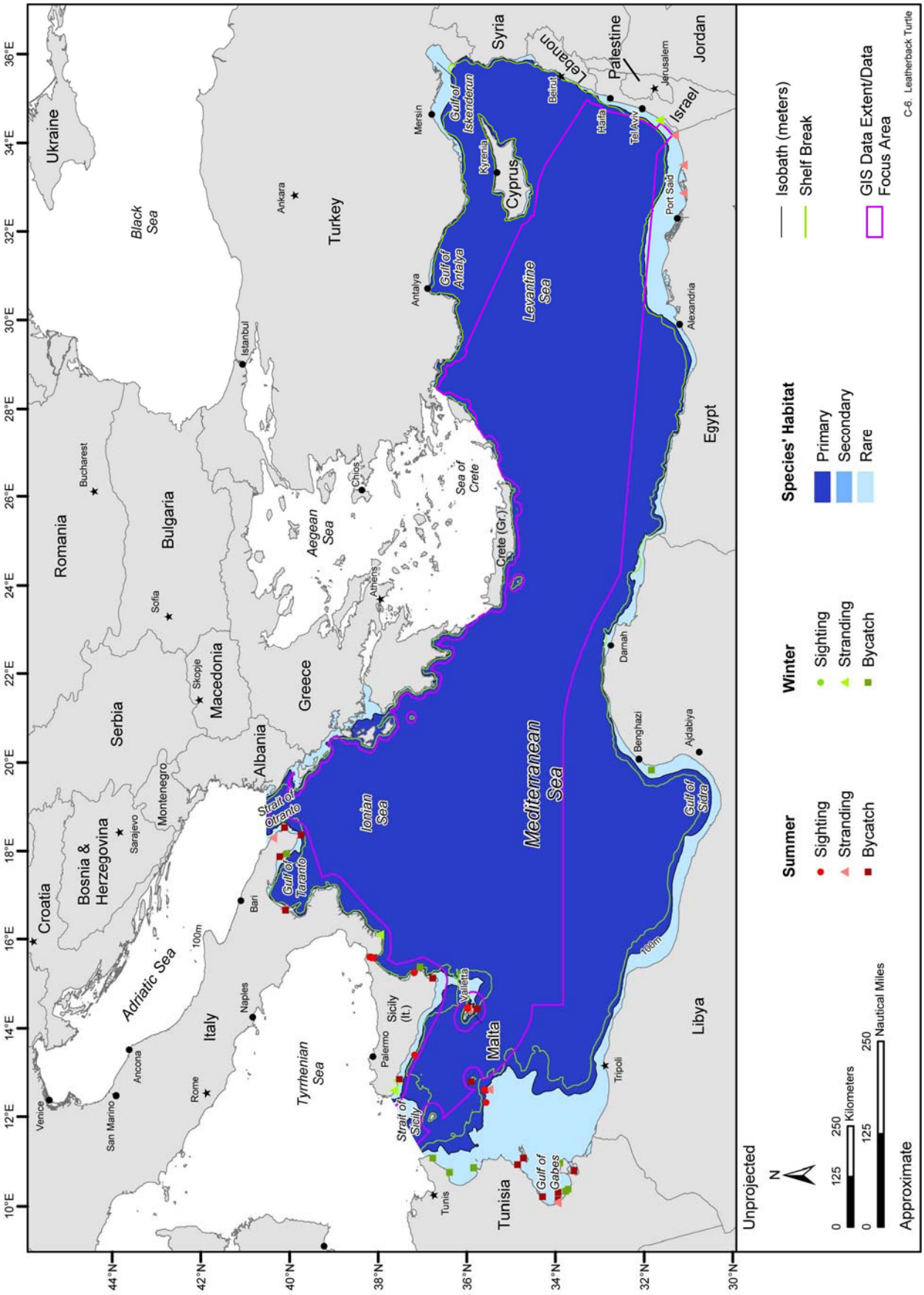


Figure C-6. Areas of occurrence for the Kemps' ridley turtle in the eastern Mediterranean Study Area. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.