MARINE RESOURCES ASSESSMENT FOR SOUTHEASTERN FLORIDA AND THE AUTEC-ANDROS OPERATING AREA

FINAL REPORT

MARCH 2007

PREPARED FOR:
DEPARTMENT OF THE NAVY,
U.S. FLEET FORCES COMMAND

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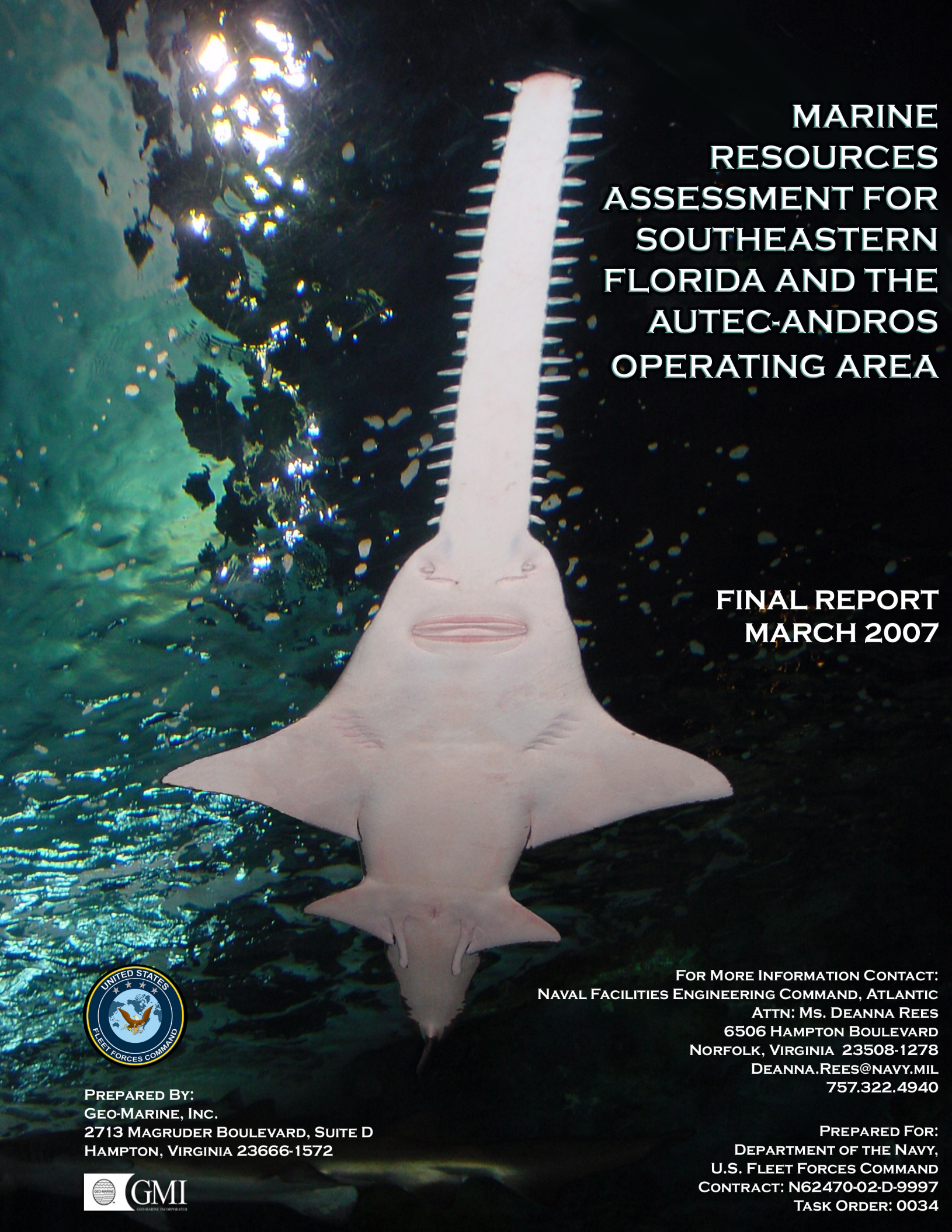

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The Department of the Navy would like to thank the many people who provided scientific data, literature, and information for this Marine Resources Assessment (MRA). This compilation would not have been possible without the generosity of many, whom we acknowledge below.

The protected species section of this report is a key component and would have been impossible to complete without the many data acquired from researchers. We are grateful for the effort expended by the scientists associated with the National Marine Fisheries Service, Southeast Fisheries Science Center (NMFS-SEFSC) who provided protected species data for the study area. In particular, we acknowledge the efforts of Drs. Keith Mullin, Lance Garrison, John Bohnsack, David McLellan, Chris Sasso, and Ms. Blair Mase-Gunthrie. Dr. Joseph Mobley with the University of Hawai‘i and Marine Mammal Research Consultants, Ltd. provided recent aerial survey data. The Bahamas Marine Mammal Survey and Ms. Diane Claridge supplied marine mammal and sea turtle occurrence data in addition to the photograph of a beaked whale used on the cover of the report. The title page photograph was provided by Mr. Andy Murch. Data for the study area from the NMFS North Atlantic Right Whale Consortium database were furnished by Dr. Robert Kenney. Dr. Allen Folley of the Florida Fish and Wildlife Conservation Commission provided sea turtle stranding data. Dr. Colin Simpfendorfer of the Center for Shark Research at Mote Marine Laboratory shared smalltooth sawfish data.

No less important to the successful completion of this MRA are those researchers who shared data on a myriad of other subject areas. We thank Dr. Ric Ruebsamen of the NMFS, Southeast Region for his continued assistance and guidance regarding essential fish habitat. Dr. Christy Pattengil-Semmens, Reef Environmental Education Association provided recreational dive site locations for the study area. Coral reef and shallow water benthic habitat data for the Bahamas were supplied by Dr. Frank Muller-Karger and Dr. Christine Kranenburg of IMaRS Coral Reef Remote Sensing Project. Ms. Cheryl McGarrity and Parsons Corporation furnished up-to-date Navy operating area boundary data. Information on the locations of deep water coral were contributed by Dr. John Reed, Harbor Branch Oceanographic Institution and Dr. Steve Ross, University of North Carolina at Wilmington.

For technical assistance with and review of the protected species material in this MRA we’d like to thank Ms. Diane Claridge (Bahamas Marine Mammal Survey), Dr. Alan Bolten (University of Florida), and Dr. Robert Kenney (North Atlantic Right Whale Consortium). We have striven to be inclusive but recognize that we may inadvertently neglect to mention someone whom assisted in this effort; the oversight was not intentional nor was the assistance any less appreciated.

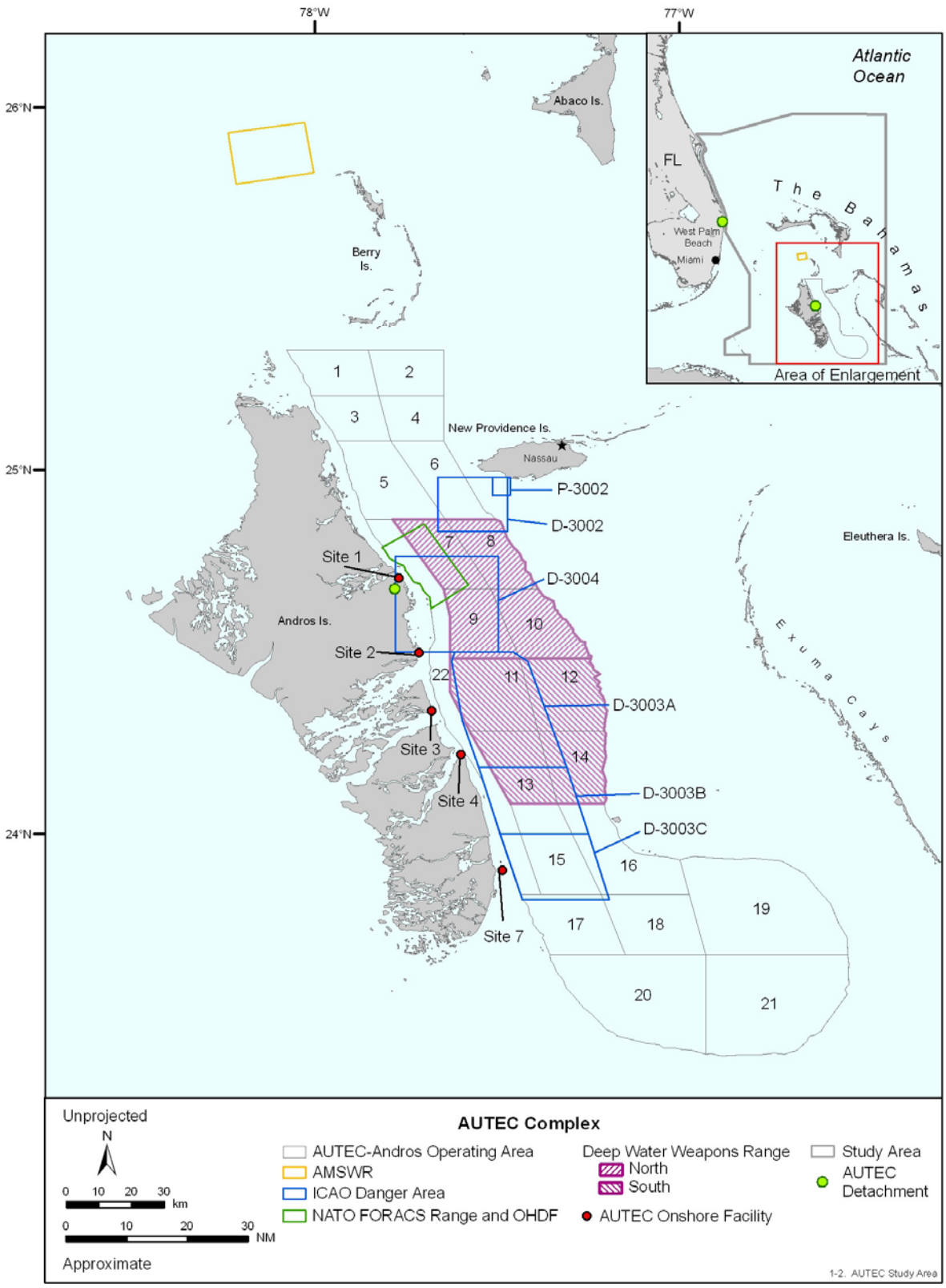
EXECUTIVE SUMMARY

The Department of the Navy (Navy) is committed to demonstrating environmental stewardship while executing its national defense mission. The 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 Magnuson-Stevens Fishery Conservation and Management Act/Sustainable Fisheries Act (MSFCMA/SFA), and Executive Order 13089 on Coral Reef Protection. The Commander, U.S. Fleet Forces Command 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). 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, ESA, and MSFCMA/SFA.

This MRA documents and describes the marine resources in waters off southeastern Florida and in the AUTEC-Andros OPAREA and AUTEC Minefield Shallow Water Range (AMSWR); this area is hereafter referred to as the study area. An overview of the marine environment found in this region provides information on the important physical parameters that may affect the occurrence and distribution of protected and managed marine species and habitats. Detailed information is included on the characteristics and life history of protected marine mammals, sea turtles, and fishes that may occur in the study area. Seasonal variations in the occurrence patterns of protected species have been identified, mapped, and described along with the likely causative factors (behavioral, climatic, or oceanographic). Pelagic *Sargassum* and marine benthic communities including coral reefs and coral, live/hard bottom, seagrass communities, blue holes, and artificial habitats have been investigated and mapped. An overview of the fish assemblages associated with the waters of the study area off southeastern Florida is included as well as detailed summaries and associated graphical depictions of essential fish habitat (EFH) for those fish and invertebrate species designated in the U.S. waters of the study area, including the status, distribution, and EFH by life history stage. Information is provided on such additional topics as the locations of U.S. and Bahamian maritime boundaries, navigable waters, marine managed areas, and recreational diving sites that are found in the MRA study area.

Thorough and systematic literature and data searches were conducted, providing as much relevant information as possible for this assessment. Available occurrence data including sighting, stranding, incidental fisheries bycatch, satellite-tracking, and nest records for marine mammals, sea turtles, fishes, and coral were compiled and interpreted to predict the occurrence patterns, when possible, in the study area for these protected species. Predictions of the seasonal occurrence patterns of marine mammals and sea turtles were derived using all compiled occurrence data, information on habitat preferences, life history information, and the assistance of regional experts.

The geographical representation of the marine resource occurrences in the study area is a major constituent of this MRA report. A geographic information system (GIS) was used to enter, store, manipulate, analyze, and visualize the spatial data and information accumulated for the southeastern Florida and AUTEC-Andros OPAREA MRA. Over 130 GIS-generated map figures are included in this assessment; data layers associated with these maps consist of bathymetry, sea surface temperature, protected and managed species' occurrences, Navy operating areas, and EFH in addition to many others. Metadata (documentation of the GIS data) were also prepared for each GIS file associated with this MRA report. The southeastern Florida and AUTEC-Andros OPAREA MRA report is provided in both paper and electronic form.



The study area (inset) with the surface and airspace attributes of the AUTEC-Andros OPAREA.

REPORT ORGANIZATION

This report consists of nine major chapters and 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 methodologies used to prepare this assessment;
- **Chapter 2 Physical Environment**—describes the physical environment of the study area for the MRA including climate, marine geology (physiography, bathymetry, and bottom substrate), physical oceanography (circulation and currents), hydrography (temperature and salinity), and biological oceanography (productivity and plankton);
- **Chapter 3 Protected Species**—details the protected marine mammals, sea turtles, and fishes found in the study area, with detailed narratives of their morphology, status, habitat preferences, distribution, behavior, life history, acoustics, and hearing;
- **Chapter 4 Habitats of Concern**—discusses the occurrence of *Sargassum*, corals, hard bottom communities, blue holes, seagrass communities, and artificial habitats located in the study area for the MRA;
- **Chapter 5 Fishes**—investigates fish assemblages and essential fish habitat (EFH) (U.S. waters only) that occur within the study area;
- **Chapter 6 Additional Considerations**—provides information on maritime boundaries, navigable waters, marine managed areas, and recreational diving locations;
- **Chapter 7 Recommendations**—suggests future avenues of research necessary to fill the data gaps identified during the completion of this project and prioritizes research needs from a cost/benefit approach;
- **Chapter 8 List of Preparers**—lists all individuals who helped prepare the MRA report;
- **Chapter 9 Glossary**—includes definitions of the terms used in the MRA report;
- **Appendix A**—contains supporting information for Chapter 1 such as data confidence levels, and map projection information, data sources of protected species research efforts, and maps of protected species survey effort;
- **Appendix B**—provides marine mammal occurrence maps;
- **Appendix C**—presents sea turtle occurrence maps;
- **Appendix D**—includes maps of EFH; and
- **Appendix E**—contains selected mylar/transparency overlays.

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	Three-dimensional
ºC	Degrees Celsius
ºF	Degrees Fahrenheit
µm	Micrometer(s)
µPa	Micropascal(s)
AAIW	Antarctic Intermediate Water
ABR	Auditory Brainstem Response
ACCSTR	Archie Carr Center for Sea Turtle Research
AGRRA	Atlantic and Gulf Rapid Reef Assessments
ALWTRP	Atlantic Large Whale Take Reduction Plan
AMNH	American Museum of Natural History
AMSWR	AUTEC Minefield Shallow Water Range
ARPA	Advanced Projects Research Agency
ASMFC	Atlantic States Marine Fisheries Commission
AUTEC	Atlantic Undersea Test and Evaluation Center
AVHRR	Advanced Very High Resolution Radiometer
BCO	Bahamas Cabinet Office
BLM	Bureau of Land Management
BNT	Bahamas National Trust
BPOA	Barbados Program of Action
BREEF	Bahamas Reef Environmental Education Foundation
BTS	Bureau of Transportation Statistics
C	Carbon
$CaCO_3$	Calcium carbonate
CARICOMP	Caribbean Coastal Marine Productivity
CBRA	Coastal Barrier Resources Act
CCC	Caribbean Conservation Corporation
CCL	Curved Carapace Length
CEP-UNEP	Caribbean Environment Programme of the United Nations Environment Programme
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFMC	Caribbean Fishery Management Council
CFR	Code of Federal Regulations
CHA	Critical Habitat
C-HAPC	Coral Habitat Area of Particular Concern
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CIA	Central Intelligence Agency
cm	Centimeter(s)
COMLANTFLT	Commander, U.S. Atlantic Fleet
CPA	Canaveral Port Authority
CR	Critically Endangered
CSC	Coastal Services Center
CWA	Clean Water Act
CZCS	Coastal Zone Color Scanner
CZMA	Coastal Zone Management Act
D	Distance
dB	Decibel
dB re 1µPa-m	Decibels at the Reference Level of One Micropascal at One Meter Distance
DCM	Deep Chlorophyll Maximum
DN	Pixel value
DNM	Deployed Noise and Measurement
DNR	Department of Natural Resources

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

DOALOS	Division for Ocean Affairs and the Law of the Sea
DoC	Department of Commerce
DoD	Department of Defense
DoF	Department of Fisheries
DoI	Department of Interior
DoN	Department of the Navy
DoS	Department of State
DoT	Department of Transportation
DPS	Distinct Population Segment
DSCS	Deep-Sea Coral and Sponge
DUML	Duke University Marine Laboratory
DWBC	Deep Western Boundary Current
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFCCA	East Florida Coast Closed Area
EFH	Essential Fish Habitat
EFS	East Florida Shelf
EIS	Environmental Impact Statement
ENSO	El Niño/Southern Oscillation
EORR	Experimental *Oculina* Research Reserve
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute, Inc.
EWS	Early Warning System
FAD	Fish Aggregating Device
FCMA	Fishery Conservation and Management Act
FDEP	Florida Department of Environmental Protection
FDT	Florida Department of Transportation
FEIS	Final Environmental Impact Statement
FFC	Fleet Forces Command
FFWCC	Florida Fish and Wildlife Conservation Commission
FGBNMS	Flower Garden Banks National Marine Sanctuary
FHCZ	Fisheries Habitat Conservation Zones
FKNMS	Florida Keys National Marine Sanctuary
FL	Florida
Fleet	U.S. Atlantic Fleet
FMNH	Florida Museum of Natural History
FORCAS	Forces Sensor and Weapons Accuracy Check Site
FMC	Fishery Management Council
FMP	Fishery Management Plan
FMZ	Fishery Management Zone
FMRI	Florida Marine Research Institute
ft	Feet
FWPCA	Federal Water Pollution Control Act
g	Gram(s)
GA	Georgia
GDAIS	General Dynamics Advanced Information System
GIS	Geographic Information System
GMFMC	Gulf of Mexico Fishery Management Council
GMI	Geo-Marine, Inc.
GOB	Government of The Bahamas
GSMFC	Gulf States Marine Fisheries Commission
GTMNERR	Guano Tolomato Matanzas National Research Reserve
HAPC	Habitat Areas of Particular Concern

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

HMS	Highly Migratory Species
HTML	Hyper Text Markup Language
Hz	Hertz
ICAO	International Civil Aviation Organization
ICRAN	International Coral Reef Action Network
IDW	Inverse Distance Weighted
IMaRS	Institute for Marine Remote Sensing
In	Inch
IOTB	Island of The Bahamas
ISOW	Iceland-Scotland Overflow Water
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
kg	Kilogram(s)
kHz	Kilohertz
km	Kilometer(s)
km^2	Square kilometers
l	Liter(s)
LC	Location Class
LAT	Latitude
LON	Longitude
m	Meter(s)
m^3	Cubic meters
MAFMC	Mid-Atlantic Fishery Management Council
MARAD	U.S. Maritime Administration
MARMAP	Marine Resources Monitoring Assessment and Prediction
MATS	Mid-Atlantic *Tursiops* Surveys
mg	Milligram(s)
mi^2	Square mile(s)
min	Minute(s)
mm	Millimeter(s)
MMA	Marine Managed Area
MMC	Marine Mammal Commission
MML	Mote Marine Laboratory
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MPA	Marine Protected Area
MPPRCA	Marine Plastic Pollution Research and Control Act
MPRSA	Marine Protection, Research, and Sanctuaries Act
MR	Marine Reserves
MRA	Marine Resources Assessment
msec	Millisecond(s)
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum Sustainable Yield
MU	Management Unit
NADW	North Atlantic Deep Water
NAO	North Atlantic Oscillation
NARP	National Artificial Reef Plan
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVO	Naval Oceanographic Office
NC	North Carolina
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NFEA	National Fishing Enhancement Act

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

NISP	National Implementation Support Partnerships
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NMPAC	National Marine Protected Area Center
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NP	National Park
NPMS	National Pipeline Mapping System
NPS	National Park Service
NRC	National Research Council
NRFCC	National Recreational Fisheries Coordination Council
NS	National Seashore
NURP	NOAA's Undersea Research Program
NWR	National Wildlife Refuge
NWRA	National Wildlife Refuge Association
OBIS	Ocean Biogeographic Information System
OCS	Outer Continental Shelf
O-HAPC	*Oculina* Habitat Area of Particular Concern
OHDF	Ocean Haul Down Facility
ONR	Office of Naval Research
OPAREA	Operating Area
OPIS	Ocean Planning Information System
PBR	Potential Biological Removal
PDF	Portable Document Format
pH	Power or potential of hydrogen
PODACC	Physical Oceanography Distributed Active Archive Center
POP	Platforms of Opportunity
psu	Practical Salinity Unit
PTT	Platform Transmitter Terminal
RBF	Reef Ball Foundation
RCMP	Range Complex Management Plan
REEF	Reef Environmental Education Foundation
RFRCP	Recreational Fishery Resources Conservation Plan
rms	Root Mean Squared
SAB	South Atlantic Bight
SAFMC	South Atlantic Fishery Management Council
SAIC	Science Applications International Corporation
SAV	Submerged Aquatic Vegetation
SC	South Carolina
SCUBA	Self-contained Underwater Breathing Apparatus
SEADESC	Southeastern Deep Sea Coral
SEAMAP	Southeast Area Monitoring and Assessment Program
sec	Second(s)
SEFSC	Southeast Fisheries Science Center
SEL	Sound Exposure Level
SETS	Southeast Turtle Surveys
SFA	Sustainable Fisheries Act
SIDS	Small Island Developing States
SL	Standard Length
SOSUS	Sound Surveillance System
sp.	Species

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

spp.	Species (plural)
SMSFP	Smithsonian Marine Station at Fort Pierce
SMZ	Special Management Zone
SST	Sea Surface Temperature
SSSRT	Smalltooth Sawfish Status Review Team
STSSN	Sea Turtle Stranding and Salvage Network
SUW	Subtropical Underwater
SV	Sverdrup ≡ 10^6 m^3 s^{-1}
SWIMA	Surface Water Improvement Management Area
TAC	Total Allowable Catch
TEWG	Turtle Expert Working Group
TIN	Triangular Irregular Network
TL	Total Length
TNC	The Nature Conservancy
TOTO	Tongue of the Ocean
TTS	Temporary Threshold Shift
U.N.	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environmental Progamme
U.S.	United States
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USCG	United States Coast Guard
USF	University of South Florida
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VU	Vulnerable
WBR	Wild Bird Reserves
WBUC	Western Boundary Under Current
WCA	Wildlife Conservation Act
WCMC	World Conservation Monitoring Centre
WCTA	Wildlife Conservation and Trade Act
WMR	Wild Marine Reserves
XBT	Expendable Bathythermograph
XML	Extensible Markup Language
YOY	Young-of-the-Year

1.0 INTRODUCTION

This marine resource assessment (MRA) was contracted by the United States (U.S.) Navy's (Navy) Commander, U.S. Fleet Forces Command (FFC) to initiate the collection, compilation, and analysis of data and information concerning the protected and commercial marine resources found in southeastern Florida and the Atlantic Undersea Test and Evaluation Center (AUTEC)-Andros Operating Area (OPAREA), including the AUTEC Minefield Shallow Water Range (AMSWR). For the purposes of this MRA, the study area for southeastern Florida and the AUTEC-Andros OPAREA (Figure 1-1), will hereinafter be referred to as "the study area."

1.1 PURPOSE AND NEED

This MRA aims to describe and document the marine resources in the study area, including both protected and commercially important marine species, and provides a compilation of the most recent data and information on the occurrences of these resources. A synopsis of environmental data for the study area and in-depth discussions of the protected species and habitats found in the region are included. The locations of essential fish habitat in southeastern Florida waters as well as other areas of interest, such as marine managed areas and scuba diving sites, are also addressed. Finally, the identification of data gaps and the prioritization of recommendations for future research in the study area are additional components of this report.

Information provided herein will serve as a baseline from which the Navy can effectively plan future actions and consider adjustments to training exercises or operations to mitigate potential impacts to commercial and protected marine resources. This assessment will contribute to the FFC's Integrated Long-Range Planning Process and represents an important component in the FFC's ongoing compliance with U.S. federal mandates that aim to protect and manage resources in the marine environment. All species and habitats that are potentially affected by the Navy's maritime exercises and are protected by U.S. federal resource laws or executive orders or Bahamian federal legislation are considered in this assessment.

Searches and reviews of relevant literature and data were conducted to summarize marine features pertinent to the study area, occurrence patterns of protected species, and the distributions of important marine habitats occurring in the study area. To describe the physical environment, physiographic, bathymetric, geologic, hydrographic, and oceanographic data for the study area and vicinity are presented. Available sighting, stranding, incidental fisheries bycatch, tagging, and nest data for protected marine mammals, sea turtles, and fishes were compiled, analyzed, and interpreted to predict occurrence patterns. Seasonal variations in occurrence patterns are identified, mapped, and described along with likely causative factors (behavioral, climatic, or oceanographic). Characteristics of protected species such as their behaviors and life histories that may be relevant to the evaluation of potential impacts of Navy operations are included. Locations of benthic communities (live/hard bottom communities, corals, and seagrasses), artificial habitats (artificial reefs and shipwrecks), and eastern Florida essential fish habitats are also addressed. To supplement these key aspects, information and data regarding U.S. and Bahamian maritime boundaries, navigable waters, marine managed areas, and scuba diving sites in the study area have been incorporated into this report. This summary of marine resources occurring in the study area is provided in both paper and electronic form.

1.2 LOCATION OF STUDY AREA

The study area for southeastern Florida and the AUTEC-Andros OPAREA encompasses waters of the western northern Atlantic along southeastern Florida (FL) and approximately half of The Bahamas (Figure 1-1). Covering an area greater than 246,000 square kilometers (km^2), the study area contains shallow to deep water habitats, continental to insular margins, and coastal to open ocean waters. The study area occupies waters three nautical miles (NM) off the eastern Florida coast from just south of West Palm Beach to just north of Cape Canaveral and extends seaward to just east of Eleuthera Island in The Bahamas. The study area is bounded to the north by the Jacksonville OPAREA, to the west by the Florida coast and the Key West Complex, and to the south by the territorial waters of Cuba. Terrestrially, The Bahamas is composed of over 700 islands that support a population of just over 300,000 people.

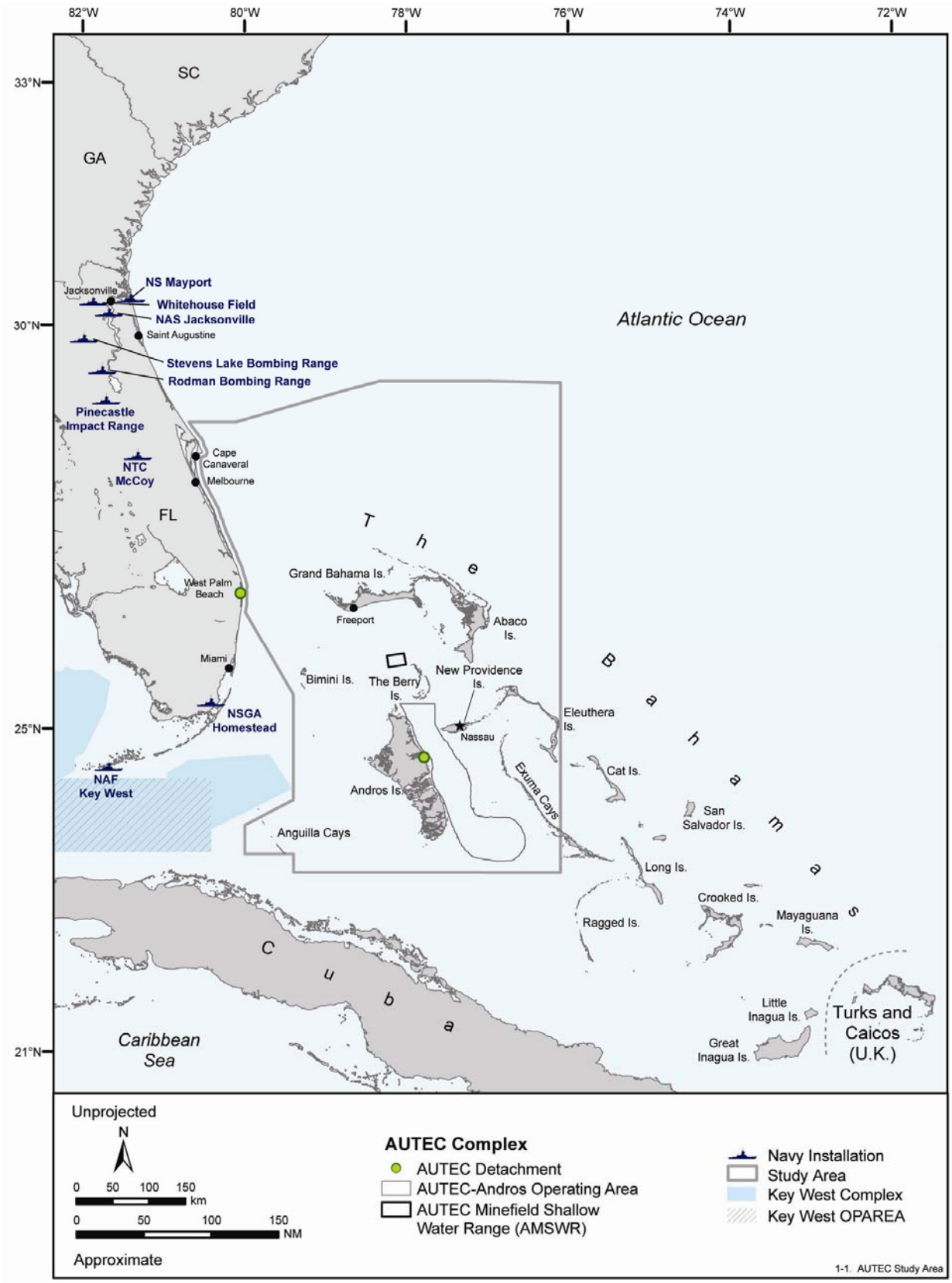

Figure 1-1. The study for southeastern Florida and the AUTEC-Andros OPAREA MRA. Source data: Parsons (2006).

More than half of the population of The Bahamas resides in the capital city of Nassau on New Providence Island, which is located just on the northeastern side of the AUTEC-Andros OPAREA.

Support, coordination, and scheduling of the AUTEC-Andros OPAREA and AMSWR are accomplished by the Naval Undersea Warfare Center with detachments located at Andros Island, West Palm Beach, FL, and in Newport, Rhode Island. The AUTEC Complex is defined as the AUTEC-Andros OPAREA, the AMSWR, six International Civil Aviation Organization (ICAO) Danger Areas, five onshore facilities (sites one through four and site seven) and the AUTEC Detachment facility (Figure 1-2).

The AUTEC-Andros OPAREA is designed around a passive hydrophone array located within the Tongue of the Ocean (TOTO), east of Andros Island (Vandenbroucke et al. 2005). This array is designed for making underwater acoustic measurements, testing and calibrating sonar systems, and the tracking of undersea and surface vessels (Jarvis and Moretti 2002). The 70 bottom-mounted hydrophones are spread approximately two NM apart at depths of approximately 1,400 meters (m) to 1,620 m (Jarvis and Moretti 2002; Lehtinen et al. 2002; Moretti 2003; Mann and Jarvis 2004; Morrissey et al. 2004, Vandenbrouke et al. 2005). This array, and the AUTEC-Andros OPAREA in general, aims to provide the Navy with a state of the art testing facility to support advances in and development of anti-submarine warfare, mine warfare, and other undersea warfare tactics, equipment, instrumentation, and platforms (DoN 2005a).

The hydrophone array is split between two Deep Water Weapons Ranges, North and South. Each Deep Water Weapons Range is parceled into four range areas, 7 through 10 in the North Weapons Range and 11 through 14 in the South Weapons Range. An additional six range areas are located north of the North Weapons Range (areas 1 through 6) and an additional seven to the south of the South Weapons Range (areas 15 through 21). A surface transit lane (range 22) is also located to the west of both the North and South Weapons Ranges. These 22 individual range areas comprise the AUTEC-Andros OPAREA. The six ICAO Danger Areas (P-3002, D-3002, D-3003A, D-3003B, D-3003C, and D-3004) are located within or near the AUTEC-Andros OPAREA and warn civilian air traffic of the possible presence of military aircraft (DoN 2005a). The North Atlantic Treaty Organization's (NATOs) Naval Forces Sensor and Weapons Accuracy Check Site (FORACS) Range and Ocean Haul Down Facility (OHDF) span the surface transit area (range 22) and the North Weapons Range and serve as a sensor calibration area for NATO units (DoN 2005a).

In addition to the AUTEC-Andros OPAREA, the AMSWR is located to the west of the Berry Islands (Figure 1-2) in waters ranging in depth from < 10 m to > 700 m. This range provides an operating environment with both shallow and deep waters (DoN 2005a). Forty-five bottom-mounted hydrophones and up to 36 buoyed acoustic sensors are present within the AMSWR (DoN 2005a).

1.3 APPLICABLE LEGISLATION

The primary environmental laws that govern Navy activities in the marine environment include the National Environmental Policy Act, the Marine Mammal Protection Act, the Endangered Species Act, and the Magnuson-Stevens Fishery Conservation and Management Act. In addition to these acts, there are several other federal mandates and executive orders that deal with resource conservation and management in ocean waters under U.S. or Bahamian jurisdiction. The following sections are chronological lists of the many laws and regulations that the Navy must consider when conducting maritime operations in the study area and vicinity.

1.3.1 Federal Resource Laws

- The National Environmental Policy Act (NEPA) of 1969 established national policies and aims for environmental protection. 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 country. 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 environmental protection, while Title II establishes the Council on Environmental Quality (CEQ), which monitors the

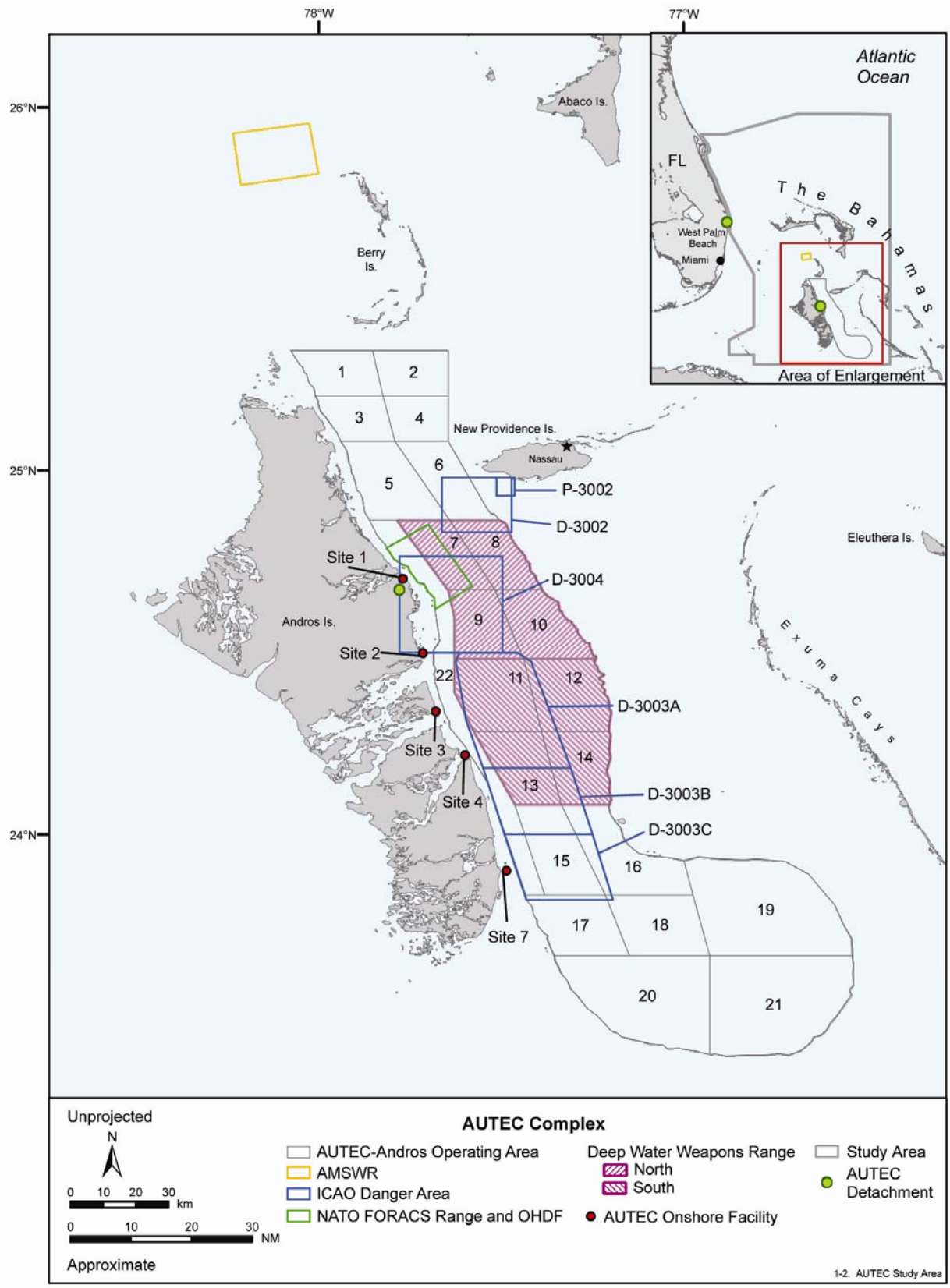

Figure 1-2. The AUTEC-Andros OPAREA and associated military attributes including the AMSWR. Source: Parsons (2006).

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.

The NEPA is a procedural law that directs all federal agencies to give appropriate consideration to the environmental effects of their decision-making. It requires federal agencies to prepare detailed environmental statements (e.g., Environmental Impact Statements) assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment. Section 102(2) of the NEPA contains "action-forcing" provisions that require federal agencies to act according to the letter and the spirit of the law.

Future studies and/or actions that require federal compliance which may utilize 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 established a moratorium on marine mammal "taking" in waters or on lands under U.S. jurisdiction. The MMPA defines taking as "harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill any marine mammal" (16 U.S. Code [U.S.C.] 1312[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 Levels 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). This can only be done when, after notice and opportunity for public comment, the Secretary: (1) determines that total takes during a five-year (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 marine mammal taking 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 Marine Protection, Research, and Sanctuaries Act (MPRSA), often referred to as the "Ocean Dumping Act," was also enacted in 1972, two days after passage of the MMPA. The MPRSA regulates the dumping of toxic materials beyond U.S. territorial waters and provides guidelines for the designation and regulation of marine sanctuaries. MPRSA Titles I and II prohibit persons or vessels subject to U.S. jurisdiction from transporting any material out of the U.S. for the purpose of dumping it into ocean waters without a permit. The term "dumping," however, does not include the intentional placement of devices in ocean waters or on the sea bottom when the placement occurs pursuant to an authorized federal or state program.

- The Coastal Zone Management Act (CZMA) of 1972 established a voluntary national program through which states can develop and implement coastal zone management plans (USFWS 2000a). The National Oceanic and Atmospheric Administration (NOAA), under the Secretary of Commerce, administers this act. States use coastal zone management plans "to manage and balance competing uses of and impacts to any coastal use or resource" (NOAA 2000). A coastal zone management plan must be given federal approval before the state can implement the plan (USFWS 2000a). The plan must include, among other things, defined boundaries of the coastal zone, identified uses of the area that the state will regulate, a list of mechanisms that will be employed to control the regulated uses, and guidelines for prioritizing the regulated uses. Currently, there are 33 U.S. states and territories with federally approved coastal zone management plans. These states and territories manage 82,880 NM (99.9%) of U.S. shoreline along the Atlantic, Pacific, and Arctic Oceans as well as the Great Lakes (NOAA 2003a).

  The CZMA also instituted a Federal Consistency requirement, which provides federal agencies with restrictions concerning their behavior in relation to state managed coastal zones. Federal agency actions that affect any land or water use or natural resource of the coastal zone (e.g., military operations, outer continental shelf lease sales, dredging projects) must be "consistent to the maximum extent practicable" with the enforceable policies of a state's coastal management program (Coastal Zone Act Reauthorization Amendments of 1990). The Federal Consistency requirement was enacted as a mechanism to address coastal effects, to ensure adequate federal consideration of state coastal management programs, and to avoid conflicts between states and federal agencies by fostering early consultation and coordination (NOAA 2000). Within each state's coastal management plan is a list of the federal agency activities for which Consistency Determinations must be prepared. Under certain circumstances, the President is authorized to exempt specific activities from the Federal Consistency requirement if they determine that the activities are in the paramount interest of the U.S.

- The Endangered Species Act (ESA) of 1973 established protection for and conservation of threatened and endangered species and the ecosystems upon which they depend. An "endangered" species is a species that is in danger of extinction throughout or within a significant portion of its range, while a "threatened" species is one that is likely to become endangered within the foreseeable future throughout or within 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 U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) 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. 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 2004a). 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 concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA (NMFS 2004a).

  A species may be a candidate for threatened or endangered status due to any of 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 USFWS and the NMFS 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 USFWS and the NMFS 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.

There are 34 marine mammal species, six sea turtle species, and numerous marine fish and invertebrate species with potential occurrences in the study area for the southeastern Florida and AUTEC-Andros OPAREA MRA. Seven marine mammals, all six sea turtles, and one fish species are listed as threatened or endangered under the ESA (Tables 3-1, 3-2, and 3-3). The NMFS has jurisdiction over cetaceans (whales and dolphins) and in-water sea turtles while the USFWS has jurisdiction over the West Indian manatee and nesting (on-land) sea turtles. The NMFS has sole jurisdiction over the smalltooth sawfish. The Minister of Agriculture and Fisheries of The Bahamas holds authority over species protected under Bahamian law, which includes all marine mammal and sea turtle species as well as the Bahamian blind cavefish.

- The Fishery Conservation and Management Act (FCMA) of 1976, later changed to the Magnuson Fishery Conservation and Management Act (MFCMA) in 1980, established a 200 NM fishery conservation zone in U.S. waters and a regional network of Fishery Management Councils (FMCs). The FMCs are comprised of federal and state officials, including the USFWS, which oversee fishing activities within the fishery management zone. The act and its later amendments through the 1980s established national standards (e.g., scientific information, allocations, efficiency, and cost/benefit) for fishery conservation and management. In 1977, the multifaceted regional management system began allocating harvesting rights, with priority given to domestic enterprises. Since a substantial portion of fishery resources in offshore waters was allocated for foreign harvest, these foreign allocations were eventually reduced as domestic fish harvesting and processing industries expanded under the domestic preference authorized by the MFCMA. At that time, exclusive federal management authority over U.S. domestic fisheries resources was vested in the NMFS.

  The authority to place observers on commercial fishing and processing vessels operating in specific geographic areas is also provided by the MFCMA. The data collected by the National Observer Program, which is overseen by the NMFS, is often the best means to obtain current data on the status of many fisheries. Without observers and observer programs, sufficient fisheries data for effective management would not exist. Observer programs also satisfy requirements of the ESA and MMPA by documenting incidental fisheries bycatch of federally protected species, such as marine mammals and sea turtles.

- In 1977, Congress addressed heightened concern over water pollution by amending the Federal Water Pollution Control Act (FWPCA) of 1948. The 1977 amendments, known as the Clean Water Act (CWA), extensively altered the FWPCA. For a synopsis of FWPCA initiatives prior to 1977, consult USFWS (2000b), which documents the history of the FWPCA since its origin.

  The CWA established the first step towards a comprehensive solution to the country's serious water pollution problems (EPA 2002). Through standards, technical tools, and financial assistance, the CWA aims to accomplish two goals: (1) to make U.S. waters fishable and swimmable and (2) to eliminate contaminant discharge into such waters. Under the authority of the Environmental Protection Agency (EPA), the act sets water quality standards for all pollutants, requires a permit for the discharge of pollutants from a point source, and funds sewage treatment plant construction (EPA 2002). Section 403 of the CWA sets out permit guidelines specific to the discharge of contaminants into the territorial sea, the contiguous zone, and waters further offshore (USFWS 2000b). The Chief of Engineers and the Secretary of the Army must approve discharges of dredged or fill material into all waters of the United States, including wetlands. In addition to regulating pollution in offshore waters, the CWA, under the amendment known as the Water Quality Act of 1987, also requires state and federal agencies to devise programs and management plans that aim to maintain the biological and chemical integrity of estuarine waters. In estuaries of national significance, the NOAA is permitted to conduct water quality research in order to evaluate state and federal management efforts. Sensitive estuarine habitats, such as seagrass beds and wetlands, are protected from pollution under this act.

- To protect undeveloped coastal barrier landforms, Congress passed the Coastal Barrier Resources Act (CBRA) in 1982. This statute created the John H. Chafee Coastal Barrier Resources System, which consists of various undeveloped coastal barriers, such as barrier islands, barrier spits, sea islands, tombolos, bay barriers (baymouth bars), and fringing mangroves. Any development on these

coastal barriers cannot receive new federal financial assistance unless it falls within one of the exceptions, such as fish and wildlife research and military activities essential to national security. The Secretary of the Interior maintains the set of maps that defines the system, which must be reevaluated at least every five years to determine if the coastal barrier boundaries should be altered.

The most significant amendment to the CBRA was the Coastal Barrier Improvement Act of 1990. This act added additional undeveloped coastal barriers to the system, altered the definition of "coastal barrier" to include more areas, such as the Florida Keys, and provided additional exemptions from the funding prohibitions (USFWS 2000c). Local and state governments and nonprofit conservation organizations can now voluntarily add lands in their possession to the system. The system now includes 5,150 km^2 of coastal barriers that cover 1,940 km of shoreline (USFWS 2000c).

- In addition to the CWA, the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 also regulates the discharge of contaminants into the ocean. 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 (NOAA 1998a).
- Passage of the Oil Pollution Act of 1990 further increased the protection of our nation's oceans. In addition to amending the CWA, this act also details new policies relating to oil spill prevention and cleanup methods. Any party that is responsible for a vessel, offshore facility, or deep water port that could potentially cause an oil spill must maintain proof of financial responsibility for potential damage and removal costs. The act details which parties are liable in a variety of oil spill circumstances and what damage and removal costs must be paid. The President has the authority to use the Oil Spill Liability Trust Fund to cover these costs when necessary. Any cost for which the fund is used must be in accordance with the National Contingency Plan, which is an oil and hazardous substance pollution prevention plan established by the CWA (USFWS 2000d). Federal, state, tribal, and foreign trustees must assess the natural resource damages that occur from oil spills in their trusteeships and develop plans to restore the damaged natural resources. The act also establishes the Interagency Coordinating Committee on Oil Pollution Research, whose purpose is to research and develop plans for natural resource restoration and oil spill prevention.
- During the reauthorization of the MPRSA in 1992, Title III of the MPRSA was designated the National Marine Sanctuaries Act. Title III authorizes the Secretary of Commerce to designate and manage areas of the marine environment with nationally significant aesthetic, ecological, historical, or recreational value as national marine sanctuaries. The primary objective of this law is to protect marine resources, such as coral reefs, sunken historical vessels, or unique habitats while facilitating all compatible public and private uses of these resources. National marine sanctuaries, similar to underwater parks, are managed according to management plans, prepared by the NOAA on a site-by-site basis. The NOAA is the agency responsible for administering the National Marine Sanctuary Program.
- In 1996, the MFCMA was reauthorized and amended as the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), known more popularly as the Sustainable Fisheries Act (SFA). The MSFCMA mandated numerous changes to the existing legislation designed to prevent overfishing, rebuild depleted fish stocks, minimize bycatch, enhance research, improve monitoring, and protect fish habitat. One of the most significant mandates in the MSFCMA is the essential fish habitat (EFH) provision, which provides the means by which to conserve fish habitat. The EFH mandate requires that the regional FMCs, through federal Fishery Management Plans (FMPs), describe and identify EFH for each federally managed species, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitats. Congress defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C.

1802[10]). The term "fish" is defined in the MSFCMA as "finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds." The regulations for implementing EFH clarify that "waters" include all aquatic areas and their biological, chemical, and physical properties, while "substrate" includes the associated biological communities that make these areas suitable fish habitats (CFR 50:600.10). Habitats used at any time during a species' life cycle (i.e., during at least one of its life stages) must be accounted for when describing and identifying EFH (NMFS 2002a).

Authority to implement the MSFCMA is given to the Secretary of Commerce through the NMFS. The MSFCMA requires that the EFH be identified and described for each federally managed species. The identification must include descriptive information on the geographic range of the EFH for all life stages, along with maps of the EFH for life stages over appropriate time and space scales. Habitat requirements must also be identified, described, and mapped for all life stages of each species. The NMFS and regional FMCs determine the species distributions by life stage and characterize associated habitats, including habitat areas of particular concern (HAPC). The MSFCMA requires federal agencies to consult with the NMFS on activities that may adversely affect EFH, or when the NMFS independently learns of a federal activity that may adversely affect EFH. The MSFCMA defines an adverse effect as "any impact which reduces quality and/or quantity of EFH [and] may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific or habitat wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR 600.810). For actions that affect a threatened or endangered species, its critical habitat, and its EFH, federal agencies must initiate ESA and EFH consultations.

Effective January 20, 2002, the EFH Final Rule was authorized, simplifying EFH regulations (NMFS 2002a). Significant changes delineated in the EFH Final Rule included: (1) clearer standards for identifying and describing EFH, including the geographic boundaries and a map of the EFH; (2) guidance for the FMCs regarding distinguishing EFH from other habitats; (3) further guidance for the FMCs on evaluating the impact of fishing activities on EFH; (4) clearer standards for deciding when FMCs should act to minimize adverse impacts on EFH; and (5) clarification and reinforcement of the EFH consultation procedures (NMFS 2002a). NMFS (2002a) describes the process by which federal agencies can integrate MSFCMA EFH consultations with ESA Section 7 consultations

- The Marine Turtle Conservation Act of 2004 was enacted to assist in the international conservation efforts for marine turtles. The Act established a fund to support conservation of nesting populations and beaches in foreign countries (USFWS 2006a). This fund, administered by the U.S. Fish and Wildlife Service (USFWS), provides financial assistance for projects conserving nesting habitats and marine turtles in such habitats, as well as addressing threats to the survival of marine turtles (USFWS 2006b). The Act also aims to promote international partnerships between governments, non-governmental organizations, and the private sector for successful marine turtle conservation (USFWS 2006a). Creation of the Act was driven by the world-wide decline of marine turtles and the recognition of the life history parameters, illegal international trade, and loss of nesting habitat that present a significant challenge for recovery (USFWS 2006a).
- The Final Governing Standards (FGS) for Environmental Protection by U.S. Forces in Andros Island implement Department of Defense (DoD) Directive 6050.16 and supplement Executive Order 12088 and serve as a single, complete source of information on environmental protection practices that U.S. forces must comply with at Andros Island (DoN 1994). These FGS are based primarily on the accepted standards for DoD installations and activities in the U.S. but also consider U.S. obligations in Andros Island as well as local policies and enforcement practices. These FGS are relevant to all installations, facilities, and activities in Andros Island; however they do not apply to operations of U.S. Navy vessels or U.S. military aircraft that operate in accordance with other DoD policies and directives as well as other international agreements.

1.3.2 Executive Orders

- Executive Order 12114 on Environmental Effects Abroad of Major Federal Actions was passed 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 Executive Order 12114, federal

agencies that engage in major actions that significantly affect a non-U.S. environment must prepare an environmental assessment of the action's effects on that environment. This is similar to an environmental impact statement (EIS) or environmental assessment (EA) developed under the NEPA for environments in the U.S. 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.

- Executive Order 12962 on Recreational Fisheries was enacted in 1995 to ensure that federal agencies strive to improve the "quantity, function, sustainable productivity, and distribution of U.S. aquatic resources" so that recreational fishing opportunities nationwide can increase. The overarching goal of this order is to promote the conservation, restoration, and enhancement of aquatic systems and fish populations by increasing fishing access, education and outreach, and multi-agency partnerships. The National Recreational Fisheries Coordination Council (NRFCC), co-chaired by the Secretaries of the Interior and Commerce, is charged with overseeing federal actions and programs that are mandated by this order. The specific duties of the NRFCC include: (1) ensuring that the social and economic values of healthy aquatic systems, which support recreational fisheries, are fully considered by federal agencies; (2) reducing duplicative and cost-inefficient efforts among federal agencies; and (3) disseminating the latest information and technologies to assist in the conservation and management of recreational fisheries (U.S. Office of the President 1995).

  In June 1996, the NRFCC developed a comprehensive Recreational Fishery Resources Conservation Plan (RFRCP) specifying what member agencies would do to achieve the order's goals. In addition to defining federal agency actions, the plan also ensures agency accountability and provides a comprehensive mechanism to evaluate achievements. A major outcome of the RFRCP has been the increased utilization of artificial reefs to better manage recreational fishing stocks in U.S. waters (NMFS 1999a).

- Executive Order 13089 on Coral Reef Protection 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." The executive order 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, co-chaired by the Secretary of the Interior and the Secretary of Commerce through the Administrator of the NOAA.

- Executive Order 13158, Marine Protected Areas, of 2000 is a furtherance of Executive Order 13089. It created the framework for a national system of marine protected areas (MPAs). MPAs are defined in Executive Order 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." This executive order strengthened governmental interagency cooperation in protecting the marine environment. It also calls for strengthening management of these existing areas, creating new ones, and preventing harm to marine ecosystems by federally approved, conducted, or funded activities (Agardy 2000). Currently, the NOAA is redefining the criteria used to designate MPAs and has recently reclassified all existing MPAs as "marine managed areas." A more in-depth discussion on the NOAA's process of redefining MPAs is included in Chapter 6.

1.4 METHODOLOGY

1.4.1 Literature and Data Search

Extensive and systematic searches for relevant scientific literature and data were conducted. Once information vital to the production of this MRA report was identified, the materials, data, or literature were obtained, reviewed, and catalogued. Of the available scientific literature (both published and unpublished), the following types of documents were utilized in the assessment: journals, books, periodicals, bulletins, monographs of scientific and professional societies, theses, dissertations, project reports, endangered species recovery plans, stock assessment reports, EISs, FMPs, and other technical

reports published by government agencies, private businesses, or consulting firms. The scientific literature was also consulted during the search for geographic locational data (geospatial or geographic coordinates) on the occurrence of marine resources within the study area.

Information to investigate the physical environment, to summarize the occurrence patterns of marine mammals and sea turtles; to determine the locations of benthic communities, artificial habitats, and EFH, and to ascertain the distribution of maritime boundaries, shipping routes, marine managed areas, and diving sites was collected from the following sources:

- Academic and educational/research institutions (College of William and Mary; Duke University; Florida Fish and Wildlife Conservation Commission; Los Angeles County Museum; Maury Oceanographic Office Library, Naval Oceanographic Office; New England Aquarium; Nova Southeastern University; Old Dominion University; Scripps Institute of Oceanography; Texas A&M University; Texas A&M University at Galveston; University of Rhode Island; University of Southern Florida-Institute of Marine Remote Sensing; and Virginia Institute of Marine Science);
- University on-line databases (Oceanic Abstracts, Aquatic Sciences and Fisheries Abstracts, Life Science Collection, Zoological Record Online, National Technical Information Service, and BIOSIS Previews, Web of Science, Environmental Science and Pollution Management, GeoRef, GeoScience World, and Cambridge Abstracts);
- The Internet, including various databases and related websites (National Oceanic and Atmospheric Administration [NOAA]-Coastal Services Center; the NMFS; Ocean Biogeographic Information System [OBIS]; Ocean Planning Information System [OPIS]; U.S. Geological Survey [USGS]; Department of State [DoS]; Department of Transportation [DoT]; Mid-Atlantic Fishery Management Council [MAFMC]; South Atlantic Fishery Management Council [SAFMC]; Gulf of Mexico Fishery Management Council [GMFMC]; United Nations Division for Ocean Affairs and the Law of the Sea [DOALOS]; National Geophysical Data Center; Elsevier Press; Bahamas National Trust; WhaleNet; Library of Congress; Blackwell-Science; FishBase; ReefBase; World Database on Protected Areas; United Nations Food and Agriculture Organization; National Aeronautic and Space Administstration [NASA] Jet Propulsion Laboratory; NASA Goddard Space Flight Center; Federal Register; University of Miami Rosenstiel School of Marine and Atmospheric Science; and Proceedings of the Annual Sea Turtle Symposium);
- Marine resource experts and specialists; and
- Federal agencies (DoN; Minerals Management Service [MMS]; Library of Congress; NASA; SAFMC, GMFMC; ASMFC [Atlantic States Marine Fisheries Commission]; the NMFS [Highly Migratory Species Division, National Marine Mammal Laboratory, Southeast Fisheries Science Center {NMFS-SEFSC}, Southeast Regional Office, Office of Protected Resources]; NOAA [Marine Managed Areas Inventory, National Ocean Service, Coral Reef Information System, Coastal Services Center]; USFWS Ecological Services Field Offices; USGS, Bureau of Land Management (BLM), and other state/regional agencies.

1.4.2 Spatial Data Representation—Geographic Information System

The geographical representation of marine resource occurrences in the study area and vicinity is a major constituent of this MRA report. The marine resources data and information 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 and reliability. The spatial or geographical component that was common to all datasets allowed the widely dissimilar data to be synthesized and visualized in a meaningful manner. Without this common data characteristic, graphical display of such disparate data would have been difficult, if not impossible, to achieve.

The ability to display and analyze multiple data themes or layers simultaneously is one of the advantages to using a geographic information system (GIS) rather than other graphic software. A GIS software system was used to store, manipulate, analyze, and display the spatial data and information accumulated for the study area. For this project, Environmental Systems Research Institute, Inc.'s (ESRI) ArcView® (versions 8.3 and 9.1) software was chosen due to its widespread use, ease of operation, and sophisticated analytical tools. Customizations were made to the software in ESRI's ArcObjects™

proprietary language, to automate the more repetitive map-making tasks and the processing and analysis of large volumes of data.

The geographic locations of important marine resources in the 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 files (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 georeferenced, 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 georeferenced 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 (or in a table referenced in the map caption but located elsewhere in the report). The full reference citations for map source data or information may be found in the Literature Cited section of each MRA chapter or section. The two primary types of spatial information used in this MRA were coordinate data and scanned maps. These two source types are associated with differing levels of data reliability or confidence (Appendix A-1). Numerical or authentic data are associated with the highest level of reliability while data obtained by scanning source maps are less reliable.

Source data were not in a standard format, nor was a standard naming convention followed for species names, and some datasets 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 the 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 often accompanied the original data. The codes or names used to identify species were not always consistent from one dataset 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. 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. Throughout the project, data imported into ArcView® had to be maintained in the most universal, least transformed manner in order to avoid conflict between theme coordinate systems and projections. In the GIS, the most flexible spatial data format is the unprojected geographic coordinate system, which uses decimal-degree latitude and longitude coordinates (Appendix A-2). The decimal-degree format is the only coordinate system format that allows unlimited, temporary, custom projection and re-projection in ArcView® and is therefore the least restrictive spatial data format. The printed maps and electronic GIS map 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 should be selected when using 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 km and NM. The majority of maps in this report are presented in one of two formats: a portrait display that includes a full-page map, and a landscape display that includes a combination of four seasonal map displays or two seasonal map displays on a single page. Maps of each display type are presented at the same approximate scale; the full-page portrait maps are at the approximate scale of 1:3,896,844, the landscape maps are at the approximate scale of 1:5,604,903.

1.4.2.1 Maps of the Physical Environment—Oceanography

- *Bathymetry*—The bathymetry data used in this MRA represent three levels of sampling resolution. Raster depth data, usually shallower than 200 m, from NOAA's (2001) National Geophysical Data Center were sampled at three arc-second resolution and extracted at 15 arc-second resolution to obtain a smaller and more usable file size. The Smith and Sandwell (1997) data (depths deeper than 200 m) were sampled and extracted at two arc-minute resolution. NAVO (2006) data for the Bahamian region were extracted at 30 arc-second resolution. Combining datasets sampled as such differing resolutions was a challenge. Each bathymetry data value contains a depth value in meters for a spatial location. The arc-second and arc-minute units of measure represent the distance between the data points or the resolution at which the data were sampled; this resolution directly impacts the accuracy of the bathymetry data (Figure 1-3). The NOAA and NAVO data are much higher resolution data and are therefore more accurate as the distance between each data point is much smaller. This consideration should be taken into account before any of the individual bathymetry data are used in processing or display.

  The individual bathymetry datasets were merged, and the resulting highly detailed vector bathymetry or depth contours (isobaths) were prepared from a continuous surface with contour intervals of 10 m for depths shallower than 200 m while depths deeper than 200 m were contoured at 100 m intervals. Selected isobaths from the resulting two-dimensional contours are shown on the bathymetry figures and on various maps throughout the MRA report.

  To illustrate the three-dimensional (3D) bathymetry of the study area, triangular irregular networks (TINs), which interpolate intermediate data values between original data points, were created in the ArcView® 3D Analyst extension using the combined bathymetry data. For this process, the NOAA (2001a) and NAVO (2006) datasets were extracted at 15 and 30 arc-second resolutions, respectively. These data were then combined with the lower resolution Smith and Sandwell (1997) bathymetry data to create the TIN. The TIN was added to the ArcView® 8.3 ArcScene™ extension to achieve the full 3D display (see Figure 2-1). The TIN was then converted to a grid form (see Figures 2-3 and 2-4) in order to achieve a smaller or more manageable file size and allow the data to be displayed more rapidly. The TINs were added to the ArcView® 8.3 ArcScene™ extension to achieve the full 3D display (see Figure 2-1). ArcScene® allows the 3D display to be manipulated (rotated and tilted). The most authentic display was exported directly from an ArcScene® view as a graphic file so that the colors and details could be refined in Adobe® Photoshop®. The graphic file was imported into ArcView to prepare the map layout.

- *True Continental Shelf Break*—The continental shelf break, defined as an abrupt increase in the sea floor gradient marking the transition between the continental shelf and the continental slope, is a feature on nearly every map in this MRA. The method used for mapping the true shelf break utilized high-resolution (three arc-second) bathymetry data available from the NOAA for U.S. shelf waters, published information on the seaward gradients of the continental shelf, slope, and the shelf break in the study area, and analyses completed in the GIS environment (ArcView® version 8.3) to map the true shelf break as a line feature. Thus, the shelf break line presented on the map figures in this report represents the actual geographic area where the seafloor gradient changes from the shallow gradient found on the continental shelf to the steeper gradient found on the continental slope. The bottom depths this line represents range from ~10 to 120 m and the gradient at which the shelf break occurs is 0.94° throughout most of the study area but transitions to 1.9° north of West Palm Beach, FL. This calculation is based primarily on an analysis of the bathymetry data and is corroborated with published bathymetry maps depicting the shelf break (Emery and Uchupi 1972).

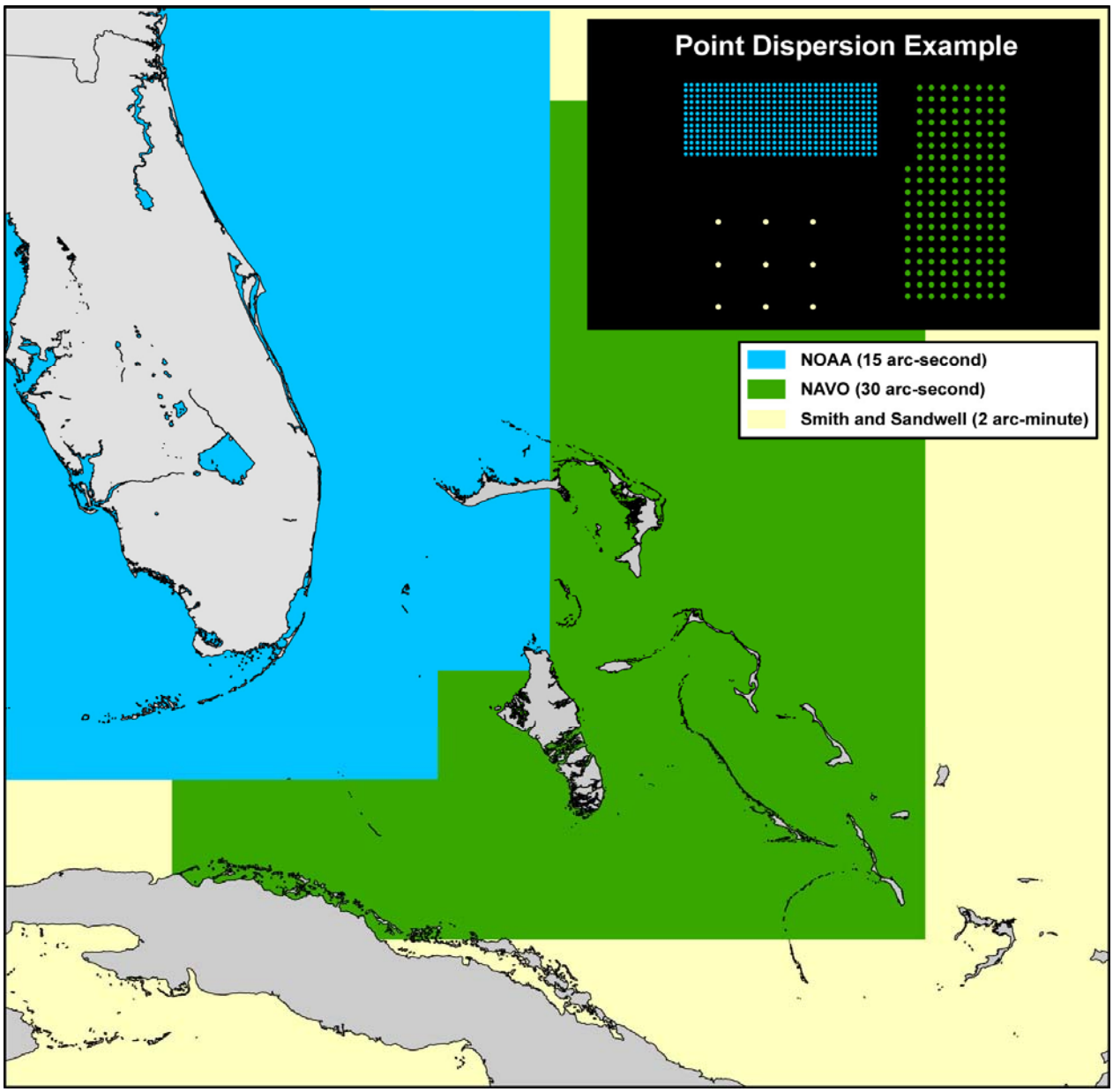

Figure 1-3. Spatial coverage in the study area of the three bathymetric datasets used in this MRA, the resolution of each dataset, and a scale model example of the spatial distribution of the bathymetry data points associated with each dataset. All three datasets had to be merged to develop a comprehensive bathymetry surface for the study area.

Using ArcView® GIS software, the bathymetry data for the shelf and slope provinces of the U.S. Atlantic east coast, including the relatively small area located in the study area, were processed to display gradients in units of degrees instead of the familiar measure of depth in meters. Bathymetry data were overlain onto a grid of cells that covered the shelf and slope provinces of the study area. Gradient values were calculated for all grid cells with the 3D Analyst extension of ArcView®, which uses a nearest neighbor method and calculates the gradient value for the center cell in each 3 x 3 sub-grid of cells. All areas where gradient values were equal to or greater than the shelf break gradient for each geographic region were highlighted. A continuous line was drawn along the shoreward border of the highlighted regions, ignoring isolated topographic features that were clearly

on the shelf. The resulting line was smoothed using the β-spline algorithm in the GIS environment to produce a geographic representation of the true shelf break.

- *Bottom Substrate*—Bottom sediments and hard bottom substrate in the study area and vicinity were mapped using a combination of sources including geo-referenced digital data available from NOAA and published geologic maps from multiple sources that required conversion to an electronic format (i.e., scanning). In general, the more modern, digital data were available for U.S. waters and the older, scanned maps were required to map bottom substrate in the Bahamas. Furthermore, the precision of the scanned maps was not as fine as the digital data with regard to spatial representation and classification of sediment types (Emery and Uchupi 1972). For example, the primary source for sediment data in Bahamian waters does not distinguish between the secondary sediment types (e.g., sandy clay and silty clay), so several hybrid sediment types (e.g., sandy-silty/clay) were used in order to map these areas and to distinguish them from the areas of more precise data. In places of overlap between digital and scanned data, the digital data were given preference.

- *Sea Surface Temperature and Seasonal Delineation*—Maps of sea surface temperature (SST) were created from data available through the Physical Oceanography Distributed Active Archive Center (PODAAC) that is sponsored jointly by the NASA and the NOAA. SST data were compiled from weekly averaged Advanced Very High-resolution Radiometer (AVHRR), version 5.0, satellite data, which contain multi-channel sea surface temperature pixel data (NASA 2000).

  Data for the study area were collected from 1985 to 2004; these data were extracted from the global dataset and the pixel values were converted to SST values using the following function:

$$\text{SST } (^\circ\text{C}) = (0.075 * \text{DN}) - 3.0 \qquad \text{(Equation 1)}$$

  where DN = pixel value. The analysis was performed using a custom application developed with the MATLAB® software package.

  Day and night SST values with a quality rating of 4 or greater were averaged (on a data quality scale of 1 to 7 where 1 is the most influenced by atmospheric conditions and 7 is the least). The data were parsed into seasons by calculating a mean SST value for a region representing the majority of the study area and plotting the annual change in the mean SST for the region. A fifth-order polynomial curve was fit to the data, and a slope analysis technique was applied to the polynomial curve to divide the calendar year into four seasons based on changes in the SST. Winter and summer are defined as the time periods when the change in SST is less than the median change, and winter is distinguished from summer by comparing the SST of each sampled point against the median SST of all sampled points (i.e., the SST of days (points) in winter will be less than the median SST, and the SST of days in summer will be greater than the median SST). Spring and fall are defined as the time periods when the change in SST is greater than the median change, and spring is distinguished from fall by comparing the sign of the change between each sampled point on the curve (i.e., in spring the SST is increasing and in fall the SST is decreasing; so the sign of a value in spring is positive and the sign of a value in fall is negative).

  The grid-cell size for the seasonal SST data was 4 x 4 km. In the GIS environment, the range of SST values for the study area were associated with a color spectrum grading from blue to red that represents cooler to warmer surface water temperatures (in °C), respectively. All seasonal SST map images reference the identical color bar; the SST image used to depict surface currents in the study area references a version of the color bar that is scaled to highlight the surface circulation.

  The resulting seasons that are used throughout this report are defined as winter (14 December through 5 April), spring (6 April through 14 July), summer (15 July through 24 September), and fall (25 September through 13 December). Although the dates each of the seasons represents may be different than the standard seasonal definitions, the intuitive meaning for each of the seasons still applies. That is, winter and summer are still the times of year with the lowest and highest temperatures, respectively, while spring and fall represent transitional periods between the two temperature extremes.

- *Chlorophyll a Concentrations*—Seasonal averages of chlorophyll *a* concentrations were compiled from monthly averaged Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data to provide a proxy for primary productivity in the study area (NASA 2003). Pixel data for the study area and vicinity from 1997 to 2005 were extracted and converted to chlorophyll *a* values using MATLAB® and the following function:

$$\text{Chlorophyll } a \text{ (mg/m}^3\text{)} = 10^{(DN * 0.015) - 2.0} \qquad \text{(Equation 2)}$$

  where DN is the pixel value.

  The chlorophyll data were parsed into seasons, converted to grid cell sizes of 9 x 9 km, and interpolated down to 4 x 4 km grid cell sizes to produce a smooth image. The seasonal range of chlorophyll *a* concentrations (in mg/m^3) is visualized in the MRA map figures as a color spectrum with chlorophyll *a* concentrations increasing from blue to red.

1.4.2.2 Biological Resource Maps—Protected Species

- *Fishes*—Two endangered fish species, the Bahamas blind cave fish (*Lucifuga spelaeotes*)and the smalltooth sawfish (*Pristis pectinata*), occur within the study area. No data are available on the occurrences of the Bahamas blind cave fish in the region. Critical habitat for the smalltooth sawfish has not been designated; however, to provide an accurate depiction of where this species may be encountered within the study area, recent sighting locations were plotted using data extracted from the sawfish database compiled and maintained by Mote Marine Laboratory (MML 2005a).

- *Corals*—Data from three sources were used to plot the distribution of endangered coral species in the study area. Acroporid coral distribution data were scanned from the Acroporid Biological Review Team Report and were used as an estimate of the potential range of Acroporids in the Bahamas (ABRT 2005). Non-species specific coral occurrence information was acquired from satellite remotely sensed data received as GIS shapefiles from The Institute for Marine Remote Sensing's (IMaRSs) Millennium Coral Reef Mapping Project at the University of Southern Florida (USF 2005a). These data provided a recent assessment of the distribution of all coral in the study area. Point coordinates identifying *in situ* observations of elkhorn and staghorn coral were acquired from the Atlantic and Gulf rapid reef assessment (AGRRA) surveys and added to the final map (Kramer et al. 2003a).

  The IMaRS shapefiles of non-species specific coral occurrences in the Bahamas were used as the base layer for the map. The ABRT (2005) data were then merged with the IMaRS data, which represent the most recent and accurate observations of coal occurrence in the Bahamas. Regions where the ABRT data coincided with the IMARS data are shaded red on the map and represent the distribution of Acroporids in the Bahamas. Lastly, point locations were added to identify known occurrences of elkhorn and staghorn coral in the Bahamas as obtained from the AGRRA surveys.

- *Marine Mammals and Sea Turtles*—Marine mammal and sea turtle occurrence data were accumulated from available sources with the focus on obtaining comprehensive datasets for the study area. An overview of all existing marine mammal and sea turtle research efforts is found in Appendix A-3. The marine mammal and sea turtle data analyzed and included in this MRA are listed in Appendix A-3 and Table A-1. Occurrence datasets analyzed for this MRA include aerial and shipboard sighting surveys, incidental fisheries bycatch, opportunistic sightings, stranding records, and sea turtle nests. In addition to data provided by various government agencies and academic institutions, miscellaneous sighting data available from the scientific literature were also used in this MRA. These data were vital to the determination of seasonal occurrence patterns for the protected marine mammal and sea turtle species known to inhabit the waters of the study area.

  When working with the marine mammal and sea turtle data, several assumptions were made. First, it was assumed that the species identifications given in the original datasets were correct. This assumption was necessary since the reliability of species identifications from one dataset to the next was not always known. For the sake of consistency, reliability of species identification was not considered for the analysis of any marine mammal or sea turtle data but potential misidentifications are mentioned in the text associated with each protected species.

  Although it was assumed that the species identifications were correct, it could not always be assumed that the geographic coordinates given in any dataset were correct. Problems were often encountered

when the original data coordinates were plotted and animals were shown to occur in unexpected locations. This was especially true of the stranding data. For example, the geographic coordinates of several strandings indicated that they occurred well out to sea or far inland. In such cases, the stranding record was verified for accuracy (since some 'strandings' are of individuals floating in the water) and then moved as close to the original geographic description as possible. If a stranding record could not be verified as accurate and was too far offshore or inland to estimate a likely shore position, it was deleted.

In conjunction with regional experts, areas of occurrence were estimated for marine mammal and sea turtle species known to occur in the study area. These areas of occurrence are based upon expert opinion (i.e., regional or local knowledge of the marine mammals or sea turtles gained from many years of survey experience in the area); known habitat preferences and life history patterns (e.g., migration if applicable); distribution patterns of the species; and available sighting, stranding, bycatch, tagging, and in the case of turtles, nest data. Where possible, quantification of occurrence records associated with each occurrence level was employed but this was not uniformly possible as so few occurrence records exist for large portions of the study area where sighting surveys are totally lacking (see Figure 7-1).

Five levels of occurrence were derived for each sea turtle or marine mammal species. A common occurrence is the most abundant occurrence category and refers to a species that regularly or frequently occurs in an area (or its appropriate habitat) and is usually observed, even if only in a specific season. A species that occurs commonly will optimally be associated with 50 or more occurrence records for a season or region. The present occurrence level in an intermediate category that is applicable to a species found in an area or in a specific season, even though it may not always be observed; when possible, this occurrence level is associated with five or more occurrence records. The rare occurrence level is the least abundant category and connotes a species that occurs only infrequently and may not occur in an area or season with regularity. The rare category is related to those species for which, at best, one to five occurrence records exist. An undetermined occurrence is assigned to those areas where insufficient information or data are available to make an accurate occurrence determination. The not expected occurrence is assigned to regions where occurrence of a species or species group is exceedingly unlikely but not beyond a reasonable possibility; this categorization is based on known habitat preferences or instances where survey effort has occurred with no resulting species observations having been documented.

A high number of sightings indicate nothing about the number of individuals in a given area. For example, a sighting of a dolphin species might involve a small group of animals or a very large group (>1,000) of individuals. The amount of detailed information regarding group size varied across datasets, but when available, especially for a species with very few sightings, could provide very useful information on anticipated occurrence in the study area.

As a supplement to the occurrence maps for certain species, satellite-tracking maps were generated from data and information collected by individuals or groups conducting research in the study area. These satellite-tracking maps were created from coordinate data as well as scannable maps, when coordinate data were not available. When coordinate data were available, the method suggested by Reid (1997) was followed where only satellite-tag coordinates with location classes (LC) of 1 (accurate to within 1 km), 2 (accurate to within 350 m), and 3 (accurate to within 150 m) were plotted. The scanned maps used in the creation of map figures detailing sea turtle movements had no accompanying information on the accuracy of each satellite-tag reading. Therefore, these maps are presented as they occurred in the original authors' work.

1.4.2.3 Biological Resource Maps—Habitats of Concern

Satellite imagery is being used to map coral reefs throughout the world due to the lower cost of global high-resolution imagery compared to field surveys and data collections, which rely on on-site surveys of relatively small geographic areas. SCUBA survey work is labor intensive and site specific, whereas satellite imagery is nearly instantaneous and covers expansive geographic areas. Various satellites (Land Satellite Thematic Mapper, Satellite Probatoire d' Observation de la Terre High Resolution Visual Imaging, and Indian Remote Sensing) provide worldwide multispectral imagery for coral reef mapping. These satellite data are accessible to researchers throughout the world via coral reef monitoring websites

(i.e., Reefbase; www.reefbase.org) (Andréfouët et al. 2001). The use of satellite imagery has enabled scientists to map coral reefs at various water depths and monitor coral bleaching globally. The Institute for Marine Remote Sensing (IMaRS) Millennium Coral Reef Mapping Project, University of Southern Florida, with funding through NASA's Oceanography Program, is creating a worldwide inventory of coral reefs using satellite imagery accessible through the organization's Reefbase website (USF 2005b). Coral reef data depicted in several Chapter 4 maps were based on satellite-derived data acquired from Reefbase and IMaRS.

The spatial extent of seagrass communities in the study area was developed from seagrass data available online from the United Nations Environment Programme. Areas of seagrass coverage within the study area were copied digitally, saved as a jpeg file, and then rectified within ArcMap®. GIS shapefiles were digitized from these images and then checked against the original source for accuracy."

1.4.2.4 Biological Resource Maps—Essential Fish Habitat

Mapping EFH and habitat areas of particular concern (HAPC) was quite challenging, since designations for managed species in the U.S. waters of the study area are under the jurisdiction of two fishery management councils (FMCs) and one federal agency: the Mid-Atlantic Fishery Management Council (MAFMC), SAFMC, and the NMFS, respectively. Furthermore, most of the EFH designations developed by the SAFMC required interpretation of the original EFH designations. Any interpretations of EFH designations, necessitated for clarity, are clearly stated in the text description of the EFH or on the map depicting that EFH extent.

EFH designated outside the study area for this MRA were depicted only when data were available in a usable electronic format. Complete EFH text designations are provided in Chapter 5 and should be consulted for areas outside the boundaries of the study area. The EFH species maps do not include seasonal designations as the FMPs presented the EFH information according to life history stages.

EFH designations can include the entire water column or a subsection of the water column or the seafloor (e.g., benthic, surface, or from depths of 50 to 250 m). The part of the marine environment where EFH is designated has been included in parentheses after the lifestage category on all EFH map figures. If no environmental partition is indicated after the lifestage, then EFH is designated for the entire water column and seafloor.

- Subtropical-Tropical Species: MAFMC Designations—To create a more uniform graphical (visual) format for the gridded EFH data for the bluefish prepared by the MAFMC, each of the EFH source maps for each lifestage of the bluefish were scanned and geo-referenced (Note: Only the bluefish has designations by the MAFMC in this MRA). A 10-minute grid was created and overlain on each scanned image in ArcView® to replicate the FMC grids. Grid blocks that corresponded to EFH grid blocks on the scanned source maps were then selected and exported into new GIS shapefiles and merged together. The merged grid blocks were then buffered 10 NM on all sides to create a smoother shape without compromising the spatial integrity. The processed grids were then converted into coverages, which were splined in ESRI ArcEdit®. Several splining iterations were done with various grain tolerances (0.15, 0.01, and 0.001). The coverages were then cleaned and converted to GIS shapefiles before being added to the EFH map of the bluefish included in Appendix D.

  The bluefish EFH designation defines EFH as extending from shore to the eastern wall of the Gulf Stream through Key West, FL. The Gulf Stream is part of a larger current system known of the Gulf Stream System, which includes not only the Gulf Stream but also the Florida Current. Although the MAFMC only designated the Gulf Stream as EFH, their designation extends to the Florida Keys, adjacent to the Florida Current, not the Gulf Stream as designated in the MAFMC text designation. After requests to the MAFMC for clarification did not result in further elucidation, an interpretation was made regarding the intent of the EFH designation. The interpretation included the Gulf Stream System (i.e., Florida Current) to Key West, FL. Therefore, the Florida Current was included and mapped as EFH for this species (Leaman et al. 1989).

- Subtropical-Tropical Species: SAFMC Designations—The EFH and HAPC designations for the subtropical-tropical species prepared by the SAFMC presented numerous issues. Only written descriptions of EFH/HAPC were available from the SAFMC, so map figures had to be created using

the SAFMC text designations (SAFMC 1998) or information from the NMFS EFH Mandate (NMFS 2002a). Contrary to the rules authorized by the SFA that were in place in 1998, the SAFMC designated EFH and HAPC by management unit (MU) rather than by individual species. It was only with the 2002 EFH Final Rule that FMCs were allowed to designate EFH/HAPC by MU rather than as individual species. As a result of this inconsistency, the NMFS was required to interpret the SAFMC's FMPs and provide guidelines, in the form of a mandate, to the delineation of EFH/HAPC for individual species in order to conduct EFH consultations for federal actions (NMFS 2002a). Due to these difficulties regarding the EFH/HAPC designations by the SAFMC, Dr. Ric Ruebsamen, EFH Coordinator for the NMFS Southeast Region, was repeatedly consulted to provide guidance on the EFH and HAPC interpretations derived for species within the SAFMC jurisdiction.

Not all SAFMC-managed species have designated EFH. Only those species for which sufficient species-specific information is available have designated EFH. For example, only 18 of the 73 members of the snapper-grouper MU have EFH designated (designations result not from the FMP but from the NMFS Mandate [NMFS 2002a]). In many instances, information used to designate EFH for individual species in the NMFS Mandate was obtained from life history information provided in the FMP, as no EFH designations had been derived for the individual species. Since the NMFS Mandate only provided a summary and not specific details of EFH requirements for the 18 designated species in the snapper-grouper MU, information from both the NMFS Mandate and the life history sections of the SAFMC's FMPs were used to accurately derive EFH/HAPC text descriptions and map depictions for those species in the snapper-grouper MU that, according to the NMFS Mandate, should have individual species EFH designations.

The following criteria and assumptions were used to accurately map EFH and HAPC for species managed by the SAFMC:

- *All Lifestages EFH and HAPC*—If the EFH or HAPC designation/interpretation did not specify to which lifestage it applies, then the designation was assumed to apply to all lifestages. Furthermore, for species with either EFH or HAPC designated as "All Lifestages," no specification is given as to which part of the habitat (e.g., part of water column or benthos) this designation encompasses because the lifestages may each utilize different habitats (i.e., eggs maybe pelagic while adults are benthic).

- *Artificial Reefs*—The National Fishing Enhancement Act of 1984 (Title II of public law 98-623) defines artificial reefs as a structure that is constructed or placed in water for the purpose of enhancing fishery resources and commercial as well as recreational fishing opportunities. Based on this definition, the SAFMC (1998) defines artificial reefs as any area within marine waters in which suitable structures or materials have intentionally been placed for the purpose of creating, restoring, or improving the long-term habitat for the eventual exploitation, conservation, or preservation of the resulting marine ecosystems that are naturally established on these materials. Therefore, no other types of artificial habitats are included as EFH in the map depictions of a species habitat unless they are specifically designated as EFH. Thus, shipwrecks will not be included on a map figure for a species for which the EFH has only been designated for artificial reefs.

  All structures and materials associated with an individual artificial reef are depicted on the map figures. Many artificial reefs consist of multiple groupings of materials, which are mapped by their individual locations as these locations are not always in direct close proximity to one another.

- *Bathymetry*—In order to depict EFH designations that extend from one depth to another (e.g., from 50 to 155 m), bathymetry data were contoured into isobaths at varying intervals. Water depths less than 200 m were contoured at 10-m intervals while those deeper than 200 m could only be contoured at 100-m intervals due to the lower resolution of the available bathymetry data. Thus, depths used in the depiction of EFH were rounded to the nearest contour interval.

- *Corals*—No lifestages were given in either the SAFMC EFH designations for coral, so EFH was assumed to be designated for all lifestages of coral in both jurisdictions. Although several types of coral have EFH designated by the SAFMC, coral EFH is depicted as one area off south Florida as the areal extents of the EFH designations were congruent.

- *Exclusive Economic Zone*—EFH and HAPC are only defined in federal waters, so the exclusive economic zone (EEZ) is often used as a boundary for these designations (GDAIS 2005).
- *Floating Debris*—Although designated as EFH for the juvenile lifestage of the greater amberjack, the unpredictable and arbitrary locations where floating debris may be found in the marine environment made this "habitat" impossible to depict on a map figure.
- *Golden Deepsea Crab*—The SAFMC partially based its EFH designation (1998) for the golden deepsea crab on seven continental slope habitats identified by Wenner and Barans (1990). Since the SAFMC's EFH designations did not specify the areal extent in which these habitats were located on the continental slope and the EFH designation generically encompasses the continental slope, the EFH for all lifestages of this species was depicted as the entire continental slope outward to the EEZ in the study area. The areal extent of the continental slope was roughly estimated for mapping purposes, with the seaward boundary of the slope being predicted from 100-m isobath contours. Additionally, the EFH designation says that EFH extends from "eastern U.S. from the Chesapeake Bay to the Florida Straits (and into the GOMEX)." Under the advice of the SAFMC, the EFH should extend at least through the Dry Tortugas (Pugliese personal communication 2005).
- *Gulf Stream Current*—The Gulf Stream is designated as EFH for numerous species in the study area (snappers-groupers, coastal migratory pelagic species, dolphin-fishes, and wahoo). The Gulf Stream is a dynamic oceanographic feature whose path and boundaries vary temporally and spatially. The SAFMC defines the southern boundary of the Gulf Stream as Cape Canaveral, Florida (SAFMC 1998).
- *Nearshore Areas*—As defined by the SAFMC, nearshore areas are all state waters extending form estuaries to three nautical miles from shore (Brouwer personal communication 2005a). These nearshore areas are not within the study area boundary and therefore, no EFH or HAPC designations for these areas are included on the map figures integrated in this report.
- *Sargassum*—Although EFH and HAPC were originally designated by the SAFMC for benthic and pelagic *Sargassum* species, the NMFS did not approve the designations due to the potential broad and nonspecific range these species encompass, particularly the pelagic species (NMFS 2003a; Ruebsamen personal communication 2005a). However, pelagic *Sargassum* was approved as EFH or HAPC for other managed species (e.g., snapper-grouper MU and tilefish) (NMFS 2002a; Ruebsamen personal communication 2004). Since the occurrence of *Sargassum* at any single location is essentially unpredictable, pelagic *Sargassum* was mapped in the areas of the FMC jurisdiction where it might occur (i.e., from the EEZ to the shoreline) (Ruebsamen personal communication 2005a).
- *Southeast Area Monitoring and Assessment Program (SEAMAP) Data:* These data (SEAMAP 2001a) were used to depict areas of hard bottom substrate for a variety of subtropical-tropical species in this study. While the SEAMAP data are available as GIS shapefiles that represent polygonal areas from Virginia to Florida, at the scale represented on the maps in this study, the polygons appear to be points.

  Information used to map the various habitat types (e.g., bottom substrates and corals) and HAPC (e.g., spawning sites and Special Management Zones [SMZs]) were derived from a variety of literature sources or from GIS data (NOAA 1996a; SEAMAP 2001a; Sedberry 2005).

➢ Highly Migratory Species—The GIS shapefiles of the EFH and HAPC for highly migratory species (HMS; tuna, sharks, swordfish, and billfish) obtained from the NMFS required some GIS processing during which the GIS data were clipped to the shoreline. Therefore, inshore EFH is not graphically depicted and the text narrative should be consulted directly for EFH beyond the shoreline or outside of the study area. Differences exist between the EFH text designations and NMFS GIS data for several species (e.g., the adult lifestage of the bigeye tuna, juvenile lifestage of the blacknose shark, and the adult lifestage of the blacktip shark). The HMS GIS data either depict more or less EFH than were described in the text designation (e.g., GIS data show EFH designated off Florida and in the GOMEX while the EFH text designation does not mention these areas) or a species might have more

than one lifestage with identical text designations, but the GIS data represent the lifestages differently (NMFS 1999b, 2003b). After consultation with the NMFS Highly Migratory Species (HMS) Division, the NMFS advised that neither the GIS data nor the text designations should be altered (Rilling 2005); this recommendation was followed for this MRA. The NMFS-HMS Division is aware of the discrepancies between the EFH text descriptions and GIS data for some species but has not yet corrected them, even in the most recent consolidated HMS FMP and EIS (NMFS 2006). These discrepancies are noted in the text descriptions in Chapter 5 as well as on the corresponding map figures.

1.4.2.5 Additional Considerations Maps

Information regarding the locations of U.S. maritime boundaries, navigable waters, marine managed areas, and scuba diving sites in, or in the vicinity of, the study area for this MRA was gathered from a wide array of sources; however much of the data used to create the maps were available for downloading from Internet sites. Coordinate data, however, on the locations of the international maritime boundaries between the The Bahamas, Cuba, and the U.S. were acquired from the Global Maritime Boundaries Database (GDAIS 2005).

On the map figures of marine managed areas, only federal sites that are currently listed in the U.S. Marine Managed Area (MMA) Inventory were displayed. A GIS shapefile downloaded from the National Marine Protected Area Center (NMPAC) website for the Reef Fish and Longline Buoy Gear Restricted Area MMA was discovered to be incorrect and was not used on the MMA map. In order to depict this particular MMA correctly, the official geo-spatial coordinates were acquired from the Code of Federal Regulations (50CFR622.34[c]), and a new GIS shapefile was created. At the time this report was created, state marine managed areas had been added to the MMA Inventory but no geospatial coordinates were available; these sites are thus not included on the map figure of the U.S. MMAs. Coordinates for the Bahamian marine protected areas (MPA) were downloaded from the online global MPA website.

Recreational diving sites in the study area and vicinity were depicted using a variety of sources including geospatial data, published dive guides, navigational maps, information acquired from scuba diving websites, and documents and databases listing artificial reefs (e.g., shipwrecks).

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 MRA. 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 XML (extensible markup language) 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 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 Sighting Survey Data

Sighting data acquired from marine surveys, whether from shipboard or aerial platforms, can provide a powerful indicator of a species' occurrence. However, it is necessary to first recognize inherent biases associated with each survey type. A primary drawback of shipboard and aerial surveys is that they count only the number of animals at or near the water's surface, a region of the water column where marine mammals and sea turtles spend relatively little time. As sea turtles spend over 90% of their time underwater, it has been estimated that marine sighting 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; Renaud and Carpenter 1994). While scientists have devised mathematical formulas to account for animals not observed at the surface, the diving behavior may vary even within the same species. Even though marine mammals and sea turtles are obligated to breathe at the surface, 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, or are known to exhibit cryptic behavior, such as beaked whales, *Kogia* spp., and sperm whales (Würsig et al. 1998; Barlow 1999). Beaked whales often occur singly, which makes their sightability much lower than a species that regularly occurs in large groups, such as dolphins in the genus *Stenella* (Scott and Gilbert 1982).

Environmental conditions also affect the sightability of marine mammals and sea turtles. Sighting frequencies vary with sun glare from the water's surface, sea state, weather, and water clarity. Both sea state and glare have statistically significant effects on sighting frequency (Scott and Gilbert 1982; Thompson 1984). When water clarity is low, animals are difficult to sight even close to the water's surface, and only animals at the water's surface that are extremely close to the observer are normally identified.

Survey methods for marine mammal and sea turtle observation are dissimilar in sampling efficiency. Since most sighting surveys target multiple species, the sampling designs, although likely cost- and labor-efficient, cannot be considered optimal for across all taxon groups (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 larger sea turtle species but usually not smaller sea turtles. The relatively small size, diving behavior, and startle responses to vessels and aircraft make smaller sea turtles difficult to observe from a ship. The youngest sea turtle age-classes, which often inhabit waters far from land, are extremely difficult to spot. Other difficulties with marine surveys include weather, time, and logistical constraints.

In addition, marine survey data do not provide adequate information for scientists to accurately describe the seasonal occurrence of marine mammals and sea turtles in expansive areas, such as the Atlantic Ocean. Marine mammal and sea turtle occurrences in an area often changes on seasonally in response to changes in water temperature, the movement and availability of prey, or an individual's life history (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 Inherent Limitations of Stranding Data

Marine mammal and sea turtle strandings are not generally considered accurate representations of distribution. Sick animals may beach themselves well beyond their normal range and carcasses may travel long distances before being noticed by observers or coming ashore. Stranding frequency in a given area is as dependent upon current regimes and coastal zone patrol efforts as it is a function of a stranded species' actual pattern of occurrence in that area. Since coastal species generally 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. Additionally, accurate stranding data depends upon the reporter competency to properly identify carcasses as a certain species, which can be difficult. For example, only the most experienced marine mammal scientists are likely able to differentiate between the several species of beaked whale in the genus *Mesoplodon*.

1.5 REPORT ORGANIZATION

This report consists of nine major chapters and four 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 physical environment of the study area, including climate, marine geology (physiography, bathymetry, and bottom sediments), physical oceanography (circulation and currents), hydrography (surface temperature), and biological oceanography (plankton and primary productivity). Chapter 3—Protected Species covers all protected species found in the study area, including marine mammals, sea turtles, and fishes. For these species, detailed narratives of their

morphology, status, habitat preferences, distribution, behavior, life history, and acoustics and hearing (if known) have been provided. Chapter 4—Habitats of Concern describes *Sargassum*, corals, live/hard bottom communities, and artificial habitats occurring in the study area and vicinity. Chapter 5—Fish presents an overview of the fish assemblages that occur within the study area and designated EFH that occur in U.S. waters. Chapter 6—Additional Considerations provides information on U.S. and Bahamian maritime boundaries, navigable waterways and commercial shipping lanes, marine managed areas, and scuba diving sites. Chapter 7—Recommendations suggests future avenues of research that may fill the data gaps identified in this project and prioritizes research needs from a cost-benefit approach. Chapters 8 and 9 are the List of Preparers and Glossary, respectively. Appendix A includes supplementary materials referred to in Chapter 1—Introduction (including the protected species data sources) while Appendices B and C contain occurrence map figures that are described or referenced in the marine mammal and sea turtle sections (3.1 and 3.2, respectively) of Chapter 3. Appendix D includes maps for all species for which EFH has been designated within the U.S. waters of the study area. Appendix E contains mylars (transparencies) of selected maps (e.g., bathymetry) intended for use as overlays in analyzing data depicted on other maps in the MRA.

This report is written in a format and reference style that follows that found in *The Chicago Manual of Style*, 14th Edition. Cited literature appears at the end of each chapter except in Chapter 3, Protected Species, where the cited literature appears at the end of each subsection.

1.6 LITERATURE CITED

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2.0 PHYSICAL ENVIRONMENT

2.1 INTRODUCTION

The study area encompasses waters off of the southeastern coast of Florida approximately between 50 km north of Cape Canaveral to 25 km south of Palm Beach and extending to the southeast into the western North Atlantic and the territorial waters of The Bahamas to a point at about 23°15'N latitude and 76°W longitude. Climate in the Bahamas and southeastern Florida is subtropical and usually warm and humid during much of the year. The region is particularly susceptible to heavy rains and winds from tropical storms and hurricanes. An area of the marine environment greater than 246,000 km^2 is covered by the study area in which water depth ranges from the mean low tide line along the east coast of Andros Island and the west coast of New Providence Island to greater than 5,300 m over the Blake-Bahama basin in the northeastern part of the study area (Figure 2-1). With the exception of the aforementioned coastal regions, which abut the AUTEC-Andros OPAREA, the study area extends from 3 NM offshore along the Florida coast and from 12 NM offshore of the remaining islands in the Bahamas. Prominent physiographic features in the study area include the Blake Plateau, Great Bahama and Little Bahama banks, *Oculina* Bank, Blake Escarpment, and the Great Bahama Canyon, which links the deep, oceanic waters of the Blake-Bahama basin with the deep-water trough adjacent to the east coast of Andros Island known as the Tongue of the Ocean (TOTO) (Figure 2-1; NGDC and IOC 2003).

Circulation in the study area is dominated by three major surface currents: the Florida Current, the Gulf Stream Current, and the Antilles Current. Currents over the shallow Bahama banks generally flow to the northwest and eventually merge with the fast-moving Gulf Stream. There is also a significant deep water boundary current flowing towards the south beneath the Antilles Current that affects deep circulation in the eastern part of the study area. Upwelling of cold, nutrient rich waters onto Florida's continental shelf often occurs in conjunction with meandering of the Florida and Gulf Stream currents; such meanders also can lead to the formation of eddies near the shelf break (Fiechter and Mooers 2003; Haus et al. 2004).

2.2 CLIMATE AND WEATHER

The maritime climate of the southwestern North Atlantic is described as subtropical and is heavily influenced by the clockwise (anticyclonic) circulation of the Bermuda-Azores High, a semi-permanent, high-pressure system centered over the island of Bermuda in the summer and fall seasons (NOAA 2005a). Winds and weather patterns in the study area predominantly flow from the east or southeast because of the influence of the Bermuda-Azores High; although, seasonal fluctuations in the location and relative strength of the pressure system can have significant effects on weather in the region. In summer and fall the high pressure system is largely responsible for the hot, humid weather conditions that are typically present along the southeastern U.S coast and in the Bahamas (NASA 2005a). During winter and spring, the Bermuda-Azores High is located in the eastern North Atlantic near the Azores, and weather patterns in the study area are more strongly influenced by cold, continental air masses from the northwest which bring strong northerly winds and drier air into the region (Buchan 2000; NOAA 2005a).

Mean daily temperature in the Bahamas ranges between 17° and 32°C, although winter temperature lows between 4.4° and 10°C are not uncommon (SENES Consultants Limited 2005; DoS 2006). In summer, weather conditions in the study area are generally hot and humid with mean monthly temperatures often reaching 32°C and with winds flowing predominantly out of the east or southeast. Winter weather conditions are more variable with winds predominantly from the west or northwest (Chen and Gerber 1990; Buchan 2000). In addition to the Bermuda-Azores High, the presence of the Gulf Stream has a significant effect on the climate in the Bahamas and southeastern Florida. By transporting warm waters from the Gulf of Mexico through the study area, the Gulf Stream System moderates winter air temperatures in the region. Because of this, Grand Bahama Island, the northern most island in the Bahamas, has a relatively mild average minimum monthly temperature of 20°C in winter (Buchan 2000).

Measurements of air temperature recorded during a nine-year period on Mangrove Cay, which is located on the east coast of Andros Island at about 24.16°N, indicate that July and August are the warmest

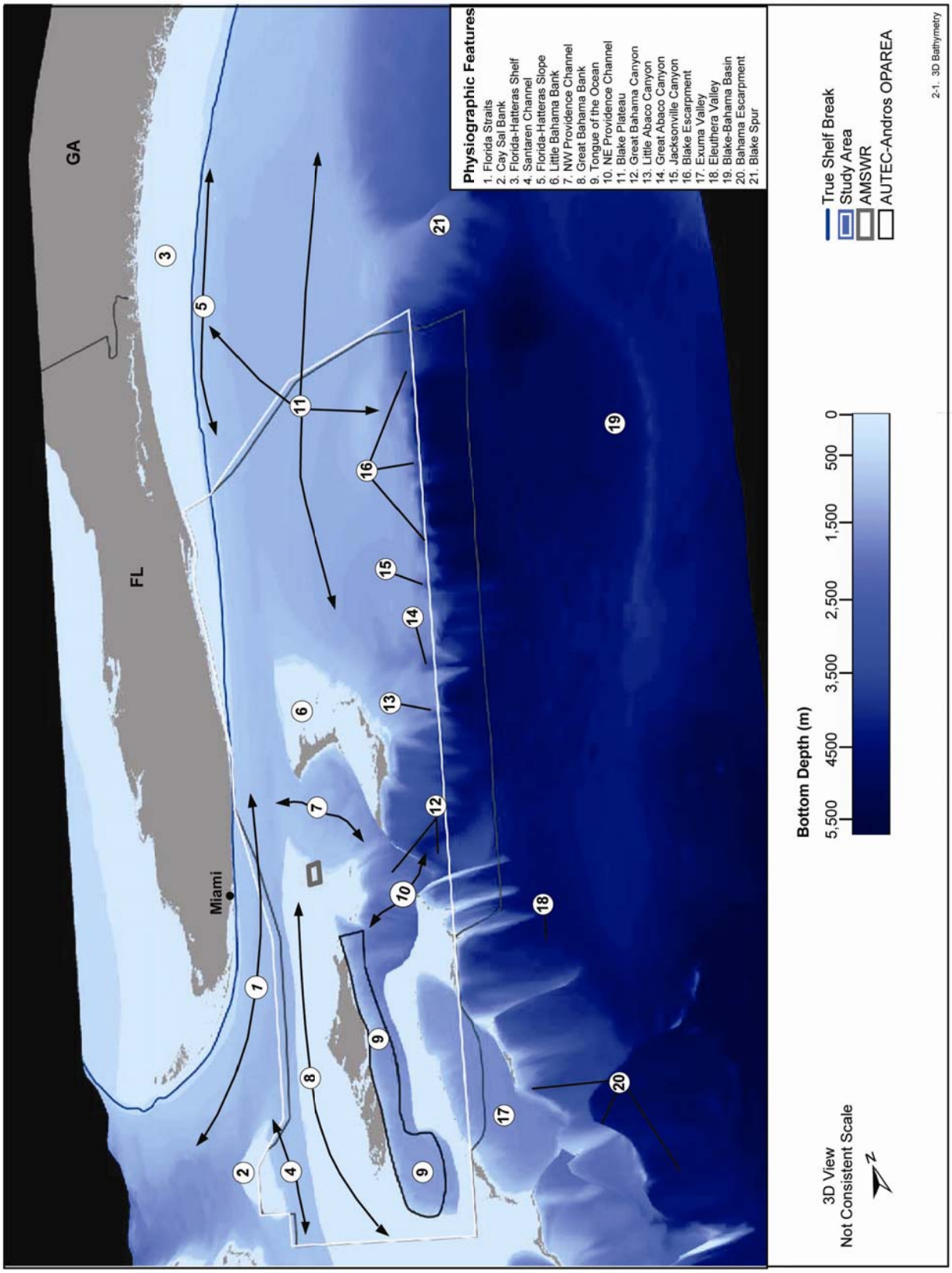

Figure 2-1. Three-dimensional bathymetry and major physiographic features located in and adjacent to the study area. Source data: Smith and Sandwell (1997), NOAA (2001), and NAVO (2006). Source Information: Emery and Uchupi (1972), NGDC and IOC (2003), and GEBCO-SCUFN (2005).

months with a mean temperature of 28°C, while December and January are the coolest months with a mean temperatures of 22°C; mean monthly temperatures over the period of the study ranged as high as 32°C and as low 16°C (Podeszwa 1991).

Precipitation in the study area is heaviest in the summer and fall seasons and lowest in winter and early spring (Podeszwa 1991; Chen and Gerber 1990). September and October are the months when rainfall totals are consistently the highest for three sites located adjacent to the study area (West Palm Beach, Florida; Melbourne, Florida; and Mangrove Cay, Andros, The Bahamas) (Podeszwa 1991; Chen and Gerber 1990). In the Bahamas, mean annual rainfall ranges from about 865 to 1,470 mm; however, regional totals vary considerably and are generally greater in the north than in the south (SENES Consultants Limited 2005). Buchan (2000) reports that Grand Bahama has an average annual rainfall total of 1,400 mm and that Grand Inagua, an island located in the southern Bahamas nearly 800 km to the southeast, has and average annual total of about half that (700 mm). Precipitation measures recorded on Mangrove Cay over a 19-year period indicate that rainfall for September and October total between 203 to 229 mm and total less than 51 mm from December through April (Podeszwa 1991). In southeastern Florida, most rainfall occurs from June through September, accounting for 50% to 60% of annual totals (Chen and Gerber 1990).

Podeszwa (1991) reported data on visibility and cloudiness for the northern half of the TOTO between 24° and 25°N. With the exception of June, September, and December, visibility was at least 5 NM all of the time, and for the three months when this was not the case, visibility was under 5 NM for less than 5% of the time. Cloud cover in the same portion of the TOTO correlates well with precipitation and visibility patterns. Only in January did the amount of cloud cover exceed 90% more than 20% of the time; for the majority of the year exceptionally cloudy days occurred less than 10% of the time. Between 40% and 80% cloud cover is reported in the TOTO more than one third of the time only during June, August, September, and December (Podeszwa 1991). The predominance of clear, high visibility days is not unusual for a region that is strongly influenced by a high pressure system.

2.2.1 Tropical Storms and Hurricanes

Most major storms, including hurricanes, occur in the study area during the North Atlantic hurricane season which extends from June through November. The islands in the Bahamas are particularly susceptible to impacts from hurricanes and major tropical storms because they are low-lying (maximum elevation is 63 m on Cat Island) and directly exposed to the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, all of which are possible generation sites for hurricanes and tropical storms that could cross the Bahamas (Buchan 2000; DoS 2006). From 1900 through 1999, 480 hurricanes have been recorded in the North Atlantic, with 14% (67 out of 480) impacting at least some part of the Bahamas (Buchan 2000). On average, three hurricanes can be expected to pass over the Bahamas every four years; however, in the last three decades of the twentieth century (1970 through 1999) only a total of eight hurricanes occurred in the Bahamas, which equates to about one hurricane every four years (Buchan 2000).

More recently, the Atlantic hurricane seasons of 2004 and 2005 were particularly active. The 2005 season produced a record number of named storms (27), a record number of hurricanes (15) including four category 5 hurricanes, and a record number (4) of major hurricanes (i.e., category 3, 4, or 5 hurricanes on the Saffir/Simpson scale) impacting the U.S. (NOAA 2006a). Nine named storms impacted at least some part of the study area in 2004 and 2005 bringing heavy rains, high to severe winds, and storm surges that frequently resulted in coastal flooding (Table 2-1).

In 2004, three hurricanes passed through the study area. Hurricane Charley (category 4) crossed over southwestern and central Florida from the Gulf of Mexico with devastating winds and entered into the Atlantic near Daytona Beach just north of the study area (NOAA 2005b). Hurricane Frances (category 3) passed directly over the northern Bahamas and made landfall on the east coast of Florida (as a category 2) near West Palm Beach bringing significant storm surge and heavy rains—over 380 mm in some areas—to much of the study area (NOAA 2004a).

Table 2-1. Tropical storms and hurricanes occurring in the study area in 2004 and 2005 (NOAA (2004a, 2004b, 2005b, 2005c, 2005d, 2005e, 2006b, 2006c, 2006d).

Storm Name	*Date in Study Area*	*Strength in Study Area*
Hurricane Charley	August 2004	Category 1
Hurricane Frances	September 2004	Category 3
Hurricane Jeanne	September 2004	Category 3
Tropical Storm Franklin	July 2005	Tropical Storm
Hurricane Katrina	August 2005	Tropical Storm
Hurricane Ophelia	September 2005	Tropical Storm
Hurricane Rita	September 2005	Tropical Storm
Tropical Storm Tammy	October 2005	Tropical Storm
Hurricane Wilma	October 2005	Category 2

Hurricane Jeanne (category 3) passed over Grand Bahama and Abaco Islands in the northern Bahamas and made landfall in the U.S. at about the same area as Frances less than one month earlier (NOAA 2004b).

Before devastating New Orleans and much of the southeastern Gulf coast with severe winds and major coastal flooding, Hurricane Katrina developed as a tropical storm over the Bahamas and reached hurricane strength just before making landfall near Miami (NOAA 2005d). Hurricane Ophelia formed into a tropical storm in the northern part of the study area east of Cape Canaveral and then moved northeast out of the study area before skirting along the North Carolina coast (NOAA 2006b). Hurricane Rita formed into a tropical storm in the southeastern Bahamas and slowly moved west passing just south of Andros Island before eventually becoming a category 5 hurricane in the Gulf of Mexico (NOAA 2006c). Hurricane Wilma developed in the northwestern Caribbean Sea quickly becoming a category 5 hurricane with the lowest central pressure ever recorded in an Atlantic hurricane (NOAA 2006d). Wilma caused extensive damage to the Yucatan Peninsula before passing over southern Florida as a category 3 hurricane where it produced 10 tornadoes and widespread damage (NOAA 2006d).

The strength and number of hurricanes developing in the North Atlantic and ultimately impacting coastal regions of the U.S. and Caribbean nations is forecast to remain above normal in the near future (NASA 2005a). A strong Bermuda-Azores High results in less cloud cover over Hurricane Alley, the tropical region of the North Atlantic Ocean between the Antilles and Africa where hurricanes typically develop, exposing ocean waters to the warming energy from the sun. Warm ocean waters are fuel for tropical storms and an increase in ocean temperatures can result in an increase in the number and intensity of tropical storms and hurricanes (DeMaria and Kaplan 1994; NASA 2005a).

2.2.2 North Atlantic Oscillation

A climatic phenomenon known as the North Atlantic Oscillation (NAO) affects both climate and oceanography primarily in the northern North Atlantic Ocean, but its influence also extends to the subtropical North Atlantic and the study area (Hurrell et al. 2001). This large-scale climatic phenomenon is another example of the dynamic relationship between the atmosphere and the ocean; however, unlike the Bermuda-Azores High which cycles seasonally, the NAO tends to cycle over decade-long time scales. The NAO has global significance as it affects sea surface temperatures, wind conditions, and ocean circulation of the North Atlantic, which in turn have significant ecological impacts on the marine ecosystems and the terrestrial environments of North America and Europe (Open University 2001; Stenseth et al. 2002; Menzel et al. 2005).

The NAO is an oscillation in the intensity of the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores Islands and the subpolar low-pressure center over

Iceland (Curry and McCartney 2001; Stenseth et al. 2002). The atmospheric pressure at sea level in the two regions tends to vary in a "see-saw" pattern—when the pressure increases in Iceland it decreases in the Azores and vice-versa (i.e., the two systems tend to intensify or weaken in synchrony) (Open University 2001; Senseth et al. 2002). The NAO is the dominant mode of decadal-scale variability in weather and climate in the North Atlantic region (Hurrell 1995).

The variability in 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-pressure regions. There are different NAO indices available that use different reference stations and/or base-line time periods. The NAO index is calculated for each day and can then be averaged over longer periods (e.g., weekly, monthly, annually). 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 for 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 (Warm) Phase*
  - Both the Iceland low and Azores high intensify (i.e., there is a larger difference between the two pressure centers)
  - Westerly winds (i.e., winds out of the west) strengthen; the jet stream flows primarily from west to east with reduced meandering
  - Climate in eastern and central North America is warmer than normal
  - Climate in Europe is warmer and wetter than normal
  - Climate in Greenland and the northern North Atlantic is colder than average
  - Climate in the Mediterranean Sea and surrounding area is colder and drier than average
- *Negative or Weak (Cold) 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
  - Climate in eastern North America is colder and drier than normal
  - Climate in Europe is colder and drier than normal
  - Climate in Greenland and the northern North Atlantic is warmer than normal
  - Climate in the Mediterranean and surrounding area is warmer and wetter than normal (Open University 2001; Visbeck 2002).

The NAO tends to remain relatively stable for extended periods ranging from several years to decades (e.g., the NAO was mainly positive from 1900 to 1950, mainly negative in the 1960s and 1970s, and has been mainly positive since 1970 (Hurrell et al. 2001). Recently the NAO index has declined rapidly resulting in a weak to nonexistent trend in the index when averaged over the past 30 years or so (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 important North Atlantic Ocean currents. The NAO influences the latitude of the Gulf Stream Current 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 so called "north wall" of the Gulf Stream Current (i.e., the northern boundary of the current east of Cape Hatteras) is located farther north than usual (Taylor and Stephens 1998; Open University 2001). Not only is the position of the Gulf Stream Current and its end-member, the North Atlantic Current, affected by the NAO, but the strength of these currents is also affected. During negative NAO years, the Gulf Stream System not only shifted southward but weakened, as witnessed during the predominantly negative NAO phase of the 1960s. During the subsequent 25-year period of predominantly positive NAO, the currents intensified to a record peak in transport rate in the 1990s, reflecting an increase of 25% to 33% (Curry and McCartney 2001). The location and strength of the Gulf Stream System are important, because the currents are an essential part of the North Atlantic climate system, moderating temperatures and weather from the U.S. to the Mediterranean, including all of the study area (Buchan 2000; Open University 2001).

A strong association has been established between the variability of the NAO and changes affecting various trophic groups in North Atlantic marine ecosystems on both the eastern and western sides of the basin (Fromentin and Planque 1996; Barton et al. 2003; Drinkwater et al. 2003). The temporal and spatial patterns of *Calanus* copepods (zooplankton) were the first to be linked to the phases of the NAO (Fromentin and Planque 1996; Stenseth et al. 2002). When the NAO index was positive, the abundance of *Calanus* copepods in the Gulf of Maine increased, with the inverse true in years when the NAO index was negative (Conversi et al. 2001; Greene and Pershing 2004). This pattern is opposite off the European coast (Fromentin and Planque 1996). Such a shift in copepod patterns has a tremendous significance to upper trophic-level species, including the North Atlantic right whale (*Eubalaena japonica*), which feeds principally on *Calanus finmarchicus*. Right whale calving rates are linked to the abundance of *Calanus finmarchicus*; when abundance is high, the calving rate remains stable, but in the late 1990s when the abundance of its favored copepod declined, the calving rate fell (Greene et al. 2003). Links between phytoplankton abundance in the North Atlantic and changes in the NAO index have been less distinct, but a positive correlation with phytoplankton abundance in shelf waters and along the north wall of the Gulf Stream appears to be present (Barton et al. 2003). No information reporting on a correlation in plankton abundance and variability in the NAO index occurring in the study area was found; although the study by Barton et al. (2003) indicates that the strongest correlations occur in the northern North Atlantic.

2.3 MARINE GEOLOGY

Marine geology in the study area is dominated by the presence of a broad, flat, carbonate terrace extending from the north and two expansive shallow-water carbonate banks rising off the seafloor in the southern two-thirds of the study area. The geologic processes that continue to influence the formation of these three physiographic features include carbonate deposition, erosion caused by ocean currents, changes in sea level, and pro-gradation of sediments (Emery and Uchupi 1972). Several wide and relatively flat-floored channels separate the two carbonate banks and connect the shallow platforms with the Atlantic Ocean basin. Marine sediments in the study area are composed primarily of calcium carbonate $CaCO_3$ derived from several sources including the skeletal remains of coral reefs (Enos 1974).

2.3.1 Physiography and Bathymetry

The continental margin (the boundary or transition between continents and ocean basins) consists of the three physiographic provinces typical of a passive margin: the continental shelf, continental slope, and continental rise (Figure 2-2). Approximately 70% of the earth's surface is below sea level, and the continental margins of the world make up about 21% of the submarine surface (or 15% of the earth's surface) (Garrison 1996). More than half of the sediments covering the ocean bottom are found on the continental margins of the world (Kennett 1982). The transition between provinces of the continental margin is largely dictated by the change in gradient of the sea floor moving seaward along the expanse of the continental margin.

The continental shelf is the seaward extension of the continent, almost like a submarine platform. A gentle incline or gradient (<1:1,000 or 0.1°), low relief (<20 m), widths of about 100 km, and maximum water depths of 130 m on average, worldwide, distinguish the continental shelf (Kennett 1982; Eisma 1988). The transition from the shelf to the continental slope occurs at the shelf break, which is marked by a sudden change in the gradient of the seafloor (Figure 2-2). Heezen et al. (1959) established a minimum gradient defining the shelf break in the North Atlantic of 1:40 or 0.4°, which has generally remained accepted. The depth of the shelf break usually represents the deepest waters found on the continental shelf with the average depth at 130 m (Shepard 1973; Pickard and Emery 1990). The worldwide average depth of the continental slope ranges from the shelf break depth (~130 m) to as deep as 3,500 m (Kennett 1982). The gradient of the continental slope changes radically from that of the shelf, averaging 1:19 to 1:9.5 or about 3° to 6°, with variability related to the morphology of the coastal region (Fairbridge 1966; Sverdurp et al. 1970; Eisma 1988). The most seaward province of the continental margin, the continental rise, is located between the continental slope and the floor of the ocean basin (or

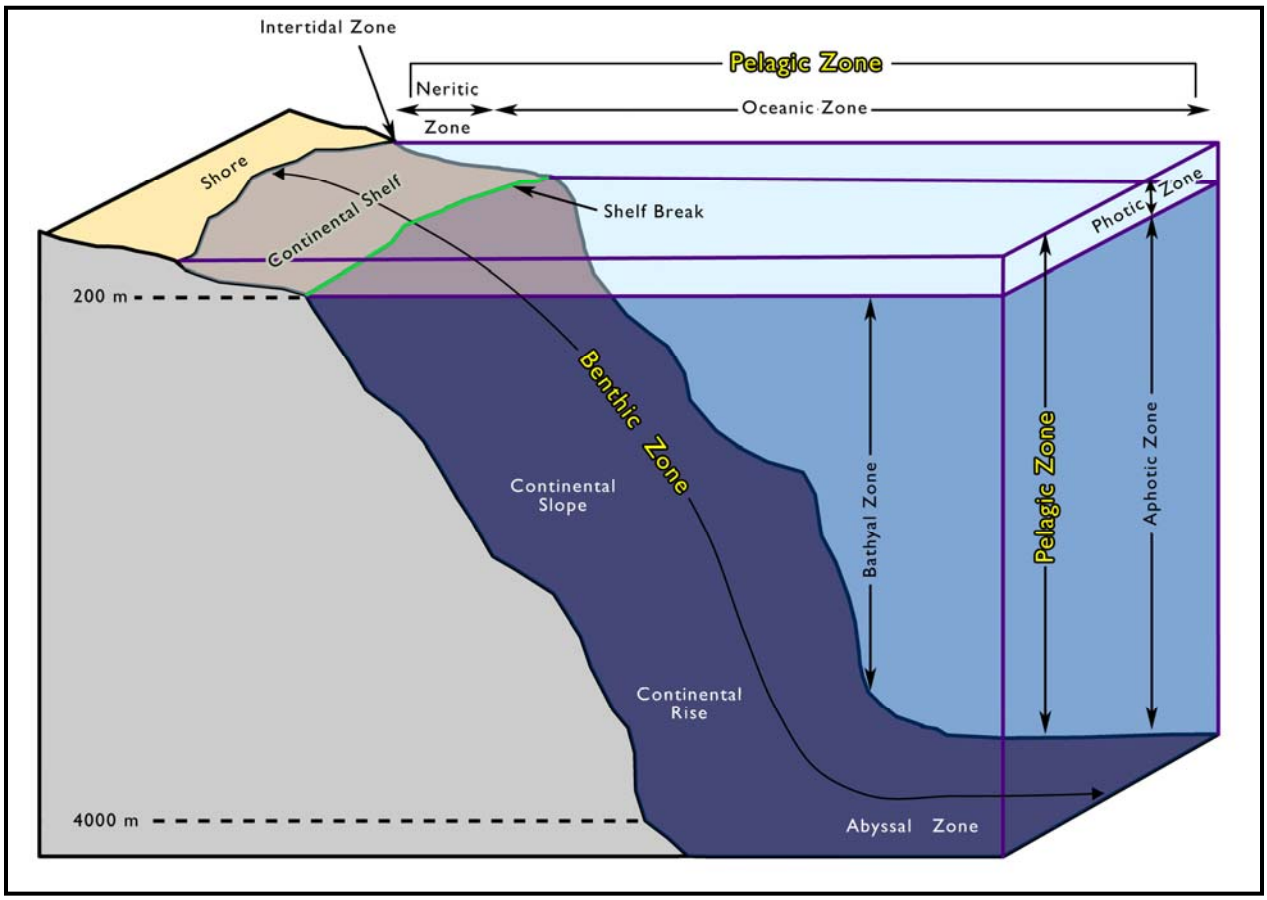

Figure 2-2. Generic three-dimensional representation of the continental margin and the major submarine zones referred to in the MRA. The continental margin includes the continental shelf, shelf break, continental slope, and continental rise, where each province is defined primarily by its seaward gradient. The pelagic zone includes the nearshore neritic and offshore oceanic zones and extends from the surface to the seafloor. The benthic zone includes the seafloor environment extending from shore to the abyssal plain.

abyssal plain). On a worldwide average, the continental rise extends from 100 to 1,000 km in width and has a gentle seaward gradient of 1:700 to 1:1,000 with low relief (Kennett 1982). The continental rise is usually covered with thick layers of sediments that have been transported from the continents. Submarine canyons and channels also cut through the continental rise in numerous locations around the world.

In the study area the continental margin includes a continental shelf, referred to as the Florida-Hatteras Shelf, located along the east coast of Florida approximately between the cities of Palm Beach and Canaveral, an adjacent continental slope province (the Florida-Hatteras Slope), and a large carbonate platform comprised of the Blake Plateau, the Great Bahama Bank, Little Bahama Bank, and Cay Sal Bank (Figure 2-1). Seaward of the continental margin is the Blake-Bahama Basin where depths exceed 5,300 m.

Only a small section of the Florida-Hatteras Shelf, which extends along the east coast up to North Carolina, overlaps with the study area (Figure 2-1). The width of the shelf in the study area increases from almost nonexistent (<3 km) east of Palm Beach to about 70 km near the study area boundary just north of Cape Canaveral (Emery and Uchupi 1972; Shepard 1973; Jones et al. 1985; Figures 2-1 and 2-3). Prominent geologic features on the Florida-Hatteras Shelf include several major capes, only one of which, Cape Canaveral, is located in the study area. Long, narrow shoal areas off of each cape stretch nearly the width of the shelf, and, off of Cape Canaveral, are nearly perpendicular to shore (Emery and Uchupi 1972). Small depressions, most likely spring holes (or sink holes) are present on the shelf. One

spring hole located just north of the study area off of Crescent Beach, Florida is described by Emery and Uchupi (1972) as about 30 m in diameter with a maximum depth of 42 m below the seafloor. The seaward extent of the Florida-Hatteras Shelf is marked by the true shelf break, which in much of the study area is formed by algal reefs and oolitic dunes. The depth at which the true shelf break occurs in the study area is not coincident with a single isobath and ranges from about 20 m off of West Palm Beach to over 70 m near the northern boundary of the study area (Emery and Uchupi 1972; Shepard 1973; Jones et al. 1985; Figure 2-3).

The Florida-Hatteras Slope is distinguished from most other continental slopes by its comparatively low relief, gentle gradient (2° to 3°) and separation from the continental rise (or ocean basin) by a broad flat terrace (i.e., Blake Plateau) (Emery and Uchupi 1972; Shepard 1973). In the study area, the southern half of the Florida-Hatteras Slope terminates in the Florida Straits at a depth of about 700 m at which point the seafloor begins to rise abruptly to form the western slopes of both Little Bahama Bank and Great Bahama Bank (Figure 2-3).

The continental rise that ordinarily would be located east of the Blake Plateau is replaced by a marginal basin, the Blake-Bahama Basin, and an adjacent outer ridge located seaward of the basin called the Blake-Bahama Ridge (Heezen et al. 1959; Figure 2-1). These two physiographic features separate the continental margin from the abyssal plain. Marginal basins, where present, are found at the base of the continental slope or a marginal escarpment (e.g., the Blake Escarpment), are shallower than ocean basins, and are bounded by an outer ridge marking the seaward extent of the basin (Heezen et al. 1959).

2.3.1.1 Bahama Banks

The three largest carbonate banks supporting most of the land area in the Bahamas are Little Bahama Bank (to the north), Great Bahama Bank, and Cay Sal Bank (to the southwest) (Emery and Uchupi 1972; Figure 2-1). Numerous smaller banks occur in the southeastern Bahamas, some of which are not much broader than the islands they support (Emery and Uchupi 1972; Carew and Mylorie 1995). The banks were created in the Mesozoic Era (248 to 65 million years ago) during the rifting of the continents that eventually resulted in the formation of the Atlantic Ocean (Carew and Mylorie 1995). The exact geologic processes resulting in the current morphology of the banks and adjacent basins has been debated extensively; however, the region is considered to be tectonically stable and in general the processes of erosion and carbonate sediment deposition have dominated the evolution of the banks (Carew and Mylorie 1995; Anselmetti et al. 2000; Brooke 2001). The banks have been described as similar in profile to atolls found in the Pacific with steep (gradients of 40 to 90°), escarpment-like walls extending down hundreds of meters to the seafloor surrounding shallow, saucer-shaped terraces (Newell 1955; Emery and Uchupi 1972; Rendle-Bühring and Reijmer 2005).

During periods of low sea level (>10 m lower than present day sea level) associated with continental glaciation periods, the Bahama banks were exposed and islands such as Andros and Grand Bahama were considerably larger than they are today. No sediment deposition took place on the banks, and all exposed land area was subject to the effects of weathering and erosion (Carew and Mylorie 1995; Brooke 2001). During interglacial periods the banks were flooded (much as they are today), and sediment deposition occurred on all submerged portions of the banks. The rate of subsidence during periods when the banks were submerged is estimated at one to two meters per 100,000 years (Carew and Mylorie 1995). Based upon measurements of the deep-sea oxygen isotope record, scientists estimate that over approximately the past two million years the banks have been exposed for periods averaging about 100,000 years and flooded for periods averaging only about 10,000 years (Carew and Mylorie 1995). Progradation of the western leeward margins of the banks has been influenced by the prevailing easterly winds as well as fluctuations in sea level (Anselmetti et al. 2000; Rendle-Bühring and Reijmer 2005). Great Bahama Bank, for example, has not always been as flat as it is today; during the Neogene Period (1.8 to 23 million years ago) it sloped in ramp-like fashion towards the west. As sea level receded, deposition of carbonate sediments continued on the still submerged portions of the banks, building them up at a greater rate and ultimately resulting in the level profile the banks have today (Anselmetti et al. 2000).

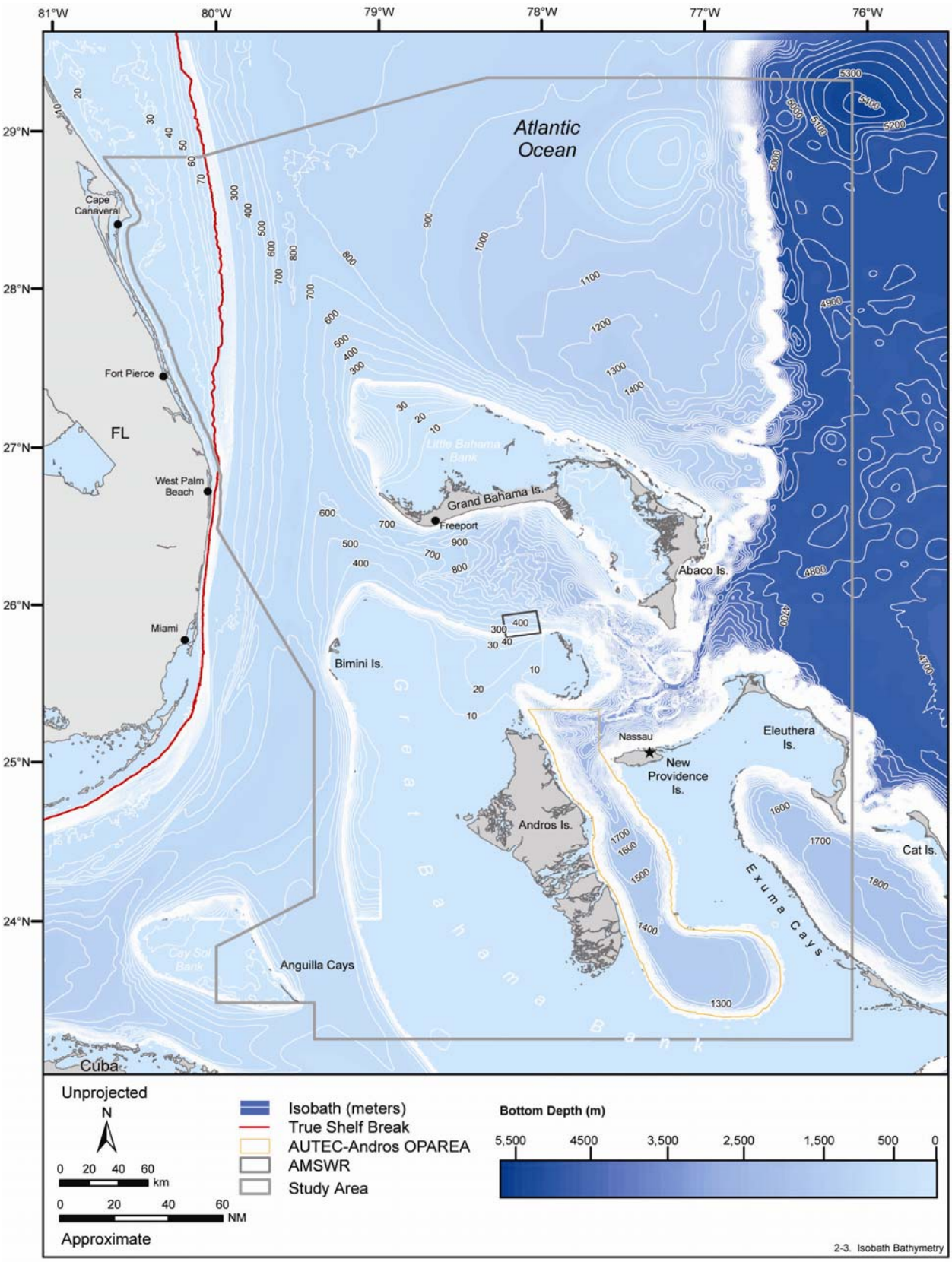

Figure 2-3. Bathymetry associated with the study area. Source data: Smith and Sandwell (1997), NOAA (2001), and NAVO (2006).

For the upper few hundred meters beyond about the 50 m isobath surrounding Great Bahama Bank, the gradient of the sea floor slopes abruptly seaward between 65° and 90° (Rendle-Bühring and Reijmer 2005). On the eastern, windward slopes (e.g., Exuma Valley; Figure 2-1) below the upper few hundred meters gradients decrease to between 32° and 38° and gradually to between 25° and 28° before reaching the sea floor. Western, leeward slopes generally exhibit gentler gradients between 15° and 20° below the first few hundred meters, which gradually decreased to between 6° and 9° before reaching the sea floor (Rendle-Bühring and Reijmer 2005).

2.3.1.2 Blue Holes

Intricate underwater cave systems are present along coastal regions of the Bahama banks, particularly along the east coast of Andros Island, and are unique physiographic features of shallow carbonate platforms (Whitaker 1998). The submerged entrance to these caves is known as a “blue hole,” a term that originates from the dark blue color of the water over the entrance to the cave system (Whitaker 1998). The darkening in the shade of blue over the cave entrance is a function of the increase in water depth in the cave. The cave systems were formed by geologic processes (e.g., erosion) associated with the rise and fall of sea level on the carbonate banks (Trott and Warner 1986; Whitaker 1998). A major fracture system located along the southeast coast of Andros Island parallel to the TOTO is the location of many previously described blue holes in the Bahamas (Trott and Warner 1986; Palmer et al. 1998a; Whitaker and Smart 1998). Three types of blue holes distinguished primarily by their morphology are found in the Bahamas: cenotes, lens-based caves, and fracture guided caves (Whitaker 1998). Cenotes are vertical shafts typically 50 to 100 m long with circular entrances 50 to 150 m in diameter. Cenotes are characterized by a lack of horizontal passages (or the presence of blocked passages) at the depth of the shaft. Conversely, lens-based caves are extensive, horizontal passages that form maze-like complexes of shafts generally 2 to 3 m in diameter. One of the world’s largest lens-based caves, Lucayan Caverns, is located off the coast of Grand Bahama Island (Whitaker 1998). Fracture-guided caves consist of deep, vertical passages formed on a major fracture system which is usually located at the steep margin of a carbonate bank. Passages are typically 2 to 5 m in diameter with rough, planar walls, and many have been explored to depths of 100 m. The most well documented examples of fracture-based caves are located off of southeast Andros Island; however, similar cave systems are also found off of Grand Bahama Island and the Exuma Cays (Whitaker 1998).

Blue holes are described in terms of four major habitat zones distinguished from each other by their physical and biological characteristics (Trott and Warner 1986; Palmer et al. 1998b). The arena, located immediately above the entrance to the cave, is well lit and highly influenced by surface circulation including hydrological currents associated with the cave. Just below the arena, the entrance zone comprises the mouth of the cave and entrance shaft to a depth of penetration by daylight (Trott and Warner 1986; Palmer et al. 1998b). A transition zone separates the entrance zone from the deep cave zone. The length of the transition zone varies considerable depending on the morphology of the cave and the strength of currents in the cave and can reach several hundred meters in some marine caves. The deep cave zone is characterized by extremely stable temperatures (24° to 26°C), low current flow, and the presence only of fauna specifically adapted to exist in such an environment (Trott and Warner 1986; Palmer et al. 1998b).

2.3.1.3 Channels of the Bahamas

Beyond about the 50 m isobath, the outer slopes of the Bahama banks descend steeply to the seafloor, whereas above 50 m, terrace-like limestone formations frame the banks supporting coral and algal reefs (Emery and Uchupi 1972; Figure 2-3). The banks are separated by several broad, flat-bottomed channels including the Santaren Channel, the Northeast (NE) and Northwest (NW) Providence Channels, Exuma Valley, and the TOTO (Figure 2-1). Bottom depth in the channels increases from west to east and ranges between about 700 m in the Santaren Channel and the western end of the NW Providence Channel to over 3,000 m in the NE Providence Channel (Figures 2-3 and 2-4). Various theories have ascribed the creation of the channels (including the Florida Straits) to erosion by currents (e.g., the Gulf Stream) and faulting; however, subsequent seismic profiling of channel walls supports Newell’s (1955) hypothesis that channel walls were built up through carbonate sediment deposition as the entire platform subsided (Shepard 1973). Deep water currents prevented the settling of sediments in the channels.

Of all the channels in the Bahamas, the TOTO has been studied more extensively than any other primarily because of its strategic interest to the U.S. Navy (Busby 1962a, 1962b; Busby et al. 1966; Emery and Uchupi 1972; Podeszwa 1991). The TOTO runs parallel to the east coast of Andros Island on average less than 3 km from shore and extends south from the NE Providence Channel to about 23°23' N (Figures 2-1 and 2-4). The total area of the TOTO as defined by the 183 m isobath and 25°N is 8,706 km^2. Sixty-two percent of this area is below 1,097 m, which emphasizes just how steep the channel walls are and how abruptly they drop off from the surrounding shallow platform (Podeszwa 1991). The width of the channel ranges from about 37 km between Andros and New Providence Islands to nearly 93 km across at the southern end of the TOTO in the section often referred to as the cul-de-sac (Busby 1962b; Podeszwa 1991). Approximately half way along its length the TOTO bulges to about 46 km (Figure 2-4). Cross-sectional profiles of the TOTO taken along its length reveal steep channel walls averaging gradients of 15° to 20° in the upper 500 m but sloping more gently below (Busby 1962b; Podeszwa 1991). In the upper few hundred meters the walls are incised by caves and troughs which are oriented at right angels to the channel walls. At the northern extreme the channel profile is V-shaped and bottom depths exceed 2,400 m; however, along the remaining length of the TOTO profiles are more U-shaped with bottom depths gradually decreasing to a minimum depth of about 1,300 m in the cul-de-sac (Podeszwa 1991; Figure 2-4). The floor of the channel slopes gradually northward to its maximum depth in the NE Providence Channel at a gradient of 1:180 or 0.3° (Busby 1962b).

2.3.1.4 Blake Plateau

North of Little Bahama Bank, the southern-most section of the Blake Plateau separates the Florida-Hatteras Slope from the Blake-Bahama Basin (Figure 2-1). The Blake Plateau is a broad, flat, carbonate platform extending south of Cape Hatteras to the Bahama banks where it reaches a maximum width of about 300 km (Shepard 1973, USGS 2006). It begins at a depth of about 700 m in the Florida Straits and slopes gradually seaward to about 1,400 m before terminating at the Blake Escarpment where the seafloor gradient increases dramatically to about 20° or more (Shepard 1973). Topography on the Plateau is varied and includes rock outcrops, ripples, and little or no recent deposition of sediments all of which are indicative of scouring by bottom currents (Shepard 1973; Emery and Uchupi 1972; USGS 2006). Deep water coral mounds and ridges constructed both by hermatypic and ahermatypic corals on top of ancient reefs are found on Blake Plateau particularly beneath the axis of the Gulf Stream (Shepard 1973; Chapter 4 of this MRA).

2.3.1.5 Submarine Canyons

Four major submarine canyons are located in the study area; three incise the Blake Plateau near its southeastern border with Little Bahama Bank and terminate at the Blake-Bahama Basin (Figure 2-1). Jacksonville Canyon, the northern-most of the three canyons, begins at a depth of about 1,900 m and terminates at a depth of about 4,300 m (Figures 2-1 and 2-3). Approximately 59 km south of the Jacksonville Canyon is the Great Abaco Canyon, the largest of the three Blake Plateau canyons. The Jacksonville Canyon extends 14 km from the canyon head before reaching the Blake-Bahama Basin at a depth of 4,300 m. Little Abaco Canyon, the third and smallest of the three Blake Plateau canyons, is shallower with a bottom depth of 3,600 m. Although submarine canyons can be formed by various processes (Shepard 1973), a major factor contributing to the formation of these three canyons was likely erosion occurring in association with changes in sea level.

The fourth canyon found in the study area, Great Bahama Canyon, underlies the NE and NW Providence channels, which separate Little Bahama Bank from Great Bahama Bank (Figures 2-1 and 2-4). The NE Branch of Great Bahama Canyon has the highest walls of any canyon in the world with a maximum wall height of 4,347 m (Shepard 1973). Great Bahama Canyon is also one of the world's longest canyons, extending 278 km along the NW and NE branches (Shepard 1973). A third branch of the canyon is called the Tongue Branch and leads directly into the TOTO. Generally the canyon profile is V-shaped exhibiting steep wall gradients locally but with overall gradients averaging only a few degrees (Emery and Uchupi 1972; Shepard 1973). At the mouth of the NE Providence Channel, the canyon terminates in a large sediment fan, a submarine feature common at the mouths of large rivers. The presence of a sediment fan supports the theory that erosional processes attributed to turbidity currents are at least in part responsible for the formation of the Great Bahama Canyon (Shepard 1973).

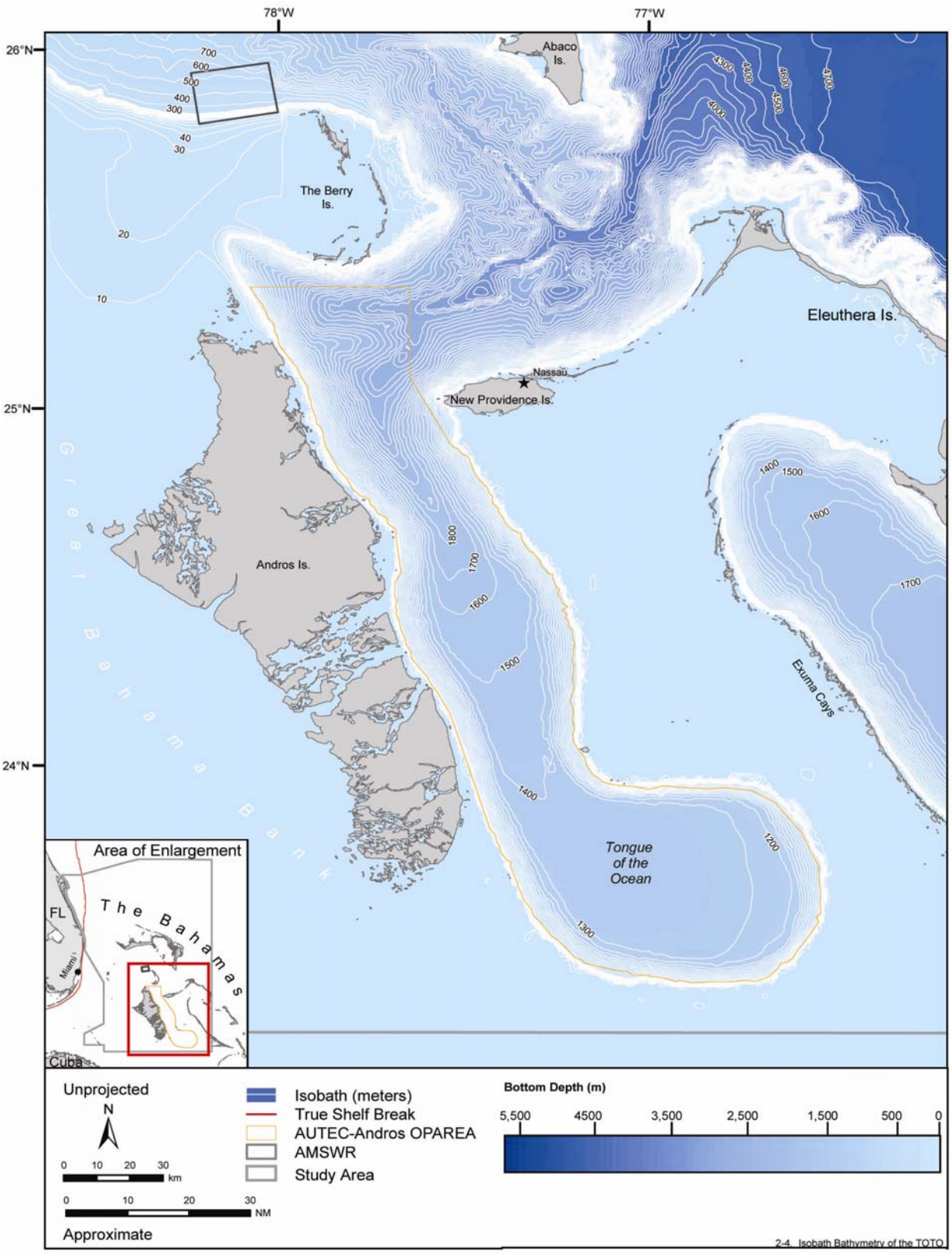

Figure 2-4. Bathymetry associated with the AUTEC-Andros OPAREA and the AMSWR including the Tongue of the Ocean and the Great Bahama Canyon. Source data: NAVO (2006).

2.3.2 Bottom Substrate

Carbonate sediments predominate throughout the entire study area making up between 50% and 95% of sediments on the Florida-Hatteras Shelf and slope, between 85% and 93% of sediments on Blake Plateau, and between 75% and 100% of sediments throughout the Bahamas (Busby 1962b; Jones et al. 1985; Emery and Uchupi 1972; Swart et al. 2005; Figure 2-5). Medium-sized sand covers much of the Florida-Hatteras Shelf and slope with accumulations of fine-grained sand and silt in nearshore areas (Jones et al. 1985). Sources of carbonate in sediments on the Florida shelf and slope include mollusks, echinoids, barnacles, coralline algae, foraminifera, pteropods, and ooids. Non-carbonate sediments, where present, are composed primarily of quartz, feldspar, glauconite and phosphorite, with quartz comprising most of the nearshore, fine-grained sand (Jones et al. 1985).

Throughout the Bahama banks, recently deposited calcium carbonate sediments are underlain by eolianite limestone formations that were compacted during glacial periods of lower sea level when the banks were exposed to weathering (Emery and Uchupi 1972). Relatively pure carbonate sediments have been measured to a depth of more than 4,400 m on Andros Island (Newell 1955). One mechanism by which modern carbonate sediments are deposited on the banks is chemical precipitation. Relatively cool seawater already saturated with $CaCO_3$ warms as it is washed onto the shallow banks by tidal or wind driven currents causing precipitation to occur and leading to deposition and build-up of the banks (Emery and Uchupi 1972). Two prominent and unique bottom features found on the Bahama banks are large sand waves and ridges that extend onto the banks from the border with a deep water channel and stromatolites which are sediment-based, stone structures constructed by algae and cyanobacteria (Alles 2006). Viewed from above, the sand waves appear as long, parallel ripples emanating from a bank edge, such as the southern end of the TOTO where they have been observed for many years (Emery and Uchupi 1972; Alles 2006). Underwater sand dunes and sand waves in the Bahamas consist mostly of oolitic sands (Shepard 1973). Stromatolites are only found in the Bahamas and Shark Bay, Australia. They are formed when sediment particles transported by currents become trapped in sticky mats created by the algae and bacteria. As the sediments build up and begin to reduce the light available to the bacteria for photosynthesis, the microbes migrate upwards, and the process begins again. Over time layers of sediments form ovular or dome-shaped stone structure which protrude about one meter from the sea floor (Alles 2006).

Shallow water bottom sediments in the study area consist primarily of course-grained sand or clayey-silty sand, whereas deep water bottom sediments are made up primarily of fine-grained silts and clays (Emery and Uchupi 1972; Busby 1962b Figure 2-5). An analysis of 315 core samples from the TOTO indicates that the primarily silt-sized sediments consist on average of 94% $CaCO_3$ and range between 82% and 100% $CaCO_3$ (Busby 1962b). In his detailed analysis of the submarine geology of the TOTO, Busby (1962b) reported that $CaCO_3$ composition remained constant with depth, organic carbon content was low (1.0% to 2.0%), and that sediment accumulation rates ranged from a high of 640 cm/1,000 years in the southern cul-de-sac region to a low of 3 to 5 cm/1,000 years at the northern extent of the channel.

Carbonate sediments on the Bahama banks are composed of both skeletal and non-skeletal (e.g., oolitic and pelletoidal) grains, and non-carbonate sediments are primarily quartz sands (Enos 1974). Recent core samples taken on northern Great Bahama Bank at 10 km intervals have revealed greater heterogeneity in carbonate sediments than shown in previous studies (Swart et al. 2005). Skeletal material (e.g., derived from mollusks, coralline algae, and foraminifera) and pelletoidal sediments were ubiquitous.

2.4 CURRENTS AND CIRCULATION

The water column can be divided into three separate layers or water masses: a surface water layer, a deep water layer, and an intermediate area called the thermocline, where the water temperature rapidly changes from the warmer surface water to the colder deep water. Wind and water density differences drive the circulation or movement of these water masses. Surface waters or currents are primarily driven by the drag of the wind over the surface. Wind-driven circulation affects primarily the upper 100 m of the water column. Variations in temperature and salinity cause differences in water density; these differences

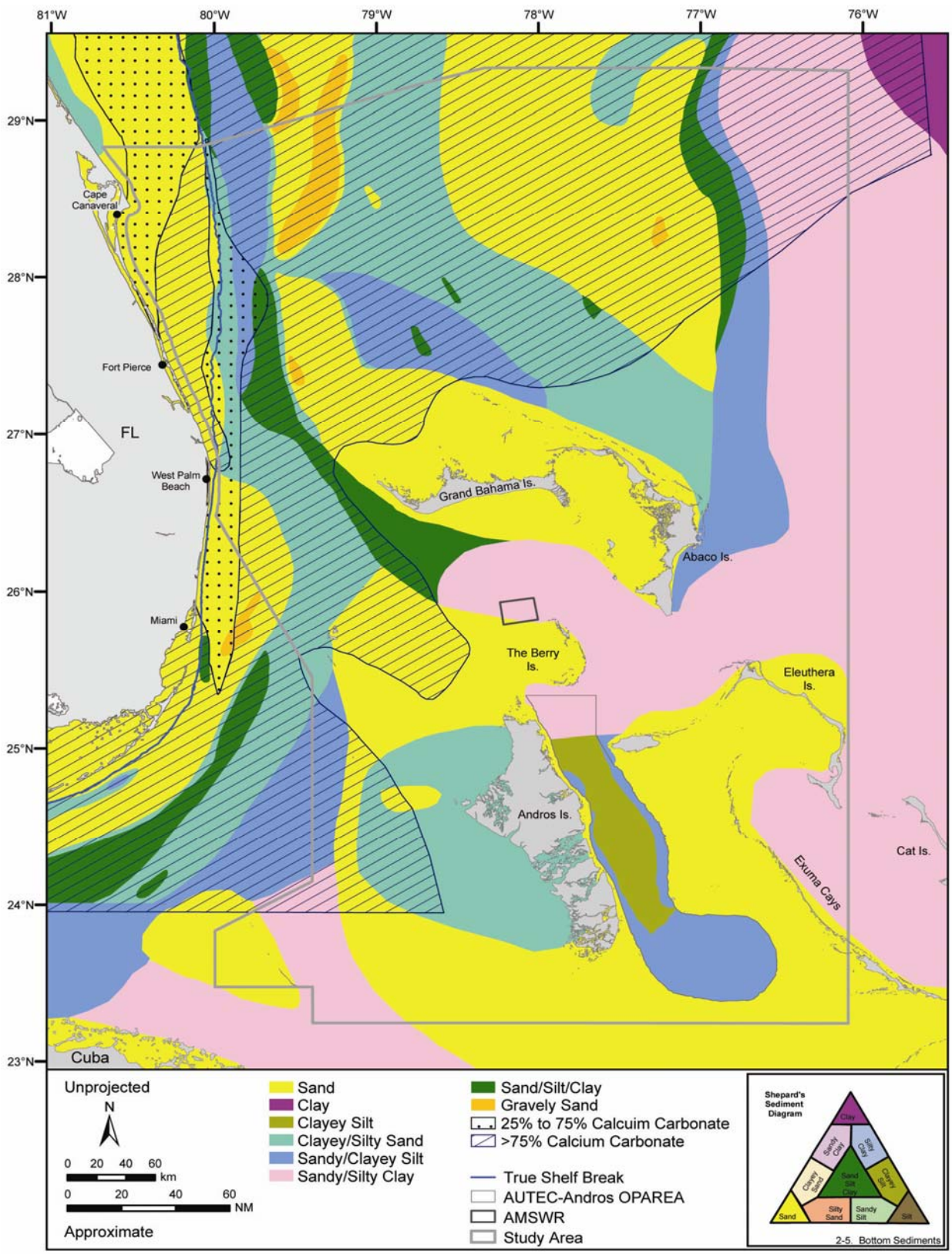

Figure 2-5. Seafloor sediment types occurring in the study area and (where available) the percentage of calcium carbonate ($CaCO_3$) contained in sediments. Source data: Amato (1994) and USGS (2000). Source information: MGS (2005). Map adapted from: Busby (1962b) and Emery and Uchupi (1972).

drive thermohaline or vertical circulation. Thermohaline circulation causes movement in water masses at all levels of the water column (i.e., deep and surface), but is dominated by wind-driven circulation at the surface (Pickard and Emery 1990; Open University 2001).

2.4.1 Surface Circulation in the Study Area

Warm (>26°C) surface waters from the Gulf of Mexico flow through the Florida Straits as the Florida Current and dominate surface circulation in the study area (Figures 2-6 and 2-7). The Florida Current and Gulf Stream Current comprise the downstream end of the Gulf Stream System, the complex system of surface currents that flows from the Caribbean Sea into the Gulf of Mexico and northwestern Atlantic Ocean. The Gulf Stream System is composed of the following surface currents: Caribbean Current, Yucatan Current, Loop Current, Florida Current, and Gulf Stream Current. The Antilles Current enters the study area from the southeast bringing warm equatorial waters into the Bahamas and ultimately feeding into the Gulf Stream north of Little Bahama Bank (Pickard and Emery 1990).

Only the Florida Current, Antilles Current, and Gulf Stream Current occur in the study area and will be discussed in detail. There has been some debate in the scientific community on the location of the transition point between the Florida Current and the Gulf Stream Current. Some oceanographers describe the Florida Current as extending along the entire east coast of Florida (Sverdrup et al. 1970; Pickard and Emery 1990; Gyory et al. 2005), whereas others terminate the Florida Current along Florida's east coast or simply refer to the current as the Gulf Stream (Jones et al. 1985; Leaman et al. 1989; Lee et al. 1991; Fiechter and Mooers 2003). In this MRA the transition between the Florida Current and the Gulf Stream Current occurs at the study area boundary off the southeast coast of Florida. The transport, circulation effects, and other oceanographic features associated with the current as it passes through the study area are described below regardless of how scientists refer to the current in the published literature.

2.4.1.1 Florida Current

The Florida Current is a strong east-northeast flowing current that connects the Loop Current to the Gulf Stream Current within the Florida Straits (Peters et al. 2002; Figure 2-7). Transport in the Florida Current is probably the most well understood of any current in the world, due primarily to the restrictive opening into the Straits and the importance of this water flow to equalizing the mass balance between the North and South Atlantic Oceans (Schmitz and Richardson 1991). Transport is measured consistently at about 30 Sverdrup (Sv ≡ 10^6 m^3 s^{-1}) in the Florida Straits at 27°N and increasing to 33 Sv at 29°N (Leaman et al. 1989; Gyory et al. 2005). More than 45% of the water flowing through the Florida Straits originated in the tropical South Atlantic while the remaining 55% originated in the North Atlantic Ocean (Schmitz and Richardson 1991). A seasonal cycle exists in the water volume transport in the Florida Current; the minimum transport occurs in fall while maximum transport occurs in summer (Maul and Vukovich 1993).

Although suggested in earlier research, there does not appear to be a statistically significant relationship between the position of the Loop Current and the volume of water transported in the Florida Current (Maul and Vukovich 1993). The Florida Current and Loop Current influence the coastal flow of water in the area of the Florida Keys. The axis of the Florida Current is located 24 km offshore of Miami in the north and 80 km offshore of Key West in the southwest, and the current meanders in an onshore-offshore shift from its axis in periods of one to two weeks (Lee et al. 1992).

Frontal eddies occur along the East Florida Shelf (EFS) throughout the entire year and vary in location, size, and duration depending on several oceanographic and climatological factors including wind stress, Florida Current transport, and tidal fluctuations (Lee and Williams 1988; Fiechter and Mooers 2003).

Frontal eddies typically form when warm Florida Current waters meander seaward beyond the shelf break allowing colder slope waters to upwell onto the EFS. The colder waters move northward with the Florida Current as cyclonic (cold-core eddies), and each eddy usually drags or detrains a warm water filament from the Florida Current along its shoreward boundary (Fiechter and Mooers 2003). The process of eddy formation significantly enhances cross-shelf transport which plays an important role in nutrient cycling, distribution of larval fish species, and the offshore transport of pollutants (Haus et al. 2004; Fiechter and Mooers 2003). The diameter of frontal eddies on the EFS ranges from 9 to 31 km between Miami and Ft.

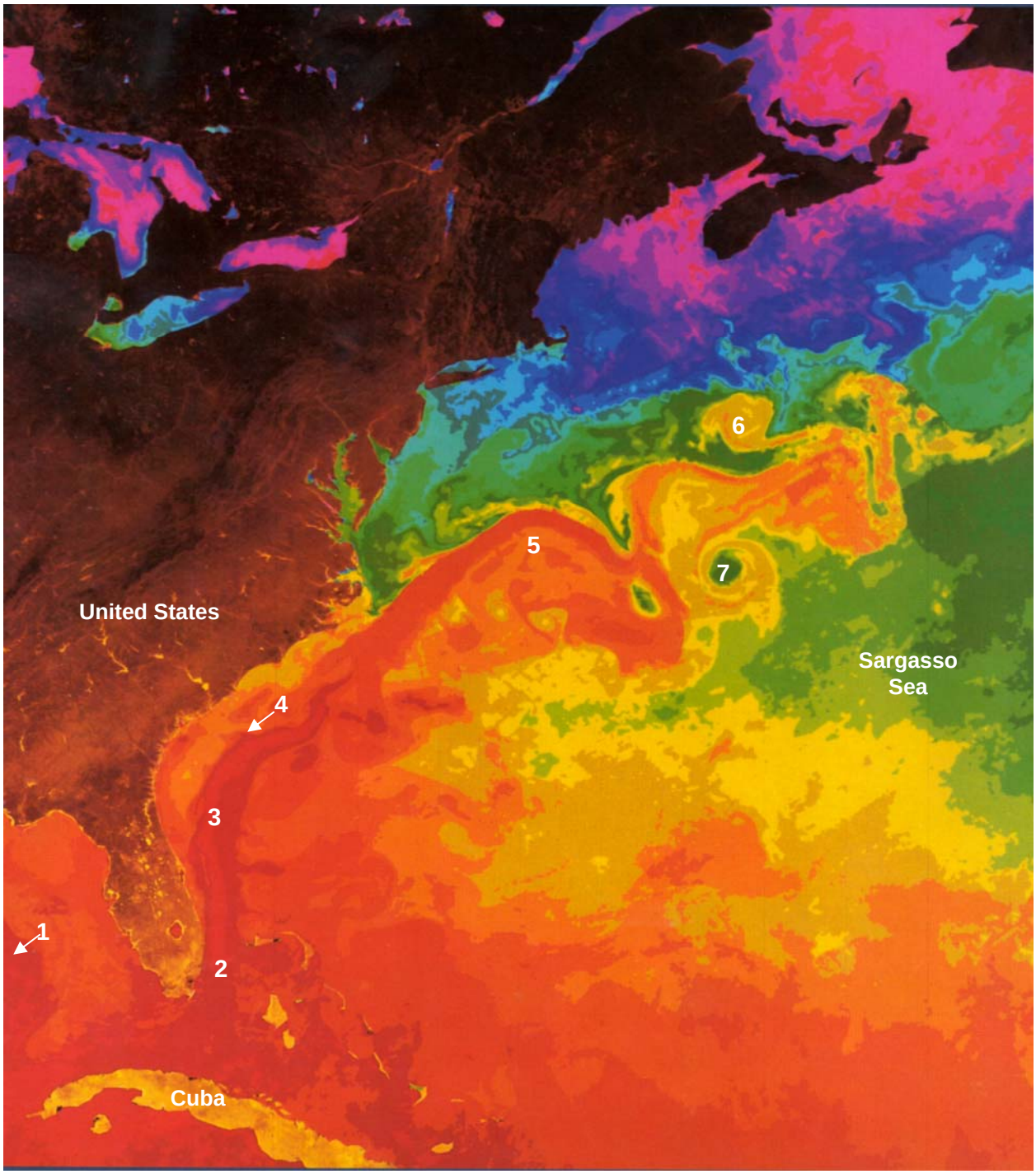

Figure 2-6. Composite image of the sea surface temperatures found in the western North Atlantic Ocean during the first week of April 1984. Data were collected using the Advanced Very High Resolution Radiometer (AVHRR) aboard NOAA polar-orbiting satellites. Red and orange colors are warm temperatures, 24° to 29°C; yellows and greens range from 17° to 23°C; blues from 10° to 16°C; and purples are cold, 2° to 9°C. The Gulf Stream System, including the Loop Current (1), Florida Current (2), and Gulf Stream Current (3), appears like a warm river as it flows northward. Along the Gulf Stream front, finger-like extensions, or frontal eddies (4), form when the Gulf Stream is farthest from shore. As the Gulf Stream moves offshore, it begins to meander (5), with some meanders pinching off to form warm-core rings (6) or cold-core rings (7). Source map (scanned): University of Miami (1995).

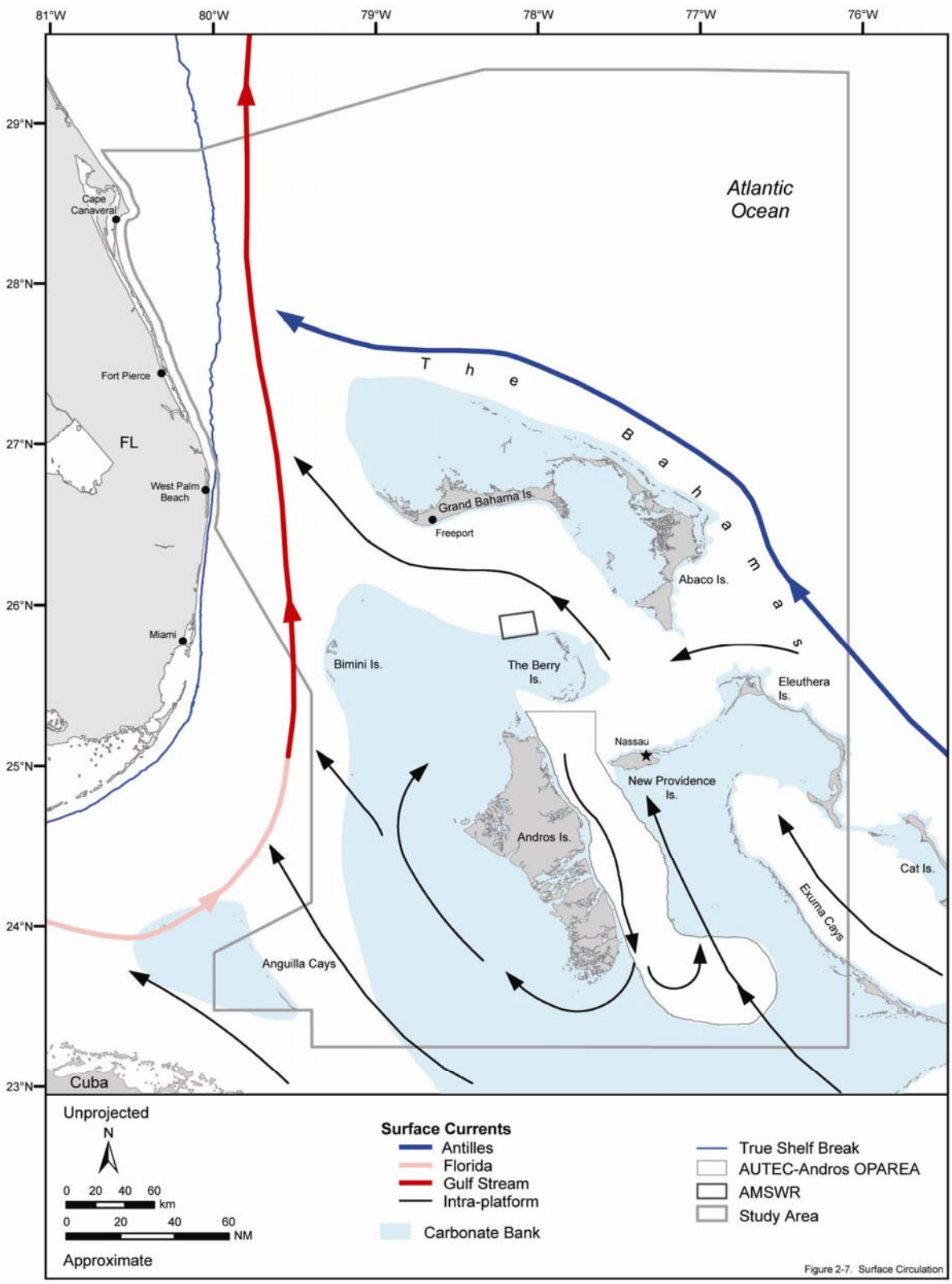

Figure 2-7. Surface circulation in the study area including major surface currents contributing to the Gulf Stream System and generalized current flow on the Bahama banks. Source map (scanned): General Oceanics, Inc. (1986) and Davis et al. (1996). Source Information: Podeszwa (1991), Colin (1995), Georges et al. (1996), Calsbeek and Smith (2003), Rendle-Bühring and Reijmer (2005), and Rowe et al. (2005).

Lauderdale. North of 27.5°N, eddy dimensions increase to 31 to 50 km in the across-shelf direction and 100 to 200 km in the along-shelf direction (Fiechter and Mooers 2003). Eddies typically last one to three weeks with a reoccurrence period of about one week, and extend to depths of about 400 m (Lee et al 1991; Fiechter and Mooers 2003).

2.4.1.2 Antilles Current

The Antilles Current is a somewhat erratic western boundary current flowing northwesterly along the eastern, discontinuous coastline of the Greater Antilles (including the Bahamas) and ultimately merging with the Florida Current to the north of Little Bahama Bank (Figure 2-7). Mooring data acquired over approximately 5 years indicate that mean northward volume transport of the Antilles Current is about 5 ± 2 Sv for the upper 800 m with an intensified jet at about 400 m (Lee et al. 1996). The intensity of the flow is highly variable with fluctuations in transport of ± 10 Sv reported on annual timescales that have led some oceanographers to dispute the existence of the current as a consistent feature (Olson et al. 1984; Rowe 2005). These fluctuations are attributed to the formation of wave-like eddies with mean periods of 30 and 100 days propagating westward at speed of 9 and 4 cm s^{-1}, respectively. The 30 day oscillations are consistent with baroclinic instabilities generated along the subtropical convergence zone in the mid Atlantic, and the 100 day oscillations appear to be caused by anticyclonic eddies propagating at the thermocline seaward of the Bahamas and resemble baroclinic Rossby waves (Lee et al. 1990; Lee et al. 1996). When they occur, both anomalies tend to intensify the northward flow of the current. The width of the Antilles Current ranges between about 80 and 100 km. A southward flowing and broader Deep Western Boundary Current (DWBC) with a mean transport estimated between 18 and 40 Sv flows beneath (>800 m) the upper level Antilles Current (Lee et al. 1996; Chave et al. 1997; Meinen et al. 2004). Lee et al. (1996) concluded that the transport of the Antilles Current is required, along with that of the Florida Current, to balance the interior Sverdrup circulation in the North Atlantic, and therefore does not contribute to exchange between the hemispheres. Instead, the Antilles Current forms the western boundary needed to close a subtropical wind-driven gyre located to the east. This conclusion is supported by the lack of tropical waters found in the Antilles Current (Lee et al. 1996). Furthermore, maximum seasonal transport has been linked with strengthening of the Bermuda-Azores High and the northeasterly trade winds in late fall and early winter (Lee et al. 1996).

2.4.1.3 Gulf Stream Current

The western continental margin of any ocean basin is the location of intense boundary currents, and the Gulf Stream Current is the western boundary current found in the North Atlantic Ocean (Figure 2-5). The Gulf Stream Current is part of a larger current system called the Gulf Stream System that also includes the Loop Current in the Gulf of Mexico, the Florida Current in the Florida Straits, and the North Atlantic Current in the central North Atlantic Ocean. The Gulf Stream Current is a powerful surface current, carrying warm water into the cooler North Atlantic just north of the study area (Pickard and Emery 1990; Verity et al. 1993). Surface velocities range from 4 to 9 km/hr and the water temperature is generally 25° to 28°C (Mann and Lazier 1996). The Gulf Stream is usually sharply defined on its west and north side (or wall) but much less so on its east or south sides (Pickard and Emery 1990). Transport in the Gulf Stream off of Cape Hatteras is estimated at 93 Sv (Leaman et al. 1989). In general, the Gulf Stream flows roughly parallel to the coastline from the Florida Straits to Cape Hatteras, where it is deflected away from the North American continent and flows northeastward past the Grand Banks. The Gulf Stream's path in the North Atlantic varies on a timescale of approximately nine months. While stratification of the water column and other factors may play a role, the variability of the Gulf Stream position is likely due to instability of its mean path in the Cape Hatteras area as well as to climatic variability such as the NAO (Schmeits and Dijkstra 2000; Pershing et al. 2001).

2.4.1.4 Circulation on the Bahama Banks

Shallow water circulation on the Bahama banks is variable and highly influenced by surface winds. In general, surface currents flow to the northwest under the influence of the prevailing easterly trade winds and geostrophic adjustment (Figure 2-7). Drifters released in Exuma Sound showed a distinctly northwesterly flow as well as the presence of small scale eddies and jets. Current speeds were measured up to 19.8 cm s^{-1} (Colin 1995). Counter currents flowing south or southwesterly are also present in the

TOTO along the east coast of Andros Island and diverging from the Florida Current towards the Bimini Islands (Podeszwa 1991; Georges et al. 1996).

2.4.2 Deep Water Circulation in the Study Area

For practical reasons, deep water circulation in the study area is not nearly as well understood as surface water circulation. Water masses derived wholly or in part from the deep water masses described below are driven primarily by thermohaline circulation but are also influenced by physical processes including drag from surface currents, geostrophic adjustment, and interaction with bottom features. Along the extreme eastern boundary of the study area bottom depths exceed 5,000 m. The Deep Western Boundary Current (DWBC) flowing south along the western North Atlantic coast and, in the study area beneath the Antilles Current, has been the focus of recent studies to better understand the return flow of deep waters in the North Atlantic (Meinen et al. 2004; Bryden et al. 2005; Johns et al. 2005). The DWBC is derived from North Atlantic Deep Water which originates in the northern latitudes of the North Atlantic as part of the global circulation process.

Baroclinic instabilities propagating westward have been shown to affect the DWBC as well as the Antilles Current. As these anomalies encounter the Blake-Bahama Escarpment the DWBC tends to shift offshore (Lee et al. 1996).

2.4.2.1 North Atlantic Deep Water

The most abundant deep water mass in the North Atlantic Ocean is North Atlantic Deep Water (NADW), which is a mixture of water from several sources and is characterized by its high oxygen content (Wüst 1964). Iceland-Scotland Overflow Water (ISOW) crosses the Mid-Atlantic Ridge into the western basin of the North Atlantic where it joins the Denmark Strait Overflow water. This combined flow mixes to form NADW and flows northward along the coast of Greenland, then southward along the Labrador coast, past the Grand Banks (Kennett 1982; Schmitz et al. 1987; Pickard and Emery 1990). Once this water mass reaches the continental slope, it is defined as the DWBC, which flows southwest along the continental rise below 2,000 m (Schmitz et al. 1987) and crosses the Gulf Stream near Cape Hatteras. This southward flow is a permanent feature of the deep circulation of the Atlantic Ocean. The NADW can be considered as a countercurrent flowing beneath the Gulf Stream and beneath the Antilles Current at a rate of 6 to 18 cm s^{-1} (Wüst 1964).

NADW also enters the study area by first flowing into the Gulf of Mexico through the Yucatan Channel (sill depth ~1,850 m) and then out of the Gulf through the comparatively shallow Florida Straits (sill depth of ~800 m) (Schmitz and Richardson 1991; Wiseman and Sturges 1999). This water mass is characterized by a salinity of 34.97 practical salinity units (psu) (Davis et al. 1996).

2.4.2.2 Antarctic Intermediate Water

Antarctic Intermediate Water (AAIW) forms at 50°S and flows northward throughout the South Atlantic Ocean into the western North Atlantic Ocean. This water mass moves north and enters the study area through the Yucatan Channel and the Gulf as a distinctive body of nutrient-rich, salt-deficient, and oxygen-poor water. Part of this water mass is also associated with the deep Gulf Stream water. A salinity signature of 34.84 to 34.88 psu characterizes AAIW and its salinity minimum occurs between 800 to 1,000 m in the eastern Gulf and at slightly shallower depths in the western Gulf (Davis et al. 1996).

2.4.2.3 Subtropical Underwater

Subtropical Underwater (SUW) forms in the North Atlantic and is characterized by a distinctive salinity maximum of 36.6 to 36.7 psu and temperature ranging from 12° to 24°C. This water mass enters the Gulf of Mexico through the Yucatan Channel, and this water mass has been detected in the Florida Current with a temperature of 18°C beneath a less saline and warmer layer of surface water (Schmitz and Richardson 1991; Davis et al. 1996).

2.4.3 Upwelling

Upwelling is the process by which departing surface water is replaced by deeper waters which “upwell” to the surface. Upwelling can either be wind-driven or dynamic, that is, induced by the interaction of currents with density layers or physiographic features. Along the U.S. Atlantic coast upwelling is both wind-driven

and a result of dynamic uplift (Shen et al 2000; Lentz et al. 2003). When coastal upwelling occurs, colder, nutrient- and oxygen-rich water from below the pycnocline is transported vertically to replace warmer, nutrient-poor surface water that has been entrained or driven seaward (Mann and Lazier 1996). In wind-driven upwelling, surface water is transported horizontally in a direction perpendicular to that of the prevailing wind (see Ekman spiral, Pickard and Emery 1990). Deep, cold water moves vertically or upwells to the surface to replace the departing surface water.

There are coastal areas of the world where persistent upwelling-favorable winds cause upwelling to occur nearly year-round. Major upwelling areas of the world are found off the coasts of Peru, California, and southwestern Africa. Upwelling usually leads to increased surface primary productivity as higher concentrations of dissolved nutrients in the upwelled water fuel growth and reproduction of phytoplankton (Mann and Lazier 1996; Open University 2001).

Upwelling also occurs along ocean fronts or frontal boundaries, such as those formed along the western perimeter of the Gulf Stream throughout the SAB, including off the coast of southeastern Florida. When Gulf Stream meanders intrude onto the Florida-Hatteras Shelf, unstable frontal boundaries are set up between the cold shelf waters and the warm Gulf Stream waters, and dynamic upwelling events often occur (Lee et al. 1991; Fiechter and Mooers 2003; Savidge 2004). The upwelling regions propagate north with the Florida Current, entraining upwelled waters along the EFS near the shelf break (Fiechter and Mooers 2003). Regions of persistent or frequent upwelling often are areas of enhanced biological productivity, and they may attract fish, seabirds, and marine mammals as foraging grounds (Fiechter and Mooers 2003; Schreiber and Burger 2001; Walker et al. 2005).

Transient upwelling and downwelling events occurring on the Bahama banks contribute to across-shelf transport and the enrichment of shelf waters with nutrients (Smith 2004). In 1998, following widespread coral bleaching due to abnormally high water temperatures, corals located in areas where frequent upwelling events occurred (e.g., southern end of Cat Island, east of Exuma Sound) recovered faster than corals that experienced frequent downwelling events (e.g., along the east coast of northern Eleuthera Island) (Riegl and Piller 2003). Colder, nutrient-rich waters that were upwelled to depths where corals were recovering enhanced growth and provided a refuge from lethally warm surface waters, whereas corals located in areas dominated by downwelling events suffered from an influx of the warmer surface waters and did not recover as well (Riegl and Piller 2003). Upwelling is also known to occur along the western margin of Exuma Sound (Riegl and Piller 2003), and transient, small-scale upwelling events are also likely where northward currents travel along the eastern coasts of islands as well as at the core of cyclonic eddies that may form downstream of islands (Hammer and Hauri 1981; Mann and Lazier 1996).

2.5 HYDROGRAPHY

Hydrography is the study of the waters on the earth's surface including the measurement of the parameters that describe those waters. Thus hydrography for marine or ocean waters encompasses temperature, salinity, nutrient concentrations, dissolved oxygen, density, and any other parameters that may describe the physical characteristics of ocean waters. The physical and even chemical properties of marine waters vary with distance from shore and depth of water. Shallow coastal or insular waters, such as those over the Bahama banks, vary more dramatically over seasonal timescales than deep oceanic waters such as are found in the Bahamian channels, which remain almost uniformly stable throughout the year with only minor fluctuations (Podeszwa 1991). Coastal waters are heavily influenced by terrestrial input, which moderates salinity, nutrient concentration, and even temperature. Water temperatures in the deep water (~1,600 m) channels of the Bahamas can vary by as much as 20°C from waters at the surface (Podeszwa 1991). Two descriptive parameters that provide basic information about marine waters are temperature and salinity, which both affect water density, and, of particular interest in the TOTO, sound propagation. Water masses and both surface and deepwater currents can be distinguished from surrounding waters by their temperature and salinity.

2.5.1 Sea Surface Temperature

The waters of the study area are tropical to subtropical and vary little in sea surface temperature (SST) throughout the year, only fluctuating by approximately 10°C annually. Despite such low variability, seasonal changes in SST can be distinguished (Figure 2-8). The Gulf Stream's intrusion into the study

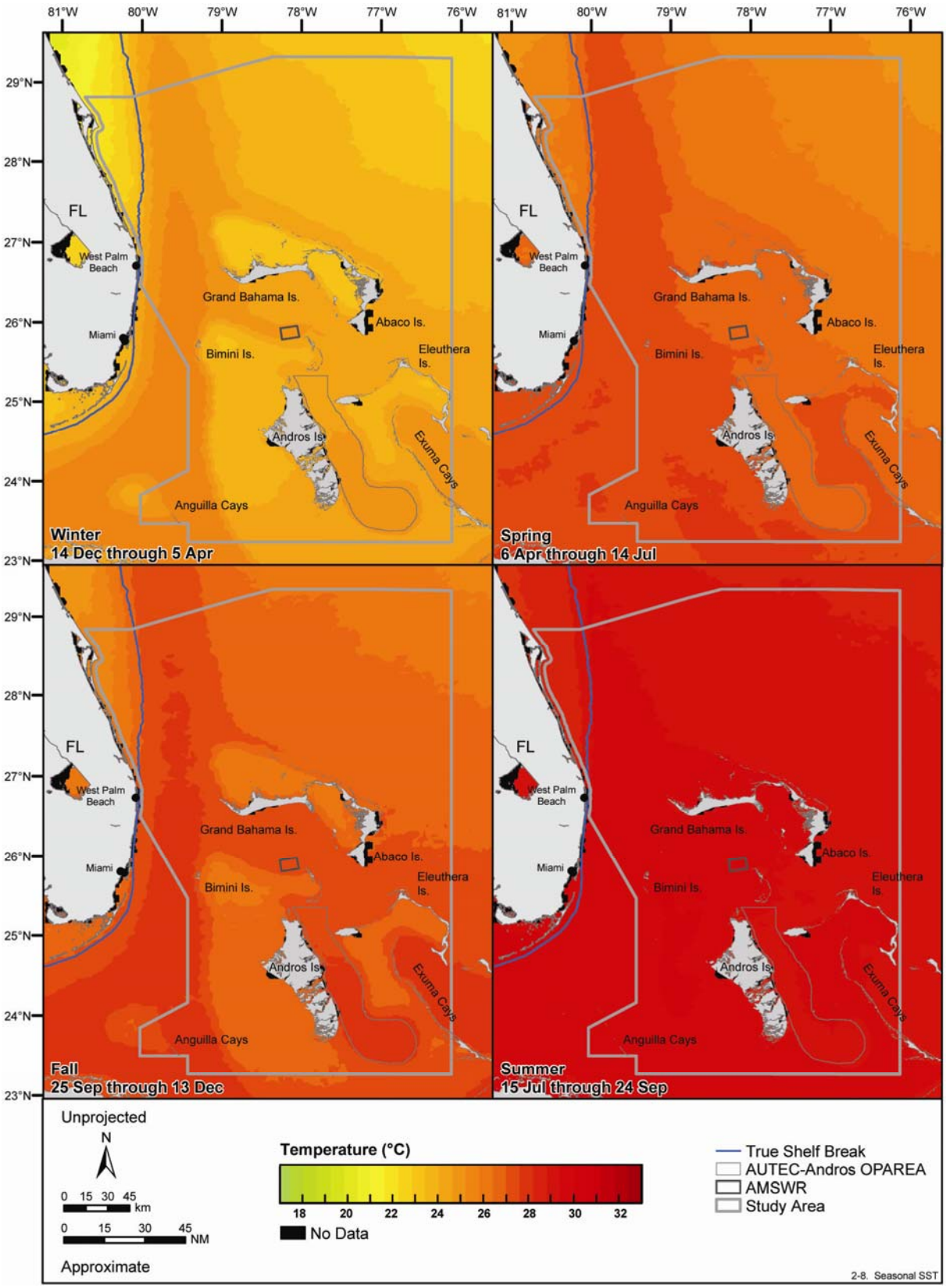

Figure 2-8. Mean seasonal sea surface temperature (SST) found in the study area from 1985 through 2004. Source data: PODAAC (2004).

area and subsequent impact on regional waters is most apparent in winter and to a lesser extent in fall; the Gulf Stream has little influence on the temperature regime in the summer when SST is nearly homogeneous (at approximately 30°C). The coolest surface water temperatures in the study area occur in waters over the EFS in winter when the water temperature drops to about 20°C. The shallow coastal waters over the EFS and the insular waters of the Bahamas become stratified in summer. As air temperatures decrease in fall, surfaces waters cool and mixing of the surface and deep water layers begins (Jones et al. 1985). The shallow shelf waters on the Bahamas banks tend to both cool and heat more rapidly as seasonal changes take place than do the surrounding deeper waters in the channels (Smith 2004).

2.5.2 Salinity

The salinity, that is the amount of dissolved minerals or salts in seawater, is most highly variable in coastal waters and in the surface ocean layer. In Florida coastal waters, the salinity ranges from 28 to 36.5 psu while the range in oceanic waters is 35 to 36.5 psu at the surface and at depth (Jones et al. 1985). Variability in shelf or coastal waters of the study area is due to the intrusion of saltier (>35 psu) water from continental slope waters and freshwater input from coastal sources. The vertical distribution of salinity does not appear to vary below 900 m depth, remaining at a fairly consistent 35 psu in the deep water channels of the Bahamas (Podeszwa 1991).

Within the waters of the AUTEC-Andros OPAREA, salinities decrease with depth and fluctuate seasonally; salinities range from 36 to 37 psu in the top 300 m and decline to 35 psu by 900 m but below that depth the salinity is unchanged (DoN 1997a). In the AMSWR, the situation differs. Surface waters in the AMSWR average about 36.4 psu but a higher salinity layer exists between 100 and 250 m and the salinity rises to about 36.8 psu; below 250 m, the salinity decreases to approximately 35.8 psu (DoN 1997a).

2.6 BIOTA

The oceanic environment in which all marine organisms exist can be divided into two primary marine zones, the pelagic zone and the benthic zone (Figure 2-2). The pelagic zone comprises the entire water column from the sea surface to the greatest ocean depths and supports the plankton and the nekton. Additional subdivisions of the pelagic zone can be made based approximately on depth; for example, the epipelagic zone ranges from the surface to 200 m and the mesopelagic zone extends from 200 m to 1,000 m (Lalli and Parsons 1997). Alternatively, the pelagic zone can be subdivided into a photic zone and an aphotic zone based on the depth to which light penetrates the water column. The photic zone extends from the surface to the depth at which light is attenuated to 1% of its surface intensity. On average this depth is approximately 200 m in the open ocean, but can be much shallower where turbidity is high such as in coastal regions. The aphotic zone begins at the depth of the photic zone and extends to the seafloor (Lalli and Parsons 1997).

The benthic zone encompasses the seafloor environment and includes the shoreline, intertidal zones, coral reefs, and the deep-sea basins. Additional subdivisions of the benthic zone are made based on depth and include the bathyal zone (200 to ~3,000 m) and the abyssal zone (~3,000 to 6,000 m). Organisms inhabiting the benthic zone are referred to collectively as the benthos; examples include attached sea grasses, sessile sponges and barnacles, corals, and any animals that crawl on or burrow into the seafloor (Lalli and Parsons 1997).

Detailed descriptions of macrofauna found in the study area, such as marine mammals, sea turtles, fish species, corals, and other invertebrates may be found in later chapters of this MRA. 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.

2.6.1 Plankton

Plankton are defined as organisms that float or drift and cannot maintain their direction against the movement of currents (Parsons et al. 1984). For the most part, they are at the mercy of their aquatic environment, moving in the direction of the prevailing current. Many zooplankton migrate vertically in the

water column, which may place them under the influence of different currents than occur at the surface, and allow them to indirectly control their lateral movement (Lalli and Parsons 1997). Plankton include phytoplankton (plant-like organisms), zooplankton (animals), bacterioplankton (bacteria), and meroplankton (individual life stages of some organisms, like the eggs or larvae of certain fish species). 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 both are quite large with some jellyfish exceeding 3 m in diameter.

2.6.1.1 Phytoplankton

Phytoplankton are single-celled organisms that are similar to plants because they photosynthesize using sunlight and chlorophyll. Phytoplankton are often referred to as primary producers, because they are at the base of the marine food chain, and are essential to the overall productivity of the ocean. Phytoplankton growth and distribution are 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 much lesser degree, other factors such as pH and salinity affect the growth and production of phytoplankton (Parsons et al. 1984). Phytoplankton distribution is patchy, occurring in environments that have optimal light, temperature, and nutrient conditions. Whenever one of these factors essential to growth 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 urban runoff. The major nutrients phytoplankton use for growth and photosynthetic processes are dissolved nitrogen (nitrate/nitrite/ammonia), phosphorous (phosphate), and silica (silicate). Phosphorous limitation is typical of freshwater systems whereas marine systems are more likely to be nitrogen limited. Important sources of nutrients in the study area include the discharge from metropolitan areas and upwelled deep waters adjacent to the Gulf Stream and Bahamian banks (Figure 2-9; Rawlins et al. 1998).

Phytoplankton biomass can be estimated from the concentration of chlorophyll measured in the water column or at the sea surface. Thus, the chlorophyll concentration is often used as a proxy for phytoplankton abundance. In continental shelf and slope waters, the concentration of chlorophyll tends to decrease with increasing distance from shore and increasing depth. Peak chlorophyll concentrations are sometimes found at the sea surface but can also be found below the photic zone (the depth to which visible light penetrates). Thus, species diversity and density of individual phytoplankton cells decreases from the coast to oceanic waters. When there is a sufficient supply of light, the amount of phytoplankton and chlorophyll will be regulated by available nutrient concentrations. Phytoplankton communities change in response to changing environmental conditions on several different scales. A phytoplankton community will change its rate of photosynthesis on a daily basis in response to changing light conditions. Large-scale variations are associated with seasonal cycles in oceanic environments, such as water temperature. Composition of the phytoplankton community varies spatially and temporally. Seasonally, blooms or high levels of phytoplankton growth are triggered by an increase in the nutrient concentration or increased availability of light. In tropical to temperate latitudes, diatoms, which are unicellular phytoplankton that possess an external skeleton consisting primarily of silica, typically bloom in the spring while dinoflagellates, which are characterized by two flagella enabling them to swim, usually bloom in the fall (Lalli and Parsons 1997).

Phytoplankton are usually found in low abundance in tropical waters due to the oligotrophic conditions (i.e., lack of nutrients). Much of the study area for southeastern Florida and the AUTEC-Andros OPAREA is oligotrophic (<0.2 milligrams chlorophyll per cubic meter [mg chl/m^3]) with a decreasing surface chlorophyll gradient (and subsequent primary productivity) from the Florida shelf break to the Sargasso Sea and in the deep water Bahamian channels throughout the year. The waters of the nearby Sargasso Sea and deep water channels of the Bahamas have levels of about 35 to 90 grams of carbon per square meter (gC/m^2) per year (Sulak 1982).

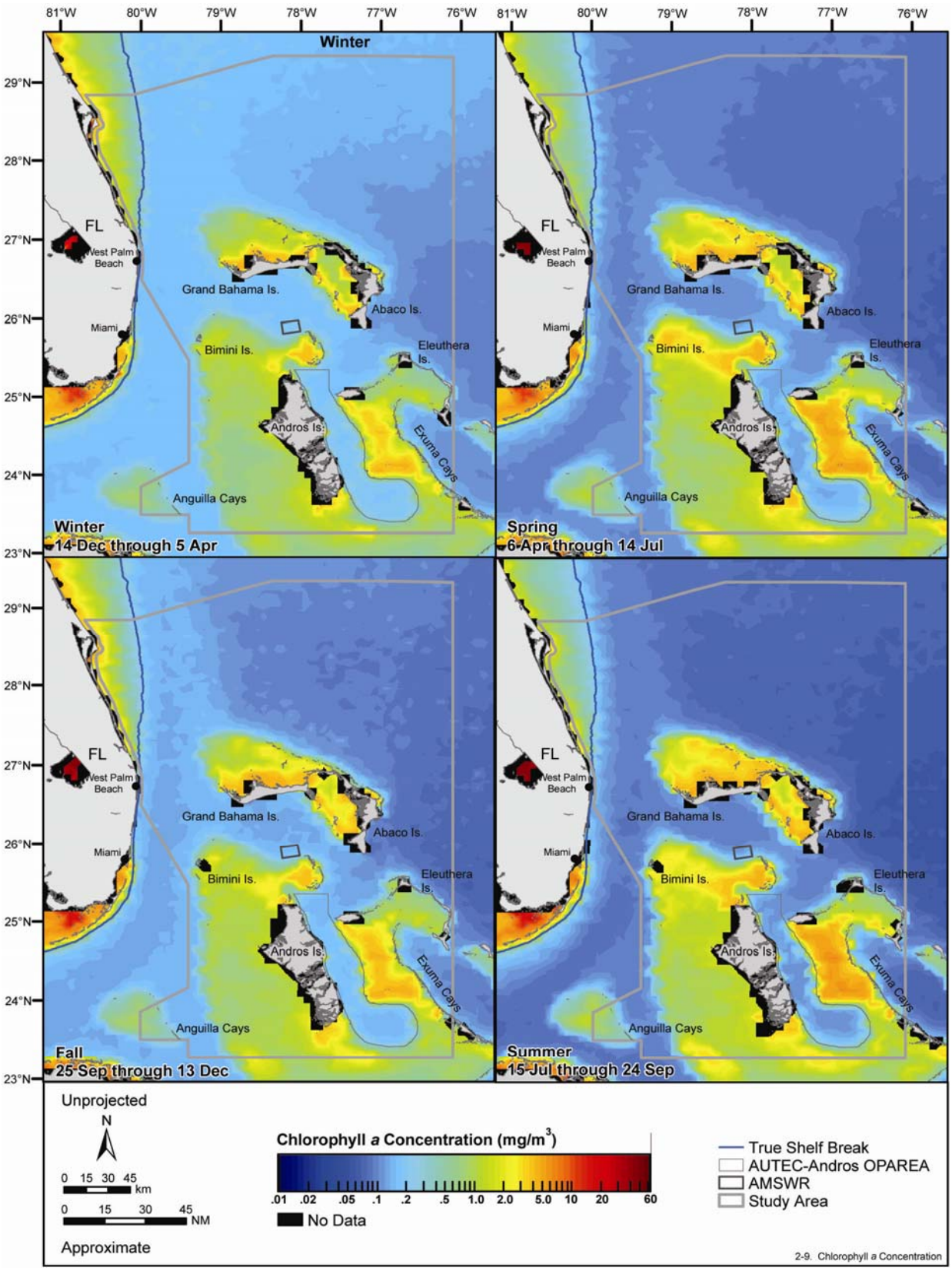

Figure 2-9. Mean seasonal surface chlorophyll *a* concentrations found in the study area from September 1997 through October 2005. Source data: NASA (2005b).

The level of primary productivity is very low (<0.2 mg chl/m^3) seaward of the continental shelf break and Bahamian channels of the study area throughout the year. The waters on the Bahama banks and Florida shelf in contrast, exhibit consistently higher productivity levels throughout the year (>2 mg chl/m^3) with highest chlorophyll concentrations consistently southeast of New Providence Island/Nassau and on Little Bahama Bank during all seasons (Figure 2-9). The higher rates of primary productivity that exist on the Bahamian banks are likely due to the constant effluent from the major urban population centers in the Bahamas (Rawlins et al. 1998).

2.6.1.2 Zooplankton

Zooplankton are aquatic animals ranging from the smallest protozoans to jellyfish. Although many are able to move sizable distances at moderate speeds and thus can perform diel vertical migrations of hundreds of meters, ocean currents and the suitability of the physical, chemical, and biological components of the hydrographic regimes they encounter determine their large-scale horizontal distributions. For instance, zooplankton will be concentrated in areas of increased primary productivity such as along frontal boundaries or upwelling areas (Lane et al. 2003). Zooplankton biomass is influenced by seasonal fluctuations in hydrography and phytoplankton abundance (Lalli and Parsons 1997).

In general, the biomass of zooplankton is higher in continental slope water (as much as four times higher; Wiebe et al. 1987) and shows stronger seasonality than in the Sargasso Sea (Allison and Wishner 1986). There is a spring enhancement of zooplankton biomass within the upper 200 m following the annual spring phytoplankton bloom (Wiebe et al. 1987). Increases in zooplankton biomass may occur when shelf water intrudes over slope water, creating a stratified water column. High nutrients and a shallow mixed layer will give rise to enhanced primary production, which in turn leads to an increase in zooplankton biomass or secondary production.

Although the warm subtropical to tropical waters of the Bahamas and the Caribbean are known for being relatively oligotrophic, the harpacticoid copepod *Macrosetella gracilis* has adopted a successful strategy for thriving in the plankton of these waters. Female *M. gracilis* attach their eggs to the cyanobacterium *Trichodesmium*, which not only provides a substrate for developing juveniles of the copepod, but also serves as a source of food. M. gracilis is common throughout the waters of the Bahamas where it constitutes an important secondary link in the food web (O'Neil 1988).

A unique physiographic feature of the Bahama banks is the presence of blue holes, submarine caves consisting of a series of interconnected vertical and/or horizontal shafts (Whitaker 1998). Several types of calanoid copepods belonging to the family Ridgewayiidae thrive in shallow waters found in these low-oxygen, alkaline cave environments, including three species recently identified belonging to the genera: *Stargatia*, *Robpalmeria*, and *Normancavia* (Fosshagen and Iliffe 2003). *Stargatia* and *Robpalmeria* were sampled from Stargate Blue Hole located along the southeast coast of Andros Island about 500 m inland; although, members Stargatia have also been taken from pelagic caves. The Normancavia species was taken from Norman's Pond Cave located in the Exumas just above the high tide line on Norman's Pond Cay (Fosshagen and Iliffe 2003). These species are generally particle feeders and are adapted to the low-nutrient (relatively clear) waters found in Bahamian blue holes. Similar species of these primitive calanoid copepods are being discovered in submarine caves worldwide, with additional genera likely to be identified as sampling in blue holes continues (Fosshagen and Iliffe 2004).

Meroplankton, including the eggs and larvae of fish and mollusk species, residing in waters over the Bahama banks are transported between the shallow water banks and the deep water channels by cross-shelf currents (Colin 1995; Smith 2004). Larvae of the commercially valuable *Strombus gigas* (queen conch) and the smaller and less commercially viable *S. costatus* (milk conch) spawn during summer, producing egg masses numbering in the hundreds of thousands, which, after hatching in 3-5 days, release larvae into the upper 5 m of the water column, where they drift with the intra-platform currents for at least 2 weeks (Stoner and Smith 1998). Intra-platform currents on the Bahama banks generally flow to the northwest; however, transient counter currents closer to sure may also be present, and some surface circulation patters bring plankton far into the Sargasso Sea (Colin 1995; Figure 2-7).

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3.0 PROTECTED SPECIES

This chapter provides detailed information on the protected marine species potentially occurring in the study area for the southeastern Florida and AUTEC-Andros OPAREA MRA. Protected species in the study area include 34 marine mammal, six sea turtle, and two fish 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, but the manatee and six large whales are also listed as endangered and thus are afforded additional protection under the ESA. Six sea turtle species are known to occur in the study area and all are threatened or endangered under the ESA. Two fish species, the smalltooth sawfish and the blind cave fish, are both designated as 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, consisting 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 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-26).

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 the movements of tagged turtles in the study area are also included in this section. Additional map figures depicting occurrence records, including nest locations, and occurrence estimates for these species in the study area may be found in Appendix C (Figures C-1 through C-7).

Section 3.3 provides information on the two protected fish species occurring in the study area. Detailed information is provided for each fish species including the description, status, habitat preferences, distribution (with a concentration on the study area), behavior, and life history. Included in this section is a map figure that portrays the locations of recent encounters with sawfish within the study area.

Section 3.4 provides an overview of the protected elkhorn and staghorn coral and includes the life history, natural and anthropogenic stressors; and distribution of both species of these Acroporid corals. Detailed information is given for each coral species consisting of the description, status, habitat preferences, and distribution in the study area for the southeastern Florida and AUTEC-Andros OPAREA. Map figures representing the known occurrence of these two protected coral species are included in this section as well.

The location of the literature citations for Chapter 3 differs from other chapters in this report. Cited literature associated with Chapter 3 is found at the end of each of the three subsections. Map figures associated with the turtle and mammal species described in Chapter 3 are located in Appendices B and C.

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3.1 MARINE MAMMALS

3.1.1 Introduction

More than 120 marine mammal species 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 34 marine mammal species with confirmed or possible occurrence within the study area are cetaceans. Cetaceans are divided into two major suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales). Toothed whales have teeth that are used to capture prey. Baleen whales use baleen to filter their prey from the water. Baleen and toothed whales also differ in aspects of life history and social organization (Tyack 1986).

3.1.1.1 Adaptations to the Marine Environment: Sound Production and Reception

Cetaceans have undergone numerous anatomical and physiological adaptations to the marine environment that are discussed in detail by Pabst et al. (1999). These include significant changes from terrestrial mammalian sensory systems to accommodate the unique challenges that a marine environment imposes. Cetaceans have well-developed senses of touch and sight, with highly-innervated skin and an eye structure that allows them to see well in air, as well as in water (van der Pol et al. 1995; Wartzok and Ketten 1999). Due to increased density, sound travels farther and faster in water than in air (Wartzok and Ketten 1999). This physical property can allow for more effective communication and echolocation but requires drastic changes in auditory and sound production structures (Wartzok and Ketten 1999). Marine mammal vocalizations often extend both above and below the range of human hearing. Sound frequencies lower than 18 hertz (Hz) are termed infrasonic and those higher than 20 kilohertz (kHz) are ultrasonic. Baleen whales generally utilize lower frequencies. Depending upon the species, mysticetes produce tonal sounds between 20 and 3,000 Hz. 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. Echolocation may allow mysticetes to navigate and orient relative to physical features of the ocean. Toothed whales also produce a wide variety of sounds (Wartzok and Ketten 1999). Species-specific broadband “clicks” with peak energies between 10 and 200 kHz are used for echolocation. Tonal vocalizations (whistles), ranging from 4 to 16 kHz, are important to communication. Individually variable burst-pulse click trains have also been identified. However, not all toothed whales fully utilize this repertoire. Sperm whales only produce clicks which presumably function in both communication and echolocation (Whitehead 2003).

Empirical data on cetacean hearing are sparse, particularly for baleen whales. However, auditory thresholds of some smaller odontocetes have been determined. It is generally believed that cetaceans should at least be sensitive to the frequencies of their own vocalizations. Indications of sensitivity ranges at various frequencies have been developed from comparisons of cetacean inner ear anatomy and structural models of ear responses to vibrations. The ears of small toothed whales are specialized for receiving high-frequency sound, while baleen whale inner ears are best suited to low or infrasonic frequencies (Ketten 1992, 1997).

General reviews of marine mammal 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: Habitat and Environmental Associations

Marine mammals inhabit most marine environments, from deep ocean canyons to shallow estuarine waters. They are not randomly distributed. Marine mammal distribution is influenced 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 associated 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. As noted by Ferguson (2005), time lags are particularly important when proxies such as chlorophyll data are used to indicate toothed whale habitat. 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 (Gregr and Trites 2001). 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; Ferguson 2005; Hastie et al. 2005; Kaschner 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 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 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 migrate. There are cases where a population probably does not have a true migration and stays year-round in an area (e.g., fin whales in the Mediterranean (Notarbartolo di Sciara et al. 2003) and possibly also in the northern Gulf of California (see Tershy et al. 1993). In other cases, the population clearly migrates, but some members may not make the full migration (e.g., gray whales, *Eschrichtius robustus*, along the west coast from California to southeast Alaska (Calambokidis et al. 2002).

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 chl *a* 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, year, and climate events (Thurman 1997).

Since most toothed whales do not have the fasting capability of baleen whales, toothed whales probably follow seasonal shifts in seasonal 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). 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). Additionally, the nearshore bottlenose dolphin stock off the mid-Atlantic U.S. coast shows a temperature-limited distribution (Kenney 1990; Barco et al. 1999), with many individuals moving in response to changes in water temperatures. These thermal shifts may cause migration directly by acting as a barrier to dolphin movement or indirectly by affecting prey movements (Barco et al. 1999).

Occurrence of cetaceans outside the area with which they are usually associated may reflect fluctuations in food availability. For example, Kenney (2001) discussed anomalous shifts in North Atlantic right whale distribution, where whales were absent from an expected area of occurrence in the Great South Channel. He attributed this to an unusually large influx of colder and fresher Scotian Shelf water that shifted zooplankton biomass. 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 (Payne et al. 1986; 1990a; 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.

Knowledge of seal composition and distribution in the northeastern U.S. has become increasingly complex. A significant increase in stranded ice seals has occurred since the late 1980s in the northeastern U.S. (Kraus and Early 1995; McAlpine and Walker 1999; Sadove et al. 1999; Slocum et al. 1999; Slocum et al. 2003). In the winter, hooded seals occur in the Gulf of Maine in increasing numbers not previously documented. McAlpine and Walker (1999) speculated that this increase may be due to overexploited fish stocks that can no longer support the currently large seal populations, forcing seals to occupy less-preferable feeding grounds to the south. Alteration in the extent and productivity of ice edge systems may affect the density of important pinniped prey, such as Arctic cod (*Arctogadus glacialis*) (Tynan and DeMaster 1997).

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). In the North Atlantic, climate variability has been directly linked to the North Atlantic Oscillation (NAO), which influences the abundance of marine mammal prey such as zooplankton and fish. In years when the NAO Index was positive, the average sea surface temperature (SST) increased, followed by 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 years, 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). More details on the NAO and climate variability in the North Atlantic Ocean may be found in Chapter 2. Much more research is necessary to gauge the direct effects on marine mammal distribution and prey due to climatic events such as the El Niño - Southern Oscillation (ENSO) and NAO.

3.1.2 Marine Mammals of Southeastern Florida and the AUTEC-Andros OPAREA

Thirty-four marine mammal species have confirmed or potential occurrence in southeastern Florida and the AUTEC-Andros OPAREA (Table 3-1). There are 31 cetacean, two pinniped (seals, sea lions, and fur seals), and one sirenian (manatee) species. Some cetacean species are resident in the study area year-round (e.g., bottlenose dolphin, beaked whales), while others (e.g., right whale, humpback whale) occur seasonally as they migrate through the area. Only rare occurrences of the West Indian manatee are anticipated in the study area. Harbor and hooded seals, as well as unidentified pinnipeds, are noted for this area, although this is well south of these species' typical ranges. Until the 1950s, the Caribbean monk seal (*Monachus tropicalis*) probably occurred off Florida and the Bahamas (Campbell 1978; Wing 1992; Claridge and Balcomb 1993; Rice 1998; Webber 2006). Additionally, a few California sea lions (*Zalophus californianus*) were found historically off Florida and in the Bahamas as feral escapees from marine parks (Layne 1965; D. Caldwell and Caldwell 1974; Campbell 1978; Schmidly 1981), though as an introduced non-native species, this species is not included in the list for the region.

The study area encompasses both the East Florida Shelf and the Bahamas, with the Gulf Stream moving through the middle, creating different oceanographic regimes. As a result, marine mammal occurrence patterns can also be different between those two areas and is presented separately within Table 3-1. Species diversity is expected to be greater off eastern Florida than in the Bahamas, in large part due to the influence of the Gulf Stream along the U.S. continental margin. The Gulf Stream Current is the single most influential oceanographic feature in this region, influencing water temperature, salinity, and nutrient availability. Meanders of the Gulf Stream typically form frontal eddies that result in localized areas of high surface primary productivity off Florida. Additionally, the Antilles Current is a western boundary current flowing northwesterly along the eastern coastline of the Greater Antilles (including the Bahamas) bringing warm waters that feed into the Gulf Stream.

In the study area, cetacean sightings are generally concentrated along Floridian and Bahamian coasts and in deep water channels of the Bahamas (Northeast and Northwest Providence channels, Tongue of the Ocean (TOTO), and Exuma Valley). This is largely reflective of the distribution of survey effort. Concentrations of sighting records in nearshore Florida waters during winter reflects the high level of survey effort to monitor North Atlantic right whales during this time of year when they occur on their calving grounds, which are federally-designated critical habitat, as well as assessing distribution of the bottlenose dolphin (Figure A-1). Critical habitat for the North Atlantic right whale does include some waters of this study area.

The cetacean community in the shallow waters of the sandy Bahamian banks (bottom depth less than 10 m) consists primarily of the bottlenose dolphin and Atlantic spotted dolphin, while deeper waters off the bank margins attract deep water cetaceans, such as pilot whales, sperm whales, and beaked whales. The TOTO is a unique inlet of deep ocean water that divides Andros from the shallow bank to the east of the Exuma Cays (see Chapter 2). The TOTO is a deep channel that in the northern extreme has a bottom depth that exceeds 2,400 m (Podeszwa 1991; Figure 2-4). AUTEC use arrays of widely spaced bottom mounted hydrophones to acoustically track undersea and surface vehicles. The Marine Mammal Monitoring on Navy Undersea Ranges (M3R) program has developed a set of signal processing tools to detect and track marine mammals using Navy range facilities (e.g., Jarvis and Moretti 2002; Ward 2002; Moretti et al. 2006a, 2006b; Morrissey et al. 2006). Marine mammal-recording activities have taken place at AUTEC for over the past 25 years, providing some information on marine mammal species transiting through the TOTO (e.g., Perkins 1987; Ward 2002). Marine mammal species identified and recorded

Table 3-1. Marine mammal species potentially occurring in the study area, their status under the Endangered Species Act (ESA) and the World Conservation Union (IUCN), and their frequency of occurrence within Florida and Bahamian waters of the study area. Naming convention matches that used in the NOAA stock assessment reports.

	Scientific Name	ESA Status	IUCN Status	Florida/The Bahamas Occurrence/Frequency[1]
Order Cetacea				
Suborder Mysticeti (baleen whales)				
Family Balaenidae (bowhead and right whales)				
North Atlantic right whale	*Eubalaena glacialis*	Endangered	Endangered	Regular/Extralimital
Family Balaenopteridae (rorquals)				
Humpback whale	*Megaptera novaeangliae*	Endangered	Vulnerable	Regular/Regular
Minke whale	*Balaenoptera acutorostrata*		Lower risk	Regular/Rare
Bryde's whale	*Balaenoptera edeni*		Data deficient	Rare/Rare
Sei whale	*Balaenoptera borealis*	Endangered	Endangered	Extralimital/Extralimital
Fin whale	*Balaenoptera physalus*	Endangered	Endangered	Regular/Rare
Blue whale	*Balaenoptera musculus*	Endangered	Endangered	Rare/Rare
Suborder Odontoceti (toothed whales)				
Family Physeteridae (sperm whale)				
Sperm whale	*Physeter macrocephalus*	Endangered	Vulnerable	Regular/Regular
Family Kogiidae (pygmy sperm whales)				
Pygmy sperm whale	*Kogia breviceps*		Lower risk	Regular/Regular
Dwarf sperm whale	*Kogia sima*		Lower risk	Regular/Regular
Family Ziphiidae (beaked whales)				
Cuvier's beaked whale	*Ziphius cavirostris*		Data deficient	Regular/Regular
Gervais' beaked whale	*Mesoplodon europaeus*		Data deficient	Regular/Regular
Blainville's beaked whale	*Mesoplodon densirostris*		Data deficient	Regular/Regular
Sowerby's beaked whale	*Mesoplodon bidens*		Data deficient	Rare/Extralimital
True's beaked whale	*Mesoplodon mirus*		Data deficient	Extralimital/Extralimital
Family Delphinidae (dolphins)				
Rough-toothed dolphin	*Steno bredanensis*		Data deficient	Regular/Regular
Bottlenose dolphin	*Tursiops truncatus*		Data deficient	Regular/Regular
Pantropical spotted dolphin	*Stenella attenuata*		Lower risk	Regular/Regular
Atlantic spotted dolphin	*Stenella frontalis*		Data deficient	Regular/Regular
Spinner dolphin	*Stenella longirostris*		Lower risk	Regular/Rare
Striped dolphin	*Stenella coeruleoalba*		Lower risk	Regular/Rare
Clymene dolphin	*Stenella clymene*		Data deficient	Regular/Rare
Common dolphin	*Delphinus delphis*		Lower risk	Rare/Rare
Fraser's dolphin	*Lagenodelphis hosei*		Data deficient	Regular/Rare
Risso's dolphin	*Grampus griseus*		Data deficient	Regular/Regular
Melon-headed whale	*Peponocephala electra*		Lower risk	Regular/Regular
Pygmy killer whale	*Feresa attenuata*		Data deficient	Regular/Rare
False killer whale	*Pseudorca crassidens*		Lower risk	Regular/Rare
Killer whale	*Orcinus orca*		Lower risk	Regular/Regular
Short-finned pilot whale	*Globicephala macrorhynchus*		Lower risk	Regular/Regular
Harbor porpoise	*Phocoena phocoena*		Vulnerable	Extralimital/Rare
Order Carnivora				
Suborder Pinnipedia (seals, sea lions, walruses)				
Family Phocidae (true seals)				
Hooded seal	*Cystophora cristata*		Lower risk	Extralimital/Extralimital
Harbor seal	*Phoca vitulina concolor*		Lower risk	Extralimital/Extralimital
Order Sirenia				
Family Trichechidae (manatees)				
West Indian manatee	*Trichechus manatus*	Endangered	Vulnerable	Rare/Rare

[1] **Regular** = A species that occurs as a regular or normal part of the fauna of an area regardless of its abundance
Rare = A species that only occurs in an area sporadically
Extralimital = A species that does not normally occur in an area and occurrence is considered to be beyond the normal range of the species even though one or more occurrence records exist

include the sperm whale, Blainville's beaked whale, minke whale, short-finned pilot whale, dolphins such as *Stenella* spp. and the bottlenose dolphin (Perkins 1987; Moretti et al. 2006a, 2006b; Morrissey et al. 2006). Note that the AUTEC marine mammal field guide (AUTEC 2000) only addresses the species that have a high expectation of being sighted in the Bahamas; therefore, some species that may possibly occur in the Bahamas (Table 3-1) are not included in the field guide. Whale and dolphin watching is a popular activity in the Bahamas. The peak season for dolphin-watching tours is late April through September (Hoyt 1999). There is a popular dolphin encounter program since the early 1980s off Grand Bahama Island, as well as Earthwatch-sponsored tours conducted by the Bahamas Marine Mammal Research Organisation (BMMRO; formerly known as Bahamas Marine Mammal Survey) since 1992 from Abaco (that includes the deep Northeast Providence Channel). Additional opportunities to swim with wild dolphins occur at Bimini, and even snorkeling tours off Andros advertise opportunities to interact with wild dolphins. Whale watching has a big impact on local economies in the area (Hoyt 1999).

The distribution of marine mammal occurrence records (sightings, strandings, and fisheries bycatch) is presented for each season (winter: 14 December to 5 April; spring: 6 April through 14 July; summer: 15 July until 24 September; and fall: 25 September till 13 December) in Appendix B. It should be noted that the number of marine mammal observations in a given area is often as much a function of the source or type of data (bycatch data versus sighting data), level of effort, and sighting conditions (sea state) as the actual marine mammal abundance in that area. Winter is the season with the highest number of occurrence records due to significant marine mammal aerial survey effort in the area, in particular, for the North Atlantic right whale and the bottlenose dolphin in coastal waters of Florida, as well as some efforts for a few years in the AUTEC-Andros OPAREA. 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.

Specific terminology and associated definitions are used to designate the occurrence levels of marine mammals in the study area. Where possible, quantities of occurrence records have been associated with occurrence levels; this was not uniformly possible as so few occurrence records exist for large portions of the study area. 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. A common occurrence is the most abundant occurrence category and refers to a species that regularly or frequently occurs in an area (or its appropriate habitat) and is usually observed, even if only for a specific season. A species that occurs commonly will optimally be associated with 50 or more occurrence records for a season or region. The present occurrence level is an intermediate category that is applicable to a species found in an area or in a specific season even though it may not always be observed; when possible, this occurrence level is associated with five or more occurrence records. A rare occurrence is the least abundant category and connotes a species that occurs only infrequently and may not occur in an area or season with regularity. The rare category is related to those species for which, at best, one to five occurrence records exist. An undetermined occurrence is assigned to those areas where insufficient information or data are available to make an accurate occurrence determination. The not expected occurrence is assigned to regions where occurrence of a species or species group is exceedingly unlikely but not beyond a reasonable possibility; this categorization is based on known habitat preferences or instances where survey effort has occurred with no resulting species observations having been documented. In the following section of this report, each marine mammal species is listed with its description, status, habitat preference, distribution (including location and seasonal study area specific occurrences), behavior and life history, and acoustic and hearing abilities. Threatened and endangered marine mammals appear first with the remaining species following in taxonomic order. Since the Bahamas adheres to the international conventions for species status outlined by the International Union for Conservation of Nature and Natural Resources (IUCN), each species' IUCN status is also given (Table 3-1).

3.1.2.1 Threatened and Endangered Marine Mammals

Seven marine mammal species with stranding or sighting records in the study area are currently listed as endangered. These include five baleen whale (North Atlantic right, humpback, sei, fin, and blue), one toothed whale (sperm whale), and one sirenian species (West Indian manatee).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The occurrence patterns for threatened and endangered (T/E) cetaceans appear in Figure B-1. Although the West Indian manatee is a T/E marine mammal, it typically occurs in waters inshore of the study area, and, therefore, is not included on this figure. The West Indian manatee is mapped separately within the MRA.
  - Winter—The right whale is driving the occurrence patterns for T/E cetaceans in Figure B-1 on the East Florida Shelf. This species is common in coastal waters off Florida north of Fort Pierce during winter. Both right whales and humpback whales are present in waters over the continental shelf off Florida. Offshore the Blake Plateau and in deep waters off the banks of the Bahamas, the sperm whale drives the occurrence patterns which reflect a common occurrence of T/E cetaceans in these areas. In shallow waters over the Bahamas, rare occurrences of both the humpback whale and the right whale might be possible.
  - Spring/Summer/Fall—In waters over the East Florida shelf, there is a rare occurrence for T/E cetaceans, based on predicted occurrence patterns for humpback and right whales. As in winter, offshore the Blake Plateau and in deep waters off the banks of the Bahamas, the sperm whale drives the occurrence patterns which reflect a common occurrence of T/E cetaceans in these areas. In waters over the Bahamian banks, there is a rare occurrence of T/E cetaceans based on the possibility of encountering humpback whales here (or even, very unlikely, a right whale).

- North Atlantic Right Whale *(Eubalaena glacialis)*

Description—Adults 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” that assist researchers in individual identification (Kraus et al. 1986a).

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 2001a). North Atlantic right whales are classified as endangered under the ESA and, therefore, considered to be a strategic stock (Waring et al. 2006).

Kraus et al. (2005) reported that there were approximately 350 individuals, including about 70 mature females, in the western North Atlantic (Kraus et al. 2001). The most recent draft NOAA Stock Assessment Report states that in a review of the photo-identification recapture database for October 2005, 306 individually recognized whales were known to be alive during 2001 (NMFS 2006a). This represents a minimum population size, and no estimate of abundance with an associated coefficient of variation has been calculated for this population (NMFS 2006a).

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.

One calving and two feeding areas in U.S. waters are designated as critical habitat for North Atlantic right whales (NMFS 1994; NMFS 2005a; Figure 3-1). Critical habitat designations affect federal agency actions or federally-funded or permitted activities.

In an effort to reduce ship collisions with critically endangered North Atlantic right whales, an early-warning system (EWS; the Right Whale Sighting Advisory System) was instigated in 1994 for the calving region along the southeastern U.S. coast. This system was extended in 1996 to the feeding areas off New England (MMC 2003). In 1999, a Mandatory Ship Reporting System was implemented by the U.S. Coast Guard (USCG 1999; USCG 2001). This reporting system requires specified vessels (Navy ships are exempt) to report their location while in the nursery and feeding areas of the right whale (Ward-Geiger et al. 2005). At the same time, ships receive information on locations of North Atlantic right whale sightings in order to avoid whale collisions. Although the Navy is exempt from ship reporting, a large investment is made by the Navy to maintain the operation of this system.

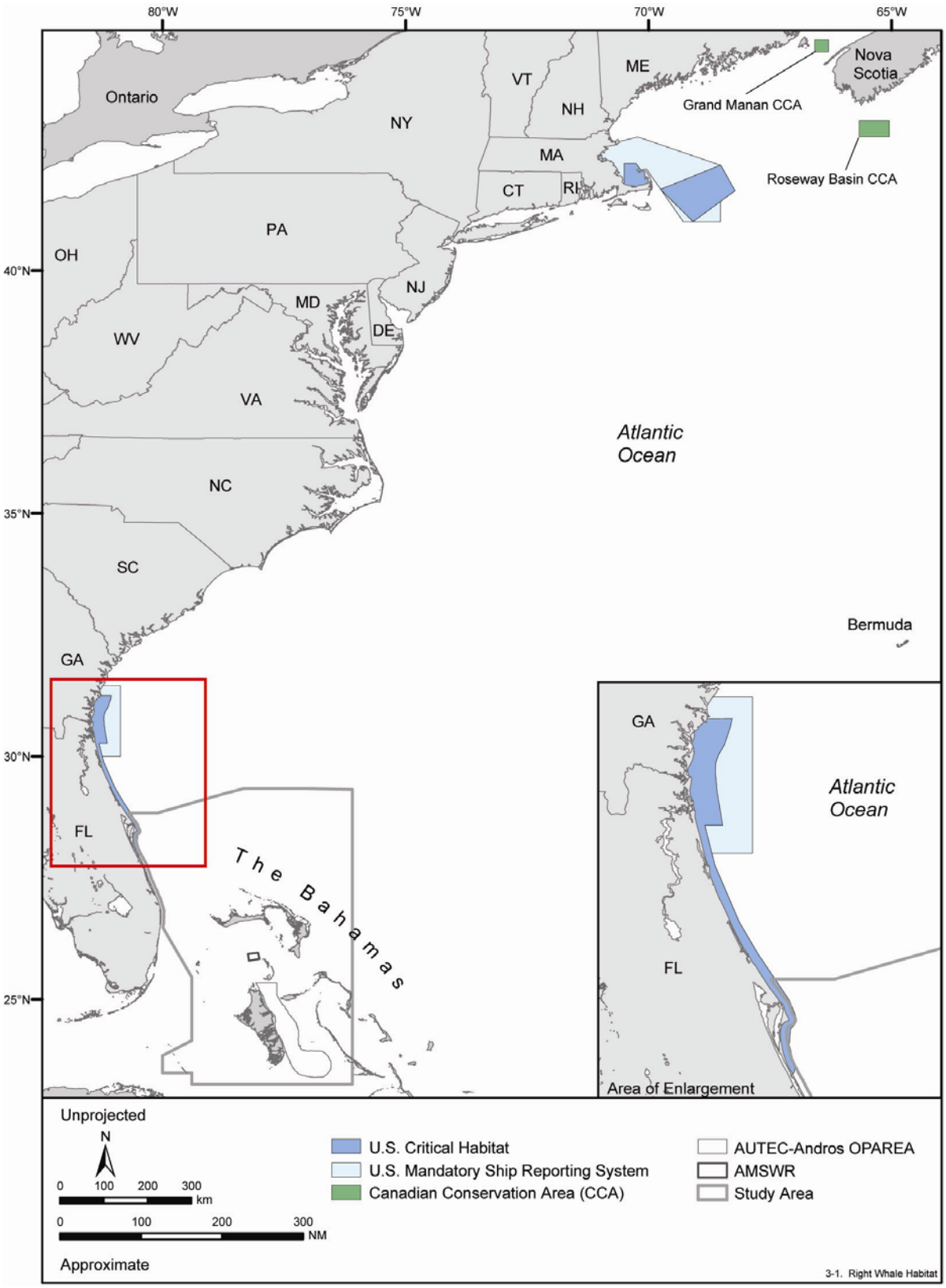

Figure 3-1. Designated critical habitats, conservation areas, and mandatory ship reporting zones for North Atlantic right whales. Source information: NMFS (1994), USCG (1999), and DFO (2003).

Geographical boundaries of the area in the southeastern U.S. include coastal waters within roughly 46 km of shore along a 167 km stretch of the Atlantic coast in Florida and Georgia (Figure 3-1). However, based upon recent modeling of North Atlantic right whale distribution and influence of water temperature, high whale densities have been shown to extend more northerly than the current boundary of the calving critical habitat (Garrison et al. 2005). Additional routing measures are also being studied to further reduce ship strikes (USCG 2005). Therefore, it is likely that the defined boundaries may soon shift to reflect this distribution. In November 2006, NOAA established new recommended routes for vessels leaving the ports of Jacksonville and Fernandina, Florida; Brunswick, Georgia; and Cape Cod Bay, Massachusetts (NOAA 2006e). These routes are voluntary at this time and are included on the updated NOAA nautical charts (http://www.noaa.gov/charts.html) (NOAA 2006e).

Reporting only takes place in the southeastern U.S. from 15 November through 15 April. In the northeastern U.S., the reporting system is year-round and the geographical boundaries include the waters of Cape Cod Bay, Massachusetts Bay, and the Great South Channel east and southeast of Massachusetts. NOAA recently proposed to modify key shipping routes into Boston which would significantly reduce the risk of ship collisions (NOAA 2006f). Additional proposed regulations include a speed restriction of 10 knots or less during certain times of the year along the U.S. east coast; these restrictions would only apply to vessels greater than 20 m in length (NMFS 2006b).

In 1993, the Canadian government designated two North Atlantic right whale conservation zones in Canada: Grand Manan Basin in the lower Bay of Fundy and Roseway Basin between Browns and Baccaro banks (Figure 3-1). There are no regulations associated with these conservation zones, although mariners are requested to be aware of North Atlantic right whale occurrences in the area. In July 2003, shipping lanes between New Brunswick and Nova Scotia in the Bay of Fundy were shifted 7.4 km to the east, away from North Atlantic right whale feeding areas (Anonymous 2003). The new lanes help to protect North Atlantic right whales by organizing ship traffic flow in and around an area where North Atlantic right whale densities are the greatest. Recent studies of North Atlantic right whales show that animals do not respond to ship noise but react strongly to alert signals produced by vessels (Nowacek et al. 2004). However, typical reaction was a rapid surfacing behavior, which may make them more vulnerable to ship strike.

The Atlantic Large Whale Take Reduction Plan (ALWTRP) was developed to reduce the incidental mortality and serious injury of four species of whales (North Atlantic right, fin, humpback, and minke) due to incidental interaction with commercial fishing activities (NMFS 1999c). The ALWTRP relies on a combination of fishing gear modifications and time/area closures to reduce the risk of whales becoming entangled in commercial fishing gear (and potentially suffering serious injury or mortality as a result). Current regulations can be viewed at http://www.nero.noaa.gov/whaletrp/.

Habitat Preferences—Right whales on the winter calving grounds are most often found in very shallow nearshore waters, in cooler SST 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 et al. 2005; Glass et al. 2005). During January and February, there is a possible southward shift in whale distribution toward warmer SSTs in the region monitored by the EWS. However, in the relatively warmer and southernmost survey zone (nearshore waters of Florida), right whales concentrate in the northern, cooler portion (Keller et al. 2006). Warm Gulf Stream waters appear to represent a thermal limit (both southward and eastward) for right whales (Keller et al. 2006).

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). 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). 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).

Distribution—Right whales occur in sub-polar to temperate waters. North Atlantic right whales are found primarily in continental shelf waters between Florida and Nova Scotia (Winn et al. 1986). 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; Silber and Clapham 2001). There are documented records for this species in the Gulf of Mexico; mother/calf pairs have been sighted as far west as Texas (Zoodsma 2006).

Most North Atlantic right whale sightings follow a well-defined seasonal migratory pattern through several consistently utilized habitats (Winn et al. 1986; Figure 3-2). 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 in 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).

During the spring through early summer, North Atlantic right whales are found on feeding grounds off the northeastern U.S. and Canada. Individuals may be found in Cape Cod Bay in February through April (Winn et al. 1986; Hamilton and Mayo 1990) and in the Great South Channel east of Cape Cod in April through June (Winn et al. 1986; Kenney et al. 1995). Right whales are found throughout the remainder of summer and into fall (June through November) on two feeding grounds in Canadian waters (Gaskin 1987, 1991). The peak abundance is in August, September, and early October. The majority of summer/fall sightings of mother/calf pairs occur east of Grand Manan Island (Bay of Fundy), although some pairs might move to other unknown locations (Schaeff et al. 1993). Jeffreys Ledge appears to be important habitat for right whales, with extended whale residences; this area appears to be an important fall feeding area for right whales and an important nursery area during summer (Weinrich et al. 2000). The second feeding area is off the southern tip of Nova Scotia in the Roseway Basin between Browns, Baccaro, and Roseway banks (Mitchell et al. 1986; Gaskin 1987; Stone et al. 1988; Gaskin 1991). The Cape Cod Bay and Great South Channel feeding grounds are formally designated as critical habitats under the ESA (Silber and Clapham 2001).

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; it is formally designated as a critical habitat under the ESA (Figure 3-1).

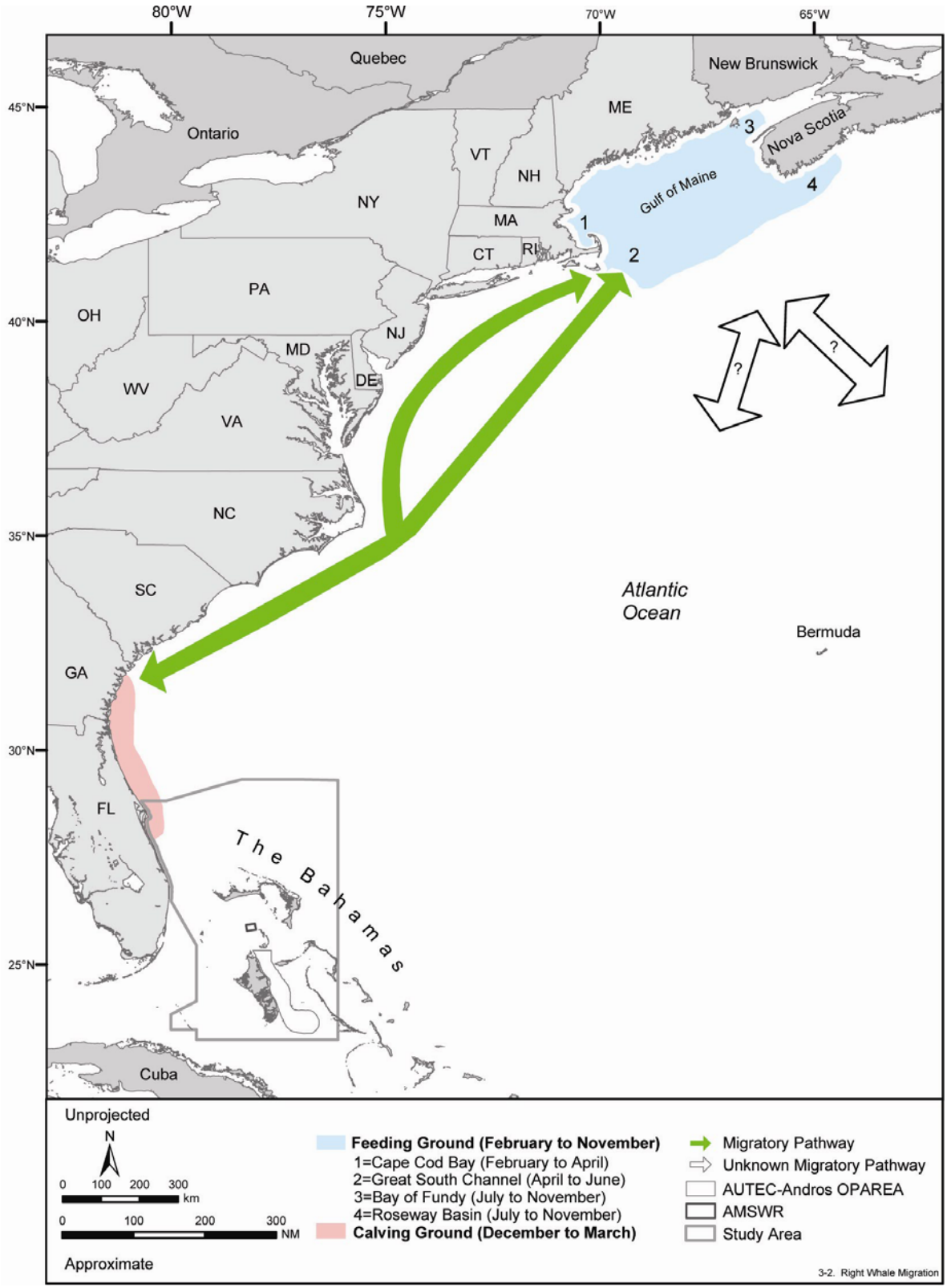

Figure 3-2. North Atlantic right whale migration patterns. This species migrates in at least two separate pathways, though some whales may remain in the feeding grounds throughout the winter. Pregnant females and some juveniles migrate to the calving grounds in late fall to winter, returning northward in late winter to early spring. Many right whales leave the feeding grounds for unknown habitats in the winter. Map adapted from: Kenney et al. (2001).

Calving occurs from December through March (Silber and Clapham 2001). On 1 January 2005, the first observed birth on the calving grounds was reported (Zani et al. 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. 1986b).

The coastal waters of the Carolinas are suggested to be a migratory corridor for the right whale (Winn et al. 1986). The Southeast U.S. Coast Ground, consisting of coastal waters between North Carolina and northern Florida, was mainly a winter and early spring (January-March) right whaling ground during the late 1800s (Reeves and Mitchell 1986). The whaling ground was centered along the coasts of South Carolina and Georgia (Reeves and Mitchell 1986). An examination of sighting records from all sources between 1950 and 1992 found that wintering right whales were observed widely along the coast from Cape Hatteras, NC to Miami, FL (Kraus et al. 1993). Sightings off the Carolinas were comprised of single individuals that appeared to be transients (Kraus et al. 1993). These observations are consistent with the hypothesis that the coastal waters of the Carolinas are part of a migratory corridor for the right whale (Winn et al. 1986). Until better information is available on the width of the right whale's migratory corridor, it has been recommended that management considerations are needed for the coastal areas along the mid-Atlantic migratory corridor within 65 km from shore (Knowlton 1997).

Radio-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 2001b; Waring et al. 2006). 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 where she remained for a period of months (WhaleNet 1998; Figure 3-3).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Right whale sighting and tagging data were considered for the determination of right whale occurrence in the study area. The coastal waters off Georgia and northern Florida are the only known calving ground for the North Atlantic right whale. Designated critical habitat, which is the core of the calving ground and essential to the conservation of this species, is shown in both Figures 3-1 and B-2. While many right whale records occur in this defined area, it should be noted that there are many additional sightings outside of this area.

  Right whale sightings are opportunistically reported off the southeastern U.S. as early as September and as late as June in some years (Kraus et al. 1993). It is only in average terms that the seasonal north-south migration of the entire population can be described. Whether or not a large baleen whale follows the "typical" migratory pattern or not can depend on a number of factors such as its previous reproductive history; its nutritional state; its state of health; its age and social status; and/or the ocean environmental conditions existing in the season in question.

  Right whale sightings in very deep offshore waters of the western North Atlantic are infrequent. There is limited evidence, however, suggesting that there may be a regular offshore component of their distributional and migratory cycle. This evidence includes a rare occurrence at Bermuda; off-shelf excursions by satellite-tracked individuals (Mate et al. 1997); disappearance of right whales from most coastal habitats in winter; genetic and sighting data indicating that there are additional summer grounds; and right whale individuals sighted seaward of the continental shelf break off Florida.

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—There is no documented occurrence for the right whale in waters of The Bahamas.

  - Winter—This species is common in coastal waters off Florida north of Fort Pierce during winter (Figure B-2). This is also the season of greatest survey effort, as aerial surveys for right whales are routinely conducted during this time when calving and breeding occur in the

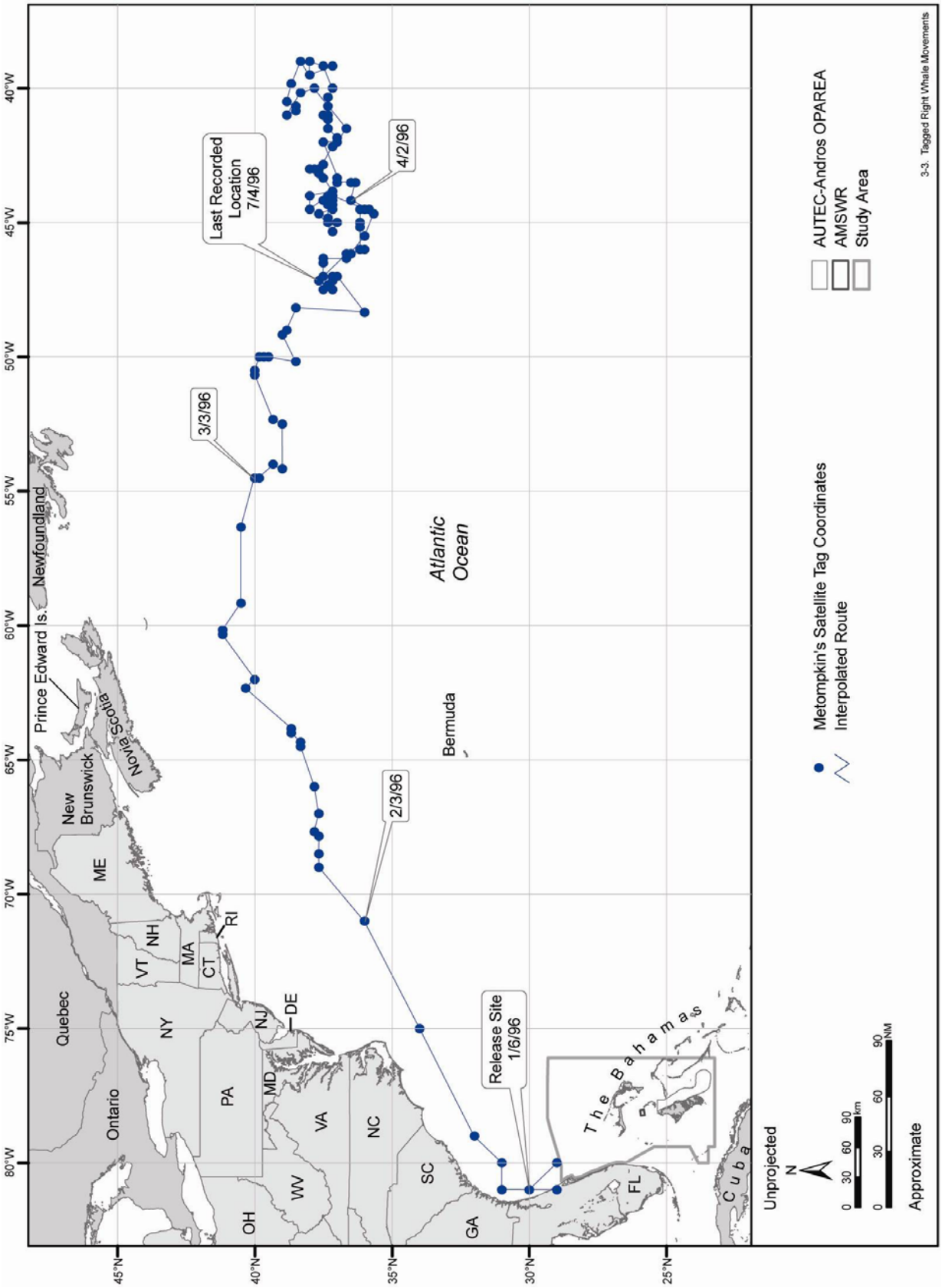

Figure 3-3. Movements of the satellite-tagged female North Atlantic right whale, "Metompkin", from January through July 1996. The presumed track of the whale's movement resulted from linear interpolation of the available coordinate data. Source data: WhaleNet (1998).

critical habitat (Winn et al. 1986). The occurrence patterns in Figure B-2 reflect the time of year that right whales are most frequently observed in this area which is during mid-December through March. North Atlantic right whales are present in waters over the continental shelf off Florida, as well as offshore of the eastern edge of the Blake Plateau. Right whales on the calving grounds respond to changing thermal regimes and move in response to water temperature changes (Garrison et al. 2005). Over the East Florida Shelf, right whales are common in waters cooler than 23˚C (also the shallowest waters over the continental shelf). This temperature regime generally extends slightly beyond the continental shelf break. There is a rare occurrence in deeper waters throughout the Bahamas that reflects the unknown occurrence of right whales in offshore waters and their highly endangered status (Figure B-2).

- Spring/Summer/Fall—There is a rare occurrence of the right whale throughout the study area during these times of the year. Right whales should occur further north on their feeding grounds. However, there are sightings off southeastern Florida during these seasons as evidenced by the three occurrence records in Figure B-2. The rare occurrence also accounts for the absence of information on where missing animals are during winter and how they get there and back during spring and fall, and the near-total absence of survey effort except off Florida and parts of the Bahamas (Kenney 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 three-year interval between calves (Kraus et al. 2001).

North Atlantic right whales feed on zooplankton, particularly large calanoid copepods such as *Calanus* (Kenney et al. 1985; Beardsley et al. 1996). 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*, *Pseudocalanus* spp., and *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 the right whales (DeLorenzo Costa et al. 2006).

When feeding, right whales skim prey from the water (Pivorunas 1979; Mayo and Marx 1990). 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 minutes (min) or longer are 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 very 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). The longest tracking of a right whale is of an adult female which migrated 1,928 km in 23 days (mean=3.5 km/hr) from 40 km west of Browns Bank (Bay of Fundy) to Georgia (Mate and Baumgartner 2001).

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). North Atlantic right whale sound production rates (duration of calls and interval between calls) are also highly-variable. 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 multiple 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 dB root-mean-square (rms) re: 1 μPa-m (Parks et al. 2005; Parks and Tyack 2005). In certain regions (i.e., northeast Atlantic), 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 estimates a hearing range of approximately 0.01 to 22 kHz, based on established marine mammal models (Parks et al. 2004; Parks and Tyack 2005). 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). The dorsal fin is set far back on the body and is triangular or falcate in shape, with a long hump cranially tapering to a pointed apex.

Status—Humpback whales are classified as endangered under the ESA (NMFS 1991) and, therefore, considered a strategic stock (Waring et al. 2006). An estimated 11,570 humpback whales occur in the entire North Atlantic (Stevick et al. 2003a). The best estimate of abundance for the Gulf of Maine Stock is 902 individuals (NMFS 2006a); this number is based on line-transect surveys conducted in 1999 (Clapham et al. 2003). There is no designated critical habitat for this species.

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. 1990a; 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, over shallow banks, and along continental coasts, where calving occurs. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep water during migration (Clapham and Mattila 1990; Calambokidis et al. 2001). Reeves et al. (2001b) inferred from sighting data that humpback whales may move across deep water within the eastern Caribbean region.

In the North Atlantic Ocean, humpbacks are found from spring through fall on feeding grounds that are located from south of New England to northern Norway (NMFS 1991). The Gulf of Maine is one of the principal summer feeding grounds for humpback whales in the North Atlantic. The largest numbers of humpback whales are present from mid-April to mid-November. Feeding locations off the northeastern U.S. include Stellwagen Bank, Jeffreys Ledge, the Great South Channel, the edges and

shoals of Georges Bank, Cashes Ledge, Grand Manan Banks, the banks on the Scotian Shelf, the Gulf of St. Lawrence, and the Newfoundland Grand Banks (CETAP 1982; Whitehead 1982; Kenney and Winn 1986; Weinrich et al. 1997). Distribution in this region has been largely correlated to prey species and abundance, although behavior and bottom topography are factors in foraging strategy (Payne et al. 1986; Payne et al. 1990b). Humpbacks typically return to the same feeding areas each year. There appears to be very little exchange between the five separate "feeding stocks": Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland (Katona and Beard 1990).

The most important feeding habitat is the shallow southwestern Gulf of Maine from Jeffreys Ledge south to the Great South Channel. 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 (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. 1990a; 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 (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, 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). 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. The calving peak is January through March, with some animals arriving as early as December and a few not leaving until June. The mean sighting date in the West Indies for individuals from the U.S. and Canada is 16 and 15 February, respectively (Stevick et al. 2003b).

Apparently, 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/age class of nonmigratory animals remains unclear. A small number of individuals remain in the Gulf of Maine during winter (CETAP 1982; Clapham et al. 1993); however, it is not known whether these few sightings represent winter residents or either late-departing or early-arriving migrants (Mitchell et al. 2002).

There has been an increasing occurrence of humpbacks, which appear to be primarily juveniles, during the winter along the U.S. Atlantic coast from Florida north to Virginia (Clapham et al. 1993; Swingle et al. 1993; Wiley et al. 1995; Laerm et al. 1997). Strandings of humpbacks (mainly juveniles) in this area have also increased in recent years (Wiley et al. 1995). Recently, winter humpback whale sightings have occurred in coastal southeastern U.S. waters during North Atlantic right whale surveys (Waring et al. 2006). None of these occurrences are fully understood. This might be due to shifts in distribution, increases in sighting effort, or habitat that is becoming increasingly important for juveniles (Waring et al. 2006). Sighting histories of mature humpback whales suggest that the mid-Atlantic area contains a greater percentage of mature animals than is represented by strandings (Barco et al. 2002). It has recently been proposed that the mid-Atlantic region primarily represents a supplemental winter-feeding ground, which is also an area of mixing of humpback whales from different feeding stocks (Barco et al. 2002).

The routes taken during the southbound and northbound migrations are not known. Examination of whaling catches revealed that both northward and southward 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 in the West Indies than females. 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).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Humpback whale occurrence in the study area is based upon seasonal breeding and feeding movements.

  - Winter—Occurrence within the study area is most likely during the winter when individuals migrate into the Caribbean Sea for breeding and calving. The Bahamas lie northwest of the Silver Bank region, the primary wintering area for the North Atlantic population of humpbacks (e.g., Smith et al. 1999). It is possible that sightings in the Bahamas during this time of year are of individuals enroute to the wintering grounds.

    Based on sightings (e.g., Winn et al. 1979, strandings (e.g., Winn et al. 1979; Schmidly 1981), and life history parameters, the humpback whale is expected to be present throughout most of the study area, except the shallow Bahamian banks, where there is a rare occurrence (Figure B-3). There are several sightings over the bank margins and within deeper waters, such as the TOTO, but not in more shallow waters here where systematic survey effort takes place. Reeves et al. (2001b) inferred from sighting data that humpback whales may move across deep water within the eastern Caribbean region.

    The high number of humpback sightings along the Florida coast in Figure B-3 is a function of the intense 20-year survey effort for right whales while they are on their calving grounds. Over one hundred aerial surveys are conducted over right whale calving grounds every winter, but humpback whales are rarely sighted. Therefore, this region is not designated an area of common occurrence for humpback whales. It should be noted that there are increasing numbers of juvenile humpback whales in this area during the winter (Wiley et al. 1995; Pitchford 2006).

    Not included in Figure B-3, but considered, are historical whaling records that suggest a significant abundance of humpback whales throughout deep waters of the area (Townsend 1935), particularly in the poorly-surveyed northeastern region of the study area. Brown (1958) mentions a sighting of seven humpbacks in the Bahamas during March but provides no further details.

  - Spring/Summer/Fall— Humpback whales have a rare occurrence throughout the study area during these seasons. This takes into consideration that humpback whales migrate to calving grounds in the Caribbean during the fall and make return migrations to the feeding grounds much further north during the spring. During the summer, humpback whales should occur further north on their feeding grounds, however, there are documented sightings in The Bahamas during this time of year. Infrequent sightings and strandings are documented generally along the edges of Bahamian banks during spring through fall (Figure B-3).

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). On rare occasions, competitive groups have 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 (*Mallotus villosus*) (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 5 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 D-tag work revealed that humpbacks are usually only a few meters below the water's surface while foraging (Ware et al. 2006). On wintering grounds, 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 (Winn and Winn 1978). 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 of 144 to 174 dB re 1 μPa-m, with a mean of 155 dB re 1 μPa-m. Au et al. (2001) recorded high-frequency harmonics (out to 13.5 kHz) and source level (between 171 and 189 dB re 1 μPa-m) of humpback whale songs. 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).

No tests on humpback whale hearing have been made. 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.

- 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). There is a single prominent ridge on the rostrum and a slightly arched rostrum with a downturned tip (Jefferson et al. 1993). The dorsal fin is prominent and very falcate. Sei whales are extremely similar in appearance to Bryde's whales, 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 and, therefore, are considered a strategic stock. The International Whaling Commission recognizes three sei whale stocks in the North Atlantic: Nova Scotia, Iceland-Denmark Strait, and Northeast Atlantic (Perry et al. 1999). The Nova Scotia Stock occurs in U.S. Atlantic waters (Waring et al. 2006). There are no recent abundance estimates for the Nova Scotia stock (NMFS 2006a). There is no designated critical habitat for this species.

The taxonomy of the baleen whale group formerly known as sei and Bryde's whales is currently confused and highly controversial. It clearly consists of three or more species; however, the final determination awaits additional studies. Reeves et al. (2004) provides a recent review; see the Bryde's whale species account below for further explanation.

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, 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 deep water, 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 western North Atlantic Ocean, sei whales occur primarily from Georges Bank north to Davis Strait (northeast Canada, between Greenland and Baffin Island) (Perry et al. 1999). Sei whales are not known to be common in most U.S. Atlantic waters (NMFS 1998a). Peak abundance in U.S. waters occurs from winter through spring (mid-March through mid-June), primarily around the edges of Georges Bank (CETAP 1982; Stimpert et al. 2003). The distribution of the Nova Scotia stock might extend along the U.S. coast at least to North Carolina (NMFS 1998a). The hypothesis is that the Nova Scotia stock moves from spring feeding grounds on or near Georges Bank, to the Scotian Shelf in June and July, eastward to perhaps Newfoundland and the Grand Banks in late summer, then back to the Scotian Shelf in fall, and offshore and south in winter (Mitchell and Chapman 1977).

As noted by Reeves et al. (1999a), reports in the literature from any time before the mid-1970s are suspect because of the frequent failure to distinguish sei from Bryde's whales, particularly in tropical to warm-temperate waters where Bryde's whales are generally more common than sei whales.

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Sei whales are not expected to occur in the study area; they are not generally found in waters this far south in the Northern Hemisphere. Sei whales are considered to be extralimital in the nearby Gulf of

Mexico (Jefferson and Schiro 1997). There is one confirmed stranding record to the south of the OPAREA from the Dominican Republic in July 1974 (Mead 1977). Sightings speculated to be of sei whales in the northeastern Caribbean (Erdman 1970; Erdman et al. 1973; Mignucci-Giannoni 1989) are not confirmed. Neither photos nor clear diagnostic features were provided and identification was based on behavioral characteristics, so these are not considered to be confirmed records. Misidentifications are likely to be of Bryde's whales; for example, a sei whale stranding in Cuba by Varona (1965) was re-identified as a Bryde's whale by Mead (1977).

Behavior and Life History—This species is the most poorly known of all rorquals. Sei whales are typically found in groups of one to five individuals (Leatherwood et al. 1976). 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). Sei whales typically follow a reproductive cycle of two years: a gestation period of about 10 to 12 months and a lactation period of six to nine months (Gambell 1985a).

Acoustics and Hearing—Sei whale vocalizations have been recorded only on a few occasions. Recordings from the North Atlantic 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]) frequency-modulated (FM) sweeps between 1.5 and 3.5 kHz; source level was not known (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). 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 2006c).

Status—Fin whales are classified as endangered under the ESA (NMFS 2006c) and, therefore, are considered a strategic stock (NMFS 2006c). The NOAA Stock Assessment Report estimates that there are 2,814 individual fin whales in the U.S. Atlantic waters (NMFS 2006a); this is probably an underestimate, however, as the data were not corrected for animals missed while diving. Incorporation of a dive correction factor brings the estimate to 5,000 to 6,000 fin whales in the waters of the U.S. Atlantic (CETAP 1982; Kenney et al. 1997). No critical habitat is designated for this species.

Habitat Preferences—The fin whale is found in continental shelf, slope, and oceanic waters. Off the U.S. east coast, the fin whale appears to be scarce in slope and Gulf Stream waters (CETAP 1982; Waring et al. 2006). Globally, 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; 1990b; Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003). In the Mediterranean, bottom depth was found to be the most significant variable in describing fin whale distribution, with more than 90% of sightings occurring in waters deeper than 2,000 m (Panigada et al. 2005).

Relatively consistent sighting locations for fin whales off the U.S. Atlantic coast include the banks on the Nova Scotian Shelf, Georges Bank, Jeffreys Ledge, Cashes Ledge, Stellwagen Bank, Grand Manan Bank, Newfoundland Grand Banks, the Great South Channel, the Gulf of St. Lawrence, off Long Island and Block Island, RI, and along the shelf break of the northeastern U.S. (CETAP 1982; Hain et al. 1992; Waring et al. 2006). Hain et al. (1992) reported that the single most important habitat in their study was a region of the western Gulf of Maine, to Jeffreys Ledge, Cape Ann, Stellwagen Bank, and to the Great South Channel, in approximately 50 m of water. This was an area of high prey

(sand lance) density during the 1970s and early 1980s (Kenney and Winn 1986). Secondary areas of important fin whale habitat included the mid- to outer shelf from the northeast area of Georges Bank through the mid-Atlantic Bight. 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 which tend to concentrate krill and herring (Woodley and Gaskin 1996). Fin 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. 2005a). Clark and Gagnon (2004) determined that vocalizing fin whales show strong preferences for shelf breaks, sea mounts or other areas where food resources are known to occur, even during summer months.

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. 2002). In general, fin whales are more common north of about 30ºN than they are in tropical zones (NMFS 2006). The overall range of fin whales in the North Atlantic extends from the Gulf of Mexico/Caribbean and Mediterranean north to Greenland, Iceland, and Norway (Gambell 1985b; NMFS 2006). In the western North Atlantic, the fin whale is the most commonly sighted large whale in continental shelf waters from the mid-Atlantic coast of the U.S. to eastern Canada (CETAP 1982; Hain et al. 1992; Waring et al. 2006). Fin whales are the dominant large cetacean species in all seasons in the North Atlantic and have the largest standing stock and food requirements (Hain et al. 1992; Kenney et al. 1997). The fin whale is also the most common whale species acoustically detected with Navy deep water hydrophone arrays in the North Atlantic (Clark 1995).

Fin whales are believed to follow the typical baleen whale migratory pattern, with a population shift north into summer feeding grounds and south for the winter. However, the location and extent of the wintering grounds are poorly known (Aguilar 2002). Peak acoustic detections of fin whales occurred in winter throughout the deep water of the North Atlantic, supporting the widely-held hypothesis about their migration. A definite southward movement of the species was detected in the fall with a northward shift in spring; the endpoints of most of the migration routes in the northwestern Atlantic were areas around Newfoundland and Labrador to the north and Bermuda through the West Indies to the south (Clark 1995). Migration routes are otherwise unknown.

Fin whales are not completely absent from northeastern U.S. continental shelf waters in winter, indicating that not all members of the population conduct a full seasonal migration. This is the most likely large whale species to be sighted off the eastern U.S. coast in winter. Perhaps a fifth to a quarter of the spring/summer peak population remains in this area year-round (CETAP 1982; Hain et al. 1992).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Fin whales are more commonly encountered north of Cape Hatteras, NC (CETAP 1982; Hain et al. 1992; Waring et al. 2006). Preliminary results from the Navy's deep water hydrophone arrays indicate a substantial deep-ocean component to fin whale distribution (Clark 1995; Waring et al. 2006).

  - Winter—All fin whale occurrence records for the study area were documented during this season; all three were strandings. Fin whales may occur in both continental shelf and offshore waters. Fin whale habitat is poorly known during winter (Aguilar 2002). Fin whales can be heard throughout deep waters of the North Atlantic from the Navy's hydrophone arrays (Clark 1995). Fin whales are present in deep waters offshore the Florida shelf break and north of the Bahamas based on acoustics data. Fin whales have a rare occurrence in continental shelf waters off Florida and throughout the deep waters of the Bahamas. There is also an area of rare occurrence bounded by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone).

    Fin whales are not expected over the Bahamian banks (Figure B-4) due to the extremely shallow waters encountered there, as well as no reported sightings during survey efforts. It should be pointed out that Bottomley and Therriault (2002) erroneously reported that a fin

whale was part of the multi-species mass stranding that occurred in March 2000 on Eleuthra Island and, therefore, is not plotted as an occurrence record in Figure B-4.

- Spring—Fin whales are not expected to occur in waters over the Bahamian banks. Their occurrence in the remainder of the study area is undetermined due to sparse sighting data. Acoustic detections support a more northerly distribution (Clark 1995); there are also no occurrence records documented during this time.
- Summer—During the summer, fin whales should be found on their feeding grounds further north off the northeastern U.S. They are not expected to occur in this OPAREA during this time of year.
- Fall—Fin whales are not expected to occur in waters over the Bahamian banks. Their occurrence in the remainder of the study area is undetermined due to sparse sighting data. Acoustic detections support a more northerly distribution (Clark 1995); there are also no occurrence records documented during this time of year.

Behavior and Life History—Fin whale feeding is accomplished by "gulping", where up to 50% of the animal's body volume in seawater enters the mouth and distends pleats along the throat (Orton and Brodie 1987; Lambertsen et al. 1995). The primary prey of fin whales is small schooling fishes, such as herring, capelin, and sand lance. However, squid, krill, and copepods are also a normal dietary component (see review in Kenney et al. 1985; NMFS 2006c). Sightings of single fin whales are most frequent, although pairs and small groups are often seen during feeding bouts.

Female fin whales in the North Atlantic mature at 8 to 11 years of age (Boyd et al. 1999). Peak calving is in October through January (Hain et al. 1992) 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 dives are typically 5 to 15 min long and separated by sequences of four to five blows at 10 to 20 sec intervals (CETAP 1982; Stone et al. 1992; Lafortuna et al. 2003). 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. Croll et al. (2001) determined that fin whales off the Pacific coast dived to a mean of 97.9 m (standard deviation [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. Panigada et al. (1999) reported fin whale dives exceeding 150 m and coinciding with the diel migration of krill.

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. 1987; 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. 1987; 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. 1987). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- Blue Whale *(Balaenoptera musculus)*

Description—Blue whales are the largest living animals. Blue whale adults in the northern hemisphere reach 22.9 to 28 m in length (Jefferson et al. 1993). The rostrum of a blue whale is broad and U-shaped, with a single prominent ridge down the center (Jefferson et al. 1993). The tiny dorsal fin is set far back on the body and appears well after the blowholes when the whale surfaces (Reeves et al. 2002). This species is blue-gray with light (or sometimes dark) mottling.

Status—Blue whales are classified as endangered under the ESA and, therefore, are considered to be a strategic stock. The blue whale was severely depleted by commercial whaling in the twentieth century (NMFS 1998b). At least two discrete populations are found in the North Atlantic. One ranges from West Greenland to New England and is centered in eastern Canadian waters; the other is centered in Icelandic waters and extends south to northwest Africa (Sears et al. 2005). There are no current estimates of abundance for the North Atlantic blue whale. However, the photo-identified individuals from the Gulf of St. Lawrence area are considered to be a minimum population estimate for the western North Atlantic stock (Waring et al. 2006); there are nearly 400 individuals based on research efforts by Sears et al. (2005). There is no designated critical habitat for this species in the North Atlantic.

Habitat Preferences—Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood 1985). Blue whales in the Atlantic are primarily found in deeper, offshore waters and are rare in shallower, shelf waters (Wenzel et al. 1988). Important foraging areas for this species include the edges of continental shelves and upwelling regions (Reilly and Thayer 1990; Schoenherr 1991). Based on acoustic and tagging data in the North Pacific, relatively cold, productive waters and fronts attract feeding blue whales (e.g., Moore et al. 2002). In the Gulf of St. Lawrence, blue whales show strong preferences for the nearshore regions where strong tidal and current mixing leads to high productivity and rich prey resources (Sears et al. 1990). Clark and Gagnon (2004) determined that vocalizing blue whales show strong preferences for shelf breaks, sea mounts or other areas where food resources are known to occur, even during summer months.

Distribution—Blue whales are cosmopolitan from arctic to tropical waters (Jefferson et al. 1993). Stranding and sighting data suggest that the blue whale's original Atlantic range extended south to Florida, the Gulf of Mexico, the Cape Verde Islands, and the Caribbean Sea (Yochem and Leatherwood 1985). The only Caribbean record for this species is from near the Panama Canal (Harmer 1923). Blue whales rarely occur in the U.S. Atlantic Exclusive Economic Zone (EEZ) and the Gulf of Maine from August to October, which may represent the limits of their feeding range (CETAP 1982; Wenzel et al. 1988). Researchers using Navy-integrated undersea surveillance system (IUSS) resources have more recently been able to detect blue whales throughout the open Atlantic south to at least the Bahamas (Clark 1995), suggesting that all North Atlantic blue whales comprise a single stock (NMFS 1998b).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—There are no records for blue whales in the study area (Figure B-5) although there are two confirmed stranding records for the nearby northern Gulf of Mexico (Jefferson and Schiro 1997). The blue whale is primarily an oceanic species. The winter grounds and the southern limits of the blue whale in the North Atlantic are not known (Croll et al. 1999). The occurrence patterns depicted in Figure B-5 take into consideration the endangered status of this species, this species' apparent preference for deeper waters, and the unknown possibility that this species might occur in the study area. In the southern North Atlantic, blue whale calls peak in January and decrease progressively through April (Lesage and Hammill 2003). In the northern North Atlantic, blue whale calls increase from April to August, and then progressively decrease in September (Lesage and Hammill 2003). There is no available acoustic data for October and November (Lesage and Hammill 2003). Clark (1995) acoustically tracked a blue whale between February and March to the same latitude as the northern Bahamas although several hundred kilometers to the east.

  - Summer—During the summer, the blue whale is not expected anywhere in the study area (Figure B-5). The species should occur in higher latitude feeding grounds during this time of the year. Acoustic detections from the IUSS hydrophones support this speculation.

  - Fall/Winter/Spring—Acoustic detections indicate that blue whales occur in lower latitudes during this time of the year (e.g., Clark 1995; Lesage and Hammill 2003), but exact locations are not known. As an oceanic species, the blue whale is not expected in shallow waters over the East Florida continental shelf inshore of the 100 m isobath (Figure B-5). The blue whale is not expected in shallow waters of the Bahamas. There is an area of rare occurrence in deeper waters of the Bahamas, since there have been no documented occurrence records even though there is survey effort and boater coverage for the region. The remainder of the

study area is demarcated as an area of undetermined occurrence due to a lack of actual occurrence data and dedicated survey effort for the area.

Behavior and Life History—Blue whales are found singly or in groups of two or three (Yochem and Leatherwood 1985). As noted by Wade and Friedrichsen (1979), apparently solitary whales are likely part of a large dispersed group. Sears et al. (1990) reported that most sightings of blue whales in the Gulf of St. Lawrence were of single animals or pairs of animals, but occasionally as many as 20 to 40 animals were also observed. Blue whales, like other rorquals, feed by "gulping" (Pivorunas 1979) almost exclusively on krill (Nemoto and Kawamura 1977).

Female blue whales reach sexual maturity at 5 to 15 years of age (Yochem and Leatherwood 1985). There is usually a two-year interval between calves that involves a 10 to 11 month gestation period (Yochem and Leatherwood 1985). Calving occurs primarily during the winter (Yochem and Leatherwood 1985).

Blue whales spend greater than 94% of their time below the water's surface (Lagerquist et al. 2000). Croll et al. (2001) determined that blue whales dived to an average of 140.0 m (S.D.=±46.01 m) and for 7.8 min (S.D.=±1.89 min) when foraging and to 67.6 m (S.D.=±51.46 m) and for 4.9 min (S.D.=±2.53 min) when not foraging. However, dives deeper than 300 m have been recorded from tagged individuals (Calambokidis et al. 2003).

Acoustics and Hearing—Blue and fin whales produce calls with the lowest frequency and highest source levels of all cetaceans. Sounds are divided into two categories: short-duration or long duration. Blue whale vocalizations are typically long, patterned low-frequency sounds with durations up to 36 sec (Thomson and Richardson 1995) repeated every 1 to 2 min (Mellinger and Clark 2003). Their frequency range is 12 to 400 Hz, with dominant energy in the infrasonic range at 12 to 25 Hz (Ketten 1998; Mellinger and Clark 2003). These long, patterned, infrasonic call series are sometimes referred to as "songs." Singing is highest during winter months but does occur during summer months in high latitudes. The short-duration sounds are transient, frequency-modulated calls having a higher frequency range and shorter duration than song notes and often sweeping down in frequency (Di Iorio et al. 2005; Rankin et al. 2005). Short-duration sounds appear to be common; however, they are underrepresented in the literature (Rankin et al. 2005). These short-duration sounds are less than 5 sec in duration (Di Iorio et al. 2005; Rankin et al. 2005) and are high-intensity, broadband (858±148 Hz) pulses (Di Iorio et al. 2005). Source levels of blue whale vocalizations are up to 188 dB re 1 μPa-m (Ketten 1998; Moore 1999; McDonald et al. 2001). During the Magellan II Sea Test (at-sea exercises designed to test systems for antisubmarine warfare) off the coast of California in 1994, blue whale vocalization source levels at 17 Hz were estimated in the range of 195 dB re 1 μPa-m (Aburto et al. 1997). Vocalizations of blue whales appear to vary among geographic areas (Rivers 1997), with clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific (Stafford et al. 2001). Blue whale sounds in the North Atlantic have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. 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 2006d), although they are globally not in any immediate danger of extinction. Due to ESA listing, this is a strategic stock

(Waring et al. 2006). The current estimate of sperm whale abundance in the western North Atlantic Ocean is 4,804 individuals (Waring et al. 2006). Stock structure for sperm whales in the North Atlantic is unknown (Dufault et al. 1999). No critical habitat is designated for this species.

Habitat Preferences—Sperm whale distribution can be variable, but is generally associated with waters over the continental shelf edge, continental slope, and offshore waters (CETAP 1982; Hain et al. 1985; Smith et al. 1996; Waring et al. 2001; Davis et al. 2002). Rice (1989) noted a strong offshore preference by sperm whales. Most tagged sperm whales in the Gulf of Mexico show a strong preference for the continental slope and submarine canyons (Mate 2003). In addition, several individuals traveled offshore into waters with a bottom depth greater than 3,000 m (Jochens et al. 2006). MacLeod et al. (2004) reported a sighting in the Bahamas in waters with a bottom depth of 730 m. 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 Islands) (Townsend 1935). These main whaling grounds are usually correlated with areas of increased primary productivity caused by upwelling (Jaquet et al. 1996).

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. (1983a) 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 deep water 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 24.9º C and bottom depths of 325 to 2,300 m (Waring et al. 2003).

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; 2002), which demonstrate that sperm whales can shift their movements in response to prey density.

Over 100 individual sperm whales have been identified over the Great Bahama Canyon (Dunphy-Daly and Claridge 2005). Of these, greater than half have been resighted and over 40% were sighted in more than one year. One individual was resighted eight years after its initial identification, indicating the potential for long-term site fidelity.

Distribution—Sperm whales are found in polar to tropical waters in all oceans, from approximately 70°N to 70°S (Rice 1998). Females are normally restricted to areas with sea-surface temperatures 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) (Whitehead 2003).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Sperm whales are associated with deep water or regions of steeply sloping ocean bottom (Waring et al. 2001; Davis et al. 2002; Mate 2003; MacLeod et al. 2004) where localized regions of upwelling, frontal convergences, or eddy formation increase the availability of squid prey (Waring et al. 1993; Jaquet et al. 1996; Griffin 1999).

  Sperm whales are not expected in shallow waters of the East Florida Shelf (inshore of the 100 m isobath) or over the Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-6). Although sperm whales normally inhabit much deeper environments, this species has been recorded in waters as shallow as 100 m (Whitehead et al. 1992; Scott and Sadove 1997). Sperm whales have a common occurrence in deep waters throughout the study area, particularly in

areas of steeply sloping bathymetry (Figure B-6). No seasonality in occurrence patterns is known for the study area.

The sperm whale is one of the most commonly seen and heard species at AUTEC (Jarvis and Moretti 2002). Ward (2002) reported that sperm whales within the TOTO were usually located over or proximate to submarine canyons. Based on a 2000 through 2001 acoustic study in the TOTO, sperm whales are acoustically recorded year-round, and a peak in recordings occurred between February and March 2001 (Ward 2002). Morrisey et al. (2006) presented information on work ongoing to detect and localize sperm whales in the TOTO via the ONR's Marine Mammal Monitoring on Navy Range's (M3R) program. On some monitored dives, individuals were tracked to depths of 1,000 to 1,200 m (Jarvis and Moretti 2002). Historical whaling data show sperm whales occurred frequently in the deepest waters in the northern region of the study area (Townsend 1935). Campbell (1978) reported that sperm whale occurrence year-round in the Bahamas was known to whalers.

Behavior and Life History—Female sperm whales form highly-social groups, while large males typically occur singly or in pairs, at times joining adult female groups for breeding (Whitehead 2003; Coakes and Whitehead 2004). Female and immature sperm whales form groups that move together in a coordinated fashion over several days. Mean group size is approximately 20 to 30 individuals, although significant variation exists; 1 to 19 individuals (mean of 6) per group were observed in the Bahamas (Dunphy-Daly and Claridge 2005). For a review of sperm whale social organization, see Whitehead and Weilgart (2000) and Whitehead (2003). Mating behavior is observed from winter through summer and calving occurs from spring through fall. Gestation lasts 14 to 15 months, lactation is approximately two years, and the typical interbirth interval is four to seven years. Sperm whales prey on large mesopelagic squids and other cephalopods, as well as demersal fishes and benthic invertebrates (Rice 1989; Clarke 1996).

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 one to five hours 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 meters per second (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 ms), 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). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals of a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997; Rendell and Whitehead 2004). Recent research in the South Pacific suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). 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 and those in the Pacific (Weilgart and Whitehead 1997). Furthermore, the clicks of neonatal sperm whales are very different from those of adults. Neonatal clicks are of low-directionality, long-duration (2 to 12 ms), low-frequency (dominant frequencies around 0.5 kHz) with estimated source levels between 140 and 162 dB re 1 μPa-m rms, and are hypothesized to function in communication with adults (Madsen et al. 2003). Source levels from adult sperm whales' highly directional (possible echolocation), short (100 μs) 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 Sri Lanka and the Mediterranean Sea

have been recorded making what are called trumpets at the beginning of dives just before commencing click production (Teloni 2005). The estimated source level of one of these low intensity sounds (trumpets) was estimated to be 172 dB re 1 µPa-m rms (Teloni et al. 2005).

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 1992). 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).

- West Indian Manatee *(Trichechus manatus)*

Description—The West Indian manatee is a rotund, slow-moving animal, which reaches a maximum length of 3.9 m (Jefferson et al. 1993). The manatee has a small head, a squarish snout containing two semi-circular nostrils at the front, and fleshy mobile lips. The tail is horizontal, rounded, and paddle-shaped. The body is gray or gray-brown and is covered with fine hairs that are sparsely distributed. The back of larger animals is often covered with distinctive scars from boat propeller cuts (Moore 1956).

Status—West Indian manatees are classified as endangered under the ESA. West Indian manatee numbers in Florida are routinely assessed by aerial surveys during winter when individuals are concentrated in warm-water refuges. Aerial surveys conducted in February 2006 produced a preliminary abundance estimate of 3,116 individuals (FMRI 2006). Along Florida's Gulf Coast, observers counted 1,474 West Indian manatees, while observers on the Atlantic coast counted 1,639. In the most recent revision of the West Indian manatee recovery plan, it was concluded that, based upon movement patterns, West Indian manatees around Florida should be divided into four relatively discrete management units or subpopulations, each representing a significant portion of the species range (USFWS 2001). West Indian manatees found along the Atlantic U.S. coast are of the Atlantic Region subpopulation (USFWS 2001). Manatees from the western coast of Florida make up the other three subpopulations: Upper St. Johns River Region, Northwest Region, and the Southwest Region (USFWS 2001).

In 1976, critical habitat was designated for the manatee in Florida (USFWS 1976). The designated area included all of the manatee's known range at that time (including waterways throughout about one-third to one-half of Florida) (Laist 2002). This critical habitat designation has infrequently been used or referenced since it is broad in description, treats all waterways the same, and does not highlight any particular areas (Laist 2002). There are two types of manatee protection areas in the state of Florida: manatee sanctuaries and manatee refuges (USFWS 2001; USFWS 2002a; USFWS 2002b). Manatee sanctuaries are areas where all waterborne activities are prohibited while manatee refuges are areas where activities are permitted but certain waterborne activities may be regulated (USFWS 2001; USFWS 2002a; USFWS 2002b).

Habitat Preferences—Sightings of manatees are restricted to warm freshwater, estuarine, and extremely nearshore coastal waters. Shallow seagrass beds close to deep channels are preferred feeding areas in coastal and riverine habitats (e.g., Lefebvre et al. 2000; USFWS 2001). West Indian manatees are frequently located in secluded canals, creeks, embayments, and lagoons near the mouths of coastal rivers and sloughs. These areas serve as locations of feeding, resting, mating, and calving (USFWS 2001). Estuarine and brackish waters, including natural and artificial freshwater sources, are typical West Indian manatee habitat (USFWS 2001). West Indian manatees rarely occur in offshore waters, where abundant seagrass and vegetation are not available (Reynolds III and Odell 1991). When ambient water temperatures drop below about 20°C in fall and winter, migration to natural or anthropogenic warm water sources takes place (Irvine 1983). Effluents from sewage treatment plants are important sources of fresh water for manatees in the Caribbean Sea (e.g., Rathbun et al. 1985). Manatees are also observed drinking fresh water that flows out of the mouths of rivers (Lefebvre et al. 2001) and out of offered hoses at harbors (e.g., Fertl et al. 2005).

Distribution—West Indian manatees occur in warm, subtropical, and tropical waters of the western North Atlantic, from the southeastern U.S. to Central America, northern South America, and the West

Indies (Lefebvre et al. 2001). Occurrence extends along both the Atlantic and Gulf coasts of Florida. During winter months, the manatee population confines itself to inshore and inner shelf waters of the southern half of peninsular Florida and to springs and warm water outfalls (e.g., power plant cooling water outfalls) just beyond northeastern Florida. As water temperatures rise in spring, manatees disperse from winter aggregation areas. West Indian manatees are frequently reported in coastal rivers of Georgia and South Carolina during warmer months (Lefebvre et al. 2001).

Several patterns of seasonal movement are known along the Atlantic coast ranging from year-round residence to long-distance migration (Deutsch et al. 2003). Individuals may be highly consistent in seasonal movement patterns and show strong fidelity to warm and winter ranges, both within and across years (Deutsch et al. 2003).

Historically, West Indian manatees were likely restricted to southernmost Florida during winter and expanded their distribution northward during summer. However, industrial development has made warm-water refuges available (e.g., power plant effluent plumes), and the introduction of several exotic aquatic plant species has expanded the available food supply. These factors have enabled an expansion of West Indian manatee winter range (USFWS 2001; Laist and Reynolds III 2005).

Although West Indian manatees are expected to inhabit nearshore areas, a few individuals have been sighted offshore. A West Indian manatee photographed in January 2000 at Bullocks Harbour (Andros Island) in the Bahamas matched a manatee that had been seen in 1994 as a juvenile on the west coast of Florida, indicating a potential for offshore movements (Reid 2000). Reynolds III and Ferguson (1984) reported two West Indian manatees sighted 61 km northeast of the Dry Tortugas Islands, an area not considered to be part of this species normal range. “Mo,” a radio-tagged individual that had been raised in captivity, was released at Crystal River, wandered offshore, and then drifted south with offshore currents before being “rescued” in deep water 37 km northwest of the Dry Tortugas (Lefebvre et al. 2001). Another manatee was also repeatedly sighted in the northern Gulf of Mexico, well over 100 km offshore in waters with a bottom depth of about 1,524 m (Fertl et al. 2005). Manatees off the east coast of Florida are also known to occasionally make their way further offshore. For example, “Xoshi” was radio-tagged and released in Biscayne Beach in March 1999. A few weeks later, she was “rescued” 60 km offshore of Port Canaveral, FL in the Gulf Stream (Reid et al. 1991). As noted by Lefebvre et al. (2001), it is unlikely that manatees deliberately or repeatedly travel between Florida and the Bahamas due to the deep waters and strong currents. Lefebvre et al. (2001) also suggested the possibility that the Greater Antilles might be a likely source for manatees that appear in the Bahamas.

Wide-ranging movements are documented for some individual West Indian manatees. For example, “Gina,” a manatee photo-identified as a calf and juvenile in the Homosassa River on the Gulf Coast of Florida, has been living in the Bahamas since about 1996 (Reid 2000; Lefebvre et al. 2001). Manatees sighted 61 km northeast of the Dry Tortugas were suggested to be wanderers from Florida, Cuba, or the Yucatan Peninsula (Reynolds III and Ferguson 1984). One individual, “Chessie,” gained fame in the summer of 1995 by swimming to Rhode Island, and after returning to Florida for the winter, wandered north again to Virginia in 1996 (USGS 2001). In early September 2001, “Chessie” was once again sighted in Virginia (USGS 2001). Additionally, a West Indian manatee hit by a boat in Louisiana was identified as an individual previously photographed in the Tampa Bay area (Fertl et al. 2005). More recently, in August 2006, a manatee was sighted in waters off Rhode Island (Beck 2006a), and one was photographed in the Hudson River in New York City (Anonymous 2006).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Manatees prefer shallow, protected areas where there is easy access to seagrasses and freshwater. Manatees have a common occurrence within 5 km of the southeastern coast of Florida, with reports of animals transiting through shallow water and into surf zones while traveling between coastal habitats (Figure B-7; Hartman 1979; Beck 2006b).

  There is a rare occurrence further offshore of the area of common occurrence that includes the Gulf Stream and the Bahamas (as well as further south) (Figure B-7). This takes into account the possibility of individual manatees moving across deeper waters to the Bahamas. No seasonality to the manatee’s occurrence is expected within the study area.

Manatee occurrence in the Bahamas is rare (Figure B-7). Odell et al. (1978) reported the first sighting of a West Indian manatee in more than 70 years; this individual was observed at Grand Bahamas Island. Since the 1990's, reports of manatees in Bahamian waters have been on the rise, with 25 sightings during that decade (Lefebvre et al. 2001). Two individuals likely were responsible for several reports in the Abaco islands chain during 1997 and 1998. During 1998 and 1999, a single manatee "Gina" was routinely seen in the AUTEC harbor; this individual was photo-matched as being originally seen in the Homosassa River along the Gulf coast of Florida during 1993, and not since 1994 (Reid 2000). "Gina" was later joined by a male in the Bahamas. "Gina" gave birth to a calf in the Berry Islands during September 2001 (Reid 2001). While "Gina" continues to be seen at Great Harbour, Berry Islands, there are no recent documented sightings of her calf or the male (Reid 2006). Although sighted in the Berry Islands and in the harbor of the Andros Island AUTEC detachment (the primary marine terminal for the AUTEC-Andros detachment), confirmed occurrence records are not known within either the AUTEC Minefield Shallow Water Range.

Behavior and Life History—Two important aspects of the West Indian manatee's physiology influence behavior: nutrition and metabolism. Manatees have an unusually low metabolic rate and a high thermal conductance that leads to energetic stress in winter (Bossart et al. 2002), which is somewhat ameliorated by migration and aggregation in warm-water refugia (Hartman 1979).

Manatees are not gregarious and are most often observed alone (Hartman 1979). Manatees in Florida do, however, aggregate in large, unorganized groups around warm-water sources (Hartman 1979). The only significant social bonds are between mother and calf during the first one to two years of the calf's life (Reeves et al. 1992). There is no defined breeding season; calves are born year-round after an 11-month gestation (O'Shea et al. 1995). West Indian manatees do not reproduce in consecutive years, except in rare instances (Kendall et al. 2004).

Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation, but they also preferentially ingest invertebrates (USFWS 2001; Courbis and Worthy 2003; Reich and Worthy 2006).

Acoustics and Hearing—West Indian manatees produce a variety of squeak-like sounds that have a typical frequency range of 0.6 to 12 kHz (dominant frequency range from 2 to 5 kHz), and last 0.25 to 0.5 sec (Steel and Morris 1982; Thomson and Richardson 1995; Niezrecki et al. 2003). Recently, vocalizations below 0.1 kHz have also been recorded (Frisch and Frisch 2003; Frisch 2006). Overall, manatee vocalizations are considered relatively stereotypic, with little variation between isolated populations examined (i.e., Florida and Belize; Nowacek et al. 2003). However, vocalizations have been newly shown to possess nonlinear dynamic characteristics (e.g., subharmonics or abrupt, unpredictable transitions between frequencies), which could aid in individual recognition and mother-calf communication (Mann et al. 2006). Average source levels for vocalizations have been calculated to range from 90 to 138 dB re: 1 μPa (average: 100 to 112 dB re: 1 μPa) (Nowacek et al. 2003; Phillips et al. 2004). Behavioral data on two animals indicate an underwater hearing range of approximately 0.4 to 46 kHz, with best sensitivity between 16 and 18 kHz (Gerstein et al. 1999), while earlier electrophysiological studies indicated best sensitivity from 1 to 1.5 kHz (Bullock et al. 1982).

3.1.2.2 Non-Threatened and Non-Endangered Marine Mammals

There are 27 non-endangered or non-threatened marine mammal species with known or potential occurrence in the study area: two baleen whale, 23 toothed whale, and two seal species. There are few records for most marine mammal species that occur in the southeastern Florida and the AUTEC-Andros OPAREA. This is primarily due to lack of survey effort, difficulty in species identification, or extralimital occurrences.

- Minke Whale *(Balaenoptera acutorostrata)*

Description—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 is 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—There are four recognized populations of minke whale in the North Atlantic Ocean: Canadian East Coast, West Greenland, Central North Atlantic, and Northeastern North Atlantic (Waring et al. 2006). Minke whales off the eastern U.S. are considered to be part of the Canadian East Coast stock, which inhabits the area from the eastern half of the Davis Strait to 45º W and south to the Gulf of Mexico (Waring et al. 2006). The best estimate of abundance for the Canadian East Coast minke whale stock is 2,998 individuals (NMFS 2006a).

Habitat Preferences—Off eastern North America, minke whales generally remain in waters over the continental shelf, including inshore bays and estuaries (Mitchell and Kozicki 1975; Ivashin and Votrogov 1981; Murphy 1995; Mignucci-Giannoni 1998; Calambokidis et al. 2004). However, based on whaling catches and global surveys, there is an offshore component to minke whale distribution (Slijper et al. 1964; Horwood 1990; Mitchell 1991). Mignucci-Giannoni (1998) found minke whales in the northeastern Caribbean distributed equally over the continental shelf and near the shelf break but less frequently offshore. Minke whales off the U.S. Atlantic coast apparently migrate offshore and southward in winter (Mitchell 1991). 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 may be due to the minke whale's staple prey species, capelin and sand lance, favoring these underwater sand dunes. Minke whales have also been known to preferentially feed in highly concentrated prey areas found within fine-scale eddies; these eddies form around islands during tidal retreat (Johnston et al. 2005a).

Distribution—Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993); they are less common in the tropics than in cooler waters. This species is most abundant in New England waters rather than the mid-Atlantic U.S. (Hamazaki 2002; Waring et al. 2006). The southernmost sighting in recent NMFS surveys was of one individual offshore of the mouth of Chesapeake Bay in waters with a bottom depth of 3,475 m (Mullin and Fulling 2003).

There appears to be a strong seasonal component to minke whale distribution (Horwood 1990). Spring and summer are periods of relatively widespread and common minke whale occurrence off the northeastern U.S. During the fall in New England waters, there are fewer minke whales, but during early winter (January and February), the species appears to be largely absent from this area (Waring et al. 2006). However, there are occasional observations in the western Gulf of Maine and in waters southeast of Cape Cod (CETAP 1982). Minke whales off the U.S. Atlantic coast apparently migrate offshore and southward in winter (Mitchell 1991; Mellinger et al. 2000). Clark and Gagnon (2004) reported that based on acoustics data, minke whales move clockwise through the Caribbean from winter into spring. Minke whales are known to occur during winter (November through March) in the southwestern North Atlantic from Bermuda to the West Indies, including the Bahamas (Struhsaker 1967; Winn and Perkins 1976; Mitchell 1991; Mellinger et al. 2000).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—It is assumed that minke whales have a similar life history as the other rorquals, with seasonal offshore/inshore movements and a population shift north into summer feeding grounds. There is a more common occurrence of the minke whale much further north of the study area. Occurrence patterns are based on data from the Navy deep water hydrophone arrays (Clark 1995; Clark and Gagnon 2004), as well as available sighting data displayed in Figure B-8.

  - Winter—Winter is the season with the most occurrence records for this species. Records summarized by Mitchell (1991) hint at a possible winter distribution in the West Indies and in the mid-ocean south and east of Bermuda. Minke whales have been detected by passive acoustic means in the southern part of the western North Atlantic during this time of year (Clark 1995; Clark and Gagnon 2004). The winter range of some rorquals (and often extrapolated to the minke whale) is thought to be in deep, offshore waters particularly at lower latitudes (Kellogg 1928; Gaskin 1982), and minke whale sightings have been reported in deep waters during this time of year (Slijper et al. 1964; Mitchell 1991).

Minke whales should be present in waters north of the Bahamas and off the East Florida Shelf based on this information and the distribution of available occurrence records (Figure B-8). Struhsaker (1967) reported sighting a single minke whale in December 1964 in Bahamian waters with a bottom depth of 5,000 m. There is a rare occurrence for the minke whale in waters over the continental shelf off Florida that extends throughout deeper waters of the Bahamas that accounts for the possibility of encountering this species elsewhere in the study area, including waters over the East Florida Shelf. Occurrence records and regional knowledge support the rarity of minke whales throughout Bahamian deep water channels; minke whales have only been sighted two times in 14 years (Claridge 2007). During March 2000's mass stranding event in the Bahamas, two minke whales stranded in a different location from the beaked whales (NOAA and Secretary of the Navy 2001). The minke whales were returned to deeper water and were not reported to re-strand. One of the animals spent over 24 hours on the beach and was physically removed to deep water by a boat, the other minke whale stayed in a shallow enclosed harbor for two days before being escorted out to deeper water by boats. The minke whale is not normally expected in shallow waters over the Bahamian banks based on a lack of sightings, despite much survey effort.

- Spring—The sparse nature of the occurrence records, coupled with little survey effort in the study area and a general lack of knowledge for minke whales in this area, makes it difficult to estimate the occurrence of this species throughout most of this region. There is an undetermined occurrence of the minke whale seaward of the Bahamas and including waters over the continental shelf of Florida. There are only two occurrence records in Figure B-8: a stranding near Miami and a stranding on Abaco Island. Minke whales are not expected over Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) during this time of year, since there is much survey effort in this area, with no sightings. The stranding in the Bahamas during this time of year supports that minke whales are present in deeper waters here. Minke whales are detected by passive acoustic means in the southern part of the western North Atlantic during this time of year (Clark 1995; Clark and Gagnon 2004). This would account for early or late migrating individual minke whales.
- Summer—During the summer, minke whales are not expected in the study area, since they occur at higher latitudes on their feeding grounds at this time of the year.
- Fall—Minke whales have a rare occurrence throughout the entire study area, except over the Bahamian banks (Little Bahama, Great Bahama, and Cay Sal), where the species is not expected to occur, since no sightings have been made during survey efforts. There are three available sighting records in offshore waters, including one within Northwest Providence Channel (Figure B-8). Minke whales have been detected by passive acoustic means in the southern part of the western North Atlantic during this time of year (Clark 1995; Clark and Gagnon 2004). This would account for early or late migrating individuals.

Behavior and Life History—Minke whales are sighted alone or in small groups of two to three 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). Gestation lasts 10 months and is followed by a four to five month lactation period (Stewart and Leatherwood 1985). Minke whales are lunge-feeding "gulpers" like the other rorquals (Pivorunas 1979). In the western North Atlantic, minke whales feed primarily on schooling fish, such as sand lance, capelin, herring, and mackerel (Kenney et al. 1985); copepods are also minke whale prey (Horwood 1990). Diel and seasonal variation in surfacing rates are documented for this species; this is probably down to changes in feeding patterns (Stockin et al. 2001). Dive durations of 7 to 380 sec are recorded (Lydersen and Øritsland 1990; Stern 1992; Stockin et al. 2001). 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 dominant frequency range of 0.06 to greater than 12 kHz, depending on sound type (Thomson and Richardson 1995). 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 ms. 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. "Boings" recorded in the North Pacific have many striking similarities to the star-wars vocalization in both structure and acoustic behavior. "Boings," recently confirmed to be produced by minke whales and suggested to be a breeding display, consist 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.

- Bryde's Whale *(Balaenoptera edeni)*

Description—Bryde's whales can be easily confused with sei whales. Bryde's whales usually have three prominent ridges on the rostrum (other rorquals generally have only one) (Jefferson et al. 1993). The Bryde's whale's dorsal fin is tall and falcate and generally rises abruptly out of the back. Adults can be up to 15.5 m in length (Jefferson et al. 1993), but there is a smaller "dwarf" species that rarely reaches over 10 m in length (Rice 1998).

It is not clear how many species of Bryde's whales exist but genetic analyses suggest at least two species (Rice 1998; Kato 2002). The taxonomy of the baleen whale group formerly known as sei and Bryde's whales is currently confused and highly controversial (see Reeves et al. 2004 for a recent review). It is clear that there are at least three species in this group, the antitropically-distributed sei whale, the tropically-distributed standard form of Bryde's whale (probably referable to *Balaenoptera brydei*), and the "dwarf Bryde's whale" (probably referable to *Balaenoptera edeni*), which inhabits tropical waters of the Indo-Pacific (Yoshida and Kato 1999). However, the nomenclature is still not resolved due to questions about the affinities of the type specimens of *Balaenoptera brydei* and *Balaenoptera edeni*.

Status—No abundance information is currently available for Bryde's whales in the North Atlantic or Caribbean.

Habitat Preferences—Bryde's whales are found in many offshore and nearshore regions. Off eastern Venezuela, Bryde's whales were occasionally sighted in shallow waters between Isla Margarita and Peninsula de Araya and in areas of high-bathymetric relief, such as the Cariaco Trench (Notarbartolo di Sciara 1982). Along the Brazilian coast, distribution and seasonal movements of Bryde's whales appear to be influenced by the behavior, distribution, and abundance of Brazilian sardine (*Sardinella brasiliensis*) schools that approach the coast to spawn in shallow waters (Zerbini et al. 1997). In the Gulf of Mexico, Bryde's whales are sighted near or over the DeSoto Canyon (Mullin et al. 1994a; Davis and Fargion 1996; Jefferson and Schiro 1997; Davis et al. 1998; Davis et al. 2000). The Bryde's whale appears to have a preference for water temperatures between approximately 15° and 20° C (Yoshida and Kato 1999). Bryde's whales are more restricted to tropical and subtropical waters than other rorquals.

Distribution—Bryde's whales are found in subtropical and tropical waters and generally do not range north or south of 40° in either hemisphere (Jefferson et al. 1993). In the Atlantic, Bryde's whales are distributed in the Gulf of Mexico and Caribbean Sea south to Cabo Frio, Brazil (Cummings 1985; Mullin et al. 1994a). There is a known concentration of this species in Venezuelan waters (Notarbartolo di Sciara 1982). There are occasional reported sightings of this species in the rest of the Caribbean (Erdman 1970; Mignucci-Giannoni 1989, 1996). Long migrations are not typical of Bryde's whales although limited shifts in distribution toward and away from the equator in winter and summer, respectively, have been observed (Cummings 1985).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The Bryde's whale has been reported to occur in both deep and shallow waters globally. There is a general lack of knowledge of this species, particularly in the North Atlantic, although records support a

tropical occurrence for the species here (Mead 1977). Bryde's whales are known to frequent the Caribbean Sea (Mignucci-Giannoni 1989, 1996) and Gulf of Mexico waters where the ocean bottom slopes steeply (Davis and Fargion 1996; Jefferson and Schiro 1997; Davis et al. 2000). There is also a confirmed stranding record for Cuba (Mead 1977).

There is only one documented occurrence record for the species in the study area, a stranding near Fort Pierce (Figure B-9). Based on survey effort and a lack of sighting data, occurrence is not expected over Bahamian banks (Little Bahama, Great Bahama, and Cay Sal). Based on a lack of available data for the remainder of the study area, there is an undetermined occurrence for the Bryde's whale here. Bryde's whales are likely to be only infrequent visitors to the deeper portions the study area. No seasonality in occurrence patterns is expected.

Behavior and Life History—This species is generally seen alone or in pairs (Tershy 1992), although they do occur in groups of up to 10 individuals (Miyazaki and Wada 1978). The Bryde's whale does not have a well-defined breeding season in most areas. There is a 2-year reproductive cycle which is composed of 11 to 12 months gestation, 6 months of lactation, and 6 months of resting (Kato 2002). Bryde's whales are lunge-feeders, feeding on schooling fish and krill (Nemoto and Kawamura 1977; Siciliano et al. 2004; Anderson 2005). Cummings (1985) reported that Bryde's whales may dive as long as 20 min.

Acoustics and Hearing—Bryde's whales produce low frequency tonal and swept calls similar to those of other rorquals (Oleson et al. 2003). Calls vary regionally, yet all but one of the call types have a fundamental frequency below 60 Hz. They last from one-quarter of a second to several seconds and are produced in extended sequences (Oleson et al. 2003). Heimlich et al. (2005) recently described five tone types. While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- Pygmy and Dwarf Sperm Whales *(Kogia breviceps* and *Kogia sima,* respectively)

Description—There are two species of *Kogia*: the pygmy sperm whale and the dwarf sperm whale. Recent genetic evidence suggests that there might even be two separate species of dwarf sperm whales; however, more data are needed to make that determination (Chivers et al. 2005).

Pygmy sperm whales have a shark-like head with a narrow, underslung lower jaw (Jefferson et al. 1993). The flippers are set high on the sides near the head. The small falcate dorsal fin of the pygmy sperm whale is usually set well behind the midpoint of the back (Jefferson et al. 1993). The dwarf sperm whale is similar in appearance to the pygmy sperm whale, but it has a larger dorsal fin that is 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. Pygmy and dwarf sperm whales reach body lengths of around 3 and 2.5 m, respectively (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, it is difficult to identify these whales to species in sightings at sea.

Status—There is currently no information to differentiate Atlantic stock(s) (Waring et al. 2006). The best estimate of abundance for both species combined in the western North Atlantic is 395 individuals (Waring et al. 2006). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al. 2006). There are no abundance estimates for this species in the Caribbean.

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). A satellite-tagged, rehabilitated pygmy sperm whale released off the Atlantic coast of Florida remained along the continental slope and western

edge of the Gulf Stream until the tag failed (Scott et al. 2001). Dwarf sperm whales in the Bahamas were found in waters with bottom depths ranging from 94 to 883 m (MacLeod et al. 2004).

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; MacLeod et al. 2004). In particular, work on strandings and feeding habits in South Africa has indicated this (Ross 1979; Plön et al. 1998). 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 (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 waters (Muñoz-Hincapié et al. 1998). 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). In the western Atlantic Ocean, *Kogia* (specifically, the pygmy sperm whale) are documented as far north as the northern Gulf of St. Lawrence (Measures et al. 2004). *Kogia* ranges as far south as 33°S in South America (Muñoz-Hincapié et al. 1998).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Sighting and stranding data are included for *Kogia* spp, which were not identified as either the pygmy sperm whale or the dwarf sperm whale. As noted earlier, identification to species for this genus is difficult, particularly at sea. Sightings that were listed as unidentified *Kogia* spp. were plotted as such. When a *Kogia* species was identified to species, pygmy sperm whale or dwarf sperm whale was plotted accordingly.

  Based on their known preference for deep waters, as well as the distribution of occurrence records, *Kogia* have a common occurrence in deep waters throughout the study area; however, they are not expected in the shallow waters of the East Florida Shelf or the Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-10). No seasonality to their occurrence is expected.

  Dwarf sperm whales are thought to be more abundant in the Bahamas than pygmy sperm whales (MacLeod et al. 2004; Claridge 2006). MacLeod et al. (2004) reported that dwarf sperm whales were the dominant species in waters less than 200 m in bottom depth in their Bahamian study. This species was sighted in bottom depths ranging from 94 to 883 m (MacLeod et al. 2004).

Behavior and Life History—*Kogia* species have small group sizes; mean group size is usually two individuals (Willis and Baird 1998). 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 and Bernard 1999). Sexual maturity is attained at around four years in both sexes of both species. *Kogia* feed on cephalopods and, less often, on deep-sea fishes and shrimps (D. Caldwell and Caldwell 1989; McAlpine et al. 1997; Willis and Baird 1998; Cardona-Maldonado and Mignucci-Giannoni 1999; Wang et al. 2002). Willis and Baird (1998) reported that whales of the genus *Kogia* make dives of up to 25 min. Median dive times of around 11 min are

documented for *Kogia* (Barlow 1999). A satellite-tagged pygmy sperm whale released off Florida was found to make long nighttime dives, presumably indicating foraging on squid in the deep scattering layer (DSL) (Scott et al. 2001). 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—The only sound recordings for the pygmy sperm whale are from a stranded individual that produced echolocation clicks ranging from 60 to 200 kHz, with a dominant frequency of 120 to 130 kHz (Marten 2000). Recently, a dwarf sperm whale was recorded producing clicks at 13 to 33 kHz with durations of 0.3 to 0.5 sec (Jérémie et al. 2006).

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

- Beaked Whales (Family Ziphiidae)

Description—Four beaked whale species have documented occurrence in this study area: Cuvier's beaked whale and three members of the genus *Mesoplodon*: Gervais', Blainville's, and True's beaked whales. The Sowerby's beaked whale has potential occurrence in the study area. *Mesoplodon* spp. are also termed 'mesoplodonts.' With the exception of the Cuvier's beaked whale, the before-mentioned beaked whale species are nearly indistinguishable at sea (Coles 2001). The Smithsonian Institution is currently developing an online system to facilitate species-level identification of stranded individuals (Allen et al. 2005).

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. 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).

All mesoplodonts 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 (2000a) 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).

Sowerby's beaked whale males and females attain lengths of at least 5.5 and 5.1 m, respectively (Jefferson et al. 1993). The beak is long and distinct. The melon also has a hump on the top. Two small teeth are evident along the middle of the lower jaw in adult males. Coloration has generally been described as charcoal gray dorsally and lighter below (Jefferson et al. 1993). Gray spotting has been noted on adults, although younger animals may also display a lesser degree of spotting (Jefferson et al. 1993).

True's beaked whales reach lengths of slightly over 5 m and weigh up to 1,400 kg (Jefferson et al. 1993). Coloration is generally similar to other mesoplodonts. Newborns are likely between 2.0 and 2.5 m long. A pair of teeth is located at the tip of the lower jaw.

Status—The best estimate of abundance for the combined grouping of beaked whales in the western North Atlantic is 3,513 individuals (Waring et al. 2006). It is not possible to obtain any additional species-specific estimates due to the difficulty of at-sea identification. Beaked whales are considered a strategic stock due to the uncertainty of stock size and the potential for human-induced mortality and serious injury because of acoustic activities (Waring et al. 2006). The only estimate of abundance for beaked whales in the Caribbean is for the Blainville's beaked whale. This was derived from acoustic data collected at AUTEC - a density estimate of 30.029 Blainville's beaked whales per one thousand square kilometers during the period of 25 April 2005 through 2 May 2005 (Moretti et al. 2006a).

A recent study of global phylogeographic structure of Cuvier's beaked whales suggested that some regions show a high level of differentiation (Dalebout et al. 2005); however, the western North Atlantic and, in particular, the Bahamas were areas that required samples in order to possibly discern finer-scale population differences.

Habitat Preferences—Little is known about beaked whale habitat preferences. Distribution of *Mesoplodon* spp. in the North Atlantic may relate to water temperature (MacLeod 2000a). The Blainville's and Gervais' beaked whales occur in warmer southern waters, in contrast to Sowerby's and True's beaked whales that are more northern (MacLeod 2000b).

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). In summer, the continental shelf break off the northeastern U.S. is primary habitat (Waring et al. 2001). Waring et al. (2003) conducted a deep water survey south of Georges Bank in 2002 and examined fine-scale beaked whale habitat use. Beaked whales were located in waters with a mean sea-surface temperature of 20.7° to 24.9º C and a bottom depth of 500 to 2,000 m (Waring et al. 2003).

World-wide, beaked whales normally inhabit continental slope and deep oceanic waters (>200 m) (Waring et al. 2001; Cañadas et al. 2002; Pitman 2002; MacLeod et al. 2004; Ferguson et al. 2006; MacLeod and Mitchell 2006). Beaked whales are only occasionally reported in waters over the continental shelf (Pitman 2002). In the Gulf of Mexico, beaked whales are seen in waters with a bottom depth ranging from 420 to 3,487 m (Ward et al. 2005). Ward et al. (2005) presented information on their attempts to characterize and predict beaked whale habitat in the Gulf of Mexico using habitat models; further work is needed for this promising technique.

In the eastern tropical Pacific, 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, 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. The authors 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.

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). At oceanic islands, Cuvier's beaked whales are found in deeper waters than Blainville's beaked whales (MacLeod et al. 2004; Baird et al. 2006; Claridge 2006). Most ecological information on Blainville's beaked whales comes from the northern Bahamas (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 (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).

Tove (1995) reported sighting a True's beaked whale off North Carolina well within the Gulf Stream in roughly 1,100 m of water along a steep portion off the continental shelf. Weir et al. (2004) sighted True's beaked whales in the eastern North Atlantic in waters with a bottom depth of 2,200 to 4,100 m.

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).

The ranges of most mesoplodonts are poorly known. In the western North Atlantic and Gulf of Mexico, these animals are known mostly from strandings (Mead 1989; MacLeod 2000b; 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). The Gervais' beaked whale is restricted to warm-temperate and tropical Atlantic waters with records throughout the Caribbean Sea (MacLeod et al. 2006). The Gervais' beaked whale is the most frequently-stranded beaked whale in the Gulf of Mexico (Würsig et al. 2000). The Sowerby's beaked whale is endemic to the North Atlantic; this is considered to be more of a temperate species (MacLeod et al. 2006). The stranding on the Gulf coast of Florida is considered to be extralimital (Jefferson and Schiro 1997; MacLeod et al. 2006). In the western North Atlantic, confirmed strandings of True's beaked whales are recorded from Nova Scotia to Florida and also in Bermuda (MacLeod et al. 2006). There is also a sighting made southeast of Hatteras Inlet, NC (Tove 1995).

- Information Specific to the Southern Florida and AUTEC-Andros OPAREA—The Cuvier's beaked whale, Blainville's beaked whale, and Gervais' beaked whale are the most likely beaked whale species to be encountered in the study area based on available occurrence records. The Blainville's beaked whale appears to be sparse in the Caribbean, however, with a regular occurrence in the Bahamas (IWC 2006). There are multiple Gervais' beaked whale strandings on the Florida Atlantic Coast (Rankin 1955; Moore 1960) and three in the Bahamas (Figure B-11). There is one sighting of three Gervais' beaked whales reported for the TOTO that was provided as part of the AUTEC marine mammal sighting database (see Figure B-11). While this species is known from strandings in the TOTO region, this is an opportunistic sighting record that should be considered suspect due to concerns with species identification (Claridge 2007; MacLeod 2006).

  There are two records for True's beaked whale in the study area; both are strandings on the Florida coast, one from August 1986 near West Palm Beach and the other from Cape Canaveral during February 2001 (Figure B-11). The southernmost record of a True's beaked whale is a skull found on San Salvador Island in the Bahamas (Anonymous 1981; (Mead 1989), which is southeast of the map view of Figure B-11, though this is an unverified record (identification is not confirmed) (MacLeod 2006). This species is not expected to occur as far south as the study area (MacLeod 2006).

  MacLeod and Mitchell (2006) described the northern Bahamas as a "key area" for beaked whales. Of particular interest is that there are repeated sightings of the same individual Blainville's beaked whales within and between years here (MacLeod et al. 2004; Claridge 2006). Notable to the study area is a mass stranding event that took place during March 2000 in the Northeast and Northwest Providence Channels in the Bahamas. These strandings were primarily composed of beaked whales (nine Cuvier's, three Blainville's, and two unidentified beaked whales). The strandings occurred over a 36-hour period during 15 to 16 March 2000, and they corresponded simultaneously with the transit of five US Navy surface ships operating mid-frequency hullmounted sonar systems through the channels as part of a training exercise. More details of this event can be found in NOAA and Secretary of the Navy (2001) and D'Spain et al. (2006).

  The patterns depicted in Figure B-11 take into consideration the known preference of beaked whales for deep waters, as well as available sighting, and in the case of the TOTO, also available acoustics data. There is a common occurrence for beaked whales throughout all deep waters of the study area. Based on sightings of beaked whales on the continental shelf further north, there is a rare occurrence of beaked whales between the 30 m isobath and the shelf break off Florida. Occurrence is not expected inshore of the 30 m isobath on the East Florida Shelf or over shallow waters of the Bahamian banks (Little Bahama, Great Bahama, and Cay Sal). No seasonality is known to beaked whale occurrence in the study area. Historical records of beaked whale occurrence in the study area are discussed by Rankin (1955), Layne (1965), D. Caldwell and Caldwell (1971), Balcomb III (1981), and Schmidly (1981).

The M3R program at AUTEC is detecting and localizing beaked whales in the TOTO (Morrisey et al. 2006; Moretti et al. 2006a, 2006b); none of the acoustic data is included in Figure B-11. Beaked whales at AUTEC have been tagged by Woods Hole Oceanographic Institution (WHOI) scientists (SERDP 2002), although no further published information is available.

Beaked whale distribution in the Northwest Providence Channel (within the Great Bahama Canyon) is segregated, possibly due to niche partitioning of prey resources (MacLeod et al. 2004; Claridge 2006). Cuvier's beaked whales are found in offshore waters with a mean bottom depth of 1,051 m, sharing habitat with sperm whales (Claridge 2006). Blainville's beaked whales in the northern Bahamas are found along shelf waters of canyon walls, in waters with a mean bottom depth of 393 m, sharing habitat with *Kogia* spp. (Claridge 2006). There is habitat portioning between adult and subadult Blainville's beaked whales; subadults are found further offshore and in deeper waters (Claridge 2006). Claridge (2006) also noted that adult female Blainville's beaked whales off southern Great Abaco Island had the highest resight rates. MacLeod and Zuur (2005) made note of areas east of Great Abaco where Blainville's beaked whales preferentially occur in the Bahamas based on possible prey concentrations. They determined that prey may be concentrated in areas with a northeast aspect, intermediate gradients and bottom depths between 200 and 1,000 m where the Deep Western Boundary Current is forced towards the surface by the local topography.

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.

Cuvier's beaked whales and *Mesoplodon* spp. are found alone or in groups of up to 15 individuals (Mullin et al. 2004; MacLeod and D'Amico 2006). Blainville's beaked whales are found in groups ranging from one to 11 individuals (Mullin et al. 2004; 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 (Claridge 2005; MacLeod and D'Amico 2006). Some groups also include a mature or subadult male (Claridge 2005; MacLeod and D'Amico 2006). Average group size for the Blainville's beaked whale in the TOTO is three individuals (Claridge 2006).

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 (MacLeod et al. 2003). Stomach content analyses of captured and stranded individuals suggest beaked whales are deep divers that feed by suction on mesopelagic fishes, squids, and deep water benthic invertebrates (Heyning 1989). 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. Stomach contents of Cuvier's beaked whales rarely contain fishes, while stomach contents of mesoplodonts frequently do (MacLeod et al. 2003). 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). Earlier reports likely overestimated the importance of squids in the diet of two beaked whale species since squid beaks are more resistant to digestion than fish otoliths (Gannon et al. 1998a).

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). Tagged Cuvier's beaked whale dive durations as long as 87 min and dive depths of up to 1,990 m have been recorded (Baird et al. 2006). Tagged Blainville's beaked whale dives have been recorded to 1,408 m and lasting as long as 54 min (Baird et al. 2006). Blainville's beaked whales tagged during November 2006 were found to dive in excess of 1,000 m (BMMRO 2007). 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 two hours; 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. 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).

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. 2005; 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 stranded subadult Blainville's beaked whale ranged in frequency from slightly less than 1 to almost 6 kHz (D. Caldwell and Caldwell 1971).

Recent studies incorporating DTAGs (miniature sound and orientation recording tag) attached to both Blainville's and Cuvier's beaked whales in the Ligurian Sea (arm of the Mediterranean Sea) recorded high-frequency echolocation clicks (duration: 175 µs for Blainville's and 200 to 250 µs 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. 2005; Zimmer et al. 2005). 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). 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). 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—The rough-toothed dolphin is relatively robust with a cone-shaped head, and 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. 2002). 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 scars. The rough-toothed dolphin reaches 2.8 m in length (Jefferson et al. 1993).

Status—No abundance estimate is available for rough-toothed dolphins in the western North Atlantic or Caribbean Sea.

Habitat Preferences—While the rough-toothed dolphin is generally regarded as a deep water species, it can occur in waters with variable bottom depths, including coastal and lagoon waters. In the Gulf of Mexico, the rough-toothed dolphin occurs primarily over the deeper waters off the continental shelf (Davis et al. 1998; Mullin et al. 2004). Likewise, stranded and rehabilitated individuals were released with tags off the Atlantic Coast of Florida in March 2005; they moved in waters as deep as 4,000 to 5,000 m in bottom depth (Manire and Wells 2005). Off the Florida Panhandle, this species can be found over the continental shelf (R. Wells et al. 1999; Fulling et al. 2003; Mullin et al. 2004). Additionally, there are reports of rough-toothed dolphins over the continental shelf in shallow waters around La Gomera, Canary Islands (Ritter 2002), Puerto Rico and the Virgin Islands (Mignucci-Giannoni 1998), the Bahamas (R. Wells 2007), 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 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 (R. Wells et al. 1999). Water depth at tracking locations of these individuals averaged 195 m off the Florida Panhandle (R. Wells et al. 1999). In March 2005, Mote Marine Laboratory released three dolphins from the 2004 mass stranding at Hutchinson Island on the Atlantic Coast of 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 by the Marine Animal Rescue Society off Miami, one with a satellite-linked transmitter (R. Wells 2007). The tagged animal moved north as far as Charleston, SC, before returning to the Miami area, remaining in relatively shallow waters (R. Wells 2007). During May 2005, seven more rough-toothed dolphins (stranded in the Florida Keys in March 2005 and rehabilitated) were tagged (two with satellite, the others with VHF) and released by the Marine Mammal Conservancy in the Florida Keys (R. Wells 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 (R. Wells 2007). The last signal placed them northeast of the Lesser Antilles (R. Wells 2007). 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 by the Marine Mammal Conservancy (R. Wells 2007). The tagging data demonstrated that these individuals proceeded south to a deep trench close to the north coast of Cuba (R. Wells 2007).

When compared to individuals tagged and released in the northeast Gulf of Mexico in 1998, rough-toothed dolphins tagged and released off the Atlantic coast of Florida in 2005 demonstrated a preference for cooler (and deeper) waters (Manire and Wells 2005). The Gulf dolphins remained in waters with an average SST of 25°C. The individuals from the Atlantic remained in waters that averaged 19°C. In the eastern tropical Pacific, rough-toothed dolphins are found where surface water temperatures are generally above 25°C (Perrin and Walker 1975).

Distribution—Rough-toothed dolphins are found in tropical to warm-temperate waters globally, rarely ranging north of 40°N or south of 35°S. This is not a commonly encountered species in the areas where it is known to occur. Not many occurrence records exist from the western North Atlantic, but they do indicate that this species occurs from Virginia south to Florida, the Gulf of Mexico, the West Indies, and along the northeastern coast of South America (Leatherwood et al. 1976; Würsig et al. 2000).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The rough-toothed dolphin is a deep water species. This species is not expected in shallow waters over the East Florida Shelf or over Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-12). Rough-toothed dolphins are present seaward of the shelf break off Florida and off the bank margins of the Bahamas throughout the study area. Within the TOTO, this species has a common occurrence based on the number of sightings made during the few surveys conducted in the area (Claridge 2007). No seasonality in occurrence is known for this species.

  Of interest are two mass stranding events in the area: 16 individuals during late May 1961 at Rock Island (Atlantic coast of Florida) (Layne 1965) and 37 individuals in August 2004 at Hutchinson Island (near Fort Pierce, FL) (Manire and Wells 2005). As noted earlier, tagging data demonstrated deep water movements (often >4,000 m) by the rehabilitated and released dolphins from the 2004 event. Also mentioned earlier was that a group of seven rehabilitated and released rough-toothed dolphins made their way into shallow waters off Andros Island. It should be noted that R. Wells (2007) attributed these movements to “apparent disorientation”, and it is suspected that this is not typical behavior for the species, based on the fact that wild, healthy individuals have never been observed elsewhere in the Bahamas in shallow water.

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. 1999b). Group sizes in the Gulf of Mexico range in size from 3 to 48 individuals (Mullin et al. 2004). Rough-toothed dolphins often associate with other cetacean species (Miyazaki and Perrin 1994; Nekoba-Dutertre et al. 1999; Ritter 2002; Wedekin et al. 2004). In the eastern tropical Pacific 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).

Cephalopods and fish, including large fish such as dorado (*Coryphaena hippurus*), are prey (Miyazaki and Perrin 1994; Reeves et al. 1999b; Pitman and Stinchcomb 2002). Gannier and West (2005) observed rough-toothed dolphins feeding during the daytime on epipelagic fishes, including flying fishes. Rough-toothed dolphins stranded on the Atlantic coast of Florida during a mass stranding event in May 1961 were found to have blanket octopus (*Tremoctopus violaceus*) and *Sargassum* in their stomachs (Layne 1965). Female rough-toothed dolphins reach sexual maturity between four and six years of age; males attain sexual maturity between 5 and 10 years (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).

Acoustics and Hearing—The rough-toothed dolphin produces a variety of sounds, including broadband echolocation clicks, barks, and whistles (Yu et al. 2003). Echolocation clicks (duration <250 microseconds [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).

There has been no data collected on rough-toothed dolphin hearing ability. However, odontocetes are generally adapted to hear high-frequencies (Ketten 1997).

- Bottlenose Dolphin *(Tursiops truncatus)*

Description—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 bottlenose dolphin (*Tursiops truncatus*) and Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998; IWC 2005). It is likely that additional species-level taxonomy will be recognized based on future genetic and morphometric analyses (Natoli et al. 2004). Indo-Pacific bottlenose dolphins are found in coastal Indo-Pacific tropics (Curry and Smith 1997), while all other forms are considered to be bottlenose dolphins.

Scientists currently recognize several nearshore (coastal) and an offshore morphotypes (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 in the worldwide (Curry and Smith 1997; Hoelzel et al. 1998). It has been suggested that the two morphotypes should be considered different species (Curry and Smith 1997; Kingston and Rosel 2004), but no official taxonomic revisions have yet been made.

Parsons et al. (2006) reported that the coastal morphotype occurs in the shallow waters of Little Bahama Bank. MacLeod et al. (2004) reported sighting two morphologically distinct types of bottlenose dolphins in the Bahamas, suggesting that the nearshore and offshore morphotypes might occur here as well. Claridge (2007) have had 17 encounters with the offshore morphotype, both on the Bahamian banks and in oceanic waters (including aggressive interactions between the two morphotypes).

Status—Two forms of bottlenose dolphins are recognized in the western North Atlantic Ocean: inshore (coastal) and offshore morphotypes. There is a complex mosaic of stocks that comprise the inshore or coastal morphotype (NMFS-SEFSC 2001; Waring et al. 2006). Seven defined

management units comprise the Western North Atlantic Coastal Morphotype stocks during the summer months (May through October (NMFS-SEFSC 2001; Waring et al. 2006). During winter (November through April), there are five seasonal management units, since three of the summer management units are found during the winter in waters off North Carolina and make up the winter North Carolina mixed management unit (NMFS-SEFSC 2001; Waring et al. 2006). The Central Florida management unit is the only coastal unit expected in the Florida component of this MRA; the best estimate of abundance is 10,652 individuals (NMFS 2006a). The entire coastal stock is presently considered strategic (NMFS 2006a).

From 1987 to 1988, the annual number of bottlenose dolphins stranded along the eastern U.S. increased tenfold relative to previous years (MMC 2002). This die-off started in the mid-Atlantic region, moved northward and then southward to encompass nearly the entire eastern seaboard from New Jersey to central Florida (MMC 2002). The pattern of strandings was considered evidence for a single coastal migratory stock along the eastern U.S. Analysis of the event suggested that more than half of this stock may have died during the event (MMC 2002). In April 2006, NMFS published a Bottlenose Dolphin Take Reduction Plan to reduce the incidental mortality and serious injury to the Atlantic coastal stocks of bottlenose dolphins in commercial fisheries to below PBR (NMFS 2006e).

Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km from the U.S. coastline (Waring et al. 2006). The current abundance estimate for this stock is 82,351 individuals (Waring et al. 2006). This stock is not currently considered a strategic stock.

The only abundance estimate for bottlenose dolphins in the Caribbean is for non-calf bottlenose dolphins at Little Bahama Bank; there were approximately 1,081 individuals during 2000 (Durban 2002, 2007). Resident groups occur throughout the Bahamas based on both photo-identification work and genetics (Claridge 1994; Durban et al. 2000; Rogers et al. 2004; Parsons et al. 2006).

Habitat Preferences—The offshore stock off the U.S. Atlantic Coast is found in continental shelf waters greater than 25 m deep and into slope waters in lower concentrations. Tentative evidence suggests that the offshore morphotype does not inhabit waters closer than 12 km from shore during summer and 27 km from shore during winter (Garrison and Yeung 2001). Torres et al. (2003) found that inshore bottlenose dolphins in the North Atlantic were always found within 7.5 km of shore and offshore bottlenose dolphins were always found further than 34 km from shore.

The greatest concentrations of offshore animals are along the continental shelf break (Kenney 1990; Waring et al. 2006). Offshore bottlenose dolphins were generally distributed between the 200 and 2,000 m isobaths in a mean water depth of 846 m from Cape Hatteras to the eastern end of Georges Bank during CETAP surveys (Kenney 1990).

MacLeod et al. (2004) reported sighting bottlenose dolphins in Bahamian waters ranging in bottom depth from about 10 to 366 m, and as noted earlier, suggested that both the nearshore and offshore morphotype of bottlenose dolphins might occur here.

Distribution—The overall range of the common 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 United Kingdom 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, CA 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 western North Atlantic, bottlenose dolphins occur as far north as Nova Scotia but are most common in coastal waters from New England to Florida, the Gulf of Mexico, the Caribbean, and southward to Venezuela and Brazil (Würsig et al. 2000). In the northern Bahamas, monitoring and genetic studies support coastal bottlenose dolphins as having strong fidelity and limited reproduction in this region and even smaller sections (Parsons et al. 2006). Therefore, Bahamian coastal bottlenose dolphins may remain for extended periods in only a few dozen square miles.

In the Bahamas, several studies have characterized bottlenose dolphin distribution. Rossbach and Herzing (1999) found that distinct inshore and offshore communities existed near the Little Bahama

Banks, with an approximate division at 27 km from shore. "Inshore" bottlenose dolphins appear to remain in relatively small geographic areas (Rossbach and Herzing 1999; Durban et al. 2000; Rogers et al. 2004) and form smaller communities that remain relatively segregated (Claridge 1994). This is further corroborated by genetic studies showing some degree of genetic exchange between inshore individuals on the Little Bahama Banks but the existence of three distinct subpopulations less than 250 km apart (Parsons et al. 2006). "Offshore" animals also appeared to exhibit significant site fidelity and occurred in certain areas for several years. In addition, these animals most-frequently associated with individuals of their own sex (Rossbach and Herzing 1999). However, non-resident individuals known to occupy the Bahamas have traveled in excess of 320 km between sightings (Rogers et al. 2004).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Both coastal and offshore stocks are mapped together. Bottlenose dolphins are present throughout the entire study area. They are common inshore of the 1,000 m isobath and throughout both shallow and deep waters of the Bahamas (Figure B-13). Occurrence to the north of the Bahamas is bounded by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone). These occurrence patterns consider bottlenose dolphin abundance off the southeastern U.S. and wide-ranging patterns of the western Atlantic offshore bottlenose dolphin stock. Local Bahamian marine scientists encounter bottlenose dolphins almost everywhere where research surveys have been conducted in Bahamian waters. No seasonal differences in occurrence patterns are anticipated, including off Florida, since coastal dolphins are not considered to be part of the coastal migratory stock this far south.

  Bottlenose dolphins range throughout southeastern Florida (e.g., Thomas 1996; McClellan et al. 2000). Thomas (1996) noted that distribution along the east coast of Florida was not uniform, with more sightings occurring in the central portion of the state around Cape Canaveral. She suggested that this was likely due to increased prey availability related to the presence of reefs (Thomas 1996). Most of the bottlenose dolphin studies off the east coast of Florida occur in the Indian River Lagoon System (IRLS), which is inshore of the study area. During Summer 2001, a noteworthy unusual mortality event took place involving at least 30 bottlenose dolphins stranded during a two month period in the IRLS at South Merritt Island, inshore of the study area (Bossart et al. 2003). A dolphin health assessment program was initiated within that area during 2003 and involved the capture, assessment, and release of individuals (Bossart et al. 2006). There is currently no evidence of individuals within the IRLS being sighted in coastal waters adjacent to the study area (Defran 2006). Work is currently underway to determine whether individuals seen coastally, north of the study area (i.e., Jacksonville) are moving south (Defran 2006).

  There are two tagged individuals that made interesting movements through the study area. "Rudy" stranded on the Gulf coast of Florida and was released in the Gulf of Mexico off central west Florida. He moved around Florida, through the study area, and northward to off Cape Hatteras, NC (R.S. Wells et al. 1999). "Gulliver" stranded near St. Augustine, Florida and was released off Cape Canaveral, FL. He swam through waters with a bottom depth of 5,000 m to 300 km offshore of the Virgin Islands (R.S. Wells et al. 1999).

  Several swim-with-wild-dolphin programs operate at Little Bahama Bank (specifically, White Sand Ridge) near Grand Bahama Island, giving people the opportunity to swim with both bottlenose and Atlantic spotted dolphins (Herzing et al. 2003; Samuels et al. 2004). Dolphins here routinely occur in waters over the shallow sandbar with a bottom depth of 7 to 10 m. There is also a dolphin swim program that includes bottlenose dolphins, north of Bimini on the Great Bahama Bank (Herzing et al. 2003; Dudzinski 2006).

  Of interest is that during June 1992, a captive female bottlenose dolphin "Bahama Mama" escaped from a swim-with-dolphins program at Great Guana Cay in the Abacos (Claridge and Balcomb 1993). This individual had been captured for captivity off North Eleuthera about 15 years earlier. During November 1992, she was resighted associating with a group of dolphins (Claridge and Balcomb 1993). Also noteworthy is that during October 2002, over 20 bottlenose dolphins

mass-stranded in Long Island between Deadman's Cay and Mangrove Bush (Anonymous 2002, Lighbourne 2003).

Behavior and Life History—Bottlenose dolphins are gregarious and typically found in groups of 2 to 15 individuals, although groups of 100 or more have been reported (Shane et al. 1986; Kerr et al. 2005). Average group size at Grand Bahama Island is three to five individuals (Rogers et al. 2004). Bottlenose dolphins inhabiting shallow waters in the Bahamas demonstrate many of the same social structure characteristics as in other well-studied coastal populations around the world (Rogers et al. 2004). Bottlenose dolphins frequently associate with other marine mammal species; the association between this species and the Atlantic spotted dolphin is well-known in Bahamian waters (e.g., Herzing 1996; Herzing and Johnson 1997; Herzing et al. 2003).

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). Water depth is 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.

Little is known of the behavior and range of offshore bottlenose dolphins. It is suspected that these animals may range beyond continental slope waters and move between the Atlantic Ocean and Gulf of Mexico (R.S. Wells et al. 1999). Based upon genetic analyses, it is possible that a single worldwide population exists (Curry and Smith 1997).

Along the U.S. Atlantic coast, bottlenose dolphin females reach sexual maturity as early as seven years of age at lengths of 220 to 235 cm, while males reach sexual maturity at 10 to 13 years of age and 245 to 260 cm (Mead and Potter 1990). Both males and females reach physical maturity at about 13 years (Mead and Potter 1990). Gestation lasts roughly one year (D. Caldwell and Caldwell 1972). Calves typically remain with their mothers for three to eight years (Wells et al. 1987). A calving interval has been suggested to be two years (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). Mead and Potter (1990) reported a prolonged calving season with a spring peak. Males are known to form alliances for enhanced mating opportunities (Connor et al. 1992; Möller et al. 2001). In the Bahamas, these alliances seem to be based at least in part upon kin relatedness (Parsons et al. 2003).

Bottlenose dolphins are opportunistic feeders that utilize numerous strategies to prey upon a variety of fishes, cephalopods, and shrimps (e.g., Rossbach and Herzing 1997, 1999; 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. Barros and Odell (1990) reported a high intake of only fish species for dolphins found stranded from Palm Beach north to Cape Canaveral, FL with sand seatrout (*Cynoscion arenarius*) being the most commonly identified prey. Rossbach and Herzing (1997) reported on an unusual feeding behavior they observed in the Bahamas and termed "crater feeding." The only prey identified was a conger eel (*Conger oceanicus*) that was dropped by a dolphin that had been crater feeding; Rossbach and Herzing (1997) did note that benthic fishes here include kelpfish and wrasses. Rossbach (1999) reported on cooperative herding of fish and predation on spawning lane snapper (*Lutjanus synagris*) in the Bahamas; feeding varied by community and sediment type. Bottlenose dolphins in the Bahamas have been filmed feeding on schooling jacks (BMMS 2005). Rogers et al. (2004) reported observing bottlenose dolphins in the Bahamas foraging along the edges of seagrass beds (turtle grass; *Thalassia testudinum*).

Navy bottlenose dolphins have been trained to reach maximum diving depths of about 300 m (Ridgway et al. 1969a). Reeves et al. (2002) 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. 2005). Dive durations up to 15 min have been recorded for trained individuals (Ridgway et al. 1969a). Typical dives, however, are more shallow and of a much shorter duration. 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. 2005).

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) (M. 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 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 (Zaretsky et al. 2005; Baron 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 et al. 2005; Mooney et al. 2005; Mooney 2006). For example, TTS has been induced with exposure to a 3 kHz, one-second pulse with sound exposure level (SEL) of 195 dB re 1 $\mu Pa^2 s$ (Finneran et al. 2005), one-second pulses from 3 to 20 kHz at 192 to 201 dB re 1μPa-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 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).

- Pantropical Spotted Dolphin *(Stenella attenuata)*

Description—The pantropical spotted dolphin is a rather slender dolphin. This species has a dark dorsal cape, while the lower sides and belly of adults are gray. The beak is long and thin; the lips and beak tip tend to be bright white. A dark gray band encircles each eye and continues forward to the apex of the melon; there is also a dark gape-to-flipper stripe (Jefferson et al. 1993). Pantropical spotted dolphins are born spotless and develop spots as they age although the degree of spotting varies geographically (Perrin and Hohn 1994). Some populations may be virtually unspotted (Jefferson et al. 1993). Adults may reach 2.6 m in length (Jefferson et al. 1993).

Status—The best abundance estimate for the western North Atlantic stock of pantropical spotted dolphins is 4,439 individuals (Waring et al. 2006). There is no information on stock differentiation for pantropical spotted dolphins in the U.S. Atlantic (Waring et al. 2006).

Habitat Preferences—Most sightings in the Gulf of Mexico and Caribbean Sea occur over the lower continental slope or offshore (Davis et al. 1998; Mignucci-Giannoni et al. 2003). Mignucci-Giannoni et al. (2003) reported a sighting over the Puerto Rican Trench, one of the deepest areas in the world. Pantropical spotted dolphins may rarely be sighted in shallower waters (e.g., Peddemors 1999; Gannier 2002; Mignucci-Giannoni et al. 2003; Waring et al. 2006). Pantropical spotted dolphins in the Gulf of Mexico do not appear to prefer any one habitat and may be found within the Loop Current, inside a cold-core eddy, or along the continental slope (Baumgartner et al. 2001). In the eastern Pacific, pantropical spotted dolphins are found most frequently in waters underlain by a sharp thermocline at depths of less than 50 m, SST over 25º C, and salinities less than 34 psu (Au and Perryman 1985).

Distribution—Pantropical spotted dolphins are distributed in subtropical and tropical waters worldwide (Perrin and Hohn 1994).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The pantropical spotted dolphin is common seaward of the shelf break and bank margins throughout the study area (Figure B-14). This is based on the distribution of sighting records as well as this species' preference for deep waters (Figure B-14; Mullin and Fulling 2003). Pantropical spotted dolphins occasionally are reported in shallow shelf or insular waters in some regions (e.g., Peddemors 1999; Gannier 2002; Waring et al. 2006). This species is considered to be present on the shelf, based on the distribution of occurrence records. It should be noted that most winter sightings in Figure B-14 were reported from a single survey (Programme Intégré des Recherches sur les Oiseaux Pélagiques; PIROP) directed towards collecting information on seabirds. Caution should be exercised though when using non-NMFS data to predict occurrences in this area as long-standing confusion has existed, even for experienced marine mammal observers, regarding the identification of the two species of spotted dolphins (pantropical and Atlantic) off the U.S. Atlantic coast (Perrin et al. 1987). Pantropical spotted dolphins are not expected to occur in shallow waters over the Bahamian banks, since they have not been sighted there, even with extensive survey effort. No seasonality to this species' occurrence in the area is known.

  Of interest is a mass stranding involving 15 individuals during February 1983, approximately 25 km north of West Palm Beach.

Behavior and Life History—Pantropical spotted dolphin group sizes range from a few individuals to several thousands (Jefferson et al. 1993). Reported group sizes along the U.S. Atlantic coast range from 35 to 145 individuals (Mullin and Fulling 2003); those in the Caribbean Sea vary between two and 400 individuals (Mignucci-Giannoni et al. 2003).

Observations of pantropical spotted dolphins caught in tuna purse seines in the eastern tropical Pacific show that subgroups contain mother/calf pairs, adult males, or juveniles (Pryor and Shallenberger 1991). In the eastern tropical Pacific, where this species has been best studied, there are two (possibly three) calving peaks: one in spring, (one possibly in summer), and one in fall (Perrin and Hohn 1994). Pantropical spotted dolphins prey on epipelagic fishes, squids, and crustaceans (Perrin and Hohn 1994; Robertson and Chivers 1997; Wang et al. 2003). Results from various tracking and feeding studies suggest that pantropical spotted dolphins in the eastern tropical Pacific and off Hawaii feed primarily at night on epipelagic and mesopelagic species, which rise towards the surface after dark (Robertson and Chivers 1997; Scott and Cattanach 1998; Baird et al. 2001). Dives during the day generally are shorter and shallower than dives at night; rates of descent and ascent are higher at night than during the day (Baird et al. 2001). Similar mean dive durations and depths have been obtained for tagged pantropical spotted dolphins in the eastern tropical Pacific and off Hawaii (Baird et al. 2001).

Acoustics and Hearing—Pantropical spotted dolphin whistles have a frequency range of 3.1 to 21.4 kHz (Thomson and Richardson 1995). Clicks typically have two frequency peaks (bimodal) at 40 to 60 kHz and 120 to 140 kHz with estimated source levels up to 220 dB re 1 μPa peak-to-peak (Schotten et al. 2004). No direct measures of hearing ability are available for pantropical spotted dolphins, but ear anatomy has been studied and indicates that this species should be adapted to hear the lower range of ultrasonic frequencies (<100 kHz) (Ketten 1992, 1997).

- Atlantic Spotted Dolphin *(Stenella frontalis)*

Description—The Atlantic spotted dolphin tends to resemble bottlenose dolphins more than it does the pantropical spotted dolphin (Jefferson et al. 1993). In body shape, it is somewhat intermediate between the two, with a moderately long but rather thick beak. The dorsal fin is tall and falcate and there is generally a prominent spinal blaze. Adults are up to 2.3 m long and can weigh as much as 143 kg (Jefferson et al. 1993). Atlantic spotted dolphins are born spotless and develop spots as they age (Perrin et al. 1994a; Dudzinski 1996; Herzing 1997). Some Atlantic spotted dolphin individuals become so heavily spotted that the dark cape and spinal blaze are difficult to see (Perrin et al. 1994a; Dudzinski 1996; Herzing 1997).

There is marked regional variation in the adult body size of the Atlantic spotted dolphin (Perrin et al. 1987). There are two forms: a robust, heavily spotted form that inhabits the continental shelf, usually found within 250 to 350 km of the coast and a smaller, less-spotted form that inhabits offshore waters (Perrin et al. 1994a). The largest body size occurs in waters over the continental shelf of North America (U.S. east coast and Gulf of Mexico) and Central America (Perrin 2002a). The smallest Atlantic spotted dolphins are those around oceanic islands, such as the Azores and on the high seas in the western North Atlantic (Perrin 2002a). It is the large body size form that occurs over the sandy banks of the Bahamas.

Status—The best estimate of Atlantic spotted dolphin abundance in the western North Atlantic is 50,978 individuals (Waring et al. 2006). Recent genetic evidence suggests that there are at least two populations of Atlantic spotted dolphins in the western North Atlantic and one in the Gulf of Mexico, as well as possible inshore and offshore segregation (Adams and Rosel 2006). Atlantic populations are divided along a latitudinal boundary corresponding roughly to Cape Hatteras (Adams and Rosel 2006).

There are no abundance estimates available for the entire Caribbean Sea. There are estimates for a few locations in the Bahamas, based on photo-identification efforts. For the Bimini Island Group, there are an estimated 100 individuals, with 85 individuals photo-identified (Dudzinski 2006). On the western edge of Little Bahama Bank in an approximately 450 square km area, there are about 200 Atlantic spotted dolphins (Herzing 2006). There is no population estimate available for around Abaco, but at least 150 individuals are photo-identified (Claridge 2007).

Habitat Preferences—This is a tropical to warm-temperate species. The large, heavily spotted coastal form of the Atlantic spotted dolphin typically occurs over the continental shelf inside or near the 185 m isobath, usually at least 8 to 20 km offshore (Perrin et al. 1994a; Davis et al. 1998; Perrin 2002a). There are also frequent sightings of this species beyond the shelf break in the Caribbean, Gulf of Mexico, and off the Atlantic U.S. coast (Mills and Rademacher 1996; Roden and Mullin 2000; Fulling et al. 2003; Mullin and Fulling 2003; Mullin et al. 2004). In the Caribbean, Atlantic spotted dolphins are often found along shelf areas of low sea floor relief or the shelf edge; this species rarely occurs offshore (Mignucci-Giannoni 1998). In the Bahamas, Atlantic spotted dolphins spend much of their time in shallow water (6 to 12 m) over sand flats (e.g., Herzing and Johnson 1997; MacLeod et al. 2004) although they are also seen in waters with bottom depths up to 2,191 m (MacLeod et al. 2004).

Distribution—Atlantic spotted dolphins are endemic to warm-temperate and tropical Atlantic waters from approximately 45º N to 35º S; in the western North Atlantic Ocean, this translates to waters from northern New England to Venezuela, including the Gulf of Mexico and the Caribbean Sea (Perrin et al. 1987). Dudzinski (1996) provides a history on the interactions between divers and the resident population on Little Bahama Bank, north of West End, Grand Bahama Island.

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The Atlantic spotted dolphin is the most abundant dolphin species off the southeastern U.S. Atlantic (Mullin and Fulling 2003). This dolphin prefers warm waters. No seasonal differences in occurrence patterns are anticipated. It is present between the shore and the 20 m isobath off Florida (Figure B-15). This species is well-known to occur in coastal waters. Occurrence records are sparse in this area, however, even though significant survey effort has been exerted here. Bottlenose dolphins are thought to occupy more nearshore waters than spotted dolphins in nearshore

habitats. The Atlantic spotted dolphin has a common occurrence in waters seaward of the 20 m isobath in shelf waters off Florida, bordered by the Gulf Stream and flow of the Antilles Current to include deep water channels of the Bahamas (Northeast and Northwest Providence Channels, TOTO, and Exuma Valley). This takes into account both coastal and offshore forms of the species. There is a rare occurrence to the north of the warm Antilles Current and west of the Gulf Stream that accounts for possibly encountering the species in cooler and deeper waters of the North Atlantic.

Atlantic spotted dolphins are rare throughout most shallow waters of the Bahamas (Figure B-15), where survey efforts have not generated sightings. The Little Bahama Bank (specifically, White Sand Ridge) near Grand Bahama Island is an exception to this pattern; this is an area of common occurrence of this species; several swim-with-wild-dolphin programs operate here (Herzing et al. 2003; Samuels et al. 2004). Dolphins here routinely occur in waters over the shallow sandbar with a bottom depth of 7 to 10 m. Atlantic spotted dolphins have a common occurrence over part of the western Great Bahama Bank, where lobster fisherman report interactions with the species (Claridge 2007). The Atlantic spotted dolphin is present around the bank margins of Grand Bahama Island and the Abaco Islands, based on the distribution of sightings made during extensive survey effort in the area. There is also a dolphin swim program north of Bimini on the Great Bahama Bank (Herzing et al. 2003; Dudzinski 2006). A study is planned of spotted dolphins at Orange Cay, south of the Bimini Island Group (Dudzinski 2006).

Missing from Figure B-15 are five sightings made in the early 1970s off the Florida coast by an unmanned submersible (Sutherland and May 1977). Of note is that during the time of the March 2000 beaked whale mass stranding event in the Bahamas, an Atlantic spotted dolphin was also found stranded (NOAA and Secretary of the Navy 2001). Pathology results indicated that this individual's death was unrelated to that of the other animals since it died with systemic debilitating disease (NOAA and Secretary of the Navy 2001).

Behavior and Life History—Atlantic spotted dolphins are generally found in groups of 50 or fewer (Jefferson et al. 1993). In the Bahamas, groups of one to ten individuals are the norm, although groups as large as 35 to 40 individuals are seen (Dudzinski 1996). The association between this species and the bottlenose dolphin is well-known in Bahamian waters (e.g., Herzing and Johnson 1997; Herzing et al. 2003).

In the Bahamas, female sexual maturation is estimated to occur at 8 to 15 years of age (Herzing 1997); there is no information available for local males. Peak calving periods in the Bahamas are early spring and late fall (Herzing 1997). Perrin et al. (1994a) present information on female and male sexual maturation relative to body length for individuals in the Gulf of Mexico and western North Atlantic. Atlantic spotted dolphins feed on small cephalopods, fishes, and benthic invertebrates (Perrin et al. 1994a). Atlantic spotted dolphins have been observed feeding on herring and anchovies near St. Augustine, Florida, and further offshore on carangid fishes (D. Caldwell and Caldwell 1966). In the Bahamas, Atlantic spotted dolphins are frequently seen foraging on the shallow sandbanks for flounder, lizardfish, mackerel-like fishes, wrass, blenny, kelpfish, eel, and benthic invertebrates (Norris and Møhl 1983; Perrin et al. 1994a; Herzing 1996). They also feed nocturnally off the continental shelf break on squid and have been observed chasing and catching flying fish (Claridge 1998; MacLeod et al. 2004; Dudzinski 2006).

The only information on diving depth for this species is based on a satellite-tagged individual from the Gulf of Mexico (Davis et al. 1996b). This individual made short, shallow dives to less than 10 m and as deep as 60 m while in waters over the continental shelf for 76% of dives.

Acoustics and Hearing—A variety of sounds including whistles, echolocation clicks, squawks, barks, growls, and chirps have been recorded for the Atlantic spotted dolphin (Thomson and Richardson 1995). Whistles have dominant frequencies below 20 kHz (range: 7.1 to 14.5 kHz) but multiple harmonics extend above 100 kHz, while burst pulses consist of frequencies above 20 kHz (dominant frequency of approximately 40 kHz) (Lammers et al. 2003). Other sounds, such as squawks, barks, growls, and chirps, typically range in frequency from 0.1 to 8 kHz (Thomson and Richardson 1995). Recently recorded echolocation clicks have two dominant frequency ranges at 40 to 50 kHz and 110 to 130 kHz, depending on source level (i.e., lower source levels typically

correspond to lower frequencies and higher frequencies to higher source levels (Au and Herzing 2003). Echolocation click source levels as high as 210 dB re 1 μPa-m peak-to-peak have been recorded (Au and Herzing 2003). There are no empirical hearing data for Atlantic spotted dolphins. Spotted dolphins in the Bahamas were frequently recorded during agonistic/aggressive interactions with bottlenose dolphins (and their own species) to produce squawks (0.2 to 12 kHz broad band burst pulses; males and females), screams (5.8 to 9.4 kHz whistles; males only), barks (0.2 to 20 kHz burst pulses; males only), and synchronized squawks (0.1-15 kHz burst pulses; males only in a coordinated group) (Herzing 1996).

There has been no data collected on Atlantic spotted dolphin hearing ability. However, odontocetes are generally adapted to hear high-frequencies (Ketten 1997).

- Spinner Dolphin *(Stenella longirostris)*

Description—This is a slender dolphin that has a very long, slender beak (Jefferson et al. 1993). The dorsal fin ranges from slightly falcate to triangular or even canted forward in some geographic forms. The spinner dolphin generally has a dark eye-to-flipper stripe and dark lips and beak tip (Jefferson et al. 1993). This species typically has a three-part color pattern (dark gray cape, light gray sides, and white belly). Adults can reach 2.4 m in length (Jefferson et al. 1993). There are four known subspecies of spinner dolphins and probably other undescribed ones (Perrin 1998; Perrin et al. 1999).

Status—There are no abundance estimates for the western North Atlantic stock of spinner dolphins (Waring et al. 2006). Stock structure in the western North Atlantic and Caribbean Sea is unknown.

Habitat Preferences—Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick 1994). Oceanic populations, such as those in the eastern tropical Pacific, are often found in waters with a shallow thermocline (Au and Perryman 1985; Reilly 1990). The thermocline concentrates pelagic organisms in and above it; spinner dolphins feed on this aggregation of prey. In the eastern tropical Pacific, spinner dolphins are associated with tropical surface water typified by extensive stable thermocline ridging and relatively little annual variation in surface temperature (Reeves et al. 1999b). Coastal populations are usually found in island archipelagos where they are tied to trophic and habitat resources associated with the coast (Norris and Dohl 1980; Poole 1995). Spinner dolphin distribution in the Gulf of Mexico and off the northeastern U.S. coast is primarily in offshore waters (CETAP 1982; Davis et al. 1998). Off the eastern U.S. coast, spinner dolphins were sighted within the Gulf Stream, which is consistent with the oceanic distribution and warm-water preference of this genus (Waring et al. 1992).

Distribution—Spinner dolphins are found in subtropical and tropical waters worldwide, with different geographical forms in various ocean basins. The range of this species extends to near 40° latitude (Jefferson et al. 1993).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Spinner dolphins are not expected in shallow waters of the East Florida Shelf or over Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-16). During the Fritts aerial surveys of the 1980s (see Appendix A-2 for details on these surveys and Figure A-1 for their coverage), sightings were recorded in waters with a bottom depth less than 200 m off the Atlantic and Gulf coasts of Florida (Fritts et al. 1983a). Based on the known habitat preferences of the spinner dolphin in the Gulf of Mexico, it is now thought that the Gulf animals were misidentified (Jefferson and Schiro 1997; Würsig et al. 2000). It is probable that these were actually sightings of Atlantic spotted dolphins (Jefferson 2006). The same is highly likely for the Atlantic Coast sighting. Spinner dolphins are also not expected in shallow waters of the Bahamas; there appears to be no island population for this species here (unlike other geographic locations, such as the Hawaiian Islands) since there have been no sightings even though there is significant survey and opportunistic sighting effort.

  Spinner dolphins are present seaward of the Florida shelf break based on available occurrence records just north of the study area and this species' preference for deep waters. There is a rare occurrence for the spinner dolphin between the Bahamian bank margin and bounded to the north

of the Bahamas by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank and to the west by the Gulf Stream (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone). There is also rare occurrence throughout deep waters of the Bahamas. During little survey effort in the TOTO, one sighting of spinner dolphins was made, confirming this species' occurrence in the area. No seasonality to spinner dolphin occurrence is known.

Not depicted in Figure B-16 is the sighting of a large group of spinner dolphins and the harpooning of one individual just west of the Bahamas off Turtle Rocks (45 NM off Miami Beach) during 1930; no further details on the actual date were available (Moore 1953).

Behavior and Life History—Group sizes range from less than 50 to several thousand individuals (Jefferson et al. 1993). Seasonal and geographic variations in group size have been recorded (Norris et al. 1985). A Hawaiian population of spinner dolphins has been studied for more than 20 years (Norris et al. 1994). Social groupings of this species are typically very fluid in Hawaiian waters; large groups form, break-up, and re-form with different subgroups throughout the day (Norris et al. 1994). In the offshore eastern tropical Pacific, there is some segregation by age and sex among dolphin groups (Perrin and Gilpatrick 1994). In the eastern tropical Pacific, spinner dolphins are often seen with pantropical spotted dolphins (Perrin and Gilpatrick 1994). Spinners in the Atlantic occasionally have been sighted and stranded in association with Clymene and pantropical spotted dolphins (Jefferson and Lynn 1994; Fertl et al. 2003).

Spinner dolphins feed primarily on small mesopelagic fishes, squids, and sergestid shrimps, and they dive to at least 200 to 300 m (Perrin and Gilpatrick 1994). Foraging takes place primarily at night when the mesopelagic community migrates vertically towards the surface and also horizontally towards the shore at night (Benoit-Bird et al. 2001; Benoit-Bird and Au 2004). Rather than foraging offshore for the entire night, spinner dolphins track the horizontal migration of their prey (Benoit-Bird and Au 2003). This tracking of the prey allows spinner dolphins to maximize their foraging time while foraging on the prey at its highest densities (Benoit-Bird and Au 2003; Benoit-Bird 2004).

The life history of the spinner dolphin has been well-described for the eastern tropical Pacific Ocean where the species is killed in large numbers in tuna purse seine nets (reviewed in Perrin 1998). Gestation lasts about 10 months and length of lactation is about 1 to 2 years. Sexual maturity occurs at lengths and ages of 1.65 to 1.70 m and 4 to 7 years (females) and 1.60 to 1.80 m and 7 to 10 years (males). There is some geographic variation, but other spinner dolphin populations probably have life history characteristics similar to those listed. Calving peaks in different populations range from late spring to fall (Jefferson et al. 1993).

Spinner dolphins are well known for their propensity to leap high into the air and spin before landing in the water; the purpose of this behavior is unknown. Norris and Dohl (1980) also described several other types of aerial behavior, including several other leap types, backslaps, headslaps, noseouts, tailslaps, and a behavior called "motorboating." Undoubtedly, spinner dolphins are one of the most aerially-active of all dolphin species.

Acoustics and Hearing—Pulses, whistles, and clicks have been recorded from this species. Pulses and whistles have dominant frequency ranges of 5 to 60 kHz and 8 to 12 kHz, respectively (Ketten 1998). Spinner dolphins consistently produce whistles with frequencies as high as 16.9 to 17.9 kHz with a maximum frequency for the fundamental component at 24.9 kHz (Bazúa-Durán and Au 2002; Lammers et al. 2003). Clicks have a dominant frequency of 60 kHz (Ketten 1998). The burst pulses are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al. 2003). Source levels between 195 and 222 dB re 1 μPa-m have been recorded for spinner dolphin clicks (Schotten et al. 2004).

There has been no data collected on spinner dolphin hearing ability. However, odontocetes are generally adapted to hear high-frequencies (Ketten 1997).

- 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 best estimate of striped dolphin abundance in the western North Atlantic is 94,462 individuals (Waring et al. 2006).

Habitat Preferences—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, 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).

Distribution—Striped dolphins have a worldwide distribution in deep and cool temperate to tropical zones. Striped dolphins generally occupy offshore habitats and rarely venture over continental shelf waters (Perrin et al. 1994b; Archer II and Perrin 1999). In the western North Atlantic, this species is known from Nova Scotia southward to the Caribbean Sea, Gulf of Mexico, and Brazil (Würsig et al. 2000). For the Caribbean, there are a few sighting and stranding records (van Bree 1975; Jefferson and Lynn 1994; Mignucci-Giannoni 1996; Debrot et al. 1998; Roden and Mullin 2000). Striped dolphins are not common in most truly tropical areas (Baird et al. 1993).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Striped dolphins in the study area appear to generally occupy the offshore cooler water habitats, rarely venturing into continental shelf waters as is expected from their known distribution in cooler waters (Perrin et al. 1994b).
    - Winter—This species is not expected in the shallow waters of the East Florida Shelf and Bahamian banks (Figure B-17). The striped dolphin has a rare occurrence within the deep waters of the Bahamas. There is also a rare occurrence as well as between the bank margin and the area bounded to the north by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank and to the west by the edge of the Gulf Stream (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone). There is one sighting record for the striped dolphin in the Bahamas during this time of year, which is within the TOTO. Based on the distribution of occurrence records and known habitat preferences of the species, the striped dolphin is present in waters seaward of the shelf break everywhere in the study area besides the Bahamas. Odell and Chapman (1976) described the first documented stranding of a striped dolphin (a pregnant female) on the east coast of Florida.
    - Spring/Summer/Fall—Striped dolphins are not expected in the shallow waters over the East Florida Shelf or Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) based on survey effort in the Bahamas and known habitat preferences for the species in the southeastern U.S. (Figure B-17). There is a rare occurrence of the species in deep waters throughout the study area based on the few sighting records during this time of the year, as well as this species' preference for deep waters.

Behavior and Life History—Striped dolphins are typically found in groups numbering between 100 and 500 individuals although sometimes they gather in the thousands. Striped dolphins have often been found in association other species of marine mammals and seabirds (Baird et al. 1993).

Life history information is based mostly on western North Pacific specimens (Archer II and Perrin 1999). Males reach sexual maturity between 7 and 15 years of age, at an average body length of 2.2 m. Females become sexually mature between 5 and 13 years of age (Archer II and Perrin 1999). Reproductive information from Mediterranean females provides an estimate of 12 years for age at sexual maturity (Calzada et al. 1996). Off Japan, where their biology has been best studied, there are two calving peaks: one in summer and one in winter (Perrin et al. 1994a).

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 diurnal vertical movements. Small, mid-water fishes (in particular, myctophids or lanternfish) and squids are the dominant prey (Perrin et al. 1994b; Blanco et al. 1995; Ringelstein et al. 2006).

Acoustics and Hearing—Striped dolphin whistles range from 6 to greater than 24 kHz, with dominant frequencies ranging from 8 to 12.5 kHz (Thomson and Richardson 1995). A single striped dolphin's hearing range, determined by using standard psycho-acoustic techniques, was from 0.5 to 160 kHz with best sensitivity at 64 kHz (Kastelein et al. 2003).

- Clymene Dolphin *(Stenella clymene)*

Description—Clymene dolphins are easily confused with spinner and short-beaked common dolphins (Fertl et al. 2003). The Clymene dolphin, however, is smaller and more robust, with a much shorter and stockier beak. The dorsal fin is tall and only slightly falcate. A three-part color pattern consisting of a dark gray cape, light gray sides, and white belly is characteristic of this species (Jefferson and Curry 2003). The cape dips in two places, first above the eye and then below the dorsal fin. The lips and beak tip are black. There is also a dark stripe on the top of the beak, as well as a dark variably-shaped "moustache" on the middle of the top of the beak. The Clymene dolphin can reach at least 2.0 m in length and weights of at least 85 kg (Jefferson et al. 1993).

Status—Clymene dolphins have only been recognized as a valid species since 1981 (Perrin et al. 1981). The best estimate of abundance for the western North Atlantic stock of Clymene dolphins is 6,086 individuals (Waring et al. 2006).

Habitat Preferences—Clymene dolphins are a tropical to subtropical species, primarily sighted in deep waters well beyond the edge of the continental shelf (Fertl et al. 2003). Clymene dolphins are found in waters with a mean bottom depth of 1,870 m (Fertl et al. 2003). Biogeographically, the Clymene dolphin is found in the warmer waters of the North Atlantic from the North Equatorial Current, the Gulf Stream, and the Canary Current (Fertl et al. 2003). Clymene dolphins in the Gulf of Mexico were found in offshore areas in regions of cyclonic or confluence circulation (Davis et al. 2002).

Distribution—Clymene dolphins are known only from the subtropical and tropical Atlantic Ocean (Perrin and Mead 1994; Fertl et al. 2003). In the western Atlantic Ocean, Clymene dolphins are known from New Jersey to Brazil, including the Gulf of Mexico and Caribbean Sea (Fertl et al. 2003; Moreno et al. 2005).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The Clymene dolphin is a deep water species that is present seaward of the 100 m isobath throughout the study area (Figure B-18). Individuals are not expected to occur in shallow waters over the East Florida Shelf (inshore of the 100 m isobath) or Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-18). There is a rare occurrence from the bank margin to an area north of the Bahamas bounded by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone). There are no confirmed records of the Clymene dolphin within the Bahamas, even though there is survey/boater coverage. It should be noted that the Clymene dolphin is often incorrectly identified as other species (or just documented as unidentified *Stenella* spp.), particularly by inexperienced observers, and that low densities of the species could also be part of the reason the species has not yet been confirmed to occur in that region. No seasonality in occurrence patterns is expected.

Behavior and Life History—Very little is known about the biology of the Clymene dolphin (Jefferson 2002). Much of the information comes from the northern Gulf of Mexico (Jefferson et al. 1995; Jefferson and Curry 2003). Sexual maturity appears to be reached by the length of about 1.8 m (Jefferson 1996). Reported group sizes range from several to 1,000 individuals (Fertl et al. 2003). Clymene dolphins are known to associate with other dolphin species, such as spinner dolphins (Fertl et al. 2003). Available information on feeding habits is limited to the stomach contents of two

individuals and one observation of feeding free-ranging dolphins; Clymene dolphins feed on small pelagic fish and squid (Perrin et al. 1981; Perrin and Mead 1994; Fertl et al. 1997).

Acoustics and Hearing—The only data available for this species is a description of their whistles. Clymene dolphin whistle structure is similar to that of other stenellids, but it is generally higher in frequency (range of 6.3 to 19.2 kHz) (Mullin et al. 1994b). There is no empirical data on the hearing ability of Clymene dolphins; however, the most sensitive hearing range for odontocetes generally includes high frequencies (Ketten 1997).

- Common Dolphin *(Delphinus delphis)*

Description—There are two species in the genus *Delphinus*: long-beaked common dolphin (*Delphinus capensis*) and short-beaked common dolphin (*Delphinus delphis*) (Heyning and Perrin 1994; Rosel et al. 1994). The short-beaked common dolphin is considered to be the only *Delphinus* species north of Venezuela.

Short-beaked common dolphins are moderately-robust dolphins, with a moderate-length beak, and a tall, slightly falcate dorsal fin. The beak is shorter than in long-beaked common dolphins, and the melon rises from the beak at a steeper angle (Heyning and Perrin 1994). Short-beaked common dolphins 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 (Heyning and Perrin 1994).

Status—The best estimate of abundance for the Western North Atlantic stock is 120,743 individuals. There is no information available for western North Atlantic common dolphin stock structure (Waring et al. 2006).

Habitat Preferences—Common dolphins 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). Along the U.S. Atlantic coast, common dolphins typically occur in temperate waters on the continental shelf between the 100 and 200 m isobaths but can occur in association with the Gulf Stream (CETAP 1982; Selzer and Payne 1988; Waring and Palka 2002). Some common dolphin populations appear to preferentially travel along topographic features such as escarpments and sea mounts (Evans 1994). In tropical regions, *Delphinus* spp. are routinely sighted in upwelling-modified (or otherwise high productivity) waters (Au and Perryman 1985; Ballance and Pitman 1998).

Distribution—The common dolphin is widely distributed globally in temperate, subtropical, and tropical seas. Common dolphins occur from southern Norway to West Africa in the eastern Atlantic and from Newfoundland to Florida in the western Atlantic (Perrin 2002b), although this species more commonly occurs in temperate, cooler waters in the northwestern Atlantic (Waring and Palka 2002).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The common dolphin is not expected to occur in the study area (Figure B-19). Occurrences south of Cape Hatteras, NC should be considered questionable, although there are old records of occurrence off Florida. Moore (1953), Essapian (1954), and Layne (1965) reported on common dolphins that were captured off St. Augustine, FL during the early 1950s for captive display. Layne (1965) also mentions a carcass found partially buried at Crescent Beach, FL. Historically, common dolphins frequented the northeastern Florida coast but for unknown reasons have been conspicuously absent since the early 1960s (D. Caldwell et al. 1971a; Leatherwood et al. 1976). Jefferson and Schiro (1997) speculated that this may be a result of population or distributional fluctuations. Several reported sighting records for *Delphinus* exist throughout the eastern and central Caribbean Sea (Mignucci-Giannoni 1989). Additionally, Varona (1973) lists the Bahamas as habitat for the species. However, any Delphinus sightings without photographic records or other documentation in this region should be considered with caution (Roden and Mullin 2000). For example, several reports of common dolphin sightings and strandings were made in the northern

Gulf of Mexico. However, once examined critically, all reports of common dolphins were reassigned as Clymene or spinner dolphins (Jefferson and Schiro 1997).

Behavior and Life History—Group sizes range from several dozen to over 10,000 individuals. Common dolphins are fast swimmers, active bowriders, and often leap out of the water. Calving peaks differ between stocks, and have been reported in spring and autumn as well as in spring and summer (Jefferson et al. 1993). Males in the North Atlantic reach sexual maturity at about 12 years of age (Murphy et al. 2005). No information is available from Atlantic females, but North Pacific females reach sexual maturity at roughly eight years of age (Ferrero and Walker 1995). Gestation is approximately 11 months and mating occurs primarily during May and June (Ferrero and Walker 1995).

Common dolphins feed on a wide variety of epipelagic and mesopelagic schooling fishes and squids in the deep scattering layer. Off the northeastern U.S., long-finned squid (*Loligo pealei*) and Atlantic mackerel (*Scomber scombrus*) are important prey (Overholtz and Waring 1991); herring, whiting (*Micromesistius poutassou*), pilchard, and anchovy are also identified as prey species (Waring et al. 1990). Common dolphins 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). Based on a small sample size from the eastern North Pacific, short-beaked common dolphins may feed more extensively on squid than the long-beaked form (Heyning and Perrin 1994). 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 deep scattering layer as it rises (Goold 2000).

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 1 μPa. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 18 kHz (Fish and Turl 1976; Thomson and Richardson 1995; Ketten 1998; Oswald et al. 2003). Maximum source levels are approximately 180 dB 1 μPa-m (Fish and Turl 1976). This species' hearing range extends from 10 to 150 kHz and is most sensitive from 60 to 70 kHz (Popov and Klishin 1998).

- Fraser's Dolphin *(Lagenodelphis hosei)*

Description—Fraser's dolphin reaches a maximum length of 2.7 m and is generally more robust than other small delphinids (Jefferson et al. 1993). This species has a short, stubby beak, small flippers and flukes, and a small subtriangular dorsal fin. The most conspicuous feature of the Fraser's dolphin coloration is the dark band running from the face to the anus (Jefferson et al. 1997), although it is not present in younger animals and appears to be geographically variable. The stripe is set off from the surrounding areas by thin, pale, cream-colored borders. There is also a dark chin-to-flipper stripe.

Status—No estimate of abundance is available for the Fraser's dolphin in the western North Atlantic or Caribbean Sea is available.

Habitat Preferences—Fraser's dolphins are an oceanic species, except in places where deep water approaches a coastline (Dolar 2002). Fraser's dolphins are found close to shore in some regions, such as around the Society Islands of French Polynesia (Gannier 2000), around several islands of the Indo-Malay archipelago in the Indo-Pacific area (Rudolph et al. 1997), and in some waters of the Philippines (Leatherwood et al. 1992). In the Gulf of Mexico, Fraser's dolphins occur well beyond the outer edge of the continental shelf and over the abyssal plain (Leatherwood et al. 1993). In the offshore eastern tropical Pacific, where most information for this species occurs, they are distributed mainly in upwelling-modified waters (Au and Perryman 1985).

Distribution—Fraser's dolphins are found in subtropical and tropical waters around the world, typically between 30ºN and 30ºS (Jefferson et al. 1993). Strandings in temperate areas are considered extralimital and usually are associated with anomalously warm water temperatures (Perrin et al. 1994c). As noted by Reeves et al. (1999b), the documented distribution of this species is skewed towards the eastern Pacific, which may reflect the intensity of research associated with the tuna fishery rather than an actual higher density of occurrence there than in other tropical regions. Few records are available from the Atlantic Ocean (Leatherwood et al. 1993; Watkins et al. 1994).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The Fraser's dolphin is a deep water species, with a rare occurrence seaward of the shelf break off Florida and offshore of the shallow waters of the Bahamian banks (Figure B-20). Two sightings of Fraser's dolphins were reported from south of Abaco Island over sloping ocean bottom. In the nearby Gulf of Mexico, Fraser's dolphins sighted in very deep waters over the abyssal plain (Leatherwood et al. 1993). Based on known habitat preferences and available sighting data and effort, this species is not expected to be found in more shallow waters of the Florida shelf or offshore of the bank margins, including north of the Bahamas bounded by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone).

  As noted earlier, there are few documented records of this species' occurrence in the western North Atlantic. The Fraser's dolphin should certainly occur within the study area.

Behavior and Life History—Fraser's dolphins are usually seen in large, fast-moving groups. Most sightings have been of groups ranging between 100 and 1,000 individuals. Mixed-species aggregations with melon-headed whales have been observed in the eastern tropical Pacific, South Pacific, and Gulf of Mexico (Jefferson and Leatherwood 1994; Reeves et al. 1999b; Gannier 2000).

Very little is known of the natural history of this species. Available data do not support calving seasonality. Sexual maturity for both sexes occurs at about seven years of age (Jefferson and Leatherwood 1994). Fraser's dolphins feed on mesopelagic fishes, squids, and shrimps (Jefferson and Leatherwood 1994; Perrin et al. 1994c). There is no information on depths to which Fraser's dolphins may dive, but they are thought to be capable of deep dives.

Acoustics and Hearing—Fraser's dolphin whistles have been recorded having a frequency range of 7.6 to 13.4 kHz in the Gulf of Mexico (duration <0.5 sec) (Leatherwood et al. 1993). There are no empirical hearing data hearing data available for this species.

- 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 best estimate of Risso's dolphin abundance in the western North Atlantic is 20,479 individuals (NMFS 2006c). There is no abundance estimate for this species in the Caribbean Sea.

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). Baumgartner (1997) hypothesized that the fidelity of Risso's dolphins on 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 true along the eastern U.S. coast between Cape Hatteras and George's Bank where individuals were distributed along the northern wall of the Gulf Stream and associated with warm-core rings (Waring et al. 1992). Leatherwood et al. (1979) and Shane (1994) reported on sightings of Risso's dolphins in shallow northeastern Pacific waters near oceanic islands. These sites are in areas where the continental shelf is narrow and deep water is closer to the shore (Leatherwood et al. 1979; Gannier 2000, 2002).

Distribution—Risso's dolphins are distributed worldwide in cool-temperate to tropical waters from roughly 60ºN to 60ºS, where SST are generally greater than 10ºC (Kruse et al. 1999). In the western North Atlantic, this species is found from Newfoundland southward to the Gulf of Mexico, throughout the Caribbean, and around the equator (Würsig et al. 2000). Water temperature appears to affect Risso's dolphin distributions in the Pacific, 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 southeastern Florida and the AUTEC-Andros OPAREA—The Risso's dolphin is a deep water species. Jennings (1982) provided the first documented oceanic sightings of Risso's dolphin off the Atlantic coast of Florida. MacLeod et al. (2004) reported two sightings for this species east of Great Abaco, one with a bottom depth of 241 m the other at 770 m. Some photo-identified individuals are seen off the coast of Abaco repeatedly, suggesting site-fidelity by at least some individuals (Claridge 1998). On the Atlantic side of the Bahamas, Risso's dolphins appear to move inshore toward the coast in the winter and spring, perhaps following prey (Claridge 1998).

  - Winter and Spring—The Risso's dolphin is a deep water species; it is present throughout all deep waters of the study area (seaward of the East Florida Shelf and off the bank margins of the Bahamas) (Figure B-21). There is also an area of common occurrence (based on available sighting data) that is bounded by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank (this is a 10 to 12 NM area that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone). There is a rare occurrence off Florida between the 40 m isobath and the shelf break which takes into account the possibility of sighting this species inshore of the shelf break, as evidenced just to the north of the study area. Three of the four sightings shown on the shelf in Figure B-21 were made during the Seawolf aerial surveys during 1997. The Risso's dolphin is not expected inshore of the 40 m isobath.

    Missing from Figure B-21 are sightings made in the Bahamas during March 1957, March 1960, and December 1967 reported by D. Caldwell and Caldwell (1977) (some of those were also mentioned by Paul (1968) that did not provide enough geographic location information for plotting. Additionally, there was as a mass stranding of five Risso's dolphins during May 1971 in Palm Beach County, FL, adjacent to the study area (D. Caldwell and Caldwell 1975).

  - Summer and Fall—The Risso's dolphin is present in deep waters seaward of the East Florida Shelf (Figure B-21). There is a rare occurrence throughout deep waters of the Bahamas; this takes into account the possibility of encountering the species in its preferred deep water habitats. There is also a rare occurrence for this species in the area bounded to the north by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank and to the west by the edge of the Gulf Stream (this is also a 10 to 12 NM area offshore of the bank margins that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone); observer effort has resulted in no sightings of this species at this time of year, even though this is a deep water species with sightings here the remainder of the year. There is also a rare occurrence off Florida between the 40 m isobath and the shelf break that takes into account the possibility of encountering this species just inshore of the shelf break.

Behavior and Life History—Little is known about the life history of this species. In the North Atlantic, there appears to be a summer calving peak (Jefferson et al. 1993). 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 (Cetacean and Turtle Assessment Program) 1982). Risso's dolphins occur in relatively stable, age and sex segregated groups, which interact fluidly with a larger population. This species commonly associates with other cetacean species, especially smaller delphinid species (CETAP 1982). Individuals may remain submerged on dives for up to 30 min and dive as deep as 600 m (DiGiovanni et al. 2005). Cephalopods are the primary prey (Clarke 1996).

Acoustics and Hearing—Risso's dolphin vocalizations 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 Risso's dolphin (Corkeron and Van Parijs 2001). Risso's dolphins also produce echolocation clicks (40 to 70 μs 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; Madsen et al. 2004a).

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). 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.

- Melon-Headed Whale *(Peponocephala electra)*

Description—Melon-headed whales at sea closely resemble pygmy killer whales; both species have a blunt head with little or no beak. Melon-headed whales have pointed (versus rounded) flippers and a more triangular head shape than pygmy killer whales (Jefferson et al. 1993). The body is charcoal gray to black, with unpigmented lips (which often appear light gray, pink, or white) and a white urogenital patch (Perryman et al. 1994). This species also has a triangular face "mask" and indistinct cape (which dips much lower below the dorsal fin than that of pygmy killer whales). Melon-headed whales reach a maximum length of 2.75 m (Jefferson et al. 1993).

Status—There are no estimates of abundance for the melon-headed whale in the western North Atlantic (Waring et al. 2006) or Caribbean Sea.

Habitat Preferences—Melon-headed whales are most often found in offshore waters. Most sightings in the Gulf of Mexico have been well beyond the continental shelf break (Mullin et al. 1994c; Davis and Fargion 1996; Davis et al. 2000; Mullin et al. 2004). MacLeod et al. (2004) reported sighting three groups of melon-headed whales in the Bahamas in waters with bottom depths ranging from 512 to 646 m. Nearshore sightings are generally from areas where deep, oceanic waters approach the coast (Perryman 2002). Melon-headed whales are found within a few km of the Society and Marquesas Islands of French Polynesia (Gannier 2000, 2002), and Lembata Island of the Indonesian archipelago (Rudolph et al. 1997), as well as in some waters of the Philippines (Leatherwood et al. 1992). In the eastern tropical Pacific, this species is primarily found in upwelling-modified and equatorial waters (Au and Perryman 1985; Perryman et al. 1994).

Distribution—Melon-headed whales are found worldwide in deep subtropical and tropical waters. There are very few records of melon-headed whales in the North Atlantic (Jefferson and Barros 1997).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The melon-headed whale is a deep water species; it is not expected to occur in shallow waters over the continental shelf (inshore of the 100 m isobath) off Florida or over the Bahamian banks (Figure B-22). MacLeod et al. (2004) reported sighting this species only three times, with all sightings in close proximity of each other over the course of one day (16 May 2001) east of Great Abaco (MacLeod 2006).

  - Winter and Spring—The melon-headed whale is present in the area bounded to the north by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank and to the west by the edge of the Gulf Stream (this is also a 10 to 12 NM area offshore of the bank margins that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone) (Figure B-22). However, throughout most of the deep waters of the study area, there is a lack of sufficient survey effort to accurately determine the occurrence patterns of this species. Individuals likely can be found in deep waters throughout the study area. Claridge reported resighting a melon-headed whale in May 1997 off Hole in the Wall that had been photographed in July 1995 off central Abaco (Claridge 2007). Not depicted in Figure B-22 are three sightings made in close proximity of one another on 16 May 2001 east of Great Abaco; these were likely subgroups of a larger group (MacLeod 2006). Also not shown in Figure B-22 is information from the mass stranding event off Florida during March 2006. On 26 March 2006, a group of more than 20 melon-headed whales were seen in shallow waters off Sebastian, Florida, and later on 29 March 2006, there was a mass stranding of five animals (there were live and dead individuals) at Vero Beach and Hutchinson Island, Florida (Southall et al. 2006).

- Summer and Fall—Melon-headed whales are not expected in shallow waters over the Bahamian banks or inshore of the 100 m isobath on the East Florida Shelf (Figure B-22). The occurrence of melon-headed whales throughout the remainder of the study area cannot be determined since there are no available occurrence records. However, occurrence is probable based on known habitat preferences.

Behavior and Life History—Melon-headed whales are typically found in large groups of between 150 and 1,500 individuals (Perryman et al. 1994; Gannier 2002), although Watkins et al. (1997) described smaller groups of 10 to 14 individuals. These animals often log at the water's surface in large schools composed of subgroups. Melon-headed whales are found in mixed-species aggregations, commonly with Fraser's dolphins (Miyazaki and Wada 1978; Perryman et al. 1994; Reeves et al. 1999b; Gannier 2002; Mullin et al. 2004). They also occur occasionally with spinner, bottlenose and rough-toothed dolphins, as well as short-finned pilot whales (Jefferson and Barros 1997; Gannier 2002; Perryman 2002). BMMS (2004) reported observing melon-headed whales briefly chasing bottlenose dolphins at Rocky Point (South Abaco).

Melon-headed whale life history is sparsely described due to lack of data. It is unclear whether significant seasonality in calving occurs (Jefferson and Barros 1997). Females reach sexual maturity at about 11.5 years of age and males at 16.5 years (Jefferson and Barros 1997). Melon-headed whales prey on squids, pelagic fishes, and occasionally crustaceans. Most fish and squid prey are mesopelagic in waters up to 1,500 m deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros 1997). There is no information on specific diving depths for melon-headed whales.

Acoustics and Hearing—The only published acoustic information for melon-headed whales is from the southeastern Caribbean (Watkins et al. 1997). Sounds recorded included whistles and click sequences. Recorded whistles have dominant frequencies between 8 and 12 kHz; higher-level whistles were estimated at no more than 155 dB re 1 µPa-m (Watkins et al. 1997). Clicks had dominant frequencies of 20 to 40 kHz; higher-level click bursts were judged to be about 165 dB re 1 µPa-m (Watkins et al. 1997). No empirical data on hearing ability for this species are available.

♦ Pygmy Killer Whale *(Feresa attenuata)*

Description—The pygmy killer whale is often confused with the melon-headed whale and less often with the false killer whale. Flipper shape is the best distinguishing characteristic; pygmy killer whales have rounded flipper tips (Jefferson et al. 1993). The body of the pygmy killer whale is somewhat slender (especially posterior to the dorsal fin) with a rounded head that has little or no beak (Jefferson et al. 1993). The color of this species is dark gray to black with a prominent narrow cape that dips only slightly below the dorsal fin and a white to light gray ventral band that widens around the genitals. The lips and snout tip are sometimes white. Pygmy killer whales reach lengths of up to 2.6 m (Jefferson et al. 1993).

Status—There are no abundance estimates for pygmy killer whales in the western North Atlantic (Waring et al. 2006) or Caribbean Sea.

Habitat Preferences—Pygmy killer whales generally occupy offshore habitats. In the northern Gulf of Mexico, this species is found primarily in deeper waters off the continental shelf (Davis and Fargion 1996; Davis et al. 2000) out to waters over the abyssal plain (Gannier 2002). In some areas, pygmy killer whales are found within a few kilometers of shore near the shelf, such as around the Marquesas Islands of French Polynesia (Gannier 2002), off Lembata Island of the Indonesian archipelago (Rudolph et al. 1997), and in some waters off the Philippines (Leatherwood et al. 1992).

Distribution—Pygmy killer whales have a worldwide distribution in tropical and subtropical waters, generally not ranging north of 40º N or south of 35º S (Jefferson et al. 1993). There are few confirmed records of this species in the western North Atlantic and in the Caribbean Sea (D. Caldwell et al. 1971b; Ross and Leatherwood 1994; Mignucci-Giannoni et al. 1999; Rodríguez-López and Mignucci-Giannoni 1999).

➢ Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—As a deep water species, the pygmy killer whale is not expected in the shallow waters over the East Florida

Shelf (inshore of the 100 m isobath) or Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-23). Although suitable habitat may be available for this species throughout the remainder of the study area, pygmy killer whale presence cannot be determined due to the lack of occurrence records even where survey effort has been expended. As noted earlier, there are few records for the species in the western North Atlantic, including the Caribbean. No seasonality to their occurrence is expected.

D. Caldwell and Caldwell (1975) reported on a group of five individuals that live-stranded in Palm Beach County during May 1971, while White (1976) provided information on a single animal that stranded on the same day in the same general area, which D. Caldwell and Caldwell (1975) suspected might have been from the original mass stranding event.

Behavior and Life History—Pygmy killer whales are one of the most poorly-described delphinid species and almost nothing is known about their reproductive biology and social organization. They occur in small to moderate herds of generally less than 50 to 60 individuals. Pygmy killer whales eat predominantly fishes and squids, and sometimes take large fish. They are known to occasionally attack other dolphins (Perryman and Foster 1980; Ross and Leatherwood 1994). There is no information available on diving behavior of this species.

Acoustics and Hearing—The pygmy killer whale emits short duration, broadband signals similar to a large number of other delphinid species (Madsen et al. 2004b). Clicks produced by pygmy killer whales have centroid frequencies between 70 and 85 kHz; there are bimodal peak frequencies between 45 and 117 kHz. The estimated source levels are between 197 and 223 dB re 1 μPa-m (Madsen et al. 2004b). These clicks possess characteristics of echolocation clicks (Madsen et al. 2004b). There are no empirical hearing data available for this species.

- 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—There are no abundance estimates for this species in the North Atlantic or Caribbean Sea.

Habitat Preferences—This species is found primarily in oceanic and offshore areas, although they do approach close to shore at oceanic islands (Baird 2002). Inshore movements are occasionally associated with movements of prey and shoreward flooding of warm ocean currents (Stacey et al. 1994). Most sightings in the Gulf of Mexico have been made in oceanic waters greater than 200 m deep, although there are some sightings in waters over the continental shelf (Davis and Fargion 1996).

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 (Baird et al. 1989; Odell and McClune 1999).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The false killer whale globally is sighted most frequently seaward of the shelf or insular break, although sightings may occur in shallower waters (e.g., Davis and Fargion 1996; Baird 2002). As a deep water species, the false killer whale is not expected in shallow waters over the East Florida Shelf or over Bahamian banks (Little Bahama, Great Bahama, and Cay Sal) (Figure B-24). There is a rare occurrence for the false killer whale in waters seaward of the shelf and bank margins, which takes into account the possibility of encountering this species in waters that are its known habitat. Occurrence patterns are anticipated to be similar throughout the year.

  Not shown in Figure B-24 are false killer distribution records for off the east coast of Florida reviewed by Bullis and Moore (1956), since only the latitude for the records was provided, so they

could not be plotted. D. Caldwell et al. (1970) reported on a mass stranding of 150 to 175 individuals near Fort Pierce, FL in January 1970.

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. 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 years (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 dorado and yellowfin tuna *(Thunnus albacares)* (Ligon and Baird 2001). Deep water cephalopods and fishes are their primary prey (Odell and McClune 1999), but large pelagic species, such as dorado, have been taken. Bullis and Moore (1956) reported the take of a false killer whale one-half mile off Miami Beach; the stomach contents of this individual contained amberjack. False killer whales also take tuna from longlines (e.g., Mitchell 1975; Baird and Gorgone 2005). 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; Thomson and Richardson 1995) 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 to 225 dB re 1 μPa-m (Madsen et al. 2004b).

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—There are no abundance estimates for killer whales in the western North Atlantic or Caribbean Sea. Most cetacean taxonomists agree that multiple killer whale species or subspecies occur worldwide (Krahn et al. 2004; Waples and Clapham 2004). However, at this time, further information is not available, particularly for the western North Atlantic.

Habitat Preferences—Overall, killer whales are one of the most cosmopolitan marine mammals and are found in offshore and coastal waters (Dahlheim and Heyning 1999). In nearshore habitats, 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 western North Atlantic are found most often along the continental shelf break and in offshore regions (Katona et al. 1988; Mitchell and Reeves 1988). Killer whales in the Gulf of Mexico are sighted most frequently in offshore waters, although there have also been occasional sightings over the continental shelf (Jefferson and Schiro 1997; O'Sullivan and Mullin 1997). In the Caribbean Sea, killer whales are found in both continental shelf and offshore waters (Mignucci-Giannoni 1998).

Distribution—Killer whales are found throughout all oceans and contiguous seas, from equatorial regions to polar pack ice zones of both hemispheres. Although found in tropical waters and the open ocean, killer whales are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999). Ford (2002) noted that this species has a sporadic occurrence in most regions. In the western North Atlantic, killer whales are known from the polar pack ice southward to Florida, the Lesser Antilles, and the Gulf of Mexico (Würsig et al. 2000), where they have been sighted year-round (Jefferson and Schiro 1997; O'Sullivan and Mullin 1997; Würsig et al. 2000). It is not known whether killer whales in the Gulf of Mexico range more widely into the Caribbean Sea and the adjacent North Atlantic (Würsig et al. 2000). Year-round killer whale occurrence in the western North Atlantic is considered to be south of 35°N (Katona et al. 1988).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Information describing killer whale sightings in the western North Atlantic Ocean and Caribbean is sparse (Katona et al. 1988). The determination of these occurrence patterns takes into consideration that killer whales can be sighted in both shallow and oceanic waters. Also considered were the likely wide-ranging movements of individual killer whales, since they are not often sighted or reported in this area. It should be noted that reliable reports of opportunistic killer whale sightings in the Bahamas are received more frequently than for other marine mammal species since killer whales are more widely recognized by the public and easily differentiated from other cetaceans (Claridge 2007). Of interest for the Bahamas are resightings of at least seven individuals from two pods (Claridge 2007). All sightings around Abaco have occurred during the spring, suggesting that these animals are returning to the same areas seasonally (Claridge 2007).

  Moore (1953) reported that five sightings of killer whales had been made in the Gulf Stream off Florida, and Backus (1961) reported on a killer whale that live-stranded on Man O'War Cay, Great Abaco Island in June 1960. Some sighting locations for the Bahamas reported in Katona et al. (1988) from whaling ships are questionable due to bottom depth (too shallow for either ships or whales) and may be misinterpreted coordinate locations (Claridge 2007).

  - Spring—There is a rare occurrence for the killer whale throughout most of the study area during the spring. The killer whale is present in the area bounded to the north by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank and to the west by the edge of the Gulf Stream (this is also a 10 to 12 NM area offshore of the bank margins that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone) (Figure B-25). Fishermen targeting billfish report sighting killer whales during this time of the year (Claridge 2007). There is also likely an association with bluefin tuna (*Thunnus thynnus*) here (Katona et al. 1988; Claridge 2007). The bluefin tuna moves through the area during mid-April through mid-June, aggregating on the Great Bahama Bank off South Cat Cay in a region known as Tuna Alley (Lutcavage et al. 1997a).

  - Summer/Fall/Winter—Killer whales are anticipated to have a rare occurrence throughout the study area during this time of year (Figure B-25). One sighting reported during September 1991 in the Bahamas is particularly noteworthy since it occurred within mangrove habitat (Claridge 2007).

Behavior and Life History—Killer whales undergo limited dispersal and form maternal groups (Baird 2000). Killer whales normally occur in small groups in the western North Atlantic Ocean, although a group of 40 individuals was recorded in the southern Gulf of Maine (Katona et al. 1988). There is no published information on killer whale reproductive behavior in the western North Atlantic Ocean. In the eastern North Pacific, females typically give birth for the first time at 11 to 15 years of age (Olesiuk et al. 2005). Males sexually mature at about 13 years of age (Olesiuk et al. 2005; Robeck and Monfort 2006).

Killer whales feed on the widest diversity of prey of any marine mammal. Fishes, elasmobranchs, sea turtles, and other marine mammals have been identified from killer whale stomachs or observed being eaten (Jefferson et al. 1991; Fertl et al. 1996; Pitman and Dutton 2004). Killer whales in the Caribbean Sea and nearby Gulf of Mexico harass and/or feed on marine mammals and sea turtles (e.g., D. Caldwell and Caldwell 1969a; Pitman et al. 2003; Fertl and Fulling 2007). In the Bahamas,

killer whales have been observed feeding on dwarf sperm whale, Fraser's dolphin, and spotted dolphin (most likely Atlantic spotted dolphin) (Claridge 2007).

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

The maximum recorded depth for a free-ranging killer whale dive was 264 m off British Columbia (Baird et al. 2005). A trained killer whale dove to 260 m (Dahlheim and Heyning 1999). The longest duration of a recorded dive was 17 min (Dahlheim and Heyning 1999). However, shallower dives were much more common for eight tagged individuals, where less than three percent of all dives examined were greater than 30 m in depth (Baird et al. 2003a).

Acoustics and Hearing—Resident killer whales produce a wide variety of clicks and whistles, but most of this species' social sounds are pulsed with frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz) (Thomson and Richardson 1995). It should be noted that the majority of acoustical studies on this species have been conducted on populations in the Pacific Northwest. Echolocation sounds recorded for this species indicate source levels ranging from 195 to 224 dB re 1 µPa-m peak-to-peak, dominant frequencies ranging from 20 to 60 kHz, and durations of 80 to 120 µs (Au et al. 2004). 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; Miller 2006). 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] associated with travel and foraging) (Miller 2006). Source levels associated with social sounds have been reported as ranging from 137 to 157 dB re 1 µPa-m (Veirs 2004).

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

- Short-Finned Pilot Whale *(Globicephala macrorhynchus)*

Description—There are two species of pilot whales globally: long-finned (*Globicephala melas*) and short-finned; only the short-finned species is expected to occur in the study area. Pilot whales are among the largest members of the family Delphinidae. In general, the short-finned pilot whale may reach lengths of 5.5 m (females) and 6.1 m (males) (Jefferson et al. 1993).

Pilot whales have bulbous heads with a forehead that sometimes overhangs the tip of the jaw; there is only a very slight or no beak (Jefferson et al. 1993). The dorsal fin is distinctive, being generally broader-based than it is tall. It is falcate and usually highly rounded at the tip and is set well forward of the middle of the back. The flippers of the short-finned pilot whale are long and sickle-shaped and range in length from 16 to 22% of the total body length (Jefferson et al. 1993). Pilot whales are black on the back and sides; in some individuals, there is a light gray saddle patch located behind the dorsal fin. Pilot whales also have a white to light gray, anchor-shaped patch on the chest (Jefferson et al. 1993).

Status—The best estimate of pilot whale abundance (combined short-finned and long-finned pilot whales) in the western North Atlantic is 31,139 individuals (NMFS 2006c). The best estimate of abundance for the southern U.S. Atlantic is 15,411 individuals (NMFS 2006c). Pilot whales currently are not a strategic stock.

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 occur close to shore at oceanic islands where the shelf is narrow and deeper waters are nearby (Mignucci-Giannoni

1998; Gannier 2000; Anderson 2005). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern U.S. (CETAP 1982; Payne and Heinemann 1993). Waring et al. (1992) sighted pilot whales principally along the northern wall of the Gulf Stream and along the shelf break at thermal fronts. A few of these sightings were also made in the mid-portion of the Gulf Stream near Cape Hatteras. MacLeod et al. (2004) reported a sighting in Bahamian waters where the bottom depth was about 962 m.

A number of 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; Bernard and Reilly 1999). Short-finned pilot whale occurrence in the Caribbean Sea seems to coincide with the inshore movement of spawning octopus (Mignucci-Giannoni 1998). Short-finned pilot whale distribution off southern California changed dramatically after the El Niño event in 1982 through 1983, when squid did not spawn in the area, and pilot whales virtually disappeared from the area for nine years (Shane 1994, 1995).

Distribution—Short-finned pilot whales are found worldwide in warm-temperate and tropical offshore waters. Short-finned pilot whales are considered to be a tropical species that usually does not range north of 50º N or south of 40º S (Jefferson et al. 1993). However, strandings have been reported as far north as New Jersey (Payne and Heinemann 1993). The apparent ranges of the two pilot whale species overlap in continental shelf, continental shelf edge, and continental slope waters of the northeastern U.S. between 35ºN and 38º to 39ºN (New Jersey to Cape Hatteras) (Leatherwood et al. 1976; Payne and Heinemann 1993). This is a commonly sighted species in the Caribbean Sea (e.g., D. Caldwell and Erdman 1963; Watkins and Moore 1982; Mattila and Clapham 1989; Toyos-Gonzalez and Mignucci-Giannoni 2001).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Identification of pilot whales to species is difficult at sea, and identification is often made to the generic level only. The study area is located well south of the suggested overlap area for the two pilot whale species; therefore, the sightings of unidentified pilot whales in Figure B-26 are more than likely to be of the short-finned pilot whale.

  The short-finned pilot whale is a deep water species; it is not expected to occur in shallow waters over the continental shelf off Florida or over the Bahamian banks (Figure B-26). The pilot whale is common in the area bounded to the north by the shoreward boundary of the Antilles Current as it sweeps along the northern flank of the Bahamian Bank and to the west by the edge of the Gulf Stream (this is also a 10 to 12 NM area offshore of the bank margins that BMMRO surveys and/or has public sighting reports from vessels utilizing waters within that zone). Pilot whales are also common within all deep water channels of the Bahamas (Northeast and Northwest Providence Channels, TOTO, and Exuma Valley) and along the eastern and northern edges of the Abaco and Eleuthera islands (Figure B-26; Bottomley and Theriault 2002; MacLeod et al. 2004; Mobley 2004). The pilot whale was a target (for oil) of the historical Bahamian whaling industry, with individuals seen off Clifton and between New Providence and Andros Island (Campbell 1978; Claridge and Balcomb 1993). The pilot whale is one of the most commonly seen and heard species at AUTEC (Jarvis and Moretti 2002). Pilot whales have been acoustically-detected by the hydrophone array at AUTEC and have then been tagged by WHOI scientists (Jarvis and Moretti 2002; SERDP 2002); results were not available in time for this report.

  Throughout most of the deep waters of the study area there is a lack of sufficient survey effort to accurately determine the occurrence patterns of this species. Individuals likely occur throughout the deep waters of this area. Occurrence patterns are assumed to be the same year-round throughout the study area. Short-finned pilot whales are likely to be resident year-round in the Bahamas.

  Layne (1965) reported on a mass stranding of over 50 pilot whales south of Melbourne (Brevard County), FL, during November 1955, while D. Caldwell and Erdman (Caldwell and Erdman 1963) reported a stranding that had occurred at West End, Grand Bahama Island in the western Bahamas, adjacent to the Gulf Stream. As noted by Claridge (1998), it is probable that many of the pilot whales seen in the Bahamas are year-round residents.

Behavior and Life History—Pilot whales are highly social and are found in groups of a few to several hundreds of individuals. Pilot whales appear to live in relatively stable maternal groups (Jefferson et al. 1993). Both pilot whale species frequently associate with other cetaceans (Bernard and Reilly 1999; Gannier 2000); BMMS (2004) reported sighting a single subadult pilot whale traveling with a group of sperm whales. Pilot whales are the most frequently-stranded cetaceans worldwide (Nelson and Lien 1996). Average age at sexual maturity for short-finned pilot whales is nine years for females and 17 years for males (Bernard and Reilly 1999). The gestation period for short-finned pilot whales is 15 to 16 months, with a mean calving interval of 4.6 to 5.7 years (Bernard and Reilly 1999). Short-finned pilot whale calving peaks in the northern hemisphere vary by stock (Jefferson 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. 2003b; Aguilar de Soto et al. 2005). Deep diving occurred mainly at night when prey within the deep scattering layer 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 eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase, attack, and may eat dolphins during fishery operations (Perryman and Foster 1980). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al. 1996).

Acoustics and Hearing—Pilot whale sound production includes whistles and echolocation clicks. Short-finned pilot whale whistles and clicks have a dominant frequency range of 2 to 14 kHz and 30 to 60 kHz, respectively, at an estimated source level of 180 dB re 1 μPa-m (Fish and Turl 1976; Ketten 1998). 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 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—There are four proposed harbor porpoise populations in the western North Atlantic: Gulf of Maine and Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland stocks (Gaskin 1992). The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,700 individuals (NMFS 2006c).

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 (Gaskin 1992). Harbor porpoises are generally scarce in areas without significant coastal fronts or topographically-generated upwellings (Gaskin 1992; Skov et al. 2003). Harbor porpoises occur most frequently over the continental shelf (NMFS 2001). 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 distribution (Read et al. 1996; Westgate et al. 1998).

Distribution—Harbor porpoises occur in subpolar to cool-temperate waters in the North Atlantic and Pacific (Read 1999). Off the northeastern U.S., harbor porpoise distribution is strongly concentrated in the Gulf of Maine/Georges Bank region, with more scattered occurrences to the mid-Atlantic (CETAP 1982; Northridge 1996). Stranding data indicate that the southern limit is northern Florida (Polacheck 1995; Read 1999). Genetic evidence suggests limited trans-Atlantic movement (Rosel et al. 1999a).

From July through September, harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy, generally in waters less than 150 m deep (Palka 1995), with a few sightings in the upper Bay of Fundy and on the northern edge of Georges Bank (Waring et al. 2006). From October through December, harbor porpoise densities are widely dispersed from New Jersey to

Maine, with lower densities to the north and south of this region (NMFS 2001). Most harbor porpoises are found on the continental shelf, with some sightings in continental slope and offshore waters (Westgate et al. 1998; Waring et al. 2006). During this time, sightings are concentrated in the southwestern and northern Gulf of Maine, as well as in the Bay of Fundy (CETAP 1982). From January through March, intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada (NMFS 2001). The New Jersey shore and approaches to New York harbor may represent an important January to March habitat (Westgate et al. 1998). During this time, significant numbers of porpoises occur along the mid-Atlantic shore from New Jersey to North Carolina, where they are subject to incidental mortality in a variety of coastal gillnet fisheries (Cox et al. 1998; Waring et al. 2006). Mid-Atlantic porpoise bycatches occur from December through May (Waring et al. 2006). Data indicate that only juvenile harbor porpoises are present in nearshore waters of the mid-Atlantic during this time (Cox et al. 1998). Harbor porpoises are not tied to shallow, nearshore waters during winter, as evidenced by a harbor porpoise caught in a pelagic drift net off North Carolina (Read et al. 1996). A largely offshore harbor porpoise distribution during winter explains the paucity of sightings in the Bay of Fundy and Gulf of Maine (CETAP 1982). However, genetic data from mid-Atlantic stranded and by-caught porpoises show a mixture of different stocks rather than simply migrants from the Gulf of Maine and Bay of Fundy stock (Rosel et al. 1999b).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The harbor porpoise is not expected to occur in the study area. The harbor porpoise primarily occurs on the continental shelf, in cool temperate to subpolar waters (Read 1999), that are at higher latitudes than that of the study area. There is one extralimital stranding inshore of the study area, which occurred during March 1984 on Canaveral National Seashore (Polacheck 1995). This stranding would correspond to the known southernmost seasonal movements of harbor porpoises along the mid-Atlantic coast (Waring et al. 2006).

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). In the Gulf of Maine, females mature at three years of age and give birth to one calf each year (Read and Hohn 1995). Calves are born in late spring (Read 1990a; Read and Hohn 1995). Many females are pregnant and lactating simultaneously (Read 1990b; 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). Atlantic herring and silver hake are the primary prey in the Bay of Fundy (Recchia and Read 1989). Atlantic herring is the most important prey of Gulf of Maine harbor porpoises during fall (Gannon et al. 1998b). 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. 1998b).

Harbor porpoises make brief dives, generally lasting less than 5 min (Westgate et al. 1995). 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 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). The dominant frequency range is 110 to 150 kHz, with source levels of 135 to 177 dB re 1 μPa-m (Ketten 1998). 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).

- Hooded Seal *(Cystophora cristata)*

Description—Hooded seals are large phocids, with average adult males reaching 2.5 m in length and 300 kg and some individuals over 400 kg (Kovacs 2002). Females are smaller, with adults averaging 2.2 m in length and weighing 200 kg (Kovacs 2002). Hooded seal pups are blue-black dorsally and silver-gray ventrally, which is where a common name of "blue-back" originates. Adults are gray to brown/black with black mottling (Reeves and Ling 1981). The most unique feature of hooded seals is the prominent two-part nasal ornament of sexually mature males giving them their most frequently used common name. This display attracts females and intimidates rival males during the breeding season. When relaxed, this nasal appendage hangs as a loose, wrinkled sac over the nose. However, when the nares are closed and the sac inflated, it becomes a large, tight, bilobed "hood" over the face and head. Adult males also have a very elastic nasal septum that they can extrude through one of their nostrils as a membranous, pink balloon.

Status—The abundance of hooded seals in the western North Atlantic is unknown. There are no recent pup counts to assess the current population size in either U.S. or Canadian waters (Waring et al. 2006). Dramatic increases in hooded seal numbers on Sable Island have occurred concurrently with the recent increases of extralimital occurrences along the northeastern U.S. (Lucas and Daoust 2002).

Global change and climate variability are affecting sea ice dynamics in northern and eastern Canada; such variability could have serious consequences for hooded seals, including increases in neonatal mortality, changes in food availability for pups and, possibly, increased risk of epizootics due to crowding on whelping patches (Lucas et al. 2003; Johnston et al. 2005b).

Habitat Preferences—Hooded seals inhabit the edge of the heavy pack ice while breeding and molting (Campbell 1987). Hooded seals follow an annual movement that keeps them in close association with drifting pack ice (Campbell 1987; Kovacs 2002) and preferentially inhabit waters at the edge of the continental shelf (Bowen and Siniff 1999; Waring et al. 2006).

Distribution—Hooded seals inhabit the pack ice zone of the North Atlantic from the Gulf of St. Lawrence, Newfoundland, and Labrador in the west to the Barents Sea (Campbell 1987). Hooded seals are not common south of the Gulf of St. Lawrence (Lucas and Daoust 2002). Hooded seals are concentrated in three discrete areas during the breeding season: in the "Front" off the coast of Newfoundland-Labrador and in the Gulf of St. Lawrence, in the Davis Strait, and on the "West Ice" around Jan Mayen Island off eastern Greenland (Campbell 1987). After the breeding season, hooded seal adults feed along the continental slope off southern Newfoundland and the southern Grand Banks for roughly 20 days before moving northward across the Labrador Basin to west Greenland in June (Bowen and Siniff 1999). Thereafter, individuals move into traditional molting areas on the southeast Greenland coast, near the Denmark Strait, or in a smaller patch along the northeast Greenland coast (Kovacs 2002). After the molt in late June and August, hooded seals disperse. Some individuals move south and west around the southern tip of Greenland and then north along western Greenland. Others move to the east and north between Greenland and Svalbard during late summer and early fall (Waring et al. 2006). Not much is known about the activities of hooded seals during the remainder of the year from molting until they reassemble in February for breeding (Campbell 1987).

The range of hooded seals may be considerably influenced by changes in ice cover and climate (Campbell 1987; Johnston et al. 2005b). Hooded seals can make extensive movements and show a tendency toward wandering, with extralimital sightings documented as far south as Puerto Rico and the Virgin Islands (Mignucci-Giannoni and Odell 2001; Mignucci-Giannoni and Haddow 2002; NOAA

2006g). Most extralimital sightings occur between late January and mid May off the northeastern U.S. and during summer and fall off the southeastern U.S. and in the Caribbean Sea (McAlpine et al. 1999a; McAlpine et al. 1999b; Harris et al. 2001; Mignucci-Giannoni and Odell 2001). These extralimital animals have primarily been immature individuals, although adults are occasionally reported, including an incidence of pupping in Maine (Richardson 1975; Jakush 2004). Between January and September 2006, a total of 55 hooded seals stranded along the East Coast of the U.S. and as far south as the U.S. Virgin Islands; the majority of these strandings occurred during July, August, and September (NOAA 2006g).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—The hooded seal is not expected to occur in the study area. Hooded seals are found in the Atlantic region of the Arctic Ocean and in high latitudes of the North Atlantic, especially near the outer edge of the pack ice. Hooded seals (particularly young ones) are recognized as great wanderers. They appear in places far from their normal breeding and foraging range, traveling as far south as Puerto Rico and the Virgin Islands (Mignucci-Giannoni and Odell 2001; Mignucci-Giannoni and Haddow 2002; NOAA 2006g). These records are considered extralimital, with the majority occurring during July through September (NOAA 2006g).

  There are records of dead and live-stranded hooded seals just outside of the study area boundaries for May through winter (Miller 1917; Mignucci-Giannoni and Odell 2001; Claridge 2007; HBOI 2006; NOAA 2006g). There is even one documented stranding from September in the southern Great Exuma Islands chain, just east of the study area (Claridge 2007). The most recent records for southern Florida were two six-month old pups that stranded near Hobe Sound and near Lake Worth inlet (Palm Beach County) in early August 2006 (HBOI 2006).

Behavior and Life History—Hooded seals are generally solitary outside of the breeding and molting seasons (Kovacs 2002). The breeding season is from late March to early April (Campbell 1987). Hooded seals demonstrate an extreme adaptation to the unstable and temporary nature of pack ice, with a nursing period of only four days (Bowen et al. 1985; Bowen and Siniff 1999). Thereafter, pups almost immediately enter the sea to make their way to the edge of the pack ice. Breeding behavior commences at weaning. Hooded seals may delay embryo implantation for as long as four months (Kovacs 2002).

Hooded seals feed primarily on deep water fishes and squids (Reeves and Ling 1981; Campbell 1987; Kovacs 2002). Hooded seal pups initially feed on krill and other invertebrates until they develop the skills to capture fishes (Kovacs 2002). Adult hooded seals can dive to depths of over 1,000 m and remain underwater for nearly an hour (Folkow and Blix 1999).

Acoustics and Hearing—Hooded seals emit five different vocalizations, although it is suspected that their vocal repertoire is more diverse (Ballard and Kovacs 1995). Both males as females, as well as different age classes, have been recorded producing sounds (Ballard and Kovacs 1995). Hooded seal calls are primarily aerial but can be produced underwater. Underwater sounds have most of their energy below 4 kHz and include “grungs”, whoops, moans, trills, knocks, snorts, and buzzes (Terhune and Ronald 1973; Ballard and Kovacs 1995). Males produce low-frequency sounds in air that coincide with dominance displays utilizing the nasal appendage. Vester et al. (2003) recorded ultrasonic clicks produced by hooded seals, with a frequency range of 66 to 120 kHz and average source levels of 143 dB re 1 μPa-m in conjunction with hunting fish.

- Harbor Seal *(Phoca vitulina)*

Description—The harbor seal (or common seal) is a small- to medium-sized seal. Adult males attain a maximum length of 1.9 m and weigh 70 to 150 kg; females reach 1.7 m in length and weigh between 60 and 110 kg (Jefferson et al. 1993). The harbor seal has a dog-like head with nostrils that form a broad V-shape; this is one of the characteristics that distinguish them from immature gray seals (Baird 2001). Adult harbor seals exhibit considerable variability in the color and pattern of their pelage; the background color is tannish-gray overlaid by small darker spots, ring-like markings, or blotches (Bigg 1981).

Status—Five subspecies of *Phoca vitulin*a are recognized; *Phoca vitulina concolor* is the form found in the western North Atlantic (Rice 1998). Harbor seals are the most common and frequently reported

seals in the northeastern U.S. (Katona et al. 1993). Currently, harbor seals along the coast of the eastern U.S. and Canadian coasts are considered a single population (NMFS 2006c).

Pressure from hunting bounties in the late 1800s through 1962 resulted in a reduction or complete elimination of harbor seals in heavily exploited areas (Barlas 1999). A limit to the southward dispersion of harbor seals from Maine rookeries indirectly lead to their present seasonal occurrence. During the winter of 1980, a large-scale influenza epidemic in Gulf of Maine harbor seals resulted in a mass mortality event (Geraci et al. 1982). The population has since rebounded.

The best estimate of abundance of harbor seals in the western North Atlantic stock is 99,340 individuals (NMFS 2006c). An estimated 5,575 harbor seals over-wintered in southern New England in 1999, increasing from an estimated 2,834 individuals in 1981 (Barlas 1999). Kraus and Early (1995) suggested that the northeastern U.S. population increase could represent increasing southward shifts in wintering distribution.

Habitat Preferences—Although primarily aquatic, harbor seals also utilize terrestrial environments where they haul out periodically. Harbor seals are a coastal species, usually found near shore, and frequently occupying bays, estuaries, and inlets (Baird 2001). Individual harbor seals have been observed miles upstream in coastal rivers (Baird 2001).

Ideal harbor seal habitat includes suitable haulout sites, shelter during breeding periods, and sufficient food within close proximity to sustain the population throughout the year (Bjørge 2002). Haulout substrates vary but include intertidal and subtidal rocky outcrops, sandbars, sandy beaches, and even peat banks in salt marshes (Wilson 1978; Schneider and Payne 1983; Gilbert and Guldager 1998). Along the majority of the New England coast, harbor seals haul out on rocky outcroppings and intertidal ledges (Kenney 1994; Gilbert and Guldager 1998; Schroeder 2000).

Distribution—Harbor seals are one of the most widespread pinniped species and are found in subarctic to temperate nearshore waters. Their distribution ranges from the east Baltic west across the Atlantic and Pacific Oceans to southern Japan (Stanley et al. 1996). Harbor seals are year-round residents of eastern Canada (Boulva 1973) and coastal Maine (Katona et al. 1993; Gilbert and Guldager 1998). The greatest concentrations of harbor seals in northeastern U.S. waters are found along the coast of Maine, specifically in Machias and Penobscot bays and off Mt. Desert and Swans Islands (Katona et al. 1993).

Harbor seals occur south of Maine from late September through late May (Rosenfeld et al. 1988; Whitman and Payne 1990; Barlas 1999; Schroeder 2000). During winter, the population divides and disperses offshore into the Gulf of Maine south into southern New England, and a portion remains in coastal waters of Maine and Canada. Harbor seals have recently been observed over-wintering as far south as New Jersey (Slocum et al. 1999). Payne and Selzer (1989) noted that 75% of harbor seals south of Maine are located at haulout sites on Cape Cod and Nantucket Island, with the largest aggregation occurring at Monomoy Island and adjacent shoals. Although harbor seals of all ages and both sexes frequent winter haulout sites south of Maine, many of the over-wintering individuals are immature, suggesting that there might be seasonal segregation resulting from age-related competition for haulout sites near preferred pupping ledges and age-related differences in food requirements (Whitman and Payne 1990; Slocum and Schoelkopf 2001). Extralimital occurrences have been observed as far south as Florida (D. Caldwell and Caldwell 1969b; Waring et al. 2006).

From at least October through December, harbor seal numbers decrease in Canadian waters (Terhune 1985) but increase three to five fold south of Maine (Rosenfeld et al. 1988). A general southward movement along the Canadian coast and northeastern U.S. is thought to occur during this period (Rosenfeld et al. 1988). Tagging efforts by Gilbert and Wynne (1985) support this hypothesis. Tagged harbor seals in Nova Scotia and Maine were later resighted in Massachusetts. Prior to pupping, this generalized movement pattern reverses as animals move northward to the coasts of Maine and eastern Canada.

- Information Specific to the Southeastern Florida and the AUTEC-Andros OPAREA—The harbor seal is not expected to occur in the OPAREA. Harbor seal distribution is associated with more temperate (cooler) waters than those encountered in the study area (Jefferson et al. 1993; Stanley et al. 1996). Individuals occurring this far south are making extralimital movements. The

one harbor seal documented for the study area is a stranding that occurred during February 2006 at Canaveral National Seashore. Additionally, D. Caldwell and Caldwell (1969b) reported a live sighting south of Daytona Beach during January 1968, and there is a February 2004 stranding reported by NMFS that also occurred south of Daytona Beach. These strandings are consistent with a more southerly harbor seal distribution in the western North Atlantic from September through May (Rosenfeld et al. 1988; Whitman and Payne 1990; Barlas 1999; Schroeder 2000).

Behavior and Life History—Harbor seals normally form small groups of 30 to 80 individuals. However, larger groups are found in areas where prey is abundant (Ronald and Gots 2003). This species is gregarious on land, although individuals do not lie in close contact. However, a well-developed social structure is not apparent and individuals disperse when foraging (Baird 2001; Ronald and Gots 2003). Harbor seals inhabit rocky haulout sites and create hierarchies based upon size and sex, with territorial adult males dominating all other sex and age classes (Baird 2001). Harbor seals co-exist with gray seals in many non-breeding sites along the northeastern U.S.; these two species often haul out in close proximity (DeHart 2002).

Tidal stage is likely one of the more important daily influences on haulout behavior (Kovacs et al. 1990). Harbor seals come ashore either individually or in groups with low tide and form loose assemblages (Gilbert and Guldager 1998). When the tide rises, animals disperse into the water and usually spend the period of high tide foraging individually. Apparently, individuals return to specific haulout sites within seasons. However, human disturbance can affect haulout choice (Harris et al. 2003).

The timing of harbor seal pupping along the eastern North American coast varies geographically (Temte et al. 1991). Pupping takes place from mid May through mid June along the Maine coast (Richardson 1976; Wilson 1978; DeHart 2002). Harbor seal pups are extremely precocial at birth, normally entering the water within hours. Suckling pups spend as much as 40% of their time in water (Bowen et al. 1999). The nursing period lasts from 24 to 31 days (Thompson et al. 1994). Mating takes place in water shortly after pups are weaned and is followed by delayed implantation. In Maine, harbor seals haul out to molt in large numbers during the first two weeks of August (Gilbert and Guldager 1998).

Harbor seals are opportunistic feeders that adjust their feeding patterns to take advantage of locally and seasonally abundant prey (Payne and Selzer 1989; Baird 2001; Bjørge 2002). Harbor seal diet consists of fishes, cephalopods, and crustaceans (Bigg 1981), including sand lance, Atlantic herring, cod, and winter flounder (Payne and Selzer 1989; Wood et al. 2001). Feeding most frequently occurs during high tide. Individual harbor seals utilize different foraging habitats, repeatedly returning to the same location to feed. This may be a result of intraspecific competition for foraging sites and fish resources in close proximity to haulout sites (Bjørge 2002).

Harbor seals are generally shallow divers. About 50% of dives are shallower than 40 m and 95% are shallower than 250 m (Gjertz et al. 2001; Krafft et al. 2002; Eguchi and Harvey 2005). Dive durations are shorter than 10 min, with about 90% lasting less than 7 min (Gjertz et al. 2001). However, a tagged harbor seal in Monterey Bay dove as deep as 481 m and dive durations for older individuals may be as long as 32 min (Eguchi and Harvey 2005). Harbor seal pups swim and dive with their mothers, although for shorter periods when mothers are performing bouts of relatively deep dives (Bowen et al. 1999; Jørgensen et al. 2001; Bekkby and Bjørge 2003).

Acoustics and Hearing—Harbor seal males produce a variety of low-frequency (<4 kHz) in-air vocalizations including snorts, grunts, and growls, while pups make individually unique calls for mother recognition (contain multiple harmonics with main energy below 0.35 kHz) (Bigg 1981; Thomson and Richardson 1995). Adult males also produce several underwater sounds during the breeding season that typically range from 0.025 to 4 kHz (duration range: 0.1 sec to multiple seconds) (Hanggi and Schusterman 1994). Hanggi and Schusterman (1994) found that there is individual variation in the dominant frequency range of sounds between different males, and Van Parijs et al. (2003) reported oceanic, regional, population, and site-specific variation (i.e., could be vocal dialects) between males.

Harbor seals hear nearly as well in air as underwater (Kastak and Schusterman 1998). Harbor seals hear frequencies from 1 to 180 kHz (most sensitive at frequencies below 50 kHz; above 60 kHz sensitivity rapidly decreases) in water and from 0.25 to 30 kHz in air (most sensitive from 6 to 16 kHz using behavior and auditory brainstem response testing) (Richardson 1995; Terhune and Turnbull 1995; Wolski et al. 2003).

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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).

Throughout the world, sea turtles are an important marine resource, representing nutritional, economic, and existence value to humans (Witherington and Frazier 2003). However, sea turtle populations have dramatically decreased over the last few centuries due to anthropogenic impacts such as coastal development, oil exploration, commercial fishing, marine-based recreation, pollution, and over-harvesting (NRC 1990; Eckert 1995; Lutcavage et al. 1997b).

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), the Caribbean Conservation Corporation (http://www.cccturtle.org), and the Archie Carr Center for Sea Turtle Research (http://accstr.ufl.edu/ index.html). Other important resources include Proceedings from the Annual Symposia on Sea Turtle Biology and Conservation, Bjorndal (1995), Lutz and Musick (1997), Bolten and Witherington (2003), and Lutz et al. (2003).

3.2.1.1 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. 1997b; Witherington and Martin 2003).

3.2.1.2 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, including pelagic invertebrates and other items that accumulate in surface circulation features (Carr 1987). Oceanographic currents and gyres are particularly influential to juvenile sea turtles. 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 1987). 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. 2000a). 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). Green turtles possess a serrated jaw, specialized for their diet of mainly seagrass (Ernst et al. 1994).

Sea turtles undergo complex seasonal movements, influenced by changes in ocean currents, turbidity, salinity, and food availability (Musick and Limpus 1997). 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 and above 40°C (Spotila et al. 1997), and may even become cold-stunned in extremely cold waters. Coles and Musick (2000) observed that loggerhead turtles (*Caretta caretta*) off North Carolina only inhabited waters between 13.3 and 28°C, which suggests that sea turtles are not randomly distributed in ocean waters but rather choose to stay within preferred temperature ranges. 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).

3.2.1.3 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 (Lohman 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).

Typically, sea turtles hear frequencies from 30 to 2,000 Hertz (Hz) and have a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969b; Lenhardt 1994). 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 (Ridgway et al. 1969b). 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 auditory brainstem response (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. 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 dB re: 1 μPa, but they eventually habituate to these sounds (Lenhardt 2002). Though, one turtle in study did exhibit temporary threshold shift (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 began to noticeably increase their swimming speed, as well swimming direction, when received levels reached 155 dB re: 1 μPa^2s for green turtles and 166 dB re: 1 μPa^2s 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).

3.2.2 Sea Turtles of southeastern Florida and the AUTEC-Andros OPAREA

Six of the seven extant sea turtle species occur in the study area; these are the leatherback, loggerhead, green, hawksbill, Kemp's ridley, and olive ridley turtles (Table 3-2). The loggerhead, green, and Kemp's ridley are the most common species of juvenile sea turtles in Florida waters. Occurrences are documented in both coastal and offshore waters, as well as small bays and lagoons (Mendonça 1983; Henwood and Ogren 1987; Schroeder and Thompson 1987). The Bahamas are home to resident populations of sea turtles, although years of harvest and exploitation have impacted their numbers (Carr et al. 1982; Fleming 2001). Green, hawksbill, and loggerhead turtles are the most commonly occurring sea turtle species in the Bahamas, followed by leatherbacks (Fleming 2001).

Several important features regulate the distribution and habitat use of sea turtles in the study area. These features include oceanographic or circulation characteristics such as major surface currents, the Gulf Stream Current, and eddies. The Gulf Stream is a transportation vector for early life stages of sea turtles. Hatchlings may enter the Gulf Stream after leaving nesting beaches in southeastern Florida or, in the case of Kemp's ridleys, enter the Gulf Stream System (the Loop or Florida Current) in the Gulf of Mexico and congregate in *Sargassum* rafts (Carr 1987; Musick and Limpus 1997). Local small-scale eddies that form off the Gulf Stream and flow onto the continental shelf of Florida may also serve to concentrate hatchlings in *Sargassum* rafts, although these oceanographic features restrain hatchlings offshore of their nesting beach for up to months at a time (Carr and Meylan 1980). At the end of the pelagic juvenile phase, sea turtles leave the current system to enter coastal developmental habitats along the U.S. Atlantic coast or in the Caribbean (Musick and Limpus 1997).

Southeastern Florida contains important nesting habitat for sea turtles in the study area. As determined from aerial surveys, the region spanning from Melbourne Beach to Sebastian Inlet represents one of the highest sea turtle nesting concentrations in eastern Florida, with more than 85% of sea turtle nesting along the southeastern U.S. coast occurring here (Shoop et al. 1985). Loggerhead, leatherback, and green turtles nest regularly in this area (Meylan et al. 1995). Florida is the principal nesting area for the

Table 3-2. Sea turtle species potentially occurring in the study area, their status under the ESA and the IUCN, and their frequency of occurrence within Florida and Bahamian waters of the study area. Taxonomy follows Pritchard (1997).

	Scientific Name	ESA Status	IUCN Status[1]	Florida/the Bahamas Occurrence/Frequency[2]
Order Testudines Suborder Cryptodira				
Family Dermochelyidae				
Leatherback turtle	*Dermochelys coriacea*	Endangered	Critically Endangered	Regular/Regular
Family Cheloniidae (hard-shelled turtles)				
Loggerhead turtle	*Caretta caretta*	Threatened	Endangered	Regular/Regular
Green turtle	*Chelonia mydas*	Threatened[3]	Endangered	Regular/Regular
Hawksbill turtle	*Eretmochelys imbricata*	Endangered	Critically Endangered	Regular/Regular
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered	Critically Endangered	Regular/Rare
Olive ridley turtle	*Lepidochelys olivacea*	Threatened[3]	Endangered	Rare/Rare

[1] The IUCN status is listed for each species because the Bahamas adheres to the international conventions for species status outlined by the IUCN.

[2] **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.

[3] Although each species as a whole is listed as threatened, the Florida and Mexican Pacific nesting stocks of the green turtle and the Mexican Pacific nesting stocks of the olive ridley turtle are listed as endangered. Since the nesting areas for green and olive ridley turtles encountered at sea often cannot be determined, a conservative approach to management requires the assumption that all greens and olive ridleys found in the study area are endangered.

southeastern U.S. loggerhead nesting population and accounts for 35 to 40% of loggerhead nesting worldwide (NMFS and USFWS 1991a). The green turtle nesting population in Florida is one of the largest in the western Atlantic Ocean (Meylan et al. 1995), with much of the nesting concentrated on the southeastern coast (FFWCC-FMRI 2004a). Southeastern Florida is the only regular nesting site of the leatherback on the continental United States (Meylan et al. 1995), with 50% of leatherback nesting occurring in Palm Beach County (FFWCC-FMRI 2004b).

The Caribbean region represents one of the most important habitats for sea turtles in the world (Bolten 2006a). Tropical waters attract sea turtles due to year-round warm water temperatures, easy access to suitable nesting beaches, and a diverse array of feeding habitats, including shallow water coral reefs, seagrass beds, and deepwater rift valleys. Leatherback, green, and hawksbill turtles have designated critical habitat in the Caribbean region (see individual species sections for more information). Several protected areas within the Bahamascontain important sea turtle habitat, such as the Exuma Cays Land and Sea Park, Conception Island National Park, and Inagua National Park (Fleming 2001). The abundant seagrass pastures and coral reef habitats found at these locations provide some of the most favorable sea turtle foraging areas in the Caribbean area (Bolten and Bjorndal 2003), particularly for adult loggerheads, greens, and hawksbills. Union Creek, a large tidal bay on Great Inagua Island, is a protected feeding area for both juvenile and adult green turtles (Bjorndal and Bolten 1978). The Bahamas also provides abundant juvenile developmental habitat for greens, hawksbills, and loggerheads (Carr et al. 1982; Fleming 2001; Bjorndal et al. 2003). Juvenile greens and loggerheads may seek developmental habitats in the Caribbean after moving from the North Equatorial Current, part of the current system in which they circle the North Atlantic Basin during their "lost year" life stage (Witham 1980; Musick and Limpus 1997). Important developmental foraging areas include shallow seagrass areas and coral reefs (Bolten 2006a) throughout the Bahamian archipelago. Low-levels of sea turtle nesting occur throughout the Bahamian archipelago as well (Fleming 2001). Cay Sal Bank is important nesting habitat for loggerheads, leatherbacks, and potentially hawksbills and greens (Addison and Morford 1996; Bolten 2000). Inagua provides nesting areas for leatherbacks and greens (Bolten 2000; Fleming 2001).

Sea turtle research efforts undertaken in the Bahamas have been conducted mainly by the Archie Carr Center for Sea Turtle Research (ACCSTR) (Fleming 2001). Main research projects on sea turtles in the Bahamas have included tagging and growth rates studies of juvenile greens, hawksbills, and loggerheads; loggerhead nesting surveys; and satellite tracking of loggerheads and greens (Fleming 2001; ACCSTR 2005). In comparison to the U.S., little quantitative data exists on sea turtle occurrences throughout the Bahamas. Studies, however, are currently in progress to gain additional information regarding demographics, genetics, and biology (Bolten 2006a).

The hard-shelled sea turtle species (loggerhead, green, Kemp's ridley, olive ridley, and hawksbill) are often difficult to distinguish to species, particularly when they are young (small size classes), and especially during aerial surveys that are dedicated to sighting multiple species. Sea turtles may respond to aircraft overflights and vessel approaches by making a quick dive, even before being sighted by observers, which makes sighting and confirmation of species identification of sea turtles quite difficult. Unidentified sea turtles (individuals that could not be identified to species) account for a large number of occurrence records, particularly sightings. A listing and description of the data sources used to determine each species occurrence is found in Appendix A-3, while the process used to create the map figures is described in Chapter 1. Map figures of sea turtle occurrence are found in Appendix C.

Specific terminology and associated definitions are used to designate the occurrence levels of sea turtles in this assessment. Where possible, quantities of occurrence records have been associated with occurrence levels; this was not uniformly possible since few occurrence records exist for large portions of the study area. A common occurrence is the most abundant occurrence category and refers to a species that regularly or frequently occurs in an area (or its appropriate habitat) and is usually observed, even if only for in a specific season. A species that occurs commonly will optimally be associated with 50 or more occurrence records for a season or region. The present occurrence level is an intermediate category that is applicable to a species found in an area or in a specific season even though it may not always be observed. When possible, this occurrence level is associated with five or more occurrence records. A rare occurrence is the least abundant category and connotes a species that occurs only infrequently and may not occur in an area or season with regularity. The rare category is related to those species for which, at best, one to five occurrence records exist. An undetermined occurrence is assigned to those areas where insufficient information or data are available to make an accurate occurrence determination. The not expected occurrence is assigned to regions where occurrence of a species or species group is exceedingly unlikely but not beyond a reasonable possibility. This categorization is based on known habitat preferences or instances where survey effort has occurred with no resulting species observations having been documented.

Each sea turtle species occurring in the study area is listed below with its description, status, habitat preference, distribution (including location and seasonal occurrence in the study area), behavior, and life history. Species appearance in the text follows the taxonomic order presented in Table 3-2.

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 southeastern Florida and the AUTEC-Andros OPAREA—Sea turtles are common throughout the study area year-round due to the preference for shallow water benthic habitats by most chelonid sea turtles and the preference of deepwater oceanic habitats by most leatherback sea turtles (Figure C-1). The concentration of sighting records in nearshore Florida waters reflects the high level of survey effort, primarily to monitor North Atlantic right whales (*Eubalaena glacialis*) on their calving grounds off Georgia and Florida (Figures A-1 through A-4). High nest densities at rookeries exist along Florida's east coast.

  The distribution of greens and hawksbills on the Bahamian banks drives the occurrence estimation of sea turtles in the shallow regions of the Bahamas (Figure C-1). Minimal sightings exist for Kemp's ridley and olive ridley turtles in the Bahamas (Carr et al. 1982), including one unconfirmed sighting of a Kemp's ridley in the Bahamas region and an olive ridley caught by fishermen at Andros Island (Fleming 2001; ACCSTR 2005). Although it is thought that a greater number of adult loggerheads and leatherbacks are found in the oceanic waters of the study area during winter, such numbers are based mainly upon fisheries bycatch, which may be biased due to the seasonality of the fishery in which animals were caught (Figure C-1).

- Leatherback Turtle (*Dermochelys coriacea*)

Description—The leatherback turtle is the largest living sea turtle. This species is placed in a separate family from all other sea turtles, in part because of its unique carapace structure. A leatherback turtle's carapace lacks the outer layer of horny scutes possessed by all other sea turtles; it is instead 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 it is almost completely black with variable spotting. All adults possess a unique pink spot on the dorsal surface of their head; this marking can be used by scientists to identify specific individuals (McDonald and Dutton 1996). Adult curved carapace lengths (CCL) range from 137 to 183 cm (NMFS and USFWS 1992). Adult leatherbacks typically 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; IUCN 2006). Counts of nesting females typically provide the best available index of leatherback sea turtle population status; the most recent summary of sea turtle nesting status in the Atlantic Ocean estimates approximately 1,437 to 1,780 individuals occurring throughout the Caribbean Islands, with an estimated global population of 34,500 females (Spotila et al. 1996). Populations that nest in southern Florida, Culebra, and the U.S. Virgin Islands (USVI) are believed to have increased significantly over the past 20 years due to improved management of the nesting habitat and heightened protection of both adults and hatchlings on the nesting beach, although survey effort has increased in St. Croix, USVI, and southern Florida as well (Hillis-Starr et al. 1998; Fleming 2001; Thompson et al. 2001). Critical habitat for leatherbacks in the Caribbean exists at Sandy Point, St. Croix, USVI (NMFS 1979).

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 1995).

Late juvenile and adult leatherback turtles are known to range from mid-ocean to continental shelf and nearshore waters (Schroeder and Thompson 1987; Shoop and Kenney 1992; Grant and Ferrell 1993; Epperly et al. 1995). 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 1990a; Davenport and Balazs 1991).

Leatherbacks commonly nest on wide sandy beaches which are inclined and backed with vegetation (Eckert 1987; Hirth and Ogren 1987). Many eggs may be lost to erosion due to their preference for high-energy, steeply sloped beaches (NMFS and USFWS 1992). During the nesting season (March through July), females are highly mobile and often move between several beaches. Results from tagging studies have indicated that Caribbean leatherbacks often nest on multiple islands during a nesting season (K.L. Eckert et al. 1989; Keinath and Musick 1993).

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. 2005a). Leatherbacks in the North Atlantic Ocean are broadly distributed from the Caribbean region to as far north as Nova Scotia, Newfoundland, Labrador, Iceland, the British Isles, and Norway (Bleakney 1965; Brongersma 1972; Threlfall 1978; Goff and Lien 1988). This species migrates further and moves into cold waters more than any other sea turtle species (Bleakney 1965; Lazell 1980; Shoop and Kenney 1992).

In the North Atlantic Ocean, leatherbacks show strong seasonal distribution patterns and make extensive movements between temperate and tropical waters (James et al. 2005a, 2005b, 2005c). One leatherback caught in the Chesapeake Bay was tagged, released, and then caught again over a year later off southern Cuba, for a minimum distance of 2,168 km (Keinath and Musick 1990). Leatherbacks tagged on Caribbean nesting beaches travel great distances across the North Atlantic Ocean and display broad variations in pan-oceanic movements. Some individuals travel north to foraging habitats off the Atlantic coasts of the U.S. and Canada. Others travel northeast to temperate waters surrounding the British Isles and the Azores while some individuals travel east to the coast of Africa (Hays et al. 2004). Female leatherbacks tagged in the USVI, Colombia, French Guiana, and Costa Rica have been found stranded along the Atlantic and Gulf coasts of the U.S. (Thompson et al. 2001). Tagging studies also indicate many variations in overwintering and onshore-offshore occurrence patterns (Lee and Palmer 1981). For example, a leatherback satellite-tagged on a Florida nesting beach traveled directly to the coast of Virginia after her last nest of the season; while there, she remained within 100 km of shore during her entire four-month stay (CCC 2002).

Aerial survey data indicate a northward movement of individuals along the southeast coast of the U.S. in the late winter/early spring. In February and March, most leatherbacks along the U.S. Atlantic coast are found in the waters off northeast Florida. By April and May leatherbacks begin to occur in large numbers off the coasts of Georgia and the Carolinas (NMFS 1995, 2000). In late spring/early summer, leatherbacks begin to appear off the mid-Atlantic and New England coasts, while by late summer/early fall, many will have traveled as far north as the waters off eastern Canada (CETAP 1982; Shoop and Kenney 1992; Thompson et al. 2001). Eckert et al. (2006) found leatherback Atlantic foraging areas to be located on the continental shelf (30 to 50°N) as well as in an offshore area (42°N, 65°W). The location of these foraging areas changed seasonally. From March through November, foraging areas occurred on the North American continental shelf yet shifted to off- shelf waters from December through February (Eckert et al. 2006).

Leatherback nesting in the western North Atlantic is restricted to coarse-grained beaches in subtropical and tropical latitudes (NMFS and USFWS 1992). Nesting occurs along the coasts of North, Central, and South America (from the southeastern U.S. to Brazil) and throughout the Greater and Lesser Antilles. The most significant nesting populations occur at French Guiana, Suriname, Guyana, Colombia, Panama, Costa Rica, and Trinidad (Thompson et al. 2001). Nesting populations at Culebra, Puerto Rico and St. Croix, USVI are on the rise (Dutton et al. 2005; Eckert, S.A., WIDECAST, pers. comm., 28 February 2006). In the northern Caribbean, Sandy Point National Wildlife Refuge, St. Croix, USVI is the principal nesting beach for leatherbacks (Hillis-Starr et al. 1998). In Florida, leatherbacks regularly nest along the beaches south of Port Canaveral (Schroeder and Thompson 1987). Leatherback nesting in the Bahamas has been observed on Abaco, Cay Sal Bank, and southern Inagua (Bolten 2000; Fleming 2001). Once the nesting season (April through October) is over, leatherbacks leave the waters adjacent to their nesting grounds to move to feeding grounds.

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—There is a common occurrence for the leatherback turtle seaward of the shoreline off Florida, extending into oceanic waters (Figure C-2). Year-round occurrence of leatherback turtles in waters off Florida is expected due to the presence of suitable nesting and potential foraging habitats. As noted earlier, Eckert et al. (2006) identified primary internesting habitat as being centered east–southeast of Cape Canaveral, Florida, from 2 to 60 km offshore and extending 215 km along the coast. Sightings, tagging data, and fishery bycatch records all provide evidence that leatherbacks occur regularly in oceanic waters of the study area. Off southeast Florida, leatherbacks are distributed primarily in mid-shelf waters (Schroeder and Thompson 1987), yet rare sightings have been documented in coastal areas, such as the Indian River Lagoon system in Florida (Witherington and Ehrhart 1989) which is adjacent to the study area. Sub-adult and adult leatherbacks may potentially be found foraging in temperate coastal waters of Florida's east coast year-round. Studies have reported high numbers of leatherback sightings off Florida's east coast during the summer and winter months (Schroeder and Thompson 1987; NMFS and USFWS 1992). The higher number of sightings during the winter (Figure C-2) is likely due to greater survey effort

(right whale aerial surveys and dedicated sea turtle aerial surveys) during this time of year, rather than more individuals frequenting the area.

Adult leatherbacks use the southeastern Florida coast as nesting habitat and commonly transit to and from shore during the nesting season (April through July). Nesting leatherbacks likely constitute a significant number of individuals in this area during this time although reports are scattered. Leatherbacks nesting in Palm Beach County, FL reach the highest densities in the continental U.S. (Stewart and Johnson 2003). Juno Beach, FL, adjacent to the study area, is the site of the most important leatherback nesting colony north of St. Croix, USVI (DUML-NSE 2004). As females nest on multiple beaches during the nesting season (K.L. Eckert et al. 1989; Keinath and Musick 1993), there is likely to be a high degree of transit between nesting beaches inshore of the study area and potentially within the study area as well.

The presence of migratory routes and suitable nesting habitat drives the occurrence patterns for leatherbacks in the Bahamas. Within 12 NM of the Bahamas, they are considered to be present based in part on available data from survey effort and reported sightings by the public (Figure C-2). Occurrence here is driven primarily by low-level nesting throughout the year. Leatherbacks may use the deeper channels and basins of the Bahamas and bank margins as migratory corridors (Bolten 2006b).

The pelagic longline fishery operating offshore of the continental shelf takes leatherbacks as fishery bycatch (Garrison and Richards 2004). However, due to the seasonality of the fishery and the leatherback's known pelagic nature, such bycatch records (Figure C-2) may underestimate numbers of leatherbacks in this area.

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). 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). The high oil content of leatherback flesh may also aid thermoregulatory functions by slowing the process of heat loss from the body (Ernst and Barbour 1994).

Mating is thought to occur prior to or during the migration from temperate to tropical waters (Eckert and Eckert 1988). Along the Atlantic coast of the U.S., leatherback turtles nest annually on beaches from southeastern Florida to Georgia, with the majority of nesting occurring in southeast Florida (FFWCC-FMRI 2004b). In southeast Florida, leatherback nesting season occurs from April through July (FFWCC-FMRI 2004b). The nesting season in the Caribbean is longer and ranges from April through October, with low-level nesting occurring throughout the rest of the year (Alberts et al. 2001). Typical clutches are 50 to over 150 eggs, with the incubation period lasting around 65 days. Females lay an average of five to seven 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 area of the nesting habitat during internesting intervals. Total residence in the nesting/internesting habitats may last up to four months (K.L. Eckert et al. 1989; Keinath and Musick 1993). Most adult females return to nest on their natal beach every two years; however, remigration intervals between one and five years have been recorded (Boulon et al. 1996).

Leatherback turtles feed predominantly upon gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas); however, they may also target a wide variety of other prey or feed in association with other marine organisms (NMFS and USFWS 1992; Grant and Ferrell 1993; Bjorndal 1997). In the Caribbean, dive patterns suggest that leatherbacks forage nocturnally on siphonophores, salps, and medusae within the deep-scattering layer (DSL) which is a strata of vertically migrating zooplankton (primarily siphonophores, salps, and jellyfish) that concentrates below the 600 m during the day and moves to the surface at night (S.A. Eckert et al. 1989). Leatherbacks feed throughout the water column and dive as deep as 1,200 m (Eisenberg and

Frazier 1983; Davenport 1988; S.A. Eckert et al. 1989). Sale et al. (2006) reported dive durations of 30 to 40 mins in the Indian and Atlantic oceans. In temperate waters of the North Pacific Ocean, leatherbacks spend most of their foraging time at depths less than 100 m, although occasionally deep dives will be made while feeding (Eckert 2006).

The leatherback is the deepest diving sea turtle. Leatherbacks in deep oceanic environments frequently exhibit V-shaped dive patterns, in which they descend to a certain depth and then immediately ascend to the surface. Leatherbacks in shallow water (continental shelf) environments more often exhibit U-shaped dive patterns, in which they swim down to the ocean floor, remain near the bottom for several minutes, and then return directly to the surface (Eckert et al. 1996). Average dive depths for post-nesting leatherbacks off the continental shelf of St. Croix (a deepwater habitat) ranged from 35 to 122 m, with estimated maximum depths of over 1,000 m. The maximum dive depth recorded for a post-nesting leatherback in the South China Sea was 62 m, the maximum depth of the ocean floor in that area (Eckert et al. 1996). Typical dive durations in deepwater habitats averaged 6.9 to 14.5 min per dive, while those in shallow water habitats averaged 7.9 to 12.1 min. On average, day dives tended to be deeper, longer, and less frequent than those at night in both types of habitats (Eckert et al. 1989; Eckert et al. 1996). Dives with durations over 70 min have been recorded from daytime observations (Sale et al. 2006).

- Loggerhead Turtle (*Caretta caretta*)

Description—Loggerheads are large, hard-shelled sea turtles. The mean straight carapace length (SCL) of adult loggerheads in southeastern U.S. waters is approximately 92 cm and the average weight is 113 kg (NMFS and USFWS 1991a). The size of a loggerhead turtle's head compared to the rest of its body is substantially larger than that of other sea turtles. Adults are mainly reddish-brown in color on top and yellowish underneath.

Status—Loggerhead turtles are listed as threatened under the ESA and endangered under the IUCN (IUCN 2006). The loggerhead is the most abundant sea turtle occurring in U.S. waters. The South Florida Nesting Subpopulation is the largest known loggerhead nesting assemblage in the Atlantic Ocean (annual nesting totals ranged from 48,531 to 83,442 nests between 1985 and 2000) and is the second largest in the world (TEWG 2000). Nest numbers at Juno Beach, Florida are consistently high with approximately 500 nests per kilometer per year (Stewart and Wyneken 2004). Nesting trends indicate that the number of nesting females associated with the South Florida Subpopulation is likely increasing (Epperly et al. 2001). However, both the Northern (North Carolina to northeast Florida) and Florida Panhandle Nesting Subpopulations are believed to be in decline as a result of decreasing numbers of nesting females over the past several years (NMFS 2002b). In the Bahamas, concentrated aggregations of loggerheads nest on the islands in the Cay Sal Bank, with an estimated 500 to 600 nests laid in a 90-day nesting season (Addison and Morford 1996; Addison 1997).

Habitat Preferences—The loggerhead turtle occurs worldwide in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd 1988). Loggerheads are primarily oceanic as post-hatchlings and early juveniles, often occurring in *Sargassum* drift lines (Carr 1987; Witherington 1994a,b). Off the southeastern coast of Florida, substantial numbers of neonate loggerheads are documented floating in *Sargassum* in convergence zones along the western edge of the Gulf Stream (Caldwell 1968; Witherington 2002). *Sargassum* likely provides optimal foraging opportunities and habitat for loggerhead hatchlings, yet individuals may also be sighted at the surface off the Florida coast and unassociated with *Sargassum* drift lines (Smith 1968).

Loggerhead migrations consist of travel to early juvenile nursery habitat, later juvenile developmental habitat, adult foraging habitat, and adult internesting or breeding habitat, and may be based upon the ontogeny of life stages (Musick and Limpus 1997). Post-hatchling loggerheads are transported throughout the ocean by dominant currents (Bolten and Balazs 1995) and often use the currents of the North Atlantic Gyre System to aid in travel during developmental migrations (Bolten et al. 1998). Once departing western Atlantic nesting grounds, post-hatchlings travel to oceanic waters surrounding the Azores and Madeira, the Great Banks (Newfoundland, Canada), and the Mediterranean Sea (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, 1998). 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), actively swimming to neritic feeding grounds near their natal beach of origin (Bowen et al. 2004). Based on growth rate estimates, the duration of the pelagic juvenile stage for North Atlantic loggerheads is estimated to be approximately 8.2 years, with Pacific loggerheads recruiting to demersal habitats at a larger size (Bjorndal et al. 2000a).

Developmental habitat for loggerheads includes lagoons, estuaries, bays, river mouths, and coastal waters typically less than 100 m deep (TEWG 1998). Mosquito Lagoon, an estuary within the northern Indian River system, represents important developmental habitat for loggerheads in central Florida (Mendonça and Ehrhart 1982). Loggerheads are not restricted to foraging in the lagoon due to their carnivorous nature, although some individuals indicate patterns of residency in this area (Mendonça and Ehrhart 1982). In 1982, an estimated 250 loggerheads utilized Mosquito Lagoon, although this number is believed to lower than the actual count (Mendonça and Ehrhart 1982). In the Bahamas region of the study area, post-hatchlings and juveniles are the predominant age class due to the existence of important available developmental habitat. Advanced hatchlings and juveniles have been observed in the weed line of the Gulf Stream and associated eddies near Little Bahama Bank (Carr 1987).

Based on growth models, immature loggerheads may occupy coastal feeding grounds for 20 years before their first reproductive migration (Bjorndal et al. 2001). Juvenile loggerheads are also known to inhabit offshore waters in the North Atlantic Ocean where they are often associated with natural and/or artificial reefs (Fritts et al. 1983b). These offshore habitats provide juveniles with an abundance of prey as well as sheltered locations where they can rest (Rosman et al. 1987). Sub-adult and adult loggerhead turtles tend to inhabit deeper offshore feeding areas along the western Atlantic coast, from mid-Florida to New Jersey (Hopkins-Murphy et al. 2003; Roberts et al. 2005).

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 1991a). Nest site selection tends to depend more upon beach slope and width than temperature, moisture, or salinity (Wood and Bjorndal 2000). Adult loggerheads exhibit strong site fidelity to nesting beaches by consistently returning to their natal beaches to nest (Comer 2002).

Distribution—Loggerhead turtles are found in subtropical and temperate waters throughout the world (NMFS and USFWS 1991a). The loggerhead numbers in the thousands throughout inner continental shelf waters of the Atlantic coast from Cape Cod to southern Florida and the Gulf Coast from southern Florida to southern Texas. In Florida, the Cape Canaveral Ship Channel is frequently utilized by adult male and adult female loggerheads whose movements into the area on a seasonal basis are most likely influenced by reproductive behavior (Henwood 1987). The distributions of resident sub-adult loggerheads that also occupy this area are likely based upon environmental parameters and foraging opportunities rather than reproduction (Henwood 1987). Sub-adult individuals likely overwinter in the Cape Canaveral Ship Channel as well. Ryder et al. (1994) found the months of April and May to be transitional periods for loggerheads at Cape Canaveral, FL, with juveniles leaving the area during this time to overwinter in warmer waters and adults immigrating to the Cape Canaveral area to mate. As later juveniles and adults, loggerheads most often occur on the continental shelf and along the shelf break of the U.S. Atlantic and Gulf coasts; they are also known to inhabit coastal estuaries and bays in both areas (CETAP 1982; Shoop and Kenney 1992).

Low water temperatures affect loggerhead turtle activity, and cold-stunned loggerheads have been found in various locales, including Long Island Sound, NY; Cape Cod Bay, MA; Indian River Lagoon, FL; and at sites in Texas (Burke et al. 1991; Morreale et al. 1992; NOAA 1993). Loggerheads become lethargic at about 13 to 15°C and adopt a stunned floating posture in water around 10°C (Mrosovsky 1980). Some loggerheads are believed to escape cold conditions by burying themselves in the bottom sediment; the reason for this is unknown. This behavior appears to occur in Florida's Cape Canaveral Ship Channel (Carr et al. 1980; Witherington and Ehrhart 1989). An age difference exists in the loggerhead's cold tolerance, with younger turtles more resistant (Schwartz 1978). Coles and Musick (2000) identified preferred sea surface water temperatures to range between 28 and 13.3°C for loggerhead turtles off North Carolina.

Loggerhead turtles nest almost exclusively in warm-temperate regions. Throughout the world, nesting on warm-temperate beaches is much more common than nesting in the tropics (TEWG 2000). Beach temperatures may also determine sex of hatchlings; male hatchlings typically occur on cooler temperature beaches (Mrosovsky 1980). Intraseasonal nesting patterns for females vary; some females may nest only once a season while others may nest several times (Webster and Cook 2001). In the western North Atlantic Ocean, there are at least five demographically independent loggerhead nesting groups or subpopulations: (1) Northern: North Carolina, South Carolina, Georgia, and northeast Florida; (2) South Florida: occurring from 29°N on the east coast to Sarasota on the west coast; (3) Florida Panhandle: Eglin Air Force Base and the beaches near Panama City, FL; (4) Yucatán: the eastern shore of the Yucatán Peninsula, Mexico; and (5) Dry Tortugas: near Key West, FL (Encalada et al. 1998; TEWG 2000; Epperly et al. 2001). Southeastern Florida represents the principal nesting site for loggerheads along the U.S. Atlantic coast (NMFS and USFWS 1991a). Post-nesting females tagged in Florida have been recaptured at Grand Bahama, Abaco, and Eleuthera in the Bahamas (Meylan 1995), as well as tracked through Bahamian waters while enroute to Cuba (Figure 3-4).

Small but significant nesting aggregations are known from the Bahamas and Cuba (Dodd 1988; Eckert et al. 1992), specifically at Cay Sal Bank (Addison and Morford 1996; Addison 1997). Low-level nesting also occurs on Grand Bahama, Great and Little Abaco, Great Inagua, Andros, and Jimento Cays (Ehrhart et al. 2003). Satellite tracking has shown post-nesting adult females to travel along the Great Bahama Bank and western Eleuthera in the Bahamas (Bolten 2000). Hatchlings from Cay Sal Bank have been subsequently found in the Azores (Bolten 2000).

Genetic evidence has shown that assemblages of benthic-feeding immature loggerheads on foraging grounds comprise a mix of subpopulations (Sears et al. 1995; TEWG 1998; Epperly et al. 2001). Mixed stock analyses of stranded loggerheads have shown that the Northern (25%), South Florida (58%), and Yucatán (17%) subpopulations of loggerheads intermingle on foraging grounds in northeast U.S. waters (Rankin-Baransky 1997). Foraging loggerheads in the central Florida area of Hutchinson Island originate from the South Florida (69%), the Yucatan (20%), and Northeast Florida-North Carolina (10%) nesting areas (Witzell et al. 2002).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Based upon available sighting, stranding, and bycatch records as well as known nesting sites and habitat preferences, loggerheads are expected to commonly occur year-round throughout the study area (Figure C-3). The occurrence off the southeastern Florida coast is likely influenced by the presence of post-hatchlings in the Gulf Stream, juveniles using developmental foraging habitats, and adult nesting in these areas. Shallow bays, lagoons, and estuaries along the southeastern Florida coast, especially the Mosquito Lagoon of the Indian River Lagoon System, serve as important development habitat for juvenile loggerheads. Juveniles may be sighted in these areas year-round. Migrating juveniles may be sighted transiting in and out of these Florida coastal areas (Mendonça and Ehrhart 1982). Southeastern Florida represents the principal nesting site for loggerheads along the U.S. Atlantic coast (NMFS and USFWS 1991a). High nest densities are found in Brevard, Indian River, and Palm Beach counties (Meylan et al. 1995). The greater number of sightings occurring in the winter along Florida's coast (Figure C-3), in contrast to other seasons, is likely due to increased survey effort (SETS) (Aero-Marine Surveys Inc. 1984) and not necessarily to a larger abundance of loggerheads at this time. The Cape Canaveral Ship Channel is frequently utilized by adult male and female loggerheads, whose movements into the area on a seasonal basis are most likely influenced by reproductive behavior (Henwood 1987). The distributions of resident sub-adult loggerheads that also occupy this area of the Florida coast are likely based upon environmental parameters and foraging opportunities rather than reproduction (Henwood 1987). Ryder et al. (1994) found the months of April and May to be transitional periods for loggerheads at Cape Canaveral, Florida, with juveniles leaving the area during this time after overwintering and adults immigrating to the Cape Canaveral area to mate.

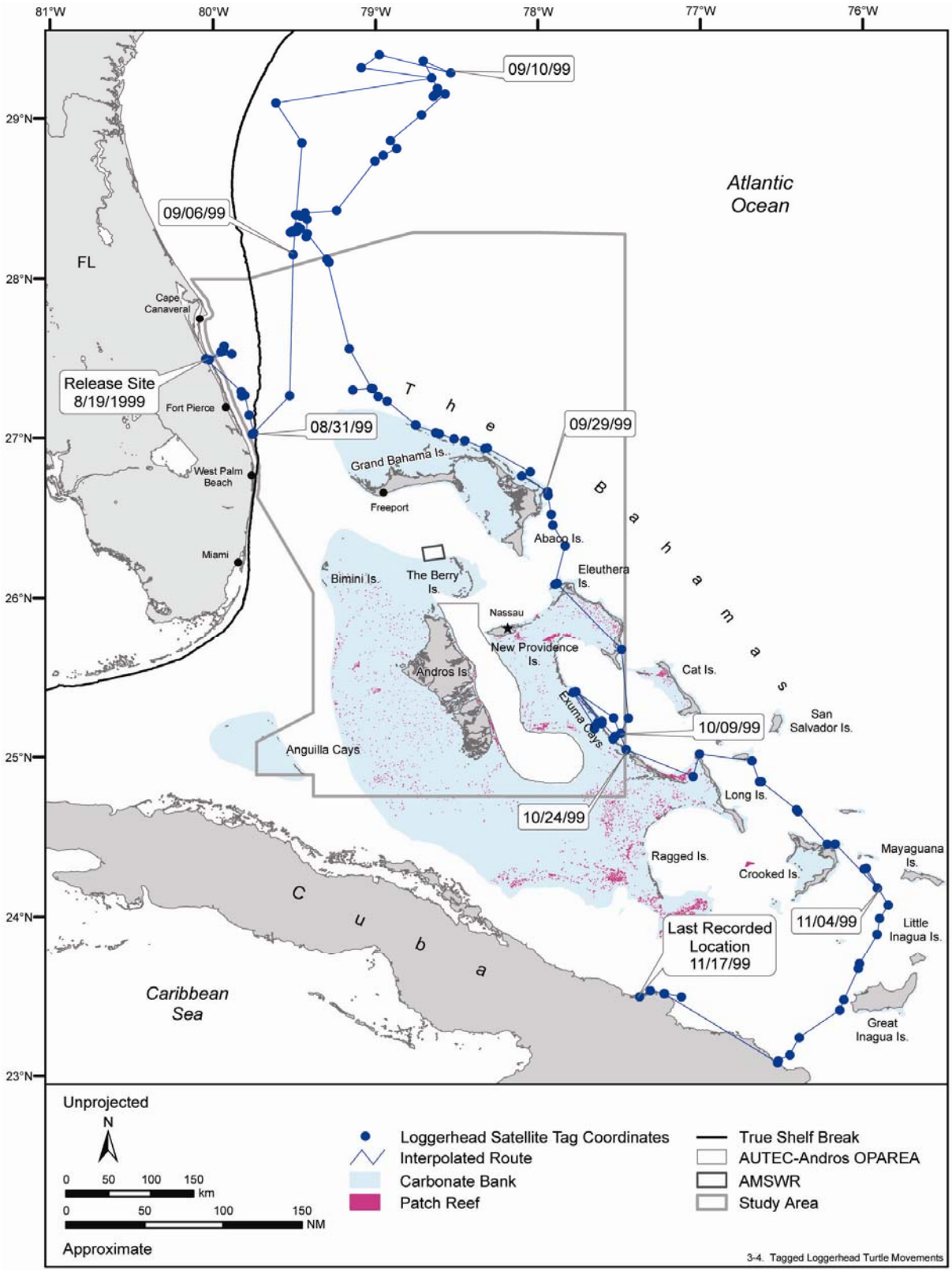

Figure 3-4. Post-nesting movements of a loggerhead turtle satellite-tagged at the Archie Carr National Wildlife Refuge near Melbourne, Florida. This adult female passed through the Bahamas to Cuba, where many loggerheads tagged along Florida's southeast coast have been recovered. Source data: Schroeder and Foley (1999).

Common occurrence between southeastern Florida and the Bahamas is also based on tagging studies that indicated movements of some post-nesting adult females between the two regions (Dodd and Byles 2003). The common occurrence of loggerheads in the Bahamian archipelago is due to the presence of developmental foraging habitat on the Bahamian Banks and the availability of nesting habitat. Advanced hatchlings and juveniles have been observed in the weed line of the Gulf Stream and associated eddies near Little Bahama Bank (Carr 1987). Juveniles sighted along eastern Abacos and Andros Islands (Figure C-3) may use the seagrass beds in these areas as developmental habitat. Low-levels of nesting occur on Grand Bahama, Great and Little Abaco, Great Inagua, Andros, and Jimento Cays (Ehrhart et al. 2003). It is likely that post-nesting females travel through the waters of the Bahamas year-round; satellite-tracking has recorded post-nesting adult females traveling along the Great Bahama Bank and western Eleuthera in the Bahamas (Bolten 2000; Dodd and Byles 2003). Dodd and Byles (2003) suggested that the shallow Great Bahama Bank could be significant non-nesting marine habitat for loggerhead turtles. However, there is a lack of quantitative information for loggerhead distributions in the Bahamas due to little survey effort (Bolten 2006a).

Offshore of Florida and the Bahamas, loggerheads are common as pelagic juveniles in the Sargasso Sea and later as juveniles and adults along the continental shelf and shelf break (CETAP 1982). The Gulf Stream may transport juvenile loggerheads to the shelf waters of eastern Florida, as well as coastal waters nearby. Off the southeastern coast of Florida, substantial numbers of post-hatchling loggerheads have been documented floating in *Sargassum* mats along the western edge of the Gulf Stream (Caldwell 1968; Witherington 2002) although such age classes are typically difficult to sight. Upon departing from nesting beaches in southeast Florida, local eddies may also concentrate juvenile loggerheads offshore in *Sargassum* for a period of up to several months (Carr and Meylan 1980). Loggerheads are caught as fisheries bycatch offshore of the continental shelf by the pelagic longline fishery (Garrison and Richards 2004). However, bycatch records likely underestimate the occurrences of loggerheads in offshore waters due to the seasonality of the fishery. Therefore, existing bycatch data, the known underestimation of loggerheads in this area, and the presence of juvenile loggerheads in the Sargasso Sea drive the common occurrence pattern offshore of southeastern Florida and the Bahamas.

Behavior and Life History—Loggerhead turtle diet changes with age and size of the individual. 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 1994b). In southeastern Florida, post-hatchling diets consist of cnidarians, larval crustaceans, and insects (Witherington 1994b). Juvenile and subadult loggerhead turtles are omnivorous, foraging on pelagic crabs, mollusks, jellyfish, and vegetation captured at or near the surface (Dodd 1988). Adults are generalized carnivores that forage on nearshore benthic invertebrates (Dodd 1988). In the Bahamas, loggerheads feed largely on conch (Bolten 2000). In Greece, loggerheads have been observed feeding opportunistically on fish discarded from fishing boats (Houghton et al. 2000; White 2004) and also on seagrass (*Posidonia oceanica*).

Tiger sharks (*Galeocerdo cuvier*) are known predators of loggerheads on turtle foraging grounds in Western Australia (Heithaus et al. 2005) and may potentially prey on loggerheads in other areas of the world. One occurrence of a loggerhead found in the stomach contents of a tiger shark has been documented in the Bahamas (Randall 1967).

Sexual maturity for western Atlantic loggerheads is attained between 12 and 30 years of age (Zug et al. 1986; Klinger and Musick 1992). Females typically nest three to five times per season at about two-week intervals (Dodd 1988; Frazer 1998). Loggerhead clutches contain between 95 and 150 eggs and often take 60 days to incubate. The most common inter-nesting interval is two years (Dodd 1988; Frazer 1998). Most nesting in the U.S. occurs between April and September (NMFS and USFWS 1991a). Nesting reports in the Bahamas are scattered; Addison and Morford (1996) report loggerhead nesting during June on Cay Sal Bank.

On average, loggerhead turtles spend over 90% of their time underwater (Byles 1988; Renaud and Carpenter 1994). Dive-depth distributions compiled by Polovina et al. (2003) in the North Pacific

Ocean indicate that loggerheads tend to remain at depths shallower than 100 m. 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; Dodd and Byles 2003). Hochsheid et al. (2005) recorded hibernation dives off Greece that had durations as long as 7 hrs.

- 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). As hatchlings, green turtles are approximately 50 millimeters (mm) long and 25 grams (g) in weight at birth. Green turtles in the Atlantic exhibit a decreased body weight growth rate as the carapace grows; this contrasts with the growth rates of Pacific greens (Bjorndal et al. 2000b). 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 displaying four costal lateral scutes on the carapace and a serrated jaw, likely adapted for grazing (Ernst et al. 1994).

Status—Green turtles are classified as threatened under the ESA, with the Florida and Mexican Pacific coast nesting populations listed as endangered (NMFS and USFWS 1991b). The IUCN lists green turtles as endangered (IUCN 2006), although contention to this listing exists (Mrosovsky 2004). In the Caribbean, critical habitat for green turtles is designated at Culebra, Puerto Rico (NMFS 1998c). Florida represents the major nesting site in the continental U.S. for adult female greens. Along the east central and southeast Florida coast, annual nesting estimates range from approximately 350 to 2,300 nests (NMFS and USFWS 1991b). Bjorndal et al. (2000b) estimated the juvenile green population at Union Creek, Bahamas to be nearing carrying capacity; this may potentially indicate a positive trend for green turtle populations in the Bahamas.

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 1987). 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) present direct evidence of hatchlings taking refuge in and around *Sargassum* rafts. 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).

The oceanic transport of juvenile greens emerging from U.S. Atlantic beaches is similar to the model proposed for juvenile loggerheads; neonate greens leave nesting beaches on the eastern Florida coast to enter the Gulf Stream (Witham 1980; Musick and Limpus 1997). Juveniles are eventually transported to the North Atlantic Gyre, a system that carries them around the North Atlantic Basin during the “lost year” phase. Once in the North Equatorial Current, individuals likely reach a carapace length of 20 to 25 cm. At this time, they migrate to nearshore development habitats and feeding areas in Florida and the Caribbean, where they spend the majority of their lives as late juveniles and adults (NMFS and USFWS 1991b; Bjorndal and Bolten 1988; Musick and Limpus 1997).

The optimal developmental habitats for late juveniles and foraging adults are warm shallow waters (3 to 5 m) with an abundance of submerged aquatic vegetation and located in close proximity to nearshore reefs or rocky areas which green turtles use for resting (Ernst et al. 1994). Green turtles may forage in deep waters as in Hawaii where green turtles are known to forage in waters as deep as 20 to 50 m (Brill et al. 1995). In southeastern Florida and the Bahamas, green turtles forage in shallow seagrass beds. Green turtles’ foraging in seagrass areas in the Bahamas is critical to the ecosystem as they play a key role in cycling nutrients throughout the seagrass community (Bolten 2000).

Immature green turtles in the Bahamas prefer shallow creeks and tidal bays for abundant foraging opportunities and exclusion from predators (Bjorndal and Bolten 1995). For example, Conception Creek, Conception Island and Union Creek, Great Inagua serve as important feeding areas for green turtles (Bjorndal et al. 2003). As the turtles grow, they migrate to deeper waters throughout the Caribbean (Bjorndal and Bolton 1995; Fleming 2001).

Distribution—Green turtles are distributed worldwide in tropical and subtropical waters (Pritchard 1997; Plotkin 2003), with major nesting and feeding grounds located in the tropics (Pritchard 1997). In U.S. Atlantic waters, greens are found around the USVI, Puerto Rico and the continental U.S. from Texas to Massachusetts (NMFS and USFWS 1991b). Important feeding areas for green turtles in the continental U.S. include waters in Florida and southern Texas, such as the Indian River Lagoon, Florida Keys, Florida Bay, Homosassa Springs, Crystal River, Cedar Keys, and the Laguna Madre Complex (NMFS and USFWS 1991b; Landry and Costa 1999).

Various life stages of green turtles range widely throughout central to southeastern Florida and the Bahamas. Benthic-feeding juveniles and adult nesting females are common green turtle life stages found in these areas. As they grow, most greens move through a series of developmental feeding habitats, which are often separated by thousands of miles (Hirth 1997). Central to south Florida bays and lagoons, such as Mosquito Lagoon and coastal habitat near Hutchinson Island, support important developmental habitat for juvenile green turtles (Mendonça and Ehrhart 1982; Witzell et al. 2002). In the Bahamas, tidal creeks and bays, specifically Union Creek and Conception Island Creek, represent important developmental feeding habitats (Bjorndal and Bolten 1995). Many turtles are resident in the shallow creeks of Union Creek National Reserve, as documented by the long-term study of immature green turtle movements and foraging habits in this area (BNT 2005a). Juvenile green turtles may travel between developmental habitats in southeastern Florida and the Bahamas (Figure 3-5). Waters of the St. Lucie Power Plant in St. Lucie, Florida and northwestern Abacos in the Bahamas may represent important developmental habitat to juvenile greens, as shown by the track of a juvenile female tagged by researchers at the University of Central Florida (CCC 2005b).

The temperature of inshore and nearshore waters is a major factor that often determines the distribution and abundance of green turtles along the U.S. Atlantic Coast. Individuals occurring in temperate waters avoid becoming cold-stunned by either moving offshore or toward more southerly latitudes prior to the onset of winter. Cold-stunning usually happens when water temperatures drop to 10°C or below and can result in death if the cold period is extended and/or the temperature drops below 6.5°C. Green turtles lose the ability to dive at 9°C and remain floating horizontally until they either warm up or die (Schwartz 1978). Green turtles are the most common turtle species to exhibit mortality during cold-stunning episodes in the Indian River system on the east coast of Florida. Based on such observations, Mosquito Lagoon, an estuary within the northern region of the Indian River system, likely represents the northern limit of green turtles during the winter (Witherington and Ehrhart 1989). In this area, it is estimated that green turtles have a critical thermal minimum range between 4 and 9°C (Mendonça 1983).

The major Atlantic nesting colonies are located at Ascension Island (in the South Atlantic Ocean, about midway between South America and Africa), at Aves Island (about 180 km west of Guadaloupe in the Caribbean Sea), and on the beaches of Costa Rica and Suriname (in Central and South America, respectively) (NMFS and USFWS 1991b). Most nesting in North America occurs in southern Florida and Mexico (Meylan et al. 1995), with scattered records in the Florida Panhandle, Alabama, Georgia, and the Carolinas (Peterson et al. 1985; Schwartz 1989; NMFS and USFWS 1991b). Green turtles rank second behind loggerheads in the number of nests laid on U.S. beaches per year (Dodd 1995; Meylan et al. 1995).

Adult nesting females occasionally occur in the Bahamas. The most important green turtle nesting areas in the Bahamas are located on Great and Little Inagua islands (Fleming 2001). Substrate temperature on nesting beaches, as in other turtles, controls sex differentiation of hatchlings during incubation (Hirth 1997). Warmer temperatures produce females while colder substrate temperatures produce males. In the Caribbean, the critical temperature for sex differentiation of green turtle hatchlings is expected to be between 28.5 and 30.3°C (Hirth 1997).

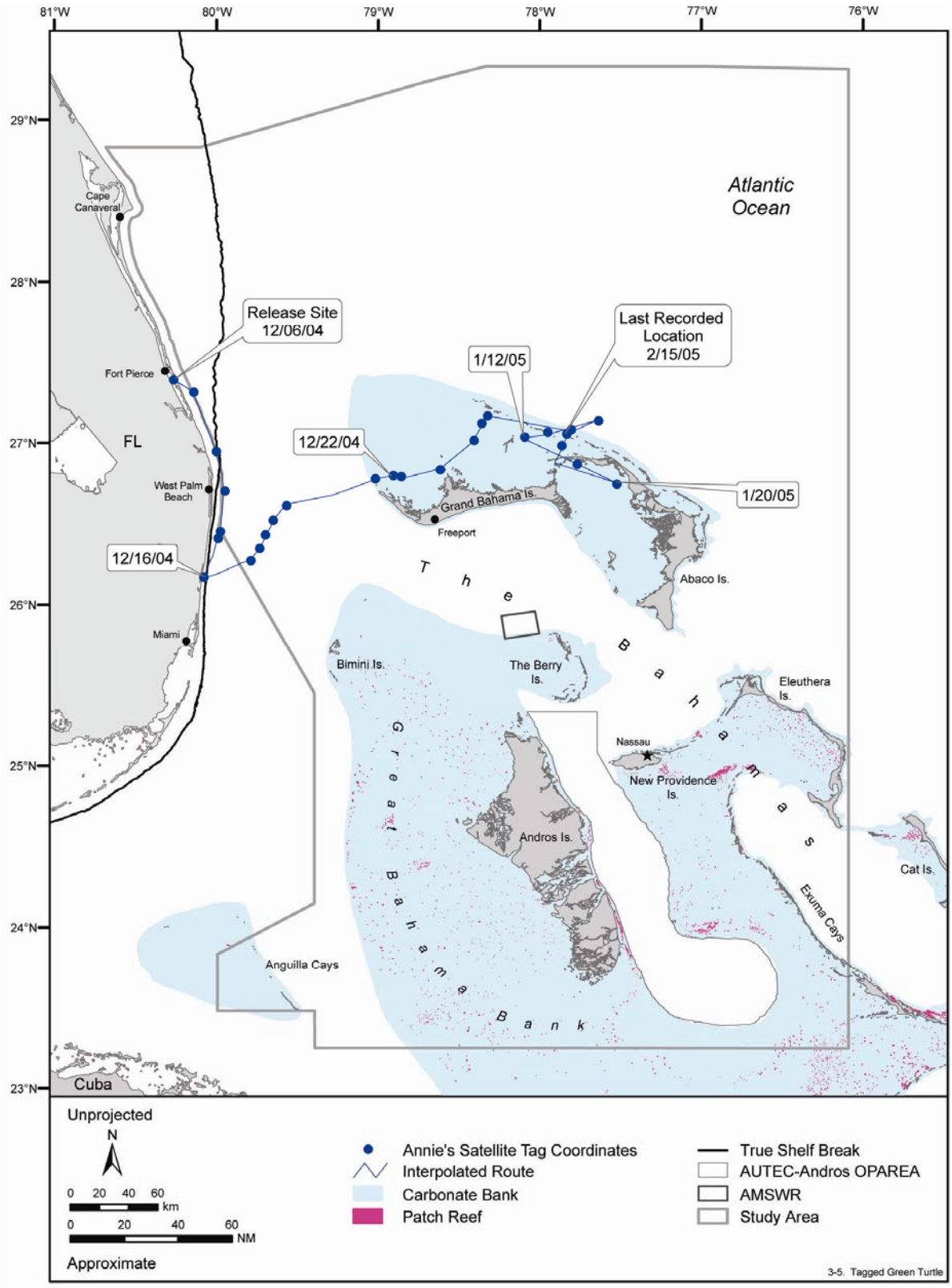

Figure 3-5. Movements of a juvenile green turtle satellite-tagged at the St. Lucie Power Plant, St. Lucie County, Florida. The juvenile traveled along Florida's southeast coast before crossing into the northern Bahamas. The turtle spent much time in the northwestern waters of the Abacos, a possible area of developmental green turtle habitat or adult foraging grounds. Source map (scanned): CCC (2005b).

Adult green turtles are known to undertake long migrations; the longest are between their foraging habitats and nesting beaches. Mixed-stock analyses on foraging populations of juveniles reveal that developmental feeding habitats likely contain green turtles from multiple stocks. Green turtles occurring on foraging grounds off the U.S. Atlantic and Gulf coasts include representatives born on Costa Rican, U.S., Mexican, Aves Island, Surinam, Ascension Island, and Guinea Bissau (West Africa) nesting beaches (Lahanas et al. 1998). At Hutchinson Island, foraging green turtles originate from Costa Rica (53%), the U.S. and Mexico (42%), Venezuela (Aves Island), and Surinam (4%) (Bass and Witzell 2000). In the Bahamas, juvenile foraging green turtles consist of a mix from the Costa Rica (80%), Venezuela (Aves Island) (6%), and Surinam (14%) nesting populations (Lahanas et al. 1998).

After leaving developmental foraging habitat in the Bahamas, juvenile green turtles may undertake extensive migrations as well. Results of flipper and satellite tag studies at Inagua Island, the Bahamas have indicated travel to Cuba, Nicaragua, Columbia, and Venezuela, as well as other areas of Central and South America (Bolten and Bjorndal 2003).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Green turtles are common year-round in continental shelf waters off Florida's east coast (Figure C-4). Occurrence in this area is based on the presence of developmental and nesting habitats. Juvenile green turtles use the developmental habitat along the coastal area of southeast Florida year-round (Mendonça and Ehrhart 1982; Witzell et al. 2002). Worm-rock reefs, spanning coastal areas from Indian River County to Key Biscayne, and coastal habitat near Hutchinson Island are also in close proximity to the study area and provide developmental habitat for juvenile green turtles (Bresette et al. 1998; Witzell et al. 2002). Mosquito Lagoon, Brevard County, which lies adjacent to the study area, supports an abundance of seagrasses, a major component of the green turtle diet (Mortimer 1995), and likely represents the northern limit of green turtles during the winter (Witherington and Ehrhart 1989).

  The common occurrence along the coast of Florida also accounts for juveniles traveling between these developmental habitats. It is also based on the movement of pre- and post-nesting adults and post-hatchlings through the coastal and shelf waters off southeastern Florida. Upon emerging from nesting beaches, post-hatchlings must travel through the southeastern Florida coastal and shelf waters to reach the Gulf Stream, from which they are likely transported into the North Atlantic Gyre and around the North Atlantic Basin. High concentrations of green turtle nesting in Florida are found during the nesting season (June through August) in Melbourne Beach (Brevard County), Hutchinson Island (St. Lucie County), and Jupiter Island (Palm Beach County) (Hirth 1997).

  Green turtles are also common on the Bahamian banks year-round (Figure C-4). Occurrence in these areas is driven by the presence of many coastal developmental habitat sites, such as worm-rock reefs, and suitable nesting habitat. Seagrass areas are also found throughout the banks and present prime foraging habitat for adults and developmental habitat for juveniles. Shallow creeks and tidal bays are preferred adult foraging areas in the Bahamas (Bjorndal and Bolten 1995).

  Green turtles are present offshore of the Gulf Stream, south of the Antilles Current, and throughout the deep channels and basins of the Bahamas (Figure C-4). Potential travel between developmental, nesting, and foraging habitats in Florida and the Bahamas provides the basis for this occurrence.

  Green turtles have a rare occurrence north of the Antilles Current and offshore of the shelf break (Figure C-4). Although post-hatchlings likely exist in this area in association with *Sargassum* (Mellgren 1994), there is no suitable habitat for juveniles or adults, but it is probable that these age classes are found here as they transit through the region.

Behavior and Life History—Late juvenile and adult green turtles feed primarily on seagrasses [e.g., turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and eelgrass (*Zostera marina*)], macro algae, and reef-associated organisms (Burke et al. 1992; Bjorndal 1997). Post-hatchlings and early juveniles are more omnivorous, feeding on a variety

of algae, invertebrates, and small fishes and show strong site fidelity to feeding areas (Bjorndal 1985; Musick and Limpus 1997). Observations of foraging adult green turtles in Hawaiian waters suggest that when benthic age classes feed, they generally lie down on the sea bottom and then crawl or move to a nearby site when food is no longer within easy reach (Hochscheid et al. 1999). The majority of green turtle diet in the central to southeastern Florida is composed of seagrasses *Syringodium filiforme, Halodule wrightii*, and *Halophila* spp., although juvenile green turtles associated with near-shore reefs may prey upon green, brown, and red algae (Bresette et al. 1998). In the Bahamas, green turtles mainly consume the readily available low forage quality seagrass, *Thalassia testudinum* (Bjorndal 1995; Mortimer 1995).

Green turtles are estimated to take 27 to 50 years to reach sexual maturity, the longest age of maturity for any sea turtle species (Frazer and Ehrhart 1985). The low forage quality of the seagrass that is the major food source for green turtles in the Bahamas contributes to limiting their growth rates and prolonging sexual maturity (Bjorndal 1995).

Mature females nest from one to seven times in a season (two to three is typical) at approximately two-week intervals and reproduce every two to four years (NMFS and USFWS 1991b). Within a nesting season, females remain in close proximity to their nesting beaches during inter-nesting intervals (Meylan 1995). Between 110 and 145 eggs are laid at a time, and the incubation period is 50 to 60 days. Green turtles may prefer nesting habitats on broad, open beaches, with loose sand and moderate to low slopes (Comer 2002). Greens that nest along the U.S. Atlantic Coast do so between June and August (Coston-Clements and Hoss 1983). In the Bahamas, green turtles nest anytime between June and September (Carr et al. 1982).

Green turtles typically make dives shallower than 30 m (Hochscheid et al. 1999; Hays et al. 2000); however, green turtles have been observed at depths of 73 to 110 m in the eastern Pacific Ocean (Berkson 1967). In 1997, a maximum dive depth of 164.5 m was recorded for a post-nesting female from Japan's Ogasawara Islands (Matsuzawa 2005). Although relatively few studies have been conducted on green turtle diving patterns in the eastern Pacific, a number of diving studies have been performed in the Hawaiian Islands and Australia. The maximum dive time recorded for a juvenile green turtle around the Hawaiian Islands is 66 min, with routine dives ranging from 9 to 23 min (Brill et al. 1995). At Heron Island, Australia, juvenile green turtles are known to alter their diving behavior seasonally. During winter, juveniles spend significantly more time in shallow water (<1 m), dive for longer periods of time, and remain at the surface for longer periods of time than during summer (Southwood et al. 2003).

- 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 from other sea turtles on the basis of their hawk-like beaks, posteriorly overlapping carapace scutes, and two pairs of claws on their flippers (NMFS and USFWS 1993). The carapace of this species is often brown or amber with irregularly radiating streaks of yellow, orange, black, and reddish-brown.

Status—Hawksbill turtles are listed as endangered under the ESA and are second only to Kemp's ridleys in terms of endangerment (NMFS and USFWS 1993; Bass 1994). The IUCN lists hawksbills as critically endangered (IUCN 2006). The most recent estimate of hawksbill abundance in the Wider Caribbean was 4,975 nesting females calculated by Meylan in 1989 (Meylan and Donnelly 1999). A recent increase in sightings of juvenile hawksbills suggests hawksbill numbers may be increasing in the Bahamas (IUCN 2001) although large adult hawksbills are rarely observed (Fleming 2001). Very little is known about the status or abundance of this species along the U.S. Atlantic Coast aside from the recognition that hawksbill populations in this area are neither declining nor showing indications of recovery (Dodd 1995; Plotkin 1995). In the Caribbean, there is designated critical habitat for hawksbills at Mono and Monito islands, Puerto Rico (NMFS 1998c).

Habitat Preferences—Hawksbill post-hatchlings and early juveniles inhabit oceanic waters where they are sometimes associated with floating patches of *Sargassum* (NMFS and USFWS 1993; Parker 1995). Hawksbills recruit to benthic foraging grounds when they are 20 to 25 cm in length (NMFS and

USFWS 1993). 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 or mangroves (Musick and Limpus 1997). Coral reefs are recognized as optimal hawksbill habitat for juveniles, sub-adults, and adults (NMFS and USFWS 1993; Diez et al. 2003). Preference for these habitats is likely related to the presence of sponges, a favored prey item of hawksbills which comprises as much as 95% of their diet in some locations (NMFS and USFWS 1993; Diez et al. 2003). Ledges, caves, and root systems, which are often interspersed among these habitats, provide hawksbills refuge and shelter (NMFS and USFWS 1993). Sparse hard-bottom communities and cliff-wall habitats with soft corals and invertebrates are also considered important hawksbill benthic developmental habitat (Diez 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).

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). Major foraging populations in U.S. waters occur in the vicinity of the coral reefs surrounding Mona Island, Puerto Rico and Buck Island, St, Croix, USVI (van Dam and Diez 1996; Starbird et al. 1999). Smaller populations of hawksbills reside in the hard bottom habitats that surround the Florida Keys and other small islands in Puerto Rico and the USVI (Witzell 1983; NMFS and USFWS 1993). Several sporadic reports exist of hawksbills residing in seagrass habitats. Diez et al. (2003) documented a seagrass community as developmental habitat for an abundance of juvenile hawksbill turtles at Saona Island, Dominican Republic.

Hawksbill turtles nest on both low- and high-energy beaches in tropical regions; they often nest 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 nesting on 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; these areas are rarely accessible to other 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). In the western North Atlantic Ocean, this species is found throughout the Gulf of Mexico, the Greater and Lesser Antilles, southern Florida, and along the mainland of Central America south to Brazil (NMFS and USFWS 1993). Juvenile and adult hawksbills are regularly found in the Gulf of Mexico, the Caribbean Sea, and along the Atlantic coast of southern Florida (Witzell 1983; NMFS and USFWS 1993).

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, individuals are now known to travel long distances over the course of their lives (Meylan 1999) mainly between nesting and foraging areas. Transoceanic migrations are known in some cases from both tagging and genetic analyses (Bellini et al. 2000; Bowen et al. 2007). For example, a subadult tagged in Sueste Bay at archipelago of Fernando de Noronha Archipelago, 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). 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 1995). In the Bahamas, hawksbill tagging studies have been conducted at Union Creek, Inagua as well as Crooked Island, Conception Island, Rum Cay, and San Salvador (IUCN 2001). Tags from hawksbills sighted at Union Creek, Inagua have been returned from Cuba as well as the Turks and Caicos, a minimum distance of approximately 150 km (Bjorndal and Bolten 1998).

Tag return, genetic, and telemetry studies have indicated that Caribbean hawksbill turtles use multiple developmental habitats as they progress from one age class to another. Within a given life stage, such as the later juvenile stage, some hawksbills may choose to be sedentary within a specific

developmental habitat for a long period of time (Meylan 1999). In addition, juvenile hawksbills that forage in the Bahamas are likely from nearby nesting colonies (Bowen et al. 2007).

Hawksbills tend to nest in multiple, small, scattered colonies. The largest nesting aggregation in the Caribbean occurs along the Yucatán Peninsula, Mexico (NMFS and USFWS 1993). An estimated 1,900 to 4,300 adult females comprise the Mexican Atlantic nesting population (Garduño-Andrade et al. 1999). Other small, yet important, nesting assemblages are found in Belize, Nicaragua, Panama, Venezuela, Cuba, Antigua, and the Grenadines (NMFS and USFWS 1993). Within the continental U.S., hawksbill nesting is restricted to beaches in southern Florida and the Florida Keys, although even there it is extremely rare (Dodd 1995). Despite rare accounts, hawksbill nesting in southern Florida may be underestimated due to the masking effects of thousands of loggerheads that nest along the same stretches of beach (Lund 1985). The Bahamas contains significant nesting habitat for hawksbills, as scattered year-round nesting occurs throughout the Bahamas archipelago (Fleming 2001). Hawksbill nesting in the Bahamas has been observed on several islands, including Abaco, Inagua, Acklins, Crooked, and Conception islands (IUCN 2001).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Hawksbills are present along the east coast of Florida, within the Gulf Stream, and in the deep channels and basins of the Bahamas throughout the year based upon scattered sightings, strandings, and nesting records (Figure C-5). Hawksbill occurrence off southeastern Florida is likely driven by the presence of nesting habitat and, potentially, foraging habitat. Typically a tropical species, hawksbills are not expected to occur frequently off the U.S. coast, yet they have been observed nesting and using coral reef habitat along the east coast of Florida (Witzell 1983; Lund 1985; NMFS and USFWS 1993). Nesting has been documented at areas adjacent to the study area, including Jupiter Island and the Canaveral National Seashore (Lund 1985). Although the nesting season in Florida is May through August, this may not affect expected seasonal distributions since hawksbill presence appears consistent year-round (Figure C-5).

  Present occurrence in offshore waters between Florida and the Bahamas and the deep channels and basins of the Bahamas (Figure C-5) is primarily based on the presence of adult nesting females in Florida and the potential for juveniles and adults to transit areas offshore of Florida and throughout the Bahamas. Hawksbills may associate with the near-shore coral reef habitat inshore of the study area off eastern Florida. In areas close to Hutchinson Island, Florida where this habitat type is abundant, hawksbills have been captured at a power plant intake canal since 1976 (Bresette et al. 1998). The occurrence of hawksbills at nesting beaches and near-shore coral reef habitats may provide an indication for their distribution offshore within the study area, as they must transit through this area to access nesting and foraging sites in southeastern Florida. In addition, the existence of nesting habitat suggests the presence of post-hatchlings in the study area as well, as they must travel through the study area to oceanic waters.

  Hawksbills are common on all of the Bahamian banks (Figure C-5); this occurrence is likely due to the presence of coral reef habitat and suitable nesting sites. The presence of nesting females as well as the juvenile benthic-stage and adult hawksbills using coral reef habitats contributes significantly to the regularity of sightings of the species in Bahamian waters. Scattered nesting is documented in the Bahamas, particularly on the Abacos Islands (Witzell 1983; IUCN 2001) where nesting takes place year-round (Witzell 1983). Although hawksbills are typically found foraging year-round in the extensive coral reefs of Bahamian waters (IUCN 2001), they may also be sighted in coastal lagoons where seagrass beds exist (Bjorndal and Bolten 1998). Hard bottom areas and cliff-wall habitats may also provide suitable habitat for juvenile and adult hawksbills (Witzell 1983; NMFS and USFWS 1993; Diez et al. 2003). The lack of hawksbill occurrence records associated with these habitats in the Bahamas and on the Bahamian banks may be merely a reflection of lack of survey effort in these areas (Figure C-5).

  Hawksbill occurrence is rare from the eastern edge of the Gulf Stream and north of the Antilles Current (Figure C-5). Although the northeastern pelagic zone of the study area does not contain suitable juvenile or adult hawksbill habitat, post-hatchling hawksbills associating with *Sargassum* (NMFS and USFWS 1993) could potentially occur in this area.

Behavior and Life History—Post-hatchlings and early juveniles are believed to utilize *Sargassum* habitat, but little is known about these turtles' diets during this stage (Witzell 1983). *Sargassum* and floating debris have been found in the stomach of stranded post-hatchlings (NMFS and USFWS 1993). Scientists believe that hawksbills are omnivorous during the later juvenile stage, feeding on encrusting organisms such as sponges, tunicates, bryozoans, algae, mollusks, crustaceans, and jellyfish (Bjorndal 1997). 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 nesting occurs from May through August in central to southeastern Florida (Lund 1985) and year-round in the Bahamas (Witzell 1983). Adult female nesting is often nocturnal and usually occurs on beaches with sufficient vegetative cover. An individual female nests two to five times per season with an inter-nesting interval of about 14 to 16 days. The typical remigration interval is two to three years. Clutch sizes are relatively large at 140 to 180 eggs, and incubation time is 50 to 61 days. Hawksbills exhibit strong philopatry for nesting beaches and return to specific beach areas (NMFS and USFWS 1993). Mating is thought to take place in waters adjacent to the nesting beach.

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. The SCL of an adult is approximately 65 cm (USFWS and NMFS 1992). Adult Kemp's ridleys typically weigh less than 45 kg (USFWS and NMFS 1992). 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 critically endangered on the IUCN Red List; it is considered the world's most endangered sea turtle (USFWS and NMFS 1992; IUCN 2006). 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 2005a). 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 2005a). 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. 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). They move to benthic, nearshore feeding grounds along the U.S. Atlantic and Gulf coasts as large juveniles and adults. Habitats frequently utilized include warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where its preferred food, the blue crab (*Callinectes sapidus*), is known to exist (Lutcavage and Musick 1985; Landry and Costa 1999).

Henwood (1987b) and Gitschlag (1996) have documented sightings and movements of juveniles within and among preferred habitats along both the Atlantic and Gulf coasts. Shallow waters are most preferred, and Kemp's ridleys are closely associated with shorelines of the red mangrove in the Florida Keys (Ernst and Barbour 1994). Coastal bays and estuaries along the U.S. Atlantic Coast are important developmental habitats (Morreale and Standora 2005); 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). In the Gulf of Mexico, 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 also identified as important developmental regions for the Kemp's ridley (Márquez-M. 1990, 1994; USFWS and NMFS 1992; Schmid et al. 2002).

Mature Kemp's ridleys likely forage along the eastern coast of Florida (Henwood and Ogren 1987). Renaud (1995) indicated that adult Kemp's ridley turtles may travel along the entire Gulf Coast of the U.S. when looking for optimal foraging habitat. Habitat suitability index models indicate that the most optimal habitats for Kemp's ridleys in the western North Atlantic Ocean are those occurring in less than 10 m in bottom depth, with temperatures between 22° and 32°C (Coyne et al. 2000).

Distribution—The Kemp's ridley is restricted to the North Atlantic Ocean (Márquez-M. 1994). Adults are largely confined to the Gulf of Mexico, with moderate numbers along the U.S. Atlantic Coast as far north as Nova Scotia (Lazell 1980; Morreale et al. 1992). It is mostly juveniles that occupy the northern part of the range (Morreale and Standora 2005), with juvenile Kemp's ridleys most often sighted along the eastern coast of Florida (Henwood and Ogren 1987). Isolated Kemp's ridley occurrences are noted for the Caribbean (Renaud and Williams 2005). For example, there is one documented record of a Kemp's ridley in Nicarauga, a capture near Bermuda, and a few unconfirmed sightings reported for Jamaica and the Bahamas (Mowbray and Caldwell 1958; Manzella et al. 1991; Fleming 2001; IUCN 2001). There is also evidence of transoceanic migrations, with some Kemp's ridleys reported as far east as northern Europe and the Mediterranean Sea (Brongersma 1995; Tomás et al. 2003).

Oceanic transport of neonate Kemp's ridleys is primarily controlled by hydrography in the Gulf of Mexico (Collard 1990b). Upon leaving the nesting beach of Rancho Nuevo, Mexico, neonate 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). Juveniles are then carried north by the Gulf Stream along the U.S. Atlantic Coast (Collard and Ogren 1990). Once they reach a size of approximately 20 to 30 cm or two years of age, they 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 Atlantic Ocean to areas such as the Azores and Madeira (Brongersma 1995; Musick and Limpus 1997). Adults appear to remain in the Gulf of Mexico, with an occasional occurrence in the Atlantic Ocean. Satellite-tracked adult females have been shown to move very little and maintain relatively small ranges; little is known of the ranging patterns of adult males (Weber 1995).

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 (Márquez-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. 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).

During the winter, Kemp's ridleys may migrate to warmer waters and then return to their former habitat or bury themselves in mud bottoms to avoid low temperatures (Márquez-M. 1994). Seasonal coastal migration occasionally brings them to overwinter in central to south Florida. Although Kemp's ridleys may be observed in Florida waters year-round, the highest abundances have been

documented during December through March (Henwood and Ogren 1987). Kemp's ridley turtles overwintering in Florida waters may be expected to move north as water temperatures increase, foraging along the way, and return south to Florida in the fall when temperatures cool. These seasonal movements may continue until turtles reach sexual maturity, at which time, turtles may return to breeding grounds in the Gulf of Mexico (Henwood and Ogren 1987).

Nesting occurs primarily on a single nesting beach at Rancho Nuevo, Tamaulipas, Mexico (USFWS and NMFS 1992), with a few additional nests in Texas, Florida, South Carolina, and North Carolina (Meylan et al. 1990; Weber 1995; CCC 1996; Foote and Mueller 2002; NPS 2003). At Rancho Nuevo, Kemp's ridleys nest in *arribadas*, synchronous mass nesting events likely triggered by physiological and environmental cues ((Márquez-M. 1990, 1994; Witzell et al. 2005). Two successful nesting attempts have been documented on the east coast of Florida; the first occurred in 1996, just south of Daytona Beach in Volusia County (CCC 1996; Foote and Muller 2002). This individual nested twice in this area. Additional nesting attempts have been recorded in Palm Beach County and on the west coast of Florida (Meylan et al. 1990; Godfrey 1996).

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Kemp's ridley turtles are common along the east coast of Florida out to the eastern wall of the Gulf Stream year-round (Figure C-6). Occurrence here is due to the presence of juvenile developmental habitat, potential adult foraging habitat, and overwintering sites (Henwood and Ogren 1987; Morreale and Standora 2005). Upon emerging from nesting beaches in the Gulf of Mexico, post-hatchlings are transported to the Gulf Stream via the Loop Current and Florida Current (Musick and Limpus 1997). In order to access Florida developmental habitats from the Gulf Stream, Kemp's ridleys must travel through the shelf waters of the study area. Juveniles also overwinter in coastal Florida waters, especially in the Cape Canaveral area (Henwood and Ogren 1987). Overwintering juvenile Kemp's ridley turtles may not significantly change the year-round abundance in Florida waters, although Henwood and Ogren (1987) found the greatest concentrations to occur in the Cape Canaveral area between December and March. Nesting-sized adult Kemp's ridley turtles are also observed overwintering from mid-November to mid-March less than 40 km offshore from Cape Canaveral, indicating that these waters may also be used for overwintering by adults (Gitschlag 1996). Mature Kemp's ridleys likely forage along the eastern coast of Florida, especially in areas where their preferred prey, the blue crab, is abundant (Henwood and Ogren 1987). During travel to and from overwintering sites and potential foraging areas, Kemp's ridleys likely enter the study area.

  Throughout the Bahamas, beyond the eastern wall of the Gulf Stream, and south of the Antilles Current, the occurrence of Kemp's ridley turtles is undetermined (Figure C-6). Occurrence patterns could not be accurately determined due to the complete lack of occurrence records in this region, particularly in areas that contain suitable habitat for this species. For instance, Kemp's ridleys have the potential to occur in the Gulf Stream due to their known association with *Sargassum*, yet no occurrence records have been documented in the Gulf Stream vicinity. Only one documented occurrence and several unconfirmed records are available for the Caribbean (Manzella et al. 1991; Fleming 2001; IUCN 2001). However, output of a habitat suitability index model based upon known habitat preferences of the Kemp's ridley turtle indicates that optimal and highly suitable habitat exists within the Bahamas, particularly around the Great and Little Bahamas banks (Coyne et al. 1998). In addition, it is likely that post-hatchlings pass near the westernmost Bahamian islands when they enter the Gulf Stream (Márquez-M. 1994). Dedicated sea turtle surveys throughout this area may eventually clarify the occurrence of this species in the Bahamas.

  Kemp's ridleys are expected to be rare east of the Gulf Stream and north of the Antilles Current in the deep oceanic waters of the study area closest to the Sargasso Sea (Figure C-6). As with many other sea turtle species, post-hatchling Kemp's ridleys may reside in Sargasso Sea/North Atlantic Gyre waters in association with *Sargassum* (Brongersma 1995; Musick and Limpus 1997). The determination of a rare occurrence is a conservative estimate based on the possibility that some Kemp's ridley post-hatchlings may be found in the oceanic waters of the study area and the lack of knowledge regarding Kemp's ridley movement patterns during this lifestage.

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, and plant material (Márquez-M. 1994). This species may also feed on shrimp fishery bycatch (Landry and Costa 1999).

Kemp's ridleys are unique in that they are daytime nesters (Márquez-M. 1990) and nest synchronously in *arribadas* (Weber 1995). Age of maturity for nesting females is undefined, although average size of nesting females is approximately 64.6 cm CCL (Miller 1997). Mature males may be smaller in size than nesting females (Witzell et al. 2005). Individuals nest approximately every two years, usually between April and mid-August. A typical female produces about three clutches averaging 110 eggs at 20- to 28-day intervals (Miller 1997) although larger turtles may produce even 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 mins) 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-hour 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).

- Olive Ridley Turtle (*Lepidochelys olivacea*)

Description—The olive ridley is named for its olive-green shell. This species is generally only slightly larger in size than the Kemp's ridley. Adults often measure between 60 and 70 cm in carapace length and rarely weigh more than 50 kg (NMFS and USFWS 1998). Olive ridley adults are sexually dimorphic in that males possess longer and thicker tails than females, as well as a more tapered carapace. The olive ridley differs from the Kemp's ridley in that it possesses a smaller head, a narrower carapace, and several more lateral carapace scutes than its relative.

Status—Olive ridleys are listed as threatened under the ESA, although the Mexican Pacific nesting stocks are endangered. Olive ridleys are further classified as endangered under the IUCN (IUCN 2006). Despite these listings and recent declines, the olive ridley is considered the most abundant of the world's sea turtles in terms of absolute numbers, although it may be considered the rarest sea turtle in the western Atlantic Ocean (Reichert 1993). Nesting populations in the western North Atlantic have declined more than 80% since 1967 (Reichart 1993).

Habitat Preferences—There is little information available on the habitat preferences of olive ridley turtles in the western Atlantic Ocean, although Marcovaldi (2001) indicates that they occur primarily in coastal habitats with some individuals ranging further offshore. An olive ridley satellite tagged and released off Andros in the Bahamas exhibited preferences for shallow areas (<200 m) near the coast of western Andros and homogenous habitat (Bolten and Bjorndal 2006; Figure 3-6). Although little survey effort for sea turtles has been conducted in this area, Bolten and Bjorndal (2006) suggested that the invertebrate fauna and soft-bottom areas of this region may provide good forging habitat for olive ridleys.

Additional information regarding olive ridley habitat preferences is derived from populations in the Pacific Ocean, where olive ridleys typically reside in oceanic habitats and forage either at the surface or at depth. These habitats often consist of a warm surface layer and a deep thermocline, and they lack strong horizontal temperature gradients and physical or biological fronts (Polovina et al. 2003). Preferred water temperatures for olive ridleys in the North Pacific Ocean range from 23 to 28°C (Polovina et al. 2004). Shallow benthic waters may also serve as foraging grounds for olive ridleys (Bjorndal 1997).

Distribution—The olive ridley is a pantropical species, occurring worldwide in tropical and warm temperate waters. In the Atlantic Ocean, the olive ridley occurs mainly along the west coast of Africa,

from Senegal to Angola (Brongersma 1995) and along the eastern coast of South America, from Venezuela to Brazil (Reichert 1993). Although rarely found north of Trinidad, olive ridley sightings are documented off Cuba, Jamaica, the Dominican Republic, Puerto Rico, Florida, and the Bahamas (Carr et al. 1982; Horta et al. 2000; Moncada et al. 2000; Foley et al. 2003). The northernmost record is of a longline-caught individual, approximately 370 km south of Newfoundland during October 2003 (Stokes and Epperly 2006). Bolten and Bjorndal (2006) suggest that the range of olive ridleys may recently have expanded northward.

The first confirmed sighting of an olive ridley in the Bahamas occurred in April 2001 (Bolten and Bjorndal 2006). A small (60 cm CCL) olive ridley was caught by a fisherman on the shallow banks of western Andros Island and subsequently rehabilitated on Paradise Island. The turtle was satellite-tagged and released off the northwestern end of Andros Island near its original site of capture (Bolten and Bjorndal 2006; Figure 3-6). Upon release, the turtle traveled south along the western coast of Andros Island, displaying movement patterns consistent with those expected of resident turtles. This individual exhibited relatively short movements in any direction and frequented a small, shallow area of homogeneous habitat composed primarily of mudflats (Bolten and Bjorndal 2006). The westernmost point of the turtle track occurs in waters approximately 700 m in bottom depth over the Grand Bahama Bank (Figure 3-6).

The largest olive ridley nesting aggregation occurs in the Indian Ocean in Orissa, along the northeast coast of India (Shanker et al. 2003) although small- and moderate-sized nesting aggregations are documented in the western Atlantic Ocean (NMFS and USFWS 1998). Regular nesting activity in the western Atlantic takes place in Guyana, Suriname, French Guiana, and Brazil (Marcovaldi 2001). Olive ridley nesting is not documented in either the Bahamas or Florida (Reichert 1993).

Adult foraging grounds are located in Venezuela and Trinidad (Reichert 1993). In the Caribbean, adults have been observed foraging in the Dominican Republic, Puerto Rico, and the USVI.

- Information Specific to the southeastern Florida and the AUTEC-Andros OPAREA—Olive ridley occurrence patterns in the study area were determined based on the known preference of this species for oceanic waters, the suggested association of post-hatchlings with *Sargassum*, and the existence of potential suitable habitat on the Bahamian banks and East Florida Shelf. This region has historically not been included in the range for the olive ridley turtle although there are a few strandings in the study area along the east coast of Florida and an April 2001 capture in fishing gear on the shallow banks off western Andros. This individual was satellite-tagged and released during May 2001 off western Andros and moved through seagrass/mudflat areas (Bolten and Bjorndal 2006; Figure 3-6). The lack of occurrence records may be a reflection of low survey effort in the study area but is most likely due to the unfamiliarity of most observers with this species, which closely resembles the Kemp's ridley turtle.

  - Winter—Olive ridleys have a rare occurrence throughout most of the study area during this time of year. Occurrence on the East Florida Shelf is undetermined based on the lack of information for this species (Figure C-7). While there is aerial survey effort here, it is difficult to identify this species from the air so any sightings would likely be coded as unidentified hardshell turtle. Due to the diverse habitat used by this species (Marcovaldi 2001), the remainder of the study area beyond the Bahamas is likely to provide suitable habitat for olive ridleys. This expectation is based upon this species preference for oceanic waters, the presence of suitable water temperatures and foraging habitat, and the potential for post-hatchlings to associate with *Sargassum* (Musick and Limpus 1997; Polovina et al. 2003; Polovina et al. 2004; Bolten and Bjorndal 2006).

  - Spring/Summer/Fall—During this time of the year, olive ridleys have a rare occurrence throughout the study area (Figure C-7). Marcovaldi (2001) suggested that olive ridley turtles may be associated with coastal and oceanic habitats in the Atlantic Ocean where they utilize a variety of habitat types which are present in the study area. During the spring, summer, and fall, water temperatures in this region fall within the range preferred by olive ridley turtles

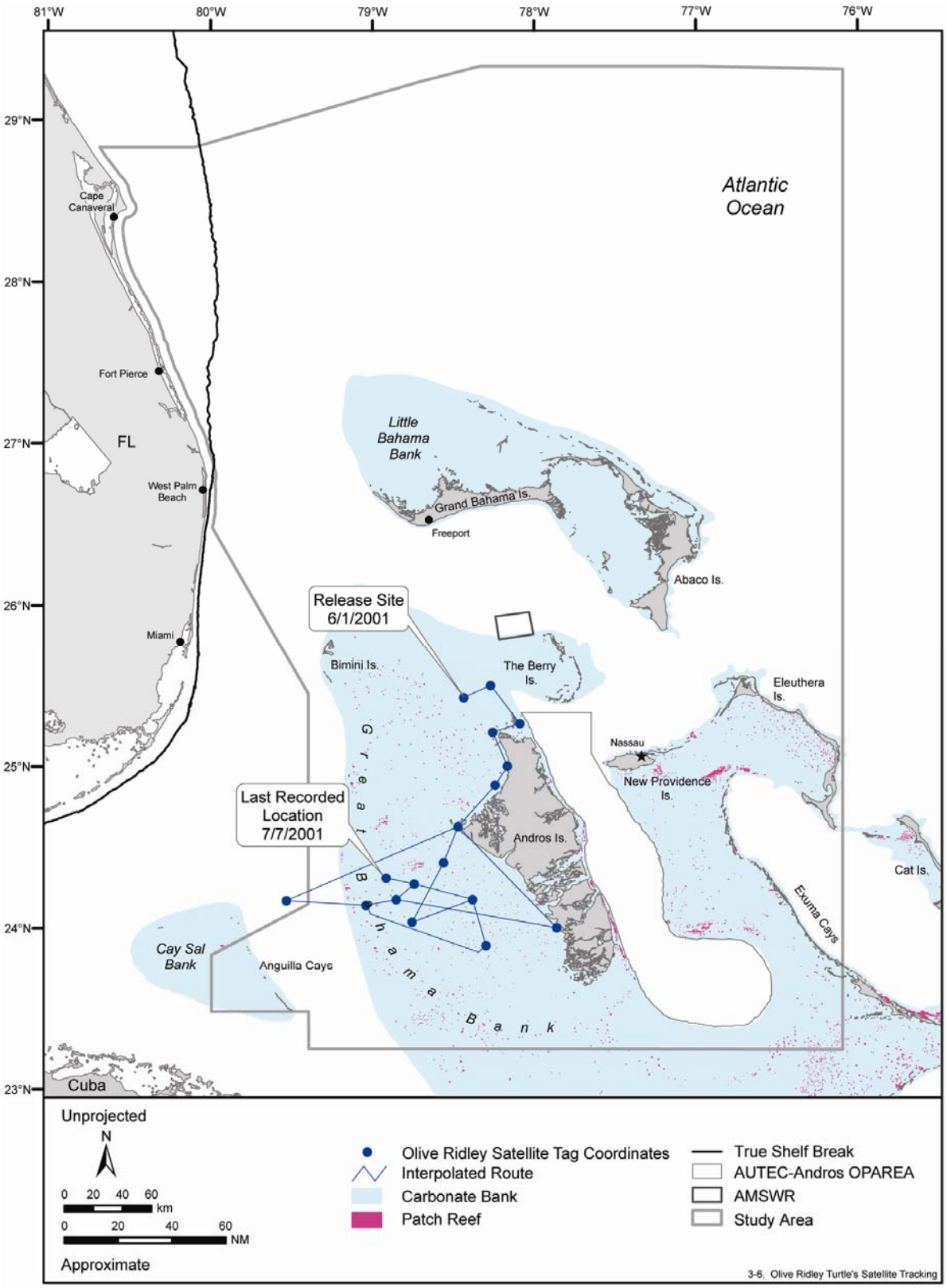

Figure 3-6. Movements of an olive ridley turtle satellite-tagged at Andros Island in the Bahamas. The turtle traveled south along the western coast of Andros to a shallow mudflat area, which is a potential foraging habitat. Satellite tracking occurred over a 16-week interval; each point on the map represents one week. Source map (scanned): ACCSTR (2006).

(Polovina et al. 2004). Since olive ridleys are sometimes associated with *Sargassum* in the eastern Pacific (Musick and Limpus 1997), it is likely that they may be associated with *Sargassum* in the study area

Behavior and Life History—Olive ridleys feed on a variety of benthic and pelagic prey items. Crustaceans, cnidarians, and fish typically serve as the major component of their diet (Bjorndal 1997; NMFS and USFWS 1998) although algae are documented as a primary food source in some parts of the world. In the Pacific Ocean, olive ridleys feed predominantly on tunicates (Polovina et al. 2004).

Olive ridleys are known for nesting in *arribadas*, which are mass nesting events (NMFS and USFWS 1998); individuals that nest in these aggregations show a strong site fidelity to nesting beaches (Plotkin 2003). Sexual maturity is reached at about 13 years of age or SCL of 60 cm (based on individuals in the north-central Pacific) (Zug et al. 2006). Nesting usually occurs between August and December, although it may take place year-round (NMFS and USFWS 1998). Females usually nest every one to two years. A typical female produces two clutches per nesting season averaging 105 eggs at 15- to 17-day intervals for lone nesters and 28-day intervals for mass nesters (NMFS and USFWS 1998). Incubation time from deposition to emergence is approximately 55 days. After nesting, olive ridleys migrate back to oceanic waters.

Olive ridleys routinely dive to depths greater than 150 m to forage (e.g., Polovina et al. 2003; McMahon et al. 2007). One individual [originally identified as a green turtle by Landis (1965) and later determined to be an olive ridley by Eckert et al. (1986)] was observed feeding on crustaceans at a depth of 290 m, and Polovina et al. (2003) reported a maximum dive depth of 254 m. The deep diving by olive ridley sea turtles is probably a result from foraging at depths associated with the DSL (Polovina et al. 2003). Typical dive durations for this species are generally around 70 mins (Beavers and Cassano 1996) although maximum dive durations of over 200 min are documented (e.g., Parker et al. 2003; McMahon et al. 2007). Nocturnal submergences tend to be longer in duration and more variable than submergences during the daytime (Beavers and Cassano 1996).

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3.3 FISHES

Of the over 704 fish species occurring in the study area for the Southeastern Florida and the AUTEC-Andros OPAREA MRA (Briggs 1958; Böhlke and Chaplin 1993; Gilmore 1977, 1995), two protected species have been designated. The smalltooth sawfish is given protection in U.S. waters under the ESA and the Bahamas blind cave fish is given protection by the Government of The Bahamas (GOB) via the Wildlife Conservation and Trade Act (WCTA) (BCO 2004). Although the NMFS, the South Atlantic Fishery Management Council (SAFMC), or the Mid-Atlantic Fishery Management Council (MAFMC) manages many fish species in the U.S. waters of the study area, the smalltooth sawfish's status provides additional protection to the species (Table 3-3). The smalltooth sawfish is designated as endangered, and though it is most often encountered in shallow waters, this species has been recorded in depths of up to 122 m (NOAA 2003; Poulakis and Seitz 2004). The Bahamas blind cave fish is endemic to the Bahamas and is found inhabiting inland and marine blue holes within the study area.

Table 3-3. Protected fish species found in the study area for the Southeastern Florida and AUTEC-Andros MRA. Taxonomy follows Nielson et al. (1999) and Nelson et al. (2004).

	Scientific Name	Status (Designating Agency)	Occurrence[1]
Class Elasmobranchii			
Order Pristisformes			
Family Pristidae			
Smalltooth sawfish	*Pristis pectinata*	Endangered (NMFS, USFWS)	Rare
Class Actinopterygii			
Order Ophidiiformes			
Family Bythitidae			
Bahamas blind cave fish	*Lucifuga spelaeotes*	Endangered (GOB)	Regular

[1] **Regular** = A species that occurs as a regular or normal part of the fauna of an area regardless of its abundance
Rare = A species that only occurs in an area sporadically
Extralimital = A species that does not normally occur in an area and occurrence is considered to be beyond the normal range of the species even though one or more occurrence records exist

- Smalltooth Sawfish (*Pristis pectinata*)

  Description—The smalltooth sawfish is an elasmobranch species (cartilaginous skeleton; sharks, skates, rays) that gets its name from its long, flat snout (~25% of body length) edged with 24 to 34 sharp teeth. It has a brownish flattened body and wing-like pectoral fins. This species typically is 5.5 m in length but has been recorded to reach up to 7.6 m in length (Passarelli and Curtis 1999; Simpfendorfer 2002, 2005).

  Status—The smalltooth sawfish was designated as endangered by the NMFS on 1 April 2003 and by the USFWS on 16 November 2005 from Florida to Cape Hatteras, NC (NOAA 2003; USFWS 2005). It is the first elasmobranch species to have this status. Habitat degradation and loss, such as loss of wetlands, eutrophication, point and non-point pollution, increased sedimentation and turbitidy, and hydrologic modifications, are considered the primary factors contributing to the endangered status of this species. Entanglements in fishing gear and incidental take as bycatch have also been factors in their decline. Currently, no critical habitat has been designated for this species because the NMFS has deemed it indeterminable (NOAA 2003). As a result of being designated as an endangered species, taking, killing, possessing, or selling of this species is prohibited (NOAA 2003). This species is also designated as critically endangered (CR) or facing an extremely high risk of extinction in the wild in the immediate future by the 2006 IUCN Red List of Threatened Species (Adams 2000).

Habitat Preferences—The smalltooth sawfish commonly inhabits shallow subtropical-tropical estuarine and marine waters but can also be found utilizing freshwater habitats in large rivers (e.g., Mississippi and St. Johns rivers) (Simfendorfer 2002; Schultz 2004). It prefers remaining close to the bottom in deep holes of sand or muddy sand and has also been reported utilizing habitats consisting of limestone hard bottom, coral reefs, and sponge bottoms (Poulakis and Seitz 2004; Schultz 2004). There is a correlation between the distance from shore and depth with the size for this species, with smaller individuals typically utilizing habitats close to shore (water <1 m deep) in areas with inshore bars, mangroves, and seagrass beds possibly to avoid predation by sharks, while larger individuals inhabit deeper waters commonly greater than 70 m but up to 122 m deep (Poulakis and Seitz 2004; NOAA 2003; Simpfendorfer 2005; Simpfendorfer and Wiley 2005a, 2005b). However, recent tagging studies indicate that adults (i.e., larger individuals) spend more time in shallow water than previously suspected and are only occasionally found in deeper waters (Simpfendorfer and Wiley 2005a). This species also associates with sea fans, artificial reefs, and oil rigs (Poulakis and Seitz 2004). Nursery areas are located in shallow nearshore regions and estuaries, especially in areas with mangroves (Seitz and Poulakis 2002; NOAA 2003; Simpfendorfer and Wiley 2005b). The lower thermal range of this species is between 16° and 18°C (SSSRT 2000).

Distribution—This species, historically, has ranged throughout the Pacific, Indian, and Atlantic oceans, including the Mediterranean Sea, the Caribbean Sea, Bermuda, and the Gulf of Mexico (Passarelli and Curtis 1999). In the western Atlantic, it was distributed from New York to Brazil. It was considered a year-round resident off Florida and only found in higher latitudes seasonally (Schultz 2004). Currently, the only remaining population in U.S. waters exists off southern Florida with the center of distribution being the Everglades National Park, including Florida Bay. The smalltooth sawfish population in U.S. waters is considered isolated from other populations making it a distinct population segment (DPS) (NOAA 2003).

- Information specific to the southeastern Florida and the AUTEC-Andros OPAREA—The current smalltooth sawfish population extends from St. John's County on the east coast of Florida through the Florida Keys and northward to Pinellas County on the western coast of Florida, north of Tampa Bay. The Mote Marine Laboratory Sawfish Encounter Database, as of April 2005, had 593 verified smalltooth sawfish encounters (Simpfendorfer and Wiley 2005a). Only nine encounters have been recorded within the boundaries of the study area (Figure 3-7; Simpfendorfer and Wiley 2005a). Encounters most commonly occur in the study area from June to September (Simpfendorfer and Wiley 2005b). Most of the Florida east coast encounters occur south of 27.2°N. Within the study area and vicinity, sightings range from Cape Canaveral to St. Lucie Inlet, primarily in state waters (Simpfendorfer and Wiley 2005b). In the Bahamas, this species has been recorded primarily around the Bimini Islands and on the west coast of Andros Island (Böhlke and Chaplin 1993; Simpfendorfer and Wiley 2005a). It is likely that the smalltooth sawfish could be found within the boundaries of the study area, especially along central Florida coast, around the Bimini Islands and along the western coast of Andros Island.

Behavior and Life History—Little information is available on the behavior and life history of the smalltooth sawfish. It is known that this species is ovoviviparous. Gestation is believed to last approximately five months to a year with between 15 and 20 pups born per litter during the summer months. Off southern Africa, female smalltooth sawfish have been recorded pupping in estuaries, and it is hypothesized that they may use this habitat elsewhere as well (Passarelli and Curtis 1999; SSSRT 2000; Schultz 2004). This species is predicted to live up to 30 years, reaching sexual maturity at ten years of age. The smalltooth sawfish uses its saw for obtaining prey, either by stirring up the substrate to expose benthic crustaceans or by stunning and slashing schooling fishes (e.g., mullet and herring) (SSSRT 2000; Schultz 2004).

- Bahamas Blind Cave Fish (*Lucifuga spelaeotes*)

*Descriptio*n—The Bahamas blind cave fish (also known as the New Providence cusk-eel) has a short eel-like body covered with overlapping scales, a depressed snout, and small, though fully developed eyes (unlike other species in this genus) (Nielsen et al. 1999). Males are characterized by a distinct

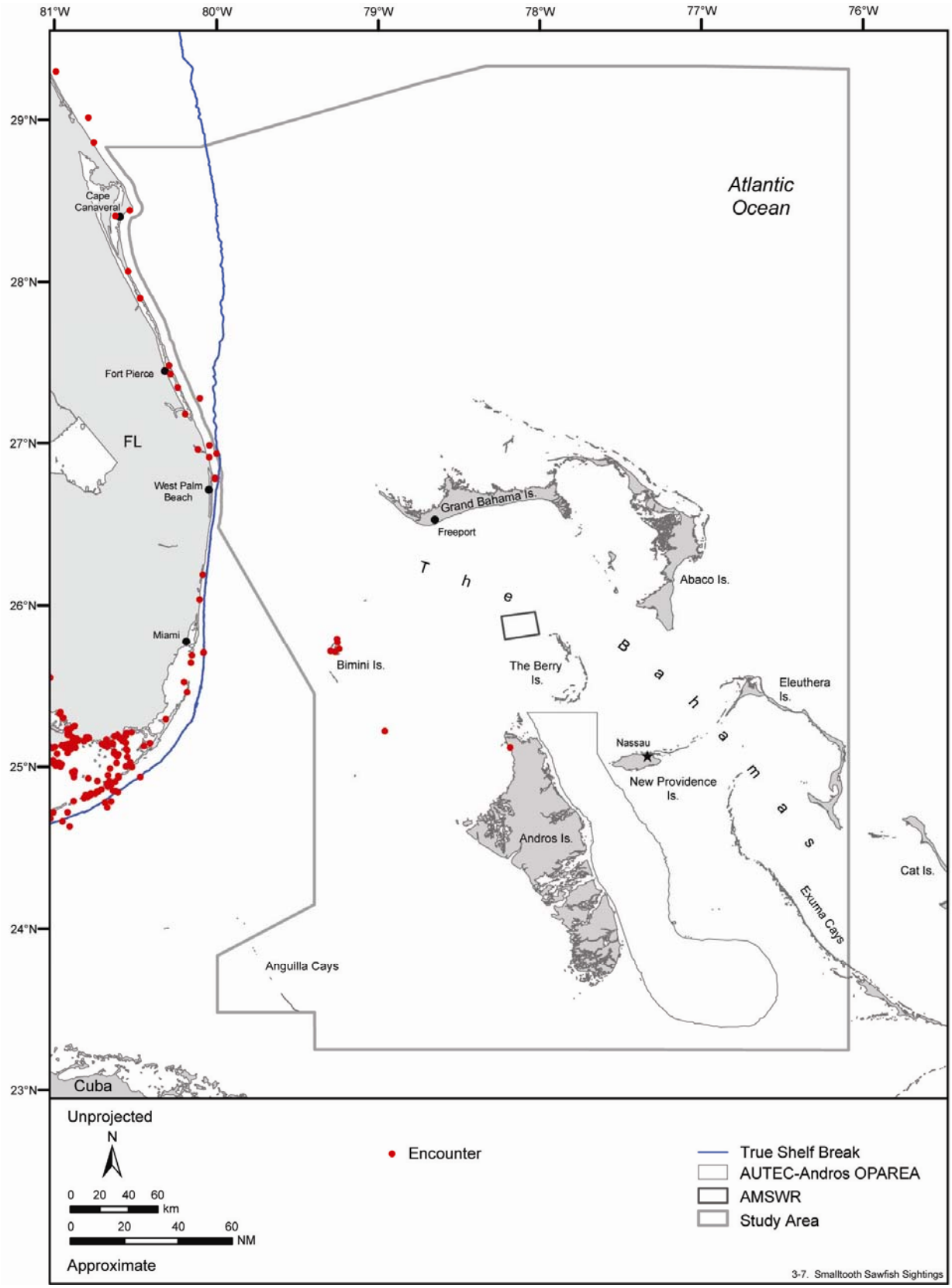

Figure 3-7. Recent encounters, from 1998 to April 2005, of smalltooth sawfish in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: MML (2005).

copulatory apparatus (i.e., multiple fleshy lobes) and a large fleshy pad at the tip of their lower jaw. This species coloration is dark brown with whitish margins on the fins. The length of only two specimens has been reported: a male of 10.9 cm standard length (SL) and a female of 7.65 c m SL (Cohen and Robins 1970). Though, Palmer et al. (1998a) reported that an individual over 25 cm (considered one of the largest individuals ever recorded) was seen in an inland blue hole on southern Andros Island.

Status—The first specimen of this species was collected in 1967 at Mermaid's Pool, which is an inland limestone sink (inland blue hole) southwest of Nassau on New Providence Island (Cohen and Robins 1970). Under The Bahamas WCTA, the Bahamas blind cave fish is included as a "species indigenous to the Bahamas and are believed to be endangered" (BCO 2004). On the IUCN Red List, this species is designated as vulnerable (VU) or a high risk of extinction in the wild in the medium-term future (Groombridge 1994 change to latest citation listed in IUCN 2006, should read WCMC 1996 – see literature for complete citation).

Habitat Preferences—This species can live in freshwater, brackish, marine and achialine (i.e., land-locked bodies of water that display tidal fluctuations but have no surface connections to the sea) environments and is typically found in habitats that are absent of light, such as caves, sinkholes, or crevices up to depths of 21 m (Nielsen et al. 1999). The Bahamas blind cave fish is considered one of the top predators in blue hole ecosystems but very little data have been collected for this species (Palmer et al. 1998b). Most sightings have been of individuals, though aggregations have been recorded in some inland blue holes (i.e., Uncle Charlie's Blue Hole) (Farr and Palmer 1984). For more information on blue holes, consult Chapter 4.

Distribution—This species is endemic to the Bahamas. Other members of this genus are found off of Cuba and the Galapagos Islands (Cohen and Robins 1970; Nielsen et al. 1999).

- Information specific to the southeastern Florida and the AUTEC-Andros OPAREA—The Bahamas blind cave fish has been recorded in caves and blue holes on (inland) or offshore (marine) of Abacos, Andros, Eleuthera, Great Exuma, Long, Berry, New Providence, and Grand Bahama islands (Proudlove 2005; Table 3-4). Many of the oceanic blue holes are located off of Andros Island near the AUTEC OPAREA. There is a possibility of encountering this species within the study area.

Behavior and Life History—Since this species is endemic to the Bahamas, data are lacking on its behavior and life history. It reproduces by internal fertilization and gives birth to live young (Cohen and Robins 1971).

Table 3-4. Specific locations of inland and marine blue holes where the Bahamas blind cave fish has been recorded. This species has also been recorded off other islands, though specific locations could not be determined (Farr and Palmer 1984, Palmer et al. 1998a, AMNH 2006, and Froese and Pauly 2006).

Andros Island	**Great Exuma Island**
Conch I Blue Hole (Marine)	Angelfish Blue Hole (Marine)
Forfar Blue Hole (Marine)	
Swimming Hole or Jellyfish Lake (Inland)	**Long Island**
Uncle Charlie's Blue Hole (Inland)	Alphonso Dean's Blue Hole (Marine)
	Twin Pillar Cave System (Inland)
Eleuthera Island	
Nixon's Blue Hole*	**New Providence Island**
	Mermaid's Pool (Inland)
	Ocean Hole (Inland)

*Unknown if blue hole is marine or inland

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3.4 CORALS

Corals exist throughout the worlds' oceans at all water depths (Veron 2000; Freiwald et al. 2004). The most widely known corals are the stony corals (Class Anthozoa, Order Scleractinia) which build coral reefs. Other essential reef coral reef builders are coralline algae. Corals found on coral reefs also include non-reef accreting scleractinians; hydrocorals (including fire corals and lace corals), and octocorals (including gorgonians and soft corals) (Veron 2000). Coral reefs occur for the most part within the inter-tropical region and in relatively shallow water (down to 50 m) (Veron 2000; Spalding et al. 2001). Corals can occur in waters as deep as 6,000 m (Freiwald et al. 2004). Those that do are considered true deep-sea corals. They exist in complete darkness and in seawater temperatures as low as 4°C. Contrary to shallow water corals, true deep-sea corals lack symbiotic zooxanthellae. Even so, deep-sea corals can form large communities ranging in size from patches of small solitary colonies to massive reef structures (mounds, banks, and forests) of up to 50 m in height and 200 m in diameter (Tucker and Wright 1990; Cairns 1994; Freiwald et al. 2004).

This section focuses on Endangered Species Act (ESA) listed shallow water corals of the study area (the Bahamas): the threatened elkhorn coral (*Acropora palmata*) and the threatened staghorn coral (*Acropora cervicornis*). Over time, corals and coralline algae have developed substantial habitats that support thousands of sedentary and mobile species including corals (stony and soft corals), algae, plants, sponges, worms, mollusks, crustaceans, echinoderms, and fishes. The staghorn and elkhorn corals are key reef framework components of coral reefs in the study area. Many of these reefs have contributed to the economic development through commercial fishing and tourism. Further, reefs of the Caribbean region have protected coastlines from storm damage and erosion by acting as buffer zones around islands. This has allowed seagrasses to flourish in a number of areas and help sustain lagoons as nursery habitats for various fish and invertebrate species. Coral reefs of the western Atlantic region are undergoing severe changes due to natural and human-induced impacts (Gardner et al. 2003, 2005; Hughes et al. 2003). Coral reef ecosystems in the study area have been impacted particularly by the recurrence of coral diseases, the loss of the long-spined urchin (*Diadema antillarum*), and the overgrowth by algae (Jones et al. 2004; Kelty 2004; PERIGEE Environmental 2005).

Coral populations of the Andros reefs began to decline in 1997 (PERIGEE Environmental 2005). Diseases and bleaching are the two leading causes of negative change in percent cover at Andros Island. Diseases affected corals of Andros reefs in 1997, 1998, and 1999. In 1998, corals of the Andros reefs incurred mass mortality as a result of the bleaching. In 2004, corals of Andros recovered in part from the bleaching and disease impacts. In 2004, high relief reefs supported the greatest amount of coral cover: 16% on high relief patch reefs and 12% on reef crests. Coral cover on high relief reef crests and patch reefs at Andros has declined by 50% from before 1998 to 2004: from 37% to 17% on high relief reef crests and from 20% to 10% on high relief fore reefs. In 2004, the percent cover on high relief reef crests at Andros compared favorably with other Caribbean reefs (PERIGEE Environmental 2005).

While incidences of coral bleaching and disease, and recent mortality were few in 2004, key reef builders, the elkhorn coral and the boulder star coral species complex (*Montastraea annularis*) showed persistent mortality and diseased tissue (PERIGEE Environmental 2005). Further, overall coral recruitment levels in 2004 were lower than those found prior to 1998. In short, the recovery of corals at Andros from disturbances that occurred from 1997 to 1999 is uncertain. It is particularly uncertain considering evidence of abundant recent mortality caused by disease and predation. The increased abundance of herbivores (long-spined urchin and herbivorous fishes) in 2004 compared to previous years (PERIGEE Environmental 2005) will limit the growth and expansion of macroalgae and favor the colonization of cleared space by corals. Since the 2004 survey, the abundance of long-spined urchin has continued to increase (M. Ciminello, Atlantic Undersea Test and Evaluation Center, Andros Island, Bahamas, pers. comm. 2 February 2007) which will undoubtedly aid the recovery of corals.

Overall, coastal development continues to be a main source of anthropogenic impacts on coral reefs in the study area (Gardner et al. 2003). At Andros Island, debris on the reefs (including fishing line, wood, rope, plastic, metal, and trash) is an additional source of impacts compounding the effects of natural stressors and may accentuate the effects of future disturbances (PERIGEE Environmental 2005).

3.4.1 Elkhorn and Staghorn Corals

The elkhorn and staghorn corals occur in the tropical western Atlantic and the Caribbean-Atlantic province (Veron 2000; ABRT 2005). They are fast growing species (unlike most stony corals) and were until recently (starting in the late 1970s) essential constituents of the framework and fish habitat of the study area (Gilmore and Hall 1976; Spalding et al. 2001; ABRT 2005). Staghorn and elkhorn corals have, however, experienced serious declines since the 1970s, mostly due to white band disease, thermal stress, predation, and hurricane impacts (Miller et al. 2003; Precht et al. 2004). No other coral species within the study area grows at such rates or provides similar functional roles. The Caribbean-wide decline of the abundance of these acroporid species prompted the National Marine Fisheries Service (NMFS) to list them as threatened under the Endangered Species Act (ESA) of 1973 (Table 3-5; NMFS 2006f, 2006g).

Table 3-5. Protected coral species found in the study area for southeastern Florida and the AUTEC-Andros OPAREA. Taxonomy follows Cairns et al. (1991).

Taxonomy	Common Name	ESA Status	IUCN Status	Occurrence[1] Florida	Occurrence[1] Bahamas
Class Anthozoa Order Scleractinia Family Acropridae Genus *Acropora* *Acropora palmata*	Elkhorn coral	Threatened	–	Rare	Regular
Class Anthozoa Order Scleractinia Family Acropridae Genus *Acropora* *Acropora cervicornis*	Staghorn coral	Threatened	–	Rare	Regular

[1] Regular = A species that occurs as a regular or normal part of the fauna of an area regardless of its abundance
Rare = A species that only occurs in an area sporadically

3.4.1.1 Life History of Staghorn and Elkhorn Corals

As reef building corals, staghorn and elkhorn corals harbor photosynthetic zooxanthellae that enhance the accretion of limestone (ABRT 2005). The optimal water temperature range for these species is 25 to 29°C. Optimal salinity for these species is 34 to 37 practical salinity units (psu). These species typically occur in relatively shallow water range from near the sea surface to a depth of 20 m (ABRT 2005).

Staghorn coral typically occurs in water depths ranging from 5 to 20 m (ABRT 2005). Up until the 1980s, staghorn coral was very abundant and played a key functional role in water depths ranging from 10 to 15 m. Indeed, with a rapid skeletal growth (3 to 11.5 centimeters per year [cm/yr]) and its branched structure, it provided reef construction, reef maintenance, and abundant habitat for fish (ABRT 2005). Elkhorn coral shared the same functional role, particularly within the 3 to 12 m depth range. Its growth rates are equally fast (4 to 11 cm/yr; measured as the linear growth of branches). In water depths of less than 5 m, elkhorn coral can form monospecific thickets. Its branches can measure 50 centimeters (cm) across and be 4 to 5 cm thick. In a shallow, wave-exposed environment, the branches of this species will usually grow in the direction of wave action. In deeper water, branches of elkhorn coral will grow vertically (ABRT 2005).

Staghorn and elkhorn *corals* reproduce sexually and asexually (Szmant 1986*)*. The most successful means of propagation for these species is asexual. Both species are broadcast spawners, fertilization is external, and larvae development is external as well (Szmant 1986). Colonies of both species will generate both male and female reproductive parts. A given polyp will produce both male and female gametes. These sexual characteristics define them as simultaneous hermaphrodites. Staghorn and elkhorn corals have a relatively brief spawning season lasting from July to August (Szmant 1986). Large colonies are known to have higher fertility rates compared to smaller colonies (Soong and Lang 1992). Planulae of these species will settle on exposed surfaces to form a crust of tubular corallites. Eventually, corallites will develop into protuberances which in turn will form proto-branches. Yet, the successful sexual recruitment of these coral species is limited. The asexual reproduction of these species occurs by fragmentation and budding of new polyps (Shinn 1976; Bothwell 1981). Fragments of colonies (branches) transported by waves and currents to surrounding substrates can rapidly grow into new colonies (Gladfelter et al. 1978; Bak and Criens 1982; Highsmith 1982; ABRT 2005). Considering the severe decline of acroporids in the study area since the late 1970s, both the asexual and sexual reproduction of staghorn and elkhorn corals is largely compromised (ABRT 2005).

3.4.1.2 Natural and Anthropogenic Stressors Impacting Acroporids

The main natural sources of impact and threats to staghorn and elkhorn corals are coral diseases, coral bleaching, hurricanes, and predation (Bruckner and Bruckner 1997; Harvell et al. 1999; Aronson and Precht 2001a; Patterson et al. 2002; ABRT 2005). Their impacts can be severe, are unpredictable, and will probably increase with time (ARBT 2005). Sources of human-induced impacts on acroporids include vessel groundings, vessel anchoring, mechanical damage caused by fishing, and sedimentation (ABRT 2005; Rogers 1983, 1990). These natural and anthropogenic impacts also contribute to reducing the availability of suitable habitat for *Acropora* spp. larval settlement and the attachment of *Acropora* spp. fragments. Such habitat reduction will prevent the growth, expansion and/or recovery of these species now in severe decline (ARBT 2005).

The Caribbean region accounts for about 8% of the world's coral reefs. In 2000, 66% of all the diseases and syndromes recorded worldwide occurred in the Caribbean (Green and Bruckner 2000). The most devastating disease in the Caribbean in the past 30 years was white band disease which is particularly devastating to elkhorn and staghorn corals and *Montastraea* spp., *Colophyllia* sp., and *Diploria* spp. (Gladfelter 1982; Rogers 1985; Aronson and Precht 2001a; Weil 2004). The other disease that affects acroporids is white pox disease (Patterson et al. 2002), also known as patchy necrosis. Both diseases cause tissue mortality and in some cases mass mortality of acroporids (Aronson and Precht 2001a; ABRT 2005). White pox disease has been on the rise since 1996 and has affected elkhorn and staghorn populations in the Bahamas, Florida, Belize, Jamaica and St. Croix (Patterson et al. 2002). White pox is a fast moving highly contagious disease that promotes tissue loss and is correlated with increased sea surface temperatures (SSTs) (Patterson et al. 2002). Yellow-band disease is another coral disease that attacks coral tissue during episodes of increased SSTs and destroyed elkhorn corals in the Caribbean in 2000 (Cervino et al. 2004).

Mass mortality of acroporids caused by disease has changed the structure of reefs in the Caribbean region including the study area (Aronson and Precht 2001a, 2001b). Acroporids formerly provided extensive habitat and vertical structure to many nearshore reefs. Since acroporids were the essential component of live coral cover, their mortality caused a substantial drop in this cover. Further, this mortality was followed by a sharp increase in macroalgal cover on reefs and the replacement of spawning corals by brooding corals (Aronson and Precht 2001a). While acroporids have been a main reef component in the Caribbean region both in terms of reef framework and live cover, diseases caused severe impacts on acroporids within a 10-year period (Aronson and Precht 2001a). Since the late 1970s, impacts caused by diseases have been more severe than those caused by hurricanes. Hurricanes did severely impact reefs in the Caribbean region, and are the main source of physical damage on reefs (Aronson and Precht 2001b; Gardner and el. 2005).

During the past 25 years, coral bleaching caused by thermal stress has also impacted acroporids in the Caribbean region (Hoegh-Guldberg 1999; Wilkinson 2000; Aronson and Precht 2001b). Mass bleaching occurred worldwide in 1997 and 1998 (Wilkinson 2000). Reefs of the Caribbean region were mostly affected by the bleaching in 1998 (Causey et al. 2000; Woodley et al. 2000) caused by elevated seawater

temperatures that coincided with a La Nina event. In 1998, bleaching in the study area was particularly intense within the upper 20 m of the water column (Wilkinson 2000; Woodley et al. 2000; PERIGEE Environmental 2005) and was primarily observed on the upper sides of acroporid colonies. Affected colonies recovered from the bleaching; the increased frequency and intensity of bleaching events may cause acroporids and other reef corals to become less resilient to the stress caused by prolonged episodes of unusually warm seawater (i.e., temperature > 32°C) (Wilkinson 2000). Widespread bleaching of corals of the Caribbean took place in 2005 as a result of record breaking warming of the upper water column in the western Atlantic. The prolonged warming of the water column from the summer and into the fall of 2005 caused not the bleaching of corals but also an outbreak of coral disease (National Parks Service and United States Geological Survey 2006). An example of the acute effects of the 2005 bleaching on corals was recorded in the United States Virgin Islands (USVI) (National Parks Service and United States Geological Survey 2006). Reports of the 2005 Caribbean-wide bleaching event are currently being compiled and will be released by the Global Coral Reef Monitoring Network in April 2007 (NOAA Coral Reef Watch 2006). The unusual seawater warming of 2005 caused the mass bleaching of corals in the USVI from the sea surface to water depths greater than 30 m (National Parks Service and United States Geological Survey 2006). The bleaching was so severe that even six months after the bleaching took place, over a third of surviving corals had not yet regained their usual coloration. Amongst other corals, a high proportion of elkhorn corals bleached in the USVI. At St. John (USVI), half of the 400 elkhorn coral colonies monitored by the National Park Service bleached in 2005. More than half of the colonies that bleached incurred tissue mortality. Fifteen percent of the bleached colonies died. Compared to other corals (e.g., *Montastraea annularis* complex species), the bleaching of elkhorn coral did not accentuate diseases (National Parks Service and United States Geological Survey 2006). The 2006 survey of coral reefs at Andros reefs will possibly include evidence of change in the coral population levels throughout the reef considering what was reported in the USVI. Further, also in light of what took place in the USVI, acroporids of Andros reefs were probably impacted and their cover substantially altered.

The other significant source of impact on acroporids is predation by invertebrates and vertebrates (ABRT 2005). Considering that acroporids in the Caribbean region currently have such a low abundance, predation while natural is no longer negligible. Predation on acroporids can cause injury, mortality, and the colonization (occupation) by other organisms. Invertebrates that feed on acroporids in the Caribbean region are the fireworm (*Hermodice carunculata*), muricid snail (*Coralliophila abreviata*), and long-spined urchin (*Diadema antillarum*) (Sammarco 1980; ABRT 2005). Vertebrate predators include the three-spot damselfish (*Pomacentrus planifrons*) which clears off coral tissue on acroporids branches to develop algal gardens and the stoplight parrotfish (*Sparisoma viride*) (ABRT 2005).

The main sources of human-induced impacts on acroporids are vessel groundings, anchor damage, and careless fishing practices (ABRT 2005). Sedimentation, when intensified by human activity (e.g., coastal development) is another source of substantial impact on acroporids (Rogers 1983). Sedimentation can cause the reduction in water transparency and/or the deposition of sediments onto the coral. Prolonged shading of acroporids will cause bleaching and in some cases mortality. Sediments deposited on acroporids are removed passively (Rogers 1983).

Natural and human-induced factors also contribute to reducing the suitable habitat for staghorn and elkhorn corals (ARBT 2005). *Acropora* spp. habitat is impacted when suitable substrate is destroyed or disrupted, and when the aquatic environment is modified. The ABRT (2005) reviewed factors that imapct *Acropora* spp. habitat and thereby contribute to the threatened status of these two coral species. A main cause of habitat loss is severe storms. They cause coral mortality and habitat destruction. Human activities that cause substrate abrasion and breakage that affect *Acropora* spp. habitat include marine transportation, boating, anchoring, fishing, recreational diving and snorkeling, and maritime construction. Land development, polluted runoff, and dredging are other human-induced sources of *Acropora* spp. habitat loss. They cause sedimentation and turbidity which are stressful and in some cases lethal to *Acropora* spp. Storm events, a natural cause of sedimentation and turbidity, can affect *Acropora* spp. as well. Polluted runoff may include excessive nutrients which favor algal growth and the reduction of suitable *Acropora* spp. habitat. Such algal growth can be rapid and cause algae to outcompete *Acropora* spp. for space.

3.4.2 Distribution of Acroporid Corals

Acroporid corals primarily inhabit areas facing the seaward margins of islands. Waves and currents in these seaward margins provide optimal mixing and flushing of seawater for acroporids, support the propagation of gametes and coral fragments, and transport essential minerals and nutrients to the corals (Ginsburg and Shinn 1964). Acroporid corals are typically found in oligotrophic, shallow water within the tropical western Atlantic and the Caribbean-Atlantic province (Kaplan 1982; Spalding et al. 2001; ABRT 2005). Environmental conditions (e.g., water temperature) across the Caribbean and western tropical Atlantic historically influenced the distribution of acroporids but more recently coral diseases and storms have decreased the abundance of acroporids in the Caribbean region and have transformed their distribution (ABRT 2005).

3.4.3 Protected Corals of Southeastern Florida and the AUTEC Andros OPAREA

Between 7,000 and 6,000 years before present (YBP), *Acropora palmata* built a three reef system from northern Miami to Palm Beach County, Florida (~ 65 kilometers [km]) (Lighty 1977; Miller et al. 2003; Moyer et al. 2003). With the rising of sea level, the *Acropora* spp. died and the reef framework was occupied by head forming corals and other reef organisms to develop the reefs currently in existence in this area. Within the southeastern Florida no living acroporids had been documented prior to 1988 when staghorn coral was discovered off the coast of Fort Lauderdale, Florida and elkhorn coral observed off the coast of northern Broward County, Florida (Vargas-Ángel et al. 2003; Precht and Aronson 2004). The increased occurrence of acroporids off southeastern Florida is believed to be associated with consistently increasing SSTs (Precht and Aronson 2004). Within the AUTEC Andros study area there are colonies of elkhorn and staghorn coral found along Andros Reef, New Providence, Grand Bahamas, Abaco, Eleuthera, and Exuma Cays. Although staghorn coral is very scarce throughout the AUTEC Andros study area, elkhorn coral is found among reef crests especially along Andros reef (Kramer et al. 2003a).

- Elkhorn Coral (*Acropora palmata*)

  Description—Elkhorn coral is a fast growing (4 to 11 cm/yr) shallow water coral that consists of large robust flat branches and grows in dense colonies creating a framework for the reef (ABRT 2005). Its tissue coloring is golden-brown with tubular cups (2 to 4 millimeters [mm] long and ~2 mm in diameter) that are white at the tip (growing end) and reaches its full height within 10 to 12 years (Kaplan 1982; NMFS 2006f, 2006g). Its polyps (located on the cups) are off white in color and have clear tentacles. It is the largest of all acroporid species growing as tall as 4 m (ABRT 2005). It has flattened branches that protrude out from a central trunk that is securely fixed to hard substrate (reef) or the shelf bottom (ABRT 2005).

  Status—The Center for Biological Diversity on 4 March 2004 petitioned the NMFS to list three species of acroporids (elkhorn, staghorn, and fused staghorn) as either threatened or endangered under the ESA. An Acropora Biological Review Team (ABRT) was tasked to document the three coral species of concern and determine whether action was warranted to protect these species (ABRT 2005). The ABRT used the following five factors to categorize the threats to elkhorn and staghorn corals: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or manmade factors affecting its continued existence (NMFS 2006f, 2006g). The threats were categorized as sources (natural or anthropogenic events create stressful conditions for organisms [e.g., climate change or coastal development]), stressors (a specific condition that causes stress to organisms, or responses [e.g., elevated temperature or sediment run-off]), and responses (the response of the organisms to that stressor is often in the form of altered physiological processes [e.g., bleaching, reduced fecundity or growth] or mortality) (ABRT 2005). Elkhorn coral was designated as threatened by the NMFS on 8 June 2006 (NMFS 2006f, 2006g). Currently, no critical habitat has been designated for this species because the NMFS has deemed it indeterminable (NMFS 2006f, 2006g). The World Conservation Union (IUCN) has not listed this species on the red list for threatened and endangered species.

  Habitat Preferences—Elkhorn corals prefer salinities between 34 and 37 psu and water temperatures between 25 and 29°C, but some colonies have been known to withstand higher

temperatures for short periods of time (ABRT 2005). Elkhorn corals are predominately found within the 1 to 5 m depth range although it can be found from in water depths less than 1 m and up to 30 m. It is found in wave exposed areas on fringing and barrier reefs, reef crests, and on spur and groove reefs (ABRT 2005).

Distribution and Abundance—Elkhorn coral is found in the U.S. from the Dry Tortugas up into the Florida reef tract northeast to Broward County Florida (Jaap 2000). It is also found in the western Atlantic including the Bahamas, Greater and Lesser Antilles, Venezuela, Aruba, Bonaire, and Curacao. This species is also found in the western Caribbean including Columbia, Panama, Nicaragua, Honduras, Belize, and Mexico (ABRT 2005). In the southwestern Caribbean (Panama) acroporid species are usually found on reef terraces and in the northwestern Caribbean (Cuba, Belize and Jamaica) elkhorn corals are distributed on reef crests and fore reefs (ABRT 2005).

- Information specific to the southeastern Florida and the AUTEC-Andros OPAREA—At Andros Island in 1997 and 1998, reef crest areas in 3 m of water were dominated by elkhorn coral (62% of coral cover) which were mostly 120 to 140 cm in diameter, with the largest colonies exceeding 400 cm. Staghorn coral, however, were very scarce (4%) Kramer et al. 2003a). Kramer et al. (2003a) had surveyed Andros reef before the 1998 Caribbean wide die-off. Surveys of the Andros reef have since been conducted in 2002, 2004, and 2006 (PERIGEE Environmental 2002, 2005; M. Ciminello, Atlantic Undersea Test and Evaluation Center, Andros Island, Bahamas, pers. comm. 2 February 2007).

  In 1998, no white band disease was observed on acroporids. The larger colonies of elkhorn coral were found along the northern end of Andros. Kramer et al. (2003a) found more elkhorn recruits (coral diameter ≤ 2 cm) on reef crests than fore reefs. In 1997, dead elkhorn coral skeleton (old mortality) was particularly abundant along Andros shallow reefs crests and somewhat less abundant on fore reefs (Kramer et al. 2003a). Small colonies (40 to 50 cm) of elkhorn were either healthy or dead, and larger colonies (124 to 140 cm) had some old partial mortality. Twenty percent of all elkhorn colonies had small white spots which were attributable either to disease (white pox) or predation from damsel fish, stoplight parrotfish, and the muricid snail (Kramer et al. 2003a).

  Coral reefs have declined at Andros Island since 1998 (PERIGEE Environmental 2005). From 1998 to 2004, elkhorn coral at Andros was afflicted by disease and mortality which prevented a recovery to pre-1998 population levels. The severe bleaching event of 1998 devastated elkhorn as well as staghorn coral at Andros. As an example, the bleaching of 1998 drove coral cover on the high relief fore reef at Long Bay Cay from 36% to less than 3% in 2004 (PERIGEE Environmental 2005). In 2004, PERIGEE Environmental (2005) also found evidence of predation on elkhorn coral by corallivorous snails (*Coralliophila abbreviata*) and stoplight parrotfishes (*Sparisoma viride*), and of three-spot damselfish (*Stegastes planifrons*) on elkhorn and staghorn corals.

  In 2004, elkhorn coral was the dominant coral species on shallow reef crests and patch reefs (PERIGEE Environmental 2005). Elkhorn coral was also common on high relief patch reefs along with *Porites astreoides* (mustard hill coral) and *Montastraea faveolata* (boulder star coral. On shallow reef crests, elkhorn coral was reoccupying dead coral skeleton. There were “dense thickets” of elkhorn coral on high relief reef crests and scattered colonies of elkhorn coral on low relief crests (PERIGEE Environmental 2005).

- Staghorn Coral *(Acropora cervicornis)*

  Description—Staghorn coral is a fast growing coral (3 to 11.5 cm/yr) that grows in colonies similar in shape to staghorn antlers (ABRT 2005). Its branches are 0.25 to 1.5 cm in diameter and can be cylindrical straight or curved (ABRT 2005). Its tissue coloring can be light yellow or medium brown and its polyps are light white to brown with blunt clear tentacles. The growing ends of branches are usually clear and the colonies are not always attached to the shelf bottom (ABRT 2005).

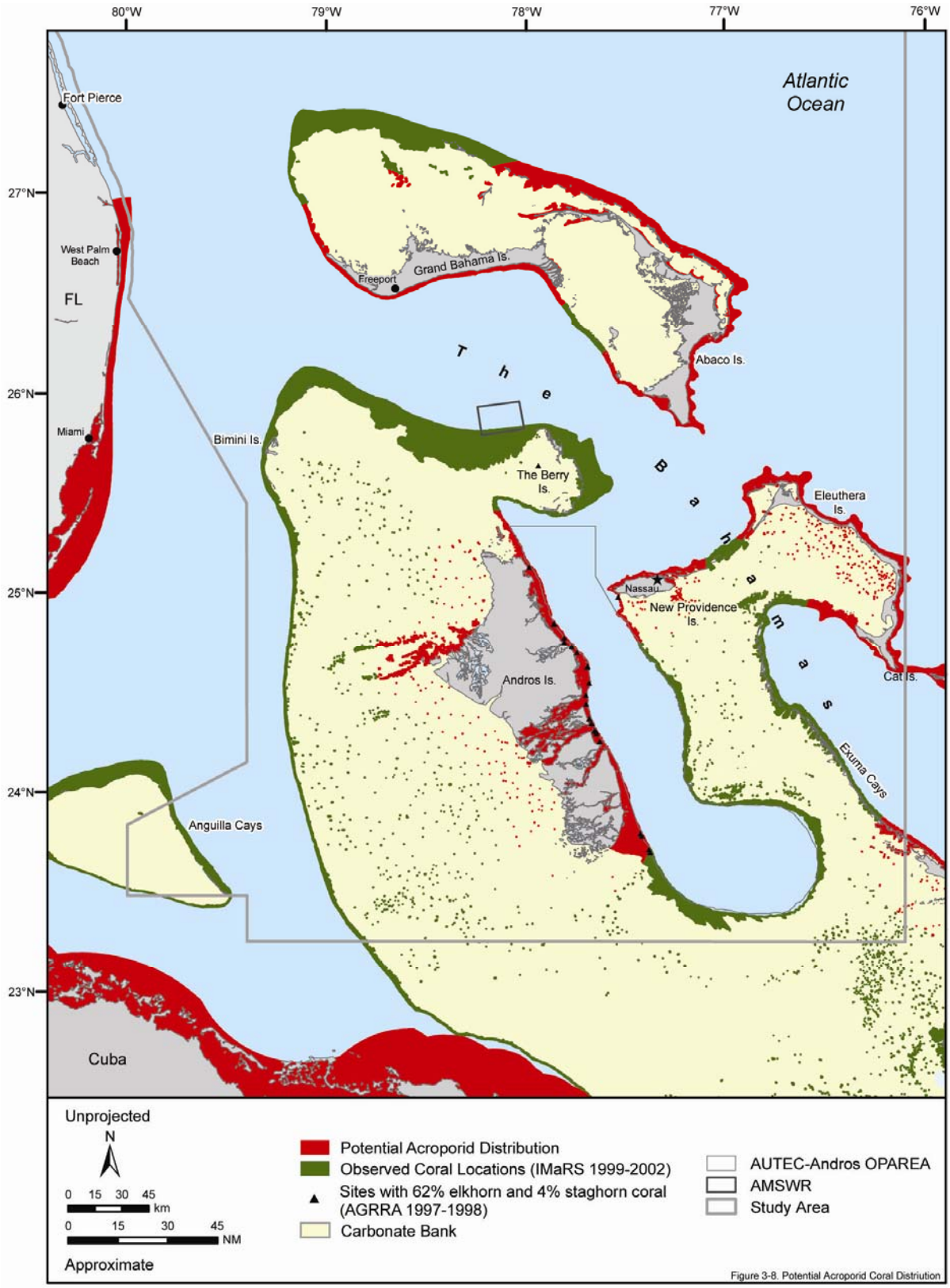

Figure 3-8 Potential acroporid coral distribution and known locations of staghorn and elkhorn corals in the study area for the southeastern Florida and AUTEC OPAREA MRA. Source data: Kramer et al. (2003a); USF (2005). Source map scanned: ABRT (2005).

Status—The Center for Biological Diversity on 4 March 2004 petitioned the NMFS to list three species of acroporids (elkhorn, staghorn, and fused staghorn) as either threatened or endangered under the ESA. Documentation provided by the ABRT for the elkhorn and staghorn corals was used to promote the designation of staghorn coral as threatened by the NMFS on 8 June 2006 (NMFS 2006f, 2006g). Currently, no critical habitat has been designated for this species because the NMFS has deemed it indeterminable (NMFS 2006f, 2006g). The IUCN has not listed this species on the red list for threatened and endangered species.

Habitat Preferences—Staghorn corals prefer water temperatures between 26 and 28°C and salinities between 34 and 37 psu (Precht and Aronson 2004; ABRT 2005). Staghorn coral is typically found within the 1 to 20 m water depth range (Goreau and Goreau 1973). It can grow in shallow areas such as patch reefs and back reef zones as dense thickets (Kramer et al. 2003a). Compared to elkhorn corals, staghorn corals prefer less turbulent deep water (10 to 15 m depth range) of reef terraces, fore reefs, and outer reef platforms where they are more scattered and have longer branches compared to shallower environments (Goreau and Goreau 1973; Gilmore and Hall 1976; ABRT 2005).

Distribution and Abundance—Staghorn coral is found in the U.S. from the Dry Tortugas up into the Florida reef tract and northeast into Broward County, Florida (Jaap 2000). It also occurs in the western Atlantic including the Bahamas, Greater and Lesser Antilles, Venezuela, Aruba, Bonaire, and Curacao. It also occurs in the western Caribbean in Columbia, Panama, Nicaragua, Honduras, Belize, and Mexico (ABRT 2005). In the southwestern Caribbean (Panama) acroporid coral species are usually found on reef terraces. In the northwestern Caribbean (Cuba, Belize and Jamaica) staghorn corals are distributed on back reefs and fore reefs (ABRT 2005).

- Information specific to the southeastern Florida and the AUTEC-Andros OPAREA—Prior to the Caribbean wide die-off of corals in 1998, Kramer et al. (2003a) found 4% of staghorn coral cover along Andros Island on reef crests and back reefs. There was 1% staghorn coral cover on fore reefs (Kramer et al. 2003a). Kramer et al. (2003a) found staghorn coral thickets at China point reef on Andros barrier reef. There were numerous dead staghorn colonies in this area as well. Overall staghorn corals are scarce around Andros reef and New Providence Island. The southeastern Bahamas is the most likely area where staghorn coral can be found. Sullivan et al. (1994) documented staghorn corals on patch reefs and spur and groove zones within the southeastern Bahamas within the 1 and 15 m depth range. It appears that staghorn corals were never as abundant along Andros as they had been in Jamaica or Belize (Kramer et al. 2003a; Dahlgren 2006).

  In 2004, staghorn corals remained the dominant coral species on the high relief reef crest at the Andros Island site, China Point (PERIGEE Environmental 2005). This location has historically been the site with the greatest concentration of staghorn coral in shallow water throughout Andros reefs. Staghorn coral cover at this site declined from 54% to 30% in 2001, and then recovered 15% cover between 2001 and 2004 which may imply that other similar sites (shallow reef crests and patch reefs) could have experienced similar recovery (PERIGEE Environmental 2005).

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4.0 HABITATS OF CONCERN

4.1 MACROALGAE COMMUNITIES: *SARGASSUM*

4.1.1 Sargassum Habitat

Sargassum (Phaeophyta) is a macroalgae, yellow-brown, olive-brown, or dark brown in coloration, and is found throughout tropical and temperate oceans of the world. Most species of *Sargassum* are benthic and grow on hard substrates (rock outcroppings) by use of basal holdfasts (Lee 1986). Two dominate species of *Sargassum* in the North Atlantic are *Sargassum natans* (Gulfweed) and *S. fluitans* (broad-toothed Gulfweed), which are free floating, continually grow in the form of clumps and mats at the sea surface, and reproduce through asexual reproduction (fragmentation) (Coston-Clements et al. 1991). Both species tolerate sea surface temperatures (SST) which change seasonally ranging from 15°C in the winter to 28°C in the summer months, have high light requirements, and tolerate salinities between 35 and 36 psu (Hanisak and Samuel 1987; Garrison 2004). *Sargassum natans,* the most abundant of the pelagic *Sargassum* comprises 90% of the total drift algae in the North Atlantic (SAFMC 2002a). *Sargassum fluitan* makes up the remaining drift *Sargassum* in the North Atlantic, (10%) (Dooley 1972). Both species have leafy blades, densely branched thalli (stems), and berry-like pneumatocysts (air bladders) and can grow up to 2 ft (Gosner 1978). Accumulations of *Sargassum* are important sources of protection and food for various marine fauna and flora (Dooley 1972; Coston-Clements et al. 1991; Settle 1993). Larval fishes also use the *Sargassum* mats as modes of transportation from the Caribbean region to estuaries and waters along the eastern shores of North America (Frias-Torres and Gilmore 1999). *Sargassum* mats also provide necessary habitat for important commercial, artisanal, and recreational fisheries throughout the North Atlantic and Caribbean regions (Moser et al. 1998). Several pelagic fish species rely on this important habitat for food and shelter.

The amount of contribution from pelagic *Sargassum* to total primary production ($gC/m^2/yr$) is variable from region to region in the western North Atlantic (Coston-Clements et al. 1991). Because pelagic *Sargassum* is found at the surface of the ocean, many organisms such as fungi, micro- and macro-epiphytes, hydroids, crustaceans, and fishes use it as a source of cover, camouflage, and food source (Butler et al. 1983; Coston-Clements et al. 1991). Free floating *Sargassum* serves as a temporary habitat for sea turtle hatchlings and larval/juvenile stages of over 100 fish species (SAFMC 2002a). Four species of sea turtles (see Chapter 3 for more information) utilize *Sargassum* as habitat (SAFMC 2002a). Sea turtle hatchlings associate with *Sargassum* mats during their “lost years” when they drift with the floating mats, which is thought to play a vital role in the life of young turtles (Carr 1987). Fronts and eddies of major currents located near the turtles’ nesting beaches are likely places where both hatchling sea turtles and *Sargassum* occur. Off the eastern central Florida coast within the study area, the Gulf Stream creates weed lines along the continental slope, where *Sargassum* collects and attracts neonate loggerhead turtles (*Caretta caretta*) (Witherington 2002). *Caretta caretta’s* pelagic stage has also been observed drifting among *Sargassum* weed lines in the Bahamas (Carr 1987). Ultimately, any *Sargassum* mats drifting at sea have the potential for hosting young sea turtles since both (juvenile sea turtles and pelagic *Sargassum*) are found associated with currents and can travel for long distances from their points of origin (Carr 1987). However, *Sargassum* mats located downstream of nesting beaches are more likely to have turtle hatchlings than *Sargassum* mats drifting in from the northeastern portions of the north Atlantic because downstream *Sargassum* mats are associated with warmer water and support denser amounts of micro- and macro-epiphytes for the hatchlings to consume (Carr 1987). Lastly, marine birds also utilize *Sargassum* as habitat such as the red-billed tropicbird (*Phaethon aethereus*) which is known to associate with *Sargassum* mats in search of fish among the floating algae (Schreiber and Burger 2002; Vanner 2004).

Juvenile fishes are by far the dominant vertebrate inhabitants of pelagic *Sargassum* mats, yet adults of many large pelagic fish species (crevalle jacks [*Caranx hippos*] mackerel scad [*Decapterus macarellus*], dolphinfish [*Coryphaena hippurus*], sailfish [*Istiophorous playerus*], and marlin [*Makaira*/*Tetrapturus* spp.]) also swim under and around *Sargassum* mats (Dooley 1972). Fishes are attracted to the drifting algal mats for a number of reasons, including its use as a foraging area, protective habitat from larger predators, and a spawning ground (Dooley 1972). Fish abundance and diversity are both dependant on mat morphology and age (more species have been recorded under large mats than small clumps) (Moser et al. 1998).

4.1.2 Status of Sargassum

The total biomass of *Sargassum* is unknown due to difficulty in sampling (cost and time), but estimates of standing crop in the Sargasso Sea range from about 4 to 11 million tons (Butler et al. 1983). Stoner (1983) sampled pelagic *Sargassum* in the North Atlantic, Caribbean, and Gulf of Mexico from 1977 to 1981 and stated that based on previous studies by Parr (1939), the overall biomass of pelagic *Sargassum* in the Sargasso Sea declined by 6%. Later analysis of Stoner's data (1983) found no decline in biomass from 1933 to 1981, except in an area northeast of the Antilles and this decline was related to seasonal changes (Butler et al. 1983; Butler and Stoner 1984).

Known threats to *Sargassum* are ocean pollution, such as petroleum from ships creating oil slicks which form within the *Sargassum* "windows", gaps in the mat where oil enters but remains trapped, ultimately leading to mortality in the *Sargassum* mat (Butler et al. 1983). *Sargassum* is also threatened by direct harvesting such as from Aqua-10 Laboratories in the past from the South Atlantic Exclusive Economic Zone (EEZ) off North Carolina from 1976 to 1997 (SAFMC 2002a). The harvest of *Sargassum* is now prohibited in the EEZ south of the South Carolina-North Carolina border and within 87 NM offshore of North Carolina (SAFMC 2006a). The only harvestable area for *Sargassum* designated in 2003 by the SAFMC is "South of the Atlantic EEZ that is greater than 100 NM from shore between the 34° N. latitude line and the latitude line representing the North Carolina/Virginia border during the months of November through June" (NMFS 2003c). In addition the Total Allowable Catch (TAC) of *Sargassum* is not to exceed 5,000 lbs. landed wet weight and all harvesting trips must have an observer present during harvesting (SAFMC 2006a). Presently, the largest harvest of *Sargassum* is the indirect bycatch associated from recreational fishermen intentionally targeting "weed lines" and entangling their gear within the mats. Commercial fishing boats tend to avoid the mats specifically because of this entanglement issue (SAFMC 2002a).

Since *Sargassum* provides a unique and diverse habitat for invertebrates, fishes, sea turtles, and marine birds, scientists in other countries have become more concerned with the survival of this macroalgae (Dooley 1972). The Caribbean Fishery Management Council (CFMC) has drawn up a Final Environmental Impact Statement (FEIS): Reef Fishery Management Plan for the U.S. Caribbean (CFMC 2004). Although there are currently no laws or regulations protecting *Sargassum* in the Bahamas, the importance of this macroalgae and the habitat it provides are recognized.

4.1.3 Distribution of Sargassum

Pelagic *Sargassum* is found in most tropical and temperate oceans and in the Red Sea. In the north Atlantic, pelagic *Sargassum* occurs mainly within the physical bounds of the north Atlantic Gyre between 20°N and 40°N and between 30°W and 70°W (the horse latitudes) at the western edge of the Gulf Stream, a region known as the Sargasso Sea (SAFMC 2002a) (Figure 4-1). The greatest concentration in the Sargasso Sea occurs between 28°N and 34°N. The area, south of Bermuda, is the center of *Sargassum* distribution in the North Atlantic (Figure 4-1) (Dooley 1972; SAFMC 2002a). Some exchange occurs between the *Sargassum* populations of the Caribbean Ocean, Gulf of Mexico, and north Atlantic. Westward-flowing currents of the southern north Atlantic Gyre carry considerable amounts of *Sargassum* to the Leeward Islands of the Antilles, and the straits between The Bahamian Bank and Cuba (Dooley 1972). The Sargasso Sea has mostly calm currents within, yet is encompassed by very strong currents (Florida, Gulf Stream, Canary, North Equatorial, Antilles, and Caribbean currents), thus effectively separating the Sargasso Sea from the rest of the Atlantic. During different seasons with accompanying fluctuations in temperature and weather patterns, the Sargasso Sea rotates slightly in location. All drift material in the area eventually converges into the Sargasso Sea and remains trapped amidst the expansive *Sargassum* mats (Butler et al. 1983).

4.2 BENTHIC COMMUNITIES

Benthic habitats are comprised of a variety of sediments, substrates, and marine life that are commercially and economically valuable. Physical and biological ocean processes influence the types of infauna/flora, epifauna/flora, and demersal organisms that populate these habitats. Benthic organisms such as crustaceans, echinoderms, anthozoans, annelids, mollusks, and ground fish play a major role in

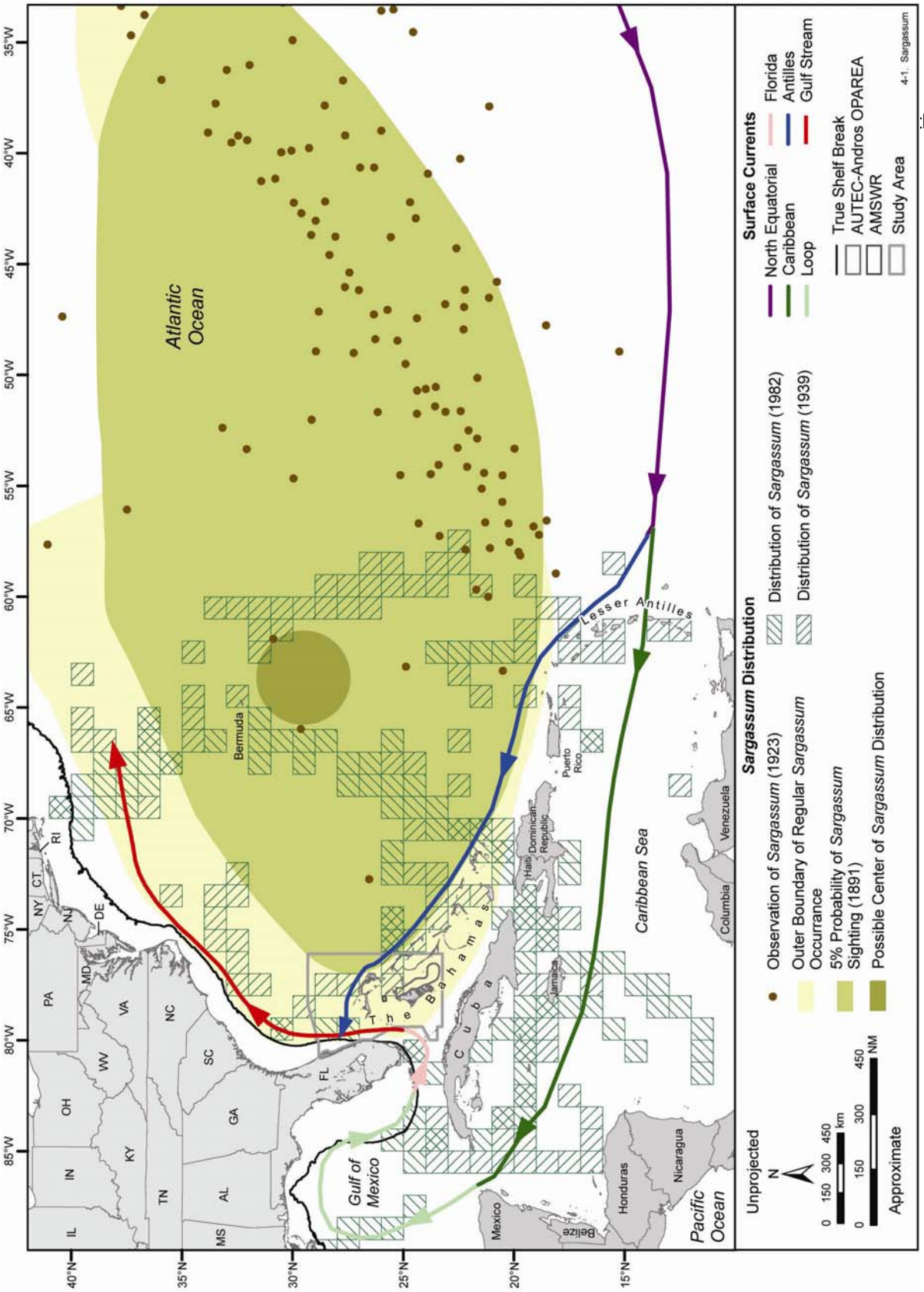

Figure 4-1. Historical distribution of pelagic *Sargassum* and the major surface currents in the Caribbean Ocean, Gulf of Mexico, and North Atlantic Ocean. Source maps (scanned): Dooley (1972), Pickard and Emery (1982), Butler et al. (1983) and General Oceanics (1986)

altering underlying benthic substrates and in breaking down organic material which provides sustenance for economically important species of pelagic fish (Sumich 1988). Increased sedimentation caused by storms, currents, and waves, and anthropogenic disturbances, such as coastal development, dredging, and runoff, cold-water influxes from storms, and red tides can negatively impact the benthic fauna and flora which in turn affects foodwebs and ecosystems (Jones et al. 1985; Liddell et al. 1997).

4.2.1 Live/Hard Bottom Communities

Hard bottom substrates can support sessile fauna, flora, and demersal species (Jones et al. 1985; Cahoon et al. 1990). Examples of hard substrates within the Florida study area include limestone outcroppings, coquina shells, coral skeletal accretions, and worm reefs. Mapping of hard bottom substrates of the U.S. southeast Atlantic Ocean area was done by Southeast Area Monitoring Program (SEAMAP 2001a) and the Bureau of Land Management (BLM 1976) (Figure 4-2).

Living organisms found on hard bottom substrates and that constitute live/hard bottom communities include sea fans, sea whips, ascidians, bryozoans, hard/soft corals, hydroids, anemones, encrusting algae, sponges, sea turtles, and commercial/recreational fishes (Jones et al. 1985).

4.2.1.1 Live/Hard Bottom Communities of Southeastern Florida

Live hard bottom communities on the continental shelf along eastern Florida from Cape Canaveral to Ft. Pierce, FL consist mostly of submerged aquatic vegetation, epifaunal (hard/soft coral), and demersal (fish and crustaceans) organisms (Emery and Uchupi 1972). Prominent hard bottom habitats of Southeastern Florida include coral reefs, tropical reefs, and worm reefs (Jaap and Hallock 1991). Worm reefs and tropical reefs are discussed here.

Worm reefs occur from Cape Canaveral to Key Biscayne (Jaap and Hallock 1991). These reefs are constructed by tube worms (*Phragmatopoma lapidosa*) and can be found from shore out to a water depth of 110 m (Gilmore 1977; Jaap and Hallock 1991). Within the study area reef-building tube worms are found along the shoreline in high energy wave areas and extend to depths of 100 m in areas exposed to strong currents (Figure 4-3) (Kirtley and Tanner 1968; Zale and Merrifield 1989). Tube worms promote coastline development and beach replenishment since their sand tubes provide vertical relief (excreted proteins cement sand grains) and prevent erosion by trapping sediment (Kirtley and Tanner 1968; Zale and Merrifield 1989). Yet, worm reefs in this area are threatened by natural and anthropogenic impacts including severe sea conditions, beach renourishment, polluted water, and trampling by humans at low tide (Jaap and Hallock 1991). Worm reefs are designated as Essential Fish Habitat-Habitat Areas of Particular Concern (EFH-HAPC for Coral, see Chapter 5 for more information). The majority of fauna associated with worm reefs are crustaceans (rock shrimp [*Sicvonia brevirostris*], stone crab [*Menippe* spp.], and spiny lobster [*Panulirus argus*]), isolated hard corals (scleractinians and hydrocorals) and octocorals (ivory tree coral [*Oculina varicosa*], gorgonians, sea fans, sea whips), bryozoans, algae, sponges, hydroids, anemones, macroalgae, annelids, fish, sea turtles, and mollusks (Emery and Uchupi 1972; Reed 1980; Jones et al. 1985; Guseman and Ehrhart 1990; SAFMC 1998). In 1976 and 1980, the BLM surveyed the northern section of the study area focusing and found hard bottom communities (i.e., coral communities) throughout the area (BLM 1981).

Along with patches of *O. varicosa* and various other scleractinians, relatively dense aggregations of octocorals (e.g., gorgonians and sea fans) are also found on shore-parallel terraces in water depths ranging from 15 to 18 m (including a middle reef and outer reef) developed by reef organisms 6,000 to 7,000 years ago (Goldberg 1973; Moyer et al. 2003). The reef communities that currently occur on these old substrates form tropical reefs that include relatively small scleractinians (less than 50 cm in diameter) that make up a low percent cover (4%) of the seafloor substrate (Moyer et al. 2003). Moyer et al. (2003) found that parts of the middle reef could be characterized as deep algae-dominated reef communities and areas of the outer reef habitat as deep, sponge and soft coral-dominated communities. The southern end of the study area contains suitable habitat and environmental conditions for octocorals. Although there is a lack of mapped data for these aggregations, soft corals can be found throughout the southeast section of the study area (Goldberg 1973).

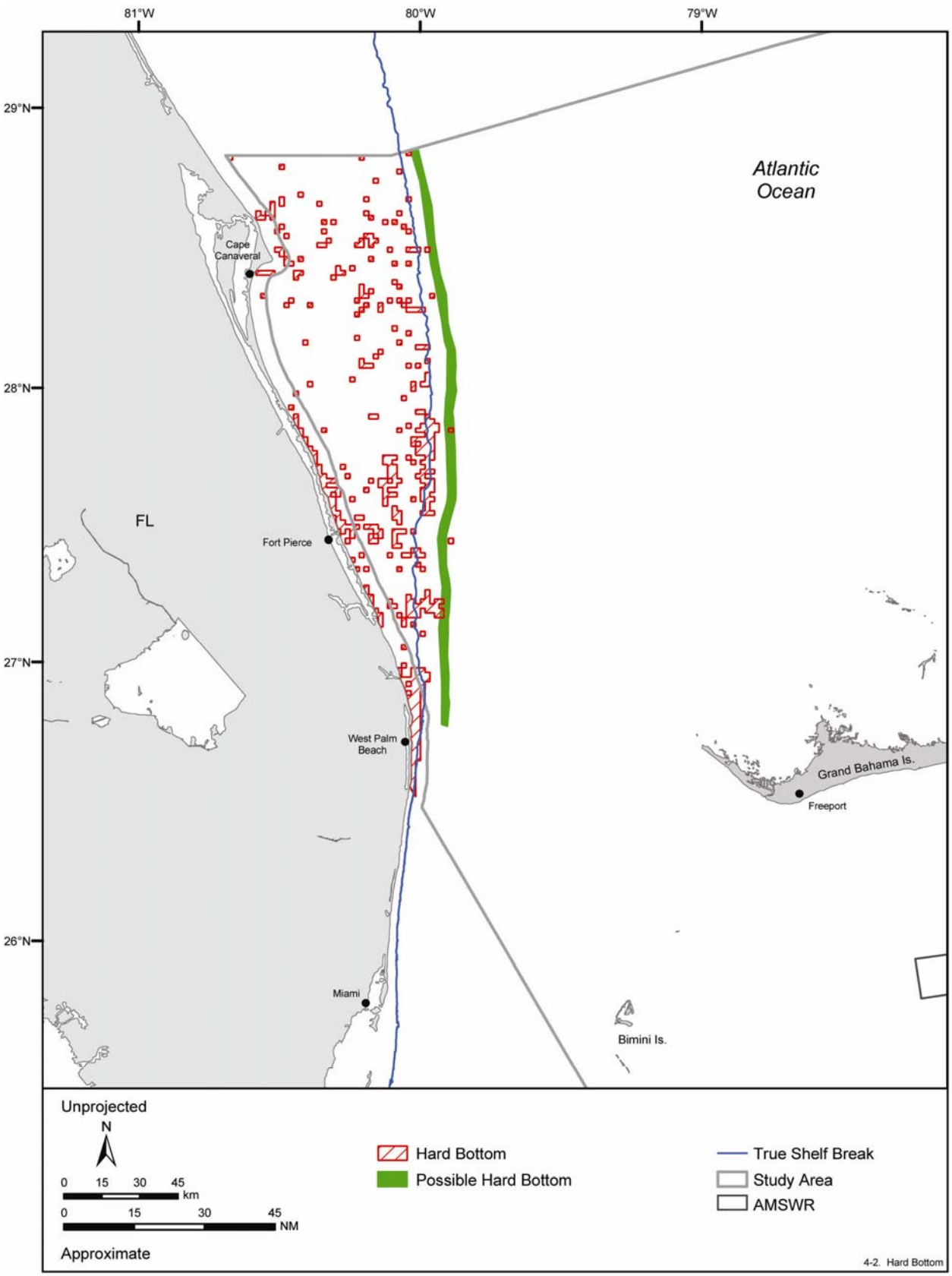

Figure 4-2. Hard bottom located in the waters of the study area off southeastern Florida. Source data: SEAMAP (2001a). Source map scanned: BLM (1976).

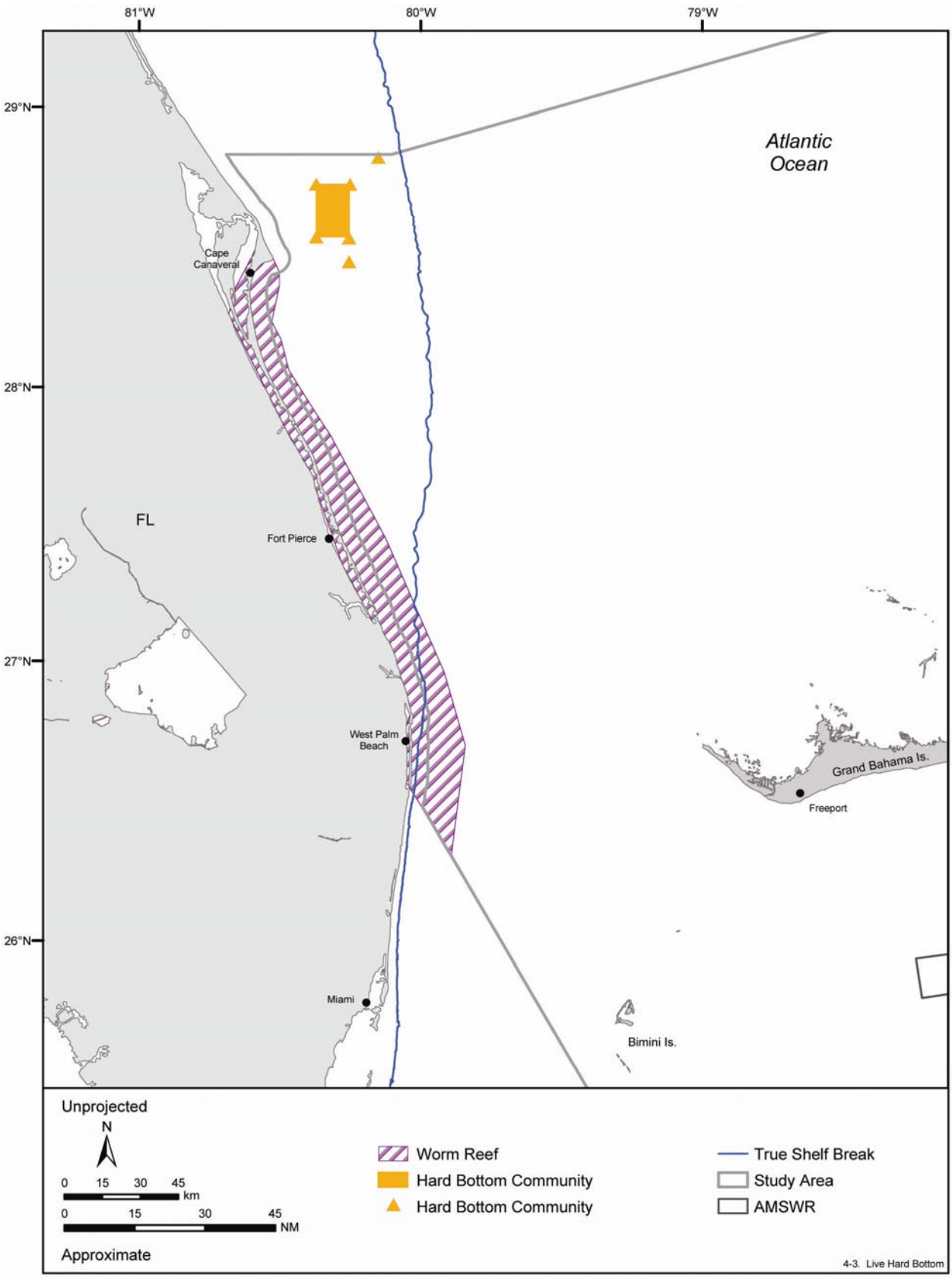

Figure 4-3. Hard bottom communities found in the study area off southeastern Florida. Source maps scanned: BLM (1976), Zale and Merrifield (1989).

4.2.1.2 Live/Hard Bottom Communities of the Bahamas

Since the islands of the Bahamas lie upon a large carbonate platform, there is abundant hard bottom substrate for epifaunal organisms such as algae, seagrasses, hard corals, octocorals, sponges, and anemones to attach (Maxwell and Sturm 1991; Liddell et al. 1997; Alevizon 2002). Benthic communities in areas ≥100 m are limited by the amount of relief and vertical overhang available, which protects organisms from sedimentation (Liddell et al. 1997). Polychaete worms, bryozoans, tunicates, and sponges dominate in deeper benthic regions (Liddell et al. 1997). Hard corals and octocorals do, however, exist at these deeper depths.

4.3 CORALS AND CORAL REEFS

Coral reefs are typically found in oligotrophic, shallow water (mostly up to a 50 m water depth) within a latitudinal range of 30°N and 30°S (Kaplan 1982; Spalding et al. 2001). They are diverse and multifunctional marine habitats created by calcium carbonate accreting organisms including scleractinians. These habitats support a variety of marine species including algae, hydrozoans, anthozoans, scyphozoans, bryozoans, tunicates, sponges, annelids, mollusks, crustaceans, echinoderms, and fishes (Kaplan 1982; Spalding et al. 2001). Although not considered reef building corals because they lack a limestone skeleton, octocorals (type of soft coral) also contribute to reef development by providing structure for the reef and protection/shelter for larval fish and invertebrates inhabiting the reef (Kaplan 1982).

Hermatypic corals contain thousands of microscopic algae called zooxanthellae as well as various types of pigments. Zooxanthellae perform photosynthesis and provide nutrition for their coral host, which promotes coral growth and reef accretion, while pigments provide solar protection from harmful ultraviolet (UV)-B radiation (Jokiel 1980; Kaplan 1982; Barnes and Chalker 1990). Light availability is the most significant physical environmental parameter supporting the coral-zooxanthellae relationship. Because corals live at or near their upper thermal tolerance limits, they are susceptible to increased SST, which have been increasing 1° to 2°C every century (Coles et al. 1976) Excessive SST's (30° to 34°C) cause coral bleaching (disruption of coral-zooxanthellae symbiosis; expulsion of zooxanthellae) and in some cases coral mortality (Hoegh-Guldberg 1999).

Corals reproduce through sexual (spawning) and/or asexual (fragmentation) reproduction and spawning in the Caribbean coral reef province occurs seasonally (Szmant 1986). Physical-environmental factors influencing the development of coral reefs include currents, substrate availability, substrate type, tides, nutrients, and salinity (Spalding et al. 2001). The most limiting regional physical-environmental parameter to reef coral distribution is substrate availability. Sedimentary regimes, substrate type, sedimentation, turbidity, and light availability all impact coral diversity and distribution (Veron 1995).

4.3.1 Corals and Coral Reefs of Southeastern Florida

There are no shallow water coral reefs found within the study area, but at depths between 2 to 40 m within the study area off the coast of Indian River Lagoon and St. Lucie Florida, patches of *O. varicosa* encrust limestone ledges where algae, sponges, hard corals, and octocorals are also found. Hard coral genera include *Diploria*, *Isophyllia*, and *Montastraea*, and octocoral genera include *Eunicea*, *Pseudopterogorgia*, and *Gorgonia* (Reed 1980, Reed et al.1982). *Oculina varicosa* is also found at deeper depths (50 to 100 m) within the study area.

4.3.1.1 Coral Reef Protection

Following the issuance of Executive Order 13089 on Coral Reef Protection in June 1989, coral reef habitats have received more attention and in some cases were afforded more protection (NOAA 1998b). There is currently one Marine Protected Area (MPA) in the study area that protects corals, the *Oculina* Bank HAPC off Florida. In May 2006, the National Marine Fisheries Service (NMFS) declared the two coral reef species, elkhorn and staghorn corals (*Acropora palmata,* and *A. cervicornis*) as threatened species under the Endangered Species Act (ESA) of 1973 (NMFS 2006g). Both species ranges extend into the study area (Florida reef tract area), and are the first coral species to be listed in the ESA Act (see Chapter 3 for more information).

4.3.2 Corals and Coral Reefs of the Bahamas

4.3.2.1 Nature and Distribution of Reefs

The Bahamas is part of the northern Caribbean. Because of its northern geographic location (temperature and light availability), species diversity is less compared to the Indo-Pacific region (Woodley et al. 2000). Coral reefs throughout the Bahamas (Figure 4-4), with few exceptions such as those around New Providence Island, are in fair, rather than poor condition as is the condition of many of the world's corals, most likely due to low anthropogenic disturbances, low population densities, and geographic remoteness. Natural impacts on the Bahamas coral reefs occurs from hurricanes, unusually cold winters in the northern islands, and increased salinity and turbidity on leeward bank margins (Spalding et al. 2001). Disease and bleaching, along with the massive decline of *Diadema* (urchins) due to disease, have affected the reefs in the Bahamas negatively (Kramer et al. 2003a). Seasonally, the skeletons of dead hermatypic corals become covered by green mesh-like algae, *Microdictyon* due to the lack of *Diadema* grazing (Spalding et al. 2001). In 1998 black band disease and white plague disease heavily infected the fore reefs of Andros Island impacting *Montastrea annularis*, *M. faveolata*, *M. franksi*, *M. cavernosa*, *Diploria labyrinthiformis*, and *Colpophyyllia natans* (Kramer et al. 2003a). White band disease has been widespread throughout the Bahamas resulting especially in *A. cervicornis* mortalities as well as *A. palmata* mortalities (Kramer et al. 2003a). In August 1998 (El Nino year) 60% of the corals bleached around New Providence Island to a depth of 20 m from increased SSTs in excess of 30°C resulting in high coral mortality, mainly destroying the reef-building corals of the *M. annularis* species complex (Spalding et al. 2001).

Andros Island is located on the Great Bahamas Bank along the western margin of the TOTO, just west of the OPAREA. It is the longest reef system in the western Atlantic (Spalding et al. 2001; Kramer et al. 2003a). Andros Island has a population of 8,100 residents (Kramer et al. 2003a). Andros reef extends the eastern shore of Andros Island from Joulter's Cays in the north to Saddleback Cays in the south (217 km) (Figure 4-5). The reef is discontinuous in many places, particularly in the central and southern portion creating channels composed of oolithic sand and coral skeletal fragments with strong currents and numerous benthic habitats (Newell 1955; Kramer et al 2003a). Andros reef can be described as a fringing-barrier reef divided into three distinct sections: fringing area (coral reefs that border the coast and are exposed to high wave energy), fore reef (reefs exposed to medium wave energy), and outer reef (reefs exposed to lowest wave energy, furthest offshore). Shelf patches and subtidal reef flats extend from shore out towards the shelf slope. The outer shelf slope is the furthest distance from shore, closest to the OPAREA and has a break at 20 m and a slope at 30 m which abuts the TOTO subjecting it to strong currents (Linton et al. 2002). The outer shelf slope supports gorgonians and sponges which feed from the zooplankton and nutrients of the TOTO (Linton et al. 2002). Physiographic structures such as shelf terrace (shallow area supporting patch reefs) and terraces (shallow seabed areas located close to islands and coral reef) also contain colonies of hard and soft corals (octocorals) as well as sponges (USF 2005a). Intertidal reef flats and fringing areas are 1 to 2 km from shore (1 to 5 m deep) and contain numerous rocks and cays. Surveys conducted by the Atlantic and Gulf Rapid Reef Assessments (AGRRA) team from August 1997 to mid 2000 found that reef crest areas (3 m depth) were dominated (60%) by *A. palmata* which forms high vertical relief (Kramer et al. 2003a). *Acropora cervicornis*, which is delicate compared to *A. palmata*, was found in lower abundances (4%) on reef crests and fore reefs (1%) (Kramer et al. 2003a).

Very dense submerged patch reefs are found scattered throughout the shelf terrace (<10 m depth) (Woodley et al. 2000) (Figure 4-5). Patch reefs contain seagrasses, algae (*Sargassum*), hermatypic (*M. annularis*) and ahermatypic corals (hydrozoans and octocorals), crustaceans (spiny lobster), gastropods (queen conch [*Strombus gigas*]), bivalves, and reef fish. Nassau grouper (*Epinephalus striatus*), the most economically important reef fish in the Bahamas, use shallow water reefs as spawning grounds (Kramer et al. 2003a). In water depths exceeding 10 m on the fore reef, there are coral pinnacles and dense patches of the reef building *M. annularis*. Hard coral coverage on the fore reefs ranges between 3% to 25% (Kramer 2003a). The outer slope which abuts the TOTO and OPAREA is subject to strong currents. Large stands of *A. palmata* are found near the top of the slope due to natural irradiance and warmer temperatures. Deeper areas of the slope (>75 m) are dominated by sponges (Liddell and Avery 2000).

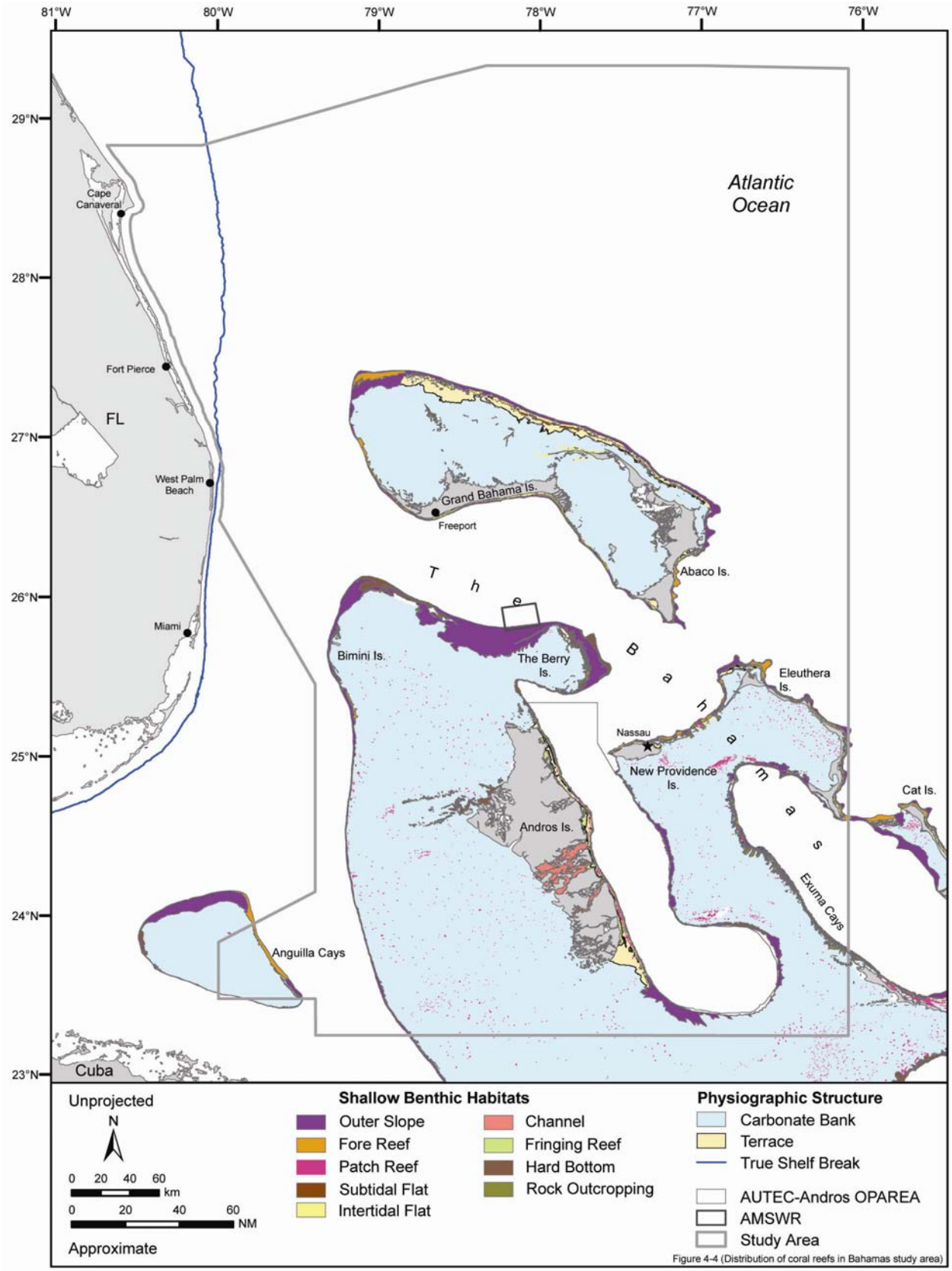

Figure 4-4. Coral reefs and shallow benthic habitats in the Bahamian waters of the study area for the southeastern Florida and AUTEC-Andros MRA. Source data: USF (2005a).

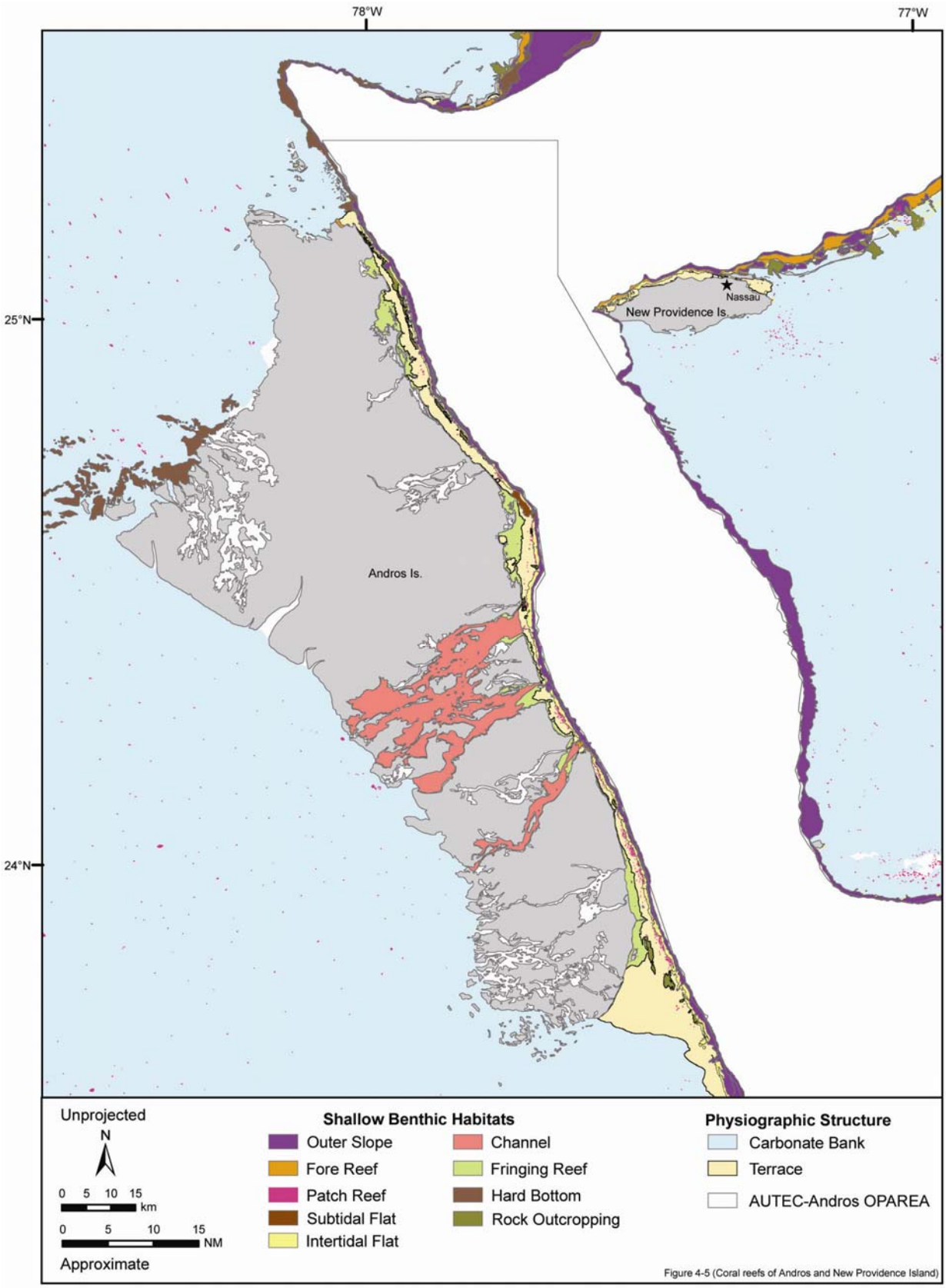

Figure 4-5. Coral reefs and other shallow benthic habitats in the waters of the study area surrounding Andros and New Providence Islands. Source data: USF (2005a).

Shallow water coral communities found within the barrier reef are more exposed to climatic changes (increased SST and hurricanes), anthropogenic disturbances (coastal development), abiotic (tides and currents), and biotic disturbances (fish grazing) than deep sea coral communities of the shelf and outer slope (Liddell and Avery 2000). Consequently, due to higher degrees of disturbance in shallow water, recruitment and growth is greater in shallow water coral communities compared to deep sea coral communities, which are not as tolerant. Some anthropogenic stressors that impact Andros reef and its inhabitants are sewage runoff from coastal development and tourism (Linton et al. 2002).

New Providence Island is one of the smallest islands in the Bahamian archipelago but has one of the largest populations (170,000, 70% of the Bahamas) (Sealey 2004). Due to heavy population densities, there is considerable coastal development and tourism which has heavily contributed to a loss of the coral reefs (Spalding et al. 2001). There are no fringing reefs along the southern shores within the study area, but there are numerous shelf patch reefs throughout the shelf terrace (Figure 4-5). The northwestern shoreline (within the study area) encompassing Clifton Point, Simms Point, and Lyford Cay is part of an extensive fringing reef system, which abuts a steep drop-off into the Atlantic Ocean (Figure 4-4). The dominant corals found at the top of the fore reef slope abutting the OPAREA on the northwestern edge are stands of *A. palmata* and lattices of *M. annularis* (Sealey 2004). Within the cays, lattices of *A. cervicornis* grow in the back reef regions along with other less abundant coral species. Within the study area along the southeastern region, dome-type patch reefs (5 to 10 m depth) are dominated by large colonies of *A. palmata*, *A. cervicornis*, *M. annularis*, *M. cavernosa*, *Siderastrea siderea*, *C. natans*, and *D. clivosa,* (Sealey 2004) (Figure 4-5). Patch reefs in the study area are important habitat, and provide shelter and food, for adult and juvenile fishery species (Sealey 2004).

4.3.2.2 Coral Reef Protection

In 1959, the Bahamas National Trust (BNT), non-governmental, self funded organization was established by an Act of Parliament (BNT 2005b) to manage Exuma Land and Sea Park allowing limited fishing within the park (Linton et al. 2002). In 1986, the park was completely closed to fishing and was established as the first no-take marine reserve, although it still kept the word 'Park' in its name (BREEF 2005a). The success of the Trust was evident after the first established no-take zone in Exuma Cays Land and Sea Park reported higher numbers of queen conch inside the reserve, and increases in other economically and ecologically valuable marine species (Caribbean spiny lobster and Nassau grouper) both inside and outside the reserve. Marine parks in the Bahamas are different from Marine Protected Areas (MPA) in the U.S. because they were established to promote tourism and recreation (Self-contained Underwater Breathing Apparatus - SCUBA diving). Marine reserves in the Bahamas, like MPAs in the U.S. protect the marine species and habitats within the reserve specifically for conservation purposes and not recreation or tourism (BREEF 2005a). Through the continued success and diligent cooperation and collaboration of the Department of Fisheries, BREEF, BNT, government representatives, and researchers, five no-take marine reserves have been approved by the Bahamian government (Commonwealth of The Bahamas) in addition to Exuma Land and Sea Park, none of which are in the study area (North Bimini, Berry islands, South Eleuthera, Exuma Cays, and Northern Abaco Cays) (Figure 4-4) (BREEF 2005a). There are no corals listed under the 2006 IUCN Red List of Threatened Species found within the Bahamas.

4.3.3 Blue Holes

In addition to hard bottom substrate, blue holes have provided habitat for corals in the Bahamas. At the end of glaciation (approximately 18,000 years ago) sea level increased and contributed to cave and sinkhole development in the carbonate rocks found throughout the Bahamas (Trott and Warner 1986). Sea water filled in pits and created blue holes, which are the entrances to underwater caves. Due to the depth of the cave, the water at the cave surface appears dark blue. Blue holes can be found inland, inshore (≤100 m from shore), or offshore (>100 m) along banks. There are three types of caves defined as blue holes: (1) cenotes; (2) lens-based caves; and (3) fracture guided caves (Palmer 1986). Cenotes (inland blue holes) are vertical shafts 50 to 100 m deep, lens-based caves are lateral zones formed between fresh and marine water systems, and fracture-guided caves are vertical steep shafts 2 to 100 m deep situated along the bank (Palmer 1986). Blue holes support a diverse fauna of crustaceans, sponges, hydroids, coral (hard corals and octocorals), mollusks, bryozoans, and ascidians which line the walls of blue holes (Trott and Warner 1986, Palmer et al. 1998a). Corals and algae are typically abundant at the surface of blue holes. With increasing depth within the blue hole, light and temperature decrease

which is correlated with a decrease in the abundance of corals and an increase in the abundance of sponges (Trott and Warner 1986).

Marine blue holes of Andros reef have been studied and explored since the 1950's (Whitaker 1998). Conch Sound Blue Hole in northern Andros was one of the first blue holes studied in 1981 and 1982 (Whitaker 1998). In 1986, 11 marine blue holes in southern Andros (adjacent to the OPAREA) were studied (the Andros Project) in detail (Palmer 1986).

Marine blue holes are threatened by natural disturbances such as storms and cold winters as well as anthropogenic disturbances from overfishing, inadequate waste treatment, fertilizer runoff, coastal development, and tourism (dive related damage) (Sullivan-Sealey and Bustamante 1999; Linton et al 2002). Currently all southern Andros blue holes are on a proposed marine protection reserve list being reviewed by the Bahamas Ministry of Agriculture and Fisheries (Iliffe 2003). Marine blue holes are found throughout the Bahamas and are popular dive sites, see Chapter 6 for more information.

4.3.4 Deep Sea Coral

Deep sea corals are usually ahermatypic (lack zooxanthellae) but can also be hermatypic (i.e., ivory tree coral), inhabit great depths (70 to 1000 m), prefer cool water (15º to 20ºC), live on top of seamounts, pinnacles, plateaus, edges of the continental shelf, bases of slopes, and grow as solitary colonies, thickets, coppices, and banks (Stetson et al. 1962; Avent et al. 1977; Cairns and Stanley 1981; Mullins et al. 1981; Freiwald et al. 2004). They are slow growing, can live thousands of years, and are limited to regions with strong currents and zones of upwelling which provide plankton and suspended sediment, laced with essential nutrients for survival and highly oxygenated water (Stetson et al. 1962; Avent et al. 1977; Reed 1980, 2002). They reproduce sexually and asexually and grow as large as their skeleton can support (Stetson et al. 1962). Many species of deep sea scleractinian corals are gonochoric as compared to shallow water scleractinians which are mostly hermaphroditic. They are also known to support hundreds of species of invertebrates and act as spawning and feeding grounds for commercially important species of fish such as groupers (Serranidae) (SAFMC 1998). In recent years deep sea corals have also been studied for their pharmaceutical and biotechnical potential including the sea feather (*Pseudopterogorgia elisabethae*) (Ata and Kerr 2000).

4.3.4.1 Southeastern Florida

Within the study area off the eastern central Florida coast, three types of deep sea corals prevail: (1) *O. varicosa*; (2) tuft coral (*Lophelia pertusa)*, and (3) *Enallopsammia profunda* (no common name) (Stetson et al. 1962; Avent et al. 1977; Reed 1980) (Figure 4-6). *Oculina varicosa* lives in shallow and deep sea zones from the Atlantic Ocean to the Caribbean, at depths between 2 to 152 m (Reed 1980). Deep sea *O. varicosa* is azooxanthellate, pink or white, and forms delicate thickets and coral banks also known as bioherms. Its average annual growth rate is 1.6 cm year^{-1}, and inhabits depths from 50 to 100 m along the upper edge of the Florida-Hatteras continental slope. The highest concentration of *O. varicosa* on the Florida-Hatteras slope is found on the southern face at 30° to 45° (Avent et al. 1977; Reed 1980, 2002) (Figure 4-6). Deep sea *O. varicosa* normally does not form reefs, except 12 to 35 NM off the eastern coast of Florida from Cape Canaveral to Ft. Pierce (27°32'N to 28°59'N) paralleling the western edge of the Gulf Stream Current. *Oculina varicosa* inhabits the tops of submarine pinnacles and ridges stretching 167 km and extending 20 m high forming the only known *O. varicosa* reefs in the world (Figure 4-6) (Avent et al. 1977; Reed 1980, 2002; Reed et al. 2005). Sebastian, Chapman, and Jeff's reefs make up the *O. varicosa* reefs. Sebastian reef is the most northern *O. varicosa* reef located south of Cape Canaveral. Sebastian reef is mostly made of unconsolidated coral rubble with no live coverage reported (Koenig et al. 2005). Chapman's reef is in between Sebastion and Jeff's reef. Chapman's reef is divided into east and west banks. The east banks have minimal coral coverage whereas the west banks have between 7% and 22% live coral coverage (Koenig et al. 2005). Jeff's Reef is as far south as *O. varicosa* is found (north of Ft. Pierce). The reef has a base-circumference of 1,000 m. It has three parallel ridges that face east to west and are about 64 m deep, with a maximum relief of 16 m (Reed 1980). The south side of the reefs are steeper (i.e., 30° to 45°) than the north side (<25°) (Reed 1980). Live coral coverage on Jeff's reef is between 9% and 21% (Koenig et al. 2005).

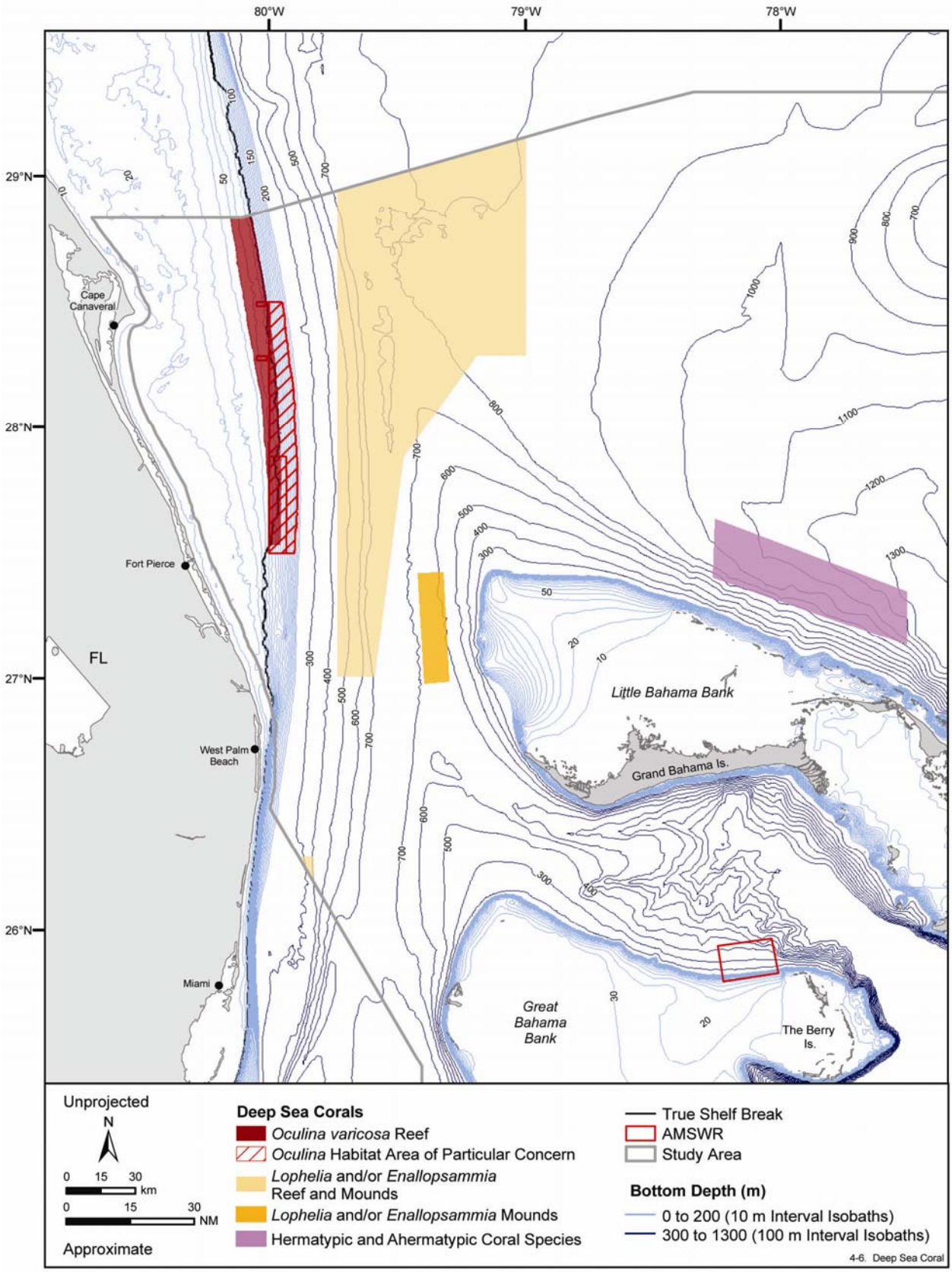

Figure 4-6. Deep water corals located in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: Reed et al. (2005), FFWCC (2005), Source map scanned: Reed (2002).

Oculina varicosa forms three types of colonies (small, large, and massive) (Reed 1980). Small colonies (≤2 m in diameter) can be found unattached on mud or attached to limestone rocks, large colonies (>2 m in diameter) have a linear form, and massive colonies form continuous thickets (≥2 m in height) (Reed 1980). *Oculina varicosa* reefs are mostly pinnacle-shaped structures with high relief (3 to 35 m) and hundreds of meters wide (Reed 1980, 2002). *Oculina varicosa* reefs provide habitat for economically important reef fish such as gag grouper (*Mycteroperca microlepis*) (one of the most important commercial species in the southeast) (Koenig 2001).They also provide habitat for hundreds of species of invertebrates (Reed et al. 1982), however, the dominant fauna of these reefs is *O. varicosa,* along with numerous species of small mollusks (bivalve: *Barbatia candida*), bryozoans, echinoderms (*Diadema sp.*), and decapod crustaceans (crabs and shrimp) (Avent et al. 1977; Reed et al. 1982, Reed 1992). The determining factor for species abundance of decapod crustaceans associated with *O. varicosa* reefs is the amount of dead coral available (*i.e.*, more decapods associated with dead *O. varicosa*), neighboring colonies for recruitment, and seasonal upwelling events providing nutrients (Reed et al. 1982).

Lophelia pertusa is an ahermatypic coral found in all oceans except polar. Its global depth range is 60 to 2,170 m, but within the study area it is found in water depths ranging from 640 to 869 m along the Straits of Florida on the top or sides of dead coral mounds and ridges (Stetson et al. 1962; Reed 2002) (Figure 4-6). *Lophelia pertusa* can form colonies up to 1 m tall creating reef-frameworks and coral banks exhibiting growth rates similar to *O. varicosa* (Wilson 1979; Reed 1992). Benthic fauna associated with *L. pertusa* reefs are massive plate-like sponges and gorgonians such as *Pachastrella monilifera*, *Phakellia ventilabrum*, and *Plumarella pourtealessi* (Reed 2002). *Enallopsammia profunda* is an ahermatypic coral and occurs in the western Atlantic from as far north as Massachusetts and as far south as the Antilles at depths between 146 to 1,748 m (Cairns and Stanley 1981). It is usually associated with tuft coral within the study area and forms colonies up to 1 m in diameter (Reed 2002). Deep-water corals such as *Madrepora oculata,* bamboo*,* and black coral also occur in the study area (Reed 2004, Reed et al. 2006).

The U.S. Navy and Johnson-Sea-Link submersibles have made dives to the base of the Florida-Hatteras slope and have witnessed dense lithotherms 5 to 150 m high and up to 1,000 m long situated perpendicular to the Gulf Stream current. There are believed to be over 40,000 lithoherms that extend from within the study area into North Carolina and that support dense aggregations of *L. pertusa* and *E. profunda* (Reed 2002).

4.3.4.2 Western Bahamas

Within the Bahamas study area, there are few hermatypic corals at depths greater than 100 m (Reed 1985). Off the western and southern edges of the Little Bahama Bank, northern Grand Bahama Bank, and San Salvador exist flat colonies of the shade tolerant *Agaricia grahamae* (119 m water depth) and *Montastraea cavernosa* (113 m) (Reed 1985).

North of Little Bahama Bank at depths between 1,000 and 1,300 m, there are mounds (bioherms; 5 to 40 m high) of unconsolidated sediments that support three species of solitary ahermatypic coral: *Solenosmilia, Madrepora, and Enallopsammia*. West of Little Bahama Bank at depths between 500 and 700 m mounds of lithified carbonate sediment (lithoherms) that are 30 to 50 m high and up to 300 m long are littered with colonies of *Lophelia* and *Enallopsammia* (Figure 4-6) (Reed 2002). Some of the fauna associated with these mounds are crinoids, mollusks, echinoderms, and crustaceans attached to dead coral structures.

Threats to deep sea corals are mainly from trawling by modern fishing vessels, although gas exploration, drilling, seabed extraction, and mining are just as destructive (Puglise et al. 2005). Because deep sea corals are fragile, slow growing, and can live thousands of years they cannot withstand these anthropogenic impacts forced upon them.

4.3.4.3 Deep Sea Coral Protection

The first area of *Oculina* Habitat of Particular Concern (O-HAPC) (315 km^2) was designated in 1984 (13 NM off Fort Pierce, FL) by the SAFMC, which was also the first deep sea coral MPA in the world (SAFMC 1998). In 1994 the lower portion of the HAPC, called the Experimental *Oculina* Research Reserve (EORR), was closed to all bottom fishing for a period of 10 years (SAFMC 1998). In 2000, the O-HAPC was expanded to 1,029 km^2, equivalent to 300 NM^2 which presently supports the only known *Oculina* reef in the world (O-HAPC) (Koenig 2001). There is a proposed HAPC for *Oculina* coral being considered off

the coast of central eastern Florida (SAFMC 1998). In 2004, The Deep Sea Coral Protection Act was proposed to Congress but never became law. "Oceana, a non-governmental organization petitioned the U.S. Department of Commerce to enforce a rule to protect deep-sea coral and sponge (DSCS) habitat from the impacts of mobile bottom-tending fishing gear" (NMFS 2005b). The NMFS found this petition not to be warranted, however, they are working with the Regional Fishery Management Councils to protect DSCS habitat when necessary (NMFS 2005b).

4.4 SEAGRASS COMMUNITIES

Unlike macroalgae, all seagrasses are flowering plants (vascular) that reproduce asexually and sexually. Depending on water transparency (turbidity), seagrasses can grow on sand or mud substrates in water from low tide to 9 m deep, depending upon water clarity (CFMC 2004). Seagrasses complete their life cycle while being fully submerged. Three common seagrass species most often found in the Caribbean are shoal grass (*Halodule wrightii*), Caribbean turtle grass (*Thalassia testudinum*), and manatee grass (*Syringodium filfiforme*) (Kaplan 1988). Seagrasses are found along the Bahamian back reefs (Figure 4-7), and turtle grass is probably the most abundant species in the study area.

Seagrass beds are among the most highly productive of all natural systems in the world (Green and Short 2003). Seagrasses generally grow in protected areas such as back reefs with slow currents and moderate wave action and are often found behind protective barrier reefs (Dahlgren and Marr 2004). In many cases seagrass beds and coral reefs are highly interconnected. Seagrass beds will trap sediments preventing sediment re-suspension and transport onto the adjacent reefs. In turn, reefs protect seagrass beds by dissipating wave energy. Seagrasses rely on terrestrial runoff and nitrifying bacteria as nutrient sources and provide filtration for the coral reefs intertwined among them thus creating oligotrophic conditions (Dahlgren and Marr 2004). Manatees play a vital role in seagrass ecology by stimulating growth catalyzed by their grazing on the plants (SMSFP 2006).

Manatee grass is found in shallow subtidal zones at depths up to 1 m but can grow as deep as 18 m from the western Atlantic of eastern Florida into the Gulf of Mexico, Caribbean, Bermuda, and the Bahamas (SMSFP 2006). Manatee grass grows in sand and mud mixed with turtle grass in the form of clumps or in monospecific patches and attracts corals and sponge species along with other marine invertebrates (Queen Conch) (SMSFP 2006).

Caribbean shoal grass grows in shallow brackish water of bays and estuaries with exposure to high salinity fluctuations (>37 psu), in disturbed environments (turbidity and nutrient fluxes) not conducive to seagrass growth (turtle grass) (Green and Short 2003). It is found from Florida extending into the Gulf of Mexico, Caribbean, South America, Northwestern Africa, Indian Ocean, and west coast of Mexico at 8 to 12 m depths and it is associated with fine sediments and sands (NOAA 2001b; Green and Short 2003; FMNH 2006).

Turtle grass is commonly found in protected shallow lagoons (≤10 m), and in low energy, deeper water (30 m) (NOAA 2001b; Green and Short 2003). Leaves are used as substrate by algae, crustaceans, mollusks, and hydrozoans. Turtle grass leaves are a primary source of food for fishes, sea turtles, sea urchins, and gastropods (CFMC 2004). Seagrasses are part of the diet of the loggerhead sea turtle (*C. caretta*) (juvenile and adult stages). Nassau grouper and queen conch, both economically important fishery species use seagrass beds as nursery grounds during their larval and juvenile stages (Dahlgren and Eggleston 2001). Several coral reef animals use seagrass beds as secondary feeding grounds. Both juveniles and adult fish use seagrass beds as foraging grounds, feeding on the epiphytic organisms attached to seagrass blades and on the crustaceans and worms living among the stalks or burrowed in the substrate. Some fish (grunts [Haemulidae], snappers [Lutjanidae]) move between seagrass beds and coral reefs, feeding in the seagrass and providing carbon for detritivores on the reef (CFMC 2004). Several fish and invertebrate species feed on the sediment itself, extracting the organic material trapped within the sediment and the small invertebrates (polychaete worms) inhabiting it.

Anthropogenic threats to seagrass beds within the Bahamas include coastal development and runoff, thermal outflow from power plants, shipping (anchoring, increased turbidty, and prop scars), and tourism (diving). Even though seagrasses are known to be resilient and repopulate regions months after disturbances from hurricanes, damage to turtle grass from boat propellers takes three to seven years for

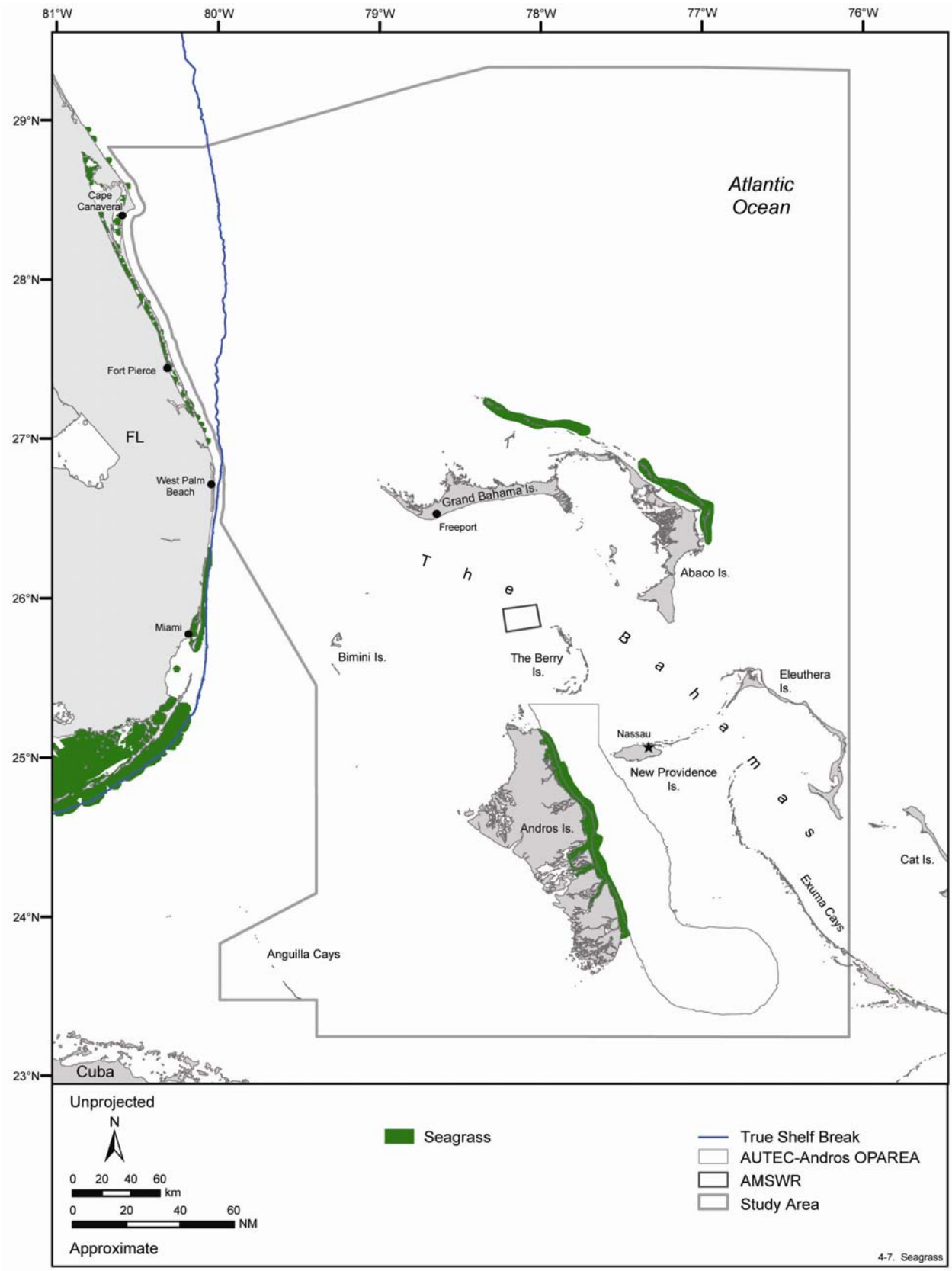

Figure 4-7. Locations of seagrass beds in the study area for the Southeastern Florida and AUTEC-Andros MRA. Scanned map: UNEP/WCMC (2003).

recovery (Green and Short 2003; FDEP 2005). Increased sedimentation from anthropogenic disturbances smothers seagrass communities thus affecting the coral reefs and fish habitats. Because seagrass beds are located within shallow backreef regions, they are not buffered by depth or oceanic influxes of fresh seawater, and increased runoff from coastal development and increased SST can have severe consequences for seagrass beds (Dahlgren and Marr 2004). Sedimentation from coastal runoff and/or dredging smothers seagrass communities and prevents light from penetrating, these disturbances coupled with increased SSTs eventually causes mortality to the seagrass beds and coral colonies (Dahlgren and Marr 2004)

Within the Bahamas, seagrasses are recognized as productive fishery habitats. The Caribbean Environment Programme of the United Nations Environment Programme (CEP-UNEP) was initiated to assist the nations and territories of the Wider Caribbean Region to protect their marine and coastal environment and promote sustainable development. The Caribbean Coastal Marine Productivity network (CARICOMP) was established in 1958 to monitor seagrass communities, coral reefs, and mangroves throughout the Caribbean (Green and Short 2003). Seagrasses that grow inside MPAs are protected but there are no laws that specifically protect them.

4.4.1 Seagrasses of Southeastern Florida and the Bahamas

There are no seagrass beds within the study area of Florida, but seagrasses in Florida are recognized as important benthic habitat. In 1998 Johnson's Seagrass (*Halophila johnsonii*) was listed as endangered and threatened under the ESA Act of 1973 and in 2000 critical habitat was designated for it. Johnson's Seagrass only grows in southeastern Florida between Sebastian Inlet and north Biscayne Bay at depths up to 3 m in isolated patches (NOAA 2002). Seagrasses in Florida are receiving more attention and protection from their greatest threat, boat propellers. Boat No-wake zones and Marine Managed Areas (MMAs) throughout Florida help protect seagrass communities as well as their residents (manatees and coral reefs). In the Bahamas study area, turtle grass is the dominant species and occurs throughout the fringing coral reefs and terraces (Nero and Sullivan-Sealey 2005) (Figure 4-7). Patch reefs, which provide nutrient-enriched sediments ideal for seagrass habitat, and isolated coral mounds throughout the Bahamas shelf patch regions often have the "halo" effect caused by herbivorous fish grazing on the seagrasses (Nero and Sullivan-Sealey 2005). Manatee grass and shoal grass are found within fringing and terrace areas off Andros Island (Green and Short 2003).

4.5 ARTIFICIAL HABITATS

Artificial habitats alter the seafloor and under the right conditions can benefit benthic communities and onshore economies. The benefits experienced by marine biological communities increase with time. When solid hard objects with numerous and varied surfaces are introduced to areas of the seafloor predominantly composed of soft sediments, they provide the appropriate substrates necessary for the settlement and colonization of epibenthic organisms such as fish (e.g., snapper), algae, sponges, barnacles, hard and soft corals, anemones, and hydroids among others (Bohnsack et al. 1991). As more organisms assemble at an introduced site, an interrelated community develops, ultimately attracting larger predatory game fish that in turn bring recreational and commercial fishermen. Preservation and good management of a successful artificial habitat can influence the biological productivity and economic value of offshore areas.

Benthic artificial reefs and shipwrecks behave like natural hard bottom communities that once seeded, attract fish and sessile organisms (Fitzhardinge and Bailey-Brock 1989; Bohnsack et al. 1991). Caribbean fishermen commonly target fish species (grunts, grouper, and squirrelfishes [Holocentridae]) that are the most abundantly associated with artificial reefs (Hixon and Beets 1989). Grouper and snapper families in the Bahamas aggregate around artificial patch reefs made of discarded materials: rubber tires, scrap aluminum, and sunken boats (Mueller 1999). The process of reef colonization and community building can extend the potential range of some commercially and recreationally important fish and invertebrate species by providing more habitats (Bohnsack et al. 1991). In addition to fish and invertebrate species, sea turtles are attracted to artificial habitats for food and shelter (Bjorndal 1997).

4.5.1 Fish Aggregating Devices (FADs)

Fish aggregating devices (FADs) are apparatus suspended throughout the water column or floated at the surface to attract pelagic fishes (Beets 1989). Unfortunately, they have had varying levels of success in

attracting species such as dolphinfish and kingfish (*Menticirrhus* spp.), possibly due to location, size of structure, fouling, and seasons (Nelson 2003). FADs are specifically built devices such as netting wrapped around floats and set adrift in the currents. However, unintentional FADs include trash, debris (washing machines and planks of wood) and oceanographic buoys deployed throughout the world's oceans. All these structures are known to attract fish, and fishermen target these objects. Certain disadvantages to FADs exist, such as sharks and marine mammal entanglement, a worldwide issue similar to the bycatch of sharks and marine mammals in purse seines used to harvest tuna in the western Indian Ocean (Romanov 2001). Under the United Nations Convention on the Law of the Sea (UNCLOS) of 1982 (Article 119, b) bycatch of associated species (marine mammals and sharks) of target fishery species is recognized for FADs along with fishery impacts (Romanov 2001).

4.5.2 Artificial Reefs

Substrate, sedimentation rate, currents, topography, depth, and turbidity are all considered when planning for the location of artificial reefs (Goodwin and Cambers 1983; Claro and Garcia-Arteaga 1999). Artificial reefs are constructed from natural materials (i.e., wood, quarry rock, and shells) and man-made materials (concrete reef balls, ships, and oil platforms) (Artificial Reef Subcommittee 1997). Originally, the primary purposes of intentionally placed artificial substrates were to enhance commercial and recreational fishing demands, draw public attention, and dispose of solid waste (Artificial Reef Subcommittee 1997). Through the deployment of artificial reefs, fishery species and invertebrate fauna were observed inhabiting these new structures and seeking out food and shelter. Because of the success of the first artificial reefs, the U.S. Congress, in 1984 as it recognized the social and economic value in developing artificial reefs, passed the National Fishing Enhancement Act (NFEA) (Title II of Public Law [PL] 98-623). One of the primary directives of NFEA was the preparation of a long-term National Artificial Reef Plan (NARP). Section 202 of the act recognized the harmful effects of overfishing on fishery resources and proposed that properly designed, constructed, and located artificial reefs could enhance the habitat and diversity of these fishery resources. The NARP was signed in November 1985 to provide guidance and/or criteria on various aspects of artificial reef use, including types of construction materials and planning, siting, designing, permitting, installing, maintaining, and managing artificial reefs (Gordon 1993). One of the most significant recommendations in the NARP was to encourage the development of state specific artificial reef plans.

4.5.2.1 Southeastern Florida

One hundred fourteen of the 595 artificial reefs located off southeastern Florida are found within the study area at water depths ranging from 2 to 60 m and averaging 21 m (SAFMC 1998) (Figure 4-8). In 1978, a recognized artificial reef development program was established by the Division of Marine Resources after years (since the 1960's) of pilot projects funded by various state governments and non-governmental agencies. Florida's artificial reef program is not solely controlled by a state agency but rather is a collaborative effort between state, local governments, and private organizations. In order to protect artificial reefs from commercial fishing pressures, Special Management Zones (SMZs) were established by the SAFMC within the Snapper/Grouper Management Plan. Within the study area 14 NM offshore of Brevard County, 150 reef balls were deployed contributing to two reef sites. In the summer of 2000 along the *Oculina* Banks, 105 reef balls were deployed at three sites (RBF 2005a).

4.5.2.2 The Bahamas

Artificial reefs within the Bahamas study area (Figure 4-8) not only attract reef fish but also seagrasses and coral (Alevizon 2002). Various recycled materials such as tires and concrete have been used throughout the Bahamas to build artificial reefs. Reef Ball, Inc. is a non-profit organization, which sells material to build igloo-shaped artificial reefs and has supplied over 5000 artificial reef projects worldwide, including throughout the Bahamas (RBF 2005b). The Bahamas Reef Environment Educational Foundation (BREEF 2005b), a non-profit organization was established to enhance marine conservation in the Bahamas through education, research, and monitoring. The BREEF reported in 2000 that over 50 reef balls were manufactured and deployed by the Cape Eleuthera Island School in the surrounding waters around the island to prevent beach erosion and attract depleted fishery species. In addition, various cruise lines have also joined the artificial reef conservation effort, such as: Disney Cruise Lines,

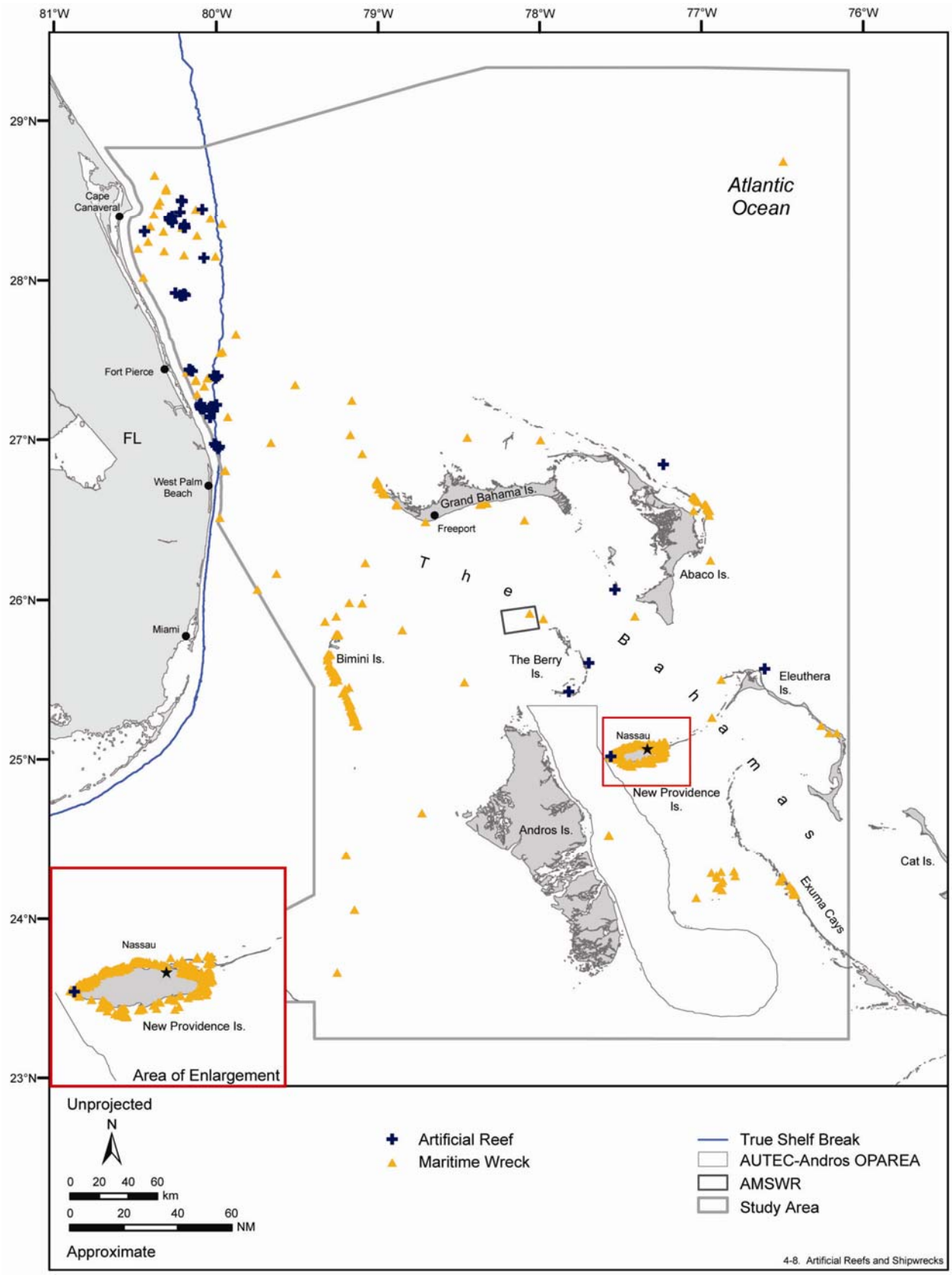

Figure 4-8. Artificial reefs and shipwrecks in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: Veridian Corporation (2001), FFWCC (2004). Source map scanned RBF (2005c).

which deployed 455 Reef Balls in the waters surrounding Abaco Island (Gorda Cay) in 1997; Holland America Cruise Lines that has deployed reef balls in the surrounding waters of San Salvador Island (Half Moon Cay); and the Royal Caribbean International cruise lines that deployed over 100 Reef Balls in the surrounding waters of the Berry Islands (Coco Cay) from 1996 to1997 (RBF 2005b).

4.5.3 Shipwrecks

Shipwrecks are found throughout the study area. The region is impacted by strong currents (Gulf Stream) and subjected to natural disturbances, such as hurricanes in the fall and northeastern storms in the winter. Throughout the past century many ships have grounded or sunk in these regions due to natural disturbances as well as human disturbances (i.e., war) (Singer 1998; Berg and Berg 1989).

4.5.3.1 Shipwrecks of Southeastern Florida

Florida's maritime history is at least 500 years old. There are numerous shipwrecks found within the study area (no historical Spanish galleons), such as casualty ships of World War II sunk by German submarines and U-boats (at least 12 in study area) (Singer 1998). Florida's shipping industry has grown over the years and in the early 1900's it was a main artery for receiving goods (coffee, molasses, sugar, and rum) from the Caribbean and South American countries. Heavy shipping traffic, World War II casualty ships, hurricanes, created a wreck haven along Florida's coastlines (Table 4-1). The popular shipwrecks found in the southeastern Florida waters of the study area (Table 4-1) are used as dive and fishing sites. It is estimated that there are between 4,000 to 5,000 wrecks off Florida's east and west coasts (See Chapter 6 for more information) (Singer 1998).

Table 4-1. Popular shipwrecks found in the southeastern Florida waters of the study area (Singer 1998).

Wreck Name	Water Depth	Wreck Location	Comments
Amazone	27 m	southeast of Ft. Pierce Inlet	78 m steel hulled Dutch freighter sunk in 1942 by a German submarine
Budweiser Bar	29 m	Delray Beach	51 m coastal freighter built in 1965; ship was intentionally sunk in 1987 to create an artificial reef
City of Vera Cruz	27 m	Port Canaveral	87 m iron framed vessel that sank in 1880
Hydro Atlantic	50 m	Boca Raton	91 m dredger that sunk while under tow in 1987
Leslie	24 m	Port Canaveral	76 m ship torpedoed and sunk in 1942 by a German U-boat
Mizpah	29 m	Riviera Beach	56 m commissioned Navy vessel intentionally sunk in 1968

4.5.3.2 Shipwrecks of the Bahamas

The islands of the Bahamas are subjected to frequent hurricanes and strong surface currents, resulting in many historical and modern shipwrecks which offer fishing and diving locations for tourists and local citizens (Table 4-2). Shipwrecks located in Bahamian waters include Spanish galleons dating back to 1492 (Berg and Berg 1989; Wood 1999). Found in the waters off New Providence Island, which is the most populated island in the Bahamas, is a dense aggregation of shipwrecks. So many shipwrecks occur in the southwestern waters off New Providence Island that it is called "Wreck City". Off Little Bahamas Bank, located ~7 NM southwest of West End, Grand Bahamas Island, a mid-sixteenth century Spanish galleon is sunk in 5 m of water . This wreck is archaeologically significant because its identity is believed to be the Santa Clara (1564); this wreck is also part of the ongoing *St. John's* Bahamas Shipwreck Project (Fisher 2005).

Table 4-2. Popular shipwrecks found in the Bahamian waters of the study area (Berg and Berg 1989; Wood 1999).

Wreck	Depth	Wreck Location	Comments
Landing Craft Mechanized (LCM) Barge	20 m	eastern Andros Island	World War II landing barge sunk in 1963
Marian	20 m	eastern Andros Island	Sunk in 1987 in the waters of the AUTEC OPAREA with a salvage crane; the Navy has made unsuccessful attempts to raise the vessel that has become seeded with reef fauna
Potomac	5 to 6 m	eastern Andros Island	All that remains of a British steel hulled tanker that ran aground off the north end of Andros during a hurricane in 1929 is scattered remains
Antinique	13 m	southeastern New Providence Island	12 m ship sunk west of *The Tears of Allah* wreck.
Tears of Allah	13 m	southeastern New Providence Island	27 m freighter also called the "*Never Say Never Again*" or "*The James Bond*" wreck
The Landing Craft Tank (LCT)	6 m	southeastern New Providence Island	World War II landing craft that ran aground on the north end and is sometimes called the "*Thunderball*"
Mahoney	10 m	southeastern New Providence Island	65 m steel hulled 1880 freighter that sank during a 1929 hurricane off the western end of Salt Key
Royal James	14 m	southeastern New Providence Island	Iron ferry intentionally sunk in 1985 close to Golden Key

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5.0 FISHES

5.1 FISHES AND INVERTEBRATES

The Southeastern Florida and AUTEC-Andros study area and vicinity is home to over 704 species of marine fishes and 481 invertebrates, including corals (Briggs 1958; Böhlke and Chaplin 1993; Gilmore 1977, 1995; SAFMC 1998; Reed 2002). Of these species, the smalltooth sawfish (endangered), elkhorn coral (threatened), and staghorn corals (threatened) are protected in U.S. waters under the ESA, and the Bahamas blind cave fish is afforded protection by the Government of The Bahamas under the Wildlife Conservation and Trade Act (BCO 2004). All four species have been recorded in the study area (refer to Chapter 3 for additional information).

Fauna of the study area are primarily classified as either warm-temperate (i.e., species with water temperature preferences between 10° and 15°C), subtropical (i.e., species with temperature preferences above 15°C), tropical (i.e., species with preferences above 20°C), or highly migratory species (e.g., billfishes, tunas, and sharks; species move great distances seasonally and vertically in the water column) (Miller and Richards 1980). Fish and invertebrate fauna off southeastern Florida and the Bahamas are extremely similar to the fauna found from Bermuda to Brazil (Briggs 1958; Böhlke and Chaplin 1993). Seasonal changes in water temperature and major currents (i.e., Florida Current/Gulf Stream) are considered the most important feature influencing distribution of the majority of the species in the study area and vicinity (Huntsman and Manooch 1978; Miller and Richards 1980).

5.1.1 Florida Fauna

The region offshore of Florida between Jacksonville and Miami is regarded as a transitional zone between warm-temperate and subtropical-tropical fauna (Miller and Richards 1980). Cape Canaveral, FL is commonly regarded as a boundary within this transitional zone due to an overlap in temperate and subtropical-tropical species of the Carolinas with the tropical fauna of the Caribbean that occur here (Briggs 1974; Gilmore 1977). Cape Hatteras, North Carolina (NC) is considered the northern boundary for eurythermic (preferring a wide range of temperatures) tropical fish species, while Cape Canaveral, FL is the northern limit for stenothermic (preferring a limited range of temperatures) tropical species (Briggs 1974; Smith-Vaniz et al. 1999). The boundary at Cape Canaveral, FL is considered less pronounced and more dynamic than the Cape Hatteras, NC boundary. Between these two capes, fishes are considered warm-temperate or eurythermic tropical, while from Cape Canaveral to West Palm Beach, FL species are primarily stenothermic tropical species that cannot maintain populations year round further north than Sebastian Inlet, FL (28°N) unless by moving to deeper, warmer waters (Miller and Richards 1980; Smith-Vaniz et al. 1999). Approximately, 28% of fishes in this region are stenothermic tropical, 22% warm-temperate, and 50% eurythermic tropical and continental shelf species (Gilmore 1977).

Gilmore (1977, 1995) did extensive research off the coast of central Florida to review and analyze fishes in this region. In the vicinity of the study area is the Indian River Lagoon and other inlets (e.g., St. Lucie Inlet, Ft. Pierce Inlet, Sebastian Inlet) that are home to 275 species of fishes. Of these 275 species, over 66% migrate from these inlets to the Atlantic Ocean to spawn, feed, or utilize the inlets as nursery areas until they mature. Over *Phragmatopoma* worm reefs and other surf zone reefs, 105 fish species have been recorded with the most common species in the area being demersal blennies (*Labrisomus nuchipinnis* and *Blennius cristatus*). Over 223 species have been recorded on reefs (i.e., *Oculina* Bank) and live-bottom habitats of the area with 86% considered tropical reef fishes (e.g., butterflyfishes, snappers, groupers, damselfishes). Open shelf waters are home to 171 benthic fish species, such as flounders, cusk eels, and searobins, while pelagic habitats consists of approximately 177 species, primarily sharks, mackerels, tunas, jacks, billfishes, herrings, and anchovies.

Many tropical species are year round residents on shallow inshore reefs (<18 m deep) south of Sebastian, FL (Miller and Richards 1980). Many of these species are seasonal migrants of the region, north (spring/summer)-south (fall/winter) (dolphin, mackerels, billfishes) and from inshore to offshore waters to spawn (drums and croakers) or from shallower to deeper waters as a result of temperature changes (snappers and groupers) (Moe 1963; Struhsaker 1969; Huntsman and Manooch 1978).

Billfishes (marlins and sailfish), swordfish, members of the mackerel family (tuna), and many shark species are classified as highly migratory fishes and are distributed from coastal waters seaward into the

open ocean. These species are capable of moving great distances seasonally (north-south or inshore-offshore) as well as vertically in the water column. In contrast to warm-temperate and subtropical-tropical fishes, highly migratory species (HMS) are not correlated with areas or features that typify most fish habitat (bottom substrate or submerged vegetation) but are instead associated with physiographic and hydrographic features such as ocean fronts, current boundaries, the continental shelf margin, or sea mounts (NMFS 1999b, 1999d, 2003d, 2006h).

The Florida and Gulf Stream Currents and their associated gyres and eddies are important features in determining the fauna of the southeast Florida region. These currents aid in the distribution of eggs and larvae as well as nutrients throughout the area (Briggs 1974; Huntsman and Manooch 1978; Limouzy-Paris et al. 1997). The Florida and Gulf Stream Currents also act to moderate the temperature (typically above 15°C year-round) in the region making it more inhabitable by subtropical-tropical species, even during the winter months, than those regions closer to shore, where more temperate species are found seasonally (Strusaker 1969; Huntsman and Manooch 1978; Gilmore 1977, 1995).

5.1.2 The Bahamas Fauna

Over 656 species of fishes, including 103 deep-water species (>918 m depth) have been recorded in the Bahamas (Sulak 1982; Smith-Vaniz and Böhlke 1991; Böhlke and Chaplin 1993; Smith-Vaniz et al. 1999). Of these species, it is estimated that less than 1% are endemic to the Bahamas (Smith-Vaniz and Böhlke 1991). Thus, even though the Bahamas may be geographically separated from Florida and other neighboring regions (i.e., Cuba and Hispanola) by the Florida Current/Gulf Stream and deep oceanic channels (e.g., Strait of Florida), it is not isolated in terms of gene flow with other nearby regions (Böhlke and Chaplin 1993; Smith-Vaniz et al. 1999; Rocha et al. 2005).

Insular tropical fauna, dependent upon substrate consisting of calcium carbonate (coral reef habitat), stable temperatures and clear water, is distributed from the Bahamas south to the South American islands of Curaçoa, Cubaqua, and Los Roques (Robins 1971). Fauna of this region can be classified into several groups: demersal and coral reef fauna (snappers, groupers, grunts, parrotfish, triggerfish, spiny lobsters, and sponges), soft-bottom demersal fauna (drums and croakers, mullets, inshore sharks, penaeid shrimp, conch, rays, sawfish), inshore pelagics (over the shelf) (mackerels, small tunas, herring, bluefish, and jacks), offshore pelagics (edge of continental shelf) (billfish, larger sharks, dolphinfish, tuna, flyingfish), and deep shelf and slope fauna (>75 m depth) (snappers, groupers, tilefish) (Robins 1971; Sturm 1991).

The three most important fisheries in the Bahamas consist of the Caribbean spiny lobster (*Panulirus argus*; commonly called “crawfish” in the region), queen conch (*Strombus gigas*), and Nassau grouper (*Epinephelus striatus*) (BREEF and MEPL 1998; Chiappone et al. 2000; MEPL 2002). All three species are considered on the verge of potential collapse in the region (BREEF and MEPL 1998; MEPL 2002). The Nassau grouper is designated as a species of concern in the U.S. (NMFS 2004a) and has an endangered status (i.e., facing a very high risk of extinction in the wild) on the IUCN Red List (Cornish and Eklund 2003). The Nassau grouper and queen conch are extremely susceptible to the threat of overfishing due to their slow growth and maturation rates (MEPL 2002). The Nassau grouper is of greatest concern since fisherman had previously targeted this species during its reproductive phase (i.e., specific localities [20 to 30 in the Bahamas] of large groups approximately 2,000 to 3,000 spawning fish), which has led to the disappearance of major spawning aggregations throughout the entire Caribbean (BREEF and MEPL 1998; Dahlgren 1999; Bolden 2000). To counter the collapse of these important fisheries, the Bahamas Government, Department of Fisheries has established no-take marine reserves (e.g., Exuma Cays Land and Sea Park; for more information see Chapter 4) and studies indicate that these areas have a greater number of species and higher density fishes, especially larger grouper species like the Nassau grouper (Sluka et al. 1997; Chiappone et al. 2000). Additionally, there is an established closed season for the Caribbean spiny lobster and harvesting/possession of the queen conch is illegal (GOB-DOF 1986). For the Nassau grouper, 2003 marked the first year of an annual closed fishing season (i.e., December through January) for this species to protect susceptible spawning aggregations (BCO 2003; NURP 2005).

5.1.2.1 Andros Island

The fauna inhabiting the estuaries of Andros Island are very similar to those found in Florida estuaries (Layman and Silliman 2002). These estuaries support a range of species due to the diversity of habitats present. In the estuaries of Andros Island, diversity of fishes (i.e., primarily damselfishes, parrotfishes, and jacks) has been correlated with rocky habitats that have surface water connectivity (tidal exchange) to the ocean (Layman et al. 2004). Additionally, the number of individual fishes has also been found to be positively correlated with the amount of nearshore habitat with bare sand, which supports invertebrates that many species feed upon (e.g., silversides, mojarras) (Cigliano 2000; Nero and Sealey 2005). Seagrass (i.e., turtle grass) and algal (*Galaxaura*) patch reef beds also serve as an important seasonal habitat, with the total number of individual fishes is higher in the summer compared to the winter months (Cigliano 2000; Nero and Sealey 2005). More than 75% of fishes commercially targeted in this region depend on estuaries for some part of their life cycle (i.e., nursery grounds, feeding grounds) (Cigliano 2000). The most common species associated with Andros Island's estuaries are snappers and mojarras (Layman et al. 2004).

Off of Andros Island, over 164 fish species have been recorded along the Andros Island Reef Tract (Kramer et al. 2003b). Fishes found in the TOTO region are similar to the fauna of Jamaica and Belize (Colin 1976). Some of the most abundant species along this tract include parrotfishes (stripped parrotfish [*Scarus croicensis*] and stoplight parrotfish [*Saprisoma viride*]) and groupers (tiger grouper [*Mycteroperca tigris*] and Nassau grouper [*E. striatus*]) (Kramer et al. 2003b).

5.1.3 Management

Many of the fish and invertebrate species within U.S. federal waters of the study area are under the management of two fishery management councils (FMCs) and one federal agency: the Mid-Atlantic Fishery Management Council (MAFMC; jurisdiction is federal waters from New York to North Carolina), the South Atlantic Fishery Management Council (SAFMC; jurisdiction is federal waters from North Carolina to eastern Florida at Key West) and the NMFS (jurisdiction over HMS in federal waters off the U.S. Atlantic coast and the Gulf of Mexico). These FMCs and the NMFS manage both commercial and recreational fisheries for these species in federal waters and designate essential fish habitat (EFH) and habitat areas of particular concern (HAPC). Though the MAFMC does not have jurisdiction in the study area, they have designated EFH for three fish species that are found off Florida (bluefish, summer flounder, and spiny dogfish). The SAFMC manages a total of 88 species of fishes and invertebrates (not including ~118 species of corals). Forty-nine HMS that occur along the U.S. Atlantic coast and Gulf of Mexico are managed by the NMFS. Several species found in the study area are managed jointly: members of the coastal migratory pelagics and the Caribbean spiny lobster are co-managed by the SAFMC and Gulf of Mexico Fishery Management Council (GMFMC), the red drum is jointly managed by the SAFMC and Atlantic States Marine Fisheries Commission (ASMFC; jurisdiction in state waters from Maine through eastern Florida), and the MAFMC and ASMFC co-manage the summer flounder. Since the study area boundary is located 3 NM from the shore of Florida, managed species in federal waters will be the focus of the remainder of the chapter.

In The Bahamas, the Ministry of Agriculture, Fisheries, and Local Government under the Department of Fisheries manages fisheries resources. This department regulates commercial and recreational fisheries and is responsible for the collection of fisheries data, the enforcement of fishery regulations, and the issuance of permits for collecting fish for scientific research (GOB-DOF 1986; BREEF and MEPL 1998).

5.2 ESSENTIAL FISH HABITAT DISTRIBUTION AND SPECIES

EFH has been designated for 64 fish and invertebrate species in the Florida waters of the study area, not including the approximately 118 species of corals; hereinafter these fish and invertebrate species will be referred to as the "managed species" (Tables 5-1 and 5-2). In this report, these managed species are categorized as subtropical-tropical (33 species, not including corals), warm-temperate (2 species) and highly migratory (29 species) fishes and invertebrates. Additionally, information about each managed species is presented in alphabetical order by species common name (Table 5-1). For each managed species, the management, status, distribution including range, habitat preference, life history, common prey species, and EFH/HAPC designations by fishery management council (MAFMC or SAFMC) or

management agency (NMFS) are provided. Map figures depicting the designated EFH for each species may be found in Appendix D.

The EFH that occurs within the U.S. waters of the study area can be broadly typified as:

- Benthic Habitat—Seafloor habitats, including the continental shelf and slope that consist of substrate such as rocks, gravel, sand, clay, mud, silt, shell fragments, and hard bottom. These habitats are utilized by a variety species for spawning/nesting, development, dispersal, and feeding (SAFMC 1998).
- Structured Habitats—Areas providing sheltered habitat for a variety of species, which may include:
  - Artificial Reefs—Human-made structures derived from various types of materials and used primarily by adults, especially spawning adults (SAFMC 1998).
  - Biogenic Habitat—Habitat created by living organisms, including sponges, mussels, hydroids, amphipod tubes, red algae, bryozoans, vermetid, worm, and coral reefs, which are used by many members of the snapper grouper and coastal migratory pelagic management units (MUs) (SAFMC 1998).
- Pelagic *Sargassum*—Mats of pelagic *Sargassum* (*Sargassum natans* and *S. fluitans*) provide an important habitat for numerous fishes, especially the larval lifestage (e.g., snapper grouper MU). In the North Atlantic Ocean, pelagic *Sargassum* occurs primarily within the physical bounds of the North Atlantic Gyre between 20°N and 40°N and between 30°W and the western edge of the Gulf Stream (Dooley 1972; SAFMC 2002a). As the areal extent and abundance of pelagic *Sargassum* at any single location is very unpredictable (Butler et al. 1983), the occurrence of pelagic *Sargassum* in this report is mapped from the shoreline to the U.S. EEZ (Ruebsamen 2005).
- Gulf Stream and Dynamic Oceanographic Features—The Gulf Stream is the dominant surface water mass in the SAB and flows roughly parallel to the coastline from the Florida Straits to Cape Hatteras, North Carolina (NC), where it is deflected and begins flowing northeastward (Bumpus 1973). The Gulf Stream provides a mechanism of dispersion for the larvae of many species (e.g., snapper grouper MU, coastal migratory pelagic species MU, golden deepsea crab MU, and Atlantic calico scallop MU) (SAFMC 1998). The Gulf Stream is part of a larger current system, the Gulf Stream System, which includes the Florida Current.
  - The SAFMC defines the Gulf Stream as starting north of Cape Canaveral, Florida (SAFMC 1998). Thus, only a small portion of the current is included in the study area as EFH.
  - The MAFMC does not define where the Gulf Stream joins the Florida Current but designates EFH as the eastern wall of the Gulf Stream through Key West, FL. for the bluefish. After requests to the MAFMC for clarification did not result in further elucidation, an interpretation was made regarding the intent of the EFH designation. The Gulf Stream System (i.e., Florida Current) to Key West, FL rather than the Gulf Stream Current is interpreted as EFH for the bluefish. Therefore, the Florida Current was mapped as EFH for this species (Leaman et al. 1989).
  - Eddies are also designated as EFH for dolphinfishes and wahoo. Frontal eddies occur along the East Florida Shelf (EFS) throughout the entire year and vary in location, size, and duration depending on several oceanographic and climatological factors including wind stress, Florida Current transport, and tidal fluctuations (Lee and Williams 1988; Fiechter and Moores 2003). Frontal eddies typically form when warm Florida Current waters meander seaward beyond the shelf break allowing colder slope waters to upwell onto the EFS. Eddies typically last one to three weeks with a reoccurrence period of about one week, and extend to depths of about 400 m (Lee et al 1991; Fiechter and Moores 2003). These dynamic and thus unpredictable eddy features could not be accurately mapped. For more information about these oceanographic features, consult Chapter 2.

Table 5-1. Fishes and invertebrates for which EFH has been designated in the U.S. waters of the study area. Taxonomy follows Nelson et al. (2004) for fishes, Turgeon et al. (1998) for mollusks, and Williams et al. (1989) for decapod crustaceans.

I. SUBTROPICAL-TROPICAL SPECIES

Atlantic calico scallop
Blackfin snapper
Bluefish
Blueline tilefish
Brown rock shrimp
Brown shrimp
Caribbean spiny lobster
Cobia
Corals (stony corals and octocorals)
Dolphinfishes
  Dolphinfish
  Pompano dolphinfish
Golden deepsea crab
Goliath grouper
Gray snapper
Greater amberjack
King mackerel
Mutton snapper
Pink shrimp
Red drum
Red porgy
Red snapper
Ridged slipper lobster
Royal red shrimp
Scamp
Silk snapper
Snowy grouper
Spanish mackerel
Speckled hind
Tilefish
Vermilion snapper
Wahoo
Warsaw grouper
White grunt
White shrimp
Wreckfish
Yellowedge grouper

II. WARM-TEMPERATE SPECIES

Bluefish
Spiny dogfish
Summer flounder

III. HIGHLY MIGRATORY SPECIES

Albacore tuna
Atlantic sharpnose shark
Bigeye tuna
Bignose shark
Blacknose shark
Blacktip shark
Blue marlin
Bluefin tuna
Bonnethead shark
Bull shark
Dusky shark
Great hammerhead shark
Lemon shark
Longfin mako shark
Night shark
Nurse shark
Oceanic whitetip shark
Sailfish
Sand tiger shark
Sandbar shark
Scalloped hammerhead shark
Silky shark
Skipjack tuna
Spinner shark
Swordfish
Tiger shark
White marlin
White shark
Yellowfin tuna

Table 5-2. Management units (MU) and managed species with EFH designated in the U.S. waters of the study area by management agency. Taxonomy follows Nelson et al. (2004) for fishes, Turgeon et al. (1998) for mollusks, and Williams et al. (1989) for decapod crustaceans.

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Bluefish MU[1]
Bluefish (*Pomatomus saltatrix*)
Spiny Dogfish MU[2]
Spiny dogfish (*Squalus acanthias*)
Summer Flounder, Scup, and Black Sea Bass MU[1]
Summer flounder (*Paralichthys dentatus*)

SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

Calico Scallop MU
Atlantic calico scallop (*Agopecten gibbus)*
Coastal Migratory Pelagics MU[3]
Cobia (*Rachycentron canadum*)
King mackerel (*Scomberomorus cavalla*)
Spanish mackerel (*Scomberomorus maculatus*)
Coral, Coral Reefs, & Live Bottom Habitat MU
Corals (stony corals and octocorals)
Dolphin Wahoo MU
Dolphinfish (*Coryphaena hippurus*)
Pompano dolphinfish (*Coryphaena equiselis*)
Wahoo (*Acanthocybium solandri)*
Golden Crab MU
Golden deepsea crab (*Chaceon fenneri*)
Red Drum MU[4]
Red drum *(Sciaenops ocellatus)*
Shrimp MU
Brown Rock shrimp (*Sicyonia brevirostris*)
Brown shrimp (*Farfantepenaeus aztecus*)
Pink shrimp (*Farfantepenaeus duorarum*)
Royal red shrimp (*Pleoticus robustus*)
White shrimp (*Litopenaeus setiferus*)
Snapper Grouper MU
Blackfin snapper (*Lutjanus buccanella*)
Blueline tilefish (*Caulolatilus microps*)
Goliath grouper (*Epinephelus itajara*)
Gray snapper (*Lutjanus griseus*)
Greater amberjack (*Seriola dumerili*)
Mutton snapper (*Lutjanus analis*)
Red porgy (*Pagrus pagrus*)
Red snapper (*Lutjanus campechanus*)
Scamp (*Mycteroperca phenax*)
Silk snapper (*Lutjanus vivanus*)
Snowy grouper (*Epinephelus niveatus*)
Speckled hind (*Epinephelus drummondhayi)*
Tilefish (*Lopholatilus chamaeleonticeps*)
Vermilion snapper (*Rhomboplites aurorubens*)
Warsaw grouper (*Epinephelus nigritus)*
White grunt (*Haemulon plumieri*)
Wreckfish (*Polyprion americanus*)
Yellowedge grouper (*Epinephelus flavolimbatus*)
Spiny Lobster MU[3]
Caribbean spiny lobster (*Panulirus argus*)
Ridged slipper lobster (*Scyllarides nodifer*)

NATIONAL MARINE FISHERIES SERVICE

Atlantic Billfish MU
Blue marlin (*Makaira nigricans*)
Sailfish (*Istiophorus platypterus*)
White marlin (*Tetrapturus albidus*)
Swordfish MU
Swordfish (*Xiphias gladius*)
Shark MU
Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)
Bignose shark (*Carcharhinus altimus*)
Blacknose shark (*Carcharhinus acronotus*)
Blacktip shark (*Carcharhinus limbatus*)
Bonnethead shark (*Sphyrna tiburo*)
Bull shark (*Carcharhinus leucas*)
Dusky shark (*Carcharhinus obscurus*)
Great hammerhead shark (*Sphyrna mokarran*)
Lemon shark (*Negaprion brevirostris*)
Longfin mako shark (*Isurus paucus*)
Night shark (*Carcharhinus signatus*)
Nurse shark (*Ginglymostoma cirratum*)
Oceanic whitetip shark (*Carcharhinus longimanus)*
Sand tiger shark (*Carcharias taurus*)
Sandbar shark (*Carcharhinus plumbeus*)
Scalloped hammerhead shark (*Sphyrna lewini*)
Silky shark (*Carcharhinus falciformis)*
Spinner shark (*Carcharhinus brevipinna*)
Tiger shark (*Galeocerdo cuvier)*
White shark (*Carcharodon carcharias*)

[1] Jointly managed by MAFMC and ASMFC
[2] Jointly managed by MAFMC (lead) and NEFMC
[3] Jointly managed by GMFMC and SAFMC
[4] Jointly managed by SAFMC and ASMFC

- Marine Water Column—All waters from the surface to the ocean floor (but not including the ocean bottom). Depending upon the species, the habitat may only include part of the water column (e.g., just surface waters). This habitat is important for a wide variety of species and their lifestages (SAFMC 1998; NMFS 1999b, 1999d, 2003d).
- Estuarine Areas—Nearshore estuarine habitats (e.g., wetlands, mangroves, and oysters) are designated as EFH for many species managed by the SAFMC and MAFMC. Since the study area boundary on the eastern coast of Florida only extends within 3 NM of shore, these habitats are not located within the study area. Thus, they are not mapped but are only referred to in the EFH text designations.
- Habitat Areas of Particular Concern—HAPC have been designated in Florida waters for 31 species (not including ~118 species of coral) by the MAFMC, SAFMC, and the NMFS. The *Oculina* Bank HAPC is also designated as a Coral Habitat Areas of Particular Concern (C-HAPC). The C-HAPC are a management concept conceived of by the SAFMC and designed to identify and focus regulatory and enforcement abilities on areas of special significance to the managed species. There are several criteria used to identify a C-HAPC: ecological, research, exploitation, and recreation. In order to be designated as a C-HAPC, at least one of the criteria must be met and "an effort should be met to ensure inclusion of areas that represent all coral community types found in the management area" (SAFMC 1998).

Mid-Atlantic Fishery Management Council

- For the juvenile and adult summer flounder, all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations within adult and juvenile summer flounder designated EFH are considered HAPC. Although classified as a macroalgae, pelagic *Sargassum* is not designated as HAPC for the summer flounder (Hoff 2005). Thus, pelagic *Sargassum* habitats are not mapped as HAPC for summer flounder.

South Atlantic Fishery Management Council

- All lifestages of the 18 species of the snapper-grouper MU for which EFH have been designated in Florida waters of the study area are included in the HAPC designation. Designated HAPC for these species includes medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs (e.g., *Oculina* Bank), council-designated Artificial Reef Special Management Zones (SMZs), and the *Oculina* Bank HAPC. Additional HAPC have been designated for this MU but are not located within the boundaries of the study area; these areas include nearshore hard bottom habitat (<4 m); mangrove habitat; seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, manganese outcroppings on the Blake Plateau; The Point, NC; the Ten Fathom Ledge, NC; and Big Rock, NC, as well as the Charleston Bump (South Carolina [SC]).
- Areas designated as HAPC in the Florida waters of the study area for all designated coral species (stony corals, black corals, and octocorals) include offshore (5 to 30 m) hard bottom from Palm Beach County, FL to Fowey Rocks, FL; *Oculina* Bank HAPC; and *Phragmatopoma* (worm) reefs (central east coast of Florida). Additional HAPC designated but not located within the Florida section of the study area is the nearshore hard bottom (<4 m) in the Florida Keys National Marine Sanctuary; from Cape Canaveral to Broward County, Florida (FL); Biscayne Bay, FL; Biscayne National Park, FL; Ten Fathom Ledge, NC; Big Rock, NC; The Point, NC; Hurl Rock, SC; Charleston Bump, SC; and Gray's National Marine Sanctuary, Georgia (GA).
- Areas designated as HAPC for all lifestages of the coastal migratory pelagic MU (cobia, king mackerel, and Spanish mackerel) include the Point off Jupiter Inlet, FL, *Phragmatopoma* reefs (worm reefs) off the central east coast of Florida, and pelagic *Sargassum*. Additional areas have been designated as HAPC but are not found within the boundaries of the study area: the Hump off Islamorada, FL; the Marathon Hump off Marathon, FL; the Wall off of the

Florida Keys; nearshore hard bottom (<4 m) south of Cape Canaveral, FL; the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, NC from shore to the ends of the respective shoals but shoreward of the Gulf stream; The Point, NC; Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and Hurl Rocks, SC.

- Amberjack Lump (FL) is designated as HAPC for all lifestages of the dolphinfish, pompano dolphinfish, and wahoo. Additional HAPC designated but not located within the study area include: the Hump off Islamorada (FL), the Marathon Hump (FL), and the Wall off the Florida Keys The Point (NC), the Ten Fathom Ledge (NC), Big Rock (NC), the Charleston Bump (SC), and the Georgetown Hole (SC).
- HAPC are designated for all lifestages of spiny lobsters as coral/hard bottom habitat from Jupiter Inlet, FL, through the Dry Tortugas, FL. Florida Bay, Biscayne Bay, and Card Sound are also designated as HAPC for this MU but are not located within the study area.
- All lifestages of the red drum have HAPC designated as all coastal inlets, all state designated nursery habitats of particular importance to the red drum; documented sites of spawning aggregations; barrier islands and the passes between them; seagrass beds or submerged aquatic vegetation (SAV) in Virginia, North Carolina, and Florida; the entire estuarine system from the lower salinity portions of the river systems through the inlet mouth or lower harbor areas in South Carolina and Georgia; and the inlets, adjoining channels, sounds, and outer bars of ocean inlets. None of these areas are located within the boundary of the study area.
- Areas designated as HAPC for the penaeid shrimp MU (brown, pink, and white shrimp) includes all coastal inlets, state designated nursery areas, and state-identified overwintering areas, none of which occur within the boundaries of the study area.

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- For all lifestages of the sandbar shark, HAPC are designated in the shallow areas at the mouth of Great Bay, New Jersey, lower and middle Delaware Bay, lower Chesapeake Bay, Maryland, and near the Outer Banks, NC in areas of Pamlico Sound adjacent to Cape Hatteras and Ocracoke Islands and offshore of these barrier islands, since they represent important nursery and pupping grounds. None of these areas are within the boundaries of the study area.

The FMCs classify EFH for subtropical-tropical and temperate managed species in terms of five basic lifestages: 1) Egg, 2) Larva, 3) Juvenile, 4) Adult, and 5) Spawning Adult (MAFMC and ASFMC 1998a, 1998b; SAFMC 1998; MAFMC and NEFMC 1999). Eggs are those individuals that have been spawned but have not hatched and are completely dependent on yolk for nutrition, while larvae are individuals that have hatched and have the ability to capture food; juveniles are those individuals with fully formed organ systems and that are not sexually mature but otherwise morphologically similar to adults, whereas adults are sexually mature individuals that are not necessarily in spawning condition, while spawning adults are those individuals in spawning condition (Moyle and Cech 1982; SAFMC 1998).

Although the individual lifestage terms and definitions are the same as those defined by the FMCs, the NMFS categorizes the lifestages of managed tuna, swordfish, and billfish somewhat differently, resulting in three categories based on common habitat usage by all lifestages in each group: 1) Spawning Adult, Egg, and Larva, 2) Juvenile and Subadult or Juvenile, and 3) Adult (NMFS 2006h). The category of spawning adult, eggs, and larvae is dependent upon spawning locations and circulation patterns that control the distribution of this lifestage. Subadults are those individuals just reaching sexual maturity. The juvenile and subadult category is a cumulative group in which all lifestages between age one and maturity have been lumped. Adults are sexually mature fishes.

The NMFS now classifies EFH for sharks in terms of three lifestages based on the most current research and the general habitat shifts that accompany each developmental stage (NMFS 2006h). The three resulting lifestage categories for sharks are: (1) Neonate (primarily includes neonates and only small young-of-the-year); (2) Juvenile (includes all immature sharks from young to older/late juveniles); and (3) Adult (sexually mature sharks; largest size class) (NMFS 2006h).

5.2.1 Subtropical-Tropical Water Species

- Atlantic Calico Scallop (*Argopecten gibbus*)

Management—Atlantic calico scallops are managed by the SAFMC through the Calico Scallop FMP (SAFMC 1998).

Status—The Atlantic calico scallop fishery is neither overfished nor is overfishing occurring (NMFS 2005b).

Distribution—Atlantic calico scallops have a patchy distribution ranging from the Delaware Bay south through Bermuda and the Gulf of Mexico to the northern side of the Greater Antilles (SAFMC 1998; FMRI 2003a).

Habitat Preferences—Larval Atlantic calico scallops are initially pelagic and planktonic but settle as spat. Spat primarily attach to shells of dead or living mollusks but also attach to objects such as navigation buoys and other floating objects (SAFMC 1998). Upon reaching 2.5 centimeters (cm), Atlantic calico scallops detach and are capable of swimming (SAFMC 1998). Larger, unattached Atlantic calico scallops prefer substrates of hard sand, sand and shell, quartz sand, smooth sand-shell-gravel, and sand and empty shells (SAFMC 1998). They are typically found ranging from depths of 10 to 400 m in open marine or saline estuarine waters (FMRI 2003a; SMS 2004).

Life History—Atlantic calico scallops are hermaphroditic and sequentially release sperm and eggs into the water where fertilization occurs (SAFMC 1998; FMRI 2003a). Spawning takes place throughout the year but occurs with the highest frequency during the late fall and spring (FMRI 2003a). They may spawn intermittently multiple times during the spawning season (SAFMC 1998).

Common Prey Species—Atlantic calico scallops primarily feed on microflora including detritus, bacteria, and organic matter (SAFMC 1998).

EFH Designations—(SAFMC 1998; Figure D-1)

- Larva—The Gulf Stream has been designated as EFH due to its role as a dispersal mechanism.
- All Lifestages—EFH for Atlantic calico scallops has been designated from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) as unconsolidated sediments including hard sand bottoms; sand and shell hash; quartz sand; smooth sand-shell-gravel; and dead mollusk shells in water depths ranging from 13 to 94 m.

HAPC Designations—There are no HAPC identified for this species.

- Blackfin Snapper (*Lutjanus buccanella*)

Management—Blackfin snapper are managed by the SAFMC through the Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in the south Atlantic Bight (SAB) (NMFS 2005b).

Distribution—Blackfin snapper range from Massachusetts to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is most common off western Florida and considered rare north of Cape Hatteras, NC (SAFMC 1998; Murray and Bester 1999a; GMFMC 2004).

Habitat Preferences—This demersal species prefers sandy or rocky habitats near ledges or drop-offs and typically occurs from bottom depths of 40 to 300 m (preference of 60 to 90 m) (Murray and Bester 1999a; SAFMC 2003a). Adults are found further offshore (near the continental shelf) than juveniles, which inhabit shallow reefs and hard bottom habitats in water depths of 6 to 50 m (SAFMC 1998; Murray and Bester 1999a; SAFMC 2003a). The availability of suitable substrate is considered more important than water depth preferences for the distribution of this species (SAFMC 2003a). Eggs and larvae are pelagic (SAFMC 1983).

Life History—This species is capable of spawning year round but peak spawning activity occurs in April and September. Spawning locations have only been identified off the coast of Jamaica (Murray and Bester 1999a).

Common Prey Species—This species is an opportunistic feeder that preys on benthic invertebrates and fishes (Murray and Bester 1999a). When associated with the Charleston Bump (SC), swimming crabs are the main component of the blackfin snapper's diet (Weaver and Sedberry 2001).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-2)

- Larva—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.
- Juvenile—Waters 12 to 40 m deep from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) with live/hard bottom habitat are interpreted as EFH for this lifestage.
- Adult—Waters of 40 to 300 m deep along the shelf edge from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-2)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, Key Biscayne, FL/Artificial Reef-H SMZ, and seagrass habitat are designated as HAPC. Additional HAPC designated, but not located within the study area, are mangrove habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC, Ten Fathom Ledge, NC; Big Rock, NC, the Charleston Bump, SC, *Oculina* Bank HAPC, council-designated artificial reef SMZs, and manganese outcroppings on the Blake Plateau.

- Bluefish (*Pomatomus saltatrix*)

Management— The bluefish population in U.S. Atlantic waters is thought to comprise a single stock managed under the Bluefish FMP, which was developed by the MAFMC and the ASMFC (MAFMC and ASMFC 1998a).

Status—The bluefish is considered overfished in the SAB (NMFS 2005c).

Distribution—The bluefish is a schooling species found in most oceans of the world, except the eastern Pacific Ocean. In the western Atlantic Ocean, the bluefish distribution ranges from Nova Scotia and Bermuda to Argentina, but the species is considered rare between southern Florida and northern South America (Fahay et al. 1999).

Habitat Preferences—Bluefish are a warm-water pelagic species that rarely occur in temperatures below 14°C and utilize both offshore and inshore habitats (Klein-MacPhee 2002a). Bluefish eggs are pelagic (water depths less than 100 m) and are found in waters with temperatures above 18°C and salinities >31 psu between the months of April and August, while bluefish larvae, also pelagic (depths from 34 to 183 m), are found from April through September in waters with a temperature above 18°C and salinity >30 psu (Pattillo et al. 1997; MAFMC and ASMFC 1998a). Larvae are transported from spawning grounds in the SAB to northeastern U.S. estuaries by the Gulf Stream (Hare and Cowen 1996). Juveniles utilize estuarine benthic habitat (shell, sand, and hard packed mud) in the SAB from March to December (Pattillo et al. 1997; MAFMC and ASMFC 1998a). Adult bluefish utilize offshore and estuarine habitats with water temperatures typically above 16°C (Fahay et al. 1999). Adults are found in estuaries of the SAB from May through January (MAFMC and ASMFC 1998a).

Life History—Bluefish adults are highly migratory and perform both north-south and inshore-offshore movements. Bluefish move north in the spring and summer seasons, when they are found in highest abundance off the coast of New York and coastal southern New England (Klein-MacPhee 2002a). In

the fall and winter, bluefish move both southward and offshore to overwinter in the SAB, between coastal Florida and the Gulf Stream. Light levels and water temperature are the primary triggers for migrational movements but offshore and inshore migrations also parallel the movements of their prey (Klein-MacPhee 2002a). The bluefish population inhabiting the Gulf of Mexico remains separate from that of the SAB (Oliver et al. 1989). Bluefish spawn by broadcasting their gametes in the water column. A spring spawning event occurs near the edge of the continental shelf in the SAB during March through May in waters with temperatures between 18° and 25°C and salinities from 25 to 31 psu (Fahay et al. 1999; Klein-MacPhee 2002a).

Common Prey Species—Bluefish are piscivorous and feed opportunistically on a variety of species, including menhaden, herring, alewife, anchovy, eel, sculpin, killifish, silverside, croaker, scup, gobies, sand lance, butterfish, and mackerel during daylight hours as they're visual feeders. This species also feeds on invertebrates (shrimp, squid, crabs, worms) and is known for cutting and tearing prey into pieces (Oliver et al. 1989; Klein-MacPhee 2002a).

EFH Designations—(MAFMC and ASMFC 1998a; NMFS 2002c Figure D-3)

- Egg—South of Cape Hatteras, NC, EFH for the bluefish includes 100% of the pelagic waters at mid-shelf depths over the continental shelf (from the coast out to the eastern wall of the Gulf Stream) to Key West, FL. Additional designated EFH not located in the study area occurs north of Cape Hatteras.
- Larva—EFH designated for this lifestage south of Cape Hatteras, NC to Key West, FL includes 100% of the pelagic, continental shelf waters deeper than 15 m from shoret to the Gulf Stream boundary. Additional areas designated as EFH for this lifestage are not found within the study area but are located north of Cape Hatteras, NC and the Slope Sea.
- Juvenile—100% of the pelagic waters of the continental shelf (from shore to the Gulf Stream boundary) from Cape Hatteras, NC to Key West, FL are designated as EFH for this lifestage of the bluefish. Additional EFH has been designated outside the bounds of the study area as the estuaries and embayments along the eastern U.S. coast areas between Cape Hatteras and the Slope Sea.
- Adult—From Cape Hatteras, NC to Key West, FL, designated EFH includes 100% of the pelagic waters over the continental shelf (from shore to the Gulf Stream boundary). Additional EFH designated for this lifestage, but not located within the study area, is the U.S. Atlantic coast estuaries and embayments and areas north of Cape Hatteras.

HAPC Designations—There are no HAPC identified for this species.

- Blueline Tilefish (*Caulolatilus microps*)

Management—Blueline tilefish are managed within the SAFMC's Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in the SAB (NMFS 2005b).

Distribution—Blueline tilefish range from Cape Charles, Virginia to Campeche Banks, Mexico but are primarily found south of Cape Hatteras, NC (Manooch 1988; SAFMC 1998).

Habitat Preferences—This benthic species is typically found in waters with depths of 68 to 236 m and temperatures between 15° and 23°C. Blue tilefish prefer irregular bottom habitats, such as troughs, ledges, crevices, and terraces, intermingled among sand, mud, and shells along the continental shelf (Manooch 1988;SAFMC 2003a). Blueline tilefish also inhabit cone-shaped burrows (Manooch 1988). Eggs and larvae are pelagic (SAFMC 1983).

Life History—Blueline tilefish spawn from February to October, peaking in the summer and correlating with photoperiod (SAFMC 1983; Manooch 1988; Sedberry et al. 2004; Sedberry et al. 2006). Off the North Carolina and South Carolina coasts, spawning was recorded in both May/June and September/October, with females capable of multiple spawning events (Ross and Merriner

1983). Numerous spawning locations have been identified from off the coast of South Carolina between the 48 and 234 m isobath from Marine Resources Monitoring Assessment and Prediction (MARMAP) surveys in waters with bottom temperatures ranging from 8.8 to 16.2°C (SAFMC 2004b; Sedberry et al. 2006).

Common Prey Species—This species feeds on other benthic species, such as crabs, shrimp, worms, snails, urchins, and fishes (Manooch 1988).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-4)

- Egg—Pelagic waters from Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage of the blueline tilefish.
- Larva—Designated EFH for this lifestage is pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion.
- Adult—EFH for this lifestage of the bluefin tilefish is interpreted as the irregular ocean bottom consisting of troughs and terraces intermingled with sand, mud, or shell hash in water depths of 68 to 236 m extending from Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-4)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, Key Biscayne, FL/Artificial Reef-H SMZ, and seagrass habitat are designated as HAPC. Additional HAPC designated, but not located within the study area, are mangrove habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC, Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC, *Oculina* Bank HAPC, council-designated Artificial Reef SMZs, and manganese outcroppings on the Blake Plateau.

- Brown Rock Shrimp (*Sicvonia brevirostris*)

Management—Brown rock shrimp are managed by the SAFMC under the Shrimp FMP (SAFMC 2002b).

Status—Currently, brown rock shrimp stocks in the SAB are not considered overfished or subject to overfishing (NMFS 2005b).

Distribution—Brown rock shrimp are found in the GOMEX, Cuba, the Bahamas, and along the U.S. Atlantic coast as far north as Virginia. The center of abundance for these shrimp in the SAB occurs off northeast Florida south to Jupiter Inlet (SAFMC 1998).

Habitat Preferences—Brown rock shrimp live mainly on sand or silt bottoms from a few meters to 183 m in depth but will occasionally occupy deeper waters if suitable bottom habitat exists. The largest concentrations of these shrimp are found between depths of 25 and 65 m. Brown rock shrimp are also known to utilize hard bottom and coral habitats, specifically the *Oculina* coral habitat off Florida's east coast. No information exists on the larval stage of this species (SAFMC 1998).

Life History—The spawning season for brown rock shrimp is variable, with peak spawning beginning between November and January and lasting three months. Peak spawning activity seems to occur monthly and coincides with the full moon. Brown rock shrimp may be present year round in the spawning areas with no trend relative to depth, temperature, salinity, and length of moon phase (SAFMC 1998). The major transport mechanisms affecting planktonic larval brown rock shrimp are the shelf current systems near Cape Canaveral, FL. These currents retain larvae on the Florida Shelf and may transport them inshore in spring. Recruitment to the area offshore of Cape Canaveral, FL occurs between April and August with two or more influxes of recruits entering within one season (SAFMC 1998).

Common Prey Species—Brown rock shrimp feed on benthic prey consisting of small bivalve mollusks and decapod crustaceans (SAFMC 2002b).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-5)

- Larva—The Gulf Stream, as well as shelf current systems near Cape Canaveral, FL, are designated as EFH, as they provide a mechanism to disperse brown rock shrimp larvae.
- Adult—EFH is interpreted as terrigenous (produced by the earth) and biogenic (produced by living organisms or biological processes) sand bottom habitats located on the continental shelf from 18 to 182 m in depth extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).

HAPC Designations— No HAPC are identified for this species.

- Brown Shrimp *(Farfantepenaeus aztecus)*

Management— Brown shrimp in Atlantic waters are managed as part of the SAFMC Shrimp FMP (SAFMC 1998).

Status—Currently, the brown shrimp is neither overfished nor subject to overfishing in the northwestern Atlantic (NMFS 2005b).

Distribution—Brown shrimp occur in the U.S. Atlantic from Martha's Vineyard, MA to the Florida Keys and in the Gulf of Mexico from Apalachicola Bay, FL to the Yucatan Peninsula, Mexico (Larson et al. 1989). In the SAB, brown shrimp are most abundant off the North Carolina coast and are considered moderately abundant from South Carolina to Florida (Pattillo et al. 1997).

Habitat Preferences—Depending upon the lifestage, brown shrimp are either pelagic or benthic, oceanic or estuarine. Both eggs and larvae are found in offshore waters, although eggs occur near the seafloor while larvae most often occur in the upper part of the water column (Larson et al. 1989). Postlarvae, juveniles, and subadults become benthic and inhabit estuarine habitats with soft, muddy bottoms (e.g., salt marshes, tidal creeks) and often associate with SAV (e.g., seagrass beds). Brown shrimp spawned in the fall typically overwinter by burrowing into sediments (Pattillo et al. 1997). Adult brown shrimp are found in offshore waters of the upper to mid-continental shelf, where they are associated with silt, muddy sand, shell, and sandy substrates. Brown shrimp can be euryhaline or stenohaline depending upon lifestage. This species can tolerate water temperatures from 4° to 36°C, but their preferred temperature range is between 15° and 31°C (Pattillo et al. 1997; SAFMC 1998; NMFS 2002c).

Life History—After females molt, brown shrimp spawn in ocean waters with depths usually between 18 and 137 m and temperatures ranging from 17° to 29°C (Larson et al. 1989; Patillo et al. 1997; GMFMC 2004). In the SAB, spawning occurs from North Carolina to northeast Florida throughout most of the year (Pattillo et al. 1997). While they may occur seasonally along the MAB, breeding populations of brown shrimp apparently do not range north of North Carolina (SAFMC 1998). Seasonal movements of brown shrimp are related to water temperature patterns. Emigration to offshore spawning grounds occurs from May through August and coincides with full moons and ebb tides. Surface ocean currents transport larval shrimp to coastal areas during late winter and early spring. The larvae then move into estuaries toward nursery grounds, using tidal cycles, when temperatures rise above 11°C (Whitaker 1981). Brown shrimp immigrate to nursery areas in North Carolina, Georgia, and Florida from March through June, to South Carolina's estuaries between March and April (Larson et al. 1989), and to estuaries of the Gulf of Mexico from February to mid-April and from June to September (GMFMC 1981).

Common Prey Species—Brown shrimp are omnivorous consuming benthic invertebrates, detritus, algae, diatoms, and small fishes, usually at night (Larson et al. 1989; Pattillo et al. 1997).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-6)

- Egg—Demersal marine habitats located between depths of 13.7 and 110 m, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W), are interpreted as EFH for this lifestage.
- Larva—Pelagic waters less than 110 m in depth ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Juvenile—Estuarine areas consisting of marshes, wetlands, tidal palustrine forested areas, mangroves, submerged aquatic vegetation, and subtidal and intertidal non-vegetated flats, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W), are interpreted as EFH for this lifestage but are not located within the study area.
- Adult—Silty sand and muddy sand bottoms located in ocean waters less than 110 m deep ranging, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W), are interpreted as EFH.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-6)

- All Lifestages—All coastal inlets, state designated nursery areas, and state-identified overwintering areas are designated as HAPC for penaeid shrimp species (brown, pink, and white). None of these areas are within the boundaries of the study area.

♦ Caribbean Spiny Lobster (*Panulirus argus*)

Management—Caribbean spiny lobsters are managed jointly by the GMFMC and the SAFMC through the FMP for the Spiny Lobster Fishery (GMFMC and SAFMC 1982). The generic term "spiny lobster" refers both to the Caribbean spiny lobster as well as the ridged slipper lobster, the other species included in the Spiny Lobster MU and fishery. The term spiny lobster when used below refers to generally to both species.

Status—The spiny lobster stock on the southeastern Atlantic coast of the U.S. is not overfished and overfishing is currently not occurring (NMFS 2005b).

Distribution—Caribbean spiny lobsters are found in the waters off the southeastern coast of the U.S. from Cape Hatteras, NC to southeast Florida, the Gulf of Mexico, Bermuda, the Bahamas, the Caribbean Sea, and the southwestern Atlantic off the coast of central Brazil (Appeldoorn et al. 1987). This species is most abundant off the southern coast of Florida (Pattillo et al. 1997)

Habitat Preferences—The eggs of the Caribbean spiny lobster remain attached to the adult for three weeks until they hatch. Upon hatching, the phyllosome (leaf-bodied) larvae disperse into the offshore waters along the deeper reef fringes (Marx and Herrnkind 1986). The larvae remain in the pelagic environment for six to twelve months as plankton while developing into pueruli (post-larvae) (Appeldoorn et al. 1987). The pueruli move across the shelf, remaining within a few centimeters of the surface and then settle to the benthic environment in shallow water upon reaching suitable habitat (GMFMC and SAFMC 1982; Marx and Herrnkind 1986; Appeldoorn et al. 1987). Juveniles are associated with rocky shorelines and seagrass beds (Marx and Herrnkind 1986). Late juveniles prefer seeking refuge in protected bays and high salinity estuaries. Such shelters include rocky outcroppings or ledges, grass bed undercuts, large sponges, solution holes, coral heads, mangrove roots, and clumps of sea urchins (Marx and Herrnkind 1986). Upon reaching maturity, adult lobsters move offshore and disperse among the rocks, artificial reefs, hard bottom substrates, ledges, caves, limestone outcroppings, or coral reefs to depths of 80 m or greater (Marx and Herrnkind 1986; GMFMC 2004).

Life History—Adult Caribbean spiny lobsters display movement patterns in the fall and during the spring reproductive period. In the spring, female spiny lobsters migrate to deeper reefs presumably to mate and shed larvae. Following the release of their larvae, females return to shallower water (Marx and Herrnkind 1986; Appeldoorn et al. 1987). In the autumn months, as temperatures decline and fall storms begin, both males and females emigrate offshore (Marx and Herrnkind 1986). The mating

season in Florida for the Caribbean spiny lobster occurs from February to April along the continental shelf edge (GMFMC and SAFMC 1982; Appeldoorn et al. 1987). In the Bahamas, spawning peaks from April to July (BREEF and MEPL 1998).

Common Prey Species—The Caribbean spiny lobster is a nocturnal predator that feed on a diverse range of food, including algae, foraminifera, sponge spicules, polychaetes, bivalves, conchs, hermit crabs, and other crustaceans (GMFMC 1998)

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-7)

- Larva—The Gulf Stream, due to its role as a dispersal mechanism, is designated as EFH.
- All Lifestages—EFH is designated for the spiny lobster as the nearshore shelf/oceanic waters, unconsolidated bottom (soft sediments), coral and live/hard bottom habitat, and sponges ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83° W). Seagrass habitat, mangrove habitat, shallow subtidal bottom, and algal communities (*Laurencia*) are also designated as EFH but do not occur within the study area.

HAPC Designations—(SAFMC 1998; Figure D-8)

- All Lifestages—Florida Bay, Biscayne Bay, Card Sound, and coral/hard bottom habitat from Jupiter Inlet, FL through the Dry Tortugas National Park, FL are designated as HAPC. Only areas from Jupiter Inlet through the Dry Tortugas National Park are located within the boundaries of the study area.

- Cobia (*Rachycentron canadum*)

Management—Cobia are managed jointly by the SAFMC and GMFMC through the FMP for the Coastal Migratory Pelagic MU (GMFMC and SAFMC 1985).

Status—This species is not overfished in the SAB (NMFS 2005b).

Distribution—Cobia are distributed worldwide throughout tropical, subtropical, and warm-temperate waters, with the exception of the eastern Pacific (Williams 2001). In the northwest Atlantic, cobia range from Massachusetts to Argentina, including Bermuda, but are most common along the U.S. coast south of Virginia and in the northern Gulf of Mexico (Franks et al. 1999; FMRI 2003b). In the Bahamas, this species if commonly found in the Bimini region of the Great Bahamas Bank (Böhlke and Chaplin 1993).

Habitat Preferences—Cobia eggs and larvae are pelagic and found at the surface or within the upper meter of the water column (Ditty and Shaw 1992). Eggs occur between May and August and larvae are found from May through September across the continental shelf from the Gulf Stream to inshore inlets and bays (GMFMC and SAFMC 1985; Ditty and Shaw 1992; Franks et al. 1999). Eggs are typically found in surface water exceeding 20°C in temperature and between 19 and 35 psu in salinity (Ditty and Shaw 1992). Developing larvae occupy waters with temperatures of 24.2° to 32°C, salinities between 18.9 and 37.7 psu, and depths of less than 100 m (Ditty and Shaw 1992). Juvenile and adult cobia are found in coastal bays and inlets and across the continental shelf. Juveniles occur at temperatures between 16.8° and 25.2°C and at salinities of 30 to 36.4 psu. Adults prefer temperatures of 19.6° to 28°C, salinities ranging from 24.6 to 36.4 psu, and waters ranging in depth from nearshore shallows out to 70 m (shallower in eastern Gulf than in northern Gulf) (GMFMC 1998). Cobia are closely associated with any type of structure, including artificial reefs, pilings, platforms, anchored boats, pelagic *Sargassum*, and flotsam (GMFMC 1998; Bester 1999a; Williams 2001).

Life History—Spawning for the cobia occurs in the daylight hours between April and September in estuarine or shelf waters of the Atlantic and Gulf of Mexico (GMFMC and SAFMC 1985; Ditty and Shaw 1992; CBP 2004). Cobia are batch spawners and form large aggregations during spawning (Bester 1999a; Williams 2001). Cobia also undergo seasonal migrations. Following the spawning season, cobia migrate south to warmer offshore waters of the Florida Keys during the autumn and

winter (CBP 2004). In the spring, they begin their migration north to the poly/mesohaline waters of coastal Virginia and the Carolinas for the summer to spawn (Williams 2001).

Common Prey Species—Demersal organisms, particularly crustaceans, make up the majority of the cobia's diet. Particularly, shrimp (mantis and penaeid), eels, squid, and crabs are consumed with the highest frequency. Several fish species have also been observed in the stomachs of cobia, including Spanish mackerel (GMFMC and SAFMC 1985). They also are commonly seen in schools following sharks, turtles, and large rays as they feed, to scavenge food from the other animals (Williams 2001; CBP 2004).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-8)

- Larva—The Gulf Stream is designated as EFH for this lifestage of the cobia as it provides a mechanism for dispersal.
- All Lifestages—EFH for the cobia is designated from the shore to the Gulf Stream boundary of the MAB and SAB as sandy shoals of capes and offshore bars, high profile rock bottoms, and the waters on the seaward side of barrier islands. Pelagic *Sargassum* within the U.S. EEZ is also designated as EFH. In addition, high salinity bays, estuaries, seagrass habitat, all coastal inlets, and all state-designated nursery habitats are also designated as EFH for this species but are not located within the study area.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-8)

- Juvenile and Adult—Although not included in the study area, the portions of Broad River in South Carolina with salinities exceeding 25 psu during the months of May through July have been designated as HAPC for these lifestages of the cobia.
- All Lifestages—HAPC for all cobia lifestages have been designated as the Point off Jupiter Inlet, *Phragmatopoma* (worm) reefs off the east coast of Florida, and pelagic *Sargassum*. Additional areas designated as HAPC but not located in the study area include the Hump off Islamorada, FL; the Marathon Hump off Florida; the Wall off the Florida Keys; nearshore hard bottom (<4 m) south of Cape Canaveral, FL; the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, NC from shore to the ends of the respective shoals but shoreward of the Gulf stream; The Point in North Carolina waters; Ten-Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and Hurl Rocks, SC.

- Corals (Stony Corals and Octocorals)

Management—In the South Atlantic Region, EFH has been identified by the SAFMC for the coral, coral reefs, and live/hard bottom habitat as one MU consisting of approximately 118 species (SAFMC 1998).

Status—Currently, there are no species within the MU that are subject to overfishing or are overfished in the SAB (NMFS 2005b). Two species of corals are designated as either a species of concern (ivory tree corals [*Oculina varicosa*] or a candidate species (fused-staghorn [*Acropora prolifera*] (NMFS 2004b). The elkhorn coral (*Acropora palmata*) and the staghorn coral (*Acropora cervicornis*) have been recently designated by the NMFS as threatened (see Chapter 3 for more information) (NMFS 2006f). All but the ivory tree corals are distributed south of the study area's U.S. waters. The threatened *Acropora* spp. ranges do extend into the southern portion of the Florida study area (Palm Beach County), although they are not currently found there. However, they do ocurr within the Bahamas portion of the study area but are not discussed in this section since EFH/HAPC are designated only for U.S. waters. Since true coral reefs do occur within the study area, the Coral Reef Protection Executive Order 13089 does apply.

Distribution—Coral reefs are tropical, primarily shallow water ecosystems, largely restricted to the area between 30°N and 30°S (UNEP/IUCN 1988). The Florida reef tract, from Miami to the Dry Tortugas National Park, represents the northernmost extent of true coral reefs along the eastern U.S. coast. Coral diversity and abundance abruptly declines north of Miami, although live/hard bottom

communities containing hermatypic corals and gorgonians (represented as solitary corals or deepwater banks/mounds) can be found as far north as Cape Lookout, NC (Jaap et al. 1990).

Habitat Preferences—Corals exist in oceanic habitats ranging from nearshore to the continental slopes and canyons, including intermediate shelf zones. Various coral species inhabit these oceanic habitats including stony corals belonging to the Class Hydrozoa (fire corals and hydrocorals) or Class Anthozoa [true stony, soft corals (i.e., octocorals), and anemones], subclass Octocorallia (sea fans, sea whips, sea pens, and sea fans) and subclass Zooantharia (black and stony corals) (Kaplan 1982, SAFMC 1998). Corals may be the primary component of a habitat (e.g., coral reefs), contribute to a habitat (e.g., hard bottoms), or exist as individuals within a community characterized by other fauna (e.g., solitary corals) (SAFMC 1998).

Corals along the eastern coast of the U.S. are dependent on continual supplies of propagules from upstream reefs transported by the Gulf Stream and coastal current. Distribution of corals is contingent on a variety of environmental parameters. Latitude-correlated environmental parameters include temperature, light, substrate, and currents. Light availability is one of the most ecologically significant of these parameters, since many corals have a symbiotic relationship with zooxanthellae algae, which directly influences coral growth and reef accretion. Furthermore, low temperatures (<11°C) will generally kill zooxanthellae, while high temperatures (30° to 34°C) will cause coral bleaching (disruption of coral-zooxanthellae symbiosis due to expulsion of the zooxanthellae). Non-latitude-correlated or regional environmental factors that affect coral growth include surface water circulation, substrate availability, sedimentary regimes, tidal regimes, and nutrients. The most limiting of these parameters to reef coral distribution is substrate availability (Veron 1995). In the Florida waters of the study area, deepwater corals are proliferate and are located along the edge of the continental shelf, on the continental slope, and in deep channels (Stetson et al. 1962; Reed 1992, 2002).

The deepwater coral, *Oculina varicosa*, has formed one of the most dominant coral communities in southeastern U.S. waters (Reed 1980). Situated from Cape Canaveral to Fort Pierce, Florida, the branching scleractinian coral has formed massive colonies on high-relief pinnacles in such profuse growth that the resulting reef structure has been termed the *Oculina* Bank. Located along the continental shelf edge in water depths ranging from 55 m to over 122 m, the majority of *Oculina* growth occurs in a 2 to 6 km-wide band that parallels the 80°W meridian (Avent et al. 1977; Barnette 2006). *Oculina varicosa* is highly adaptable and is capable of growing in a wide range of water depths; in shallow waters the ivory tree coral forms small colonies and relies on zooxanthellae and photosynethesis as its food source but in deeper water, *Oculina varicosa* lacks zooxanthellae, depending upon plankton for food as its food source and forms profuse tree-shaped thickets (Reed 1980). In recognition of the importance of the habitat on *Oculina* Bank, the SAFMC in 1984 designated a portion of *Oculina* Bank 92 km^2 in size as a Coral-HAPC (C-HAPC) (see Figure 4-6; SAFMC 1998).

Another deepwater coral*, Lophelia pertusa,* is an ahermatypic species found in study area water depths from 670 to 866 m growing on dead coral mounds and ridges (SAFMC 2006b). This coral forms colonies up to 1 m tall, creating reef-frameworks and coral banks (Wilson 1979; Reed 1992). *Lophelia* colonies provide habitat for commercially important species of fish; within the study area a *Lophelia* HAPC site has been proposed off the east coast of Florida from Jupiter to Jacksonville between 700 and 800 m (SAFMC 2006b). Additionally, the deepwater corals *Enallopsammia profunda* and *Madrepora oculata* also occur in the study area but no EFH or HAPC have been designated for these species (Reed 2004, 2006).

Life History—Octocorals reproduce by releasing sperm into the water column with internal fertilization and development. Larvae are released and later settle on substrate to complete metamorphosis. Hermatypic stony corals have separate sexes or can be hermaphroditic, as well as being able to reproduce by external or internal fertilization (Jaap 1984).

Common Prey Species—Stony coral and octocoral species derive nutrients from photosynthesis via symbiotic algae (zooxanthellae) but other corals, particularly the deepwater species, ingest zooplankton, bacteria, detritus, or dissolved organics (SAFMC 1998).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-10)

- Hermatypic (Stony) Corals—Rough, hard, exposed, and stable substrate in waters from the subtidal zone to depths of 30 m with temperatures between 15 and 35°C, high salinity (30 to 35 psu), and turbidity levels low enough to allow for an adequate amount of light for photosynthesis are designated as EFH in the study area.
- Ahermatypic (Stony) Corals—Hard substrates ranging from subtidal to outer shelf depths are designated as EFH in the study area.
- Black Corals (*Antipatharia*)—EFH is designated as rough, hard, exposed, and stable substrate in waters <18 m with high salinity (30 to 35 psu) that are not light restricted. No shallow-water black corals are located in the study area but do occur south of the study area boundary.
- Octocorals (excluding sea pens and sea pansies)—EFH, in the study area, is designated as rough, hard, exposed, and stable substrate with a wide range of salinity and light penetration from the subtidal zone to outer shelf depths.
- Sea Pens and Sea Pansies (*Pennatulacea*)—Muddy and silty bottoms in waters with a wide range of salinity and light penetration, from the subtidal zone to outer shelf depths, are designated as EFH in the study area.

HAPC Designation —(SAFMC 1998; Figure D-9)

- Stony corals, black corals, and octocorals)—Areas designated as HAPC for these coral species in the study area include the *Oculina* Bank; *Phragmatopoma* (worm) reefs (off eastern Florida); and offshore (5 to 30 m) hard bottom from Palm Beach County, FL to Fowey Rocks, FL. Additional HAPC designated but not located within the study area includes Ten Fathom Ledge, NC; Big Rock, NC; The Point, NC; Hurl Rock, SC; Charleston Bump, off SC; Gray's National Marine Sanctuary (off GA); Biscayne Bay, FL; Biscayne National Park, FL; the Florida Keys National Marine Sanctuary; and nearshore hard bottom (<4 m) from Cape Canaveral to Broward County, FL.

C-HAPC Designation —(SAFMC 1998; Figure D-9)

- All Coral Species (stony corals, black corals, and octocorals)—*Oculina* Bank HAPC is designated as a Coral-Habitat Particular Concern (C-HAPC).

- Dolphinfishes (*Coryphaena* spp.)

Management—There are two species of dolphinfish managed by the SAFMC (2003b) through the FMP for the Dolphin and Wahoo Fishery of the Atlantic, the dolphinfish (*Coryphaena hippurus*) and the pompano dolphinfish (*C. equiselis*) (SAFMC 2003b).

Status—Neither of the dolphinfish species in the northwestern Atlantic is considered overfished (NMFS 2005b).

Distribution—Dolphinfishes have a worldwide distribution throughout tropical and subtropical waters (Rivera and Appeldoorn 1999). In the western Atlantic, these species have been observed as far north as Prince Edward Island and as far south as Rio de Janeiro, but they generally prefer areas of warmer water (greater than 20°C) influenced by the Gulf Stream (Manooch 1988; Schultz 2004). The dolphinfish is common throughout the Bahamas, while the pompano dolphinfish is often found on Little Bahamas and Great Bahamas Banks (Böhlke and Chaplin 1993).

Habitat Preferences—Dolphinfish eggs are found in oceanic waters over or beyond the continental shelf and are pelagic (Ditty et al. 1994). The larvae most often occur in water temperatures exceeding 24°C and salinities above 33 psu, with concentrations increasing with an increase in pelagic *Sargassum* abundance (Ditty et al. 1994). Juvenile dolphinfishes are found throughout the Atlantic but also tend to congregate around pelagic *Sargassum* and floating objects (Beardsley 1967). Adult dolphinfishes are epipelagic with the 20°C isotherm considered to be the limit of their distribution (SAFMC 2003b; GMFMC 2004). Adult dolphinfishes have been found in the highest concentrations in water temperatures ranging from 26° to 28°C, during late spring and summer (Beardsley 1967).

Females and smaller males associate with pelagic *Sargassum* and floating debris, while larger males more often frequent the open ocean (SAFMC 2003b).

Life History—Spawning in dolphinfishes takes place throughout the year in the Atlantic in waters warmer than 24°C, with peak spawning periods occurring in the spring and early fall (Beardsley 1967; GMFMC 1998). Two stocks of the dolphinfish (*C. hippurus*) have been proposed for the western Atlantic with separate migration patterns. The two stocks are located to the southeast and the northwest of Puerto Rico and the Virgin Islands. The northwest stock moves in a clockwise circular migration pattern. It is found off of Puerto Rico between December and February, between Florida and Georgia during May and June, off of South Carolina and southeastern North Carolina between June and July, and around Bermuda during July through August (Rivera and Appeldoorn 1999).

Common Prey Species—Dolphinfishes are non-selective, opportunistic foragers that feed during daylight hours in surface waters (SAFMC 2003b). Their diet consists of both fishes and invertebrates. Dolphinfishes consume small oceanic pelagic fishes (e.g., flying fish, halfbeaks, and rough triggerfish), the young of large oceanic pelagic species (e.g., jacks, dolphinfishes, tunas, and billfish), and the pelagic larvae of neritic, benthic species (e.g., grunts, triggerfish, pufferfish, and flying gurnards). Cephalopods, crabs, scyphozoans, and mysids are included among the invertebrate species that dolphinfishes prey upon (FMRI 2003c; SAFMC 2003b).

EFH Designations—(SAFMC 2003b, 2004a; Figure D-10)

- All Lifestages—The Gulf Stream and associated gyres and eddies occurring in the Atlantic EEZ, the Florida Current and associated gyres and eddies, and the Charleston Gyre have been designated as EFH for dolphinfishes in the northwestern Atlantic.

HAPC Designations —(SAFMC 2003b, 2004a; Figure D-10)

- All Lifestages—The Amberjack Lump is designated as HAPC for this species and is located in the study area. Additional HAPC designated, but not occurring within the study area, are the Hump off Islamorada, FL; the Marathon Hump, FL; and the Wall off the Florida Keys, The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, off SC; and the Georgetown Hole, SC.

- Golden Deepsea Crab (*Chaceon fenneri*)

Management—Golden deepsea crabs are managed by the SAFMC through the FMP for the Golden Crab Fishery of the South Atlantic Region (SAFMC 1995).

Status—It is unknown whether this species is overfished or if overfishing is currently occurring (NMFS 2005b).

Distribution—Golden deepsea crabs are distributed off the eastern U.S., from the Chesapeake Bay south through the Florida Straits and into the Gulf of Mexico on the continental slope (Wenner et al. 1987; Wenner and Barans 1990; SAFMC 1995).

Habitat Preferences—Golden deepsea crabs are found in highest abundance in the SAB at depths of 367 to 549 m. Their relative abundance is primarily driven by sediment type, with the largest catches occurring over substrates composed of a mixture of silt-clay and foraminiferan (Wenner et al. 1987). Wenner and Barans (1990) identified seven habitats on the continental slope inhabited by the golden deepsea crab. The first and most frequently encountered habitat was ooze characterized by foraminifera/pteropod debris mixed with larger shell fragments, which occurred at depths of 405 to 567 m. Golden deepsea crabs were also found to be relatively abundant in habitats containing distinct mounds, primarily of dead coral, found between 503 and 555 m of depth. Other areas of occurrence include ripple habitat, substrates with current crescents and occasional depressions of 1-2 m (320 to 539 m); dunes (389 to 472 m); black pebble habitat (446 to 564 m); low outcrop habitat (466 to 512 m); and soft-bioturbated habitat (293 to 475 m). The SAFMC (1998) based its EFH designations on the seven habitats identified by Wenner and Barans (1990) but used additional survey data to expand the depth ranges of the habitats

Life History—Female golden deepsea crabs are typically found in shallower areas than males. The female crabs position themselves against the prevailing current, such as the Gulf Stream in the SAB, prior to releasing larvae. This position minimizes the risk of larvae being flushing from the area and results in the maximum recruitment into the parent population (SAFMC 1999).

Common Prey Species—The feeding habits of the golden deepsea crab are not well known. They are often described as opportunistic scavengers feeding upon the dead carcasses that settle to the bottom from the overlying waters (SAFMC 1999).

EFH Designations—(SAFMC 1998; Pugliese 2005; Figure D-11)

- Larva—The Gulf Stream has been designated as EFH for this lifestage of the golden deepsea crab due to its role as a dispersal mechanism.
- All Lifestages—The continental slope of the eastern U.S. from the Chesapeake Bay to the Florida Straits (and into the Gulf of Mexico through the Dry Tortugas) has been interpreted as EFH for golden deepsea crabs. Specifically, seven essential fish habitat types on the continental slope have been identified as EFH for golden crabs: a flat foraminiferan ooze habitat (405 to 567 m); distinct mounds, primarily of dead coral (503 to 555 m); ripple habitat (320 to 539 m); dunes (389 to 472 m); black pebble habitat (446 to 564 m); low outcrop (466 to 512 m); and soft bio-turbated habitat (293 to 475 m).

HAPC Designations—No HAPC are identified for this species.

- Goliath Grouper (*Epinephelus itajara*)

Management—This species is managed by the SAFMC as part of the Snapper Grouper MU via the Snapper Grouper FMP (SAFMC 2003a).

Status—The goliath grouper is overfished in the SAB (NMFS 2005b). From North Carolina south to the Gulf of Mexico, goliath grouper were designated as a species of concern (former candidate species 1999) by NMFS (2004a), but a recent status report indicates that this species no longer meets the criteria for designation as a species of concern (NMFS 2006g). This grouper is listed as critically endangered or facing an extremely high risk of extinction in the wild in the immediate future by the IUCN Red list (Chan Tak-Chuen and Padovani Ferrera 2006).

Distribution—In the northwest Atlantic, goliath grouper are distributed from Florida to Brazil, including Bermuda, The Bahamas (Great Bahamas Bank and southeastern Bahamas), the Caribbean Sea, and the Gulf of Mexico (Böhlke and Chaplin 1993; Robins 1999). These groupers are most abundant off eastern Florida south to the Florida Keys (SAFMC 1998). This species is also found in the eastern Atlantic from Senegal to Congo and in the eastern Pacific from the Gulf of California to Peru (Robins 1999).

Habitat Preferences—Rocks, corals, caves, shipwrecks, pilings, ledges, and muddy substrates in waters with depths less than 46 m are the preferred habitat of territorial adult goliath groupers, while juveniles are found in estuarine areas associated with mangroves and oyster bars (Robins 1999; Sadovy and Eklund 1999). Eggs and larvae are pelagic, with larvae becoming benthic approximately 25 days after hatching (Robins 1999).

Life History—Spawning events occur around shipwrecks, rock ledges, and reefs from July through September and are correlated with lunar events (Robins 1999). Spawning aggregations containing over 100 goliath groupers have been observed with all recorded aggregations (except Bermuda) occurring between 15º and 26º N latitudes (Robins 1999; Sadovy and Eklund 1999). These aggregations primarily consist of the largest and oldest individuals of the population (Coleman et al. 2000). Goliath grouper are considered sedentary and typically do not move among reefs, except to form aggregations (Sadovy and Eklund 1999)

Common Prey Species—Goliath grouper are opportunistic feeders that prey mainly on crustaceans (spiny lobster, shrimp, and crabs) and fishes (stingrays and parrotfishes) but also consume octopus and young sea turtles (Robins 1999).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-12)

- Larva—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.
- Juvenile—Benthic habitats consisting of high relief ledges, reefs, piers, bridges, and mangrove-lined shores in waters with depths <50 m throughout Florida are interpreted as EFH.
- Adult—Benthic habitats consisting of high relief ledges, reefs, piers, bridges, and mangrove-lined shores in waters <50 m throughout Florida are interpreted as EFH for this lifestage of the goliath grouper.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-12)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and council-designated Artificial Reef SMZs are designated as HAPC. Additional HAPC designated, but not found within the study area, are seagrass habitat; mangrove habitat; oyster/shell habitat; all coastal inlets; all state-designated nursery habitat; nearshore hard bottom habitat (<4 m); The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Gray Snapper (*Lutjanus griseus*)

Management—Gray snapper are managed within the SAFMC's Snapper Grouper FMP in the Atlantic (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in the SAB (NMFS 2005b).

Distribution—Gray snapper range from North Carolina to Brazil, including Bermuda, Bahamas, the Caribbean, and northern Gulf of Mexico (SAFMC 1998; Böhlke and Chaplin 1993; Burton 2001). Juveniles can occasionally be found as far north as Massachusetts (Allen 1985; Manooch 1988). In the Gulf of Mexico, they are most abundant off southern and southwestern Florida (GMFMC 1998).

Habitat Preferences—Gray snapper are capable of inhabiting a wide variety of habitats. Offshore benthic habitats include shipwrecks, oil and gas platforms, ledges, hard bottom, coral reefs, and rocky outcroppings to depths of 180 m, while inshore habitats consist of seagrasses, mangroves, and rock piles (Manooch 1988; Bortone and Williams 1986; Bester 1999b). Smaller, younger fish are typically found utilizing more inshore habitats, such as seagrass beds and areas of soft sediments, compared to larger, older adults (Manooch 1988; Bester 1999b). Gray snapper are especially abundant in seagrass beds of the Florida Keys, which provide nursery areas for juveniles but also feeding areas for adults (Starck and Schroeder 1971). Adults and juveniles are euryhaline and can tolerate a salinity range from 0 to 37 psu and have even been recorded in freshwater lakes and rivers of southern Florida (SAFMC 1998; Bester 1999b). They also are found utilizing waters with temperatures between 13° and 32.5°C (Bortone and Williams 1986). Eggs are pelagic and hatch approximately 20 hours after being spawned (Allen 1985). Larvae are pelagic until settling in inshore nurseries consisting of seagrass beds (specifically *Thalassia*, *Halodule*, and *Syringodium*), mangroves, jetties, or pilings approximately three weeks after hatching, typically from July through September (Bortone and Williams 1986; Domeier et al. 1996; GMFMC 1998; SAFMC 1998; Bester 1999b).

Life History—This species does not exhibit extensive movements and remains in the same area for extended periods of time, except during spawning season (SAFMC 1998; Bester 1999b). Gray snapper do demonstrate short distance daily movements associated with feeding and schooling (Bester 1999b). Gray snapper migrate from inshore waters to offshore waters and spawn between April and November, with spawning correlated with lunar cycle (Manooch 1988; Domeier et al. 1996; Bester 1999b). Specific spawning locations have not been identified but are believed to be associated with reefs and shipwrecks (Domeier et al. 1996). In the Gulf of Mexico, spawning occurs on the West

Florida shelf and Florida Keys from June through September (Allman and Grimes 2002). Individuals are capable of spawning multiple times during a season (Allen 1985; Bester 1999b).

Common Prey Species—This species is an opportunistic carnivore. Adult gray snapper prey nocturnally on fishes (especially toadfish and grunts), shrimp, and crabs (Manooch 1988; Bester 1999b; Denit and Sponaugle 2004), but crustaceans seem to be the primary component of the adult gray snapper's diet (Starck and Schroeder 1971; Pattillo et al. 1997).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-13)

- Egg—Pelagic waters from Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this planktonic lifestage.
- Larva—EFH for this planktonic lifestage of gray snappers is interpreted as pelagic waters from North Carolina to Florida, pelagic *Sargassum*, and the Gulf Stream, which provides a mechanism of dispersion.
- Juvenile—Although not located within the study area, aquatic vegetation, mangroves, and muddy substrates in nearshore areas (<5 m depths), as well as hard bottom habitats from Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage of the gray snapper.
- Adult—Coral reefs, hard bottom, artificial structures, channel ledges, mangroves communities, seagrass beds, and sponges in depths less than 77 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-13)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC for the gray snapper. Additional HAPC have been designated including mangrove habitat, seagrass habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump; and manganese outcroppings on the Blake Plateau; none of these habitats are located within the study area.

- Greater Amberjack (*Seriola dumerili*)

Management—Greater amberjack are managed within the SAFMC's Snapper Grouper FMP in the Atlantic (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in the SAB (NMFS 2005b

Distribution—Greater amberjacks inhabit the Pacific, Atlantic, and Indian Oceans, as well as the Mediterranean Sea (Manooch 1988). In the northwest Atlantic, their distribution ranges from Nova Scotia, Canada to Brazil, including the Gulf of Mexico, Bahamas (Great Bahamas Bank), and Caribbean Sea (Manooch 1988; Böhlke and Chaplin 1993).

Habitat Preferences—The greater amberjack is pelagic and epibenthic, preferring habitats consisting of shipwrecks, reefs, buoys, and rocky outcrops around the continental shelf (Manooch 1988; SAFMC 2003a). Off Louisiana, adults strongly associate with offshore oil and gas rig structures (GMFMC 1998). Juveniles and adults also associate with floating debris and plants (pelagic *Sargassum*) in offshore waters (SAFMC 2003a; Wells and Rooker 2004). This species is commonly found inhabiting waters with depths as great as 360 m in the Atlantic. Smaller individuals (< 1 m total length [TL]) prefer depths of less the 10 m, while larger individuals have a preference for depths ranging from 18 to 72 m (Manooch and Haimovici 1983; Manooch and Potts 1997a; GMFMC 1998; SAFMC 2003a). Eggs and larvae are found in offshore waters with salinities of 30 to 35 psu (GMFMC 1998).

Life History—Spawning for the greater amberjack occurs from January to July but peaks from April to June in the Atlantic (Manooch 1988; Sedberry et al. 2006). Spawning aggregations have been recorded off southeast Florida and in the Florida Keys from depths of 45 to 122 m along shelf-edge reef sites and in waters with bottom temperature around 24°C (SAFMC 1998; Sedberry et al. 2006). The majority of spawning females have been collected south of 30°N (Sedberry et al. 2006). Greater amberjack exhibit seasonal migrations along the U.S. Atlantic coast, moving south during December through May and northward from June through November (SAFMC 1983).

Common Prey Species—Greater amberjack feed over reefs and shipwrecks on crab, squid, and fishes (herring, scad, filefish, and little tunny) (Manooch and Haimovici 1983; Manooch 1988).

EFH Designations—(SAFMC 1998; NMFS 2002c; SAFMC 2003a; Figure D-18)

- Larva—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH for this lifestage of the greater amberjack.
- Juvenile—Floating vegetation (*Sargassum*) and debris from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Adult—Pelagic waters overlying reefs in water depths of 18 to 360 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage of the greater amberjack.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-14)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC for the greater amberjack. Additional HAPC have been designated including mangrove habitat, seagrass habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump; and manganese outcroppings on the Blake Plateau; none of these habitats are located within the study area.

- King Mackerel (*Scomberomorous cavalla*)

Management—This species is co-managed under the FMP for the Coastal Migratory Pelagic Resources by the GMFMC and SAFMC (1985).

Status—The king mackerel stock on the Atlantic coast of the U.S. is not overfished nor is overfishing occurring (NMFS 2005b).

Distribution—King mackerel are commonly distributed along the continental shelf in the warmer waters of the western Atlantic from North Carolina to Brazil but occasionally stray as far north as Massachusetts (Gold et al. 2002; Collette 2002a). This species does not typically occur beyond the shelf break (GMFMC and SAFMC 1985).

Habitat Preferences—The pelagic eggs of the king mackerel occur offshore over depths of 35 to 180 m during the spring and summer (GMFMC 1998). Larvae occur over the middle and outer continental shelf off the eastern coast of the U.S. from May through November in waters with temperatures ranging from 22° to 28°C, salinities between 30 and 37 psu, and depths of 35 to 180 m (GMFMC and SAFMC 1985; Godcharles and Murphy 1986; GMFMC 1998). Juvenile and adult king mackerel can be found ranging from inshore waters to the shelf break but are commonly found at depths of less than 80 m. They prefer areas of temperatures greater than 20°C and salinities between 32 and 36 psu. As adults, king mackerel rarely enter estuaries but feed upon estuarine dependent species (GMFMC 1998)

Life History—King mackerel are highly fecund serial spawners (Gledhill and Lyczkowski-Schultz 2000). They have a protracted spawning season, which runs from May to October (Godcharles and

Murphy 1986). King mackerel exhibit seasonal movements. During the summer, these fish migrate north occurring in the waters off Virginia and the Carolinas through fall. As the waters become cooler in the winter, they migrate south again to Florida (Jones et al. 1985; Godcharles and Murphy 1986; Schaefer and Fable 1994).

Common Prey Species—King mackerel feed on a variety of fish species including sardines, thread herrings, menhaden, scad, jacks, snappers, mackerels, and grunts. Invertebrate species such as shrimp and squid, also make up a large portion of their diet (GMFMC and SAFMC 1985; Collette 2002a).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-8)

- Larva—The Gulf Stream is designated as EFH for this lifestage of the king mackerel as it provides a mechanism for dispersal.
- All Lifestages—EFH in the MAB and the SAB is designated as the sandy shoals of capes and offshore bars, high profile rock bottoms and waters from barrier island shores to the Gulf Stream. Pelagic *Sargassum* within the U.S. EEZ is also designated as EFH. Although not found within the study area, all coastal inlets and state-designated nursery areas are designated as EFH.

HAPC Designations—(SAFMC 1998; Figure D-8)

- All Lifestages—HAPC for all king mackerel lifestages have been designated as the Point off Jupiter Inlet, *Phragmatopoma* (worm) reefs off the east coast of Florida, and pelagic *Sargassum*. Additional areas designated as HAPC but not located in the study area include the Hump off Islamorada, FL; the Marathon Hump off Florida; the Wall off the Florida Keys; nearshore hard bottom (<4 m) south of Cape Canaveral, FL; the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, NC from shore to the ends of the respective shoals but shoreward of the Gulf Stream; The Point in North Carolina waters; Ten-Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and Hurl Rocks, SC.

- Mutton Snapper (*Lutjanus analis*)

Management—Mutton snapper are managed within the SAFMC's Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in SAB (NMFS 2005b). It is designated as vulnerable or facing a high risk of extinction in the wild in the medium-term future by the IUCN Red List (Huntsman 1996a).

Distribution—Mutton snapper are distributed from Massachusetts to Brazil, including the Gulf of Mexico, but are most commonly observed in the tropical waters of Florida, the Bahamas (Little Bahamas and Great Bahamas Banks), and the Caribbean (Allen 1985; Böhlke and Chaplin 1993; Murray and Bester 1999b).

Habitat Preferences—Adults are typically solitary and have a diverse benthic habitat preference ranging from shallow seagrass beds to hard bottom substrate and deep-water reefs (Domeier et al. 1996). Though, in the Exuma Cays, Bahamas small groups of adults have been recorded aggregating around seagrass meadows (Mueller 1994, 1999). Juveniles utilize inshore seagrass beds, mangroves, jetties, and pilings as nursery habitats during the months of July through September (Bortone and Williams 1986). This species has a temperature tolerance of 19° to 28°C and is most commonly found between depths of 25 and 95 m (Bortone and Williams 1986; Murray and Bester 1999b). Eggs and larvae (<10 mm TL) are planktonic (Murray and Bester 1999b). Larvae settle to inshore habitats after reaching a size of 10 to 20 mm TL (SAFMC 1998).

Life History—Mutton snapper form aggregations in order to spawn over a period of several weeks (Domeier et al. 1996). They exhibit high site fidelity for spawning locations and have been recorded to spawn on the exact same days of the lunar calendar yearly, typically during a full moon (Domeier et al. 1996). Aggregations of over 1,000 fish have been recorded on Riley's Hump in the Dry Tortugas National Park in May though July, while spawning in the northern Caribbean occurs during February

(Domeier et al. 1996; Murray and Bester 1999b; Burton et al. 2005). This snapper species demonstrates very little movement, other than to form spawning aggregations (Bortone and Williams 1986).

Common Prey Species—This opportunistic species feeds on benthic prey, as well as on species at midwater depths throughout the day and into the night (Allen 1985; Murray and Bester 1999b). Mutton snappers feed on fishes and crustaceans, with crabs being a substantial portion of their diet (Bortone and Williams 1986).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-15)

- Egg—EFH is interpreted as pelagic waters of Florida for this lifestage of the mutton snapper.
- Larva—Pelagic waters, pelagic *Sargassum*, and the Gulf Stream for its role in larval dispersion are interpreted as EFH.
- Juvenile—Aquatic vegetation, mangroves, as well as sand and mud substrates in Florida water depths >30 m are interpreted as EFH.
- Adult—Reef/hard bottom benthic environments as well as substrates of sand and mud at depths <100 m in Florida are interpreted as EFH.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-15)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC for the greater amberjack. Additional HAPC have been designated including mangrove habitat, seagrass habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump; and manganese outcroppings on the Blake Plateau; none of these habitats are located within the study area.

- Pink Shrimp (*Farfantepenaeus duorarum*)

Management—The pink shrimp is managed by the SAFMC as part of the Shrimp FMP in the U.S. Atlantic waters (SAFMC 1998).

Status—This shrimp species is not currently overfished nor is subject to overfishing in the northwestern Atlantic (NMFS 2005b).

Distribution—Pink shrimp occur from southern Chesapeake Bay to the Florida Keys and throughout the northern Gulf of Mexico to Cape Catoche and Isla Mujeres at the tip of the Yucatan Peninsula. The centers of pink shrimp abundance occur off southwestern Florida and in the southeastern Gulf off Campeche, Mexico (Pattillo et al. 1997).

Habitat Preferences—Pink shrimp are common in broad, shallow continental shelf areas and in shallow bays and estuaries. They are most often found in waters 11 to 37 m deep, although in some areas they may be abundant to depths of up to 65 m (Bielsa et al. 1983). Pink shrimp eggs and adults are demersal, while larvae are planktonic up until the post-larval stage. Pink shrimp occur over a range of bottom substrates including sand/shell, sand, coral-mud, and mud bottoms (Pattillo et al. 1997). Juveniles and subadults prefer sand/shell bottoms around submerged aquatic vegetation, while adults prefer calcareous sediments but can also be found on hard shell-sand bottoms in non-turbid waters (Williams 1958; NMFS 2002c). This species exhibits different degrees of salinity preference at different stages of its life cycle, while tolerance to water temperature varies with latitude (Bielsa et al. 1983).

Life History—This shrimp species spawns throughout the year in waters that are 4 to 48 m in depth. Pink shrimp probably spawn in deeper waters as well, although the majority of spawning activity occurs at depths of 4 to 16 m (Pattillo et al. 1997). Spawning pink shrimp may be most abundant off

Cape Canaveral, FL and Cape Lookout, NC since the species has a great affinity for hard, coarse, and particularly calcareous bottom sediments, which are very common in these two areas. In North Carolina, egg-bearing females are found as early as May, and by June most pink shrimp are sexually mature. Off eastern Florida, peak-spawning activity occurs during the summer. Spawning occurs when water temperatures rise, as water temperature is apparently critical to reproductive development (Bielsa et al. 1983). Off the Dry Tortugas National Park, FL spawning occurs year round but peaks in the spring and fall (GMFMC 2004). The annual rise in sea level that occurs during warmer months, when spawning is occurring, may facilitate current-borne movement of post-larval shrimp from the continental shelf into the estuaries of the SAB and eastern Gulf of Mexico (Allen et al. 1980). Hettler (1992) reported that water temperature often determines the northern extent of their range. At the onset of cold weather, pink shrimp found in temperate waters will either move into deeper waters or burrow deeply in the bottom substrate to protect themselves from winter mortality. Pink shrimp that survive the winter grow rapidly in early spring before migrating to waters further offshore.

Common Prey Species—Pink shrimp are omnivorous consuming benthic prey, including crustaceans, squid, worms, mollusks, plant material and detritus, and fishes. Feeding activity peaks during daytime and during the summer (Bielsa et al. 1983).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-16)

- Egg—Nearshore demersal marine habitats located between the 3.7 and 16 m isobaths ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Larva—Pelagic ocean waters <16 m in depth, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Juvenile—Although not located within the study area, estuarine areas consisting of marshes, wetlands, tidal palustrine forested areas, mangroves, submerged aquatic vegetation, and subtidal and intertidal non-vegetated flats ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Adult—Hard sand/shell bottoms in waters less than 100 m deep ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.

HAPC Designations—(SAFMC 1998; Figure D-16)

- All Lifestages—All coastal inlets, state designated nursery areas, and state-identified overwintering areas are designated as HAPC for penaeid shrimp species (brown, pink, and white). These areas are not located in the study area.

- Red Drum (*Sciaenops ocellatus*)

Management—Red drum are managed by the SAFMC through the Atlantic Coast Red Drum FMP (SAFMC 1990).

Status—The red drum stock on the Atlantic coast of the U.S. is overfished and overfishing is currently occurring in the SAB (NMFS 2005b).

Distribution—Red drum occur throughout estuarine and coastal waters of the U.S. Atlantic coast from Massachusetts to the tip of Florida. They are also found throughout the Gulf of Mexico from southwest Florida to Tuxpan, Mexico (Reagan 1985; Manooch 1988). Their centers of abundance are off North Carolina and in the Gulf of Mexico (Pattillo et al. 1997).

Habitat Preferences—Eggs and early larvae of red drum occur in high salinity waters of estuaries, as well as inside inlets and passes (Nelson et al. 1991). Late larvae and juveniles prefer the low salinity nurseries in the upper portions of estuaries with substrates of mud, sand, or oyster reefs (Pattillo et al. 1997; GMFMC 1998; SAFMC 1998). Sub-adult red drum leave shallow nursery habitats

and begin utilizing a variety of habitats within the estuaries. Changes in temperature and food availability have been linked to the movement of sub-adults within the estuaries (ASMFC 2002). Less is know about the habitat preferences of adults. Adult red drum tend to spend more time in the coastal waters following sexual maturity but continue to frequent estuaries on a seasonal basis (ASMFC 2002). Adults can primarily be found in high salinity surf zones and around live/hard bottom and artificial reefs (SAFMC 1998; GMFMC 2004).

Life History—The red drum spawns in nearshore areas around inlets and passes throughout their range and in high-salinity estuarine areas along the southeastern coast of the U.S. from July through December, with a peak in late September and October. There is also evidence to suggest that within-season spawning peaks coincide with full moons (ASMFC 2002). Adult red drum tend to migrate offshore and south along the Atlantic coast in the fall and return north and move inshore during the spring of each year (ASMFC 2002).

Common Prey Species—Decapod crustaceans, primarily mud crabs and fiddler crabs, and fishes, mostly juvenile spot, striped mullet, pinfish, pigfish, and mummichog, are the primary food of adult red drum in the Gulf of Mexico and along the southeastern coast of the U.S. (ASMFC 2002; GMFMC 2004).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-17)

- Adult—Unconsolidated bottom (soft sediments) and artificial reefs, from shore to the 50 m isobath, extending from Virginia to the Florida Keys have been designated as EFH in the study area for this lifestage of the red drum. Additional EFH designated, but not occurring in the study area, includes tidal freshwater; estuarine emergent vegetated wetlands (flooded salt marshes, brackish marshes, and tidal creeks); estuarine scrub/shrub (mangrove fringe); submerged rooted vascular plants (seagrasses); oyster reefs and shell banks; and ocean high salinity surf zones.
- All Other Lifestages—Although not occurring within the study area, tidal freshwater; estuarine emergent vegetated wetlands (flooded salt marshes, brackish marshes, and tidal creeks); estuarine scrub/shrub (mangrove fringe); submerged rooted vascular plants (seagrasses); oyster reefs and shell banks; and ocean high salinity surf zones to depths of 50 m are designated as EFH.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-17)

- All Lifestages—HAPC are designated as all coastal inlets, all state designated nursery habitats of particular importance to red drum, documented sites of spawning aggregations, barrier islands and the passes between them, seagrass beds or SAV in Virginia, North Carolina, and Florida, the entire estuarine system from the lower salinity portions of the river systems through the inlet mouth or lower harbor areas in South Carolina and Georgia, and the inlets, adjoining channels, sounds, and outer bars of ocean inlets. None of these areas occur within the boundary of the study area.

- Red Porgy (*Pagrus pagrus*)

Management—The red porgy is managed by the SAFMC within the Snapper Grouper FMP (SAFMC 2003a).

Status—Red porgy are overfished (NMFS 2005b) and designated as endangered or facing a very high risk of extinction in the wild in the near future by the IUCN Red List (Huntsman 1996b).

Distribution—This species is found throughout the Atlantic Ocean (Manooch 1988). In the northwest Atlantic, red porgy range from New York to Argentina, including the Gulf of Mexico but are most common from Cape Hatteras, NC to Cape Canaveral, FL (SAFMC 1983). Red porgy have not been reported in the Caribbean Sea (SAFMC 1998).

Habitat Preferences—The red porgy are a benthic species that prefers waters with a temperature range of 15° to 23°C, depths from 18 to 280 m, and substrates consisting of rock, rubble, or sand (Manooch 1988; SAFMC 1998). Juveniles are found closer to shore than adults typically utilizing

seagrass beds (SAFMC 1998). Eggs and larvae are pelagic until larvae settle on bottom habitats (Manooch 1988).

Life History—Red porgy's exhibit protogynous hermaphroditism (capable of sex reversal, first mature as a female and later become a male), with most fish over 45 cm TL consisting of males (SAFMC 1983). Spawning off North Carolina occurs from December through May, peaking in March and April, in waters with depths of 21 to 100 m and bottom temperatures between 16° and 22°C (Manooch 1976; SAFMC 2003a). Data from MARMAP surveys found spawning females at specific shelf-edge reef sites from depths of 26 to 57 m (Sedberry et al. 2006). Spawning events are correlated with increased photoperiod (SAFMC 1983). Red porgy do not undergo long distance migrations and tagging studies indicate that local movements are restricted (Grimes et al. 1982; SAFMC 1983).

Common Prey Species—The red porgy is an opportunistic feeder that preys primarily on benthic invertebrates (crabs, shrimp, squid, octopus, snails, worms, sea urchins) but also small fishes (scad and tomtate) (Manooch 1977; SAFMC 1998). This species feeds predominantly in the morning and afternoon (Grimes et al. 1982).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-18)

- Egg—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage of the red porgy.
- Larva—Pelagic waters Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W); pelagic *Sargassum*; and the Gulf Stream, which provides a mechanism of dispersion; are interpreted as EFH for this lifestage.
- Adult—Rough ocean bottom from the depths of 18 to 280 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-18)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Additional HAPC designated, but not located within the study area, includes mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump; and manganese outcroppings on the Blake Plateau.

- Red Snapper (*Lutjanus campechanus*)

Management—The red snapper stock is managed by the SAFMC through the FMP for the Snapper Grouper Fishery in the Atlantic (SAFMC 2003a).

Status—The stock of red snapper in the southeastern U.S. Atlantic is overfished and is currently subject to overfishing (NMFS 2005b).

Distribution—Red snappers occur in the western Atlantic from Massachusetts to Brazil, including the Gulf of Mexico (Bester 1999c). They are most frequently found between Cape Hatteras, NC and the Campeche banks of Mexico (Nelson and Manooch 1982; GMFMC 2004).

Habitat Preferences—The eggs of red snappers are free-floating, pelagic, and occur in offshore waters, usually in depths of 18 to 37 m, and hatch 20 to 27 hours after spawned (Allen 1985; GMFMC 2004). Larval red snapper are also pelagic and occur in continental shelf waters with temperatures ranging from 17.3° to 29.7° C, salinities of 32.8 to 37.5 psu, and depths of 17 to 183 m (GMFMC 1998). Both juvenile and adult red snapper are reef or structure dependent beginning shortly after leaving the planktonic larval stage. Upon initial settlement, the smallest red snappers are able to satisfy their habitat requirements by the presence of small structures, including burrows and shells.

However, as they grow, they display a greater preference for larger and more complex structures (Workman et al. 2002). Juvenile and adult red snapper occur most frequently over low and high relief hard bottom and artificial structures at temperatures of 13° to 32°C, salinities ranging from 33 to 37 psu, and depths of 10 to 190 m off the southeastern U.S. (Moran 1988; Manooch and Potts 1997b; SAFMC 2003a). Juvenile red snapper are typically found in shallower waters (20 to 46 m in depth) than the adults (Moran 1988).

Life History—Spawning of the red snapper occurs during the warmer months of April through October along the southeastern U.S. coast, with a peak occurring between July and September (Manooch and Potts 1997b; SAFMC 2003a). Red snapper do not undergo seasonal migrations. They display a high degree of site fidelity and rarely venture far from their home reef (Szedlmayer and Shipp 1994; Workman et al. 2002; Szedlmayer and Schroepfer 2005). However, movements up to 189 NM have been noted for this species (Watterson et al. 1998; Patterson et al. 2001). Large-scale climatic events, such as hurricanes, have been implicated as a dispersal mechanism for red snapper (Watterson et al. 1998).

Common Prey Species—Red snappers have a diverse diet consisting of fishes, crabs, shrimp, worms, cephalopods, gastropods, tunicates, and some planktonic species (Moran 1988; SAFMC 2003a; GMFMC 2004).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-19)

- Egg—EFH is interpreted for this lifestage of the red snapper as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Larva—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W); pelagic *Sargassum*; and the Gulf Stream, which provides a mechanism of dispersion; are interpreted as EFH for this lifestage.
- Adult—EFH is interpreted as rocky bottom habitats at depths of 10 to 190 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations— (SAFMC 1998; Figure D-19)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Additional designated HAPC include mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau; none of these habitats are located within the study area.

- Ridged Slipper Lobster (*Scyllarides notifer*)

Management—Ridged slipper lobsters and Caribbean spiny lobsters are both included in the spiny lobster MU and fishery, which is managed jointly by the GMFMC and the SAFMC through the FMP for the Spiny Lobster Fishery (GMFMC and SAFMC 1982). Since the ridged slipper lobster is such a small part of the spiny lobster fishery, is so widely and sparsely distributed over the range of the MU, and is data and information deficient, the GMFMC and SAFMC generically refer to both the Caribbean spiny and ridged slipper lobsters as “spiny lobsters”; hereafter this term references both species comprising this MU (GMFMC and SAFMC 1982, 1987).

Status—The spiny lobster stock in the southeastern U.S. Atlantic is not overfished nor is overfishing currently occurring (NMFS 2005b).

Distribution—Spiny lobsters are found in the waters off the southeastern coast of the U.S. from North Carolina to Brazil; the ridged slipper lobster occurs uncommonly from North Carolina to the West Indies in the Atlantic and from Florida to Texas in the GOMEX (Appeldoorn et al. 1987).

Habitat Preference—The ridged slipper lobster specifically prefers benthic habitats in water depths of 2 to 100 m (most common from 30 to 42 m) consisting of sand or mud mixed with shell or coral (GMFMC 2004a). The larvae of ridged slipper lobsters remains in the pelagic environment as plankton; upon reaching maturity, adult lobsters are found on soft substrates or reefs (GMFMC 2004a).

Life History—The eggs of the ridged spiny lobster remain attached to the adult for at least 30 days (GMFMC 2004a). Upon hatching, the phyllosome (leaf-bodied) larvae disperse into offshore waters (Marx and Herrnkind 1986). The adult lifestage of the ridged slipper lobsters is demersal with adults moving to shallow, warm waters off Florida to spawn over areas of soft sediments from April through August (GMFMC 2004a).

Common Prey Species—Spiny lobsters are nocturnal predators that feed on a diverse range of food, including algae, foraminifera, sponge spicules, polychaetes, bivalves, conchs, hermit crabs, and other crustaceans (GMFMC 1998, 2004a).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-7)

- Larva—The Gulf Stream, due to its role as a dispersal mechanism, is designated as EFH for this lifestage.
- All Lifestages—Nearshore shelf/oceanic waters; seagrass habitat, unconsolidated bottom (soft sediments), coral and live/hard bottom habitat, and sponges from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83° W) are designated as EFH. Additional EFH designated, but not occurring in the study area, includes mangrove habitats, shallow subtidal bottom, and red algal (*Laurencia*) communities.

HAPC Designations—(SAFMC 1998; Figure D-7)

- All Lifestages—Florida Bay, Biscayne Bay, FL, Card Sound, FL, and coral/hard bottom habitat from Jupiter Inlet, FL through the Dry Tortugas NP, FL are designated as HAPC. Only areas from Jupiter Inlet, FL through the Dry Tortugas NP, FL are located within the boundaries of the study area.

- Royal Red Shrimp (*Pleoticus robustus*)

Management—Royal red shrimp are managed as part of the SAFMC Shrimp FMP in the Atlantic (SAFMC 1998).

Status—Very little information is available on the status of the royal red shrimp in the SAB other than the stock is not overfished nor is subject to overfishing (NMFS 2005b).

Distribution— Royal red shrimp are found throughout the U.S. Atlantic and Gulf of Mexico, ranging from Cape Cod, MA to French Guiana. In the southeast U.S Atlantic and Gulf of Mexico, royal red shrimp are found in large concentrations primarily around St Augustine, FL, Dry Tortugas National Park, FL, and the Mississippi River Delta (Anderson and Linder 1971).

Habitat Preferences—Little is known about the habitat preferences of this deepwater shrimp species. Unlike the penaeid shrimp species (brown, pink, white), royal red shrimp are not estuarine dependent and spend their entire life in open waters (SAFMC 1993, 1998; GMFMC 2004). Royal red shrimp are typically found at depths ranging from 180 to 730 m but are most abundant between 250 and 550 m over soft substrates consisting primarily of mud (Anderson and Linder 1971; GMFMC 1998). The depth distribution of this species is influenced by temperature; the preferred temperature ranges from 5° to 15°C (Christmas and Etzold 1977). Off the Mississippi River Delta, this species is associated with blue-black terrigenous silt and silty sand, while around the Dry Tortugas National Park, FL it occurs on whitish, gritty calcareous mud (GMFMC 2004). Information on early lifestages of this species is lacking.

Life History—Spawning of the royal red shrimp is believed to occur year round but peaks in January through May. Spawning sites have been recorded off St. Augustine, FL (Anderson and Linder 1971). Other details about the life history characteristics (i.e., migration and movement patterns) of this species are not known (GMFMC 1981).

Common Prey Species—Royal red shrimp consume benthic invertebrates and have been observed burrowing into the substrate in search of food (Anderson and Linder 1971).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-20)

- Larva—The Gulf Stream, as it provides a mechanism to disperse royal red shrimp larvae, is designated as EFH for this lifestage.
- Adult—EFH is designated as the upper regions of the continental slope from depths of 180 to 730 m over blue/black mud, sand, muddy sand, or white calcareous mud bottoms ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).

HAPC Designations—There are no HAPC designated in the study area.

- Scamp (*Myteroperca phenax*)

Management—Scamp are managed within the SAFMC's Snapper Grouper FMP in the U.S. Atlantic (SAFMC 2003a).

Status—Currently, the scamp is neither overfished nor is overfishing occurring in the waters of the SAB (NMFS 2005b).

Distribution—The distribution of scamp ranges from North Carolina to Florida, the Gulf of Mexico, and southern Caribbean Sea (Manooch 1988; SAFMC 2003a). Juvenile scamp have been captured as far north as Massachusetts but are considered rare in these higher latitudes.

Habitat Preferences—The scamp prefers low relief live/hard bottom habitats, though they can also be found associating with shipwrecks, ledges, high-relief hard bottom, rock outcroppings, and *Oculina* coral reefs (Manooch 1988; GMFMC 2004). Adult scamp are typically found in waters with depths of 12 to 189 m (most common from 40 to 80 m), while juveniles are found closer to shore (12 to 33 m) (GMFMC 1998; SAFMC 2003a). Eggs and larvae are pelagic (SAFMC 1983). Larvae associate with surface waters before settling to benthic habitats.

Life History—Scamp are protogynous hermaphrodites; most scamp >70 cm are females (SAFMC 2003a). MARMAP surveys have identified numerous spawning locations from the coast of North Carolina to Florida at shelf-edge reef sites, from the 33 to 93 m isobath (SAFMC 2004b; Sedberry et al. 2006). Spawning occurs offshore of the Carolinas in April and September, peaking in May and June when bottom water temperatures are between 22° and 25°C (Manooch 1988; Matheson et al. 1986; Manooch et al. 1998a). Spawning aggregations of over 100 fish have been observed off the east coast of Florida in April and September (Manooch et al. 1998a). *Oculina* coral reefs are identified as key spawning areas (GMFMC 2004). Aggregations primarily consist of the largest and oldest individuals of the population with spawning occurring between afternoon and night (Coleman et al. 2000; Sedberry et al. 2004). The scamp has been observed moving to deeper waters during the winter and tagging studies indicate that this species migrates to specific areas to spawn (SAFMC 1983; Sedberry et al. 2006).

Common Prey Species—Scamp feed opportunistically on crab, shrimp, cephalopods, and benthic fishes (scad, tomtate, and vermilion snapper) (Manooch 1988; Matheson et al. 1986).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-21)

- Larva—EFH is designated for this lifestage from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) including pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion.
- Adult—Bottom habitats from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) consisting of low- and high-profile rock outcroppings encrusted with soft corals, sponges, hydroids, and bryozoa from depths from 20 to 100 m are interpreted as EFH.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-21)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Additional designated HAPC include mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau; none of these habitats are located within the study area.

- Silk Snapper (*Lutjanus vivanus*)

Management—Silk snapper are managed within the SAFMC's Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in the SAB (NMFS 2005b).

Distribution—Silk snapper are distributed from Cape Hatteras, NC to Brazil, including Bermuda, Bahamas (Little Bahamas and Great Bahamas Banks), Caribbean, and the Gulf of Mexico (Manooch 1988; Böhlke and Chaplin 1993).

Habitat Preferences—Off the Carolinas, adult silk snapper typically inhabit waters with depths ranging from 64 to 242 m (most common between 90 and 140 m) and associate with limestone cliffs and rocky ledge habitats along the continental shelf edge (Allen 1985; SAFMC 1998). From North Carolina to the Florida Keys, adult silk snapper primarily occur from depths of 25 to 72 m (Cummings 2003). Young adults and juveniles generally are found at shallower depths than adults (SAFMC 1998). Bottom habitat type is considered more important in influencing distribution of this species than depth (SAFMC 2003a). Eggs and larvae are pelagic.

Life History—Silk snapper are capable of spawning year round but generally form aggregations from July to September or from October through December (SAFMC 1998). Spawning has been recorded from June through August off North Carolina and from March through May and September through November in the Caribbean Sea (SAFMC 1983). Year round spawning has been recorded in Puerto Rico and Jamaica (SAFMC 1983).

Common Prey Species—The silk snapper feeds opportunistically on invertebrates (e.g., shrimp, crabs, shovel-nose lobster) and fishes (Manooch 1988). Silk snapper typically move to shallower water to feed at night (Cummings 2003).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-22)

- Larva—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, is interpreted as EFH.
- Juvenile—EFH for this lifestage of the silk snapper is interpreted as structure and hard bottom habitat from depths of 12 to 242 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Adult—EFH is interpreted as continental shelf edge (limestone cliffs and ledges) from depths of 64 to 242 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-22)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten

Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Snowy Grouper (*Epinephelus niveatus*)

Management—Snowy grouper are managed within the SAFMC's Snapper Grouper FMP (SAFMC 2003a).

Status—The snowy grouper is overfished and is subject to overfishing in the SAB (NMFS 2005b). The IUCN Red List designates this species as vulnerable to extinction or facing a high risk of extinction in the wild in the medium-term future (Huntsman 1996c).

Distribution—In the western Atlantic, the snowy grouper ranges from Massachusetts to Brazil, including the Gulf of Mexico, Lesser Antilles, and Cuba (Manooch 1988). Only juvenile snowy grouper are found utilizing the northern extreme of this range, while adults are typically found only as far north as North Carolina (Manooch 1988; SAFMC 1998). Snowy grouper can also occur in the eastern Pacific from Baja California to Panama (Manooch 1988; SAFMC 1998).

Habitat Preferences—This benthic species is found from depths of 30 to 525 m (SAFMC 2003a). Adult snowy groupers are territorial and inhabit irregular benthic habitats of boulders and limestone ridges interspersed with sand, broken shells, and rock fragments, and they prefer waters with temperatures from 16° to 29°C (Manooch 1988; SAFMC 1998). Juveniles and small adults (< 40 cm TL) are typically found closer to shore, out to depths of 61 m, in bottom waters with temperatures ranging from 15° to 29°C (Matheson and Huntsman 1984; SAFMC 1998). Eggs and larvae are pelagic (SAFMC 1998). The Florida Current, Gulf Stream, and other currents disperse larvae (Moore and Labisky 1984).

Life History—Snowy groupers are a protogynous hermaphrodite with spawning occurring from April through September north of Cape Canaveral, FL, and from May through July south of Cape Canaveral (Manooch 1988; SAFMC 1998; Wyanski et al. 2000; SAFMC 2003a). Numerous spawning locations have been identified off the coast of South Carolina, from MARMAP surveys at depths from 187 to 302 m (SAFMC 2004b; Sedberry et al. 2006). Adults are typically sedentary but do undergo migrations to form spawning aggregations (Moore and Labisky 1984).

Common Prey Species—This species of grouper is an ambush predator that feeds opportunistically on fishes (snappers and porgies), cephalopods, and crustaceans (Manooch 1988; SAFMC 1998). On the Charleston Bump (SC), swimming crab and other benthic crustaceans are the major components of this species' diet (Weaver and Sedberry 2001).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-23)

- Egg—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Larva—EFH is interpreted for this lifestage of the snowy grouper as pelagic waters, including the Gulf Stream and areas with pelagic *Sargassum*, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Adult—Bottom habitats consisting of boulders and limestone ridges, with vertical relief up to 10 m, interspersed with sand, broken shells, and rock fragments in depths less than 180 m, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-23)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-

designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Spanish Mackerel (*Scomberomorous maculatus*)

Management—Spanish mackerel are managed jointly by the SAFMC and the GMFMC under the FMP for Coastal Migratory Pelagic Resources (GMFMC and SAFMC 1985).

Status—The stock is not currently being over-exploited nor is it considered overfished in the SAB (NMFS 2005b).

Distribution—Spanish mackerel are abundant from Chesapeake Bay south through the Gulf of Mexico; however, they occasionally occur as far north as the coastal southern New England (Collette 2002a). This species' center of abundance is the Atlantic coast of Florida; Spanish mackerel are considered less common west of the Mississippi River Delta (Pattillo et al. 1997).

Habitat Preferences—The eggs of the Spanish mackerel are pelagic and usually occur over depths of less than 50 m along the inner continental shelf during the spring and summer (Godcharles and Murphy 1986; GMFMC 1998). Larvae occur in coastal waters with temperatures ranging from 20° to 32°C, salinities between 28 and 37 psu, and over depths of 9 to 84 m (most abundant in waters of less than 50 m) (Godcharles and Murphy 1986; GMFMC 1998). They occur between May and September off the southeast U.S. coast (GMFMC and SAFMC 1985). Juvenile Spanish mackerel utilize a variety of habitats as nursery grounds ranging from low salinity estuaries to high salinity nearshore waters (Godcharles and Murphy 1986). Juvenile Spanish mackerel prefer clean sand substrates (Pattillo et al. 1997; GMFMC 1998) and prefer water temperatures greater than 25°C and tolerate a wide range of salinities, typically greater than 10 psu (GMFMC 1998). Adults are surface feeders that form large schools of similar sized fish and often frequent nearshore coastal waters. They also frequently enter tidal estuaries, bays and lagoons (GMFMC and SAFMC 1985). Adult Spanish mackerel are found in waters exceeding 20°C and at depths of less than 75 m (GMFMC 1998).

Life History—Spanish mackerel have a protracted spawning season, which runs from April to October (GMFMC and SAFMC 1985; Godcharles and Murphy 1986). The onset of spawning progresses from south to north in waters 12 to 34 m deep. Spawning starts in April off the Carolinas, in mid-June in the Chesapeake Bay, from late August into September off of the coasts of New Jersey and New York, and from April through October (peaking in May) in the Gulf of Mexico (GMFMC and SAFMC 1985; Godcharles and Murphy 1986; Collette 2002a). Spanish mackerel make seasonal migrations along the Atlantic coast. They are found off Florida during the winter and migrate north as the waters warm. They show up off the Carolinas in April, off Virginia by May, and as far north as Narragansett Bay by July, in some years. They remain in the cooler northern waters until September before beginning their migration south again (GMFMC and SAFMC 1985). In the eastern Gulf of Mexico, this species overwinters in southern Florida and then migrates north and west to Cape San Blas, FL (Lukens 1989).

Common Prey Species—Spanish mackerel feed primarily at the surface on small fishes as well as shrimp, crabs, and squid. Round herring, menhaden, alewives, anchovies, pilchards, and mullets comprise the majority of this species' diet (GMFMC and SAFMC 1985; Collette 2002a).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-8)

- Larva—The Gulf Stream is designated as EFH for this lifestage because it provides a mechanism for dispersal of this lifestage.
- All Lifestages—Designated EFH in the MAB and the SAB includes sandy shoals of capes and offshore bars, high profile rock bottoms and waters seaward of barrier islands to the shelf break or the Gulf Stream boundary. Pelagic *Sargassum* within the U.S. EEZ is also designated as EFH. Additionally, all coastal inlets and state-designated nursery areas are designated as EFH for the Spanish mackerel but are not located within the study area.

HAPC Designations—(SAFMC 1998; Figure D-8)

- Juvenile and Adult—The portions of Bogue Sound in North Carolina with salinities exceeding 30 psu during May through September and the portions of New River in North Carolina with salinities exceeding 30 psu during May through October have been designated as HAPC for the juvenile and adult lifestages of the Spanish mackerel; these regions are not included within the study area.
- All Lifestages—HAPC for all Spanish mackerel lifestages have been designated as the Point off Jupiter Inlet, *Phragmatopoma* (worm) reefs off the east coast of Florida, and pelagic *Sargassum*. Additional areas that are designated as HAPC but are not located in the study area include the Hump off Islamorada, FL; the Marathon Hump off Florida; the Wall off the Florida Keys; nearshore hard bottom (<4 m) south of Cape Canaveral, FL; the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, NC from shore to the ends of the respective shoals but shoreward of the Gulf stream; The Point in North Carolina waters; Ten-Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and Hurl Rocks, SC.

- Speckled Hind (*Epinephelus drummondhayi*)

Management—The speckled hind is managed within the SAFMC's Snapper Grouper FMP (SAFMC 2003a).

Status—Speckled hind are overfished and subject to overfishing in the SAB (NMFS 2005b). This species is designated as a species of concern (formerly a candidate species in 1999) by the NMFS from North Carolina southward through the Gulf of Mexico (NMFS 2004a) and is listed by the IUCN Red List as critically endangered or facing an extremely high risk of extinction in the wild in the immediate future (Chuen and Huntsman 2005a).

Distribution—Speckled hind range from North Carolina to Cuba, including Bermuda, The Bahamas, and the Gulf of Mexico (Manooch 1988).

Habitat Preferences—Typically, speckled hind inhabit warm, deep waters 25 to 400 m (most common from 60 to 120 m) deep and temperatures of 15.5° to 29.4°C (Manooch 1988; SAFMC 2003a). Smaller individuals are found utilizing more inshore waters compared to larger adults. Eggs are pelagic, while larvae utilize surface waters before migrating to bottom habitats (Manooch 1988). Adults, which are typically solitary, are found utilizing high and low profile hard bottom habitats (SAFMC 1998; SAFMC 2003a).

Life History—Speckled hind are protogynous hermaphrodites, and the majority of the older, larger fish are males (Manooch 1988). Spawning aggregations are formed from July to September offshore with specific locations recorded off South Carolina (Manooch 1988; SAFMC 2003a; Sedberry et al. 2006). *Oculina* Bank is believed to serve as a nursery area for this species (Koenig 2001).

Common Prey Species—This species feeds on benthic prey, including crab, shrimp, mollusks, squid, octopus, and fishes (Manooch 1988; SAFMC 1998).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-24)

- Larva—EFH is designated for this lifestage as the Gulf Stream and areas with pelagic *Sargassum* from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Adult—Bottom habitats consisting of high- and low-relief hard bottom from depths from 27 to 122 m, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-24)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated

including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Tilefish (*Lopholatilus chamaeleonticeps*)

Management—There are two tilefish stocks recognized in the northwestern Atlantic. One (northern stock) is found primarily in the MAB and the other (southern stock) occurs south of Cape Hatteras, NC and into the Gulf of Mexico (Steimle et al. 1999). Only the southern stock occurs in the study area and is managed by the SAFMC as part of the FMP for the Snapper Grouper Fishery (SAFMC 1998).

Status—Both stocks of tilefish are overfished and overfishing is currently occurring (NMFS 2005b).

Distribution—Tilefish occur over the outer continental shelf and upper slope ranging from Nova Scotia to Florida, throughout the Gulf of Mexico to Campeche Bank, and in South America off Venezuela, Guyana, and Surinam (Freeman and Turner 1982).

Habitat Preferences—Tilefish eggs have been most commonly collected in waters ranging from 8º to 19ºC and at depths of 80 to 800 m (Steimle et al. 1999). Based on observations, it has been suggested that larval tilefish are planktonic and prefer a relatively narrow band of temperatures of 13º to 18ºC and shallow waters with depths ranging between 50 and 150 m (Steimle et al. 1999). Both juvenile and adult tilefish are shelter seekers, and typically inhabit burrows, the size and shape of which varies depending on the size of the fish and the proximity of associated species (Able et al. 1982). Juveniles are believed to be more tolerant of low temperatures than adult tilefish. The majority of the observations of juvenile tilefish are from waters with temperatures of 9° to 11°C (24% of tilefish were observed in waters of 8°C or less) and depths between 90 and 170 m (some were collected in water as deep as 264 m) (Steimle et al. 1999). Juveniles have been observed using structures such as lobster and crab pots and traps, shipwrecks, and other solid structures as shelter (Freeman and Turner 1982; Steimle et al. 1999) but more commonly inhabit simple vertical shaft burrows in semi-lithified clay (Able et al. 1982). Adults prefer waters ranging from 8° to 18°C and depths of 105 to 274 m in the northwest Atlantic (Steimle et al. 1999). They are primarily associated with both horizontal and vertical burrows in semi-lithified clay outcrops along the shoulders, flanks, and upper slopes of submarine canyons but also have been observed using rocks, boulders, and exposed rocky ledges as shelters (Able et al. 1982; GMFMC 1998; Steimle et al. 1999).

Life History—Spawning in tilefish generally occurs from March to November, with peaks from May through September (Able 2002). Female tilefish are fractional spawners, only releasing small batches of eggs at a time (Grimes et al. 1988). Tilefish have no discernable movement patterns (Freeman and Turner 1982).

Common Prey Species—Adult tilefish prey upon a wide range of vertebrates and invertebrates. Their diets consist of a variety of fishes, shrimp, crabs, squid, sea cucumbers, sea urchins, worms, tunicates, and anemones (SAFMC 1998).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-25)

- Larva—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage of the tilefish.
- Adult—EFH for this lifestage is interpreted as clay substrate in 76 to 457 m water depths from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-25)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated

including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Vermilion Snapper (*Rhomboplites aurorubens*)

Management—Vermilion snappers are managed by the SAFMC within the Snapper Grouper FMP (SAFMC 2003a).

Status—In the SAB, the vermilion snapper are not overfished but are subject to overfishing (NMFS 2005b).

Distribution—Vermilion snappers range from Cape Hatteras, NC to Brazil, including Bermuda, Caribbean Sea, and the Gulf of Mexico (Manooch 1988). They are most abundant in the Gulf of Mexico, specifically off western Florida, and off the southeastern U.S. (SAFMC 2003a; GMFMC 2004).

Habitat Preferences—Habitat preference of the vermilion snapper is influenced more by substrate type than depth (SAFMC 2003a). In the SAB, the vermilion snapper prefers benthic habitats in water depths of 180 to 300 m near the continental shelf break that consist of sand, gravel, or rock while in the Gulf of Mexico, the water depth range is 20 to 200 m (GMFMC 1998; SAFMC 2003a). In the Gulf of Mexico, vermilions snappers are abundant and associated with hard bottom habitat, reefs, and rocky substrates of the central Florida coast, Florida Middle Grounds HAPC, and Flower Gardens (TX) (Hood and Johnson 1999). Vermilion snapper typically utilize the part of water column 2 to 6 m above the ocean bottom (Dixon 1975). Younger vermilion snapper typically utilize shallower habitats than adults (<25 m) (Allen 1985). Eggs are pelagic and hatch after several days (Manooch et al. 1998b). Larvae, also pelagic, have been collected in waters with temperatures less than 27°C and depths of less than 22 m (SAFMC 1983).

Life History—Vermilion snapper spawn in continental shelf waters at depths of 31 to 119 m (Manooch et al. 1998b). Recent MARMAP surveys have identified numerous spawning locations from the coast of North Carolina to Florida at depths from 18 to 97 m (SAFMC 2004b; Sedberry et al. 2006). Spawning aggregations occur in waters with temperature between 21° and 25°C from April through September (Manooch 1988; Manooch et al. 1998b). This species is capable of spawning multiple times during a season off the U.S. coast but spawn year round in more tropical waters (i.e., Puerto Rico) (Manooch 1988). The vermilion snapper does not demonstrate seasonal movements (Grimes et al. 1982; Manooch et al. 1998b).

Common Prey Species—Vermilion snapper examined from North Carolina were found to be feeding primarily on small invertebrates, specifically amphipods, and partially on fishes and fish eggs (Dixon 1975; Manooch 1988). This species feeds opportunistically throughout the water column, rather than on the bottom, primarily during the late afternoon and early evening (Dixon 1975; Grimes et al. 1982).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-26)

- Egg—EFH is interpreted as the pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Larva—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W); pelagic *Sargassum*; and the Gulf Stream, which provides a mechanism of dispersion; are interpreted as EFH for this lifestage of the vermilion snapper.
- Juvenile and Adult—Reef and hard bottom habitats in depths of 20 to 200 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-26)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Wahoo (*Acanthocybium solandri*)

Management—Wahoo are managed by the SAFMC through the FMP for the Dolphin and Wahoo Fishery of the Atlantic (SAFMC 2003b).

Status—The wahoo stock in the northwestern Atlantic is not overfished nor is it subject to overfishing (NMFS 2005b).

Distribution—Wahoo are found throughout the tropical and subtropical waters of the Atlantic, Pacific, and Indian oceans (Manooch 1988). In the western Atlantic, wahoo have been reported from New York to Columbia, as well as in the Gulf of Mexico, the Caribbean, Bermuda, and the Bahamas (SAFMC 2003b).

Habitat Preferences—There are currently no data available describing the habitat association of wahoo eggs in the Atlantic Ocean (SAFMC 2003b). The only reported wahoo larvae in the Atlantic were obtained in the Straits of Florida and Yucatan Channel in depths exceeding 400 m (with the exception of one larva which was collected at 32 m). It is speculated that the larvae display a preference for depths of 100 m or greater (Wollam 1969). Little is known about the habitat preferences of the juvenile wahoo, although they are thought to associate with pelagic *Sargassum* and prefer water temperatures ranging from 22° to 30°C (SAFMC 2003b). Adult wahoo are pelagic and commonly found near mats of pelagic *Sargassum* and prefer water temperatures ranging from 22° to 28°C (SAFMC 2003b).

Life History—Wahoo spawn from May to October. The peak spawning period occurs in June near Cuba, in the Straits of Florida, and the Yucatan (Wollam 1969). Wahoo are believed to undergo migrations through the Florida Straits and into the Gulf Stream (Wollam 1969).

Common Prey Species—Wahoo are primarily piscivorous, preying upon mackerels, scads, jacks, flying fish, butterfishes, pompanos, and porcupine fish, among others. Their diet infrequently includes some invertebrates, such as squid and the paper nautilus (SAFMC 2003b).

EFH Designations—(SAFMC 2003b, 2004a; Figure D-10)

- All Lifestages—The Gulf Stream and its associated gyres and eddies that occur in the U.S. Atlantic EEZ, the Florida Current and its associated gyres and eddies, and the Charleston Gyre have been designated as EFH for the wahoo in the western North Atlantic.

HAPC Designations—(SAFMC 2003b, 2004a; Figure D-10)

- All Lifestages—Amberjack Lump is designated as HAPC. Designated HAPC not found in the study area include The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Hump off Islamorada, FL; the Marathon Hump, FL; and the Wall off the Florida Keys; the Charleston Bump, off South Carolina; and Georgetown Hole, SC.

- Warsaw Grouper (*Epinephelus nigritus*)

Management—Warsaw groupers are managed by the SAFMC within the Snapper Grouper FMP (SAFMC 2003a).

Status—Warsaw grouper are overfished and are subject to overfishing in the SAB (NMFS 2005b). This species is also designated as a species of concern (formerly a candidate species) by the NMFS from Massachusetts to the Gulf of Mexico (NMFS 2004a) and listed as critically endangered or facing

an extremely high risk of extinction in the wild in the immediate future by the IUCN Red List (Chuen and Huntsman 2005b).

Distribution—The distribution of the warsaw grouper typically ranges from North Carolina south through the Florida Keys, Caribbean, Gulf of Mexico, and northern coast of South America, though it has been reported as far north as Massachusetts (Manooch 1988; SAFMC 2003a).

Habitat Preferences—Adult warsaw groupers utilize irregular benthic habitats, including steep cliffs, notches, valleys, rocky ledges, and drop-offs at depths ranging from 76 to 219 m (Manooch 1988; SAFMC 1998). Juveniles are found closer to shore around jetties or shallow reefs (SAFMC 2003a). Eggs and larvae are pelagic (SAFMC 1998).

Life History—Little data exist on the reproductive habits and spawning locations of the warsaw grouper. Spawning has only been reported off Cuba from April to May (SAFMC 2003a). Insufficient data exist to determine if this species forms spawning aggregations (Coleman et al. 2000).

Common Prey Species—The warsaw grouper preys opportunistically on benthic fishes and crustaceans (SAFMC 1998).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-27)

- Egg—EFH is interpreted as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Larva—Pelagic waters, including the Gulf Stream and areas of pelagic *Sargassum*, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage as the Warsaw grouper.
- Adult—EFH is interpreted as bottom habitats of cliffs, notches, and rocky ledges in depths from 76 to 219 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-27)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- White Grunt (*Haemulon plumieri*)

Management—The SAFMC manages the white grunt under the Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, the white grunt is neither overfished nor is overfishing occurring (NMFS 2005b).

Distribution—White grunts are distributed from Virginia to Brazil, including Bermuda, the Gulf of Mexico, and Caribbean Sea (Manooch 1988). The two stocks of this species, and where they occur most numerously, are found off the Carolinas and from Palm Beach, FL south through the Florida Keys. White grunts are considered rare off Georgia and northeast Florida (Potts and Manooch 2001).

Habitat Preferences—Juvenile and adult white grunts inhabit waters from shore to depths of at least 35 m, with substrates consisting of reefs, hard bottom, seagrasses, and mangroves (SAFMC 1998). Eggs and larvae are pelagic (SAFMC 1983). Around islands, grunt species are more common around those with extensive shelf habitat (Robins 1991).

Life History—White grunts do not exhibit long-range migrations but have been recorded moving to deeper waters in the winter (SAFMC 1983). Juveniles also move from reef habitats to feeding grounds in seagrass beds at night (SAFMC 1983). Off the southeastern U.S. coast, spawning can occur throughout the year but peaks from May to July (Manooch 1988; SAFMC 1998). White grunt typically spawn in warmer waters (bottom temperatures from 18.9° to 27.4°C) than most members of the snapper grouper MU (Sedberry et al. 2006).

Common Prey Species—White grunts are opportunistic foragers that prey upon benthic invertebrates (worms, crab, shrimp, and mollusks) and fishes (Manooch 1988).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-28)

- Egg—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Larva—EFH is interpreted for this lifestage of the white grunt as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W); pelagic *Sargassum*; and the Gulf Stream, which provides a mechanism of dispersion.
- Juvenile and Adult—Reef, hard bottom, grass flats, and mangrove habitats from shore to depths of 35 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-28)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Additional HAPC have been designated, although not occurring within the study area, including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- White Shrimp (*Litopenaeus setiferus*)

Management—White shrimp are managed by the SAFMC as part of the Shrimp FMP (SAFMC 1998).

Status—The white shrimp is neither classified as overfished nor is subject to overfishing in the northwest Atlantic (NMFS 2005b).

Distribution—In U.S. Atlantic waters, white shrimp range from Fire Island, NY to the St. Lucie Inlet, FL. In the Gulf of Mexico, this species is found from Ochlockonee River of Apalachee Bay, FL to Ciudad Campeche, Mexico. Centers of abundance in the U.S. Atlantic exist off North Carolina, South Carolina, Georgia, and northeastern Florida (Whitaker 1981). In the Gulf of Mexico, the greatest densities of white shrimp are found off the Louisiana coast (GMFMC 2004).

Habitat Preferences—White shrimp are generally concentrated in waters less than 27 m deep, although they are occasionally found in deeper waters up to 82 m (Muncy 1984). White shrimp can be pelagic or benthic and oceanic or estuarine, depending upon the lifestage. Eggs are demersal and larvae are mainly pelagic but both occur in the oceanic environment. Post-larvae, juveniles, and subadults are benthic and estuarine, inhabiting mostly soft sediments with mud or peat bottoms with large quantities of decaying organic matter or vegetative cover and prefer areas of low salinity (<10 psu) (Pattillo et al. 1997; GMFMC 2004). This species can be found throughout the year in Texas bays but are most common in these areas in the summer and fall (Christmas and Etzold 1977). Adults are oceanic and found on soft mud or silt bottoms in shallow, continental shelf waters (Williams 1984). This species is tolerant of temperatures ranging from approximately 7° to 38°C and can be considered euryhaline, since most lifestages tolerate fairly wide salinity ranges (Pattillo et al. 1997).

Life History—Water temperatures can directly or indirectly influence white shrimp spawning, growth, habitat selection, osmoregulation, movement, migration, and mortality (Muncy 1984). Spring water temperature increases (to between 22° and 29°C) trigger spawning, and rapid water temperature declines (to below 20°C) in the fall signify the end of spawning. Along the U.S. Atlantic coast, spawning begins in May and extends through September in offshore waters with depths of 9 to 34 m. Peaks in spawning activity occur in the summer from June through July (Pattillo et al. 1997). In the Gulf of Mexico, spawning occurs from spring through fall with white shrimp spawning multiple times in one season at depths from 8 to 34 m (Christmas and Etzold 1977; GMFMC 1981, 2004). White shrimp migrate southward along the U.S. Atlantic coast during fall and early winter and then move northward in late winter and early spring. More specific migrations show a major southerly migration from North Carolina to Cape Canaveral, FL in the fall and a northerly migration from Cape Canaveral in the spring (Pattillo et al. 1997). Fall and winter emigration of white shrimp from estuaries along the U.S. Atlantic and Gulf coasts is governed largely by body size, age, and environmental conditions (Muncy 1984). White shrimp offshore movements are primarily driven by feeding (Christmas and Etzold 1977).

Common Prey Species—White shrimp are omnivorous feeding on detritus, gastropods, annelids, mollusks, copepods, insect larvae, sponges, corals, algae, vascular plants (stems and roots), and small fishes (GMFMC 1981, 2004a; Muncy 1984; Pattillo et al. 1997).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-29)

- Egg—Nearshore, demersal marine habitats in 6.1 to 24.4 m of water depth ranging from the Virginia/North Carolina border to the St. Lucie Inlet, FL are interpreted as EFH for this lifestage.
- Larva—EFH for this lifestage of the white shrimp is interpreted as pelagic ocean waters <24.4 m deep, ranging from the Virginia/North Carolina border to the St. Lucie Inlet, FL.
- Juvenile—Although not located within the study area, EFH for this lifestage is interpreted as estuarine areas consisting of marshes, wetlands, tidal palustrine-forested areas, mangroves, SAV, and subtidal and intertidal nonvegetated flats ranging from the Virginia/North Carolina border to the St. Lucie Inlet, FL.
- Adult—Soft mud bottoms located shoreward of the 27 m ranging from the Virginia/North Carolina border to the St. Lucie Inlet, FL are interpreted as EFH for this lifestage.

HAPC Designations—(SAFMC 1998; NMFS 2002c; Figure D-29)

- All Lifestages—All coastal inlets, state designated nursery areas, and state-identified overwintering areas are designated as HAPC for penaeid shrimp species (brown, pink, and white). These areas are not located within the boundaries of the study area.

- Wreckfish *(Polyprion americanus)*

Management—Wreckfish are managed within the SAFMC's Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring (NMFS 2005b). However, it is designated by the IUCN Red List as data deficient, with the possibility that future research may warrant a threatened classification (Sadovy 2003).

Distribution—Wreckfish are found in the Indian, Pacific, and Atlantic Oceans as well as the Mediterranean Sea (McClane 1978). In the western Atlantic, wreckfish are distributed from Newfoundland to Argentina (SAFMC 1998). Juveniles are more abundant in the eastern than western Atlantic (Vaughan et al. 2001).

Habitat Preferences—Wreckfish are a deepwater species typically found in water depths to 610 m (with minimum and maximum reported depths of 42 to 1,000 m) and are associated with rocky ledges, seamounts, pinnacles, and shipwrecks (SAFMC 1998; Schultz 2004). In the northwest Atlantic Ocean, adult wreckfish have only been reported occurring on the Blake Plateau and in the Straits of Florida from depths of 400 to 650 m (Sedberry et al. 2001). The Charleston Bump, a high-relief ridge off South Carolina has been identified as an important habitat (shelter, feeding, spawning)

for this species (Popenoe and Manheim 2001). Wreckfish are predominantly pelagic and associate with floating debris during their early lifestages (≤60 cm TL) (Sedberry et al. 1996; SAFMC 1998). Juveniles inhabit surface waters from several months to two years (Sedberry et al. 1996; Sedberry et al. 1999). As the species matures, wreckfish begin to utilize bottom water habitats. Eggs and larvae are pelagic, and the Gulf Stream plays an essential role in dispersal (Klein-MacPhee 2002b).

Life History—There are little data available on the life history of this species. Wreckfish spawn from November to May (peaking from February and March) along the Charleston Bump, which is the only known spawning site for this species in the northwest Atlantic (Sedberry et al. 1996; Sedberry et al. 2006). Specifically, spawning females have been collected at depths of 433 to 595 m in this region of the Charleston Bump (Sedberry et al. 2006). Not enough data exist to determine if this species forms spawning aggregations (Coleman et al. 2000).

Common Prey Species—Wreckfish feed on crustaceans, mollusks, and fishes located in the vicinity of underwater objects, such as shipwrecks (Schultz 2004). Off the Carolinas, wreckfish have been reported to specifically feed on eels, black-belly rosefish, snake mackerels, shrimp, squid, and mesopelagic fishes (Klein-MacPhee 2002b). Squid are the predominant prey species eaten by wreckfish off the Charleston Bump (Sedberry et al. 2001).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-30)

- Larva and Juvenile—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are interpreted as EFH.
- Adult—EFH for this lifestage of the wreckfish is interpreted as areas of significant relief on the Blake Plateau, such as manganese-phosphate pavement, phosphorite slabs, as well as coral banks and mounds at depths less than 1,000 m ranging from North Carolina south to Florida (Blake Plateau).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-30)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

- Yellowedge Grouper (*Epinephelus flavolimbatus*)

Management—The SAFMC manages the yellowedge grouper within the Snapper Grouper FMP (SAFMC 2003a).

Status—Currently, this species is neither overfished nor is overfishing occurring in the SAB (NMFS 2005b).

Distribution—This grouper species ranges from North Carolina to Brazil, including the Caribbean and Gulf of Mexico (Manooch 1988). It is considered more abundant in the western Gulf of Mexico than in the Atlantic Ocean (SAFMC 1998).

Habitat Preferences—The yellowedge grouper is a demersal species found at depths ranging from 64 to 365 m (Cass-Calay and Bahnick 2002; SAFMC 2003a). Solitary adults inhabit regions of the continental shelf break distinguished by drop-offs, troughs, and terraces (Manooch 1988). This species also utilizes hard bottom, rocky, and soft bottom habitats of sand or mud (SAFMC 2003a). In the Gulf of Mexico, the highest concentrations of yellowedge groupers are found between depths of 128 and 274 m, where they may inhabit burrows (Matlock et al. 1990). Eggs and larvae are pelagic (Manooch 1988). Larval yellowedge grouper cannot be distinguished from that of the snowy grouper

(Cass-Calay and Bahnick 2002). Therefore, there is little known about the early lifestages of this species.

Life History—The yellowedge grouper is a protogynous hermaphrodite, with larger individuals (>76 cm) being males. In the Atlantic, spawning occurs offshore from April to October, peaking in September (Manooch 1988). Spawning females have been collected at depths from 160 to 194 m at bottom water temperatures of 14.5°C (Sedberry et al. 2006). Not enough data exist to determine if this species forms aggregations to spawn (Coleman et al. 2000).

Common Prey Species—This species feeds opportunistically on a variety of prey, including squid, octopus, eel, crabs, and fishes (seahorses, scorpionfish, searobin, lizardfish) (Manooch 1988).

EFH Designations—(SAFMC 1998; NMFS 2002c; Figure D-31)

- Egg—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH.
- Larva—EFH for this lifestage of the yellowedge grouper is interpreted as pelagic waters, including the Gulf Stream and areas of pelagic *Sargassum*, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W).
- Adult—Hard bottom and rocky outcropping from depths from 190 to 220 m, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary at 83°W) are interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; Figure D-31)

- All Lifestages—Medium- to high-profile offshore hard bottom habitat where spawning normally occurs, areas of known spawning aggregations, pelagic *Sargassum*, all hermatypic coral habitats and reefs, the *Oculina* Bank HAPC, and Council-designated Artificial Reef SMZs are designated as HAPC. Although not found within the study area, additional HAPC have been designated including mangrove habitat, seagrass habitat oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard bottom habitat (<4 m), The Point, NC; the Ten Fathom Ledge, NC; Big Rock, NC; the Charleston Bump, SC; and manganese outcroppings on the Blake Plateau.

5.2.2 Warm-Temperate Species

- Bluefish (*Pomatomus saltatrix*)—A full description of the bluefish and its designated EFH is presented under the Subtropical-Tropical section above.
- Spiny Dogfish (*Squalus acanthias*)

Management—Spiny dogfish are jointly managed by the MAFMC and the NEFMC through the Spiny Dogfish FMP (MAFMC and NEFMC 1999).

Status—The spiny dogfish stock is not subject to overfishing (NMFS 2005b). Although no biomass target was defined in the FMP, the NMFS' recommended biomass threshold for this species indicates that at the current biomass level the stock is overfished (NMFS 2005b). According to the IUCN Red List, the northwest Atlantic population of this species is considered endangered or facing a very high risk of extinction in the wild (Fordham et al. 2006).

Distribution—In the northwestern Atlantic Ocean, the spiny dogfish ranges from Greenland to southern Florida and Cuba but is most abundant between Newfoundland and Georgia (Nammack et al. 1985).

Habitat Preferences—Spiny dogfish are ovoviviparous and eggs develop internally (Burgess 2002). The offspring, known as pups, are born live as fully developed juveniles following a gestation period of two years (Cohen 1982). Both juvenile and adult spiny dogfish are epibenthic but move throughout the water column. They inhabit nearshore shallow waters out to depths of 900 m along the inshore

and offshore continental shelf (Burgess 2002). Adults and juveniles have a temperature preference between 7° to 15°C (McMillan and Morse 1999).

Life History—Spiny dogfish spawn in the winter in offshore waters (Cohen 1982; Burgess 2002). Parturition occurs between November and January in offshore wintering grounds but can occur as late as May in areas of colder temperatures (Nammack et al. 1985; McMillan and Morse 1999; Burgess 2002). Spiny dogfish migrate north in the spring and summer, typically north of Cape Cod, MA, and return south again in the fall and winter, usually off the North Carolina coast (McMillan and Morse 1999). Seasonal inshore-offshore migrations are also common for this species and are related to water temperature. Spiny dogfish overwinter in deeper offshore waters and move into the nearshore shallow waters during the summer (McMillan and Morse 1999; Burgess 2002).

Common Prey Species—Spiny dogfish are very aggressive piscivores that feed primarily on fishes, such as mackerel, herring, menhaden, sand lance, capelin, wolffish, flatfish species, cod, and haddock. They also consume mollusks, crustaceans, and other invertebrates (Burgess 2002).

EFH Designations—(MAFMC and NEFMC 1999; Figure D-32)

- Juvenile—EFH for this lifestage of the spiny dogfish is designated as waters with depths to 390 m from Cape Hatteras to Cape Canaveral, FL. Although not located within the study area, addition EFH is designated in offshore waters north of Cape Hatteras and in southern New England estuaries and bays.
- Adult—South of Cape Hatteras to Cape Canaveral, FL, EFH is designated in waters to depths reaching 450 m. Additional EFH is designated offshore north of Cape Hatteras as well as in southern New England estuaries and embayments have also been designated as EFH for this lifestage of the spiny dogfish.

HAPC Designations—No HAPC are identified for this species.

- Summer Flounder (*Paralichthys dentatus*)

Management—The summer flounder stock is jointly managed by the MAFMC and ASMFC under Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP (MAFMC and ASMFC 1998b).

Status—The summer flounder stock is subject to overfishing and overfishing is occurring (NMFS 2005b).

Distribution—The range of summer flounder is from Nova Scotia to Florida, but their occurrence north of Cape Cod, MA and south of Cape Hatteras, NC is rare (Byrne and Azarovitz 1982; Klein-MacPhee 2002c).

Habitat Preferences—Summer flounder eggs are pelagic and occur over the continental shelf in waters with temperatures ranging from 9º to 23ºC, although the majority of eggs have been observed at temperatures between 12º and 19ºC. Eggs are most common in the MAB between Long Island, NY and Cape Hatteras, NC within 25 NM of shore (Byrne and Azarovitz 1982). The larvae are also pelagic and found primarily over the continental shelf. Larvae thrive in waters with temperatures between 0º and 23ºC but appear with the most frequency in waters between 9º and 18ºC (Byrne and Azarovitz 1982). Following their metamorphosis into juveniles, the summer flounder seeks inshore demersal habitats (Byrne and Azarovitz 1982). They display a preference for portions of estuaries containing sandy substrates or where there is a transition from fine sand to silt and clay and water temperatures ranging between 3º and 27ºC (Packer et al. 1999). Adults share the same temperature preferences as the juveniles but upon reaching maturity, move out of the estuaries and onto the continental shelf (Byrne and Azarovitz 1982; Packer et al. 1999).

Life History—Summer flounder have two distinct annual spawning periods. The first is also the most intense and occurs over the coastal southern New England and MAB regions during autumn and winter. The second spawning period occurs in the southern part of the MAB in the spring (Berrien and Sibunka 1999). Female summer flounder continually produce egg batches throughout the spawning period (Klein-MacPhee 2002c). Summer flounder begin moving into the inshore waters of coastal

southern New England in April and continue through July or August. Those fish that move inshore from the Chesapeake Bay and north move offshore again in the fall. This offshore migration begins in September, and by October or November, most of the summer flounder have left the northern part of their range (Klein-MacPhee 2002c).

Common Prey Species—Bony fishes (sand lance, anchovy, herring, silver hake, and flatfish species) and squid are the primary components of the summer flounder's diet (Klein-MacPhee 2002c). Summer flounder feed benthically and pelagically (Klein-MacPhee 2002c).

EFH Designations—(MAFMC and ASFMC 1998b; Figure D-33)

- Egg—EFH is designated in continental shelf waters (from the coast to the U.S. EEZ) from Cape Hatteras, NC to Cape Canaveral, FL in depths to110 m. EFH is designated in regions north of Cape Hatteras, but these areas do not occur within the study area.
- Larva—EFH for this lifestage of the summer flounder is designated as nearshore (to 44 NM from shore or to the U.S. EEZ) waters from Cape Hatteras, NC to Cape Canaveral, FL. Additional EFH not occurring within the study area has been designated including the mixing (0.5 to 25 psu) and seawater (>25 psu) zones of the Indian River, offshore of north of Cape Hatteras, and the numerous estuaries and bays in the region.
- Juvenile—From Cape Hatteras, NC to Cape Canaveral, FL, EFH is designated as continental shelf waters (from the coast out to the limits of the U.S. EEZ) to depths of 152 m. Additional EFH not occurring within the study area has been designated including the mixing (0.5 to 25 psu) and seawater (>25 psu) zones of the Indian River, areas offshore of north of Cape Hatteras, as well as the numerous estuaries and bays in the region.
- Adult—EFH is designated as the continental shelf (from the coast out to the limits of the U.S. EEZ) waters from Cape Hatteras, NC to Cape Canaveral, FL at depths to 152 m. Additional EFH not occurring within the study area has been designated including the mixing (0.5 to 25 psu) and seawater (>25 psu) zones of the Indian River, areas offshore of north of Cape Hatteras, as well as the numerous estuaries and bays in the region.

HAPC Designations—(MAFMC and ASFMC 1998a; Figure D-26)

- Juvenile and Adult—Although not occurring within the study area boundary, all native species of macroalgae, seagrasses, and freshwater/tidal macrophytes in any size bed and loose aggregations within the adult and juvenile summer flounder EFH are considered as HAPC for the summer flounder. Although classisfied as a macroalgae, pelagic *Sargassum* is not designated as HAPC for the summer flounder (Hoff 2005).

5.2.3 Highly Migratory Species

Each taxon group of HMS is managed as discrete MUs (NOAA 2006h), but recently the FMPs for all HMS taxa were consolidated into one FMP, the Final Consolidated Atlantic Highly Migratory Species FMP (NMFS 2006h). The HMS are presented below in alphabetical order as a group.

- Albacore Tuna (*Thunnus alalunga*)

Management—The albacore tuna is managed by the NMFS under the Final Consolidated Atlantic Highly Migratory Species FMP (NMFS 2006h).

Status—This species consists of two separate stocks, the north and south Atlantic stocks (NMFS 2003d). These stocks are separated at 5°N with no evidence of mixing occurring between the two stocks (NMFS 1999d). According to the current NMFS stock assessment and fishery evaluation reports (NMFS 2005c, 2004c), the north Atlantic albacore tuna is overfished and overfishing is occurring. The north Atlantic albacore tuna stock is also listed by the IUCN Red List (Uozumi 1996a) as vulnerable or facing a high risk of extinction in the wild.

Distribution—Albacore tuna are distributed worldwide in temperate and subtropical waters of the Atlantic, Indian, and Pacific oceans (Gusey 1981; Collette and Nauen 1983). In the western Atlantic Ocean, this species occurs from New England to southern Brazil. Although widespread in the

Caribbean Sea and off the coast of Venezuela, this species is absent from the Gulf of Mexico and the Straits of Florida. In the western Atlantic Ocean, the albacore ranges from 40°N-45°N to 45°S (Gusey 1981; Collette and Nauen 1983).

Habitat Preferences—The albacore tuna is an epi- and mesopelagic species that is typically found in waters with a temperature range of 15.6° to 19.4°C and in areas around thermal discontinuities, such as ocean fronts. In the Atlantic Ocean, typically larger albacore tuna are found in cooler, deeper waters (up to 600 m) and can tolerate a wider temperature range (13.5° to 25.2°C) than younger, smaller individuals. Schools typically associate with other tuna species (skipjack, yellowfin, and bluefin tuna) and floating objects, including pelagic *Sargassum* mats (Collette and Nauen 1983; NMFS 1999b).

Life History—Albacore tuna undergo extensive seasonal movements (north-south and transoceanic migrations). In the western Atlantic Ocean, populations above 25°N migrate north starting in November, while those south of this region remain throughout the fall and winter in the warm waters of the eastern Caribbean and western tropical Atlantic (Gusey 1981). Albacore tuna also tend to aggregate near temperature discontinuities and migrate with water masses; however, they do not seem to cross temperature and oxygen gradient boundaries (Gusey 1981; Collette and Nauen 1983; NMFS 1999b). This species spawns in the spring and summer in the western tropical Atlantic (NMFS 1999b).

Common Prey Species—Albacore tuna, as other tuna, are considered opportunistic feeders that prey on a diversity of fishes and invertebrates (NMFS 1999b).

EFH Designations—(NMFS 1999b; Figure D-34)

- Spawning Adult, Egg, and Larva—Insufficient information is currently available to identify EFH for this lifestage of the albacore tuna within the U.S. EEZ.
- Juvenile (<90 cm fork length {FL})—EFH is designated for this lifestage (north of the Maryland/Virginia border) but is not located within the study area.
- Adult (>90 cm FL)—EFH for this lifestage of the albacore tuna is designated as surface waters with temperatures between 13.5° and 25.2°C off the coast of Florida, on the Blake Plateau and Blake Spur region, from 79°W east to the U.S. EEZ boundary and 29°N south to the U.S. EEZ boundary. Additional EFH has been designated for this lifestage but is north of the study area (from the Virginia/North Carolina border northward).

HAPC Designations—No HAPC are identified for this species.

- Atlantic Sharpnose Shark *(Rhizoprionodon terraenovae)*

Management—The Atlantic sharpnose shark is managed by the NMFS as a Small Coastal Shark under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—Currently, this shark species is not overfished or subject to overfishing (NMFS 2005b).

Distribution—Atlantic sharpnose sharks are found throughout the Atlantic. The Atlantic sharpnose shark inhabits the waters of the northeastern coast of North America from New Brunswick to Florida and extending to the Yucatan in the Gulf of Mexico (Castro 1983; Delius and Morgan 1999). This shark is a common year-round coastal inhabitant from South Carolina south to the Gulf of Mexico and is a seasonally abundant migrant off Virginia (NMFS 1999b).

Habitat Preferences—The Atlantic sharpnose shark is most abundant in warm-temperate to subtropical waters of the continental shelf, from inshore areas such as estuaries to the surf zone and out over the shelf in water as deep as 280 m, but it primarily remains in waters <10 m deep (Delius and Morgan 1999). This demersal shark has a broad salinity tolerance and has been found in rivers, such as the Pascagoula River in Mississippi (Allen 1999). The nursery areas of this species are estuarine habitats of the Atlantic and the Gulf of Mexico (Castro 1993; McCandless et al. 2002). Nursery areas are typically used from spring until fall (McCandless et al. 2002; Bethea et al. 2004).

Life History—The Atlantic sharpnose shark performs inshore-offshore movements seasonally moving into deeper offshore waters during winter as water temperatures fall, especially in the Gulf of Mexico (Compagno 1984; Delius and Morgan 1999). Atlantic sharpnose sharks typically mate in late spring and early summer with females migrating offshore during their pregnancy (Delius and Morgan 1999). This species moves inshore from North Carolina to central Florida to give birth to live young in shallow, protected areas during the late spring to early summer of the following year (Castro 1983; Castro 1993).

Common Prey Species—This species feeds on fishes (menhaden, eels, silversides, wrasses, jacks, toadfish, filefish, smallmouth flounder, herring, anchovy, pipefish, searobin stargazer, puffer), worms, shrimp, crabs, mollusks, and turtle grass (*Thalassia testudinum*) (Delius and Morgan 1999; Branstetter 2002a; Bethea et al. 2004).

EFH Designations—(NMFS 1999b; Figure D-35)

- Neonate (≤40 cm TL)—EFH designated for this lifestage, but not located within the study area, includes regions north of Daytona Beach, FL and shallow areas within the Gulf of Mexico.
- Juvenile (41 to 78 cm TL)—EFH designated for this lifestage of the Atlantic sharpnose shark includes regions north of Cumberland Island, GA and shallow areas within the Gulf of Mexico but neither of these habitats are located within the study area.
- Adult (≥79 cm TL)—EFH is designated for this lifestage of the Atlantic sharpnose shark as waters inshore to the 100 m isobath from St. Augustine, FL to Cape Canaveral, FL. Areas north of Cape Hatteras, NC and within the Gulf of Mexico are also designated as EFH but are not located within the study area.

HAPC Designations—No HAPC are identified for this species.

- Bigeye Tuna (*Thunnus obesus*)

Management—The bigeye tuna is managed by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—According to current stock assessment and fishery evaluation reports by the NMFS (2004c, 2005b), the bigeye tuna is overfished and overfishing is occurring. This species is listed by IUCN Red List as vulnerable or facing a high risk of extinction in the wild (Uozumi 1996b).

Distribution—Bigeye tuna are distributed worldwide in the tropical and subtropical waters of the Atlantic, Indian, and Pacific oceans (Schultz 2004). Its range practically extends over the entire Atlantic Ocean from 50°N to 45°S. In the western Atlantic, this species occurs from Massachusetts to Argentina but is uncommon in the Gulf of Mexico and the Straits of Florida (NMFS 1999b).

Habitat Preferences—Bigeye tuna can inhabit water depths up to 250 m, deeper than most species of tuna. The bigeye tuna commonly occurs in regions where water temperatures range from 13° to 29°C, with an optimal temperature range between 17° and 22°C (NMFS 1999b). Variation in occurrence is closely related to seasonal and climatic changes in surface temperature and the thermocline depth (Collette and Nauen 1983; NMFS 1999b). Juveniles often school near the surface with other tuna species (i.e., yellowfin and skipjack) and associate with floating objects, whale sharks, and sea mounts. Eggs and larvae are pelagic (NMFS 1999b).

Life History—Bigeye tuna are believed to spawn between 15°N and 15°S, with peak spawning occurring in June and July in the northwestern tropical Atlantic (Collette and Nauen 1983). Additionally, the Gulf of Guinea, off the coast of central Africa, is identified as important habitat for spawning adults, eggs, and larvae (NMFS 1999b). Larger bigeye tuna migrate to temperate waters, while smaller individuals are restricted to the tropical range of their distribution (NMFS 1999b).

Common Prey Species—Bigeye tuna feed during the day and night on fishes, cephalopods, and crustaceans (Collette and Nauen 1983).

EFH Designations—(NMFS 1999b; Figure D-36)

- Spawning Adult, Egg, and Larva—Insufficient information is currently available to identify EFH for this lifestage of the albacore tuna within the U.S. EEZ.
- Juvenile (<100 cm FL)—Off the eastern coast of Florida, designated EFH extends from the Blake Plateau off Cape Canaveral, FL (29°N) to the U.S. EEZ boundary (28.25°N) and from 79°W to the U.S. EEZ boundary (76.75°W). Additional EFH designated for this lifestage but not found in the study area includes areas from Cape Hatteras, NC northward.
- Adult[1] (>100 cm FL)—EFH is designated as pelagic waters from the surface to a depth of 250 m: ranging from Cape Canaveral, FL (29°N) to the U.S. EEZ boundary (28.25°N) and from 79°W to the U.S. EEZ boundary (76.75°W). Although not occurring in the study area, additional EFH has been designated for this lifestage as regions north of Cape Lookout, NC.

HAPC Designations—No HAPC are identified for this species.

- Bignose Shark (*Carcharhinus altimus*)

Management—The NMFS manages the bignose shark, which is classified as a Prohitied Species, under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—Possession of this shark is prohibited in the U.S. by NMFS (1999b, 2006h) as a precautionary measure so that directed fisheries do not develop. The bignose shark stock is overfished and currently is subject to overfishing (NMFS 2005b).

Distribution—The bignose shark frequents the tropical and subtropical regions of the Atlantic, Pacific, and Indian Oceans (Castro 1983). In the western Atlantic Ocean, this species is found in the Gulf of Mexico, the Caribbean Sea, and from Florida northward to the Delaware/Maryland border (NMFS 1999b).

Habitat Preferences—The bignose shark is a bottom-dwelling species that inhabits the deeper waters of the continental shelf and insular slope (Bester 1999d; NMFS 1999b). While this species has been observed from the surface to as deep as 430 m, it most frequently occurs at depths exceeding 90 m. Juveniles, however, tend to inhabit shallower waters than the adults (Bester 1999d).

Life History—The bignose shark is viviparous and gives birth to live young in the summer. Little else is known about the reproductive history of this shark. These sharks occasionally migrate vertically at night into the upper levels of the ocean (Castro 1983).

Common Prey Species—The diet of the bignose shark consists of other cartilaginous fishes including chimaeras, smaller sharks, dogfish, catsharks, and stingrays; bony fishes such as mackerels, soles, and batfish; and cephalopods including squid and octopuses (Castro 1983; Bester 1999d).

EFH Designations—(NMFS 2006h; Figure D-37)

- Neonate (≤67 cm TL)—Although EFH is designated for this lifestage, it occurs north of the study area (from Bull's Bay, SC northward).
- Juvenile (68 to 225 cm TL)—Between the 100 and 500 m isobaths, EFH is designated for this lifestage of the bignose shark from offshore from St. Augustine, FL (30°N) to offshore West Palm Beach, FL (27°N). Additional EFH is designated from Bull's Bay, SC northward for this lifestage but occurs north of the study area.
- Adult (≥226 cm TL)—Insufficient data are currently available to identify EFH for this lifestage of the bignose shark.

[1]The FMP EFH text description of the adult bigeye tuna does not match the GIS data provided by the NMFS (2003b). Dr. Chris Rilling, NMFS HMS Division, was consulted about this discrepancy and indicated that the NMFS was aware of the discrepancy but that it would not be addressed until sometime in the future; the discrepancy was not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

HAPC Designations—No HAPC are identified for this species.

- Blacknose Shark (*Carcharhinus acronotus*)

Management—The blacknose shark is classified as a Small Coastal Shark in the Shark MU, which is managed by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—This species is neither overfished nor is subject to overfishing (NMFS 2005b).

Distribution—The blacknose shark ranges from North Carolina to southeastern Brazil in the western Atlantic, including the Caribbean Sea, Bahamas, and Gulf of Mexico (Castro 1983; Bester 1999e). During the summer and fall, this species can be found with the greatest abundance from the Carolinas to Florida and in the Gulf of Mexico (Castro 1983). In the Bahamas, this species is commonly found on the Great Bahamas Bank (Böhlke and Chaplin 1993).

Habitat Preference—In the western Atlantic Ocean, the blacknose shark is found in coastal tropical and warm temperate waters of the continental shelf over sand, shell, and coral bottoms. This species commonly segregates by size, with juveniles found in shallow water and adults located at greater depths, typically between 8 and 64 m (Bester 1999e; Compagno et al. 2005).

Life History—The blacknose shark is viviparous. The birthing season occurs from January to April off southwestern Florida, during late May to early June off the Carolinas, and from May through early June in the Gulf of Mexico (Castro 1983; Driggers et al. 2004). This species is considered non-migratory off Florida. Nursery areas have been identified in shallow water areas of South Carolina, including Bulls Bay and in the northeastern and north central Gulf of Mexico (e.g., Apalachee Bay, FL, Tampa Bay, FL, St. Andrew Bay, FL, Charlotte Harbor, FL, and the Florida Keys) (NMFS 1999b; McCandless et al. 2002).

Common Prey Species—The blacknose shark feeds on small fishes including croakers, pigfish, porgies, porcupine fish, spiny boxfishes, and anchovies; as well as octopus (Bester 1999e).

EFH Designations—(NMFS 1999b; Figure D-38)

- Neonate (≤52 cm TL)—EFH is designated as shallow coastal waters to the 25 m isobath from the North Carolina/South Carolina border south to Cape Canaveral, FL. Additional EFH designated for this lifestage, but not located in the study area, includes areas off western Florida.
- Juvenile[2] (53 to 106 cm TL)—EFH is designated for this lifestage of the blacknose shark as the shallow coastal waters from the 25 m isobath at the Georgia/Florida border south to West Palm Beach, FL. Additional EFH designated for this lifestage, but not located in the study area, includes areas off the Florida Keys, western Florida, and shallow (<5m deep) estuaries and bays containing seagrass beds from Apalachee Bay to St. Andrews Bay, FL.
- Adult (≥107 cm TL)—EFH is designated as shallow coastal waters to the 25 m isobath from St. Augustine, FL south to Cape Canaveral, FL. Additional EFH designated for this lifestage but not located in the study area, includes areas within the eastern Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Blacktip Shark (*Carcharhinus limbatus*)

Management—The blacktip shark is managed as a Large Coastal Shark in the Shark MU under the Final Atlantic Consolidated FMP for HMS (NMFS 2006h).

[2]The EFH text description for the juvenile lifestage of the blacknose shark includes habitat found within the study area but the GIS data provided by the NMFS (2003b) includes no juvenile EFH within the study area. Dr. Chris Rilling, NMFS HMS Division, was consulted about this discrepancy and indicated that the NMFS was aware of the discrepancy but that it would not be addressed until sometime in the future; the discrepancy was not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

Status—The IUCN currently designates the northwest Atlantic subpopulation of the blacktip shark as vulnerable or facing a high risk of extinction in the wild in the medium-term future (Shark Specialist Group 2000a). This species is not considered overfished nor is overfishing occurring (NMFS 2005b).

Distribution—Blacktip sharks are found worldwide in predominantly subtropical and tropical seas but occur seasonally in warm-temperate coastal waters. In the western Atlantic Ocean, it ranges from coastal southern New England southward to southern Brazil, encompassing nearly all of the eastern U.S., Gulf of Mexico, and Caribbean Sea (Garrick 1982). The blacktip is considered rarer in New England and is most abundant off South Carolina, Georgia, and Florida in summer (Castro 1983). In The Bahamas, this species is considered one of the most common shark species in the region, especially on the Great Bahamas Bank (Böhlke and Chaplin 1993).

Habitat Preferences—The blacktip shark can be found in coastal and estuarine waters, including bays and mangrove swamps, and in offshore surface waters over the continental or insular shelf but rarely occurs in waters deeper than 30 m (Compagno et al. 2005; NMFS 2006h). Although often recorded offshore, it is not a considered a true oceanic shark species. It has a wide salinity tolerance, tolerating reduced salinities but generally does not move far into riverine systems as it can't tolerate freshwater (Compagno 1984). Neonate and juvenile sharks utilize nursery areas and can remain there for up to a year. Blacktip shark nurseries have been identified in nearshore and estuarine waters (muddy substrates or seagrass beds with depths of 2 to 4 m) from North Carolina through the Gulf of Mexico (NMFS 1999b; McCandless et al. 2002). Recent analyses have determined that sharks in Gulf of Mexico and Atlantic nurseries are genetically distinct and separate from one another (Keeney et al. 2003).

Life History—Off the coast of Florida, large schools of blacktip sharks seasonally migrate north to south along the coast up to 1,159 NM (NMFS 1999b; Keeney et al. 2003). This shark species migrates to deeper waters during the winter and utilizes coastal waters of the southeastern U.S. during the summer (Castro 1983; Manooch 1988). Blacktip sharks give birth to live young in inshore nursery grounds, during late spring to early summer (April to June) after 10 to 11 months gestation period (Castro 1983; Compagno 1984).

Common Prey Species—Blacktip sharks are active mid-water hunters, feeding on benthic and pelagic fishes (menhaden, rays, herring, butterfish, sardines, other shark species), cephalopods (squids), and other invertebrates (Compagno 1984; Manooch 1988). This species often performs acrobatics when it leaps out of the water in pursuit of prey, driving prey species to the surface (Compagno 1984). The blacktip may also enter into a feeding frenzy when feeding on highly concentrated groups of prey (Compagno et al. 2005).

EFH Designations—(NMFS 1999d, 2003d; Figure D-39)

- Neonate (≤69 cm TL)—EFH for this lifestage is designated as shallow coastal waters (to 25 m isobath) from Bull's Bay, SC (33.5°N) to Cape Canaveral, FL (28.5°N). Additional EFH designated for this lifestage but not found in the study area includes areas within the Gulf of Mexico.
- Juvenile (69 to 155 cm TL)—EFH designated for this lifestage is not found within the study area but includes regions north of Ponce de Leon Inlet, FL (29°N) and in the Gulf of Mexico.
- Adult[3] (≥155 cm TL)—EFH is designated for this lifestage of the blacktip shark as the shallow coastal waters to the 50 m isobath from St. Augustine, FL (30°N) to Cape Canaveral, FL (28.5°N). Additional EFH designated for this lifestage, but not located in the study area, are regions north of St. Augustine, FL and in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

[3]There is a discrepancy between the EFH text description in the FMP and that presented in the GIS data provided by the NMFS (2003b) for the adult lifestage of the blacktip shark. Dr. Chris Rilling, NMFS HMS Division, was consulted about this discrepancy and indicated that the NMFS was aware of the discrepancy but that it would not be addressed until sometime in the future; the discrepancy was not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

- Blue Marlin (*Makaira nigricans*)

Management—Blue marlin are managed by the NMFS through the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—Currently, blue marlin are overfished and overfishing is occurring (NMFS 2004c, 2005b).

Distribution—Blue marlin occur in oceanic and continental shelf waters throughout the tropical and subtropical waters of the Atlantic, Pacific, and Indian Oceans. The geographic distribution of this species ranges from 45°N to 35°S, and in the western Atlantic, this species is found from southern Georges Bank through the Gulf of Mexico and the Caribbean Sea and the waters of Bermuda south to the Guinea Current off the coast of Brazil (NMFS 1999d; Schultz 2004).

Habitat Preference—This epipelagic (surface to a depth of 91 m), oceanic species typically inhabits deep waters that have a temperature range from 22° to 31°C (NMFS 1999d; Collette 2002b). Blue marlin can also be found utilizing coastal habitats, such as those found near the Mississippi River delta (Gardieff 1999a). Eggs are planktonic (Gardieff 1999a).

Life History—Blue marlin are generally solitary and do not occur in schools. They undergo extensive movements including trans-equatorial and trans-Atlantic migrations in response to changing sea surface temperatures (Gusey 1981; Nakamura 1985; Gardieff 1999a; NMFS 1999d). Two seasonal concentrations occur in the Atlantic: in the southwest Atlantic (5°S to 30°S) from January to April and from June to October in the northwest Atlantic (10° to 35°N) (NMFS 1999d; Schultz 2004). The months of May, November, and December are considered transitional months. Tag-recapture data from the northern Gulf of Mexico and The Bahamas suggest seasonal movements between the former in summer and the latter in the winter. Spawning in the northwestern Atlantic is believed to occur between the period of May and November, with May and June as the peak spawning months off Florida and The Bahamas (Prince et al. 1991; de Sylva and Breder 1997; NMFS 1999d). Waters north of Exuma Sound, The Bahamas are a confirmed spawning ground for this species with Exuma Sound, itself, serving as an important summer nursery habitat (Serafy et al. 2003a, 2003b). Blue marlin larvae have also been collected within the Florida Straits (Sponaugle et al. 2005).

Common Prey Species—Blue marlin are generalists that feed primarily on near-surface pelagic fishes (tuna, dolphin fishes, mackerel), as well as deep-sea fish species and cephalopods (NMFS 1999d; Gardieff 1999a).

EFH Designations—(NMFS 1999d; Figure D-40)

- Spawning Adult, Egg, and Larva[4]—EFH is designated as the area bounded by the 100 m isobath and 43 NM (79.25°W) seaward from Ponce de Leon Inlet, FL (29.5°N) south to Melbourne, FL and the area bounded by the 100 m isobath and the U.S. EEZ from Melbourne, FL south to Key West, FL. Additional EFH designated for this lifestage, but not occurring within the study area, includes areas off Puerto Rico.
- Juvenile and Subadult (20 to 189 cm lower jaw fork length [LFJL])—EFH is designated for this lilfestage of the blue marlin as the pelagic waters with temperatures ≥24°C bounded by the the 100 m isobath and 26 NM (at 29°N) from St. Augustine, FL (30°N) to Fort Lauderdale, FL (26°N) and bounded by the 100 m isobath and the U.S. EEZ boundary from 29°N south. Although not located within the study area, additional EFH for this lifestage includes regions north of Cumberland Island, GA and regions in the Gulf of Mexico.
- Adult[4] (>190 cm LFJL)—EFH is designated for adult blue marlin as the pelagic waters with temperatures ≥24°C bounded by the 100 m isobath and 43 NM (79.25°W) from Ponce de Leon Inlet (29.5°N) to offshore Melborne, FL and the bounded by the 100 m isobath and the U.S. EEZ

[4] There is a discrepancy between the EFH text description in the FMP and that presented in the GIS data provided by the NMFS (2003b) for the adult and spawning/egg/larva lifestages of the blue marlin. These two lifestages should be depicted exactly the same but are not in the GIS data. Dr. Chris Rilling, NMFS HMS Division, was consulted about these discrepancies and indicated that the NMFS was aware of them but they would not be addressed until sometime in the future; the discrepancies were not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancies, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

from Melbourne, FL south to Key West, FL. Additional EFH designated for this lifestage but not located within the study area include regions north of the Georgia/Florida border, the Gulf of Mexico, the U.S. Virgin Islands, and Puerto Rico.

HAPC Designations— No HAPC are identified for this species.

- Bluefin Tuna (*Thunnus thynnus*)

Management—Bluefin tuna are managed by the NMFS through the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The current stock assessment and fishery evaluation reports by the NMFS (2004c, 2005b) indicate that bluefin tuna in the western Atlantic are overfished and overfishing occurs. The IUCN Red List (Safina 1996a) lists the western Atlantic stock as critically endangered or facing an extremely high risk of extinction in the wild.

Distribution—Bluefin tuna have a worldwide distribution in tropical and temperate waters, from Argentina and South Africa north to Labrador and northern Scandinavia in the Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea (Schultz 2004). In the western Atlantic Ocean, bluefin tuna typically range from 0°N to 45°N but have been reported as far north as 55°N (Collette and Nauen 1983; NMFS 1999b).

Habitat Preferences—This species can tolerate a considerable range of temperatures (typically above 10°C) and has been observed at depths greater than 1,000 m (Block et al. 2001). Although bluefin tuna are epipelagic and oceanic, they often occur over continental shelf waters and in embayments during the summer months (Collette 2002a). In The Bahamas, giant bluefin tuna (>185 cm and >107 kg) are found to aggregate on the Great Bahamas Bank off South Cat Cay in a region known as Tuna Alley (Lutcavage et al. 1997); it is believed that these giant tuna are spawned from populations in the Florida Straits or Gulf of Mexico. In 1995, over 750 bluefin tuna were surveyed in this region in The Bahamas and were most abundant around Victory and Gun Cays (Lutcavage et al. 1997). Juveniles typically inhabit regions off the continental shelf, from North Carolina to Rhode Island, in waters with depths less than 40 m and temperatures greater than 20°C in the summer (June and July) (Schuck 1982; Brill et al. 2002). Juveniles occurring in continental shelf waters utilize the entire water column including the benthic habitat but spend the majority of their time near the surface (Brill et al. 2002). Fertilized eggs are buoyant (Collette 2002a). Larvae are associated with the Gulf Stream (NMFS 1999b).

Life History—The bluefin tuna spawns from mid-April to mid-June in the Gulf of Mexico, western edge of the Bahamas Banks, and along the eastern portion of the Florida Current in waters with temperatures ranging from 24.9° to 29.5°C (Gusey 1981; Collette and Nauen 1983; NMFS 1999b). The Gulf of Mexico is considered the primary spawning area for this species in the northwest Atlantic (Mather et al. 1995; Block et al. 2001). The adult bluefin tuna moves seasonally from offshore spawning grounds in the Gulf of Mexico through the Straits of Florida to inshore seasonal feeding grounds in the northern part of their range in the northwestern Atlantic (Jeffreys Ledge, Stellwagen Bank, Cape Cod Bay, Great South Channel, and south of Martha's Vineyard) in the early spring and summer (April through mid-June) and finally to North Carolina, Blake Plateau, or the Bahamas for the winter (Gusey 1981; Schuck 1982; Lutcavage et al. 1997; Block et al. 2001; Chase 2002). Data on the three-way movements of adults from these feeding areas to wintering areas and back to breeding areas are limited. It is postulated that juveniles have a shorter two-way movement from feeding to wintering areas (Mather et al. 1995; Chase 2002).

Common Prey Species—Bluefin tuna prey on squid, pelagic crustaceans, and fishes (anchovies, sauries, and hakes) (Schuck 1982; NMFS 1999b).

EFH Designations—(NMFS 1999b; Figure D-41)

- Spawning Adult, Egg, and Larva[5]—EFH is designated as the pelagic and near coastal surface waters for this lifestage of the bluefin tuna from the North Carolina/South Carolina border (33.5°N) south to Cape Canaveral, FL in the area bounded from 13 NM from shore to the 200 m isobath and all waters extending from 13 NM from shore to the U.S. EEZ boundary from the coast of Cape Canaveral, FL (28.25°N) south around peninsular Florida to the U.S./Mexico border.
- Juvenile[5] (<145 cm TL)—EFH is designated as all surface waters bounded by the 200 m isobath and the U.S. EEZ extending from the Florida Straits at 27°N south around peninsular Florida to 81°W. Additional EFH designated for this lifestage, but not found within the study area, includes areas north of Cape Hatteras, NC.
- Adult[5] (>145 cm TL)—EFH is designated for the adult lifestage of the bluefin tuna as the pelagic waters bounded by the 100 m isobath and U.S. EEZ boundary from Daytona Beach, FL (29.5°N) south to Key West, FL (82°W). Additional EFH designated outside the study area includes regions north of Cape Lookout, NC and regions in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Bonnethead Shark (*Sphyrna tiburo*)

Management—The bonnethead shark is managed in U.S. Atlantic waters as a Small Coastal Shark by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—This species is neither overfished nor is overfishing currently occurring (NMFS 2005b).

Distribution—The bonnethead shark is limited to warm waters in the Atlantic Ocean ranging from coastal southern New England south to the Gulf of Mexico and Brazil and is most common in the Caribbean Sea, including Cuba and the Bahamas (Little Bahamas and Great Bahamas Banks). In the Pacific, this shark species also ranges from southern California to Ecuador (Castro 1983; Böhlke and Chaplin 1993).

Habitat Preferences—Bonnethead sharks inhabit shallow coastal waters, where they are typically associated with sandy or muddy substrates (Castro et al 1999). This species inhabits continental and insular shelves, over reefs, estuaries, seagrass beds, and shallow bays from depths of 10 to 80 m (most common from depths of 10 to 25 m) (Compagno 1984; Compagno et al. 2005). Bonnethead shark nurseries have been identified in estuaries from South Carolina south along the Atlantic coast into the Gulf of Mexico (McCandless et al. 2002).

Life History—Bonnethead sharks prefer water temperatures warmer than 21°C and migrate accordingly back and forth to the equator throughout the year. This species migrates to inshore areas of the North Carolina, South Carolina, and Georgia during the summer and off Florida and the Gulf of Mexico from spring through fall. During the winter, it moves southward to deeper waters. This species mates, off the coast of Florida, during the spring and autumn and gives birth to live young during the late summer through early fall in shallow waters (e.g., Tampa Bay and Florida Bay) (Castro 1983; Branstetter 2002b; Lombardi-Carlson et al. 2003).

Common Prey Species—Bonnethead sharks prey primarily upon benthic species, including shrimp (mantis and pink), crab (blue, spider, purse, and stone), octopus, and fishes during the daytime (Castro 1983; Branstetter 2002b).

EFH Designations—(NMFS 1999b, Figure D-42)

[5]A discrepancy exists between the EFH text description in the FMP and that presented in the GIS data provided by the NMFS (2003b) for the outer EFH boundary of the spawning adult/egg/larva, juvenile, and adult lifestages of the bluefin tuna. The outer boundary for all EFH lifestages should be depicted exactly the same but is not in the GIS data. Dr. Chris Rilling, NMFS HMS Division, was consulted about this discrepancy and indicated that the NMFS was aware of the discrepancy but that it would not be addressed until sometime in the future; the discrepancy was not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

- Neonate (≤38 cm TL)—The shallow waters <25 m deep are designated as EFH for this lifestage from Jekyll Island, GA to just north of Cape Canaveral, FL. Additional EFH not found within the study area is designated for this lifestage include regions in the Gulf of Mexico.
- Juvenile (39 to 82 cm TL)—EFH for this lifestage of the bonnethead shark is designated as shallow coastal waters, inlets, and estuaries <25 m deep from Cape Fear, NC to West Palm Beach, FL. Areas south of Miami and in the Gulf of Mexico are designated as EFH for this lifestage but are not located within the study area.
- Adult (≥83 cm TL)—EFH is designated as shallow coastal waters, inlets, and estuaries from Cape Fear, NC to Cape Canaveral, FL. While additional EFH is designated for this lifestage, such as regions in the Gulf of Mexico, they are not found within the study are.

HAPC Designations—No HAPC are identified for this species.

- Bull Shark (*Carcharhinus leucas*)

Management—Bull sharks are managed as a Large Coastal Shark in U.S. Atlantic waters by the HMS Division of the NMFS through the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The bull shark stock is subject to overfishing and is classified as overfished (NMFS 2005b). The IUCN currently lists the bull shark as a near threatened species or taxa, which are not conservation dependent but are close to qualifying as a vulnerable species (Simpfendorfer and Burgess 2000).

Distribution—Bull sharks are circumglobal in subtropical and tropical waters. In the northwest Atlantic, they are distributed from Massachusetts to southern Brazil, including Bermuda, the Gulf of Mexico, and Caribbean Sea. This species occurs most commonly off southern Florida, in the Gulf of Mexico, and in the Caribbean (Castro 1983; Compagno 1984; Pattillo et al. 1997).

Habitat Preferences—This shallow-water species is common in marine, estuarine, and freshwater habitats and can journey long distances up large rivers (e.g., Mississippi River) (NMFS 1999b). Temperature is the primary restricting factor for the bull shark's movement into riverine habitats and estuaries. For example, temperatures must exceed 24°C for this species to enter the Mississippi River and above 18°C to enter most estuaries (Pattillo et al. 1997). The bull shark typically occupies shallow coastal waters <30 m deep but has been observed at depths up to 152 m deep. Adults occupy deeper waters than juveniles. Bull sharks typically stay near the bottom, rarely utilizing surface waters (Compagno 1984). Bull shark nurseries have been recorded in low salinity estuaries extending from North Carolina to the Gulf of Mexico (McCandless et al. 2002).

Life History—Bull sharks migrate north, as far as Massachusetts, along the coast during the summer and then return south as waters cool (Compagno 1984). These north-south movements also occur in the Gulf of Mexico (Pattillo et al. 1997). Mating occurs in late spring or early summer (June or July), with birth to live young occurring in estuaries and river mouths the following year, from April to June (Castro 1983; Compagno 1984). In warmer areas, mating and parturition can occur throughout the year (Pattillo et al. 1997).

Common Prey Species—Bull sharks are opportunistic feeders that prey on a wide variety of bony fishes, shark species, and invertebrates. Additionally, stomach contents have revealed that this species also consumes sea turtles, sea birds, and marine mammals (Compagno 1984). Feeding primarily occurs during the evening, particularly around bridges and channels (Pattillo et al. 1997).

EFH Designations—(NMFS 1999b; Figure D-43)

- Neonate (≤83 cm TL)—EFH is designated as shallow coastal waters, inlets, and estuaries <25 m deep from just north of Cape Canaveral, FL (29°N) to just south of Cape Canaveral, FL (28°N). Additional EFH designated for this lifestage of the bull shark, but not located within the study area, includes regions in the Gulf of Mexico.
- Juvenile (84 to 225 cm TL)—Shallow coastal waters, inlets, and estuaries in waters <25 m deep are designated as EFH for this lifestageof the bull shark from Savannah Beach, GA (32°N) to the

Dry Tortugas National Park, FL. Although not located within the study area, additional EFH is designated in regions in the Gulf of Mexico.

- Adult (≥226 cm TL)—EFH is designated for this lifestage in areas not located within the study area off the west coast of Florida.

HAPC Designations—No HAPC are identified for this species.

- Dusky Shark (*Carcharhinus obscurus*)

Management—The NMFS manages the dusky shark as a Prohibited Shark species under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The dusky shark is currently identified as a species of concern (formerly a candidate species) by the NMFS (2004a) and is considered overfished and is subject to overfishing (NMFS 2005b). The IUCN Red List designated the northwest Atlantic and Gulf of Mexico dusky shark population as vulnerable or facing a high risk of extinction in the wild in the medium-term future (Shark Specialist Group 2000b).

Distribution—Dusky sharks are wide-ranging distribution in warm-temperate and tropical continental waters throughout the world and can be found in the western Atlantic from southern Massachusetts and the Georges Bank southward through the northern Caribbean Sea and Gulf of Mexico to Nicaragua and southern Brazil (Compagno 1984; Castro 1993).

Habitat Preferences—Dusky sharks are coastal and pelagic in distribution and occur from the surf zone to well offshore and from surface waters to depths of 400 m (Compagno 1984; Branstetter 2002a). Adult dusky shark often avoid estuarine areas (Compagno et al. 2005). Major nursery areas have been identified in coastal waters from Massachusetts to South Carolina coast (Castro 1993; McCandless et al. 2002).

Life History—Mating in the dusky shark in the western Atlantic occurs in the spring, and birth to live young can occur over several months from late winter to summer (Compagno 1984). In Bulls Bay, NC, dusky sharks typically give birth from April to May, while in the Chesapeake Bay, this occurs in June and July (NMFS 2003d). Females mate in alternate years as a result of their long gestation period (9 to 16 months) (Compagno 1984). The dusky shark undertakes long seasonal, temperature-related migrations. On both coasts of the U.S., this species migrates northward in summer as the waters warm and retreats southward in fall as water temperatures decline (Compagno 1984; NMFS 2003d). Migrations are often segregated by sex and lifestage as adult dusky's undertake different movement patterns than other lifestages (Compagno et al. 2005).

Common Prey Species—Bony fishes (eels, menhaden, herring, anchovies, hakes, goosefish, black sea bass, scup, croaker, bluefish, sand lance, mackerel, tuna, flatfish) are the most important component of the dusky shark's diet, but they also prey upon sharks (including young of their own species), crustaceans, and squid (Branstetter 2002a; Compagno et al. 2005).

EFH Designations—(NMFS 1999b, 2003d; Figure D-44)

- Neonate[6] (<110 cm TL)—EFH for this lifestage of the dusky shark is designated as shallow coastal waters, inlets, and estuaries as well as offshore areas to the 90 m isobath extending from Cape Lookout, NC (34.5°N) to West Palm Beach, FL (27.5°N). Additional EFH designated for this lifestage, but not located within the study area, includes regions north of Cape Lookout, NC.

- Juvenile (111 to 299 cm TL)—Shallow coastal waters, inlets, and estuaries to the 500 m isobath from Jacksonville, FL to the Dry Tortugas, FL (83°W) are designated as EFH for this lifestage. Although not located within the study area, additional EFH is designated for this lifestage

[6]There is a discrepancy between the EFH text description in the FMP and that presented in the GIS data provided by the NMFS (2003b) for the neonate lifestage of the dusky shark. Dr. Chris Rilling, NMFS HMS Division, was consulted about this discrepancy and indicated that the NMFS was aware of the discrepancy but that it would not be addressed until sometime in the future; the discrepancy was not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

including areas from Jacksonville, FL to Assateague Island at the Virginia/Maryland border (38°N) and off southern New England.

- Adult (≥299 cm TL)—EFH for this lifestage is designated as coastal and pelagic waters bounded by the 25 m and 200 m isobaths from the Georgia/Florida border to south of Cape Canaveral, FL (28°N).

HAPC Designations—No HAPC are identified for this species.

- Great Hammerhead Shark (*Sphyrna mokarran*)

Management—The great hammerhead shark, categorized as a Large Coastal Shark by the NMFS, is managed under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—Great hammerheads are currently overfished and are subject to overfishing (NMFS 2005b). The great hammerhead shark is considered data deficient by the IUCN, due to the lack of adequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status (Denham 2000).

Distribution—This shark species has a circumtropical distribution (40°N to 37°S), and in the western Atlantic, ranges from North Carolina south to Uruguay, including the Gulf of Mexico and Caribbean regions (Compagno 1984; Bester 1999f).

Habitat Preferences—The great hammerhead is a large coastal/semi-oceanic shark found offshore at depths of 300 m as well as in shallow coastal areas such as lagoons (Compagno 1984; Bester 1999f). Known nursery areas occur in Tampa Bay and Charlotte Harbor, FL as well as estuarine and offshore waters of the Gulf of Mexico (McCandless et al. 2002).

Life History—The great hammerhead is considered a HMS and moves poleward to cooler water during the summer months. Mating has been recorded in surface waters in contrast with most other shark species, which mate near the bottom. This shark species gives birth to live young in the spring and summer (Compagno 1984; Bester 1999f).

Common Prey Species—Great hammerheads feed on rays, small sharks, bony fishes, and invertebrates (crab, lobster, squid, and octopus) with stingrays as the most preferred prey (Castro 1983). Great hammerhead sharks feed at dusk using electroreception to locate prey (Bester 1999f).

EFH Designations—(NMFS 1999b; Figure D-45)

- Neonate (≤74 cm TL)—Insufficient data currently exist to identify EFH for this lifestage of the great hammerhead.
- Juvenile (75 to 220 cm TL)—EFH is designated for this lifestage of the great hammerhead as shallow coastal waters to the 100 m isobath from 30°N off the east Florida coast south around peninsular Florida. Additional EFH not located in the study area is designated for this lifestage off western Florida including Florida Bay.
- Adult (≥221 cm TL)—EFH is designated as the shallow coastal waters to the 100 m isobath off the entire east coast of Florida south of 30°N. Further EFH for this lifestage is designated off western Florida.

HAPC Designations—No HAPC are identified for this species.

- Lemon Shark (*Negaprion brevirostris*)

Management—The lemon shark is managed by the HMS Division of the NMFS in U.S. Atlantic waters in the Large Coastal Shark category. This shark pecies is managed via the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The IUCN lists this shark species as lower risk or near threatened (Gruber and Sundström 2000). The lemon shark stock is regarded as overfished and is subject to overfishing (NMFS 2005b).

Distribution—Lemon sharks are found in the temperate/tropical regions of the Atlantic and Pacific Oceans and Caribbean Sea. In the northwest Atlantic, the distribution of the lemon shark ranges from New Jersey to southern Brazil, including the Gulf of Mexico (Compagno 1984; Morgan 1999). The primary population in U.S. waters is located off southern Florida but is considered common on the Bahamas banks (Böhlke and Chaplin 1993; NMFS 1999b). Populations in the western Atlantic, Caribbean, and Gulf of Mexico have considerable gene flow and are not separated into distinct stocks (Feldheim et al. 2001a).

Habitat Preferences—Utilization of diverse habitats is a characteristic of the lemon shark, including oceanic waters, coral reefs, mangroves, bays, sounds, estuaries, and river mouths (Morgan 1999). The lemon shark is found from surface waters to depths of 90 m (Morgan 1999). Young sharks are typically found utilizing habitats closer to shore than adults (Compagno 1984; Gruber et al. 2001). Lemon shark nurseries have been recorded in the Florida Keys and Tampa Bay, FL and along the Gulf coast of Texas (McCandless et al. 2002). Additionally, Bimini Lagoon, The Bahamas is a confirmed pupping and shallow water (~2 m depth) nursery ground for approximately 250 lemon sharks (Feldheim et al. 2001b; Gruber et al. 2001).

Life History—Lemon sharks typically inhabit deeper waters during the daytime and move to shallower waters at night (Morgan 1999). Diel movement patterns have also been observed in The Bahamas, with lemon sharks off Bimini staying on the east side of the lagoon during the day and moving to the west side of the lagoon at night to feed (Sundström et al. 2001). Off Florida, this species also migrates south into deeper water during the winter (Compagno 1984). A newborn lemon shark tagged off Bimini was captured 10 years later in Apalachacola Bay, FL (Feldheim et al. 2001a); it has not been determined if these long distance movements are typical for this species. Lemon sharks mate and give birth to live young during the spring and summer, from May to September (Compagno 1984). Recent studies indicate that this species exhibits site fidelity to nursery grounds in Bimini, The Bahamas and that a single litter can be fathered by multiple males (Feldheim et al. 2001b). Females are believed to reproduce biennially (Feldheim et al. 2001b).

Common Prey Species—Lemon sharks consume a variety of crustaceans, mollusks, and fishes (croaker, jack, mullet, rays, other shark species) located over sandy or muddy substrates (Compagno 1984; Morgan 1999).

EFH Designations—(NMFS 1999b; Figure D-46)

- Neonate (≤68 cm TL)—None of the EFH designated for this lifestage of lemon sharks is located within the study area. Designated EFH includes areas north of Indian River Inlet, FL, south of Miami, FL, and into the Gulf of Mexico.
- Juvenile (68 to 235 cm TL)—EFH is designated for the lemon shark as shallow coastal waters, inlets, and estuaries to the 25 m isobath from Bull's Bay, SC (79.75°W) to near Cape Canaveral, FL (28°N). Additional EFH not found within the study area includes regions south of Miami, in the Gulf of Mexico, and off Puerto Rico.
- Adult (≥236 cm TL)—Inlets, estuaries, and shallow coastal waters to the 25 m isobath from West Palm Beach, FL (27°N) around peninsular Florida to near Anclote Key, FL (28.5°N) is designated as EFH for the adult lifestage of the lemon shark. Other EFH for this lifestage not located within the study area is designated as areas north of St. Augustine, FL.

HAPC Designations—No HAPC are identified for this species.

- Longfin Mako Shark *(Isurus paucus)*

Management—Longfin mako shark stocks are managed under the Final Consolidated Atlantic HMS FMP (NMFS 2006h) as a Prohibited Shark by NMFS.

Status—The NMFS prohibits possession of the longfin mako as a precautionary measure (NMFS 1999b). Additionally, the IUCN Red List designates this species as vulnerable or facing a high risk of extinction in the wild (Reardon et al. 2005).

Distribution—In the western Atlantic Ocean, longfin mako sharks can be found from Georges Bank to the Gulf of Mexico; they occur commonly in the southern sections of the Gulf Stream and probably have a wider distribution than is currently known (Castro 1983).

Habitat Preferences—There is very little information available on the habitat preferences of this shark species. Longfin mako sharks prefer deep tropical to warm-temperate oceanic waters and have been recorded at depths from 18 to at least 219 m (Castro 1983).

Life History—Specifics on the location and reproductive behavior for this ovoviviparous species are unknown, but longfin makos are believed to come close to shore to give birth (Castro 1983; Compagno 2001). Specific information on migrational patterns of the longfin mako shark does not exist.

Common Prey Species—Longfin mako sharks primarily prey upon schooling fish species and pelagic cephalopods (Compagno 2001; Compagno et al. 2005).

EFH Designations—(NMFS 1999b; Figure D-47)

- All Lifestages—EFH is designated as the waters bounded by the 100 m and 500 m isobaths from 35°N south to Cape Canaveral, FL (28.25°N) and in waters bounded by the 200 m isobath and U.S. EEZ from Cape Canaveral, FL south around peninsular Florida to 92.5°W in the Gulf of Mexico. Additional EFH designated for these lifestages, but not located within the study area, includes regions north of Georges Bank.

HAPC Designations—No HAPC are identified for this species.

- Night Shark (*Carcharhinus signatus*)

Management—The night shark is managed through the HMS Division of the NMFS in U.S. Atlantic waters and is included in the Prohibited Shark category of the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—Night sharks are overfished and are subject to overfishing (NMFS 2005b). The Atlantic and Gulf of Mexico populations of the night shark are currently identified as species of concern (formerly a candidate species) by the NMFS (2004a). Additionally, the night shark is designated by the IUCN Red list as vulnerable or facing a high risk of extinction in the wild (Santana et al. 2005).

Distribution—Night sharks inhabit the waters of the Atlantic Ocean and, in the northwest Atlantic, range from Delaware south to Argentina, including the Gulf of Mexico (Barzan 1999). This species also is distributed off the coast of western Africa (Compagno et al. 2005).

Habitat Preferences—This benthopelagic, coastal, and semi-oceanic species is found on or along the outer continental and insular shelves and off the upper slopes (Compagno 1984). Night sharks prefer depths from 50 to 100 m but have been recorded in waters up to 600 m deep (Compagno 1984; Compagno et al. 2005). No information exists on nursery locations for this species (NMFS 1999b).

Life History—Night sharks exhibit vertical migrations and are found in shallower waters at night (to 183 m) rather than during the daytime (to 366 m) (NMFS 1999b; Compagno et al. 2005). Off Cuba, this species has been recorded making seasonal migrations (Compagno 1984). Little information has been collected on the reproductive behavior or locations of this species, but it is known that they give birth to live young (Castro 1983; NMFS 1999b).

Common Prey Species—Night sharks feed primarily on squid and bony fishes, including butterfish, flyingfish, tuna, mackerel, and sea bass (Compagno 1984).

EFH Designations—(NMFS 2003d; Figure D-48)

- Neonate (≤70 cm TL)—At this time data and information are insufficient to describe EFH for this lifestage of the night shark.
- Juvenile (71 to 177 TL)—Designated EFH for this lifestage occurs north of from Cape Fear, NC, which is but not included within the study area.

- Adult (≥178 cm TL)—EFH is designated from Oregon Inlet, NC (36°N) to 25.5°N, off the coast of Miami, FL in waters bounded by the 100 m isobath and whichever of the following is nearest: the 2,000 m isobath, a distance 87 NM from shore, or the U.S. EEZ boundary.

HAPC Designations—No HAPC are identified for this species.

- Nurse Shark (*Ginglymostoma cirratum*)

Management—The nurse shark is managed by the NMFS in the Large Coastal Shark category of the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—This species is overfished and is subject to overfishing (NMFS 2005b). The IUCN Red List designates the western Atlantic nurse shark subpopulation as near threatened or likely to qualify for a threatened category in the near future (Rosa et al. 2005).

Distribution—The nurse shark is found in the Atlantic and Pacific Oceans. In the northwest Atlantic, it ranges from Cape Hatteras, NC to Brazil (Guarracino 1999).

Habitat Preferences—This nocturnal species is usually benthic, lying on sandy substrates or beneath coral reefs, crevices, or rocks typically in waters with depths <12 m (Castro et al 1999; Guarracino 1999; Compagno et al. 2005). They often congregate in groups, even lying on top of each other. Juveniles typically are found in shallower waters than adults (Guarracino 1999). Nurse shark nurseries have been recorded in turtle grass beds in western Florida (Charlotte Harbor, Florida Keys, Tampa Bay) (McCandless et al. 2002; Compagno et al. 2005).

Life History—Nurse sharks do not exhibit seasonal movements but larger individuals inhabit deeper waters during the day (up to 75 m) and migrate to shallower waters at night (<20 m). Nurse sharks are ovoviviparous with mating occurring in the summer, typically June and July, and births in November and December. Reproductive behavior has been observed in the Florida Keys, Dry Tortugas National Park, FL, and The Bahamas in shallow seagrass beds or coral reefs (4 to 6 m) (Guarracino 1999; NMFS 1999b; Pratt and Carrier 2001).

Common Prey Species—Nurse sharks feed at night on fishes, especially stingrays, mollusks (octopus, squid, clams), and crustaceans (lobster, shrimp, crabs) via suction (Castro 1983; Guarracino 1999; Robinson and Motta 2002).

EFH Designations—(NMFS 2003d; Figure D-49)

- Neonate (≤36 cm TL)—Designated EFH for this lifestage of the nurse shark does not occur within the study area but is located in shallow coastal areas <25 m deep from West Palm Beach, FL south to the Dry Tortugas National Park, FL and at Charlotte Harbor, FL (82°W, 26.8°N).
- Juvenile (37 to 221 cm TL)—EFH is designated as shallow coastal waters bounded by the shoreline and the 25 m isobath from Cumberland Island, GA (30.5°N) to the Dry Tortugas National Park, FL. Additional EFH designated for this lifestage, but not located within the study area, includes areas off western Florida in Apalachee Bay, Apalachicola Bay, and Crooked Island Sound as well as regions off Puerto Rico.
- Adult (≥221 cm TL)—Shallow coastal waters bounded by the shoreline and the 25 isobath: from Cumberland Island, GA (30.5°N) to the Dry Tortugas National Park, FL are designated as EFH for this lifestage of the nurse shark. Additionally, EFH has been designated for this lifestage outside of the study area in regions off western Florida and Puerto Rico.

HAPC Designations—No HAPC are identified for this species.

- Oceanic Whitetip Shark (*Carcharhinus longimanus*)

Management—Oceanic whitetip sharks are managed through the Final Consolidated Atlantic HMS FMP (NMFS 2006h); this shark is categorized as a Pelagic Shark by NMFS.

Status—Currently, the oceanic whitetip shark stock is not overfished nor is subject to overfishing (NMFS 2005b). This species is designated as vulnerable or facing a high risk of extinction in the wild by the IUCN Red List (Baum et al. 2005).

Distribution—This shark species is the most common large shark in circumtropical (20°N to 20°S) oceanic waters. In the western Atlantic, oceanic whitetip sharks range from Georges Banks to Argentina, including the Gulf of Mexico and Caribbean (Compagno 1984).

Habitat Preferences—Oceanic whitetip sharks are most abundant in the tropics but can occur far beyond their normal range when moving in conjunction with warm-water masses. The oceanic whitetip shark seldom swims into shallow waters <37 m deep and is most often found offshore in the open ocean. This shark typically inhabits waters deeper than 152 m with temperatures above 21°C (Compagno 1984; Compagno et al. 2005). Nurseries are believed to be located in offshore waters over the continental shelf (NMFS 1999b).

Life History—Oceanic whitetip sharks give birth to live young during the early summer in the north Atlantic. Little data exist on the migratory patterns of this species (Compagno 1984).

Common Prey Species—This shark species feeds in schools on fishes (lancetfish, oarfish, threadfin, barracuda, jacks, dolphinfish, tuna, marlin, and stingray), squid, crustaceans, sea birds, sea turtles, dead marine mammals, and garbage (Compagno 1984; Bester 1999g; Compagno et al. 2005).

EFH Designations—(NMFS 2003d; Figure D-50)

- Neonate (≤83 cm TL)—Designated EFH for this lifestage of the oceanic whitetip shark does not occur within the study area but is found off the Charleston Bump, SC.
- Juvenile (84 to 136 cm TL)—EFH is designated for this lifestage from 32°N to 26°N in waters bounded by the 200 m isobath and either the U.S. EEZ or 75°W, whichever is closer to shore.
- Adult (≥137 cm TL)—Although not located within the study area, EFH for this lifestage is designated between 36°N and 30°N and south of the U.S. Virgin Islands.

HAPC Designations—No HAPC are identified for this species.

- Sailfish (*Istiophorus platypterus*)

Management—This species is managed by the NMFS as part of the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—Sailfish are subject to overfishing and are considered overfished (NMFS 2005b).

Distribution—Sailfish have a circumtropical distribution ranging from Massachusetts south to Brazil, including the Caribbean Sea and the Gulf of Mexico (40°N to 40°S) in the western Atlantic Ocean (Manooch 1988). Sailfish are concentrated off Florida, in the Caribbean Sea, and in the Gulf of Mexico and are considered more rare north of Virginia (Gusey 1981; Gardieff 1999b).

Habitat Preferences—Sailfish are epipelagic, coastal to oceanic associating primarily with waters above the thermocline with a temperature range between 21° and 28°C and depths between 10 and 250 m (Gardieff 1999b). However, they do occasionally dive into deeper, colder waters. Sailfish are found over the continental shelf edge and are often associated with landmasses, including islands and reefs, and the inside edge of the Gulf Stream (Jolley 1977; Gusey 1981). Larvae are initially associated with the Gulf Stream and then move inshore to mature further (NMFS 1999d).

Life History—During the summer, sailfish move north along the western wall of the Gulf Stream to the Gulf of Maine, and during winter, sailfish regroup off the east coast of Florida, Florida Keys, Caribbean, and offshore waters in the Gulf of Mexico (Gilmore 1977; Jones et al. 1985; NMFS 1999d). No trans-Atlantic migrations have been documented for this species. Sailfish are multiple spawners, with spawning activity moving northward as summer progresses (de Sylva and Breder 1997). From the presence of larvae recorded from the Carolinas to Cuba, spawning is believed to occur in depths greater than 100 m from April to September and in the Gulf of Mexico from March to

October. Spawning events have been recorded from Palm Beach, FL to the Florida Keys in shallow waters with depths from 9 to 12 m (de Sylva and Breder 1997; NMFS 1999d).

Common Prey Species—Sailfish prey opportunistically on pelagic fishes, such as little tunny, halfbeaks, mackerels, tunas, cutlassfish, rudderfish, jacks, and pinfish, as well as squid and octopus, at the surface or mid-water depths (Jolley 1977; Manooch 1988; Gardieff 1999b). They have also been reported to feed on demersal species (searobin, cephalopods, gastropods) (Manooch 1988; NMFS 1999d). Feeding occurs during daylight hours.

EFH Designations—(NMFS 1999d; Figure D-51)

- Spawning Adult, Egg, and Larva[7]—EFH is designated from 28.25°N south to Key West, FL in waters associated with the Gulf Stream and the Florida Straits from 4 NM offshore to the U.S. EEZ boundary.
- Juvenile and Subadult[7] (20 to 142 cm LJFL)—For this lifestage of the sailfish, EFH is designated as pelagic and coastal surface waters 21°C to 28°C in temperature from 32°N to Key West, FL that are between 4 NM from shore and either a distance of 109 NM from shore or the U.S. EEZ boundary, whichever is closer to shore. Additional EFH, not located in the study area, has been designated for this lifestage from west of Key West, FL throughout the Gulf of Mexico.
- Adult[7] (≥143 cm LJFL)—EFH is designated as pelagic and coastal surface waters between 21° and 28°C from 34°N south to Key West, FL that are between 4 NM from shore and either 109 NM offshore or the U.S. EEZ boundary, whichever is closer to shore. Additionally, EFH not located in the study area has been designated for this lifestage north of 29°N and from west of Key West, FL throughout the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Sand Tiger Shark (*Carcharias taurus*)

Management—The sand tiger sharks is managed by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h) as a Prohibited Shark.

Status—Under this FMP, the sand tiger shark receives full protection from harvest on the Atlantic coast. The Atlantic and Gulf of Mexico populations of the sand tiger shark are currently identified as a species of concern (formerly a candidate species) by the NMFS (2004a). The sand tiger shark is also considered vulnerable or facing a high risk of extinction in the wild in the medium-term future according to the IUCN Red List (Pollard and Smith 2000).

Distribution—Sand tiger sharks are known to have a broad inshore distribution in tropical and warm-temperate waters throughout the world but are nonexistent in the eastern Pacific Ocean (Castro 1983; Branstetter 2002c). In the western Atlantic, the sand tiger shark occurs from the Gulf of Maine to Florida, the northern Gulf of Mexico, The Bahamas, Bermuda, and southward to Argentina (Castro 1983; Compagno 1984). In warmer months, this species is common from Cape Cod, MA to the Delaware Bay (Castro 1983).

Habitat Preferences—Sand tiger sharks are demersal sharks primarily found in shallow bays and around coral or rocky reefs (depths <20 m) but also can be found to depths of 191 m over the continental shelf (Compagno 1984; NMFS 1999b; Branstetter 2002c). Neonate and juvenile sand tiger sharks utilize estuarine waters as nurseries from Massachusetts to South Carolina (McCandless et al. 2002).

[7]The FMP text descriptions for these EFH lifestages does not match the GIS data provided by the NMFS (2003b). The text describes EFH for the juvenile/subadult and adult lifestages identically but they are not portrayed identically in the GIS data; the spawning, egg, larva lifestage's text description begins at 28.25°N while the GIS data depict an area beginning at ~27.25°N. Dr. Chris Rilling, NMFS HMS Division, was consulted about these discrepancies and indicated that although the NMFS was aware of them, that they would not be addressed until sometime in the future; the discrepancies were not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

Life History—Sand tiger sharks mate in the winter and spring, with parturition beginning during the winter from late October to the end of November (NMFS 1999b; Branstetter 2004c). In Florida, sand tiger sharks are born from November to February (Castro 1983). The neonates then migrate northward to summer nurseries. Sand tiger sharks are migratory in the northern portion of its range moving northward and inshore during the summer and south to deeper waters in the fall and winter (Castro 1983; Compagno 1984).

Common Prey Species—Sand tiger sharks feed primarily on fishes (skates, goosefish, searobin, scup, spot, bluefish, and butterfish), specifically summer flounder, as well as invertebrates (lobster, crab, and squid) (Branstetter 2002c).

EFH Designations—(NMFS 1999b; Figure D-52)

- Neonate (≤117 cm TL)—EFH is designated for this lifestage of the sand tiger shark as shallow coastal waters to 25 m from Barnegat Inlet, NJ to Cape Canaveral, FL.
- Juvenile (118 to 236 cm TL)—Insufficient data and information exist to adequately describe EFH for this lifestage.
- Adult (≥237 cm TL)—EFH is designated as the shallow coastal waters to 25 m from St. Augustine, FL to Cape Canaveral, FL. Additional EFH is designated for this lifestage but north of the study area (north of Cape Lookout, NC).

HAPC Designations—(NMFS 1999b, 2003d)

- Sandbar Shark (*Carcharhinus plumbeus*)

Management—The NMFS manages the sandbar shark under the Final Consolidated Atlantic HMS FMP in the Large Coastal Shark category (NMFS 2006h).

Status—The sandbar shark does not have an overfished status but is considered subject to overfishing (NMFS 2005b). The IUCN Red List designates the northwest Atlantic stock as a lower risk but conservation dependent (Shark Specialist Group 2000c).

Distribution—Sandbar sharks are cosmopolitan in distribution, ranging from shallow coastal waters off Cape Cod, MA, southward to Brazil, including the Gulf of Mexico and Caribbean Sea. Sandbar sharks are most commonly found in waters from South Carolina to Florida and in the eastern Gulf of Mexico (Castro 1983; Branstetter 2002a).

Habitat Preferences—This bottom-dwelling species is found in temperate to tropical waters over the continental shelf and in deeper waters adjacent to the shelf break. Sandbar sharks are found in water depths ranging from the intertidal zone to depths of 280 m during migration but are common in 20 to 65 m depths (Compagno 1984; Knickle 1999a). Sandbar sharks avoid surf zones, coral reefs, or rough benthic substrates, preferring smooth substrates (Castro 1983; Compagno 1984). This shark species is common in inshore areas with mud or sand substrates such as estuaries, river mouths, and harbors but does not enter freshwater (Compagno 1984). Juvenile sandbars are typically found in waters <10 m deep and are prevalent in the Chesapeake Bay.

Life History—The sandbar shark makes an extensive seasonal migration, moving to the northern part of its range in the summer and the southern part during the winter (Castro 1983). Seasonal temperature changes are the primary trigger for the migration; however, oceanographic features also influence migratory behavior (Compagno 1984). Male sandbar sharks typically migrate earlier in the year and to deeper waters than females (Knickle 1999a). In the northwest Atlantic, mating occurs from May to June with the young being born from March to August after a gestation period of approximately one year (Castro 1983; Knickle 1999a; NMFS 1999b). This species segregates by sex with large females dominating shallow, nursery areas from Delaware Bay to Cape Canaveral, FL, as well as the Gulf of Mexico (Castro 1983; Castro 1993; McCandless et al. 2002). The Chesapeake Bay is regarded as one of the primary nursery grounds in the mid-Atlantic (Bransetter 2002a).

Common Prey Species—Sandbar sharks feed opportunistically on a variety of prey, such as fishes (eels, skates, rays, dogfish) and invertebrates (squid, octopi, bivalves, shrimp, crabs) (Knickle 1999a). They feed all day but are most active at night.

EFH Designations—(NMFS 1999b, 2003d; Figure D-53)

- Neonate (≤71 cm TL)—EFH is designated for this lifestage of the sandbar shark as shallow coastal areas seaward to 25 m from Montauk, Long Island, NY (72°W) to Cape Canaveral, FL (80.5°W), except from the Virginia/Maryland border (37.8°N) south to Pamlico Sound, NC, where the seaward extent of the EFH is 17 NM from shore. Seasonally (summer), nursery areas within the shallow coastal waters from Great Bay, NJ to Cape Canaveral, FL, especially the Delaware and Chesapeake Bays, are designated as EFH. Additional EFH designated for this lifestage is in the Florida Keys and off western Florida.
- Juvenile (72 to 147 cm TL)—Shallow coastal waters to the 25 m isobath are designated as EFH from Barnegat Inlet, NJ (40°N) to south of Cape Canaveral, FL at 27.5°N. Additional EFH designated for this lifestage, but not found within the study area, are areas north of Barnegat Inlet, NJ and regions off western Florida.
- Adult (≥148 cm TL)—EFH is designated from Nantucket, MA south to Miami, FL in the shallow coastal areas from the shore seaward to 50 m. EFH excludes areas from 39.2°N off the coast of New Jersey south to 35.2°N off Cape Hatteras, NC (finger-like projection roughly following the 200 m isobath). Additional EFH designated for this lifestage is found in the Florida Keys and off western Florida.

HAPC Designations—(NMFS 1999b, 2003d)

- All Lifestages—Althougth not found within the study area, HAPC are designated for the sandbar shark in the shallow areas at the mouth of Great Bay, NJ, lower and middle Delaware Bay, lower Chesapeake Bay, MD, and near the Outer Banks, NC, in areas of Pamlico Sound adjacent to Hatteras and Ocracoke Islands, and offshore of these barrier islands since they represent important nursery and pupping grounds.

- Scalloped Hammerhead Shark (*Sphyrna lewini*)

Management—Scalloped hammerhead sharks are managed under the Final Consolidated Atlantic HMS FMP in the Large Coastal Shark category (NMFS 2006h).

Status—They are listed as lower risk but near threatened by the IUCN Red List (Kotas 2000). The scalloped hammerhead shark is subject to overfishing and is overfished (NMFS 2005b).

Distribution—Scalloped hammerhead sharks are found in warm-temperate to tropical waters worldwide over the continental shelf and slope (Castro 1983; Compagno 1984). In the western Atlantic, the scalloped hammerhead's range extends from New Jersey to Brazil, as well as the Gulf of Mexico and the Caribbean Sea (Bester 1999h).

Habitat Preferences—This shark species inhabits waters from the surface to depths of 275 m and can be found close to shore, in bays and estuaries, preferring water temperatures of at least 22°C (Castro 1983; Compagno 1984). Typically, scalloped hammerhead sharks spend the day close to shore and move to deeper waters at night to feed (Bester 1999h).

Life History—Scalloped hammerheads give birth once a year in the summer starting around June in shallow coastal nurseries found from Virginia to the Gulf of Mexico (Castro 1993; McCandless et al. 2002). This species forms large schools when it migrates seasonally north to south along the eastern U.S coast (NMFS 1999b).

Common Prey Species—Scalloped hammerhead sharks consume a wide variety of bony fishes, as well as invertebrates, other sharks, and rays and have only been reported feeding at night (Compagno 1984).

EFH Designations—(NMFS 1999b; Figure D-54)

- Neonate (≤62 cm TL)—Although not found within the study area, EFH has been designated for this lifestage in areas north of 30°N and estuaries from Apalachee Bay, FL to St. Andrews Bay, FL.
- Juvenile (63 to 227 cm TL)—EFH is designated for this lifestage of the scalloped hammerhead as all shallow coastal waters to the 200 m isobath from 39°N to the vicinity of the Dry Tortugas National Park and the Florida Keys (82°W). Additional EFH is designated in the Gulf of Mexico.
- Adult (≥228 cm TL)—Waters from the 25 m to 200 m isobaths are designated as EFH from 30°N south to 28°N. Additionally, EFH for this lifestage has been designated in regions north of 30°N and in the Florida Straits.

HAPC Designations— No HAPC are identified for this species.

- Silky Shark (*Carcharhinus falciformis*)

Management—Silky sharks are managed via the Final Consolidated Atlantic HMS FMP in the Large Coastal Shark category (NMFS 2006h).

Status—The silky shark is considered subject to overfishing and is overfished (NMFS 2005b).

Distribution—Silky sharks are found in the Pacific, Indian, and Atlantic Oceans. In the western Atlantic, this species is ranges from Massachusetts to southern Brazil, including the Gulf of Mexico and Caribbean Sea (Manooch 1988). In The Bahamas, it has been recorded frequently on the Great Bahamas Bank (Böhlke and Chaplin 1993).

Habitat Preferences—The silky shark inhabits tropical to warm-temperate waters (23° to 24°C) from depths of 18 to 500 m (most common in waters greater than 200 m) and associates with deep-water reefs and shelf edges (Compagno 1984; Compagno et al. 2005). Nurseries have been recorded in offshore waters of Florida and Texas as well as in the Caribbean (Compagno 1984; McCandless et al. 2002). Campeche Bank is considered the primary nursery area in the Gulf (NMFS 1999b). Adults are typically found further offshore than younger sharks while neonates utilize reef habitats (Knickle 1999b).

Life History—Very little is known about the silky shark. This species mates and gives birth to live young in late spring (May through June) during alternating years (Knickle 1999b). Juvenile silky sharks migrate inshore during the summer (NMFS 1999b).

Common Prey Species—Silky sharks feed on fishes (mullet, mackerel, tuna), pelagic crabs, and squid (Compagno 1984; Manooch 1988).

EFH Designations—(NMFS 1999b; Figure D-55)

- Neonate (≤97 cm TL)—EFH is designated for this lifestage of the silky shark as waters between 25 m and 1,000 m from St. Augustine, FL to Miami, FL (likely along the west edge of the Gulf Stream). Additional EFH designated for this lifestage, but not located within the study area, includes areas north of St. Augustine, FL and in the Gulf of Mexico.
- Juvenile (98 to 231 cm TL)—Waters from the North Carolina/South Carolina border south to Key West, FL paralleling the 200 m isobath are designated as EFH for this lifestage. Additionally, EFH has been designated for these areas not located within the study area: regions north of the North Carolina/South Carolina Border and areas off southwestern Florida.
- Adult (≥232 cm TL)—Insufficient information exists to describe EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Skipjack Tuna (*Katsuwonus pelamis*)

Management—This important commercial and recreational species is managed by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—According to current stock assessment and fishery evaluation reports by the NMFS (2004c, 2005b), the status of the west Atlantic skipjack tuna is unknown due to a lack of knowledge about the species' stock structure (biomass and fishing mortality).

Distribution—The skipjack tuna is circumglobal in tropical and warm-temperate waters. In the northwest Atlantic, the skipjack typically ranges from Cape Cod, MA south to Brazil (NMFS 1999b; Schultz 2004).

Habitat Preferences—Skipjack tuna are an epipelagic, oceanic species that remains at the surface during the day, descending to depths of up to 260 m at night (Collette and Nauen 1983). Aggregations of skipjack tuna are associated with convergence zones and other hydrographic fronts. Adult skipjack tuna prefer waters with a temperature range of 14.7° to 30°C (Collette 2002a). Skipjack tuna exhibit a strong tendency to school in surface waters with birds, whales, sharks, and other tuna species, as well as drifting objects (Collette and Nauen 1983).

Life History—Near the equator the skipjack tuna spawns year round, while at higher latitudes spawning is restricted to warmer months, from spring to early fall (Gardieff 1999c; NMFS 1999b). Larvae have been collected off the east coast of Florida from October to December and in the Gulf of Mexico and Florida Straits from June to October (NMFS 1999b).

Common Prey Species—Skipjack tuna are opportunistic feeders that prey upon fishes (herring, anchovies, sardines), cephalopods, and crustaceans with peak feeding occurring at dawn or dusk (visual feeders) (Gardieff 1999c; NMFS 1999b). Additionally, pelagic *Sargassum* and species associated with pelagic *Sargassum* have been recorded in their stomachs (NMFS 1999b). Cannibalism is also considered common amongst this species (Gardieff 1999c).

EFH Designations—(NMFS 1999b; Figure D-56)

- Spawning Adult, Egg, and Larva—EFH is designated for this lifestage of skipjack tuna as offshore waters from the 200 m isobath to the U.S. EEZ boundary from 28.25°N south around peninsular Florida. Addition EFH has been designated in the Gulf of Mexico.
- Juvenile and Subadult (<45 cm fork length)—EFH is designated as pelagic surface waters 20° to 31°C in temperature bounded by the 25 m and 200 m isobaths from 27.25°N to 24.75°N off southern Florida.
- Adult[8] (>45 cm fork length)—No EFH is designated for this lifestage in the study area but EFH is designated in regions of the MAB north of Oregon Inlet, NC.

HAPC Designations—No HAPC are identified for this species.

- Spinner Shark (*Carcharhinus brevipinna*)

Management—The spinner shark is managed in U.S. Atlantic waters as a Large Coastal Shark by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The IUCN lists the northwest Atlantic subpopulation of spinner shark as vulnerable or facing a high risk of extinction in the wild in the medium-term future (Burgess 2000). Spinner sharks are also considered overfished and subject to overfishing (NMFS 2005b).

Distribution—Spinner sharks are found in the Atlantic, Pacific, and Indian Oceans, as well as the Mediterranean Sea. In the western Atlantic the spinner shark ranges from North Carolina to Argentina, including the northern Gulf of Mexico, Cuba, and the Bahamas (Manooch 1988)

[8]The EFH text description for the adult lifestage of the skipjack tuna does not match the GIS data provided by the NMFS (2003b). The GIS data show adult EFH designated off Florida and in the Gulf of Mexico but no EFH are designated in the study area according to the FMP text. Dr. Chris Rilling, NMFS HMS Division, was consulted about this discrepancy and indicated that although the NMFS was aware of the problem that it would not be addressed until sometime in the future; the discrepancy was not resolved in the recent Final Consolidated FMP for HMS (NMFS 2006h). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2005).

Habitat Preferences—The spinner shark ranges from inshore to offshore waters over continental and insular shelves and is typically found in depths ranging <30 m to depths of more than 75 m (Compagno 1984; Bester 1999i). Juveniles inhabit shallower waters, including lower portions of bays (Bester 1999i). Spinner shark nurseries have been recorded from Cape Hatteras, NC through the Gulf of Mexico (McCandless et al. 2002).

Life History—The spinner shark is considered a highly migratory species, especially in the Gulf of Mexico, moving south into deeper waters during autumn and winter months and inshore for reproducing or feeding in the spring and summer. This shark usually migrates in schools. In the Gulf of Mexico and off Florida, live young are born in spring to early summer (Compagno 1984).

Common Prey Species—Spinner sharks feed on schooling fishes (sardines, herring, anchovies), squid, skates, rays, and other sharks (Manooch 1988). This species is often seen in schools, leaping out of the water while spinning in pursuit of prey (Bester 1999i).

EFH Designations—(NMFS 1999b; Figure D-57)

- Neonate (≤71 cm TL)—EFH is designated for this lifestage of the spinner shark as shallow coastal waters to the 25 m isobath from Cape Hatteras, NC (35.25°N) south around peninsular Florida. Shallow coastal waters of the northeastern Gulf of Mexico are also designated as EFH for this lifestage but are not located within the study area.
- Juvenile (72 to 184 cm TL)—Shallow coastal waters to the 200 m isobath are designated as EFH from the Florida/Georgia border (30.7°N) to 28.5°N.
- Adult (≥185 cm TL)—EFH is designated for this lifestage off the east coast of Florida from 30°N to 28.5°N as shallow coastal waters to the 100 m isobath.

HAPC Designations— No HAPC are identified for this species.

- Swordfish (*Xiphias gladius*)

Management—The NMFS manages swordfish through the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—According to current stock assessment and fishery evaluation reports by the NMFS (2004c, 2005b), the north Atlantic swordfish stock is overfished but overfishing is not occurring and the stock is in recovery. The north Atlantic stock is designated as endangered, or facing a very high risk of extinction in the wild in the near future, on the IUCN Red List (Safina 1996b).

Distribution—Swordfish inhabit the tropical, temperate, and sometimes cold-water regions of the entire world's oceans and seas (Nakamura 1985). In the northwest Atlantic, they occur from Cape Breton Island, Nova Scotia to Jamaica, including Cuba and Bermuda. They are also common in the Gulf of St. Lawrence and on the Grand Banks. Their presence in the waters of the western Atlantic is generally restricted to the warmer seasons (Gusey 1981).

Habitat Preferences—Eggs of swordfish are pelagic, buoyant, and present in offshore waters throughout the year but are most common between April and November (Palko et al. 1981; Gardieff 1999d; Govoni et al 2003). The distribution of larval swordfish is relative to surface water temperatures, with larvae commonly occurring at temperatures ranging between 24° and 29°C (Palko et al. 1981; Govoni et al. 2003). The greatest densities of larvae in the northwest Atlantic occur between the Straits of Florida and Cape Hatteras, NC (Palko et al. 1981). Adults are oceanic, midwater fish that primarily occupy depths of 200 to 600 m, although they can be found throughout the water column ranging from the surface to depths of 650 m. They also display a preference for water temperatures of 18° to 22°C but can tolerate a range from 5° to 27°C (Gardieff 1999d).

Life History—Swordfish spawn year-round in the northwest Atlantic, with variations in occurrence depending on area and season (Palko et al. 1981; Arocha 1997; Govoni et al. 2003). Peak spawning occurs between April and September (Palko et al. 1981; Nakamura 1985). It is believed that spawning occurs near the Yucatan Channel, the Straits of Florida, and also south of the Sargasso Sea (Gusey 1981; Arocha 1997). Water temperatures in spawning grounds typically exceed 20° to

22°C, and spawning occurs at salinities of 33.8 to 37.4 psu and depths up to 75 m (Nakamura 1985; Gardieff 1999d). In the northwest Atlantic, as the waters warm in the summer months, swordfish migrate north and east along the edge of the continental shelf. They return south and west in autumn. There is also evidence suggesting that other groups of swordfish may migrate toward the continental shelf from deeper waters in the summer and return in the fall (Gusey 1981).

Common Prey Species—Swordfish are opportunistic predators that prey primarily on pelagic fishes but also feed on squid and demersal fishes. They use their sword to slash, stun, and obtain larger prey, while consuming smaller prey whole (Gardieff 1999d).

EFH Designations—(NMFS 1999b; Figure D-58)

- Spawning Adult, Egg, and Larva—EFH is designated between the 200 m isobath and U.S. EEZ from offshore Cape Hatteras, NC (~35°N) south around peninsular Floridap; EFH is also associated with the western edge of the Gulf Stream in the Atlantic. Additional EFH designated for this lifestage, but not occurring within the study area, includes regions in the Caribbean and Gulf of Mexico.
- Juvenile and Subadult (<180 cm LHFL)—EFH for this lifestage of the swordfish is designated between the 100 m isobath and U.S. EEZ boundary from Cape Canaveral, Florida (~29°N) around peninsular Florida. Additional EFH designated for this lifestage, but not found within in the study area, includes regions north of Georgia and in the Gulf of Mexico.
- Adult (>180 cm LJFL)—Pelagic waters (to depths of 500 m) warmer than 13°C bounded by the 100 to 2,000 m isobaths or the U.S. EEZ boundary (whichever is closer to shore) are designated as EFH from Cape Cod, MA to Biscayne Bay, FL (25.5°N). Areas within the Gulf of Mexico are also designated as EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Tiger Shark (*Galeocerdo cuvier*)

Management—The tiger shark is managed is managed as a Large Coastal Shark by the NMFS under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—This species is considered overfished in the northwest Atlantic and is subject to overfishing (NMFS 2005b). The IUCN Red List has designated the species as one of lower risk but near threatened (Simpfendorfer 2000).

Distribution—Tiger sharks are found throughout the temperate and tropical coastal waters of the world, with the exception of the Mediterranean Sea (Knickle 1999c; Natanson et al. 1999). In the northwest Atlantic, tigers are year-round residents in the coastal waters of Florida but make seasonal migrations ranging from Cuba to as far north as Nova Scotia (Natanson et al. 1999). Tiger sharks are considered common in The Bahamas (Böhlke and Chaplin 1993).

Habitat Preferences—Tiger sharks are present over a wide variety of marine habitats but display a preference for cloudy or turbid coastal waters (Compagno 1984; Knickle 1999c; Ferrari and Ferrari 2002). They are found across the continental shelf, as well as in estuaries, harbors, and inlets, and from surface waters to depths of up to 350 m (Compagno 1984; Knickle 1999c). They also prefer waters with temperatures exceeding 18°C (Branstetter 2002a). Tiger sharks are nocturnal, hunting in shallow waters of bays, estuaries, and lagoons, then returning to deeper waters during daylight hours (Compagno 1984; Tricas et al. 1997; Ferrari and Ferrari 2002). Nurseries have been identified along the coasts of Florida through Louisiana (McCandless et al. 2002).

Life History—Tiger sharks are ovoviviparous. In the northern hemisphere, mating occurs between March and May, and pupping is reported to occur from April to June of the following year (Compagno 1984; Knickle 1999c). This shark species undergoes extensive seasonal migrations throughout the north Atlantic and have been known to travel distances as far as 1,242 NM to Cuba and Africa (Natanson et al. 1999; Ferrari and Ferrari 2002).

Common Prey Species—Tiger sharks feed on a wider variety of prey than most other shark species, including other sharks, skates, fishes (goosefish, bluefish), squid, horseshoe crab, other crab species, conch, birds, marine mammals, and sea turtles (Branstetter 2002a).

EFH Designations—(NMFS 1999b; Figure D-59)

- Neonate (≤90 cm TL)—EFH for this lifestage is designated as shallow coastal areas to the 200 m isobath from north of Cape Canaveral, FL to New York. Additional EFH designated for this lifestage, but not located within the study area, are regions in the Gulf of Mexico and regions north of 28.75°N.
- Juvenile (91 to 296 cm TL)—Shallow coastal areas bounded by the shore and the 100 m isobath from the Florida/Georgia border south around peninsular Florida are designated as EFH for this lifestage of the tiger shark. Additionally, EFH has been designated for this lifestage outside of the study area in regions north of the Florida/Georgia border, Gulf of Mexico, and Puerto Rico.
- Adults (≥297 cm TL)—EFH is designated offshore from the Chesapeake Bay, MD south to Ft. Lauderdale, FL along the western edge of the Gulf Stream. Additional EFH designated for this lifestage and not located within the study area include regions offshore of Puerto Rico and in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- White Marlin (*Tetrapturus albidus*)

Management—The white marlin is managed as part of the the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The white marlin stock in the northwest Atlantic is overfished and overfishing is occurring (NMFS 2004c, 2005b). Additionally, NMFS (2004a) has included the Atlantic stock of white marlin on their species of concern list.

Distribution—White marlin are an oceanic, epipelagic species that occur only in the Atlantic (NMFS 1999d). They are commonly distributed from Cuba, The Bahamas, and southern Florida to Delaware Bay in the northwest Atlantic but range as far as southern New England in lesser abundance during warmer months (Collette 2002b).

Habitat Preference—White marlin prefer oceanic waters exceeding 100 m in depth, with temperatures between 20° and 29°C and salinities of 35 to 37 psu (Gardieff 1999e; Collette 2002b). They often occur in the upper 20 to 30 m of the water column but can be found down to depths of 200 to 250 m, when the thermocline is deep (NMFS 1999d). In addition, they typically frequent oceanic currents with flow rates of 0.8 to 3.7 kilometers per hour and are often associated with rip currents, weed lines, areas of upwellings, and regions with benthic geographic features including drop-offs, shoals, and submarine canyons (Gardieff 1999e; NMFS 1999d).

Life History—The spawning season for white marlin occurs between March and June, with females spawning up to four times per season. Spawning occurs in deep oceanic waters with surface temperatures between 20° and 29°C and high salinities in excess of 35 psu (Gardieff 1999d; NMFS 1999b). White marlin migrate extensively over large distances, some recorded making trans-Atlantic movements (NMFS 1999d). Tagging data indicates that individuals of this species found in the MAB from Cape Hatteras, NC to Cape Cod, MA in the summer migrate south to the Caribbean during the winter (Jones et al. 1985).

Common Prey Species—In the Atlantic, white marlin feed primarily on round herring and squid but also consume jacks, mackerels, triggerfish, filefish, dolphinfish, flyingfish, and crabs (NMFS 1999d). As with other billfishes, white marlin are suspected to use their spear to stun prey species (Manooch 1988).

EFH Designations—(NMFS 1999d; Figure D-60)

- Spawning Adult, Egg, and Larva—Currently, insufficient information are available to identify EFH for this lifestage of the white marlin.
- Juvenile (20 to 158 cm LJFL)—EFH is designated as pelagic waters bounded by the 50 and 2,000 m isobaths with temperatures warmer than 22°C from Georges Bank (41°N) south to near Miami, FL (25.25°N). Although not located in the study area, EFH has also been designated for this lifestage in the Gulf of Mexico and north of 29°N.
- Adult (≥159 cm LJFL)—Pelagic waters warmer than 22°C bounded by the 200 m isobath and the U.S. EEZ from 29°N (offshore Cape Canaveral, FL) south around penisular Florida to Key West, FL is designated as EFH for this lifestage of the white marlin. Additional EFH designated for this lifestage, but not found within the study area, includes regions north of Cape Canaveral, FL and in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- White Shark (*Carcharodon carcharias*)

Management—White sharks are managed by the NMFS as Prohibited Sharks under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status—The white shark is designated as vulnerable or facing a high risk of extinction in the wild on the IUCN Red List (Fergusson et al. 2000). Currently, this species has an overfished status and is subject to overfishing (NMFS 2005b).

Distribution—White sharks are found worldwide in temperate, subtropical, and tropical waters. In the northwest Atlantic, it occurs from Newfoundland to Florida, the northern Gulf of Mexico, The Bahamas, and Cuba, as well as from Brazil to Argentina (Castro 1983; Compagno 1984). The white shark is rare south of Cape Hatteras, NC and in the Gulf of Mexico except during the winter (Castro 1983).

Habitat Preference—Although principally an epipelagic shark, the white shark can be found utilizing depths of over 250 m ranging from the surfzone to offshore, including oceanic islands (Castro 1983; Compagno 1984b; Martins and Knickle 1999). This shark commonly occurs in areas of small coastal archipelagos inhabited by pinnipeds (main prey), offshore reefs, banks, and shoals, as well as rocky headlands where deeper water is closer to shore (Martins and Knickle 1999). Larger white sharks are more common in subtropical and tropical waters than smaller white sharks (less than 3 m in length), which typically are confined to temperate waters (Compagno 1984).

Life History—Very little is known about the white shark's reproductive behavior and habitat association, but records indicate that live young are born in temperate shelf waters during the spring to late summer (Martins and Knickle 1999). The white shark inhabits waters over the continental shelf in the summer and migrates to warmer waters during the winter months (Castro 1983).

Common Prey Species—White sharks feed on marine mammals, such as seals, sea lions, dolphins, and also fishes during the day (sharks, tuna, and rays) (Martins and Knickle 1999; Branstetter 2002a). They have also been reported feeding on sea turtles and have a complex predatory behavior repertoire (Martins and Knickle 1999).

EFH Designations—(NMFS 1999b; Figure D-61)

- Neonate (≤166 cm TL)—Currently, insufficient data or information are available to identify EFH for this lifestage of the white shark.
- Juvenile (167 to 479 cm TL)—EFH is designated as pelagic waters bounded by the 25 m and 100 m isobaths off the Cape Canaveral, FL from 29.5°N to 28°N. Additional EFH is designated for this lifestage of the white shark off the region encompassing the New York Bight.
- Adult (≥480 cm TL)—Insufficient data or information are available to identify EFH for this lifestage of the white shark.

HAPC Designations—No HAPC are identified for this species.

- Yellowfin Tuna (*Thunnus albacares*)

Management—Yellowfin tuna are managed under the Final Consolidated Atlantic HMS FMP (NMFS 2006h).

Status— According to current stock assessment and fishery evaluation reports by the NMFS (2004c, 2005b), the Atlantic yellowfin tuna is not overfished and overfishing is not occurring, but it is approaching an overfished status.

Distribution—Yellowfin tuna are circumglobal in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans but are absent from the Mediterranean Sea. In the western Atlantic, yellowfin tuna range from 45°N to 40°S, including the area from Massachusetts to Brazil, as well as Bermuda, the Gulf of Mexico, and the Caribbean (Gusey 1981; Gardieff 1999f; NMFS 1999b).

Habitat Preference—Yellowfin tuna are an epipelagic, oceanic species found in waters with temperatures between 18° and 31°C (Collette and Nauen 1983). Adult yellowfin tuna typically only utilize the top 100 m of the water column due to their intolerance of oxygen concentrations less than 2 milliliters per liter (ml/l) (Collette and Nauen 1983). It is a schooling species, segregated primarily by size in groups of its own species, with other tuna species (Atlantic skipjack and Atlantic bigeye tuna), or floating objects (e.g., driftwood, seagrass, boats, marine mammals) (Collette and Nauen 1983; Gardieff 1999e). As this species moves away from the surface, it is less likely to be found aggregating in schools. Larger tuna typically inhabit deeper waters and higher latitudes than smaller individuals, which are found closer to shore (NMFS 1999b). Larvae distribution is restricted to waters above the thermocline with temperatures above 24°C and salinities greater than 33 psu (Collette and Nauen 1983; NMFS 1999b).

Life History—Spawning for this tuna species occurs throughout the year in waters with temperatures greater than 26°C but peaks in the summer in the Atlantic Ocean between 15°N and 15°S as well as the Gulf of Mexico and the Caribbean Sea (Gardieff 1999f; NMFS 1999b). Movement patterns for this highly migratory species are not well documented, but tuna spawned in the Gulf of Guinea, central Africa, are believed to migrate toward the U.S. coast (Collette and Nauen 1983; NMFS 1999b).

Common Prey Species—The yellowfin tuna feeds opportunistically on fishes (dolphin, pilchard, anchovy, flying fish, mackerel, lanternfish, squirrelfish, other tuna species) and invertebrates (cuttlefish, squid, octopus, shrimp, lobster, crabs) from the surface to depths of 100 m (Gardieff 1999f; NMFS 1999b). Pelagic *Sargassum* and *Sargassum*-associated species have been recorded in yellowfin tuna stomach contents (NMFS 1999b). Yellowfin tuna are considered sight-oriented predators that feed during daylight hours (Gardieff 1999f).

EFH Designations—(NMFS 1999b; Figure D-62)

- Spawning Adult, Egg, and Larva—EFH is designated for this lifestage as offshore waters bounded by the 200 m isobath and the U.S. EEZ from 28.25°N south around peninsular Florida. Additional EFH has been designated for this lifestage in the Gulf of Mexico and Caribbean.
- Juvenile and Subadult (<110 cm fork length)—The top 100 m of pelagic waters between 18° and 31°C in temperature off eastern Florida that are bounded by ~79°W, 29°N, 28.25°N, and the U.S. EEZ is designated as EFH for this lifestage of yellowfin tuna. Additional EFH designated for this lifestage outside of the study area includes regions north of Jekyll Island, GA and in the Gulf of Mexico.
- Adult (>110 cm fork length)—The top 100 m of pelagic waters between 18° and 31°C in temperature off eastern Florida that are bounded by ~79°W, 29°N, 28.25°N, and the U.S. EEZ is designated as EFH for this lifestage of yellowfin tuna. Additional EFH designated for this lifestage outside of the study area includes regions north of Jekyll Island, GA and in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

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6.0 ADDITIONAL CONSIDERATIONS

6.1 MARITIME BOUNDARIES: TERRITORIAL WATERS, CONTIGUOUS ZONE, AND EXCLUSIVE ECONOMIC ZONE

Maritime boundaries are critical elements that affect the planning of activities in the marine environment as they delimit the extent of a nation's sovereignty, exclusive rights, jurisdictions, and control over the ocean areas off its coast (GDAIS 2005). Maritime boundaries may include a 12 NM territorial sea, an 18 to 24 NM contiguous zone, and a 200 NM exclusive economic zone (EEZ) (Figure 6-1). Maritime boundaries are delimited, rather than demarcated, so there is generally no physical evidence of the boundary. As a result, there can be confusion and disagreement among nations and/or territories as to the exact location of marine boundaries (NOAA 2005f).

6.1.1 U.S. Maritime Boundaries

Historically the U.S. and other nations have used 3 NM as their seaward territorial limit, although some American states, such as Texas and the Gulf Coast of Florida, and U.S. territories, such as Puerto Rico, have seaward boundaries of three marine leagues or 9 NM. These territorial limits are measured from the baseline of each nation or state. The U.S. has traditionally used the "rule of the tidemark" to establish the baseline from which to measure the seaward extent of its territorial waters. This baseline coincides with the low-water, or low-tide, line found along the coast and is often termed the "normal" baseline (Kapoor and Kerr 1986; Prescott 1987). At the mouths of bays, rivers, or other areas where the coastline is not continuous, a straight baseline is drawn over the coastal feature (Figure 6-1). Rather than use the normal baseline, an increasing number of countries use either the straight baseline or archipelagic baseline system from which to measure their territorial waters (Kapoor and Kerr 1986; Prescott 1987).

The 3 NM limit was the standard until the latter half of the twentieth century when the extent of the U.S. territorial waters was redefined. In 1945, President Truman issued Proclamation Number 2667, which claimed jurisdiction and control over all natural resources of the seabed and subsoil on the U.S. continental shelf. In 1953, Proclamation Number 2667 was nullified and replaced by the Outer Continental Shelf (OCS) Lands Act (Table 6-1), which, similarly, placed the subsoil and seabed and all natural resources therein under U.S. jurisdiction. Section 1331 of this act defines the OCS as "…all submerged lands lying seaward and outside of the area of lands beneath navigable waters as defined in Section 1301 of this title, and of which the subsoil and seabed appertain to the United States and are subject to its jurisdiction and control…". As with Proclamation Number 2667, the OCS Lands Act did not give the U.S. authority over the waters above the continental shelf seabed, leaving them open to navigation and fishing.

It is important to clarify that the continental shelf, as defined in the OCS Lands Act, is not limited to the portion of the continental margin located landward of the shelf break (the geologically defined boundary of the continental shelf), but actually includes the entire continental margin as discussed in Chapter 2 of this MRA. Both the U.S. and the Bahamas are claiming the same portion of the seabed and seafloor located well beyond the shelf break as a part of their respective continental shelves. Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS) addresses this inconsistency between the legal and geologic definitions of the continental shelf and allows nations to base their claims on the extent of the continental margin instead of the continental shelf; however, claims are limited to 350 NM from a nation's baseline and 100 NM from the 2,500 m isobath. These restrictions prevent claims by any nation to the deep ocean basin (CIA 2006a).

Following the trend established in the United Nations (U.N.), the U.S., with the 1976 Fishery Conservation and Management Act (FCMA), established a 200 NM fishery conservation zone extending outward from its baselines or contiguous to its territorial seas. This 200 NM zone was designed to protect and conserve the fisheries of the U.S and its territories. With the enactment of the FCMA in 1977, the U.S. formally claimed the 200 NM fishery conservation zone, in which it exercises exclusive fishery management authority, except where countries lie closer than 400 NM. Pending the establishment of permanent maritime boundaries by treaty or agreement with these nations, the FCMA set forth fishery limits based on a median line drawn equidistantly between two nations where a 200 NM limit is not possible (DoS 1977).

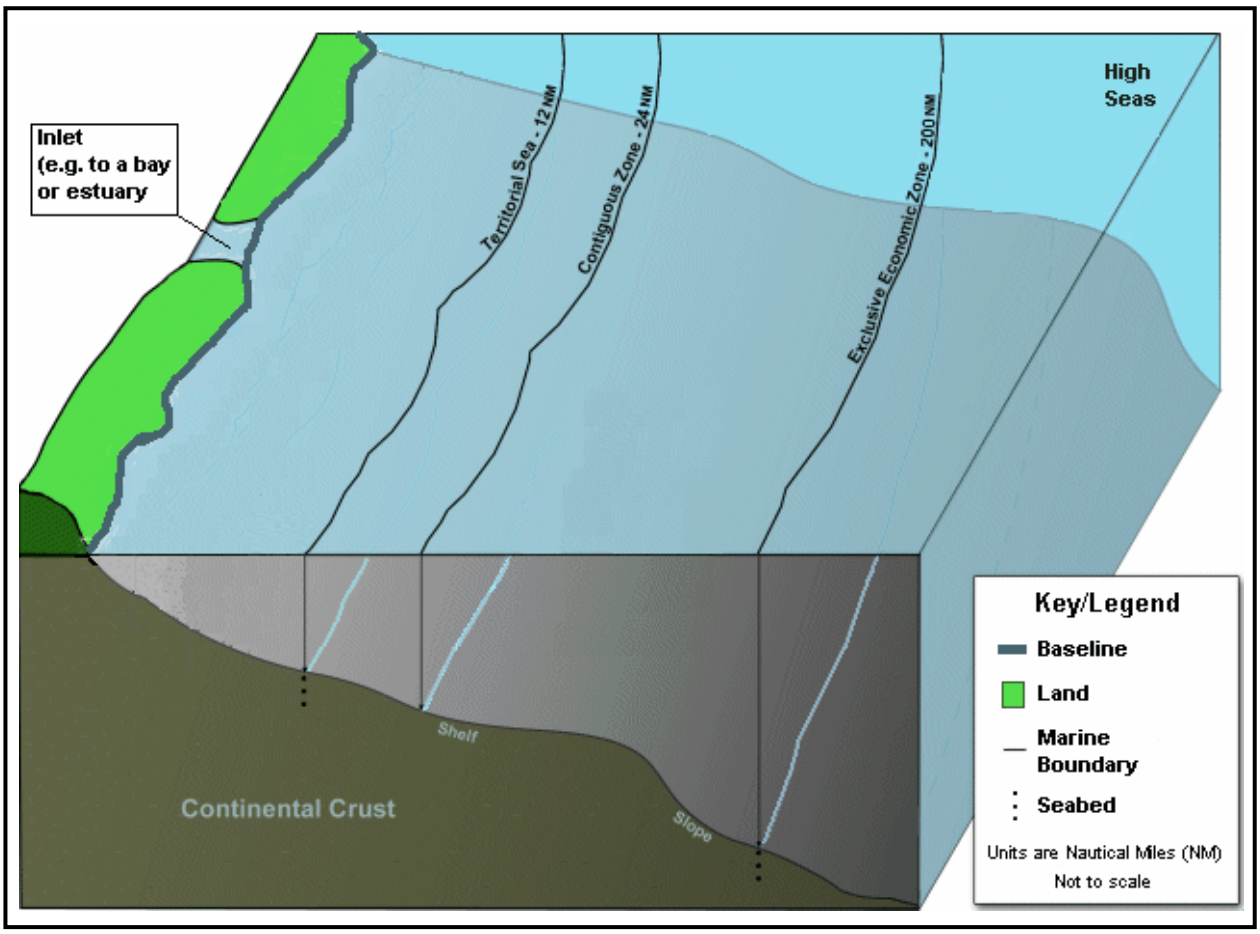

Figure 6-1. Generic three-dimensional representation of maritime boundaries with the baseline defined as the mean low water/tide line along the coast or a straight line drawn across coastal bays or other inlets. Adapted from NOAA (2005f).

By the early 1980s, it was evident that the U.S. needed to control more than fisheries outside of its territorial waters. In 1983, President Reagan recognized the necessity of protecting, controlling, and developing the ocean area adjacent to the territorial waters of the U.S. by issuing Presidential Proclamation Number 5030. This proclamation established a 200 NM EEZ from the U.S. baseline that included all areas adjoining the territorial waters of the U.S. and its territories, except where another country lies closer than 400 NM from the U.S. In the study area, for instance, several islands of the Bahamas are less than 400 NM from the east coast of Florida, so, since the U.S. and the Bahamas have yet to establish any formal maritime agreement (GlobalSecurity.org 2005; Turnquest 2005; CIA 2006b), the boundary delimiting the extent of the EEZs of both the U.S. and the Bahamas is located equidistantly between the baselines of each country (Figure 6-2).

The establishment of an EEZ gave the U.S. sovereign rights over the natural resources within the 200 NM zone (or less depending on the proximity of a neighboring nation). Sovereign rights include the rights to explore, exploit, conserve, and manage the natural resources within a country's EEZ, but sovereignty does not affect the lawful use of an EEZ by other nations for navigation or overflight (Table 6-2).

The U.N. Law of the Sea Treaty (created in 1982, entered into force in 1994) delimits the international maritime sovereignties of coastal nations as 12 NM for territorial seas, 18 to 24 NM for a contiguous zone, and 200 NM for an EEZ (U.N. 2001). While the U.S. has not yet signed the Law of the Sea Treaty, it does

Table 6-1. Timeline detailing the establishment of U.S. jurisdiction and maritime boundaries in the study area as determined by treaty, legislation, and presidential proclamation (DoS 1977; DOALOS 2005; Rosenberg 2005).

- **From Antiquity to the Early Twentieth Century:** nations individually established seaward boundaries of 3 to 9 NM under the "cannon shot" concept.
- **1945–Truman Presidential Proclamation Number 2667 on the Continental Shelf:** for the purpose of conserving and utilizing natural resources, the U.S. claimed jurisdiction and control of the subsoil and seabed of the continental shelf contiguous to its coast. The waters overlying the continental shelf were not affected. Proclamation 2667 is viewed as an important legal landmark in establishing a nation's jurisdiction over submarine territory and in creating a legal definition of the continental shelf.
- **1945–Truman Presidential Proclamation Number 2668 on Coastal Fisheries:** conservation zones were established in areas of the high seas contiguous to U.S. coasts for the purpose of protecting coastal fishery resources.
- **1953–Outer Continental Shelf Lands Act:** the subsoil and seabed of the OCS was declared to be under U.S. jurisdiction, control, and power. The waters overlying the OCS were not affected by this act, so fishing and navigation were unrestricted. This act nullified Presidential Proclamation Number 2667 (67 Stat. 462, 43 U.S.C. 1331 et seq.).
- **1958–U.N. Convention on the Law of the Sea I:** the U.N. convened the first international conference on maritime boundaries.
- **1960–U.N. Convention on the Law of the Sea II:** the second U.N. conference convened on international maritime boundaries.
- **1973–U.N. Convention on the Law of the Sea III:** the third U.N. conference convened on international maritime boundaries.
- **1976–Fishery Conservation and Management Act:** this legislation established a fishery conservation zone extending 200 NM from U.S. baselines, except in several areas such as the Caribbean Sea, where to the west, south, and east of Puerto Rico and the U.S. Virgin Islands (USVI), the limit of the fishery conservation zone was determined by geodetic or straight lines connecting points of latitude and longitude that were delineated in the act.
- **1977–Fishery Conservation and Management Act:** the fishery conservation zone, established by the 1976 Fishery Conservation and Management Act, went into effect.
- **1982–U.N. Convention on the Law of the Sea Treaty:** an international treaty developed by the U.N. but not yet ratified by the U.S. Most nations, including the U.S., adhere to its guidelines for maritime boundaries, including territorial seas, contiguous zones, and EEZs.
- **1983–Reagan Presidential Proclamation Number 5030 on the EEZ:** an EEZ was formally established to facilitate wise development and use of the oceans consistent with international law as well as to recognize the zone adjacent to a nation's territorial seas where a nation may assert certain sovereign rights over natural resources. Establishment of the U.S. EEZ advanced the development of ocean resources and promoted protection of the marine environment but did not affect other lawful uses of the zone, including navigation and overflight. This proclamation set the EEZ at 200 NM from the baselines of the U.S. and its territories, except where nations are less than 400 NM apart. In such cases, equidistant lines delineated the EEZ boundary. The EEZ boundaries coincided with those established by the 1976 FCMA. This proclamation did not affect existing U.S. policies concerning the continental shelf, marine mammals, or fisheries. Jurisdiction and sovereign rights will be exercised in accordance with rules of international law.
- **1988–Reagan Presidential Proclamation Number 5928 on the Territorial Sea:** the seaward extent of the U.S. territorial sea was extended to 12 NM from the baseline of the nation and its territories by this proclamation. The territorial sea is the zone over which the U.S. exercises supreme sovereignty and jurisdiction from the airspace over the sea to the seabed and its soil. This extension of the territorial sea advanced national security and other interests of the U.S. This proclamation did not extend or alter existing federal or state laws (jurisdiction, rights, legal interests, or obligations).

Table 6-1. Timeline detailing the establishment of U.S. jurisdiction and maritime boundaries in the study area as determined by treaty, legislation, and presidential proclamation (DoS 1977; DOALOS 2005; Rosenberg 2005) (cont'd).

- **1994–U.N. Convention on the Law of the Sea:** the U.N. entered into force the 1982 Law of the Sea Treaty. It has yet to be ratified by the U.S
- **1999–Clinton Presidential Proclamation Number 7219 on the Contiguous Zone:** the contiguous zone of the U.S. was established 24 NM from the nation's baseline by this proclamation. The contiguous zone is the area where the U.S. exercises the control necessary to prevent and punish infringement of its fiscal, customs, immigration, or sanitary laws and regulations within its territorial sea. Establishment of the U.S. contiguous zone advanced the law enforcement and public health interests of the nation. This proclamation did not change existing federal or states law and did not alter the rights of the U.S. in the EEZ.

recognize and abide by many of its rules. For instance, in 1988, U.S. Presidential Proclamation Number 5928 extended the seaward territorial limit of the U.S. to 12 NM from the U.S. baseline. This expansion of federal territorial waters from 3 NM (or in some cases 9 NM) to 12 NM provided the U.S. with jurisdiction and supreme power over this area (Table 6-2). The seabed and its resources, the biota found in the water column, and the airspace above the territorial seas, as well as the use of surface waters, are all under the jurisdiction of the U.S. Although the territorial waters of the U.S. extend 12 NM seaward from its baseline, the part of the territorial sea closest to shore (3 to 9 NM) remains under the jurisdiction of each coastal state. U.S. control over the waters adjacent to its shores was further solidified in 1999 when President Clinton's Presidential Proclamation Number 7219 extended U.S. federal jurisdiction by the additional 12 NM maximum allowed by international law. This 24 NM contiguous zone is measured from the U.S. baseline and, as its name implies, is an area contiguous or next to a nation's territorial waters that provides an added area of limited jurisdiction (Table 6-2). The U.S. makes no territorial claims within its contiguous zone, but it does, however, claim the right to exercise the control necessary to prevent infringement of its fiscal, customs, immigration, or sanitary laws/regulations and to punish infringement of these laws/regulations committed within the zone. Additionally, the establishment of the U.S. contiguous zones advances both the law enforcement and public health interests of the nation.

6.1.2 The Commonwealth of The Bahamas Maritime Boundaries

In 1970, the government of the Bahamas enacted the Continental Shelf Act claiming for the Bahamas "the seabed and subsoil of the submarine areas adjacent to the coasts…of the Bahamas, to a depth of two hundred meters or, beyond that limit, to where the depth of the superjacent waters admits to the exploration of the natural resources of the said areas" (Law Reform and Revision Commission 2002) Much like the U.S. OCS Act of 1953, the Bahamian Act establishes the right to explore the continental shelf, as it is defined above and to exploit all natural resources (e.g., petroleum) found on the shelf. The Act also claims ownership of any structure placed on or above the shelf for the purpose of exercising those rights and sets forth rules of navigation that restricts passage by any unauthorized vessel to within 500 m of the structure.

In 1977, the Bahamas passed the Fisheries Resources (Jurisdiction and Conservation) Act, which, much like the U.S. FCMA of 1976, established an exclusive fishery zone extending 200 NM from the baseline from which the Bahamian territorial sea is measured (Parliament of the Bahamas 1977). Within the exclusive fishery zone, the Bahamas claims sovereign rights and exclusive authority over the seabed, subsoil, and all associated waters for the purposes of exploration, exploitation, conservation, and management of fishery resources.

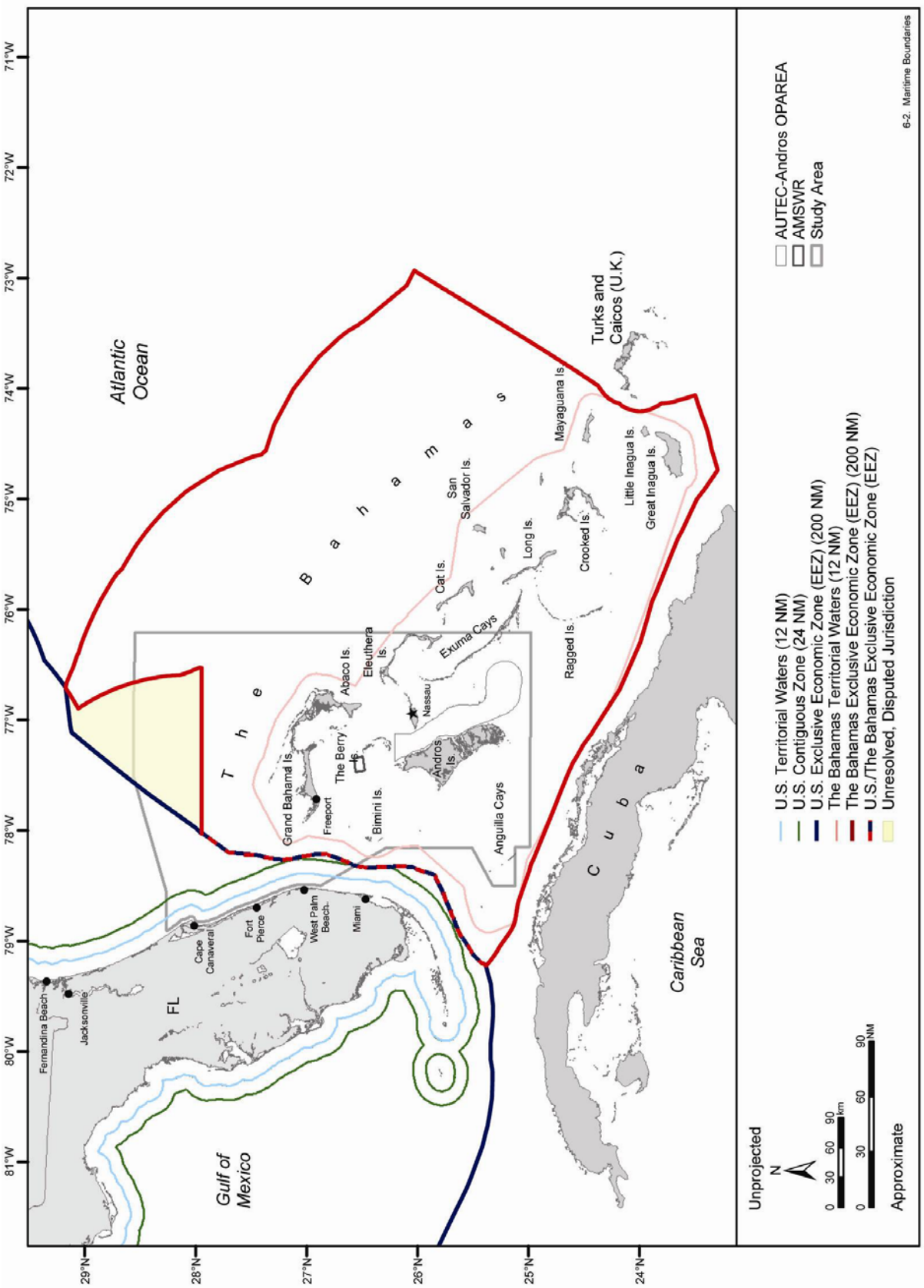

Figure 6-2. Proximity of the study area to maritime boundaries of the U.S. and The Bahamas. The territorial waters (12 NM), U.S. contiguous zone (24 NM), and exclusive economic zones (EEZs) (200 NM) of each nation are measured outward from their respective baselines (usually the mean low-tide line along the shore). Source data: GDAIS (2005).

Table 6-2. The maritime boundaries found in the study area as well as a description of their associated jurisdictional extent (Parliament of the Bahamas 1993; DOALOS 2005).

Maritime Boundary	Seaward Extent of Boundary	Jurisdictional Extent
U.S. State Waters	3 to 9 NM from U.S. baseline (depending on state's historical maritime boundary)	State jurisdiction of the air, sea, and seabed
Territorial Waters—U.S. and the Bahamas	12 NM from each nation's baseline	Full territorial jurisdiction of the air, sea, and seabed at the federal level of government.
U.S. Contiguous Zone	24 NM from the U.S. baseline (the Bahamas has not delineated a Contiguous Zone)	Power to prevent and punish infringement of fiscal, customs, immigration, and sanitary laws or regulations
Exclusive Economic Zone (EEZ)—U.S. and the Bahamas	200 NM from each nation's baseline (unless neighboring nations are less than 400 NM apart)	Sovereign rights over all natural resources and jurisdiction to protect the marine environment

6.1.3 U.S. Maritime Boundary Effects on Federal Legislation and Executive Orders

The Archipelagic Waters and Maritime Jurisdiction Act of the Bahamas was enacted by the Parliament of the Bahamas in 1993, and came into force in 1996. The Act establishes a 200 NM EEZ and extends the territorial waters of the Bahamas from 6 to 12 NM from an archipelagic baseline (Parliament of the Bahamas 1993; Figure 6-2). An archipelagic baseline differs from a traditional baseline, which uses the low-tide mark along a nation's coastline to establish maritime boundaries, in that it joins the traditional baselines of two or more islands forming an archipelago by extending a straight baseline, or series of straight baselines, across open water (Parliament of the Bahamas 1993). According to the Act, points by which the archipelagic baseline of the Bahamas may be delineated can include any charted physical feature or simply geographical coordinates. The Bahamas declared its right to establish an archipelagic baseline in the 1993 Act, and the U.N. recognizes the Bahamas claim to archipelagic status; however, before an archipelagic baseline is accepted as an internationally recognized maritime boundary, the nation claiming such a status must meet certain criteria outlined in the UNCLOS (UNCLOS, Part IV, Article 47). It is unclear where in the process the Bahamas is in delimiting and in gaining acceptance of its archipelagic baseline (U.N. 2001; Turnquest 2005). A recent case study sponsored by the U.N. and the Nippon Foundation concluded that the drawing of an archipelagic baseline is an integral step for the Bahamas in establishing a claim to any portion of the continental shelf beyond 200 NM (Turnquest 2005).

The 1993 Act also grants the Governor-General the power to define internal waters of the Bahamas as those waters extending landward from closing lines, which like the archipelagic baseline, are lines delineated between the islands of the Bahamas using selected geographical coordinates or mapped physical features. Internal waters within an archipelago have a similar jurisdictional extent to the territorial waters of a territorial sea, except that they do not extend the right of innocent passage to foreign vessels (U.N. 2001).

A region of the continental shelf located partially within the study and extending north beyond the study area is currently claimed by both the U.S. and the Bahamas (GDAIS 2005; CIA 2006b; Turnquest 2005; Figure 6-2). The region is approximately 33,000 km^2 and represents an area where the EEZs of the U.S. and the Bahamas overlap, and also includes a portion of the continental margin beyond 200 NM claimed by both nations under their respective continental shelf acts. As a signatory to the UNCLOS, the Bahamas has until 13 May 2009 to submit a claim for any portion of the continental margin beyond 200

NM to the U.N. Commission on the Outer Limits of the Continental Shelf (Turnquest 2005). Since the U.S. has not ratified the UNCLOS, the requirement to submit a claim does not apply. Unless a bilateral agreement between the U.S. and the Bahamas is reached, it is possible that a third party, such as the International Court of Justice, could be called upon to settle the dispute and help delineate the maritime boundary in this area.

The establishment of maritime boundaries by the U.S. defines the jurisdictional extent of laws and executive orders governing the actions of the U.S. and its citizens. The following laws and executive orders relevant to this MRA are affected by maritime boundaries.

- The Marine Mammal Protection Act (MMPA) protects, conserves, and manages marine mammals in waters under the jurisdiction of the U.S., which are defined by the MMPA as the U.S. territorial seas, EEZ, and the eastern special areas between the U.S. and Russia. The act further regulates "takes" of marine mammals on the global commons (i.e., the high seas or Antarctica) by vessels or persons under U.S. jurisdiction.
- The Endangered Species Act (ESA) regulates the protection, conservation, or management of endangered species in the U.S. territorial land and seas as well as on the high seas.
- The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), also known as the Sustainable Fisheries Act (SFA), claims sovereign rights over fish and fishery management in the U.S. EEZ (except for highly migratory species). The U.S. cooperates with nations or international organizations involved in fisheries for the highly migratory species in order to conserve and promote optimum yields of the species in their entire range in and beyond the U.S. EEZ.
- The National Environmental Policy Act (NEPA) establishes a Council on Environmental Quality (CEQ) and a national policy that will encourage productive harmony between humans and their environment and prevents or eliminates damage to the environment; boundaries include the territorial lands and waters of the U. S. to the limit of the territorial seas.
- The Marine Protection, Research, and Sanctuaries Act (MPRSA) regulates the dumping of materials in the ocean. It is applicable to material transported by any U.S. person, vessel, aircraft, or agency from any location in the world and by any person outside the U.S. intending to dump materials in U.S. territorial seas and the contiguous zone.
- Executive Order (EO) 12114 extends environmental impact evaluation requirements beyond the territorial seas and contiguous zone of the U.S. to include the environment of other nations and the global commons outside the jurisdiction of any nation.
- The Marine Plastic Pollution Research and Control Act (MPPRCA) prevents pollution of the marine environment by any vessel with U.S. registry or under U.S. authority and all vessels in the U.S. territorial waters or EEZ.

6.2 COMMERCIALLY NAVIGABLE WATERWAYS

Navigable waterways of the U.S. are those waters that are presently used to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the water body and is not extinguished by later actions or events that impede or destroy navigable capacity (33 CFR 329.4). More than 40,000 km (21,000 NM) of commercially navigable waterways exist within the U.S. transportation system (BTS 2004).

Traffic within the study area includes ships traveling along Florida's Atlantic coast as well as through the northern and southern waters of the Bahamas (Figure 6-3). Three primary waterways radiate east from Florida's Atlantic coast and intersect two waterways that parallel the coast, one nearshore and one farther offshore. Both of these waterways extend south through the Florida Straits to the Gulf of Mexico and the Caribbean as well as north to the northeastern U.S. and Canada. Three major waterways transverse the open ocean northeast of Abaco Island in the Bahamas and travel through the southeastern Bahamian Islands to the Caribbean Sea via the Windward Passage. A major waterway also passes through the southern portion of the study area along the Great Bahama Bank and north of Cuba (NPMS 2002).

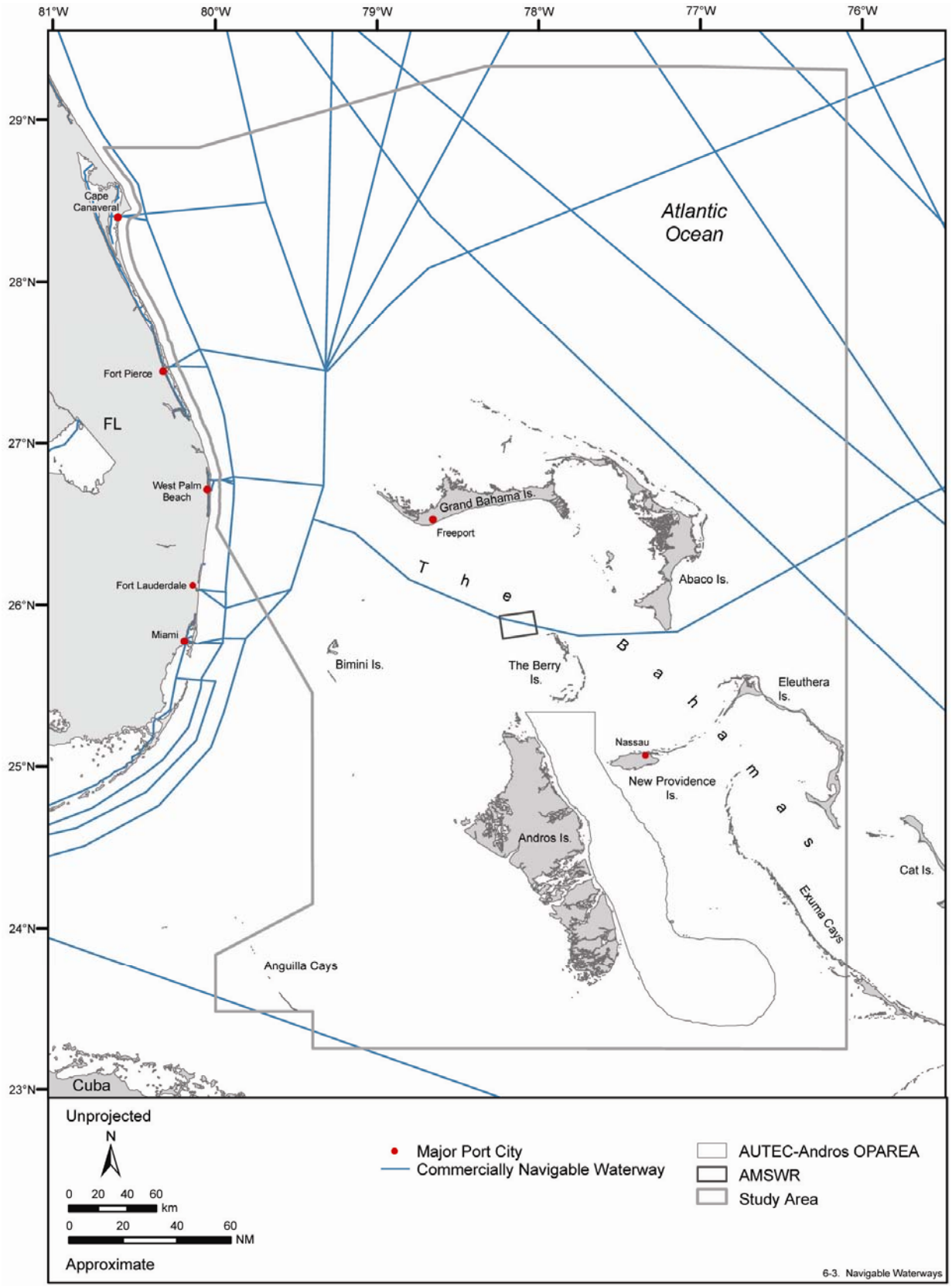

Figure 6-3. Commercially navigable waterways found in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NPMS (2002) and MapTech (2006).

International commercial shipping vessels and cruise ships comprise the vast majority of traffic along waterways traversing and adjacent to the study area. With Florida ports in close proximity to foreign markets, the state of Florida contributes significantly to the U.S. foreign trade market (FDT 2005). An abundance of cruise ships transit the study area between Florida and the Bahamas as well. Port Canaveral, Florida, located at the northeastern border of the study area, is the second busiest cruise port in the world (CPA 2005; Figure 6-3). Many major seaports exist within the study area, the largest of which are Port Canaveral, Florida; Prince George Wharf at Nassau, Bahamas; and Freeport, Bahamas. Several other major commercial shipping ports are adjacent to the study area including Miami, Florida and Jacksonville, Florida (Figure 6-3).

A request for a description of navigable waterways that enter the territorial waters of the Bahamas was made to the government of the Bahamas, but no response had been received by the time this document was published.

6.3 MARINE MANAGED/PROTECTED AREAS

Many areas of the U.S. marine environment receive some level of management protection. The Department of Commerce (DOC) and the Department of the Interior (DOI) are in the process of documenting all marine sites receiving management protection. Together the DOC and the DOI implement the Marine Protected Area (MPA) EO 13158 through the National MPA Center, a part of the NOAA. The National MPA Center is compiling a comprehensive inventory of all federal, state, tribal, and local sites that meet certain criteria of either a Marine Managed Area (MMA) or a MPA. Marine Managed Areas and MPAs are similar in that they both have conservation or management purposes, defined boundaries, and some legal authority to protect resources. Marine Managed Areas encompass a wider range of management intents than MPAs. Marine Managed Areas may include areas of protection for geological, cultural, or recreational resources that might not meet the definition provided in Executive Order 13158 for MPAs. Marine Managed Areas may also include areas that are managed for reasons other than conservation (e.g., security zones, shellfish closures, sewage discharge areas, and pipeline and cable corridors).

Marine Protected Areas are defined in Executive Order 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." Section 5 of EO 13158 stipulates, "each" Federal agency whose actions affect the natural or cultural resources that are protected by MPAs shall identify such actions. To the extent permitted by law and to the maximum extent practicable, each federal agency, in taking such actions, shall avoid harm to the natural and cultural resources that are protected by an MPA." Executive Order 13158 also calls for the preparation of annual reports by federal agencies describing the actions they have taken over the previous year to implement the order.

Executive Order 13158 asks for the development of a national system of MPAs. The EO provides a formal, albeit vague, definition of a MPA. In order clarify what specifically constitutes a MPA the National MPA Center has developed a MPA Classification System, providing definitions and qualifications for the various terms within EO 13158 (NMPAC 2005). The new MPA Classification System uses six functional criteria to objectively describe the key features of most MPAs: (1) Primary conservation focus (i.e. natural heritage, cultural heritage, or sustainable production); (2) Level of protection (i.e. no access, no impact, no take, zoned with no take area(s), zoned multiple use, or uniform multiple use); (3) Permanence of protection; (4) Constancy of protection; (5) Ecological scale of protection; and (6) Restrictions on extraction.

These six criteria are designed to provide a clear picture of why the site was established, what it is intended to protect, and how it may affect local ecosystems and their associated human uses. In practice, the first two characteristics: (1) the primary conservation goal and (2) the level of protection—address most of the issues and concerns relevant to an individual MPA. This classification scheme will allow efficient efforts to develop and disseminate the science, tools, and training needed for the effective design, management, and evaluation of the nation's system of MPAs. The designation of MPAs is considered an effective conservation tool for sustaining ocean ecosystems (Agardy 1999; NRC 2000).

The first step in designating areas of the marine environment as MPAs is to create a list or inventory of MMAs, from which MPAs will eventually be chosen. The goal of the MMA Inventory effort is to be as

inclusive as possible, while maintaining a consistent and systematic approach to adding sites to the database. Sites included in the inventory must meet criteria related to six terms: “Area,” “marine,” “reserved,” “lasting,” “protection,” and “cultural.”

There are currently 1,513 sites listed in the MMA Inventory encompassing over 7 million km^2 (NOAA and DOI 2005a). Of these, 274 are federally designated, 1,081 are state designated, 31 are designated through a federal/state partnership, 39 are designated by a U.S. territory, and the remaining 88 are designated either by a local municipality or county, or through a partnership between a state and a local government. No sites in the MMA Inventory are currently managed by a tribal authority. Once the MMA Inventory is complete, the MPA Classification System will be applied to sites in the MMA Inventory and official MPA designations will be made. The National MPA Center anticipates that between 1,500 and 2,000 U.S. marine sites will be classified as MMAs once the inventory is complete sometime in 2006 (NOAA and DOI 2005b). There are currently (as of 01 April 2006, the date data were last downloaded) seven U.S. federally designated and 52 state designated MMAs located in or in the vicinity of the study area (NOAA and DOI 2005c; Figure 6-4). No GIS data is currently available for the state designated MMAs. There are also 39 MPAs in the study area designated by the Bahamas through the International Union for Conservation of Nature-World Commission on Protected Areas (IUCN-WCPA) and in partnership with the United Nations Environment Programme—World Conservation Monitoring Centre (UNEP-WCMC) (UNEP-WCMC 2006a).

6.3.1 Federally Designated Marine Managed Areas in the U.S.

6.3.1.1 National Park System: National Seashores and National Parks/Monuments

The National Park System is composed of 388 sites covering more than 341,000 km^2 in 49 states, the District of Columbia, American Samoa, Guam, Puerto Rico, Saipan, and the U.S. Virgin Islands. National Parks (NPs) are generally large natural areas with a wide variety of attributes or significant historic assets. The American Antiquities Act of 1906 authorizes the President to publicly proclaim a landmark, structure, or other object of historic or scientific interest as a national monument if it is situated on lands owned or controlled by the federal government (16 U.S.C 431-433).

The National Park Service (NPS) protects and manages 10 National Seashores (NSs) in the U.S. Only Canaveral NS is located within the study area. The DOD is not exempt from NS regulations; Title 36, Parts 1 through 199 of the CFR determines which regulations the DOD must abide by when its agencies operate in these NS areas.

Canaveral National Seashore (Figure 6-4; Table 6-3) is a barrier island on the eastern central Florida coast which supports beach, dunes, hammock, salt marsh, and pine flatland habitats. It claims the longest stretch of undeveloped beach on the east coast of Florida (39 km or 24 miles) and was established as a NS in 1975 (NOAA and DOI 2005c). Mosquito lagoon located within the park is part of Indian River Lagoon and is a nationally recognized commercial and recreational fishery for finfish, clams, oysters, blue crabs (*Callinectes sapidus*) and shrimp. Endangered species of loggerhead, green and leatherback sea turtles, and West Indian manatee are also found in this region (NPS 2005).

6.3.1.2 Fisheries Management Zones

One of the many responsibilities of the NMFS includes rebuilding and maintaining sustainable fisheries. To satisfy this responsibility, the NMFS uses fisheries management zones (FMZs) and fisheries habitat conservation zones (FHCZs) as tools to conserve both fish stocks and fish habitat.

Fisheries Management Zones are areas that are closed, at least partially, to fishing activity. The NMFS has the jurisdiction to restrict or even prohibit the use of one or more types of fishing gear in some areas to protect habitats, fish stocks, or species assemblages and/or to promote the recovery of threatened and endangered species, such as marine mammals and sea turtles. These area closures can be either

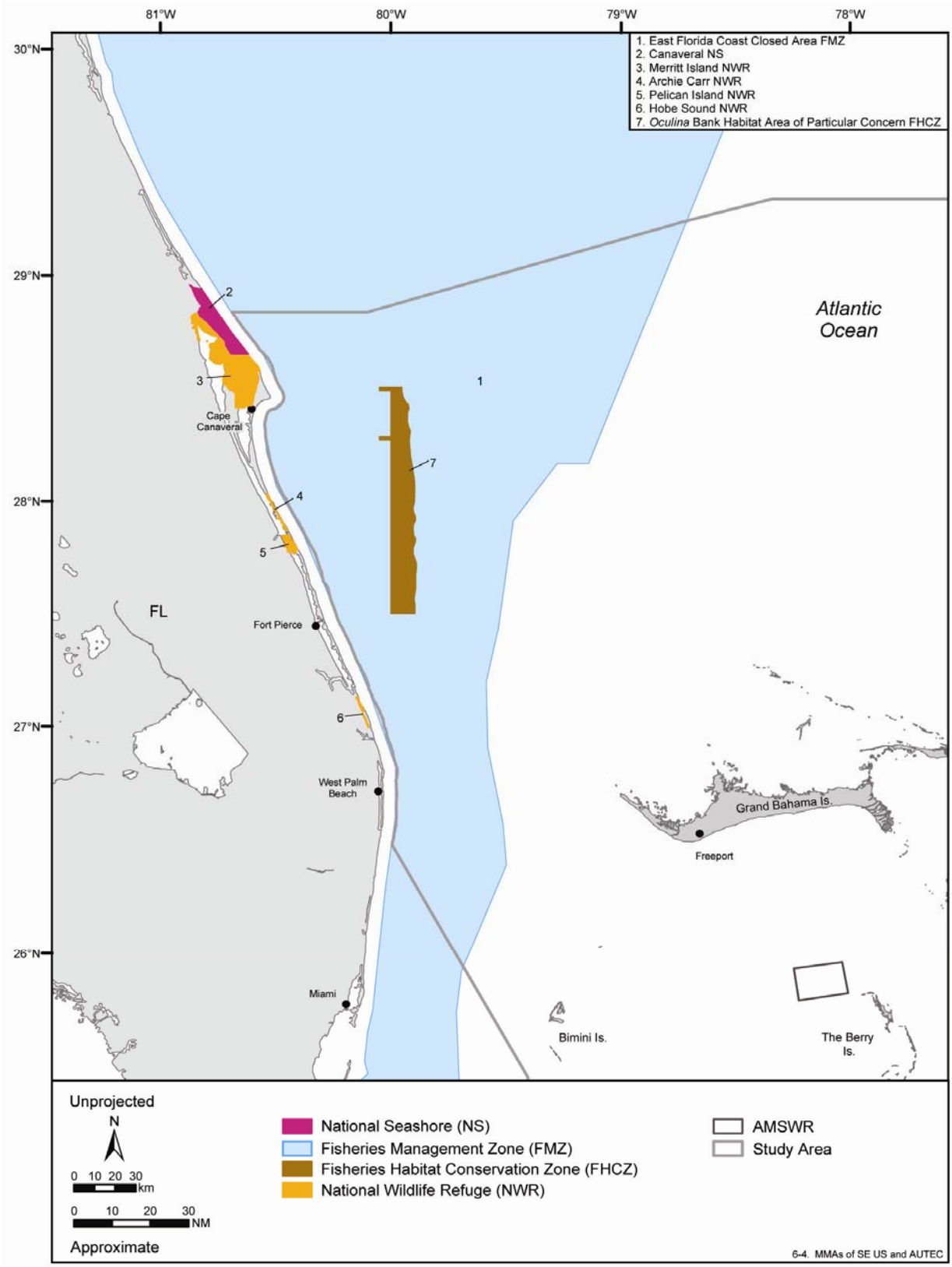

Figure 6-4. U.S. marine managed areas designated as of April 2006 that are located in or adjacent to the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NOAA and DOI (2006).

Table 6-3. Summary of federally designated marine managed areas (MMA) in or adjacent to the study area (NOAA and DOI 2005a).

Marine Managed Area	*MMA Designation*	*Area (km^2)*
Canaveral	National Seashore	230.74
Oculina Bank-HAPC	Fishery Habitat Conservation Zone	1,038.49
Archie Carr	National Wildlife Refuge	3.75
Hobe Sound	National Wildlife Refuge	3.43
Merritt Island	National Wildlife Refuge	546.33
Pelican Island	National Wildlife Refuge	23.74
East Florida Coast CA	Fishery Management Zone	101,641.40

seasonal or year-round. In the study area, the FMZ experiences year-round closures. For additional information on fishery management areas not currently included in the MMA Inventory refer to Chapter 5.

Fisheries Management Zones have a wide variety of name designations including closed area (CA), closure (C), and aggregation area (AA). Only one FMZ, the East Florida Coast CA, occurs in the study area. The East Florida Coast CA extends from Key West north to Jekyll Island, Georgia, and from 3 NM offshore and out to the U.S. EEZ. This entire area is comprised of Pleistocene and Holocene reefs as well as diverse assemblages of fauna (NOAA and DOI 2005d).

6.3.1.3 Fisheries Habitat Conservation Zones

Fisheries Habitat Conservation Zones (FHCZs) are designated by the NMFS to protect the habitat of certain fisheries by reducing human impacts that can arise from the use of specific types of fishing gear (e.g., bottom longlines, pots and traps, and bottom trawls) as well as other forms of exploitation, such as removing corals or other marine artifacts from a reef (GMFMC 2001). Only one FHCZ, the *Oculina* Bank Habitat Area of Particular Concern (HAPC), lies within the study area: In 1984 a 315 km^2 portion of the *Oculina* reefs off eastern Florida was designated as the *Oculina* HAPC by the SAFMC, which was the first deep sea coral MMA in the world (SAFMC 1998). For more information on the *Oculina* Bank HAPC refer to Chapter 4 of this MRA.

6.3.1.4 National Wildlife Refuges

The USFWS protects over 388,000 km^2 of habitat through the National Wildlife Refuge System, with 545 established National Wildlife Refuges (NWRs) and 37 Wetland Management Districts under its jurisdiction (USFWS 2003, 2004). The refuge system encompasses all types of habitat, including 162 refuges nation-wide that contain marine and estuarine habitat (NOAA and DOI 2005e). These MMAs provide habitat for numerous species including some endangered species that occur in the study area, such as the West Indian manatee and sea turtles. The refuge system also contains nearly 12,000 km^2 of ocean habitat (NWRA 2000).

Within the study area there are four NWRs: Archie Carr, Hobe Sound, Merritt Island, and Pelican Island (Figure 6-4, Table 6-3). Archie Carr NWR is located along 33 km of Florida's east coast shoreline between the cities of Melbourne and Wabasso. It is the second most significant nesting beach (17,000 nests laid annually) in the world for endangered loggerhead and green sea turtles. The number of nests

laid annually within this refuge comprises 25% to 35% of all loggerhead and green sea turtle nests laid each year in the U.S. (NOAA and DOI 2005e).

Hobe Sound NWR is located in Martin County, Florida and is divided into a mangrove swamp and coastal sand dune. The sand dunes provide ideal nesting habitat for several species of sea turtles (NOAA and DOI 2005f). The refuge also provides habitat for the endangered scrub jay (*Aphelocoma coerulescens*), sand pine-scrub oak (*Pinus clausa-Querus Ilicifolia*) (<1 km^2), and the gray tortoise (USFWS 2006c).

Merritt Island NWR is located east of Titusville, Florida at the John F. Kennedy Space Center. The NWR is owned by NASA and serves the unique purpose of providing a natural buffer zone for the space center (USFWS 2006d). About half of the NWR's 468 km^2 is made up of brackish estuaries and marshes, with the remaining habitat comprised of coastal dunes, pine forests, and other vegetation. Merritt Island was established as an NWR in 1963 and serves as habitat for migratory birds and threatened and endangered species (USFWS 2006d).

Pelican Island NWR was designated in 1903 by President Theodore Roosevelt as the nation's first federal bird reservation (forerunners to the NWRs). Its purpose was and still is to provide a refuge for breeding, roosting, and over-wintering birds (NOAA and DOI 2005g). In 1995 its lease was renewed for another 25 years.

6.3.1.5 Other Marine Managed Areas

There are no MMAs classified as National Estuarine Research Reserve Systems, Coral Reef Ecosystem Reserves, Marine Mammal Protection Areas, Critical Habitats or Protected Areas for Threatened/ Endangered species, National Marine Sanctuaries in the study area for this MRA.

6.3.2 State Designated Marine Managed Areas in the U.S.

State designated MMAs were recently added to the MMA Inventory and 52 Florida-designated MMAs are located adjacent to the study area (Table 6-4). Presently no GIS coordinates are available for these state-designated MMAs but the NMPA website (www.mpa.gov) is constantly being updated with the latest available information. The Florida state MMAs adjacent to the study area are of the following MMA types: Outstanding Florida Water, Manatee Speed Zone, Aquatic Preserve, State Park, Surface Water Improvement Management Area, Manatee Safety Haven, and Underwater Archaeological Preserve (NOAA and DOI 2005a).

6.3.3 Marine Protected Areas in the Bahamas.

The Bahamas has some of the most pristine marine habitat in the world and recognizes the ecological importance of that habitat. It has engaged the international community by seeking guidance through various internationally recognized agencies, such as the UNEP-International Coral Reef Action Network and the WCPA Caribbean Region in order to sustain its marine (coral and fisheries) and terrestrial ecosystems. The Bahamas along with Caribbean nations are particularly aware of the need for MPAs because of the important role that the natural resources in their EEZs play in providing both pristine marine habitats and economic livelihoods. Unfortunately, these natural resources are being threatened by various physical and natural disturbances such as coastal development, over-fishing, and climate change (Lutchman 2005). Outreach and education provide the Caribbean residents with explanations as to why restricting certain fishing practices or tourism is necessary to sustain their ecosystems. In 1994 The Barbados Program of Action (BPOA) was established to help Small Island Developing States (SIDs) maintain their ecosystems and human resources. In January 2005 there was a ten year review of the BPOA in Mauritius, South Africa (UN 1994). From this meeting the Mauritius Strategy was implemented to strengthen the BPOA. Some of the strategies implemented in the Bahamas to promote the BPOA include:

- Ramsar Treaty signed in 1997 to protect wetlands.
- In 2003 and 2004 there were seasonal commercial fishery closures for Nassau grouper in the Bahamas.
- In June 2004 The Clifton Heritage Trust was established to protect just under 1 km^2 (200 acres) in southwestern New Providence Island from coastal development.

Table 6-4. Summary of state designated marine managed areas located adjacent to the study area (NOAA and DOI 2005a).

MMA Type	Name of Florida State-Designated MMAs
Outstanding Florida Water	Gamble Rogers Memorial State Recreation Area at Flagler Beach Hobe Sound National Wildlife Refuge Malabar to Vero Beach Aquatic Preserve Indian River North Beach Vero Beach to Ft. Pierce Aquatic Preserve Jensen Beach to Jupiter Inlet Aquatic Preserve John D. McArthur Beach State Park Loxahatchee River-Lake Worth Creek Aquatic Preserve Merritt Island National Wildlife Refuge North Fork, St. Lucie Aquatic Preserve Pelican Island National Wildlife Refuge Pellicer Creek Aquatic Preserve Archie Carr National Wildlife Refuge Avalon State Park Banana River Aquatic Preserve Canaveral National Seashore Fort Pierce Inlet State Recreation Area Fred Gannon Rocky Bayou State Recreation Area Seabranch
Manatee Speed Zone	Idle Speed Idle Speed (Fall to Spring) Slow Speed Slow Speed (Spring to Fall, Variable Regulations) Maximum 25 MPH Maximum 25 MPH/ Slow Speed Buffer Maximum 30 MPH Maximum 30 MPH in Channel/Slow Speed or 20 MPH Outside Channel Maximum 35 MPH
Aquatic Preserve	Banana River Indian River Lagoon State Park Indian River - Malabar to Vero Beach Indian River - Vero Beach to Ft. Pierce Jensen Beach to Jupiter Inlet Loxahatchee River - Lake Worth Creek North Fork, St. Lucie
State Park	Avalon State Park Fort Pierce Inlet State Recreation Area John D. MacArthur Beach State Park Jonathan Dickinson State Park Seabranch Preserve State Park St. Lucie Inlet Preserve State Park

Table 6 4. Summary of state designated marine managed areas located adjacent to the study area (NOAA and DOI 2005a) (cont'd).

MMA Type	Name of Florida State-Designated MMAs
Surface Water Improvement Management Area	Indian River Lagoon Coastal Rivers Indian River, Reliant Corporation Delespine Power Plant No Entry Zone
Manatee Safety Havens	Indian River, FPP Frontenac Power Plant No Entry Zone Indian River, Reliant Corporation Delespine Power Plant Motorboats Prohibited Zone Vero Beach Power Plant No Entry Zone FPL Riviera Beach Power Plant Motorboats Prohibited Zone Harbor Branch No Entry Zone Moore's Creek Motorboats Prohibited Zone
Underwater Archaeological Preserve	Urca de Lima Lofthus Underwater

- In November of 2004 the Bahamian government signed a National Implementation Support Partnership which promoted relations between international non-government organizations, local non-government organizations, and government agencies such as the Department of Fisheries (Cohen 2004; ICRAN 2005).

A combination of government (e.g., Department of Fisheries) and non-government (e.g., Bahamas National Trust) agencies manage the MPAs (e.g., National Parks, Wild Bird Reserves) in the Bahamas. The MPAs throughout the Bahamas follows protocols adopted and developed by the UNEP-WCMC and the IUCN-WCPA (UNEP-WCMC 2006a). The IUCN-WCPA has established the following six categories for protected areas. The categories are not ranked by importance but rather by primary management objective (Table 6-5).

Within the Bahamas, various designations of marine protected areas exist, including Managed Nature Reserves (MNRs), National Parks (NPs), Wild Bird Reserves (WBRs), and Wildlife Marine Reserves (WMRs). There are 31 Bahamian MPAs within the study area (and two MPAs just east of the study area), consisting of 10 NPs, 23 WBRs (Figure 6-5; Table 6-6). All Bahamian MPAs in the study area are classified as either IUCN-WCPA Category II or IV protected areas. Even though not cited specifically by the UNEP-WCMC, all Bahamian MPAs encompass intertidal, coastal, and barrier areas can be expected to contain species of coral, seagrasses, and other benthic habitat. Refer to Chapter 4 for more information on these habitat types.

6.3.3.1 Bahamian National Parks

Ten NPs exist within the study area; however, only a few are described in the text as examples of the habitats types that are protected as Bahamian NPs. Exuma Cays Land and Sea Park is a NP and Coral Reserve located 106 km (57 NM) southeast of Nassau; this NP was established by the Bahamas National Trust in 1959 as the first Land and Sea Park in the world. It was the first no-take marine reserve established in the Bahamas; successfully protecting queen conch, Nassau grouper, and spiny lobster within the park. The commercial harvest of these economically important species outside the park has allowed local fishermen to sustain their livelihood, while remaining conservation oriented (TNC 2005).

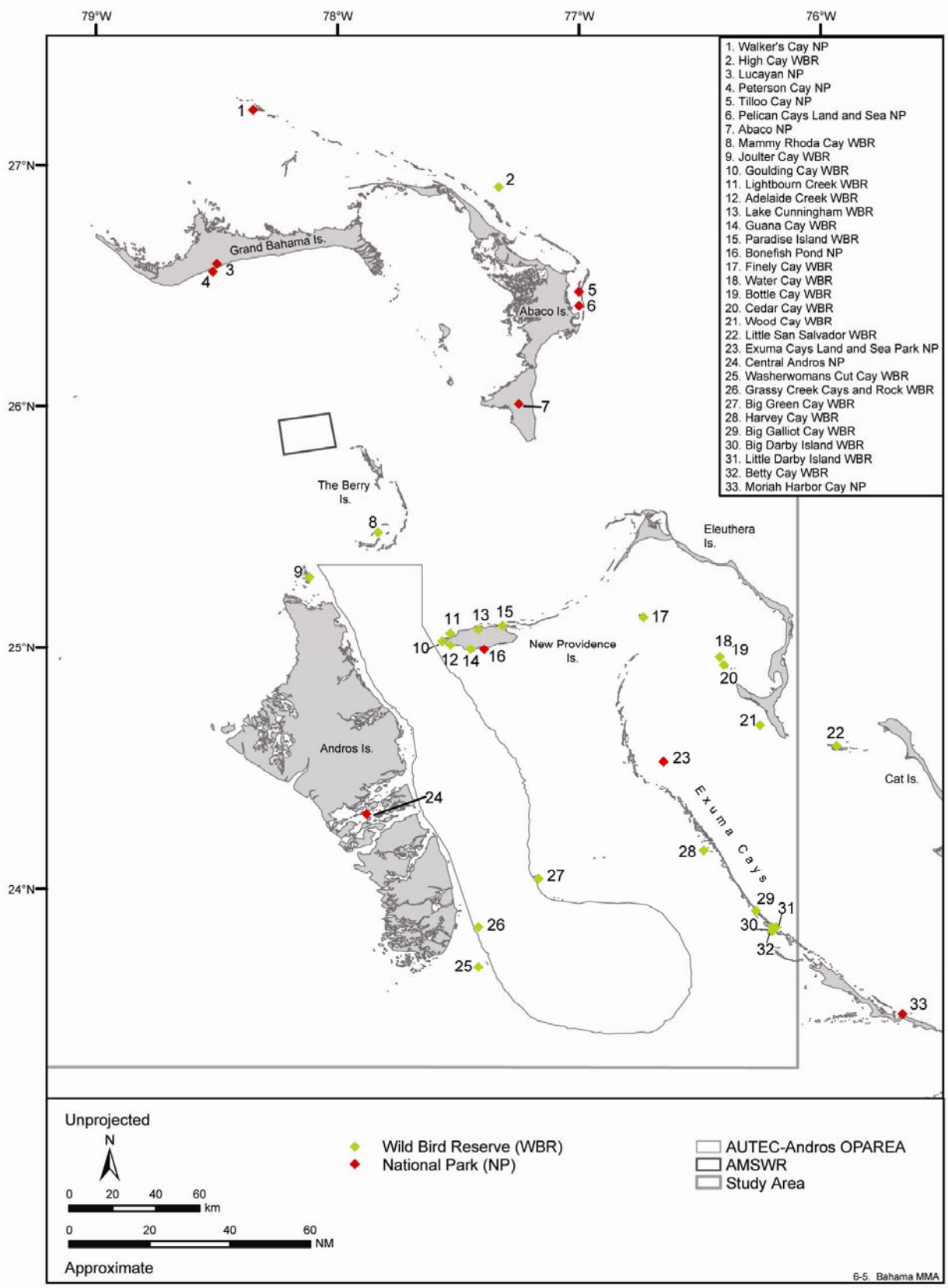

Figure 6-5. Marine protected areas located in the Bahamian sector of the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: WDPA (2005).

Table 6-5. IUCN-WCPA categories and descriptions of marine protected areas (UNEP-WCMC 2006b).

Category	*Purpose*
Category Ia	Strict Nature Reserve—protected and managed for science (i.e., Managed Nature Reserves)
Category Ib	Wilderness Area—protected and managed for wilderness protection
Category II	National Park—protected and managed for conservation and recreation (i.e., National Parks)
Category III	Natural Monument—protected to preserve specific natural features
Category IV	Habitat/Species Management Area—protected for conservation through management (i.e., Wild Bird Reserves)
Category V	Protected Landscape/Seascape—protected to preserve landscape/seascape conservation and recreation
Category VI	Managed Resource Protected Area—for the sustainable use of natural ecosystems

Central Andros NP is 956 km^2 and was created by the Bahamian government in 2002. This NP contains two sections of the Andros reef, numerous blue holes (the most in the Bahamas), wetland areas significant for nursery purposes, and abundant terrestrial habitat (IOTB 2006). Some of the important commercial marine species found within the national park are queen conch, Nassau grouper, and spiny lobster (IOTB 2006). The portions of reef located in the Central Andros NP have been spared from both anthropogenic natural disturbances making them pristine habitat. The barrier reef along with seagrass habitat and numerous patch reefs not only support the commercially important marine species but also attract tourism, which promotes economic stability for the Bahamas (IOTB 2006). Bone Fish Pond is a NP recently established by the Bahamian government in 2002. It is located on the south central coast of New Providence Island. It serves as a marine nursery for crawfish, stocks of fish, and queen conch. It also supports populations of waterfowl and native plants (UNEP-WCMC 2006c).

Of the 23 WBRs (Figure 6-5) found in the region (22 in the study area), information on only a few is mentioned here. Grassy Creek Cays and Rock is located on the southern tip of Andros Island near the AUTEC-Andros OPAREA. It includes coastline and intertidal areas and was established in 1954 (UNEP-WCMC 2006d). Guana Cay is a WBR located on the southern coast of New Providence Island; it was established in 1951 and encompasses coastal and intertidal areas (UNEP-WCMC 2006e). Joulter Cay is a WBR located on the northern tip of Andros Island in the vicinity of the AUTEC-Andros OPAREA. It was established in 1968 and encompasses coastal and intertidal areas (UNEP-WCMC 2006f). Lightbourn Creek is a WBR located on the northwestern tip of New Providence Island. Like Joulter Cay, it was established in 1968 and encompasses intertidal and coastal areas (UNEP-WCMC 2006g). Washerwoman's Cut Cays is a WBR established in 1954 and located on the southern tip of Andros Island and within AUTEC-Andros OPAREA (UNEP-WCMC 2006h). It includes intertidal and coastal areas. No specific information on species found in these WBRs is provided by the UNEP-WCMC.

6.4 SCUBA DIVING SITES

6.4.1 Southeastern Florida

The east coast of Florida offers a diverse array of dive sites to recreational divers (Table 6-7) and has been steadily increasing in popularity with divers over the years. Diving along Florida's east coast, from Titusville to Palm Bay, is characterized by World War II freighter wrecks and vast limestone ridges (DeLoach 2000). The *Damocles*, a 148-foot coastal freighter wreck, is a popular dive site, resting in

Table 6-6. Bahamian MPAs located within the study area with their IUCN-WCPA categories, designations, and the area each encompass (UNEP-WCMC 2006b).

Protected Area	*Category*	*Designation*	*Area (km^2)*
Abaco	II	NP	205.0
Adelaide Creek	IV	WBR	1.5
Betty Cay	IV	WBR	0.01
Big Darby Island	IV	WBR	2.02
Big Galliot Cay	IV	WBR	0.08
Big Green Cay	IV	WBR	2.1
Bonefish pond	II	NP	7.28
Bottle Cay	IV	WBR	0.04
Cedar Cay	IV	WBR	0.02
Central Andros (North Bight, Fresh Creek, Blanket Sound, and Staniard Creek)	II	NP	1,158.0
Exuma Cays Land and Sea Park	II	NP	455.84
Finley Cay	IV	WBR	0.05
Goulding Cay	IV	WBR	0.02
Grassy Creek Cays and Rock	IV	WBR	1.72
Guana Cay	IV	WBR	0.02
Harvey Cay	IV	WBR	0.02
High Cay	IV	WBR	0.08
Joulter Cay	IV	WBR	1.17
Lake Cunningham	IV	WBR	0.7
Lightbourn Creek	IV	WBR	2.0
Little Darby Island	IV	WBR	1.36
Little San Salvador	IV	WBR	1.82
Lucayan	II	NP	1.16
Mammy Rhoda Cay	IV	WBR	0.01
Moriah Harbor Cay	Not determined	NP	54.39
Paradise Island	IV	WBR	2.83
Pelican Cays Land and Sea	II	NP	8.5
Peterson Cay	II	NP	0.01
Tilloo Cay	II	NP	0.1
Walker's Cay	Not determined	NP	<26.0
Washerwomans Cut Cay	IV	WBR	0.79
Water Cay	IV	WBR	0.03
Wood Cay	IV	WBR	0.06

Table 6-7. Popular dive sites in the southeastern Florida waters of the study area (DeLoach 2000; ScubaDivers WorldSite 2005).

Dive Site	Approximate Depth (m)	Approximate Location
Amazone	33	shipwreck, east-southeast of Ft. Pierce Inlet
Breakers Shallow	10	reef, south of Palm Beach Inlet
Cable Crossing	8	ledge, south of Palm Beach Inlet
The Cave	53	reef, south of Jupiter Inlet, offshore
Damocles	22	shipwreck, east-southeast of Port Canaveral
Dive-a-rama	19	ledge, south of Palm Beach Inlet
Ernst Reef	23	artificial reef, southeast of St. Lucie Inlet
Esso Bonaire	30	shipwreck, east-northeast of Jupiter Inlet
Flower Gardens	23	south of Palm Beach Inlet
Halsey	22	shipwreck, east-southeast of Ft. Pierce Inlet
Horseshoe Reef	20	reef, northeast of Lake Worth Pier
Jolly Jacks	28	drift dive, south of Jupiter Inlet
Sirotkin Reef	27	artificial reef, east of St. Lucie Inlet
The Trench	19	wall dive, south of Palm Beach Inlet
USS Rankin	40	shipwreck, northeast of St. Lucie Inlet

approximately 22 m of water, 16 km (8.7 NM) east-southeast of Port Canaveral (DeLoach 2000). An area known as Florida's Treasure Coast lies further south and encompasses Indian River, St. Lucie, Martin, and Palm Beach counties; this area is well-known for its abundance of marine life, due to the close proximity of the Gulf Stream, and is renowned for being the site of the demise of the Spanish Plate Fleet in 1715 (DeLoach 2000). World War II wrecks and drift dives are most popular off the Treasure Coast, although natural and artificial reef dives are abundant as well (Blue Planet Dive and Surf Shop 2005). Sites at Sebastian Inlet south to Vero Beach and Fort Pierce offer numerous wreck dives on sunken Spanish galleons (Adventure Diving Florida 2005). The *Halsey* Wreck, located approximately 21 km (11.3 NM) east-southeast of Ft. Pierce Inlet, is one of the state's most popular World War II wreck dives (DeLoach 2000; Earth Day Journal 2006). From Stuart to Jupiter, in Palm Beach County, diving on reefs and rock ledges is most popular in the summer, as the water is calmer and visibility is greater (DeLoach 2000). Rock ledges located in deep waters (40 to 54 m) are available for divers in this area as well. The *Esso Bonaire* is one of the area's most popular wrecks (Blue Planet Dive & Surf Shop 2005) and lies approximately 6.4 km (3.5 NM) east-northeast of Jupiter Inlet (DeLoach 2000).

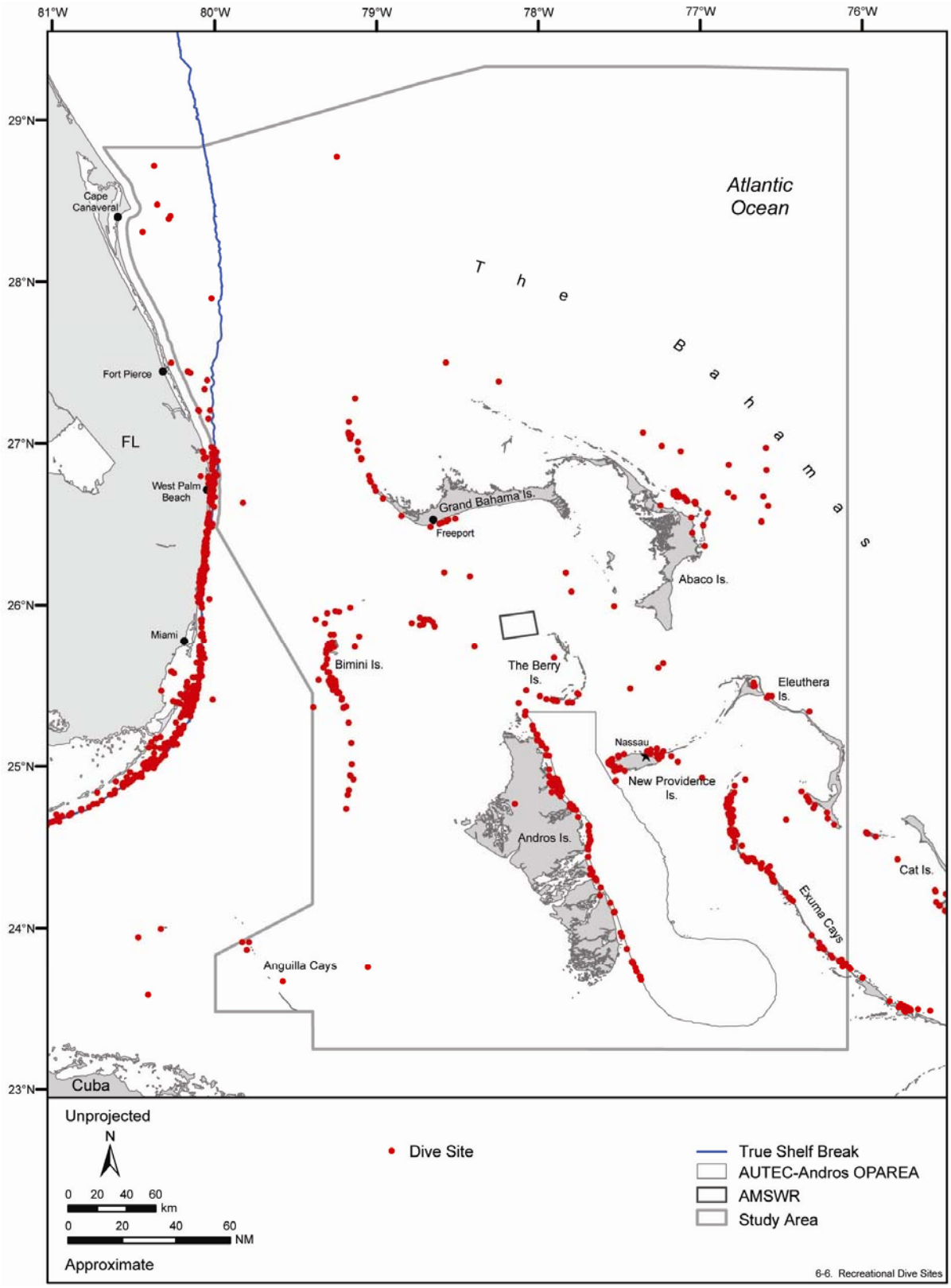

Figure 6-6. Popular recreational scuba diving sites located in the study area for the Southeastern Florida and AUTEC-Andros MRA (DeLoach 2000; Waterproof Charts, Inc. 2003; ScubaDivers WorldSite 2005; REEF 2006).

Near West Palm Beach, water clarity and temperature increase with greater proximity to the Gulf Stream (DeLoach 2000). The West Palm Beach area is the most popular area for diving along the Treasure Coast as many dive sites are concentrated in this area, most of which are close to shore (see Figure 6-6). Reef and wreck dives teem with marine wildlife and are the most popular types of dives off West Palm Beach. Horseshoe reef is a popular ledge system for divers and is located northeast of Lake Worth Pier; this ledge teems with schools of reef fish due to the strong currents that flow through this area (DeLoach 2000).

6.4.2 The Bahamas

The Bahamas is one of the most popular dive destinations in the Caribbean and offers a diversity of scuba diving activity (Table 6-8). Every island in the Bahamas is surrounded by coral reefs (Dive Travel Info. 2005), and the second largest barrier reef in the Northern Hemisphere is located along the eastern coast of Andros Island (Wood 1999). Waters surrounding the Bahamas offer exceptional visibility, averaging 24 to 31 m, and comfortable, year-round temperatures ranging between 17° and 28°C (Wood 1999; Dive Travel Info. 2005). Most of the islands have a shallow reef at 3 to 5 m in depth, a deeper reef at 15 m, and an additional reef at 24 to 27 m (Keller and Keller 1988). Further offshore, the ocean floor quickly descends to depths that cannot be reached by divers. Aside from shallow water reefs, the Bahamas also offer divers a variety of ship and airplane wrecks (Dive Travel Info. 2005). The Bahamas are well-known for the numerous wall dives located along the steep channels at the edges of the Bahama Banks, and Bahamian waters are also regarded as the shark-diving capital of the world (Wood 1999). There are also a number of blue holes, caves, dolphin dives, drift dives, and night dives that can be undertaken in the Bahamas (Dive Travel Info. 2005).

Most dive sites in the Bahamas are monopolized by particular resorts or dive operators. Nearly all scuba diving in the Bahamas takes place from boats, although beach diving is permitted on select islands where waters are very shallow (Keller and Keller 1988).

6.4.2.1 Andros Island

Despite being the largest island found in the Bahamas, Andros Island waters are probably the least exploited for recreational diving (Keller and Keller 1988). Despite this, hundreds of chartered and named dive sites exist in the waters surrounding Andros Island, the majority of which are located off the east coast. Small Hope Bay Lodge, located on the island's northeast coast and the oldest family-owned dive resort in the Caribbean (Wood 1999), has over 60 different dive sites in its dive schedule (Small Hope Bay Lodge 2005). Most dive operations and resort hotels are located in the central and northern part of the island.

Andros has a diverse array of underwater habitats and boasts the largest concentration of blue hole diving in the Bahamas (Wood 1999). The Ocean Blue Hole, located northeast of Small Hope Bay, is a popular blue hole site for all levels of divers. It boasts a massive collapsed cavern and abundant Caribbean reef sharks (*Carcharhinus perezii*) and barracuda (*Sphyranae barracuda*) (Wood 1999). Andros is also home to the third largest barrier reef ecosystem in the world and second largest in the Northern Hemisphere. The reef runs for more than 225 km along the island's eastern shore and borders the deep channel known as the TOTO (Keller and Keller 1988). The 1,828 m drop-off to the TOTO is a popular site for divers to explore canyons, caves, caverns, and blue holes (Wood 1999). The *Marion* is a popular shipwreck located off the east side of Andros Island, between the mid-level reef and the slope to the drop-off of the TOTO (Wood 1999). Northeast from Small Hope Bay, the U.S. Naval Buoy, also known as Shark Buoy/TOTO Buoy is a popular dive site visited by divers from both Andros and New Providence Island. Pelagic fish frequent the area of the U.S. Deployed Noise and Measurement (DNM) buoy to feed upon the algae and planktonic organisms that grow on the underside of the buoy (Wood 1999). Many experienced divers are attracted to the area by the high probability of silky shark (*C. falciformis*) encounters (Wood 1999).

Table 6-8. Popular dive sites in the study area off the islands of the Bahamas (Waterproof Charts, Inc. 2003; REEF 2006).

Island	*Dive Site*	*Approximate Depth (m)*	*Approximate Location*
Andros	Brad's mountain	15	coral mound, south of AUTEC cable winding station
	Conch Sound Blue Hole	27	blue hole, northeast side, nearshore
	Diana's Dungeons	36	wall dive, east side
	Hole-in-the-Wall	60	wall dive, east side
	Klein's Reef	15	sand patch/reef, east side
	The *Marion*	21	shipwreck/artificial reef, east side
	Ocean Blue Hole	42	cavern, east side
	Peter's Place	4	reef, east side, near Calabash Bay
	Shark Buoy	25	U.S. naval buoy, northeast side, midway between Andros and New Providence
	Skeebo's Surprise	33	wall dive, east side, near Calabash Bay
	The Wreck of the *Potomac*	6	shipwreck, east side
Berry Islands	*Panther*	20	shipwreck
New Providence	*Bahama Mama*	15	shipwreck, southwest corner
	Black Forest Wall	18	wall dive, southwest corner
	Cessna Wreck	15	sunken aircraft, southwest corner
	David Tucker	12	shipwreck, southwest corner
	Dolphin Pens	6	reef, southwest corner
	Fish Bowl	6	reef, southwest corner, north of Goulding Cay
	Goulding Cay Reef	6	reef, southwest corner, north of Goulding Cay
	Goulding Cay Wall	21	wall dive, southwest corner, west of Goulding Cay
	Hole-in-the-Head	33	wall dive, south of New Providence, near the TOTO
	Karen's Reef	15	reef, southwest of New Providence
	Lampton's Wall and Tunnel Wall	9 to 25	wall dive, southwest corner
	Palace Wall	18	wall dive, southwest corner

Table 6-8. Popular dive sites in the study area off the islands of the Bahamas (Waterproof Charts, Inc. 2003; REEF 2006) (cont'd).

Island	Dive Site	Approximate Depth (m)	Approximate Location
New Providence (cont'd)	Pumpkin Patch	15	wall dive, southwest of New Providence
	Razorback Wall	20	wall dive, south of New Providence, offshore
	Royal James	14	shipwreck/artificial reef, near Golden Key
	Sand Chute	25	sand chute/wall, southwest corner
	Sea Viking Wreck	20	shipwreck, southwest of New Providence
	Shark Valley	15	wall dive, south of New Providence, offshore
	Shark Wall	20	wall dive, south of New Providence, offshore
	Southwest Reef	8	reef, south of New Providence, offshore
	Tears of Allah	14	shipwreck, southwest corner
	Willaurie	18	shipwreck, south of Goulding Cay
	Wreck on the Wall	12	shipwreck, southwest corner

6.4.2.2 Berry Islands

Lying 56 km northeast of Nassau, New Providence, the Berry Islands are known for their excellent game fishing, bonefishing (*Albula* spp.), and diving. Most diving takes place near Chub Cay and Whale Cay, as these southwestern reefs are more sheltered and less open to the adverse weather conditions that plague other reefs in the Berry Islands. The Berry Islands are sparsely populated; the only resort catering to divers is the Chub Cay Club on Chub Cay and the occasional live-aboard dive boat (Wood 1999).

6.4.2.3 New Providence Island

There is a diverse array of dive sites located off New Providence Island, some of which can be found in waters as shallow as 3 m in depth. These sites range from natural reefs to underwater wrecks, many of which were formerly used as movie props (Wood 1999). The Bahama Mama wreck, a 33 m long former party boat sunk as a dive attraction, is located off the tip of the Southwest coast of New Providence and is a popular dive site (Wood 1999). Wall dives along the eastern edge of the TOTO and shark dives also draw divers to the southwest coast of New Providence (Wood 1999). In fact, the Black Forest Wall and Palace Wall sites make up the eastern limit of the TOTO (Wood 1999). Six dive centers operate out of New Providence, with the majority of centers located on the southwest coast. Two dive centers are located on the south side of the island; they also cater to divers looking to explore the steep walls of the TOTO (Bahama Travel Net 2005).

6.5 AUTEC HYDROPHONE ARRAY

The passive hydrophone array that is a central feature of the AUTEC-Andros OPAREA is located within the TOTO off the east coast of Andros Island (24°30'N, 77°40'W) (Vandenbroucke et al. 2005). There are 70 bottom-mounted, broad-band (approximately 100 Hz to 45 kHz), omni-directional hydrophones in the array. The hydrophones are mounted widely spread apart (~2 NM) at depths of approximately 1,400 m to 1,620 m on 4.5 m booms and stand vertically above the seafloor (Jarvis and Moretti 2002; Lehtinen et al. 2002; Moretti 2003; Mann and Jarvis 2004; Morrissey et al. 2004, DoN 2005a; Vandenbrouke et al. 2005). The hydrophones became operational in December of 1967 and are designed to track both undersea and surface vessels (Alspaugh 1967; Jarvis and Moretti 2002). The TOTO is considered ideal for acoustic monitoring due to in part to low shipping traffic, since access can only occur from the north

via the Northeast Providence Channel (Lehtinen et al. 2002). Logistical support for the array is provided from offices in Newport, Rhode Island and West Palm Beach, Florida (DoN 1997a).

The AUTEC Hydrophone Replacement Program (AHRP) was conceived to replace the original hydrophones and associated software. The AHRP was completed in 1999 and resulted in a single electro-optical cabled, multiplexed hydrophone array, which terminates at a single location (Main Base Command Control Building) on Andros Island (DoN 1997a, 2005a; SAIC 1997). The hydrophones in this array are a two-part network that can be operated individually or together (DoN 2005a). The original hydrophones were deactivated and remain in their original location (DoN 1997a). Refer to Figure 1-2 for location of Deep-Water Weapons Ranges that include the two-part network of hydrophones (North and South) that comprise the array.

Recently algorithms have been created to detect and track vocalizing marine mammals in the area (Jarvis and Moretti 2002). This range, including the hydrophones, is part of the Office of Naval Research (ONR) Marine Mammal Monitoring on Navy Ranges (M3R) project whose goal is to passively detect and localize marine mammals in real-time in the region (Moretti et al. 2004). The hydrophones off Andros Island allow for three-dimensional tracking capabilities over an area of 500 NM^2 (DoN 1997a).

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7.0 RECOMMENDATIONS

Although research efforts have occurred in the study area for certain types of marine resources, such as benthic communities and EFH, few broad-scale efforts have been undertaken to delineate these resources at the ecosystem level. In particular, few dedicated line-transect surveys for marine mammals or sea turtles have been completed in the open ocean or Bahamian waters of the study area. Specific small-scale areas of the waters of the Bahamas have been thoroughly researched for the marine mammals but no dedicated turtle surveys are known in these waters.

Much, therefore, remains to be learned. The following recommendations are designed to improve our understanding of the marine resources in the study area for the southeastern Florida and the AUTEC-Andros OPAREA, especially those resources that may be potentially affected by Navy operations. Each recommendation is assigned a priority value of 1, 2, or 3 with 1 being the highest and 3 the lowest priorities. The priority designations are relative to each other and in no way refer to a project's overall value. The relative cost of each recommendation is labeled 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 are ranked by priority value and are grouped into those related to the production and evaluation of the MRA and those needed to adequately complete environmental documentation for the study area.

7.1 MARINE RESOURCE ASSESSMENTS

- Revise the MRA for southeastern Florida and the AUTEC-Andros OPAREA once every five years. The MRA will require revisions to update the text, data, and other informational components so that newly available datasets and published literature can be incorporated. The Navy requires the best available information and data to evaluate future actions and consider adjustments to training excercises or operations to mitigate any potential impacts to protected marine resources. An update of the MRA will provide the Navy with the updated most current available information to meet these goals. Periodic updates would be of moderate cost relative to that of the initial MRA. **Cost**: Moderate. **Priority**: 1.
- Subject the MRA to peer review. Peer review by regulatory agencies (e.g., NMFS), the general scientific community, and potential government users (e.g., MMS) will only increase the quality and effectiveness of this MRA. Scientists and specialists in fields relevant to this MRA can provide critical comments and review (Table 7-1). **Cost**: Low. **Priority**: 1.
- Obtain marine mammal and sea turtle datasets for the study area that may not have been available for inclusion in this assessment. While all available comprehensive data have been included (see Appendix Table A-1), acquiring the following datasets may ensure more complete data coverage:
  - Southeast turtle surveys (SETS) for 1982 through 1984 from NMFS-SEFSC; although we have data from these surveys for two species of sea turtles, the remaining data for the other turtle species would be useful to delineate the seasonal distributions of those species.
  - Mid-Atlantic *Tursiops* surveys (MATS) for 1994 through 1995 and 2002 to complete our MATS inventory from NMFS-SEFSC; sea turtle data was provided for the 1994 through 1995 surveys but complete datasets would provide the marine mammal records for these years and all data for 2002.
  - Geographic coordinates for juvenile green turtles tagged in Florida in 2004 by the University of Central Florida.
  - Geographic coordinates for the loggerhead turtles tagged in 1999 off the southeastern U.S. by NMFS-SEFSC.
  - Geographic coordinates for the olive ridley turtle tagged in 2005 by the Archie Carr Center for Sea Turtle Research.

Table 7-1. Suggested expert reviewers of the MRA for southeastern Florida and the AUTEC-Andros OPAREA.

Name	Affiliation	Area of Expertise
Dr. Kate Holmes	American Museum of Natural History	Bahamian benthic habitat
Dr. Steve Ross	University of North Carolina, Wilmington	Deepsea coral of southeast U.S. waters
Dr. John Reed	Harbor Branch Oceanographic Institution	*Oculina varicosa* of southeast U.S. waters
Dr. Karen Bjorndal	University of Florida /Archie Carr Center for Sea Turtle Research	Sea turtle biology
Dr. Alan Bolten	University of Florida /Archie Carr Center for Sea Turtle Research	Sea turtle telemetry
Dr. Colin Simpfendorfer	Mote Marine Laboratory	Smalltooth sawfish
Dr. Ric Ruebsamen	NMFS-Southeast Region	Essential fish habitat
Dr. Kathleen Sullivan-Sealy	University of Florida	Bahamian fishes
Dr. Thomas Lee	University of Miami, Rosenstiel School of Marine and Atmospheric Sciences	Physical oceanography
Joseph Uravitch	National Oceanic and Atmospheric Association	U.S. marine managed areas
Dr. Lance Garrison	NMFS-SEFSC	Marine mammals
Diane Claridge	Bahamas Marine Mammal Survey	Bahamian marine mammals

- Sea turtle nesting data in the Bahamas from Archie Carr Center for Sea Turtle Research.
- Marine mammal and sea turtle strandings in the Bahamas from The Bahamas Department of Fisheries/Bahamas National Trust.

➢ Acquisition and analysis of these existing data will be less expensive than collecting authentic marine mammal and sea turtle survey data. The potential contribution of these datasets to our understanding of the distribution of these protected species in the study area is high. **Cost**: Low. **Priority**: 1.

➢ Support the publication on the internet of geospatial data for state and locally designated MMAs. The number of state-designated MMAs is continuously increasing; in the course of preparing this MRA, Florida designated over 150 MMAs that were added to the approved National MPA list. As geospatial coordinates were unfortunately not available for these newly approved state MMAs, they were thus not mapped for this MRA. Because the list of approved MMAs is constantly being updated with new state and locally-designated MMAs, it is recommended that the Navy also frequently check the list of approved MMAs (www.mpa.gov) for newly added areas. **Cost**: Low. **Priority**: 1.

7.2 ENVIRONMENTAL DOCUMENTATION

- Conduct dedicated marine mammal and sea turtle aerial and/or shipboard surveys in the sections of the study area not covered or inadequately covered by previous survey efforts (Figure 7-1). While it is essential to continue surveying in previously studied areas to account for seasonal and inter-annual variation in distribution and abundance of protected species stocks, it is 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 concept of marine mammal and sea turtle distribution may emerge. Surveys are recommended in the deep waters of the northeastern section of the study area beyond the U.S. EEZ during all seasons as very little data except from fisheries bycatch exist for this region. Given the high-profile status of these protected species, it would be beneficial to learn as much as possible about them, especially their distribution. **Cost**: Moderate to High. **Priority**: 1.
    - Winter—In the Bahamas, dedicated surveys should be conducted off the east coast of Andros Island (i.e., TOTO) and around New Providence Island since these areas are close to the AUTEC OPAREA and have been surveyed the least. Although some surveys have been conducted around the Grand Bahamas Islands, Abacos Islands, and northern Exuma Islands, marine mammal surveys are needed in the deeper waters north of the Bahamas. Off southeastern Florida, surveys are needed in the waters beyond the continental shelf, especially in the northern region of the study area during this season as this is a significant region for potentially sighting right and humpback whales.
    - Spring—Although surveys along the eastern coast of Andros Island and around New Providence Island during this season would be optimal, surveys throughout the Bahamas are needed as very little survey work has taken place during this time of year. Surveys are also recommended throughout the continental shelf and slope waters of southeastern Florida, with an emphasis on sea turtle surveys, in particular, during this season. Post-hatchling sea turtles are known to transit from lagoon areas into the Gulf Stream Current and juvenile sea turtles use the coastal areas of southeastern Florida as developmental habitat.
    - Summer—Surveys throughout any of the Bahamian waters (i.e., TOTO) are recommended during this season, particularly in the vicinity of the AUTEC Minefield Shallow Water Range (AMSWR). Areas off Abacos Island are the only regions in the Bahamas that have been studied during this season. Surveys are also suggested in waters beyond the continental slope to the U.S. EEZ or beyond.
    - Fall—Surveys throughout The Bahamas (i.e., TOTO) are suggested although those off the eastern coast of Andros Island and around New Providence Island are of key importance are as well as in the vicinity of the AUTEC Minefield Shallow Water Range (AMSWR). The deeper waters beyond the continental slope of southeastern Florida to the EEZ and beyond should be surveyed during this season to provide additional data on the movements and distribution of sea turtles and marine mammals in these waters.
- Support surveys within the TOTO that allow experienced observers to collect cetacean sighting data during NMFS ichthyoplankton, fish, or other dedicated surveys. This can be done at 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, offers the benefit of controlling survey design and focus, but is very expensive). **Cost**: Low. **Priority**: 1
- Provide cetacean acoustic researcher access to the Navy Sound Surveillance System (SOSUS) audio recordings. This would provide an unparalleled opportunity for researchers to listen to, identify, and track large whales (many of whom are endangered) throughout the entire North Atlantic Ocean basin (Clark 1995). This would benefit the Navy by having researchers track whales remotely without the cost of ship or aerial surveys. Individual detections could last for a continuous period of weeks

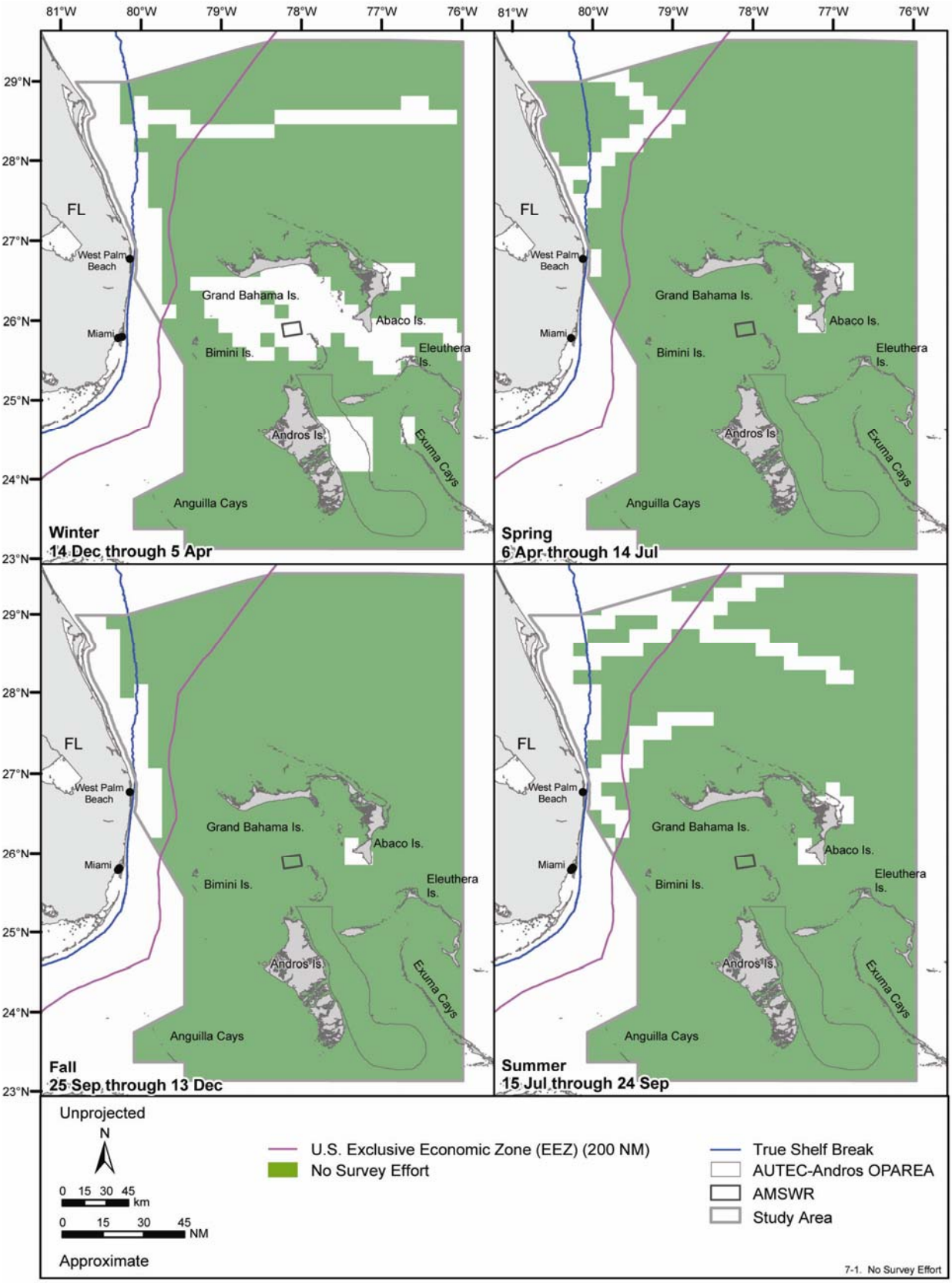

Figure 7-1. Areas where no aerial nor visual sighting surveys (no effort) occurred in the study area for the Southeastern Florida and AUTEC-Andros MRA.

that would permit identification of whale movement, abundance, and association patterns. Thus, an understanding of poorly known species could be greatly improved and naval operations could be conducted with a reduced possibility of marine mammal interactions. **Cost**: Low. **Priority**: 1.

- Develop a program to train Navy personnel as observers so that Navy ships may be utilized as platforms of opportunity for the collection of hydrographic data as well as marine mammal and sea turtle sighting data. Experienced marine animal observers onboard Navy ships transiting the southern Florida and AUTEC-Andros study area provide a less costly means of collecting needed information. Observers would be trained to properly record data, collect hydrographic data, as well as identify marine mammal and sea turtle species at sea. Standardized data collection methods and forms, as well as a centralized database for storage and analysis of the information, would be required to make this program viable. The cost of training observers is relatively modest, especially considering the comparable cost of surveys (i.e., dedicated ship surveys). The quantity and quality of data collected will be a function of the number of observer deployments, as well as the specific cruise tracks of the ships. The potential for the acquisition of large amounts of quality data is a major benefit of this program. **Cost**: Low to Medium. **Priority**: 1.
- Subsidize sea turtle occurrence studies in the Bahamas, with an emphasis on green, loggerhead, and hawksbill turtle research efforts. Extensive research on sea turtle movement patterns and life history has been conducted on the foraging grounds in the southern Bahamas, little sea turtle information or data exists within the Bahamian waters of the study area. Preliminary surveys (Bolten 2006a) suggest an abundance of sea turtles within the study area but this supposition has not be quantified nor verified. Trends in overall sea turtle abundance in the Bahamas can best be quantified by the combination of aerial/vessel surveys and mark-recapture studies. Aerial and vessels surveys would provide measures of relative abundance over large areas (Bjorndal et al. 2005). A continuation of aerial surveys completed by Mobley (Mobley 2004a) should be conducted over the Northwest Providence Channel and AUTEC OPAREA but a greater emphasis should be placed on observing sea turtles. **Cost**: Moderate. **Priority**: 1.
- Additional emphasis should be placed on conducting tagging studies (satellite tags, Platform transmitter terminal [PTT] tags, or flipper tags) of sea turtles along Florida's east coast to provide sufficient data to fully understand growth rates, foraging ecology, and movement patterns in this region. Such studies are particularly lacking due to the time, logistics, and funding necessary to study sea turtles. **Cost**: Moderate to High. **Priority**: 1.
- Finance habitat mapping and classification research related to deepsea corals in the U.S. waters of northwestern Atlantic Ocean. Dr. Steve Ross (University of North Carolina, Wilmington) is currently working on the NOAA Southeastern Deep Sea Coral (SEADESC) Initiative project, which involves submersible and remotely-operated-vessel dives to gather deepsea *Lophelia* coral and habitat data off North Carolina. Dr. Ross has made numerous dives (2005) in this area supporting the SEADESC project and the field portion of the project is nearly complete. The second phase of the project involves the production of a coral atlas for this region documenting all published and unpublished data into both hard copy and searchable electronic (i.e., web or DVD) resources. While the current project is limited to North Carolina, the goal is to survey the waters of southeast U.S. region and document deepsea coral habitats. This research is critical as deepsea coral are being considered for federal protection (Deepsea Coral Act) and knowledge about the locations of these communities will be essential to ensuring naval operations are conducted to reduce detrimental impacts to these habitats. **Cost**: High. **Priority**: 1.
- Continue to conduct acoustic surveys for marine mammals by towing passive acoustic arrays behind research vessels. 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**: Medium to High. **Priority**: 2.
- Support mark-recapture studies that may provide insight into demographic parameters and movement patterns of sea turtles in the Bahamas (Bjorndal et al. 2005). Tagging using PTT or satellite tags should be focused on post-nesting turtles, specifically loggerheads, near Grand Bahama, the Abacos and Andros islands as well as leatherbacks on the Abacos Islands. Juvenile

green, hawksbill, and loggerhead turtles should also be tagged to determine utilization of their developmental habitat around Andros and Abacos islands. **Cost**: Moderate. **Priority**: 2.

- Fund efforts for the continued mapping of the deepsea coral, *Oculina varicosa* off the eastern coast of Florida. The *Oculina* reefs extend from off Cape Canaveral to off Ft. Pierce, FL (27°32'N to 28°59'N) and the reef has not yet been mapped north of Cape Canaveral. Mapping of this coral habitat is necessary as EFH and HAPC have been designated for those species that use the reef habitat as spawining grounds (i.e., gag grouper) yet no accurate locational information exists for the reef's full extent. **Cost**: Moderate. **Priority**: 2.
- Finance efforts of the SAFMC to update and provide clear and concise EFH and HAPC designations, including maps, for the U.S. waters of the study area. Currently the majority of the SAFMC's designations do not comply with the EFH Final Rule (January 2002) (i.e., designations are made for MU rather than individual species). Thus, life history information must be interpreted to provide designations for individual species. Furthermore, the SAFMC does not provide maps to accompany their designations. Supporting these EFH efforts would ensure that the most accurate EFH/HAPC designations/maps would be available to the Navy so that the extent of the protected habitat areas would be clearly discernible and no interpretations would be necessary. **Cost**: Low. **Priority**: 2.
- Support research efforts related to the endangered smalltooth sawfish that is found in the study area. Research efforts such as that of the Mote Marine Laboratory's (Florida) Smalltooth Sawfish Program have compiled the available data on this species. Knowledge and data for all lifestages of this endangered species is essential to its continued survival of this species. **Cost**: Low. **Priority**: 3.
- Subsidize research efforts related to fishes of the Bahamas, specifically around Andros Island. The majority of literature and research in the study area pertaining to fishes is focused on the waters off southern Florida. Further studies would provide a more complete understanding of this important resource in the OPAREA region. **Cost**: Low. **Priority**: 3.
- Support mapping of the navigable waterways or shipping lanes traversing the territorial waters of the Bahamas. Little data or information on the waterways of the Bahamas could be located for this assessment. Supporting the demarcation and publication of navigable waterway information within the Bahamian territorial waters would be a way for Navy environmental planners to have access to the locations of commercial shipping traffic in this region. **Cost**: Low. **Priority**: 3.
- Data on the geospatial or areal extent of MMAs in the Bahamas were not available. Without this information, the extent of the environmental protection afforded by these MMAs is not known. Support for the acquisition of geospatial data associated with the areal extent of Bahamaian MMAs and the subsequent publication on the internet is recommended. **Cost**: Low. **Priority**: 2.
- Support for an expeditious and mutually satisfactory settlement regarding the conflicting claims of the U.S. and the Bahamas for the disputed region of sovereign jurisdiction is suggested. Neither a formal treaty nor other type of international agreement currently exists between the U.S. and the Bahamas regarding the delineation of their coincident maritime boundaries. The jurisdiction of the waters and seafloor area approximately 33,000 km^2 extending into the study area from the north is currently claimed by both the U.S. and the Bahamas. Until a formal agreement on maritime boundaries is established between the two nations, jurisdiction over the region will remain in dispute. **Cost**: Low. **Priority**: 2.
- Subsidize research describing the marine geology of The Bahama Banks, specifically regarding the classification and mapping of marine sediments by sediment particle size. While some recent geological research has been conducted in this area (Swart 2005), much of the marine sediment data for the Bahamas is at least 30 years old. **Cost**: Low. **Priority**: 3.
- Support research investigating the physical-biological processes of upwelling and increases in primary production around the Bahamas. Regions of high primary productivity (i.e., increases in phytoplankton biomass) have been described as preferential areas for cetacean foraging (Wormuth et al. 2000). Increases in primary production can have significant influences on cetacean occurrences. **Cost**: Low. **Priority**: 3.

- Collect limited temperature and depth (oceanographic) data with Navy ships. The deployment of add to acronyms expendable bathythermographs (XBTs) from Navy ships transiting the study area would provide a means to collect low-cost information from areas potentially out of the range of standard oceanographic cruises. This approach would be similar to the successful "ship of opportunity" program where hydrographic data are collected aboard commercial merchant vessels. **Cost**: Low. **Priority**: 3.

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9.0 GLOSSARY

Abiotic—non-living factor

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 rise and the mid-ocean ridge at a depth greater than 4,000 to 5,000 m

Accidental—in the case of sea turtles, accidental means they have been recorded only a time or two; it is so far from its usual range that further observations are considered unlikely; extralimital

Acroporid—family of colonial and zooxanthellate hard corals to which the genus *Acropora* belongs; there are three *Acropora* species in the Atlantic: *Acropora palmata*, *A. cervicornis*, and *A. prolifera*

Adult—developmental stage characterized by sexual or physical (full size and strength) maturity

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

Ahermatypic coral—non-reef building types of coral that lack symbiotic zooxanthallae and are not restricted by depth, temperature, or light penetration; may be solitary or colonial

Algae—a diverse group of marine plants ranging from unicellular plankton to large benthic seaweeds; all lack true roots, stems, leaves, and do not produce flowers or seeds

Amphipods—a large group of crustacean with a shrimp-like appearance, usually with a laterally compressed body

Anadromous—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

Anemones—marine polyps that resemble flowers but have oral rings of tentacles; differ from corals in forming no hard skeleton

Annelids—segmented worms

Anomaly—something irregular or abnormal

Anthozoans—any class of marine organisms, such as the corals and sea anemones, that have radial segments and grow singly or in colonies

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 the warm-core ring

Aquatic resources—those plants and animals that live within or are entirely dependent upon the water to survive; living resources found in aquatic habitats

Archipelagic baseline—a baseline from which an island nation's maritime boundaries are measured that is constructed of a series of straight baselines joining the outmost points of the outermost islands and drying reefs of an archipelago. The archipelagic baseline is used to define a nation's territorial sea, contiguous zone, and exclusive economic zone.

Archipelago—a group of islands, including parts of islands, interconnecting waters, and other natural features which are so closely inter-related that such islands, waters, and other natural features form an intrinsic geographical, economic, and political entity, or which historically have been regarded as such (UNCLOS legal definition).

Arribada—a large aggregation of female sea turtles exiting the ocean together to nest at the same place and time

Artificial reefs—human-made structures (sunken ships, concrete igloos, rubble) purposefully placed into the navigable waters of the U.S. or into the marine waters overlying the continental shelf to attract aquatic life; the SAFMC defines these as habitat areas within marine waters in which suitable structures or

materials have intentionally been placed by humans for the purpose of creating, restoring, or improving long-term habitat for the eventual exploitation, conservation, or preservation of the resulting marine ecosystems that are naturally established on these materials (shipwrecks are not considered artificial reefs under this definition); the GMFMC defines these areas to include shipwrecks as well as oil and gas platforms.

Ascidians—minute sedentary marine invertebrate having a saclike body with siphons through which waters enters and leaves

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

Attribute table—database management system (DBMS) or other tabular file consisting of rows and columns; these tables are associated with geographic features where each row represents a type of data and each column represents one attribute of the data

Audiogram—a hearing sensitivity curve drawn as a function of frequency and sound pressure level; describes the hearing ability of an animal

Autotroph—an organism that produces or synthesizes the organic materials they require from inorganic sources; organisms, such as plants, that produce their food are autotrophs

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

Bank—a submerged ridge, shoal, sandbar, or other unconsolidated material that rises from the seafloor to near the water's surface, sometimes creating a navigational hazard

Barnacles—are crustaceans that have jointed legs and shells of connected overlapping plates that glue themselves to substrate

Baroclinic—conditions or flow in which surfaces of constant density (isopycnals) and surfaces of constant pressure (isobars) in the water column are inclined with respect to each other (i.e., slopes of the surfaces intersect) Under baroclinic conditions horizontal gradients in density are present which increasingly affect the pressure surfaces with depth. At shallow depths, isobars are parallel to the sea surface, but with increasing depth the influence of sea surface height decreases and the influence of the horizontal density gradient increases such that the slope of the isobars no longer resembles the slope of the sea surface. Geostrophic flow at depth will be affected by this change and will not be the same throughout the water column.

Barotropic—conditions or flow in which surfaces of constant density (isopycnals) and surfaces of constant pressure (isobars) in the water column are parallel (i.e., slopes of the surfaces are equal with depth). Under barotropic conditions geostrophic flow is constant with depth and at right angles to the horizontal pressure gradient

Baseline—the line from which maritime boundaries (exclusive economic zone, 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

Bathymetry—the topography of the ocean floor

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—in, on, or near the ocean floor; the term is used irrespective of whether the sea is shallow or deep

Benthopelagic—the ecological zone from the seabed to 100 m above the seabed

Benthos—organisms that live in, on, near, or are attached to the ocean bottom substrate

Biogenic structure—feature created by an organism while it is still living (e.g., tubes, shells)

Biogenic—originating from living organisms

Bioherm—a mass of rock exclusively or mainly constructed by marine sedentary organisms such as corals

Biomass—the amount of living matter per unit of water surface or water volume

Biotic—pertaining to life or living organisms

Bivalve—a group of marine or freshwater mollusks that consists of a soft body protected by two hinging shells (e.g., scallops and oysters)

Bloom—the seasonal dense growth of algae or phytoplankton that is triggered by an increase in the nutrient concentration or increased availability of light

Blow—air exhaled through the blowhole of a cetacean mixed with surrounding water that is displaced by the exhalation

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

Blue holes—pits developed in carbonate rock with a depth to width ratio greater than one that extend below sea level for a majority of their depth

Bottlenose dolphin—the former common name for *Tursiops truncatus,* now called the common bottlenose dolphin

Bottom longline—a longline that is not suspended in the water with floats and uses weights or anchors to ensure gear is placed on or close to the ocean floor

Brachipods—lamp shells; a type of bivalve lophophorate that differ from mollusks, are generally benthic, and belong to the phylum Brachiopoda

Broadcast spawner—a fish that releases its gametes into the water, where fertilization occurs; without parental care

Bruminate—the behavior exhibited by sea turtles of burrowing into bottom sediments to escape cold water conditions

Bryozoan—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 net—the deployment of bubbles in columns, curtains, nets, and clouds to concentrate prey aggregations

Buffer—polygon or area that is a specified, equal distance around a geospatial feature

Burst pulse—an impulse sound in which peak amplitude is reached very quickly

Calving—the process of giving birth by a whale, dolphin, porpoise, or manatee

Cape—a darker region on the back of many species of dolphins and small whales, generally with a distinct margin

Carapace width—the distance between the tips of the lateral spines on the sides of the crab; often used to used to enforce size limit for harvestable crabs

Carapace—the outer covering on 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

Carbonate—type of rock or sediment formed of carbonate (CO_3^{-2}) and another elements such as calcium or magnesium; limestone and dolomite are common carbonate rocks

Caribbean Environment Programme of the United Nations Environment Programme (CEP-UNEP) —program developed to assist the nations and territories of the Wider Caribbean Region to protect their marine and coastal environment and promote sustainable development

Caribbean Coastal Marine Productivity (CARICOMP)—program set-up to monitor seagrass communities, coral reefs, and mangroves throughout the Caribbean

Carnivore—an animal that feeds exclusively on another animal's tissue

Cay—a small low island consisting mostly of sand or coral

Cell size—the length and width of a raster cell in map units

Center frequency—the frequency that will result in a maximum amplitude of vibration; the frequency at which a neuron is most sensitive

Centripetal—moving or pulling toward a center or axis

Cephalopods—any marine mollusk of the class Cephalopoda, with the mouth and head surrounded by tentacles (squid, octopus, nautilus, and cuttlefish)

Cetaceans—aquatic mammals of the order Cetacea; whales, dolphins, and porpoises

Coral habitat areas of particular concern (C-HAPC)—C-HAPC are a management concept, conceived by the SAFMC, designed to identify and focus regulatory and enforcement abilities on areas of special significance to the managed species

Charter boat—a vessel typically less than 91 metric ton that carries six or fewer passengers for hire

Chelae—claws

Cheloniidae—the family of hard-shelled sea turtles that include the green, hawksbill, Kemp's ridley, and loggerhead turtles

Chemoautotroph—an organism that obtains its nutritive energy through inorganic chemical oxidation

Chemosynthesis/Chemosynthetic—the autotrophic, microbial process in which organic (carbon) compounds are synthesized via oxidation; chemical rather than solar energy (as in photosynthesis) drives the process

Chevron—a V-shaped stripe

Circumglobal—the distribution pattern displayed by organisms around the world, within a range of latitudes

Clastic—types of sediments or rocks composed of fragments derived from pre-existing rocks or minerals that have been transported a good distance from their place of origin

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

Clutch—a total number of eggs from one nesting

Cnidarians—animals of the phylum Cnidaria 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

Coastal water—water that is along, near, or relating to a coast

Coast—geographic term that refers to the zone of contact between land and water

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 eddy/ring—an eddy or circular current of cold water; in the North Atlantic Ocean, the water in cold-core rings circulates cyclonically (counterclockwise)

Cold-stunning—the behavior exhibited by sea turtles in response to cold water temperatures; the turtle becomes lethargic and adopts a stunned floating posture

Common—in the case of sea turtles, common means that sea turtles have been recorded in all, or nearly all, proper habitats, but some areas of the presumed habitat are occupied sparsely or not at all and/or the region regularly hosts large numbers of the species

Competitive exclusion—a concept that two or more resource-limited species having identical patterns of resource use cannot coexist in a stable environment

Conch—any of various tropical marine gastropod mollusks, especially of the genera *Strombus* and *Cassis*, having large, often brightly colored spiral shells and edible flesh

Congener—a member of the same species or genus

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 of the continental margin where the gradient of the seafloor rapidly changes from gently sloping (~1:1,000) to steeply sloping (~1:40) and where the continental shelf transitions into the continental slope

Continental shelf—the province of the continental margin with a gently seaward-sloping seabed (1:1,000 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 (usually around 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

Coppices—a thicket or group

Corralline algae—red algae of the family Corallinaceae characterized by a hard thallus resulting from calcareous deposits in cell walls; most species are pink or some shade of red to purple, but some are yellow, blue, or green

Coral reef—a massive, wave-resistant structure built largely by colonial, stony coral via deposition of calcium carbonate

Coriolis effect—results from the Earth's rotation which causes objects in motion to be deflected to the right in the northern hemisphere and to the left in the southern hemisphere (centripetal force)

Cosmopolitan—having a broad, wide-ranging distribution

Coverage—a file-based, vector data storage format used to store the location, shape, and attributes of geographic features; a coverage maintains geographic features as primary features (e.g., arcs, nodes, polygons) and secondary features (e.g., tics, map extent, links, annotation)

Cranial—of or relating to the skull or cranium

Creek—in the Bahamas region synonymous with tidal bays; saltwater bays not associated with freshwater

Crinoid—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 feathery arms

Critical band—frequency band within which background noise has strong effects on detection of a sound signal at a particular frequency

Critical habitat—the portion (minimum) of the habitat that is essential for the survival of threatened and endangered species and may include areas essential for feeding or reproduction by those species as designated by NMFS or USFWS

Crustaceans—arthropods that have two pairs of antennae and a hard exoskeleton, such as lobster, shrimp, and crabs

Crustose—forming a thin crust on a substrate, as certain sponges do

Cyanobacteria—a division of bacteria that derive their energy from photosynthesis; also referred to as blue-green algae; although they are prokaryotes and not a type of algae

Cyclonic—counterclockwise circulation in the Northern Hemisphere or clockwise in the Southern Hemisphere; in oceanography, synonymous with cold-core ring

Datum—set of parameters and control points used to define the three-dimensional shape of the earth and which defines part of a geographic coordinate system that is the basis or backbone for a planar coordinate system

Decibel (dB)—a logarithmic measure of sound strength; it is a ratio of intensity (pressure) at a reference range compared with a reference level; in air, the reference pressure is 20 μPa and the reference range is 1 m, while for underwater sound, the reference is 1 μPa and the reference range is also at 1 m

Decimal degrees—degrees of latitude and longitude in decimal format instead of degrees, minutes, and seconds

Deep scattering layer—a layer of dense aggregation of fishes, squid, and other species found at depth that migrate vertically in the water column each day; the layer of organisms moves toward the surface at night to feed and returns to depth at dawn

Deep sea corals—fragile, long-lived, slow growing stony and soft-branching corals that are found in dark, cold oceanic waters (200 to 1,500 m) worldwide

Deepwater—the area of the ocean that is past the continental shelf break, deeper than 100 to 200 m of water

Deepwater rift valley—underwater valleys formed by geological faulting, where the land between the two parallel faults drops down to give a broad central plain with steep sides

Delimitation—fixing a boundary

Delta—fan-shaped deposit of sediments such as sand and clay that is formed at the mouth of a river

Demarcate—to determine or mark-off the boundaries or limits of jurisdiction; as in a nation's maritime boundaries

Demersal—applied to fishes that live close to the seafloor, such as cod and hake

Density—physical property measured by mass per unit volume; in biology, the number of organisms per unit of distance

Dermochelyidae—the family of sea turtles that includes only one species, the leatherback turtle

Developmental habitat—an environment crucial to the growth of late-stage juvenile animals; for some sea turtles, this environment can be a shallow, sheltered habitat where forage items such as seagrasses, sponges, mollusks, and crustaceans are abundant

Diatoms—unicellular phytoplankton that possess an external skeleton consisting primarily of silica; typically bloom in the spring

Diel—refers to 24-hour activity cycle based on daily periods of light and dark

Digitizing—encoding geographic features into a digital geographically referenced form

Dinoflagellates—unicellular phytoplankton characterized by two flagella enabling self propelled movement; usually bloom in the fall

Diurnal—active or occurring during daylight hours; having a daily cycle

Dominant frequency range—the frequencies over which hearing is most sensitive

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

Echinoderms—marine invertebrates of the phylum Echinodermata, characterized by radial symmetry, a calcareous endoskeleton, and a water vascular system; sea stars and sea urchins are common examples

Echinoid—referring to echinoderms (e.g., sea urchins and sand dollars)

Echolocation—the production of high-frequency sound waves and reception of echoes to locate objects and investigate the surrounding environment

Echo-ranging—the emission of sound and reception of return echoes to judge distance

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

El Niño—the interannular climatic change that results in the warming of waters in the equatorial Pacific Ocean and the suppression of upwelling into the euphotic zone of nutrient rich waters off the coast of Peru; also referred to as the El Niño/Southern Oscillation (ENSO)

Elasmobranch—fishes of the class Chondrichthyes that are characterized by having a cartilaginous skeleton; includes sharks, skates, and rays

Embayment—an indentation in the shoreline that forms a bay

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 (terrestrial species, sea turtles on land, manatees) and NMFS (most marine species) under provisions of the Endangered Species Act (ESA); endangered species and their habitats are protected by ESA

Endogenous—originating within or produced by the body

Energy flux density—the average rate of sound energy flow per area for one period

Enter into force—point in time from which a treaty is enforced for those states that gave consent

Entrainment—the process of picking up and carrying along

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

Ephemeral—lasting a day

Epibenthic—refers to organisms living on the ocean floor

Epifauna—animals living on the surface of the ocean floor; any encrusting fauna

Epipelagic—the oceanic zone from the surface to 200 m

Epiphyte—a plant that uses another plant for support but does not depend on it for nutrition

Equidistant line or equidistance—a median line, every point of which is the same distance from the nearest points on the baselines of two countries

Escarpment—a steep slope in topography, as along the continental slope, generally separating two elevated levels

Essential fish habitat (EFH)—those waters and substrate necessary to fish or invertebrates for spawning, breeding, feeding, and growth to maturity (16 U.S.C. 1802[10])

Estuary—a semi-enclosed body of water where freshwater mixes with saltwater; often an area of high biological productivity and important as nursery areas for many marine species

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 a wide range of water depths

Euryhaline—an organism that can tolerate waters with a wide range of salinity

Eurythermal—an organism that can tolerate a wide range of temperatures

Eutrophication—the process by which nutrient-rich water promotes a rapid growth of algae and phytoplankton, which reduces the water's dissolved oxygen content

Exclusive economic zone (EEZ)—all waters from a nation's baseline (usually the low-tide line) outwards to 200 NM (except where nation's are separated by less than 400 NM as with the U.S. and The Bahamas) in which the country has sovereign rights over all natural resources and jurisdiction to protect the marine environment

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

Extralimital—outside the normal limits of an animal's distributional range

Extrapolate—to estimate a value that falls outside a range of known values

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

Fauna—animal life of a region

Final Environmental Impact Statement (FEIS)—as used here, the Reef fishery management plan for the U.S. and Caribbean

Fish aggregating device (FAD)—single or multiple floating structures that are connected to the ocean floor by ballast or anchors; device used to attract fishes

Fish haven—an off-shore artificial reef preservation site

Fishery management plan—a plan created by a regional Fishery Management Council to achieve specified management goals for a fishery; it includes data, analyses, and management measures (including guidelines for harvest) for a fishery

Flora—plant species of a given area

Flukes—the horizontally spread tail of a cetacean

Forage—search for food

Fore reef slope—the fore reef slope consists of a series of subtidal coral ridges and valleys usually oriented perpendicular to the reef crest

Foraminifera—planktonic or benthic protozoans with an calcareous exoskeleton and pseudopodia; also referred to as forams

Fork length—length of a fish measured from the tip of the snout to the fork of the tail

Fundamental frequency—lowest frequency of a harmonic series; generally equals the rotation or blade rate (q.v.), in Hz, of the source

Fusiform—spindle-shaped or torpedo-shaped and tapering at one or both ends

Galumph—to move with a clumsy heavy tread

Gape—the mouth in cetaceans, usually referring to the junction of upper and lower lips

Gastropods—class of symmetrical, univalve mollusks that have a true head, an unsegmented body, and a broad, flat foot

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

Georeference—the method of defining how data are situated in map coordinates

Geostrophic adjustment—the process by which a balance between the large-scale pressure gradient force and the Coriolis effect is achieved following a perturbation that disrupts a previously established geostrophic balance

Gestation—period of development in the uterus from conception until birth (pregnancy)

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

Gonochoric—sexually reproducing species in which individuals or colonies are distinctly male or female

Gorgonians—any of the various corals, such as sea fans, in the order Gorgonacea

Gregarious—used to describe animals that form social groups

Grid—geographic depiction of the world as a group of equally sized square cells arranged in rows and columns

Groundfish—group of fishes that spends most of its life on or near the ocean floors (e.g., cod, haddock, hakes, and flounders); also known as demersal species

Gulp—a feeding technique performed by, mainly, rorquals thrusting forward with open mouths and taking in a large quantity of prey; synonymous with lunge feeding

Gyre—circular movement of waters, larger than an eddy; usually applied to oceanic systems

Habitat areas of particular concern (HAPC)—legally these areas are defined as subsets of EFH identified based on one or more of the following considerations: (1) the importance of the ecological function, (2) extent to which the habitat is sensitive to human-induced degradation, (3) whether, and to what extent, development activities are stressing the habitat type, or (4) rarity of habitat type (50 CFR 600.815[a][8])

Habitat preference—the choice by an organism of a particular habitat over other available habitats

Habitat—the living place of an organism or community of organisms that is characterized by its physical or living properties

Handgear—term used for types of fishing gear that are mainly operated by hand including harpoons, handlines, rods and reels

Handline—fishing gear that is set and pulled by hand and consists of one vertical line to which may be attached leader lines with hooks

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

Hard bottom—area of the sea floor, usually on the continental shelf, associated with hard substrate such as outcroppings of limestone or sandstone that may serve as attachment locations for organisms such as corals, sponges, and other invertebrates or algae

Hatchling—a newly hatched bird, amphibian, fish, or reptile

Haul out—the act of a seal leaving the ocean and crawling onto land or ice

Haven—refuge or sanctuary

Hematology—a medical science that deals with the blood and blood-forming organs

Herbivore—an animal that eats plants as its main source of energy

Hermaphrodite—an organism that has both male and female sex organs

Hermatypic coral—reef-building coral containing symbiotic, unicellular zooxanthallae in their endodermal tissue; usually colonial, may be solitary, found in shallow, warm, and sunlit waters

Holopelagic—an organism that remains pelagic throughout its entire life

Hydrocorals—any of various colonial marine hydrozoans of the order Hydrocorallinae, having a limestone skeleton and thus resembling stony corals

Hydrography—the science of measuring and describing the surface waters of the Earth

Hydroids—class of solitary or colonial coelenterates that have a hollow cylindrical body closed at one end and a mouth surrounded by tentacles at the other end

Hydrophone—transducer for detecting underwater sound pressures; an underwater microphone

Hypoxia—waters with a low oxygen concentration, usually less than 2.0 milligrams per liter; hypoxic waters are considered oxygen-depleted and not capable of supporting sea life

Ichthyofauna—all fish that live in a particular area

Ichthyoplankton—fish eggs and larvae drifting in the water column

In situ—in the natural or original position

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

Incubation time—the length of time it takes for sea turtle embryos to develop within the eggs in a nest

Infauna— Aquatic animals that live in the substrate of a body of water, especially in a soft sea bottom

Infrasonic—sound at frequencies too low to be audible to humans, generally below 20 Hz

Inshore—lying close to the shore or coast

Insular—pertaining to or situated on an island

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

Intertidal—the area of shore exposed between high and low tide

Irruptive—entering an area where not characteristically seen

Isobath—bathymetric contour of equal depth; usually shown as a line linking points of the same depth

Isopods—large group of small crustaceans lacking a carapace, having a set of seven pairs of legs, and usually having a depressed body

Isotherm—contour of equal temperature; usually shown as a line linking points of the same temperature

Juvenile—mostly similar in form to an adult but not yet sexually mature; a smaller replica of the adult

Kilopascal (kPa)—standard unit of pressure in the International System of measurements

Kogia—the genus comprised of the pygmy sperm whale (*Kogia breviceps)* and dwarf sperm whale (*Kogia sima*)

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 (ENSO) event

Lactation—secretion or formation of milk by the mammary glands for the purpose of nursing offspring

Lagoon—a shallow body of water, especially one separated from the sea by dunes, sandbars, or coral reefs

Lateral—situated on, directed towards, or coming from the side

Ledge—rocky outcrop; an underwater ridge of rocks, especially near the shore

Life history—a history of the changes through which an organism passes in its development from the primary stage to its natural death

Lithoherm—high relief, lithified carbonate limestone mounds

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

Live rock—as defined by the SAFMC for live rock aquaculture harvests, living marine organisms or assemblages attached to hard substrate, including dead coral or rock and excluding individual mollusk shells

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

Lower jaw fork length—longest distance from tip of lower jaw to midline of the tail fin; used to measure billfish

Low water line—the line along a coast or shoreline indicating the minimum height reached by a falling tide. Debris, flotsam, and seaweed may often be used to note the low and high water lines along a beach or coast. Equivalent to low tide line

Low tide line—see low water line

Lunge—a term for a thrusting of the forward part of an animal through the water surface, showing less than 40% of the body (often the result of feeding at the surface)

Macroalgae—true oceanic plants, large in size, including bubble algae, large varieties of kelp, and *Sargassum*

Mangrove—a variety of salt-tolerant trees and shrubs that inhabit the intertidal zones of tropical and subtropical regions; tropical equivalent of salt marshes

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—any area of the marine environment set aside by federal, state, local, or tribal governments to protect geological, cultural, or recreational resources, 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—any area of the marine environment 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 within the area

Mean—(arithmetic) average

Megalopa—postlarval stage of a crab

Melon—a fatty cushion forming a bulbous "forehead" in toothed whales; may act to focus sound for echolocation

Meristics—counting of serial or segmental structures (e.g., fin rays, scales**)**

Mermaid purse—an egg-case of an Elasmobranch fish, usually oblong in shape with horns or tendrils

Mesohaline—water with salinity of 5 to 18 practical salinity units (psu)

Mesopelagic—occurring in the oceanic zone from 200 to 1,000 m

Mesoplodon—a genus of beaked whales, which includes the Blainville's beaked whale, Gervais' beaked whale, and Sowerby's beaked whale

Mesoscale—large scale

Metabolism—all biochemical reactions that take place in an organism necessary for the maintenance of life

Metadata—documentation or information about geospatial data (such as 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

Migration—the 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 animal's life history

Mollusk—members of the Phylum Mollusca; a group of marine and terrestrial invertebrates consisting of snails, slugs, squids, octopus, clams, and others

Monospecific—only one known species

Morphology—the form and structure of an organism considered as a whole; appearance

Morphometric—the study of comparative morphological measurements

Multiplexing—sending multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end

Mysticeti—suborder of cetaceans comprised of the baleen whales

Nautical mile (NM)—a distance unit used in the marine environment that is equal to one minute of latitude or 1.85 km

Navigable waters—those waters that are subject to the ebb and flow of the tide and/or are presently used, have been used in the past, or may be susceptible for use to transport interstate or foreign commerce

Nearshore—an indefinite zone that extends seaward from the shoreline; for this report, this term is defined as waters from shore out to 3 NM

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

Niche segregation—partitioning of resources by individuals, populations, or species to reduce competition

No effort occurrence—area where the likelihood of encountering a protected species is not known because no line-transect surveys have been completed in that area (e.g., zero survey effort), resulting in a lack of sighting data and no possible calculation of sightings per unit effort

Nocturnal—applied to events that occur during nighttime hours

North Atlantic Oscillation (NAO)—the climatic phenomenon leading to warmer winter ocean and atmospheric temperatures from the east coast of the U.S. to Siberia and from the Arctic Ocean to the subtropical Atlantic Ocean; this phenomenon is caused by a north-south atmospheric pressure shift and this oscillation leads to mild, rainy weather in Europe while causing cold, dry weather in the northeastern U.S. and Canada

North Atlantic—the part of the Atlantic 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

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

Nutrification—process by which saltwater or freshwater systems develop high nutrient concentrations

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, one occurrence record from a marine mammal sighting survey may indicate that 34 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 corridor—a type of ecological corridor; a narrow area of the ocean used by sea turtles for migration and selected for this purpose based upon location, habitat, or a variety of other favorable ecological characteristics of the area

Ocean front—a boundary between two water masses that have different densities; water density differences are caused by differences in temperature or salinity

Oceanic zone—the deepwater portion of pelagic ocean waters; ocean waters beyond the continental shelf or that are deeper than the depth of water overlying the continental shelf break (typically 100 to 200 m deep)

Oceanography—the scientific study of the oceans, including the chemistry, biology, geology, and physics of the ocean environment

Octocorals—are soft corals with eight pinnate arms

Odontoceti—the suborder of cetaceans comprised of toothed whales (e.g., beaked whales, dolphins, porpoises, sperm whale)

Offshore—open ocean waters over the continental slope and beyond that are deeper than 200 m; water seaward of the continental shelf break

Olfactory—relating to the sense of smell

Oligohaline—water with salinity of 0.5 to 5.0 practical salinity units (psu)

Oligotrophic—water that is lacking in nutrients, which results in low primary production

Omnivore—an animal that feeds on both plant and animal tissue

Ooid—a small (<2mm in diameter), spherical, layered grain most often composed of calcium carbonate ($CaCO_3$) that forms on the sea floor in shallow tropical seas (e.g., on the Bahama banks). After being covered over by additional sediment, ooids can become cemented together to form sedimentary rock

Oolitic—composed of or resembling oolite; a small, round calcareous grain commonly found in limestones

Ophuiroid—referring to brittle stars and basket stars

Opportunistic—used to describe organisms that take advantage of all feeding opportunities and do not prey on a few specific items

Otolith—a calcareous concentration in the inner ear of a vertebrate or in the otocyst of an invertebrate

Otter trawl—a type of bottom trawl gear that utilizes two wooden doors (otter doors) to keep the mouth of the trawl net open while being dragged along the seafloor

Outer reef slope—the seaward edge of the reef that is fairly steep and slopes down to deeper water

Overfish—a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis

Overfished—a stock size that is below a prescribed biomass threshold

Overfishing—harvesting at a rate above a prescribed fishing mortality threshold

Overwinter—staying the winter in one area

Ovoviviparous—giving birth to live young which have developed from eggs that hatched within the mother's body

Pagophylic—associated with ice

Pantropical—-distributed throughout tropical regions

Patch reef—small isolated reef formations that are circular or oval in shape and develop in calm protected waters behind barrier reefs

Peak frequency—the frequency (period/wavelength) of waves represented by a peak (maximum energy) in the wave spectrum; sometimes known as the dominant frequency

Peak sensitivity—the frequency at which hearing is most sensitive and amplitude is lowest for a perceived sound

Pectoral fin—flipper; flattened fore-limb of a cetacean (supported by bone); for fishes, this fin is part of pair, which is supported by the pectoral girdle and usually located just behind the gill opening

Pelage—the hairy covering of a mammal

Pelagic longline—a longline suspended by floats in the water column (i.e., not fixed or in contact with the ocean bottom)

Pelagic—the water or ocean environment, excluding the ocean bottom; the major environmental division or zone in the ocean that included the entire water column and can be subdivided into the neritic (waters over the continental shelf) and oceanic (deeper waters seaward of the continental shelf) zones

Pelecypod—marine or freshwater mollusks having a soft body with plate-like gills enclosed within two hinged shells

Pelletoidal—composed of or referring to pelletoids; sediment grains formed in the shape of a pellet

Penaeid—a group of shrimp, chiefly found in warm water

Philopatry—when an animal migrates from a breeding area to a feeding area and then back again

Photic zone—the uppermost zone in the water where sunlight penetrates and permits photosynthesis

Photosynthesis—the autotrophic process in which solar energy is converted into organic matter by synthesizing water and carbon dioxide with chlorophyll; plants, algae, and phytoplankton synthesize organic compounds via this process

Physiography—physical geography of the ocean bottom and continental margins

Phytoplankton—microscopic, photosynthetic plankton, which are the base of the food chain on which ultimately most shellfish, fishes, birds, and marine mammals depend

Pinnacle—a high tower or spire-shaped pillar of rock or coral found on the seafloor

Planktivore—an animal that feeds on plankton

Plankton—organisms that drift in the water column or on the water's surface by either passively floating or weakly swimming

Plastron—bony shield composing the ventral side of a turtle's shell

Platform—offshore structure from which development wells are drilled

Plume—a column of water

Point—single x, y coordinate pair that represents a single geographic feature (e.g., sea turtle sighting)

Polychaete—a class of marine worms

Polygon—area represented by a two-dimensional feature

Polyhaline—water with salinity of 18 to 30 practical salinity units (psu)

Population—a group of individuals of the same species occupying the same area

Portunid—crab of the family Portunidae, which includes the swimming crabs (i.e., blue crab)

Posterior—situated near or toward the back of an animal's body

Post-hatchlings—sea turtles that are larger and older than those of the hatchling stage, yet not large enough or old enough to be considered juveniles

Practical salinity unit (psu)—the currently used dimensionless unit for salinity, replacing parts per thousand (ppt)

Precision—number of significant digits used to store coordinate values; imperative for accurate feature representation, analysis, and mapping

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

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

Propagule—a part of a plant or fungus such as a bud or a spore that becomes detached from the rest and forms a new organism

Protogynous hermaphrodite—Sequential hermaphrodite in which the fish functions first as a female and then changes to a male

Protozoa—single-celled organisms whose cells possess nuclei (i.e., eukaryotes) and that show characteristics typically associated with animals (i.e., mobility and heterotrophy)

Pteropod—a snail possessing two swimming wings that spends it's entire life as part of the plankton; also referred to as a sea butterfly

Purse seine—a large commercial fishing net pulled by two boats, with ends that are pulled together around a shoal of fish so that the net forms a pouch or "purse"

Pycnocline—a layer of water across which a rapid change in density occurs with increasing depth; in marine environments the depth of the pycnocline is affected by changes in both temperature and salinity

Quartile—the values that divide a frequency distribution into four parts, each containing a quarter of the sample population

Query—a question or request that is often a statement or logical expression to select specific features of data

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

Raster—any data source that stores geographic information in a grid structure

Ratify—to affirm or approve; in the case of a treaty, to agree to be bound by the treaty

Recreational fishing—fishing for sport or pleasure

Reef crest—the reef crest separates the lagoon from the open ocean, and is an area of prolific coral growth

Relief—the inequalities (elevations and depressions) of the sea bottom

Remigration interval—the amount of time between successive sea turtle nesting seasons

Robust—powerfully built

Rookery—an animal's breeding ground; for sea turtles, it is the specific beach on which they nest

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

Rossby wave—a large-scale (~100 of kilometers) periodic motion in the ocean (or atmosphere) propagating to the west relative to the current (or air stream) along lines of latitude; the restoring force is the change in the Coriolis Effect with latitude; also referred to as a planetary wave. Rossby waves can be baroclinic or barotropic.

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

Saffir-Simpson Scale—the Saffir-Simpson Hurricane Scale is a 1-5 rating based on a hurricane's intensity. The scale is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline in the landfall region.

Salinity—the concentration of salts in water, measured in practical salinity units (psu)

Sargasso Sea—the oligotrophic central portion (North Atlantic gyre) of the North Atlantic Ocean bounded in the west by the Gulf Stream

Sargassum—a genus of brown algae commonly found in temperate and tropical waters both as pelagic and benthic 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 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

Scyphozoans—characterized by the absence of a velum and by a polyp stage that is very small or lacking entirely (e.g., true jellyfish)

Sea anemones—large, heavy, complex polyps that belong to the cnidarian class Anthozoa

Sediment—solid fragmented material, either mineral or organic, that is deposited by ice, water, or air

Serial spawner—a fish that spawns in bursts or pulses more than once in a spawning season in response to an environment stimulus

Sessile—used to describe an animal that is attached to something, such as substrate, rather than free moving

Sexually dimorphic—differences in the appearance, such as size, body shape or color, of the sexes of a species

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

Shelf break (continental)—region where the slope of the seabed rapidly changes from gently to steeply sloping and the continental shelf gives way to the continental slope; the shelf break usually occurs in waters with a depth of 100 to 200 m

Shelf break region—the geographic area surrounding the continental shelf break and including waters overlying both the outer continental shelf and upper continental slope

Shoals—a submerged ridge, bank, or bar consisting of, or covered by, unconsolidated sediments (mud, sand, gravel) which is at or near enough to the water surface to constitute a danger to navigation

Sirenia—the order of marine mammals that consists of manatees and the dugong

Skim—feeding behavior in which whales swim through swarms of plankton with their mouths open

South Atlantic—the part of the Atlantic Ocean found south of the Equator; the NMFS and the general public often erroneously refer to the region between Cape Hatteras and Cape Canaveral as the South Atlantic, which, however commonly used, is incorrectly applied

Spatial analysis—study of and relationship between the locations and shapes of geographic features and the process of analyzing, modeling, and interpreting those results; there are four main types or categories of spatial analysis: topological overlay and contiguity analysis; surface analysis; linear analysis; and raster analysis

Spawn—the release of eggs and sperm during mating

Special management zones (SMZs)—established by the SAFMC, SMZs are established off South Carolina, Georgia, and Florida to provide gear and harvest regulations for members of the snapper grouper complex; the purpose of SMZs is to reduce user conflicts via gear and harvest regulations at locations that feature limited resources and are managed for a specific user group, as well as prevent overfishing of these resources

Species diversity—the number of different species in a given area

Species—a population or series of populations of organisms that can interbreed freely with each other but not with members of the other species

Spline—interpolation method that minimizes the overall surface curvature for a coverage using a mathematical function that estimates cell values, creating a smoother surface that passes exactly through the input points

Standard deviation—a statistical measure of the amount by which a set of values differs from the arithmetical means; simply, a measure of how widely values are dispersed from the mean

Standard length—the length of a fish measured from the tip of the snout to the end of the backbone and does not include the tail

Stenella—the genus of oceanic dolphins consisting of striped, Atlantic spotted, pantropical spotted, Clymene, and spinner dolphins, which are similar in appearance

Stenellid—refers to dolphins of the genus *Stenella*

Stock structure—the genetic diversity of a stock

Stock—a group of individuals of a species that can be regarded as an entity for management or assessment purposes; a separate breeding population of a species

Straight baseline—an internationally recognized baseline, from which a nation's territorial sea is measured, that is drawn straight across areas where a coastline is deeply indented (e.g., across a bay or other inlet) or seaward of a group of fringing islands located along the coast; geographic coordinates may be used to define, delimit, and join together a series of straight baselines.

Straight carapace length—the body length of sea turtles; it is a straight-line measurement from the rear of the eye socket parallel to the center line of the carapace to the posterior edge of the carapace

Stranding—the act of marine mammals or sea turtles accidentally coming 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

Submarine canyon—deep, steep-sided valley cut into the continental shelf or slope

Subpopulations—an identifiable fraction or subdivision of a population

Substrate—the material to which an organism is attached or in which it grows and lives; also, the underlying layer or substance

Subtropical—the regions lying between the tropical and temperate latitudes

Subtropical fishes—species that tolerate a minimum water temperature between 10º to 20ºC

Surface-active—behaviors of whale groups performed at the surface

Sverdrup—a measure of the rate of volume transport, as in ocean currents, where 1 Sv = 10^6 m^3 s^{-1}

Symbiont—organism involved in a mutualisitc (both species benefit) symbiotic relationship

Symbiosis—the interrelationship between individuals of two different species; both species benefit in a symbiotic relationship

Sympatric—species or subspecies occurring together; having overlapping areas of distribution

Tailstock—peduncle; region from just behind the dorsal fin to the flukes

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

Teleost—bony fishes in the of the subclass Teleostei

Temperate—the region of the Earth at the mid-latitudes that is characterized by a mild, seasonally changing climate

Temperate fishes—species that prefer water temperatures of 10ºC or below, with a maximum temperature tolerance of 15ºC

Temporary threshold shift (TTS)—exposure to sound causing a loss of hearing which disappears after a period of recovery

Terrigenous—derived from land or a continent

Thermocline—the depth in the ocean (water column) in which there is an abrupt temperature change

Thermohaline circulation—density-driven water circulation caused by differences in temperature and/or salinity

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 USFWS (terrestrial species, sea turtles on land, manatees) and National Marine Fisheries Service (most marine species) under provisions of the ESA

Tolerance—numerical value defining the acceptable error range a feature will have from its actual point found on earth; these tolerance values are used as defaults in many automation, editing, and processing operations

Topography—physical features of the ocean floor, such as mounds or ridges

Topology—spatial relationship between connecting or adjacent features (e.g., arcs, nodes, polygons, or points); topological associations are built from simple elements into complex elements, points, arcs (sets of connected points), areas (sets of connected arcs), and routes (sets of sections, which are arcs or portions of arcs)

Total length—the longest measurable distance from the outermost portion of a fish's snout lengthwise to the outermost portion of the tail fin

Trap—a portable, enclosed type of baited fishing gear used to capture fishes or crustaceans (lobsters and crabs) that possesses one or more entrances but no exits and one or more lines attached to surface floats; can be made of many types of materials (wood, reeds, or wire) and in many shapes or configurations; "trap" and "pot" are fairly synonymous

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

Triangular irregular networks (TINs)—surface representation developed from sample points and breakline features that contains topological relationships between points and their neighboring triangles where each sample point has an x and y coordinate and a z value; these points are connected by edges, which make up a set of non-overlapping triangles that represent the surface

Trip—fishing during part or all of one waking day

Trophic level—a step in the transfer of food or energy within a food chain or food web

Tropical fishes—species that prefer a water temperature of 20ºC or above

Tropical—the geographic region found in the low latitudes (30º north of the equator to 30º south of the equator) characterized by a warm climate

Tunicates—primitive marine animals having a saclike, unsegmented body enclosed in a tough outer covering (e.g., sea squirts, salps).

Tursiops—the genus of bottlenose dolphins comprised of the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)

Upwelling—upward movement or rising of deep, usually nutrient- and oxygen-rich, water to the surface; may be caused by wind-forcing, divergent currents, or density differences

Vector—coordinate-based data structure most commonly used to represent linear geographic features; each feature is written or represented as an ordered list of vertices

Ventral—relating to the underside (or belly side) of an animal

Vermetid reefs—a buildup of worm-like gastropod *Petaloconchus* mollusks

Vertebrates—animals with a backbone

Warm-core eddy/ring—an eddy or circular current of warm water; in the North Atlantic Ocean and Gulf of Mexico, 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 and Loop Current

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 or salinity

Weed line—line of floating algae usually concentrated by the wind or currents

Well—a hole bored or drilled into the earth for the purpose of obtaining hydrocarbons or water

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 (either freshwater or saltwater) frequently enough to support vegetation that requires saturated soil conditions for growth and reproduction; generally includes swamps, marshes, springs, seeps, or wet meadows

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

Zoeal—larval stage of crabs

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

Zooxanthallae—single-celled algae that live symbiotically within certain types of coral; it is the presence of these organisms that gives coral its color

Z-value—value that represents elevation or depth (i.e., water depth or depth beneath the water's surface) and lies on the z-axis within a three-dimensional x, y, and z coordinate system

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APPENDIX A: DATA SOURCES

	Title
Table A-1.	Inventory of marine mammal and sea turtle data included in the MRA for southeastern Florida and the AUTEC-Andros OPAREA A-15
Figure A-1.	Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the winter season. A-18
Figure A-2.	Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the spring season. A-19
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Figure A-4.	Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the fall season. A-21

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Appendix A-1. Data confidence and the geographic information system (GIS) maps for the Southeastern Florida and AUTEC-Andros OPAREA MRA.

The level of data confidence is dependent upon three factors: precision, accuracy, and currency. Each of these three factors are affected by all the variables involved in obtaining data and putting the data into a GIS 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.

MRA Map Examples	Description of Map Data	Confidence Level
Bathymetry, Sea Surface Temperature, Chlorophyll *a*, Occurrence Maps for Species of Concern, Essential Fish Habitat (minority of the maps), and Marine Managed Areas	Data from original/reliable source. Provided in a digital format with geographic coordinates given. Identified as "*source data*" in map captions.	**High** 93 maps (71% of total number of maps)
Artificial Habitats, Bottom Sediment, Seagrass, turtle satellite-tagged, and Essential Fish Habitat (majority of the maps)	First- or second-hand data sources. Locations obtained through scanning geo-referenced* maps. Identified as "*source map(s) scanned*" in map captions.	**Medium** 35 maps (27% of total number of maps)
Surface Currents, Bottom Sediment, and Migration Maps	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** 3 maps (2% 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 three dimensions) to planar coordinate (two dimensions), 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 kilometers versus zero kilometers 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 marine resource assessment (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 MRA Reports are in geographic coordinates, the map figures should not be used for measurement and the scale information only provides approximate distances. 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 study area for the Southeastern Florida and AUTEC-Andros OPAREA.

To derive seasonal occurrence patterns of marine mammals and sea turtles in the study area, an investigation of the research efforts related to marine mammal and sea turtle occurrences was undertaken. The results of that investigation are described below, and are intended to provide a summary of the many directed research efforts in the study area conducted and/or sponsored by federal, state, private and academic institutions, agencies, or organizations. Datasets were acquired from those research efforts that were deemed most appropriate and comprehensive for representing turtle and marine mammal occurrences in the study area.

Aerial and Shipboard Surveys

- Records from aerial and shipboard surveys constitute the majority of the 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 collect line-transect data during daylight hours, weather permitting (i.e., no rain, Beaufort sea state <4). Surveys are conducted along pre-designated transect lines following established sampling methods that allow for abundance estimates in an area of interest. Any 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. While off-effort sightings may not be used for abundance and/or density estimates, they are nonetheless useful since they can provide additional sighting records for a species in areas where occurrence patterns may not be well known.

➢ **Aerial Sighting Surveys**

The typical goal of an aerial survey is to estimate the overall density or abundance of a given marine mammal or sea turtle species. 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 sub-region of a study area.

- **NMFS-SEFSC Aerial Sighting Surveys**
  - From **April 1982 to March 1984**, the NMFS-SEFSC contracted Aero-Marine Surveys, Inc. to conduct aerial line-transect surveys from Cape Hatteras, NC to Key West, FL in offshore waters to the approximate edge of the Gulf Stream (Aero-Marine Surveys, Inc. 1984). The purpose of these surveys, also known as the Southeast Turtle Survey Program (SETS), was to determine sea turtle population estimates in the southeastern U.S. by collecting information on spatial and temporal distribution, behavior, ecological correlates, and sightability of sea turtles (Aero-Marine Surveys, Inc. 1984).
  - The Southeast Cetacean Aerial Surveys (SECAS) were aerial line-transect surveys conducted during 1992 and 1995 by NMFS-SEFSC with the purpose of estimating cetacean abundance in the southeastern Atlantic region and obtaining abundance estimates, in particular, for bottlenose dolphins (*Tursiops truncatus*) (NMFS-SEFSC 1992a; Blaylock and Hoggard 1994; Garrison and Yeung 2001). The SECAS 92 survey took place from **20 January to 02 March 1992** and covered continental shelf waters off Cape Hatteras, NC to Fort Lauderdale, FL (NMFS-SEFSC 1992a). Sea turtle sightings were recorded as well. The SECAS 95 survey was conducted between **27 January and 06 March 1995**, covering the area from Cape Hatteras, NC to Fort Pierce, FL from the shore to 9.25 km beyond the inshore edge of the Gulf Stream or <200 km offshore (Garrison and Yeung 2001).

- In 1992, the NMFS-SEFSC and U.S. Coast Guard (USCG) Miami Air Station established a cooperative agreement to monitor marine mammals along southeastern Florida coast and vessel activity in the Florida Keys (McClellan 1996). Aerial surveys between Fort Pierce and Key West, FL were performed aboard USCG helicopters and fixed wing aircraft from September 1992 through March 2004. The objectives were to document sea turtle and marine mammal distribution and seasonal occurrence along the southeastern coast of Florida and to describe vessel usage patterns in Biscayne National Park and the Florida Keys National Marine Sanctuary (McClellan 1996; McClellan et al. 2000). Data for 1999 thru 2001 were received from Mr. David McClellan at NMFS-SEFSC. Aerial surveys within the MRA study area took place from **21 April 1995 to 14 February 1997**, covering waters from Sebastian Inlet to approximately West Palm Beach, FL (McClellan 1996).
- The Mid-Atlantic *Tursiops* Surveys (MATS) were conducted by the NMFS-SEFSC to examine the distribution Atlantic bottlenose dolphins inhabiting the coastal waters of the Mid-Atlantic and South Atlantic bights and estimate their relative abundance (Blaylock 1995). The MATS were primarily bottlenose dolphin surveys, however, sightings of other cetaceans, sea turtles, and fishes also were recorded.
  - MATS 1994, was a pilot study conducted from **12 July to 14 August 1994** along the coast from Long Island, NY to Vero Beach, FL (Blaylock 1995). This pilot study involved two types of aerial surveys: (1) surveys within 1 km of the shore and (2) line-transect surveys flown over the inner continental shelf north of Cape Hatteras, NC (Blaylock 1995).
  - MATS 2002 was conducted during **15 January to 28 February 2002 from the** Georgia/Florida state line to southern Delaware Bay and **15 July to 31 August 2002** from Sandy Hook, NJ to Vero Beach, FL (Hoggard 2002; Waring et al. 2006). Surveys were flown perpendicular to shore, out to the 40 m isobath (Waring et al. 2006).
  - MATS 2004 occurred during **16 July to 31 August 2004** from Sandy Hook, NJ south to Cape Canaveral, FL.
  - MATS 2005 occurred during **30 January to 09 March 2005** from the southeastern shore of Virginia south to Cape Canaveral, FL.

- **Non-NMFS Aerial Sighting Surveys**
  - **Right Whale Aerial Sighting Surveys**
    - The New England Aquarium (NEAQ) flew standardized aerial transect surveys for right whales (*Eubalaena glacialis*) from **05 January to 15 March** from **1984 to 1988** over coastal waters of the southeastern U.S. (Kraus et al. 1988; Kraus et al. 1993). Surveys covered coastal waters of Georgia out to 74 km offshore and from the Georgia/Florida border to Cape Canaveral, FL, out to 28 km offshore. In 1984, surveys covered the coastal waters from Cape Canaveral, FL to Jupiter Inlet, FL; in 1986 and 1987, survey coverage was extended south to Boca Raton, FL (Kraus et al. 1988). The purpose of the aerial surveys was to identify the distribution and abundance of right whales in the southeastern U.S. (Kraus et al. 1988). These surveys are included in the North Atlantic Right Whale Consortium (NARWC) database.
    - In **February and March 1987**, the University of Rhode Island (URI) initiated a survey program to monitor right whales off Georgia and Florida (Kraus et al. 1993). Six surveys were conducted over right whale habitat in the southeastern U.S. This survey program evolved into the Early Warning System (EWS), which was established in 1993 and 1994 (Hain et al. 1999). These surveys are included in the NARWC database.
    - The EWS was established to alert ships to the presence of right whales while transiting the winter calving grounds (Hain et al. 1999). EWS surveys have been conducted daily since 1994 in the southeastern U.S. every year from approximately **01 December to 31 March**, weather-permitting (Slay et al. 2002). Initial aerial surveys conducted daily from

airships (blimps) were flown to estimate sightability of right whales. Surveys took place from **09 to 17 January 1992, 05 January to 12 February 1993,** and **15 to 26 February 1995** (Hain et al. 1999). The study area extended from just north of Brunswick, GA south to the coastal waters of Cape Canaveral, FL, from the shoreline to approximately 28 km offshore (Hain et al. 1999). Researchers spend approximately 6 hours each day, surveying the designated southeastern critical habitat area for right whales, and relaying whale locations to mariners to avoid collisions with whales (NOAA 2006j). Opportunistic right whale sightings are also reported by ships transiting the area. These surveys are included in the NARWC database.

- The Right Whale Conservation Project of the Fish and Wildlife Conservation Commission-Florida Marine Research Institute (FFWCC-FMRI) has been performing aerial surveys as part of EWS survey effort since 1991, with the purpose of detecting and reporting right whales in Florida waters (Kraus et al. 1993; Taylor Thomas and Ciano 2000; Ciano and Taylor Thomas 2001). From **15 December 1999 to 15 March 2000** and **21 December 2000 to 22 March 2001**, aerial surveys were flown perpendicular to the shoreline, from Ponte Verda Beach (30°15'N) to Fort Pierce, FL (27°30'N) and out to 81°00'W, approximately 5 to 20 NM offshore (Taylor Thomas and Ciano 2000; Ciano and Taylor Thomas 2001). Since that time, FFWCC-FMRI aerial surveys have been conducted annually from December through March. Approximately 60 surveys are flown each survey season up to 30 NM offshore (FFWCC-FWRI 2006). FFWCC-FWRI surveys are included in the NARWC database. Aerial survey data from January 1992 through April 1996 was analyzed to assess the temporal abundance, spatial distribution, and herd structure of coastal bottlenose dolphins (Thomas 1996; Thomas et al. 1997). Transect lines were from Jacksonville, FL south to Fort Pierce, FL, from approximately 2.4 (1.3 NM) to 8.3 km (4.5 NM) offshore (Thomas 1996). These surveys are included in the NARWC database.

o From **07 November 1989 to 14 February 1992,** the NEAQ conducted aerial surveys along the southeastern the U.S. coast to assess the impacts of offshore petroleum activity on endangered whales (Kraus et al. 1993). The study area ranged from Cape Hatteras, NC south to Miami, FL, running parallel to the coast at 1, 4, 8, and 12 NM intervals. Of the 49 surveys flown, 13 were conducted within the MRA study area. Surveys were not conducted year-round and tracklines in the study area extended from Jacksonville, FL south to Miami, FL and Jacksonville, FL south to Cape Canaveral, FL. The objectives were to determine right whale distribution, abundance, seasonality, and habitat use patterns in the southeastern U.S. during the winter. All sightings of cetaceans, sea turtles, and large fishes were recorded during all surveys. In 1991, survey tracklines south of Cape Canaveral, FL were dropped due to low numbers of right whale sightings relative to effort. This data is incorporated into the NARWC database.

Navy-Supported Aerial Surveys

o From **calving season 1996/1997 through calving season 1998/1999**, Continental Shelf Associates, Inc. was contracted by the Navy to collect annual data pertaining to the spatial and temporal distributions and abundances of marine mammal and sea turtle species relative to local Navy aerial, surface, and subsurface operations within selected OPAREAs offshore of South Carolina, Georgia, and Florida (DoN 1997b, 2002). The survey area and timing selection were based: (1) on high historical frequency and volume of Navy ship traffic and areas subject to other potential impacts associated with offshore Navy activities, (2) to coincide with seasonal migrations of right whales to and from near coastal waters off southeastern Georgia and northeastern Florida, and (3) on logistical limitations of fuel, daylight limitations, and expected survey observer fatigue (DoN 1996). The aerial survey area was modified during the 1997/1998 surveys so that greater emphasis could be placed on select Navy high-use areas, as well as high-use areas for right whales determined during the 1996/1997 surveys (DoN 2000). The 1998/1999 Year 3 survey design included a significant reduction in the geographic size of the survey area from areas surveyed during Year 1 and Year 2 in part due to the increase in the repetitive survey coverage of selected Navy areas of

concern and to avoid overlap of survey area coverage by other organizations (FMRI, GADNR, NEA) (DoN 2001, 2002). The NARWC database, however, does contain the sightings from Year 1 (calving season 1996/1997) and Year 2 (calving season 1997/1998). Only Year 3 is not contained in the NARWC database. Data files for all three survey years were provided by the Navy and are included in this report.

- To supplement information for the proposed shock testing of the *SEAWOLF* submarine in the Mayport area (Jacksonville) off Florida, monthly aerial surveys of marine mammals and sea turtles were conducted by Continental Shelf Associates, Inc. to determine temporal and spatial abundance of marine mammals and sea turtles from **April through September 1995** (DoN 1995) and from **May through September 1997** (DoN 1998). The survey transects were over the 91 to 213 m (300 to 700 ft) isobaths and centered over the shelf break. Data and survey transects are north of the MRA study area, yet appear in the MRA map view.
- Four monthly surveys were conducted by Continental Shelf Associates (CSA) from **December 1998 to March 1999** (DoN 2002). Surveys were flown from Charleston, SC to approximately Cape Canaveral, FL (DoN 2002). The purpose of the surveys was to determine spatial and temporal distributions, abundances, and frequencies of listed marine mammal and sea turtle species within offshore Navy OPAREAs (DoN 2002). The 1998-1999 surveys were the third of a set of surveys conducted by CSA; prior surveys were conducted from October 1996 through April 1997 (Year 1) and November 1997 through April 1998 (Year 2) (DoN 2002).
- From **03 to 08 June 1999 and 16 to 18 August 1999**, aerial surveys for marine mammals and sea turtles were conducted at the Mayport test area to supplement information for the proposed shock testing of the *Winston S. Churchill* (DoN 1999; Clarke and Norman 2005). Standard line-transect surveys were flown over continental slope waters off northeast Florida and southern Georgia. Data and survey transects are north of the MRA study area, yet appear in the MRA map view.
- Line-transect surveys were flown as part of the Marine Mammal Monitoring on Navy Undersea Acoustic Ranges (MMMNUAR) program. Surveys took place from **05 January to 12 January 2003** over the AUTEC range off Andros Island and the Northwest Providence Channel, Bahamas. Daily aerial surveys were flown off the east coast of Andros Island and over the Northwest Providence Channel. The purpose of these surveys was to identify the location, species, and numbers of marine mammals in this area (Mobley 2004b). Visual sightings would later be correlated with acoustic detections of marine mammals derived from instrumented naval ranges. These surveys were included in this report.

- **Shipboard Sighting Surveys**

Shipboard surveys are designed to collect data to address many informational needs. To meet the mandate established in Section 117 of the amended Marine Mammal Protection Act (MMPA), the NMFS must prepare, in consultation with regional Scientific Review Groups, stock assessment reports for each marine mammal stock that occurs in U.S. waters. These stock assessment reports contain several items, including a description of the stock and its distribution, as well as a minimum population estimate (Wade and Angliss 1997). One of the primary ways the NMFS collects marine mammal population data to use in stock assessments is from shipboard surveys.

The NMFS is also responsible for assessing and monitoring sea turtle stocks, which requires distribution and population estimates for determination of the status of stocks in relation to past and future human activities. While shipboard surveys are not the optimal survey technique to gain sea turtle population data, sighting data from shipboard surveys often provide valuable information that can be used to calculate turtle stocks. The NMFS-SEFSC conducts the majority of all shipboard surveys conducted in the western North Atlantic Ocean. Sea turtle surveys are often “piggybacked” onto marine mammal, fish, and oceanographic surveys in this region, as it is a cost-effective means for conducting multiple surveys on the same platform.

- **NMFS-SEFSC Shipboard Sighting Surveys**
  - The R/V *Oregon II* Cruise OT-92-01 (198) was conducted from **03 January to 10 February 1992**, with the purpose of studying marine mammals and apex pelagic predators in the Atlantic Ocean. Line-transect surveys covered the Blake Plateau (between 28º and 35ºN) from the coastline to the U.S. Exclusive Economic Zone (EEZ) (NMFS-SEFSC 1992). The specific objectives of this cruise were to conduct marine mammal surveys during the daylight hours and to deploy longline fishing gear during the evening for the purpose of catching and sampling pelagic apex predators (primarily swordfish, other billfish, tunas, and sharks).
  - From **08 July to 17 August 1998**, the R/V *Relentless* Cruise 98-01(3) surveyed between Maryland and central Florida to establish baseline estimates of cetacean abundances in the western North Atlantic (Mullin et al. 2001). Line-transect surveys were conducted between 38°N and 28°N, between the 10 m isobath and the boundary of the EEZ (approximately 200 NM from the coast) (Mullin 1999; Mullin et al. 2001; Mullin and Fulling 2003). The specific objectives of this cruise were to obtain cetacean abundance, distribution, and stock structure.
  - The R/V *Oregon II* Cruise OT-99-05 (236) of **04 August to 30 September 1999** collected data used for abundance, distribution, and stock structure evaluations of cetaceans in southeastern U.S. Atlantic waters (NMFS-SEFSC 1999a). Line-transect surveys covered the ocean area between the 10 m isobath and 185 km offshore from Cape Canaveral, FL north to the Delaware Bay. The specific objectives of this cruise were to obtain abundance estimates for each cetacean species in the area, collect biopsy tissue samples to evaluate stock structure, establish and build time-series databases for monitoring trends in abundance, examine distributions of cetaceans in relation to physiographic and oceanographic features, and to conduct photo-identification studies of particular species through obtaining photographs and video images.
  - From **10 February to 08 April 2002**, the Mid-Atlantic Cetacean Survey (MACS) R/V *Gordon Gunter* Cruise GU-0201 (21) conducted visual line-transect surveys over U.S. Atlantic waters of the continental shelf and inner continental slope; survey coverage extended from Cape Canaveral, FL north to Delaware Bay (Garrison et al. 2003). The purpose of the cruise was to conduct a population assessment of marine mammals in the mid-Atlantic region, to collect information on winter spatial distributions and abundances (Garrison et al. 2003). The specific objectives of the cruise were to examine marine mammal abundance and spatial distribution within the study area, continue development and application of passive hydro-acoustic methods to detect marine mammals, and opportunistically collect marine mammal skin biopsy samples, particularly of bottlenose dolphins (Garrison et al. 2003).
  - The R/V *Gordon Gunter* Cruise GU-04-03 (28) took place from **22 June to 19 August 2004** (NMFS-SEFSC 2004). Line-transect surveys occurred in the waters between the 50 m isobath and the EEZ from the Maryland/Delaware border south to southern Florida (NMFS-SEFSC 2004). The purpose of this survey was to update marine mammal abundance estimates in the mid-Atlantic in order to evaluate the current status of stocks (NMFS-SEFSC 2004). The specific objectives were to determine cetacean abundance and distribution, conduct simultaneous passive hydroacoustic surveys, collect biopsy samples from cetaceans, conduct photo-identification on cetaceans, collect data on sea turtle and sea bird distributions and abundances, as well as oceanographic and environmental information to quantify acoustic backscatter of fish and zooplankton (NMFS-SEFSC 2004).
- **Non-NMFS Shipboard Sighting Surveys**
  - During **July through September 1976** and **January through May 1977**, the Ocean Research and Education Society of Boston, MA conducted strip censuses and photo-identification of humpback whales (*Megaptera novaeangliae*) from aboard the R/V *Regina Maris*. Surveys took place from July through September 1976 in the Newfoundland/Labrador area. From January through May 1977, surveys were conducted from the Newfoundland/Labrador area south to the Caribbean, transiting past the eastern coast of Eleuthera, Bahamas and the northern coast of New Providence, Bahamas on the return trip

(Balcomb III and Nichols 1978). The purpose of these surveys was to collect photographic information on individual humpback whales in the feeding and breeding grounds as well as to promote the use of non-lethal techniques in whale research (Balcomb III and Nicholas 1978).

- **Visual and Acoustic Surveys**
  - The NMFS-SEFSC R/V *Gordon Gunter* Cruise GU-01-01 (11) was conducted from 12 February 2001 to 08 March 2001 to investigate current winter distributions and abundances of cetaceans in the northeastern Caribbean. Acoustic and visual line-transect surveys occurred around Puerto Rico and the Virgin Islands. Leg 1 (**12 February 2001 to 19 February 2001**) transited through the MRA study area, beginning south of Abaco Island, continuing south along the eastern side of The Bahamas, through the Mona Channel and commencing at the Port of San Juan (Swartz et al. 2002). The specific objectives of the cruise were to determine winter distributions and abundances of cetaceans in waters to the east of the Bahamas and around Puerto Rico and the Virgin Islands, collect cetacean vocalization recordings, record associated environmental data, and deploy and retrieve acoustic bottom recorders to investigate the possibility of long-term acoustic monitoring at various sites (Swartz et al. 2002).

Stranding Data Sources

- Marine mammal stranding networks are under the jurisdiction of NMFS and are nominally based on the administrative regions of the NMFS (Geraci and Lounsbury 1993). Wilkinson and Worthy (1999) discuss the genesis of marine mammal stranding networks in the U.S. Legal authority for U.S. stranding networks is contained in the Marine Mammal Protection Act (MMPA). In the Marine Mammal Health and Stranding Response Act (in the 1992 Amendments to the MMPA), Congress made it a national policy to monitor the various factors affecting the health of marine mammal populations; collection and analyses of stranded marine mammals have contributed much to what is known about each species (Becker et al. 1994). To respond to strandings, volunteer stranding networks were established in all coastal states of which the Southeast Marine Mammal Stranding Network (SEMMSN) is an example. The NMFS is responsible for cetacean and pinniped strandings in the vicinity of the MRA study area, while manatee (*Trichechus manatus*) strandings are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). The SEMMSN was established in 1977 to collect and archive stranding data (Odell 1991). The Smithsonian Institution traditionally has been the final repository of stranding data.
- The Sea Turtle Stranding and Salvage Network (STSSN) is a network of private citizens as well as state and federal agencies from the coastal states of the Atlantic and Gulf of Mexico established to document and collect important information on sea turtles that strand along the coast. The STSSN encompasses the coastal areas of the 18-state region from Maine through Texas, and includes portions of the U.S. Caribbean (Teas 1993). There are four regions (U.S. Gulf of Mexico, southeast U.S. Atlantic, northeast U.S. Atlantic, and Caribbean). Regions are further broken down into statistical zones originally designed by the NMFS for shrimp catch and effort data collection (Teas 1993). The STSSN is under the jurisdiction of NMFS. Sea turtle strandings along the Atlantic coast have been recorded since 1980 (Shaver and Teas 1999). The Department of Natural Resources (DNR) from each state collects the stranding data, which are then reported to the NMFS, and with permission of each state, releases the sea turtle stranding data. Species, size, location, condition, and final disposition of stressed or dead turtles are recorded. Permission for NMFS-SEFSC (Wendy Teas) to release turtle stranding data from each state bordering the study area is required for use of the data. Sea turtle stranding data for Florida are derived from multiple sources, including FMRI's Atlas of Marine Resources (Flamm et al. 2000) and directly from the FFWCC-FMRI.
- The Bahamas Marine Mammal Research Organisation (BMMRO; formerly known as Bahamas Marine Mammal Survey, see below for more information on the BMMRO) has compiled marine mammal stranding records for The Bahamas since 1944.
- The Caribbean Stranding Network (CSN), established in October 1989, was created to coordinate stranding efforts of marine vertebrates throughout the Caribbean region (Pinto-Rodríguez et al. 1992). The CSN is under the direction of the Puerto Rico Department of Natural Resources (PRDNR) and has a stranding agreement with NMFS for marine mammal stranding response and rehabilitation

(Mase 2007). The CSN documents stranding events throughout the Caribbean region, organizes stranding records into a marine mammal stranding database, coordinates with local and federal agencies in U.S. territories and local Caribbean governments, and assists in the creation of regional stranding networks in the Caribbean (Mignucci-Giannoni et al. 1999). This database includes records for Bahamian waters from 1851 to 2001.

Data Sources for Incidental Fisheries Bycatch

The Pelagic Longline Observer Program began in 1992 at the Miami Laboratory of the NMFS-SEFSC, when systematic sampling by scientific observers on board U.S. pelagic longline vessels (permitted to land and sell swordfish) was mandated by 1991 amendments to the U.S. Fishery Management Plan for Swordfish (Yeung 2001). Since October 1995, the NMFS-SEFSC has fully assumed the implementation and data management of the observer program for the entire Atlantic longline fishery, which was previously shared with the NMFS-NEFSC (Yeung 2001). The focus is on the pelagic longline fishery operating in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. The target species are swordfish and tuna. Bycatch and incidental catch of undersized swordfish, Atlantic billfish (marlins, sailfish), sea turtles, marine mammals, and other non-target species by pelagic longline gear has been a major concern for several years. The program's mission is to collect data on-effort, directed catch and bycatch quantity, morphometrics, biological characteristics, and interaction with marine mammals, sea turtles, and birds (Scott and Brown 1997). Longline fisheries are known to cause injury and/or mortality to loggerhead and leatherback turtles (Epperly et al. 2001), as well as small numbers of other turtle species.

Tagging Data Sources

- Since 1975, the University of Central Florida (UCF) Marine Turtle Research group has studied marine turtles along Florida's central east coast. Current sea turtle studies take place in the central region of the Indian River Lagoon and in the Trident Submarine Turning Basin at Pt. Canaveral (CCC 2005b). From **2001 to 2005**, UCF researchers conducted the Florida Juvenile Green Turtle Tracking Project to determine movement patterns of juvenile green turtles once they leave the Florida coast. Since 2001, 10 green turtles (*Chelonia mydas*) have been satellite tagged and tracked by researchers.
- The Florida Leatherback Tracking Project of **1994** was conducted jointly between researchers from the UCF and Hubbs-SeaWorld Research Institute (CCC 2003). The purpose of this project was to track post-nesting migrations of leatherbacks from the central Florida coast. In 1994, one leatherback (*Dermochelys coriacea*) was satellite-tagged after nesting near Melbourne, FL.
- From **July 1998 to August 2000**, researchers from the NMFS, Florida Department of Environmental Protection (DEP), and UCF have attached satellite transmitters to post-nesting loggerheads near Melbourne, FL as part of the Florida Atlantic Coast Loggerhead Turtle Tracking Project (CCC 2005a). The purpose of the project is to locate the primary foraging grounds and migratory routes of Florida loggerheads (*Caretta caretta*). Since 1998, 15 loggerheads have been tagged and tracked from the Melbourne, FL area.
- Loggerheads and green turtles, satellite tagged and tracked by various organizations along the Western Atlantic coast have been observed passing through the MRA study area. Sea turtles within the study area were tagged by the U.S. Geological Survey, USWFS, Georgia Loggerhead Tracking Project, South Carolina Loggerhead Sea Turtle Study, Duke Marine Laboratory (DUML) Sea Turtle Telemetry Project, Virginia Institute of Marine Science (VIMS) Sea Turtle Tracking Program, and the Marine Turtle Research Group.
- From **2000 to 2002**, the Strategic Environmental Research and Development Program (SERDP), Office of Naval Research (ONR), and researchers from Wood Hole Oceanographic Institute (WHOI) coordinated on the Acoustic Response and Detection of Marine Mammals using an Advanced Digital Acoustic Recording Tags (CS-1188) project (SERDP 2002). Sperm whales (*Physeter macrocephalus*), beaked whales (*Ziphiidae*), and pilot whales (*Globicephala macrorhynchus*) in the AUTEC range were tagged with digital acoustic recording tags to track how marine mammals respond, behaviorally and physiologically, to man-made noise. The specific objectives of this study were to examine the feasibility of using acoustic tagging to monitor the location, abundance, and behavior of marine mammals in Navy testing areas, as well as evaluate long-term effects of defense training on marine mammals (SERDP 2000, 2002).

- Since **2000**, researchers at the Marine Life Center of Juno Beach, DUML, and Wider Caribbean Sea Turtle Conservation Network (WIDECAST) have coordinated on the Leatherback Project to determine critical habitat for leatherbacks during the inter-nesting period (Eckert et al. 2006; MCJB 2004a and 2004b). Researchers have been attaching satellite transmitters to adult leatherbacks after nesting at Juno Beach and Melbourne Beach, FL and tracking their subsequent movements. One hundred and forty-five leatherbacks have been tagged since the inception of the project (MCJB 2004a). Eckert et al. (2006) describes the satellite tracking of post-nesting leatherbacks, tagged at Juno Beach and Melbourne Beach from May 2000 through June 2003. This satellite tracking study was a collaborative effort between the Marine Life Center of Juno Beach, DUML, WIDECAST, and UCF.
- The Archie Carr Center for Sea Turtle Research (ACCSTR) has conducted several sea turtle telemetry projects in the Bahamas to determine sea turtle migratory and distribution patterns as well as identify environmental correlates of such behaviors (ACCSTR 2005). Current telemetry studies in the Bahamas include tracking the movements of a rehabilitated olive ridley (*Lepidochelys olivacea*), post-nesting movements of loggerheads, and movement patterns of juvenile green turtles. On **01 June 2001**, an olive ridley sea turtle, previously caught by a fisherman, was released off western Andros and satellite-tracked for a 16-week interval (Bolten and Bjorndal 2006). This particular tracking study was collaboration between the ACCSTR, The Bahamas Department of Fisheries, and The Bahamas National Trust (BNT).
- The Florida Fish and Wildlife Conservation Commission (FFWCC) has conducted in-water tagging of green, loggerhead, Kemp's ridley (*Lepidochelys kempii*), and hawksbill turtles (*Eretmochelys imbricata*) in Florida and adjacent waters (FFWCC 2005g). Turtles are captured at sea, measured, tagged, and released. Blood samples are collected as well. The objectives of this study are to characterized life history stages of Florida sea turtles and identify habitats and threats specific to life history stages.
- On **03 March 2005**, Mote Marine Laboratory (MML) collaborated with Harbor Branch Oceanographic Institution (HBOI) to release three rough-toothed dolphins (*Steno bredanensis*) off Hutchinson Island, southeast of Fort Pierce, FL (Manire and Wells 2005). All three dolphins had previously stranded in August 2004 during a mass stranding event at Hutchinson Island, FL. The dolphins, tagged with VHF and satellite transmitters, traveled into the Gulf Stream, parallel to the continental shelf off Florida, Georgia, and South Carolina (Manire and Wells 2005).
- In **April 2005**, the Marine Animal Rescue Society (MARS) released two rough-toothed dolphins, previously stranded in the March 2005 Florida Keys mass stranding event, off Miami, FL. One dolphin was tagged with a satellite transmitter and moved along the coast as north as Charleston, SC (Wells 2007). In **May 2005**, an additional seven rough-toothed dolphins, previously stranded in the Florida Keys mass stranding event, were released with satellite and VHF tags near Key Largo, FL (Wells 2007). All seven dolphins traveled to shallow water habitats off of Andros Island in the Bahamas. The tracking and release program was a cooperative effort between the Marine Mammal Conservancy (MMC), Dolphins Plus, and the MARS. In **September 2005**, the MMC satellite tagged and released an additional two rough-toothed dolphins, previously stranded during the Florida Keys mass stranding event. Individuals were released east of the Florida Keys and traveled to the northern coast of Cuba (Wells 2007). More information regarding satellite tracking efforts may be found at: http://www.sarasotadolphin.org/DolphinRescues/roughtooth2006.asp
- From **17 October to 05 November 2006**, a beaked whale tagging study was conducted at AUTEC in the Tongue of the Ocean (TOTO) as a collaborative effort between BMMRO and Woods Hole Oceanographic Institution (WHOI) and with the support of the Naval Undersea Warfare Center (NUWC) (BMMRO 2007a). A D-tag was successfully deployed on an adult female Blainville's beaked whale (*Mesoplodon densirostris*) on 23 October. The purpose of the study was to collect baseline data on beaked whale diving behavior.

Miscellaneous Data Sources

- The Programme Intégré des Recherches sur les Oiseaux Pélagiques (PIROP) is a database for seabird observations collected from the whole eastern Canadian coast, from the Gulf of Maine to the Canadian Arctic, and some other regions, between 1966 and 1992 (Hüttmann and Lock 1997). PIROP was established as a monitoring program for the vulnerability of seabirds to oil spills in eastern Canadian waters. Vessel-based surveys were carried out year-round from platforms of opportunity during the years **1966 to 1992**, with most surveys occurring in the summers of **1975 to 1987**. Most platforms were provided by the Bedford Institute of Oceanography in Dartmouth (Halifax). During surveys, marine mammal sightings were also documented.
- From **1978 to 1984**, the NMFS conducted trawling research to capture and tag sea turtles in the Cape Canaveral, FL area. Research trawls were conducted to assess seasonal occurrences, size compositions, and movement patterns of Kemp's ridleys, greens, and loggerheads (Henwood 1987; Henwood and Ogren 1987). The study area encompassed the coastal waters of eastern Florida from 28°15'N north to 28°30'N. For Kemp's ridley turtles, the study area was extended north to include Georgia and South Carolina coastlines (Henwood and Ogren 1987).
- The Wild Dolphin Project (WDP) has conducted a long-term study of Atlantic spotted dolphins (*Stenella frontalis*) in The Bahamas since **1985** (WDP 2005). Small boat-based surveys have been conducted over shallow sandbanks, north of Grand Bahama Island to document life history parameters as well as examine the behavior and communication of Atlantic spotted dolphins (Herzing 1996; 1997). Bottlenose dolphin behavioral studies have also been conducted by researchers in coordination with the WDP in waters along the western edge of Little Bahama Bank, north of Grand Bahama Island (Rossbach and Herzing 1999). The majority of WDP surveys are in shallow waters, adjacent to the study area.
- The Southeast Area Monitoring and Assessment Program (SEAMAP) collects, manages, and disseminates fishery-independent data for the southeastern U.S. to provide resource survey data to state/federal management agencies and universities (SEAMAP 2001b). In the South Atlantic region, SEAMAP surveys include a shallow water trawl survey, the Pamlico Sound survey, benthic characterization, and a bottom mapping project. Sea turtle data were collected during shallow water trawl surveys, which were conducted from Cape Hatteras, NC to Cape Canaveral, FL from **April 1989 through April 2001** (excluding winter season sampling) in waters 4.6 to 9.1 m in depth. Whenever sea turtles were caught, the location was recorded and the turtle was measured, weighed, and tagged. These trawl surveys were both SEAMAP- and South Carolina Department of Natural Resources (SCDNR)-directed sea turtle surveys.
- Since **1991**, the BMMRO (formerly known as BMMS), has conducted line-transect and opportunistic small boat-based surveys as part of a long-term study to determine the occurrence of cetaceans in Bahamian waters (BMMRO 2007b). The specific objectives of the study are to determine the occurrence, seasonality, and abundance of marine mammals in the Bahamas as well as to examine the life history parameters, population size, and habitat requirements of the resident bottlenose dolphin population near central Abaco (BMMRO 2007b). Marine mammal surveys have been conducted around Abaco in the Atlantic as well as in the NE and NW Providence Channel, northern Grand Bahama and Bimini in the Florida Straits, northern Andros near the TOTO, northern Eleuthera in the Northeast Providence Channel, and the northern Exuma Cays in Exuma Sound. Aerial surveys were conducted in 1999. Sea turtle sightings were recorded from aerial and vessel platforms in 1999 as well.
- Small boat surveys were conducted **May and August between 1998 and 2000 in May 2001** east of Great Abaco, The Bahamas (MacLeod et al. 2004; MacLeod and Zuur 2005; MacLeod 2007). The study area was constructed to cover a wide range of habitat types and was approximately 35 km in length and up to 16 km in width, with the southern edge aligned with the 26°20'N parallel and the western edge aligned with the 77°00'W meridian.
- The Dolphin Communication Project (DCP) has documented Atlantic spotted dolphin behavior and communication at White Sand Ridge, north of Grand Bahama Island, The Bahamas since **1991** (DCP 2005). In 2001, an additional study was initiated to collect behavioral and communication data on

Atlantic spotted dolphins around Bimini, along the Great Bahama Bank. Data is collected aboard small vessels as well as by underwater video and bioacoustic recordings. The specific objectives of these studies are to analyze group dynamics and signal exchange among dolphins. Most DCP research is conducted adjacent to the study area.

- The NMFS-SEFSC conducted aerial surveys for bluefin tuna (*Thunnus thynnus*) over the Great Bahama Bank and in the vicinity of the Bimini Islands and sand cays from **19 May to 09 June 1995** (Lutcavage et al. 1997a). Marine mammal and sea turtle sightings were recorded opportunistically. Aerial survey transects for bluefin tuna were flown along Tuna Alley, near the Great Bahama Bank from 24 45'N north to approximately 25 48'N. The objectives of the surveys were to document the abundance and behavior of bluefin tuna, and compare the results with those of previous NMFS aerial surveys.
- The Northern Right Whale Project is managed by Fleet Area Control and Surveillance Facility, Jacksonville (FACSFACJAX), as directed by COMCLANTFLT. The Navy partially funds state fish and wildlife agencies' efforts to patrol right whale migration routes with light aircraft, to spot and report whale sightings. Sightings are used to coordinate Navy ship and aircraft clearance into the critical habitat and the surrounding OPAREA based on a host of factors, including the frequency of whale sightings. Right whale sightings are reported to ships, submarines, and aircraft. All sightings made during aerial surveys were reported to FACSFACJAX in real time and then relayed to the EWS. The FACSFACJAX has a communications network and reporting system that ensures the widest possible exchange and distribution of right whale sighting information to Department of Defense and civilian shipping. The database that FACSFACJAX maintains is accessible to the public at its website (http://www.facsfacjax.navy.mil) and contains sighting information from EWS (NEAQ, FMRI, Georgia Department of Natural Resources (GADNR)), shore-based observers, Navy, USCG, and private boaters. Data was incorporated into the NARWC database.
- The NARWC is a collaborative effort supported by the NMFS and managed by the URI, with the purpose of collecting and centralizing North Atlantic right whale research in the western Atlantic Ocean. The database was provided by the NARWC.
- The AUTEC marine mammal environmental compliance program collected opportunistic sightings in the AUTEC range from **1997 to 2002** (DoN 2005b). Sightings of marine mammal species and sea turtles were recorded as well as environmental correlates and type of platform.
- Sea turtle nesting data for leatherbacks, loggerheads, and green turtles has been collected by the FFWCC from Palm Beach, FL north to Brevard County, FL since **1988** (FFWCC 2005e; FFWCC 2005f; FFWCC 2005g). All nesting data includes nesting totals for each county as well as dates of first and last nests per season for each species.
- Marine mammal acoustic detection studies have been conducted at AUTEC in the TOTO for the past 30 years (Perkins 1987; Ward 2002). From **27 June 2000 through 18 October 2001**, the NUWC conducted a sperm whale bioacoustics characterization study using the M3R systems (Ward 2002). Passive acoustic data was recorded from hydrophones located on the TOTO seafloor at AUTEC to detect and localize marine mammals in the area (Ward 2002). The specific objectives of the project were to spatially and temporally characterize sperm whale bioacoustics behavior, population structure, and spatial distribution within the TOTO (Ward 2002). More recent passive acoustic studies at AUTEC have focused on the detection and localization of beaked whales using the M3R systems (Moretti et al. 2006b).
- From **March through December 2001**, the Canadian Navy coordinated with the Bahamas Marine Mammal Survey (BMMS) (now known as BMMRO) to conduct visual and acoustic monitoring for marine mammals in Exuma Sound, Bahamas (Bottomley and Theriault 2002). Monitoring was conducted during sea trials of LFA sonar, Towed Integrated Active Passive Sonar (TIAPS), developed by the Defense Research and Development Canada (DRDC).

Published Literature and Reports

Oftentimes published papers and reports are the most useful media for presenting opportunistic sightings, strandings, and even whaling catches. The occurrence data contained within the following documents were especially useful for species that are not frequently seen during dedicated surveys (e.g., killer whales), that are not easily distinguished to species (e.g., beaked whales), or for which there is little information regarding their occurrence in the study area (e.g., smaller sea turtles).

- Moore (1953) compiled reports of marine mammal species occurrences in FL waters to compose the first list and identification key for Florida marine mammal species. Information was dated from as early as **1513 and extended to 1953**. The list included two seal species, one manatee species, nine whale species, and nine dolphin species (Moore 1953).
- Sighting and stranding records of killer whales (*Orcinus orca*) ranging from the Bay of Fundy to the Equator were synthesized for the period from **1817 to 1987** by Katona et al. (1988). One hundred and seventy-seven reports of killer whales were compiled from published and unpublished literature as well as from data files of major data clearinghouse centers (Katona et al. 1988); data was also received by request of solicitations sent to cetacean researchers known to work within the study area.
- Odell et al. (1978) summarized manatee sightings in the Bahamas. Four manatee records were available for **1904, 1965, and 1975**.
- Several reports of stranded hooded seals (*Cystophora cristata*) were documented from North Carolina to The Virgin Islands from **1910 to 1996** (Mignucci-Giannoni and Odell 2001). Three hooded seal strandings occurred within the study area during this time.
- Jefferson and Schiro (1997) assembled and analyzed all available historical, published, and unpublished cetacean records in the northern Gulf of Mexico. The authors reviewed all records to verify species identifications. In addition to the data used in the Jefferson and Schiro (1997) paper, the historical database also included marine mammal occurrence data from the southern Gulf of Mexico and Florida Keys. Dates of the historical database span from 1921 to 1994. Sightings appear on the MRA map, west of the MRA study area; these sightings span from **1942 to 1985** (Jefferson 2002).
- A report of a single beaked whale stranding on Green Turtle Cay, The Bahamas was summarized by Moore (1958). The documented stranding occurred on **17 October 1944** on the shore of Green Turtle Cay, near the western side of Abaco Island.
- From **1953 to 1963**, Layne (1965) collected records of distribution, measurements, and ecology of 12 cetacean species, one pinnipeds species, and one manatee species in Florida waters. Species accounts were based on live sightings and strandings recorded in Florida.
- On **08 December 1964**, Struhsaker (1967) documented the occurrence of a minke whale (*Balaenoptera acutorostrata*) in the northern Bahamas. The whale was located 28 km east of Great Abaco Island and 37 km north of the Northeast Providence Channel. This sighting represents one of the earliest reliable reports of free-ranging minke whales in the study area.
- Beaked whale life history, occurrence, and morphology information were compiled from worldwide stranding records (Mead 1989). Many stranding records provided insight into beaked whale anatomical characteristics, morphometrics, and distribution. Gervais' beaked whale and Blainville's beaked whale strandings were documented in southeast Florida from **1965-1984**.
- In **1971**, the *RV Pillsbury* of the University of Miami recorded sightings of a minke whale in Exuma Sound (Winn and Perkins 1976). Three adults and one calf were also sighted in **1974** in the Old Bahama Channel (Winn and Perkins 1976). Acoustic recording and visual observations were collected to determine ranges of minke whales in tropical waters. Minke whale records for the Caribbean were reviewed by Winn and Perkins (1976).
- In 1974, the Virginia Institute of Marine Science (VIMS) completed a baseline summary report for the U.S. Atlantic region between Cape Hatteras, NC and Cape Canaveral, FL for the Bureau of Land Management (BLM; currently known as the MMS). The area covered included the continental shelf to the 200 m isobath. The purpose of this report was to provide a comprehensive listing and description

of marine mammal species from Cape Hatteras, NC to Cape Canaveral, FL (Caldwell and Caldwell 1974).

- The first documented striped dolphin (*Stenella coeruleoalba*) sighting on the east coast of Florida was reported by Odell and Chapman (1976). On **14 January 1974**, one striped dolphin was reported stranded on Hutchinson's Island, FL.
- Taruski and Winn (1976) reported the occurrences of odontocete sightings in the Caribbean. This report documents three pilot whale sightings within the study area.
- Beaked whale life history, occurrence, and morphology information were compiled from worldwide stranding records (Mead 1989). Many stranding records provided insight into beaked whale anatomical characteristics, morphometrics, and distribution. Between **1976 and 1983**, five Gervais' beaked whales (*Mesoplodon europaeus*) were documented in the portion of the Florida study area. One Blainville's beaked whale was documented at Cocoa Beach, FL in 1984.
- In 1979, the Center for Natural Areas updated the 1974 VIMS report for the BLM and expanded the geographic coverage to the 1,500 m isobath. This report reviewed published literature, unpublished data, and research programs, as well as identified information gaps. Winn et al. (1979) summarized marine mammal information from this study.
- From **April 1980 through April 1981**, the USFWS conducted systematic aerial surveys for the BLM (currently known as the MMS) over the outer continental shelf and adjacent waters of the western Atlantic Ocean and Gulf of Mexico from Cape Hatteras, NC to the U.S.-Mexico border near Brownsville, TX (Fritts et al. 1983a, 1983b). A pilot study was initiated in June 1979 and data were collected in four areas of the Gulf of Mexico during August and November 1980 (Fritts et al. 1983a). The purpose of these surveys was to determine faunal composition (marine mammals, sea turtles, and birds), estimate faunal densities related to geographic and seasonal parameters, and identify areas of major biological importance for decision-making related to offshore oil and gas resource development (Fritts et al. 1983a).
- Balcomb (1981) reported three sightings of one to five beaked whales in the Bahamas. Although species level was generally not identified, this is one of the earliest sighting records of beaked whales in the cruise the study area.
- Schmidly (1981) synthesized all available data and literature about cetaceans and pinnipeds from Cape Hatteras, NC to the Florida Keys (and from the Florida Keys to the U.S./Mexico boundary near Port Isabel/Brownsville, TX) for the BLM and the USFWS in 1981. Unfortunately, in many cases only the year for the sighting or stranding was reported, so these compilations could not be used to determine seasonal occurrence patterns for whales, dolphins, or porpoises. The original sources for Schmidly's summary were utilized (e.g., stranding data and Caldwell and Golley 1965).
- Wilson et al. (1987) provided numerous records of striped dolphins occurring within the study area. These records, most of which are sightings and strandings, summarize older NOAA data, vessel of opportunity sightings, and museum collection data.
- Reeves and Mitchell (1988) summarized the stranding, sighting, and other published and unpublished records of killer whales in the western North Atlantic. This paper documents four killer whale sightings in the study area.
- Reid (2000, 2001) provided reports of manatee sightings from **1998 to 2001** in the Bahamas. All sightings were likely of one individual.
- Manatee sightings and strandings in the Bahamas were summarized by Lefebvre et al. (2001). Reports occurred from **1904 to 1999** in areas including Grand Bahama Island, the Exumas, Eleuthera, New Providence, Andros, Berry Islands, Bimini, and Abaco. Several sightings were documented by BNT. Reports summarized in Odell et al. (1978), Reid (2000), and Reid (2001) were described as well.
- Foley et al. (2003) summarizes the first records of olive ridley occurrences in the eastern United States. All records took place in Florida and were reported between 1999 and 2001. One olive ridley

record occurs in the AUTEC map view, a pelagic-phase juvenile stranded just north of Miami, FL in **2001** (Foley et al. 2003).

- Fertl et al. (2003) compiled worldwide sighting and stranding records of the Clymene dolphin (*Stenella clymene*) to update the status of this species.

Protected Species Data Included in the Southeastern Florida and AUTEC-Andros OPAREA MRA

Comprehensive datasets and occurrence records for aerial and shipboard sighting surveys, strandings, incidental fisheries bycatch, tagging, and miscellaneous and opportunistic encounters in the study area as well as those from published literature and reports were compiled for this MRA. The datasets compiled for this MRA report, acquired from federal, state, private, and academic institutions, agencies, and organizations, are not representative of all data records ever recorded for marine mammals or sea turtles in the study area. The compiled datasets (Table A-1) acquired for this MRA represent the datasets that were available for inclusion in this report; the compiled data, however, are sufficient to detail the protected species occurrences potentially occurring within the study area.

Datasets from aerial and shipboard sighting surveys represent the vast majority of the datasets obtained for inclusion in this MRA. While aerial and shipboard sighting surveys are designed to follow a pre-determined survey design consisting of transect lines, surveys often for many reasons deviate from the planned lines or do not follow the plan in straight line segments. Where possible, we have noted the actual survey track rather than the pre-determined track so that the extent of the study area covered by sighting surveys will be accurately depicted (Figures A-1 through A-4). It should be noted that aerial and shipboard surveys have been conducted over a large portion of the continental shelf of Florida, especially during winter (Figures A-1 through A-4).

Table A-1. Inventory of marine mammal and sea turtle data included in the MRA for southeastern Florida and the AUTEC-Andros OPAREA.

DATA SOURCE	RECORD DATES
NMFS-SEFSC Aerial Surveys	
Southeast Turtle Surveys (SETS)—leatherback and loggerhead turtle records only	1982-1984
Southeast Florida Surveys (McClellan)	1995-1997
Southeast Cetacean Aerial Surveys (SECAS)	1992, 1995
Mid-Atlantic *Tursiops* Surveys (MATS)—turtle data only	1994 to 1995
Mid-Atlantic *Tursiops* Surveys (MATS)	2004, 2005
Non-NMFS Aerial Surveys	
Bahamas Marine Mammal Research Organisation (BMMRO)	1999, 2001-2005
MMMNUAR—NW Providence Channel and AUTEC OPAREA	2003
DoN *SEAWOLF* Shock Trials	1995, 1997
DoN CSA Surveys	1998-1999
DoN *Winston S. Churchill* Shock Trial	1999
North Atlantic Right Whale Consortium (NARWC) Database	
URI Right Whale Surveys	1987
New England Aquarium (NEAQ) Right Whale Surveys	1989 to 1992
DoN Northern Right Whale Project: FACSFACJAX Database	1996 to 2002
NMFS-SEFSC Shipboard Surveys	
NOAA Ship R/V *Oregon II* Cruise OT-92-01 (198)	1992
NMFS-SEFSC R/V *Relentless* Cruise 98-01 (3)	1998
NOAA Ship R/V *Oregon II* Cruise OT-99-05 (236)	1999
NOAA Ship R/V *Gordon Gunter* Cruise GU-02-01 (21)	2002

Table A-1. Inventory of marine mammal and sea turtle data included in the MRA for southeastern Florida and the AUTEC-Andros OPAREA (cont'd).

DATA SOURCE	RECORD DATES
NOAA Ship R/V *Gordon Gunter* Cruise GU-04-03 (28)	2004
NMFS-SEFSC Visual and Acoustic Surveys	
NOAA Ship R/V *Gordon Gunter* Cruise GU-01-01 (11), Leg 1	2001
Strandings	
Smithsonian Marine Mammal Stranding Database	1882 to 2000
Bahamas Marine Mammal Research Organisation (BMMRO) Marine Mammal Stranding Data	1944 to 2006
Caribbean Stranding Network (CSN) Marine Mammal Stranding Database	1971 to 1995
Florida Sea Turtle Strandings (FFWCC)	1989 to 2005
NMFS-SEMMSN Marine Mammal Stranding Data	1981 to 2006
Incidental Fisheries Bycatch	
NMFS-SEFSC Longline Fishery Bycatch	1992 to 1999
NMFS-SEFSC Pelagic Observer Program	2000 to 2004
Tagging	
Duke North Atlantic Tracking Program	2003 to 2004
WhaleNet	1998
Archie Carr Center for Sea Turtle Research (ACCSTR)	2001
Caribbean Conservation Corporation (CCC)	1999; 2004 to 2005
Miscellaneous	
Caribbean Stranding Network (CSN) Marine Mammal Sighting Database	1851 to 1995
North Atlantic Right Whale Consortium (NARWC) Database	1935 to 2005
PIROP Opportunistic surveys	1966 to 1992
Bahamas Marine Mammal Research Organisation (BMMRO), Boat-based Surveys	1987 to 2005
SEAMAP (SCDNR)	1989-2001
NMFS-SEFSC Longline Bycatch (logbook sightings)	1992 to 1999
Navy AUTEC Opportunistic Marine Mammal Sightings	1997 to 2002
Sea Turtle Nests—Florida (FFWCC)	1988, 2001, 2004
Published Literature and Reports	
Reeves and Mitchell (1988)	1851 to 1876
Fertl et al. (2003)	1905 to 2001
Katona et al. (1988)	1913 to 1960
Mignucci-Gianonni and Odell (2001)	1916 to 1993
Wilson et al. (1987)	1938 to 1986
Jefferson and Schiro (1997)	1942 to 1985
Moore (1958)	1944
Moore (1953)	1948-1951, 1988

Table A-1. Inventory of marine mammal and sea turtle data included in the MRA for southeastern Florida and the AUTEC-Andros OPAREA (cont'd).

DATA SOURCE	RECORD DATES
Struhsaker (1967)	1964
Mead (1989)	1965-1984
Taruski and Winn (1976)	1971
Winn and Perkins (1976)	1971 to 1974
Odell and Chapman (1976)	1974
Fritts et al. (1983a)	1979 to 1981
Balcomb (1981)	1980 to 1981
Winn et al. (1979)	1975, 1977
Foley et al. (2003)	2001

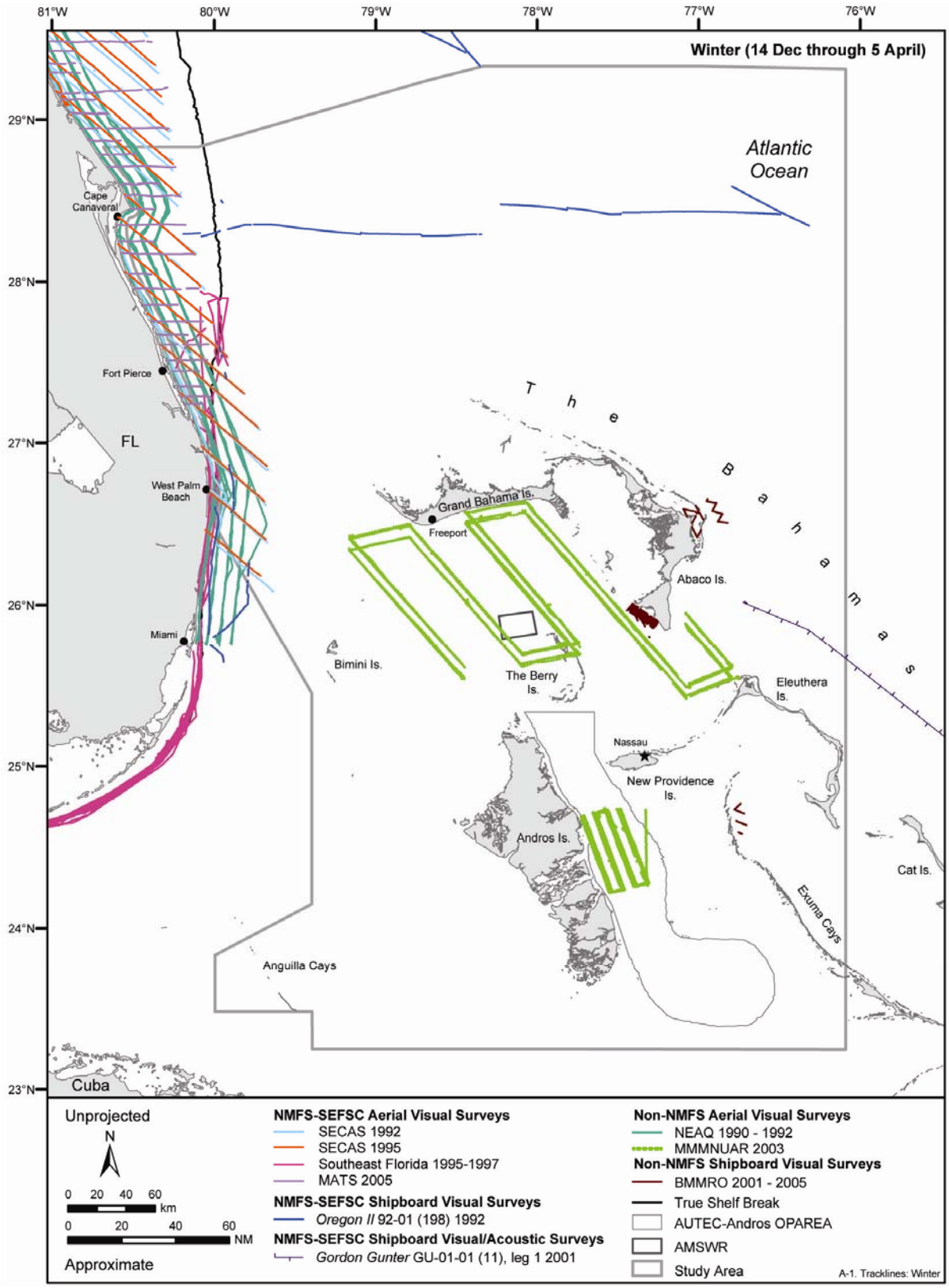

Figure A-1. Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the winter season.

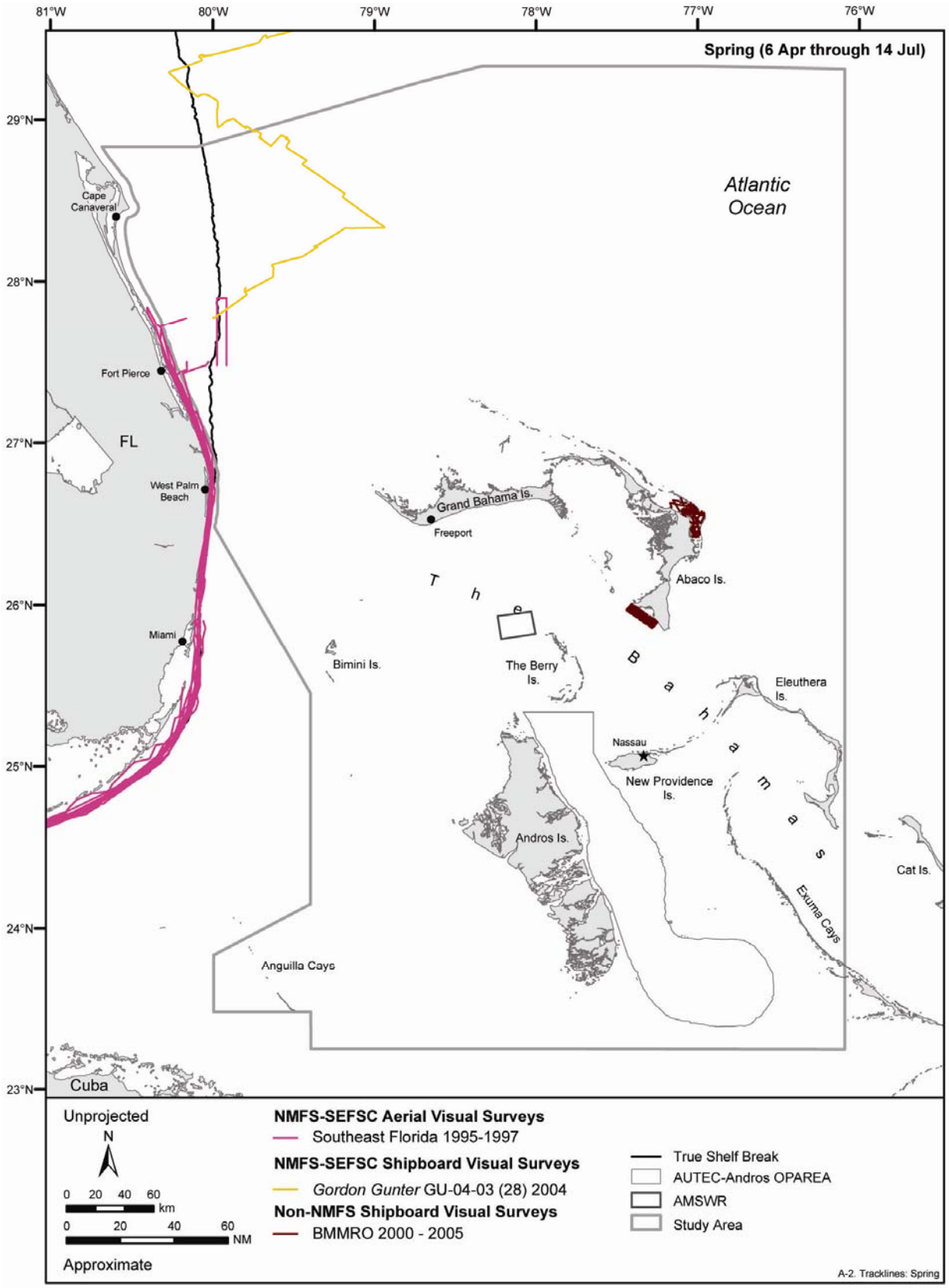

Figure A-2. Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the spring season.

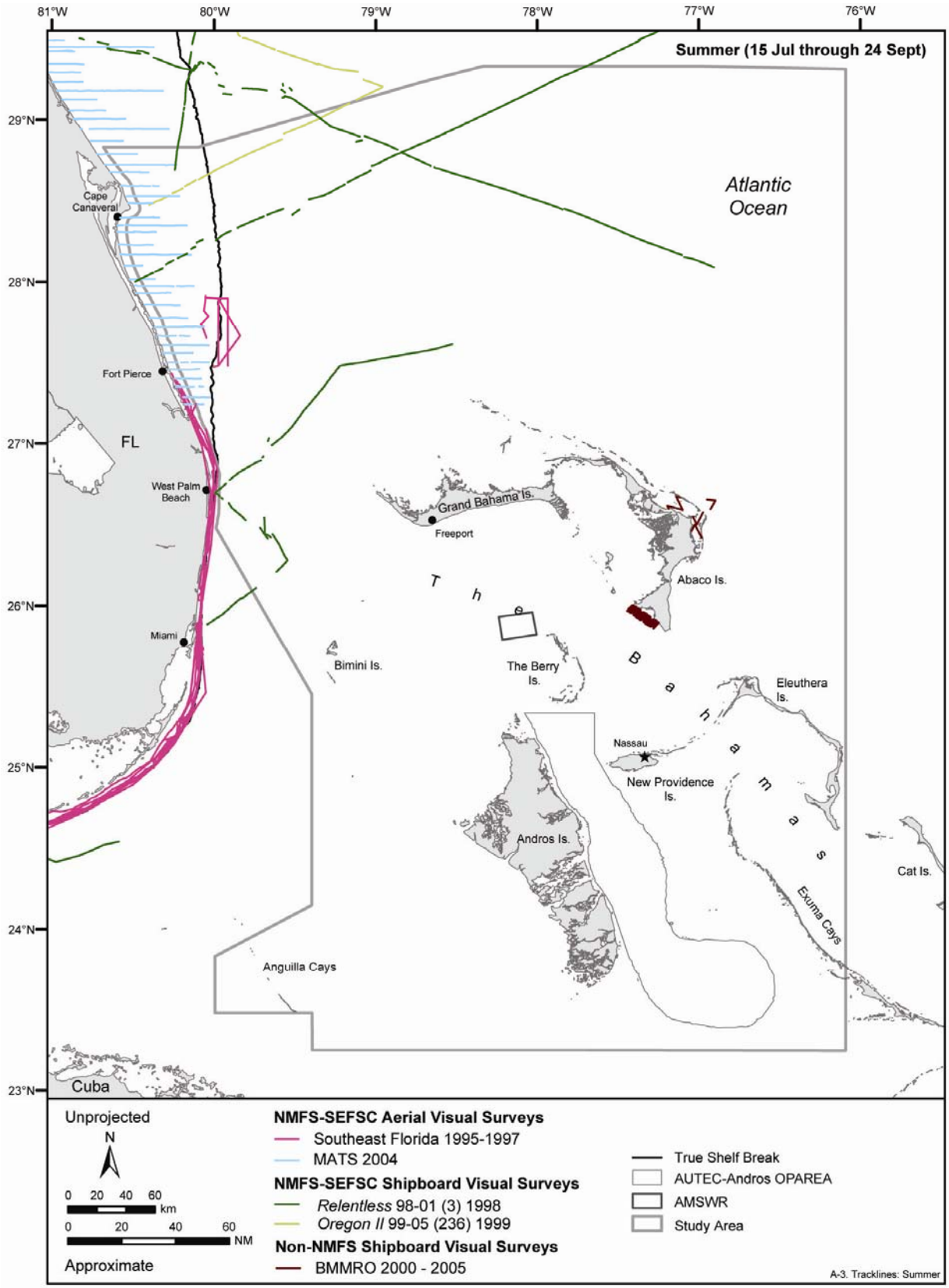

Figure A-3. Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the summer season.

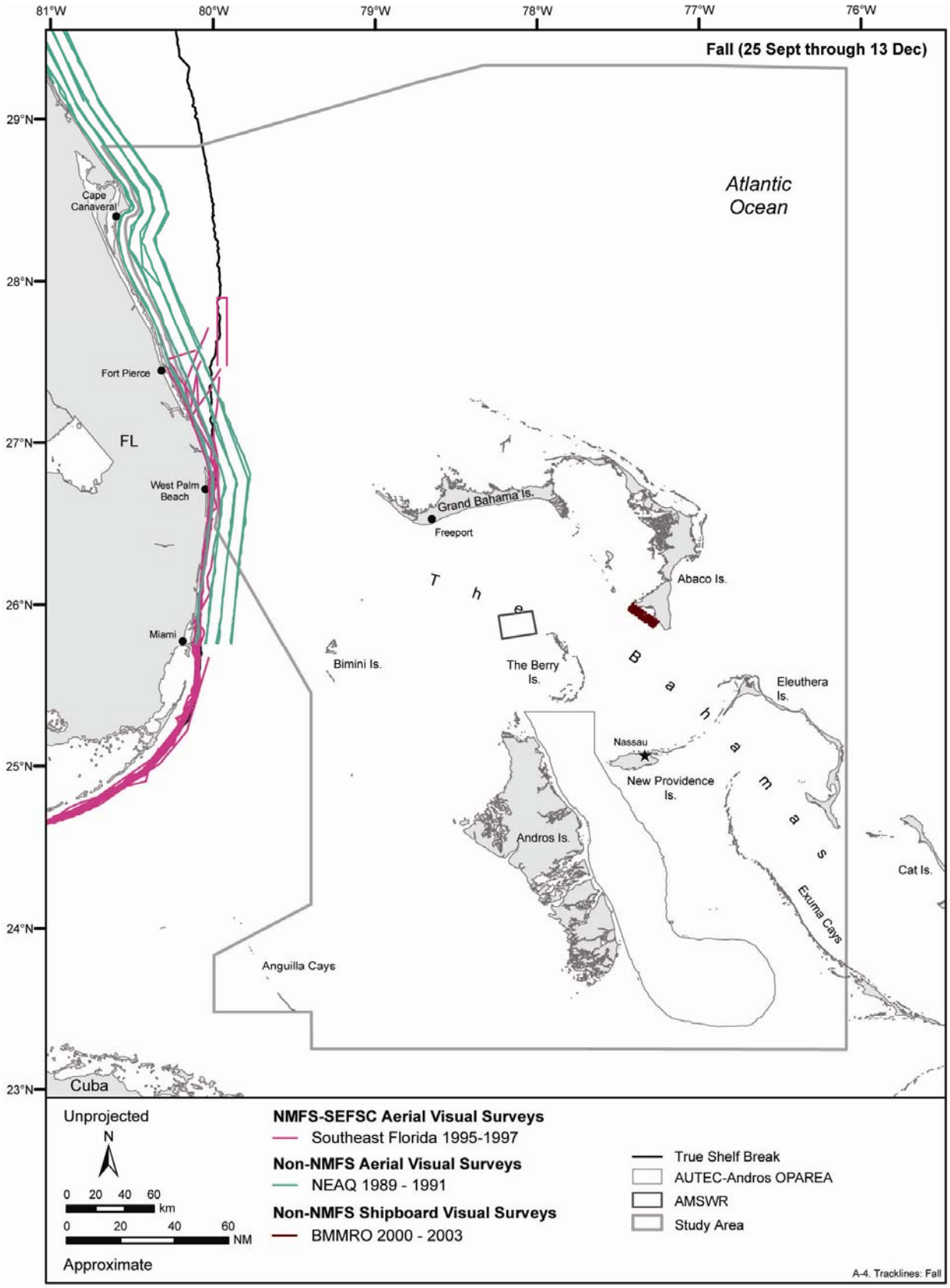

Figure A-4. Tracklines and transect coordinates for aerial and shipboard surveys in the study area for the Southeastern Florida and AUTEC-Andros MRA during the fall season.

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APPENDIX B: MARINE MAMMALS

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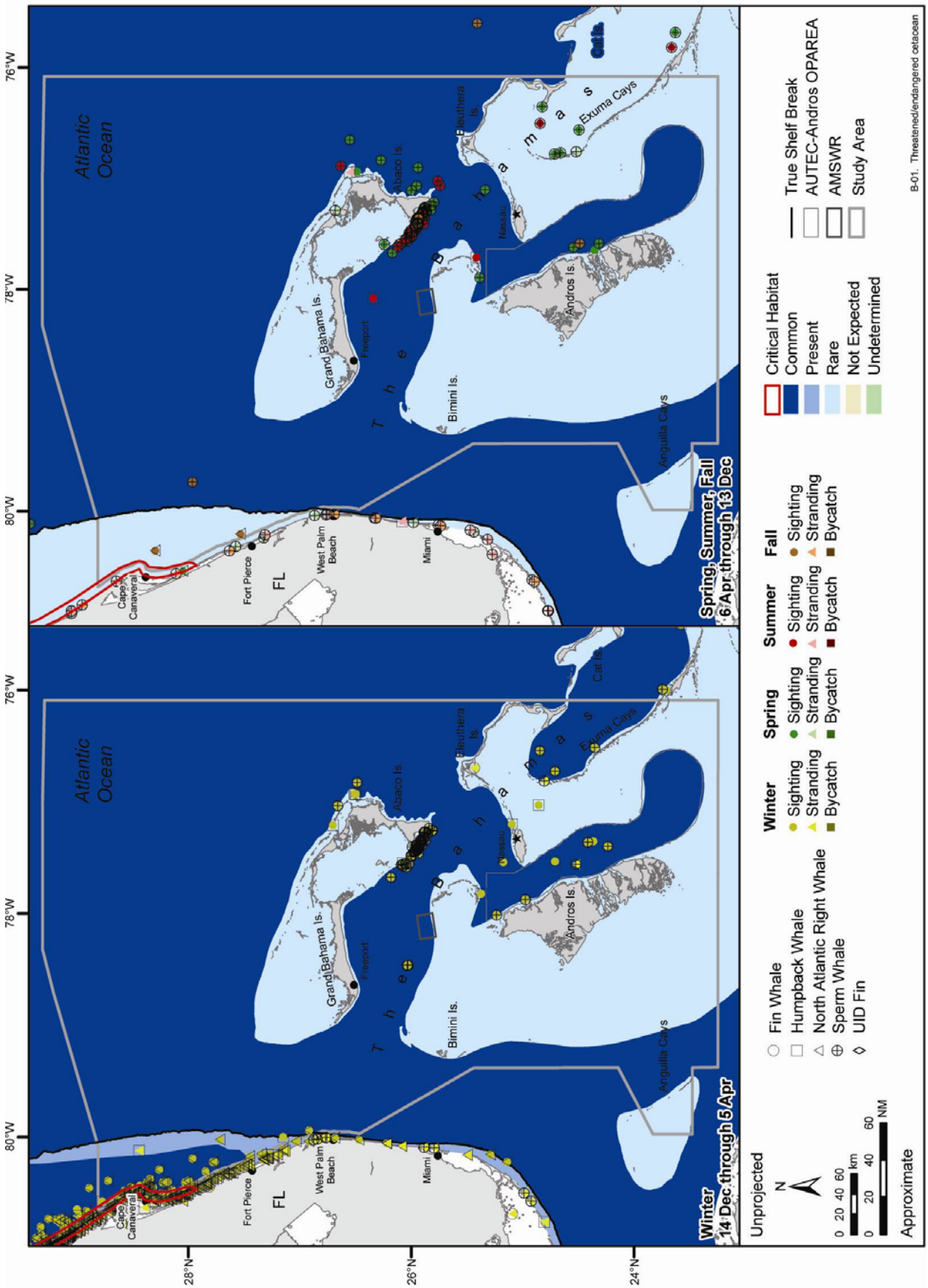

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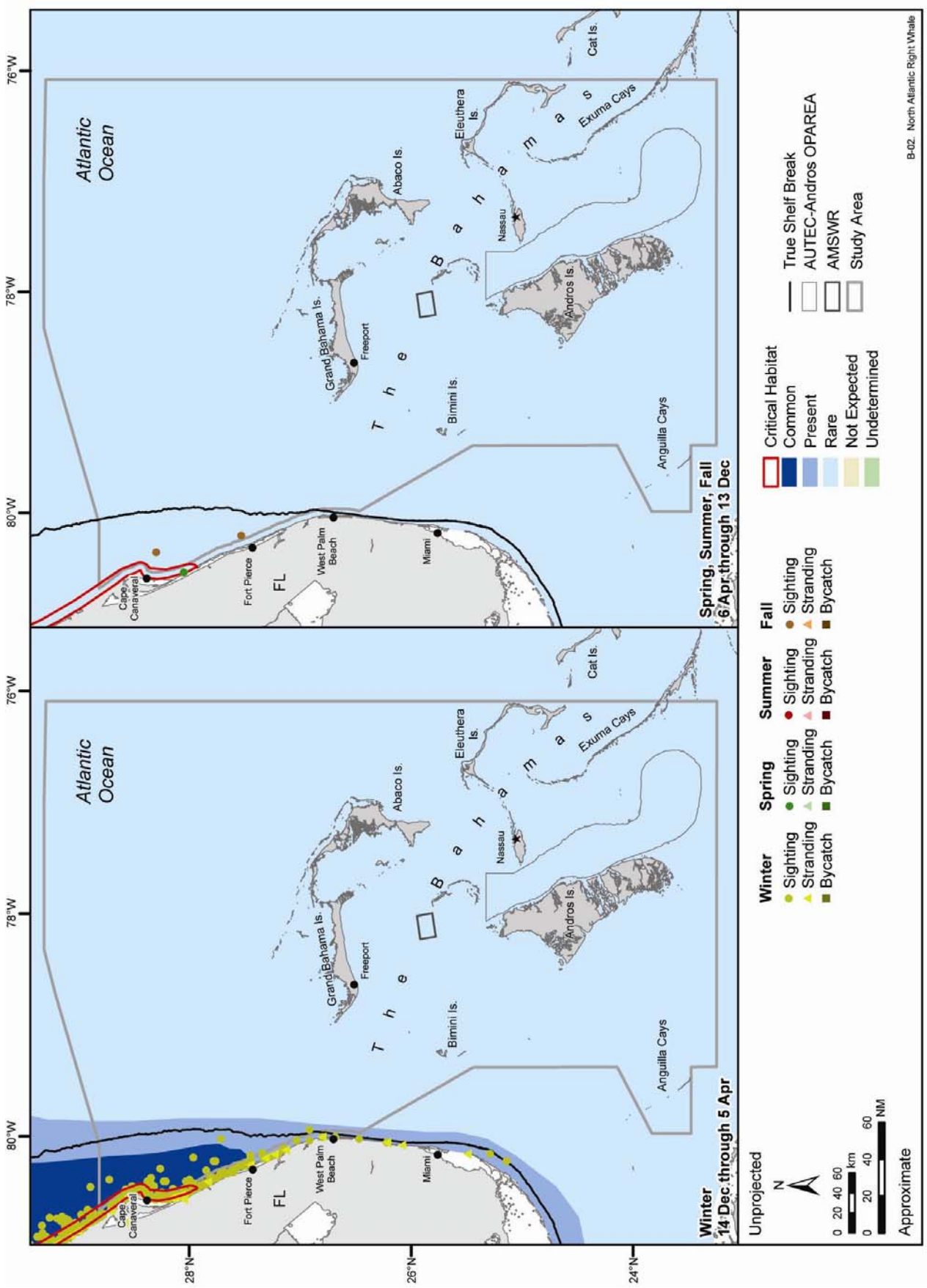


Figure B-2. Occurrence of the North Atlantic right whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

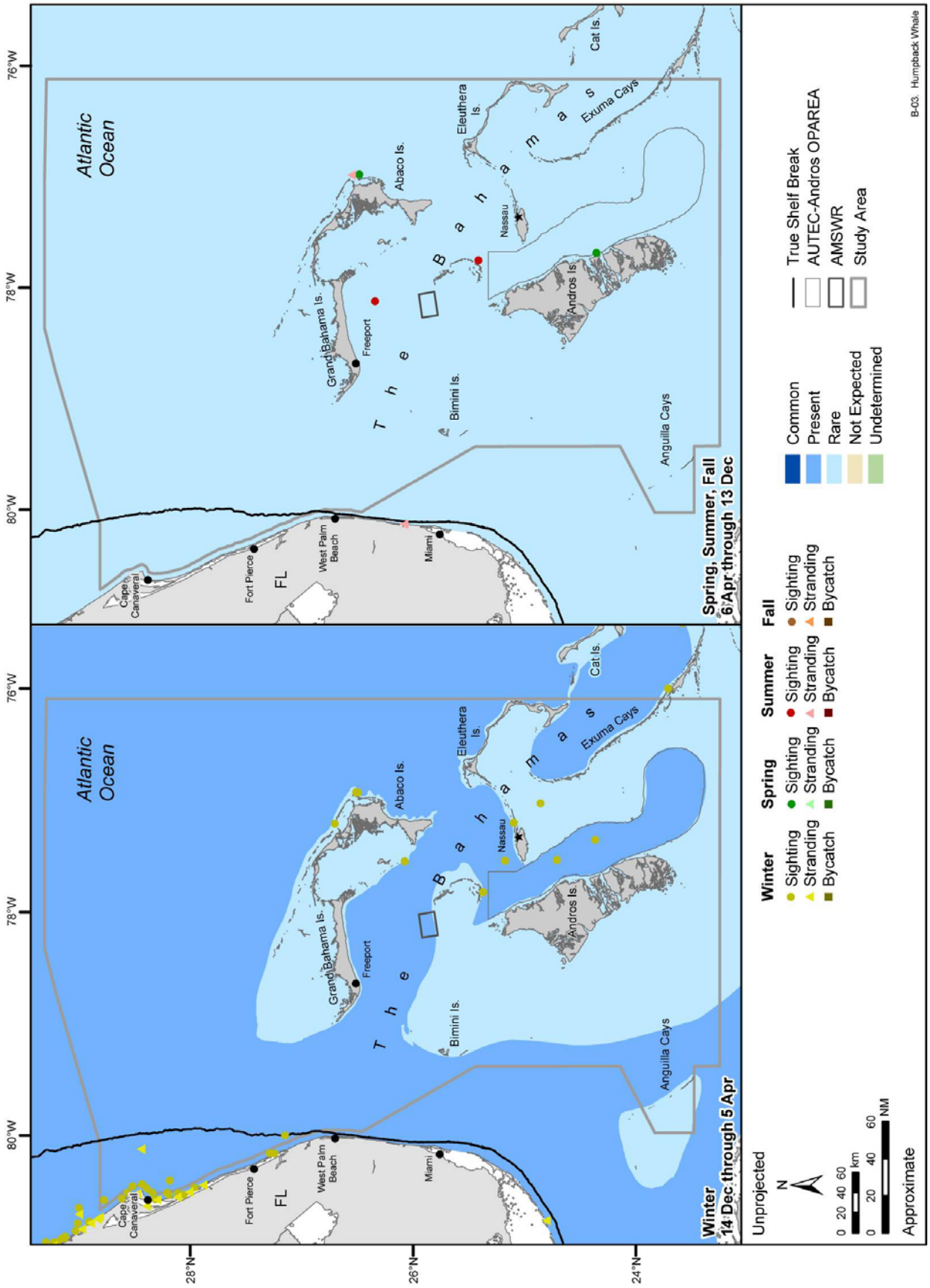


Figure B-3. Occurrence of the humpback whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

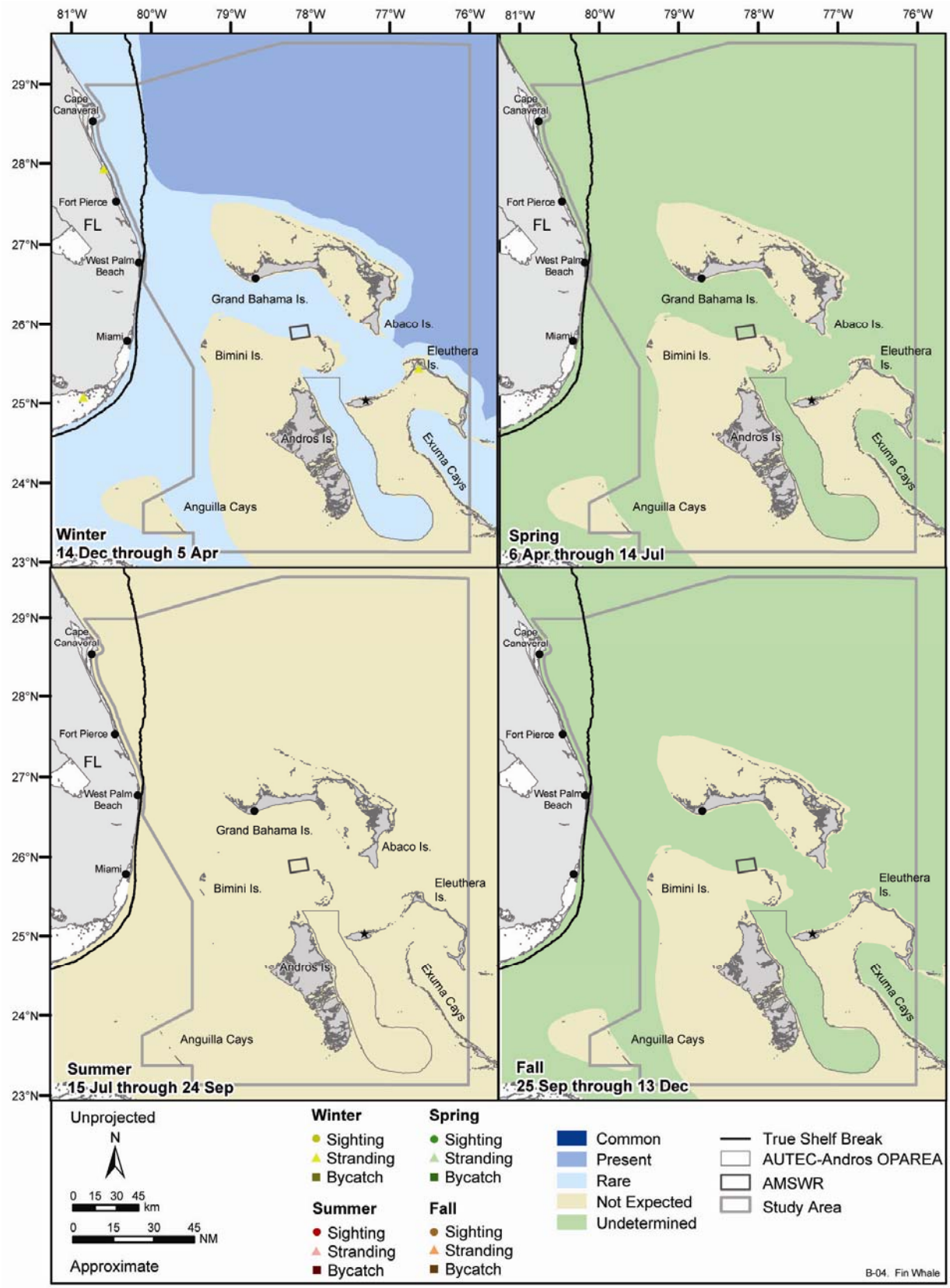


Figure B-4. Occurrence of the fin whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

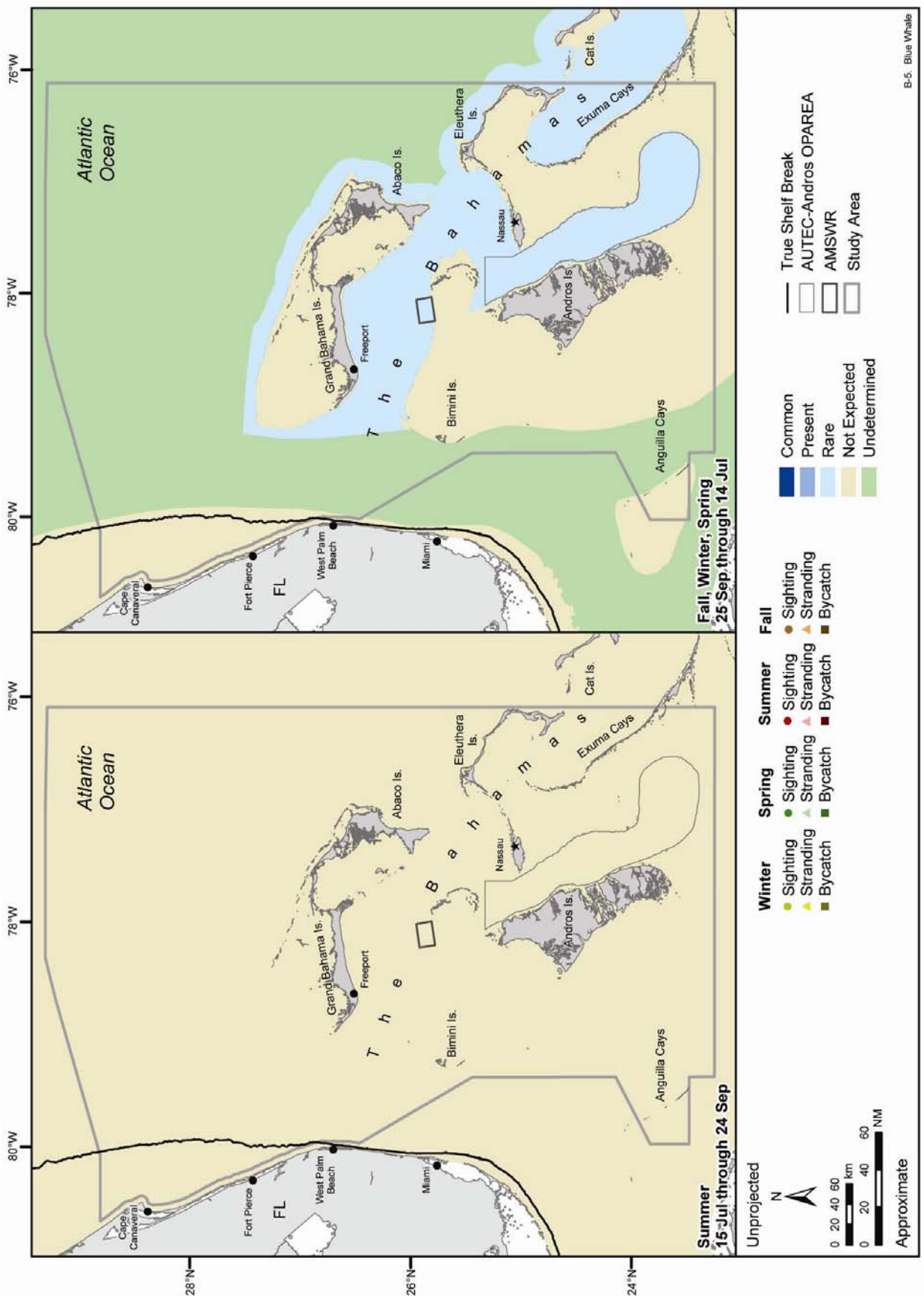


Figure B-5. Occurrence of the blue whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

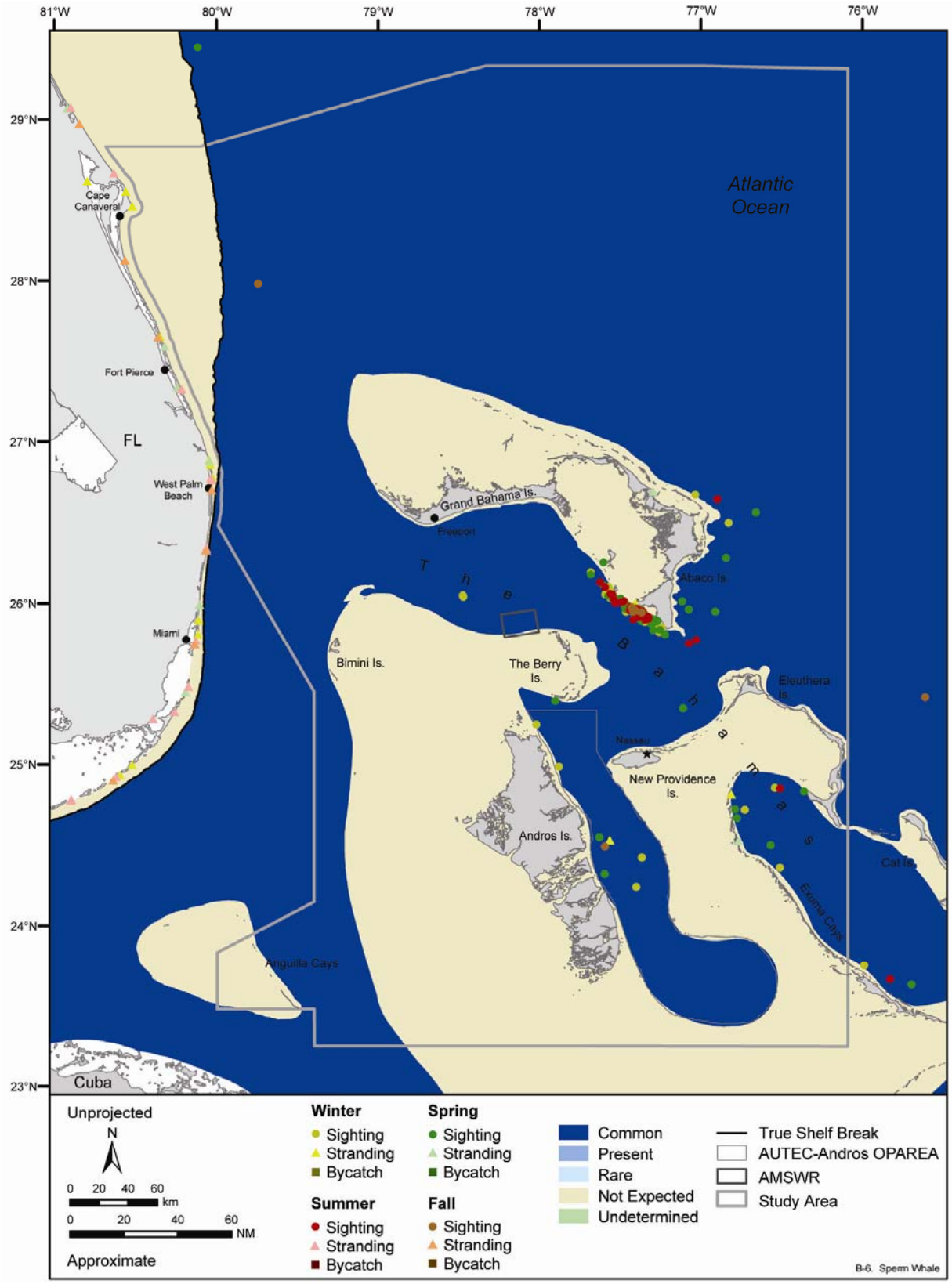


Figure B-6. Occurrence of the sperm whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

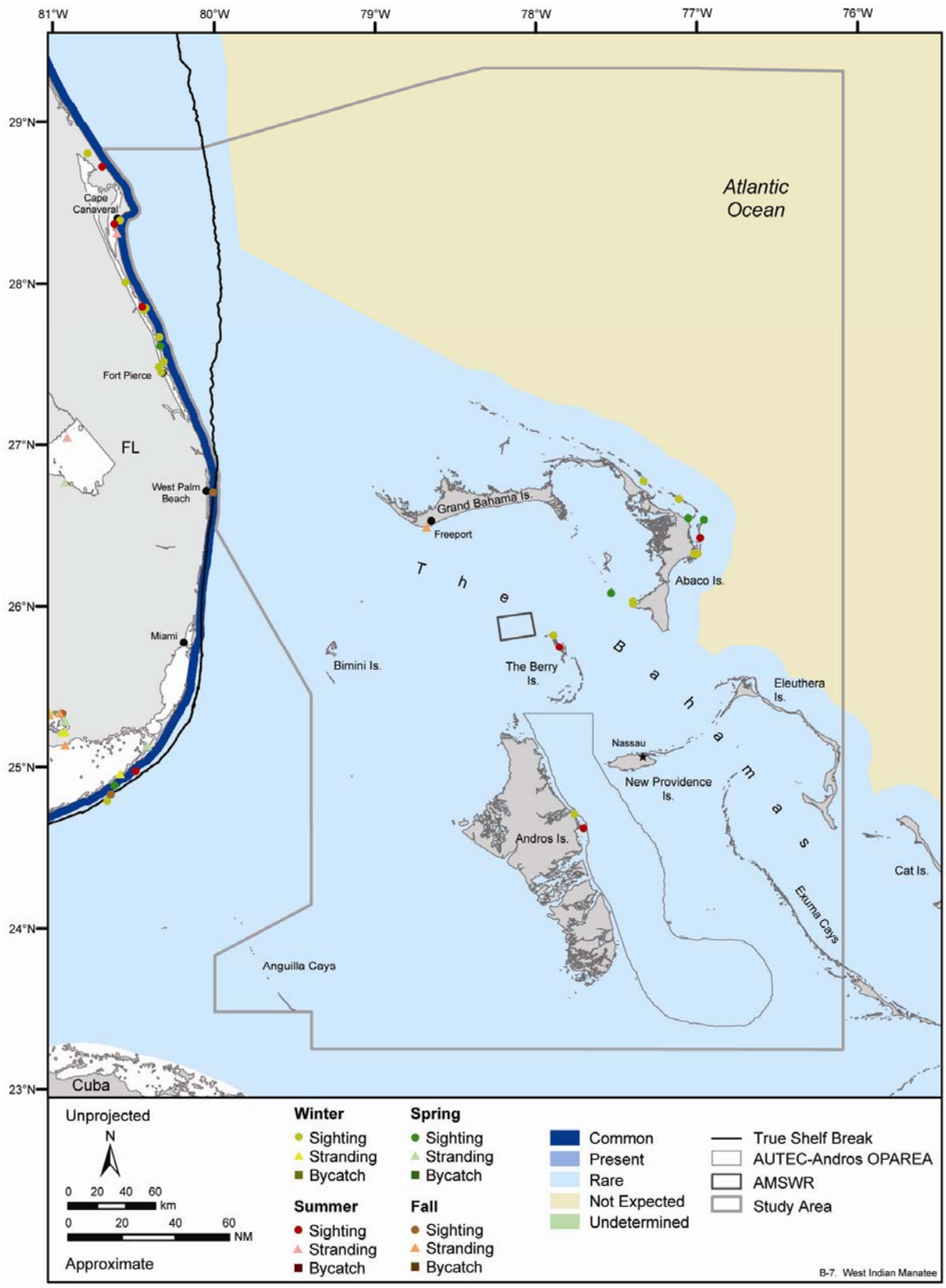


Figure B-7. Occurrence of the West Indian manatee in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

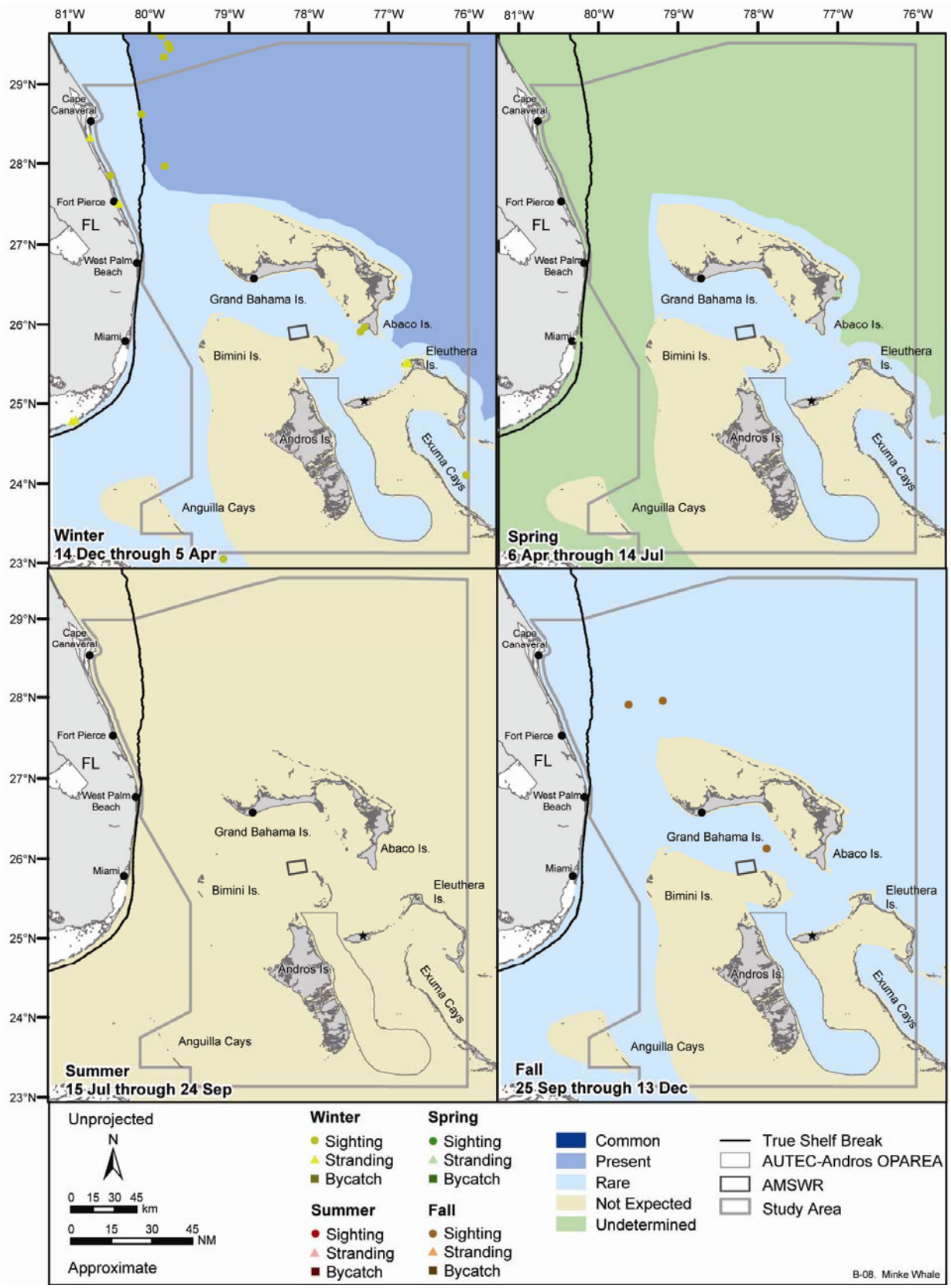


Figure B-8. Occurrence of the minke whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

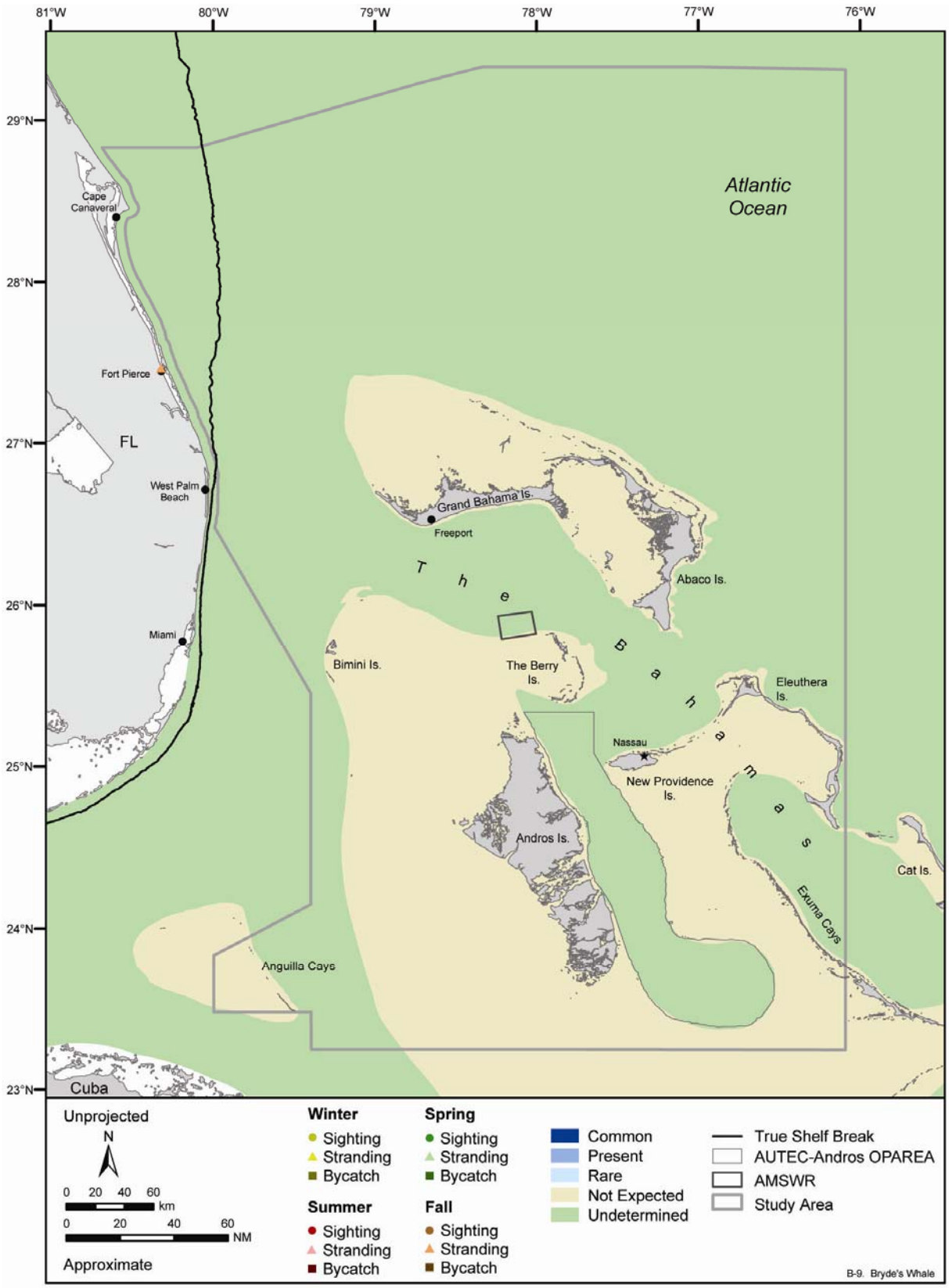


Figure B-9. Occurrence of the Bryde's whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

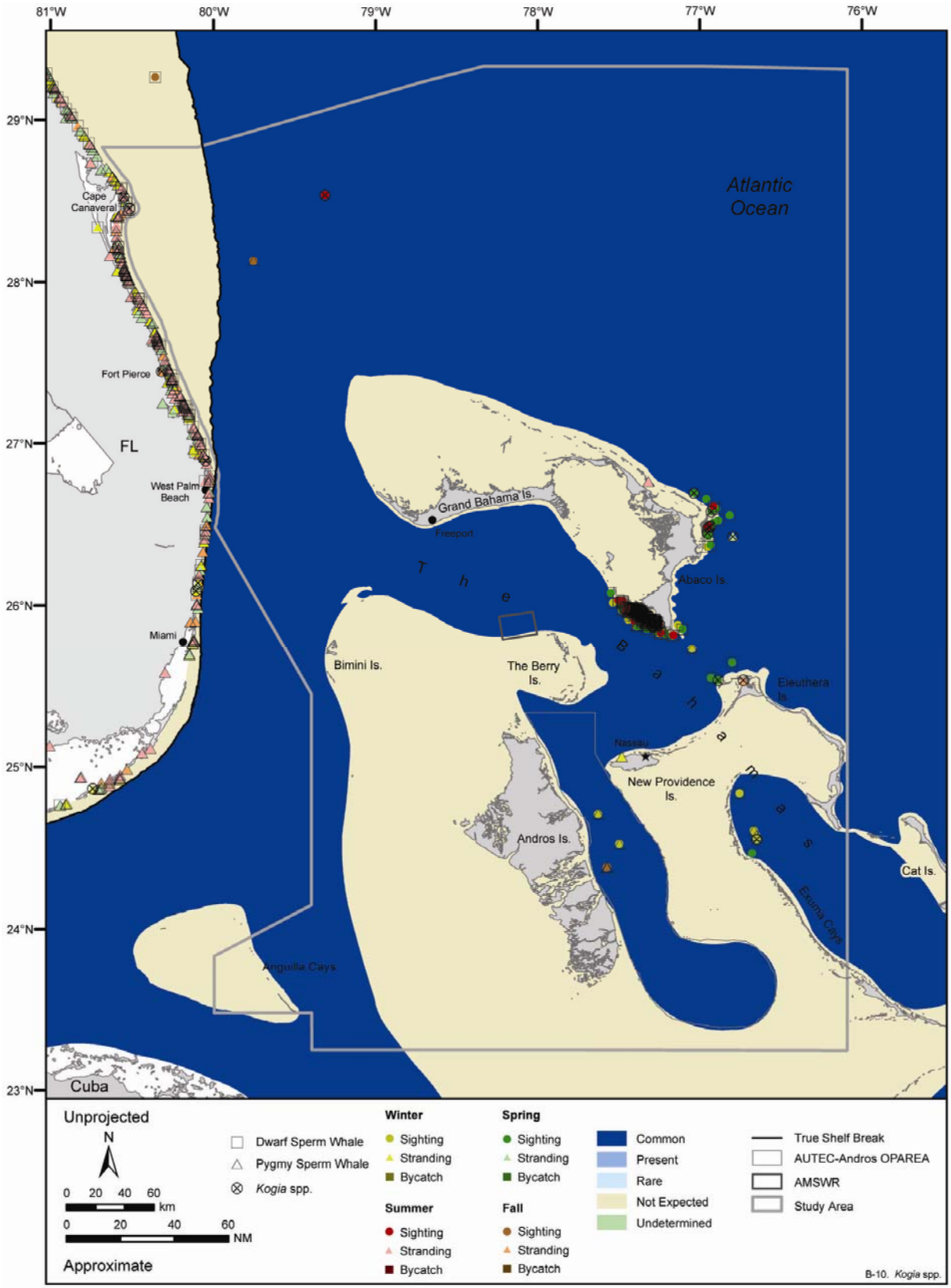


Figure B-10. Occurrence of *Kogia* spp. in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

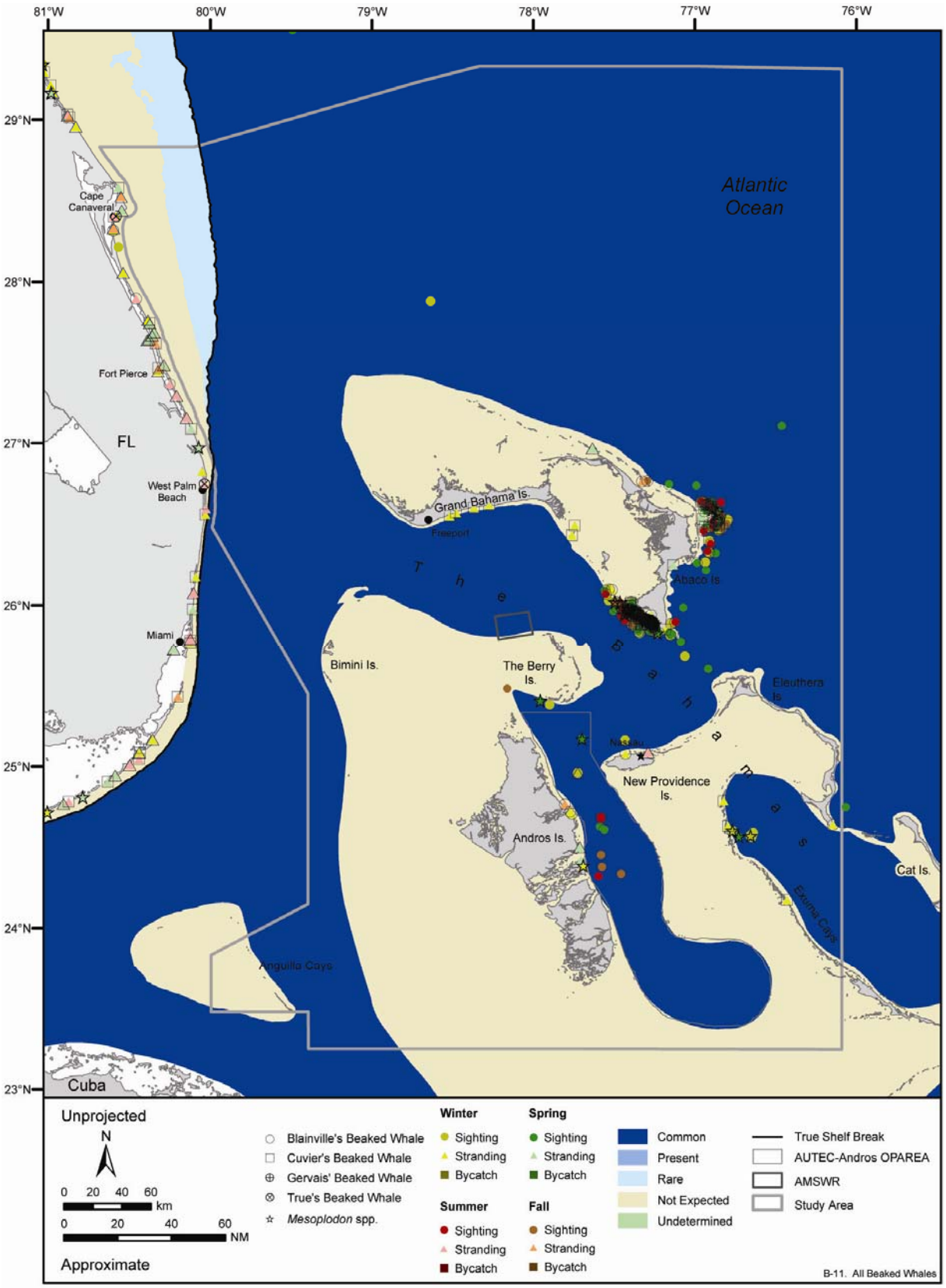


Figure B-11. Occurrence of beaked whales in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

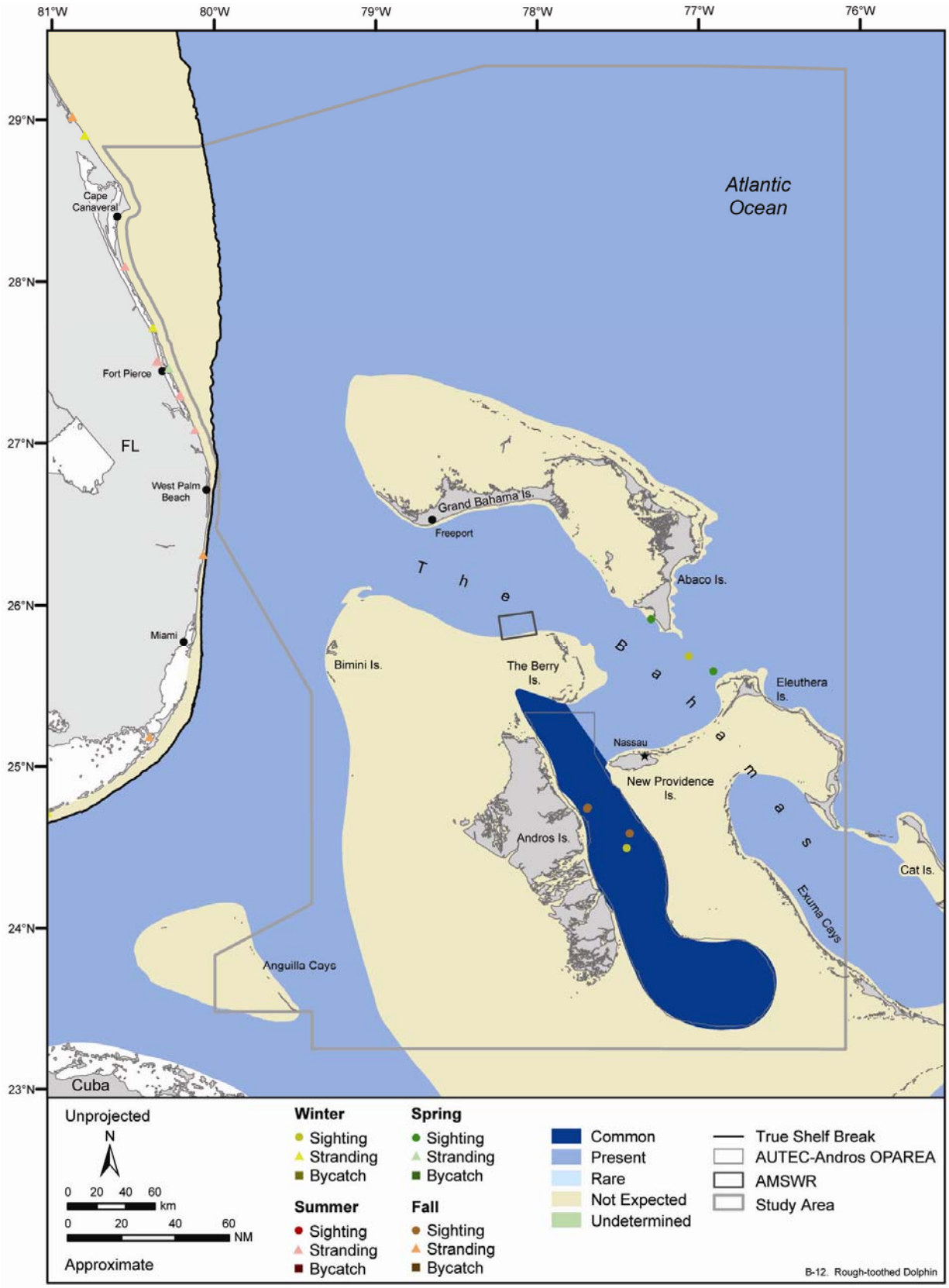


Figure B-12. Occurrence of the rough-toothed dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

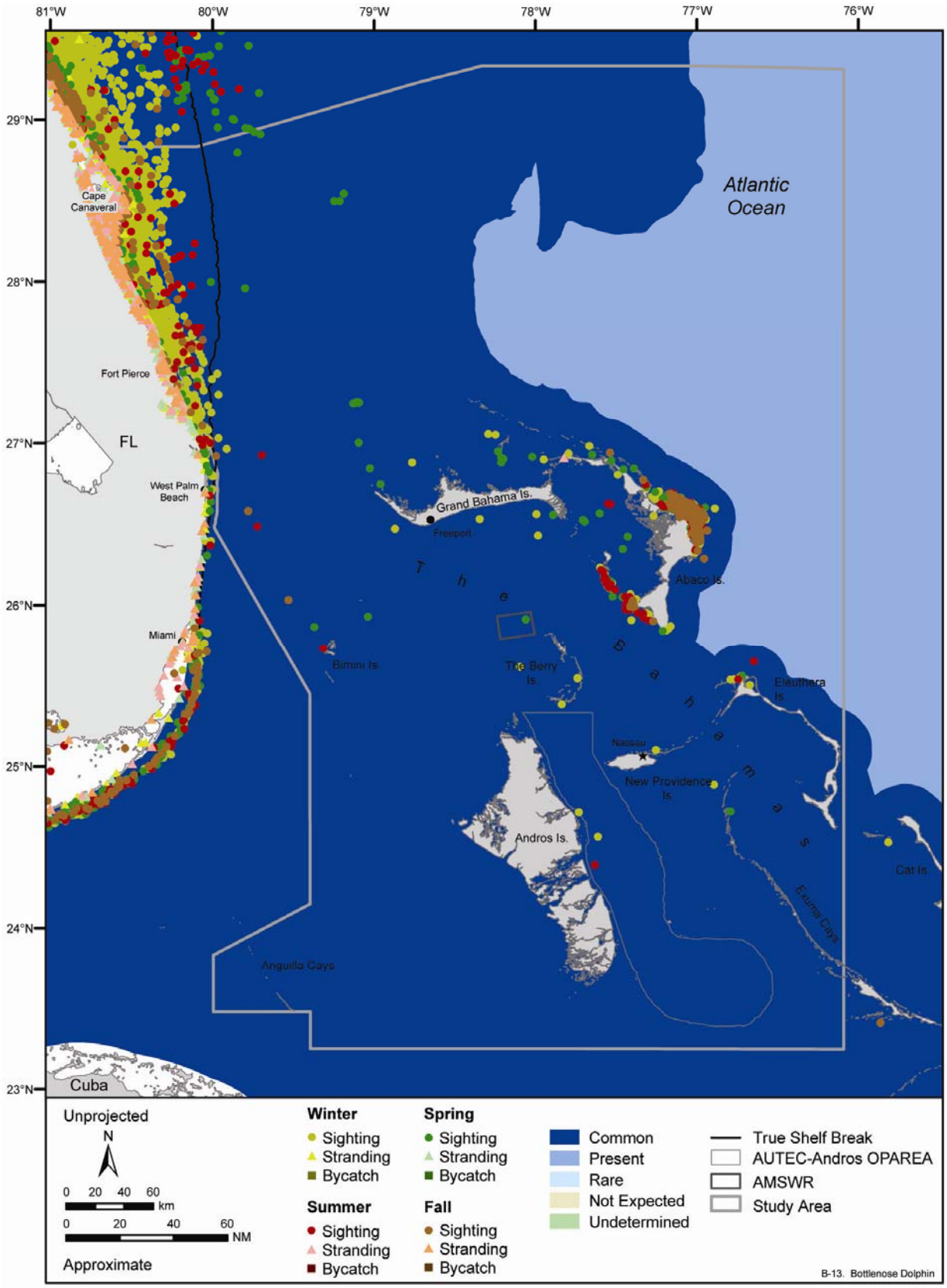


Figure B-13. Occurrence of the bottlenose dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

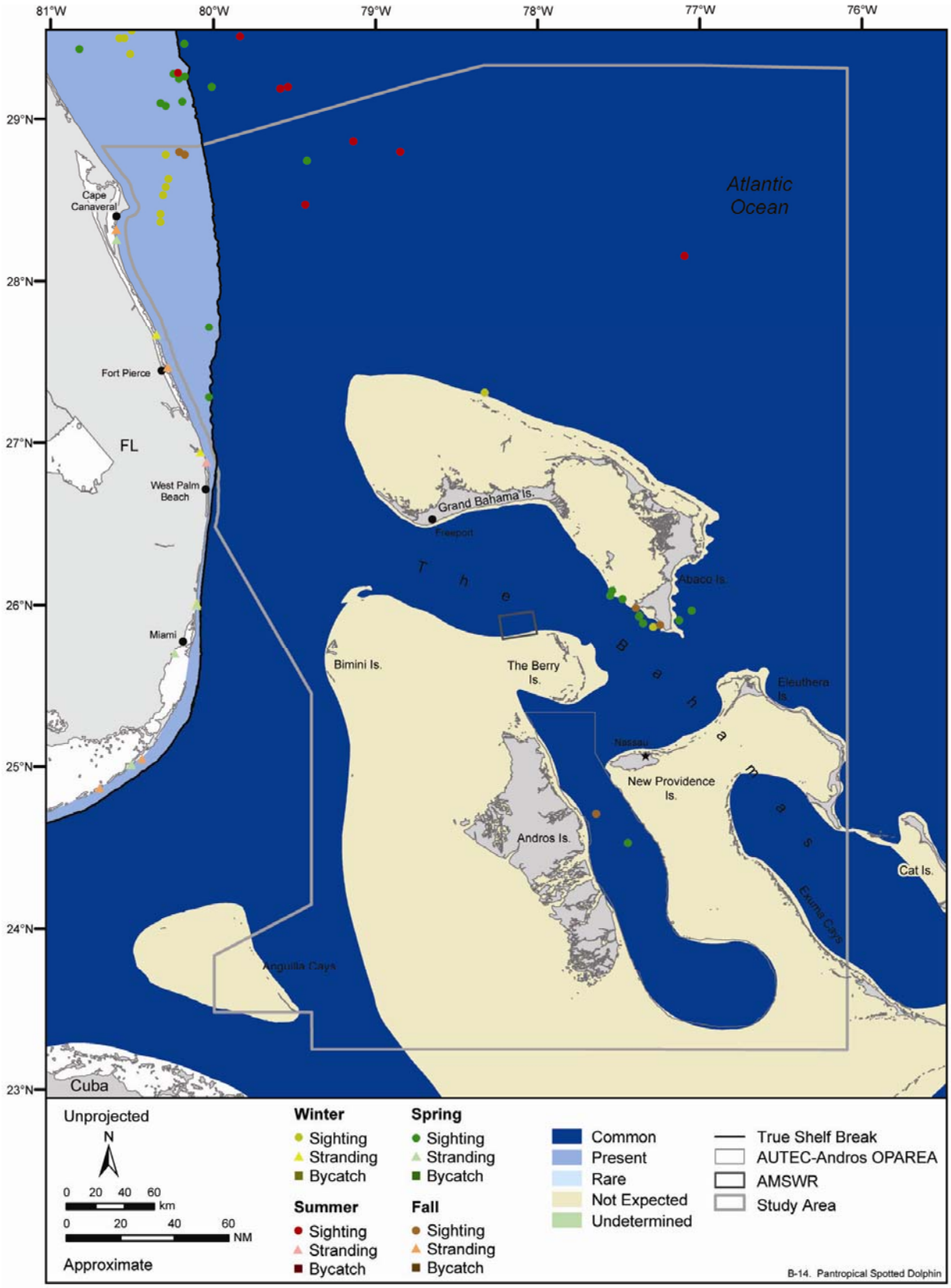


Figure B-14. Occurrence of the pantropical spotted dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

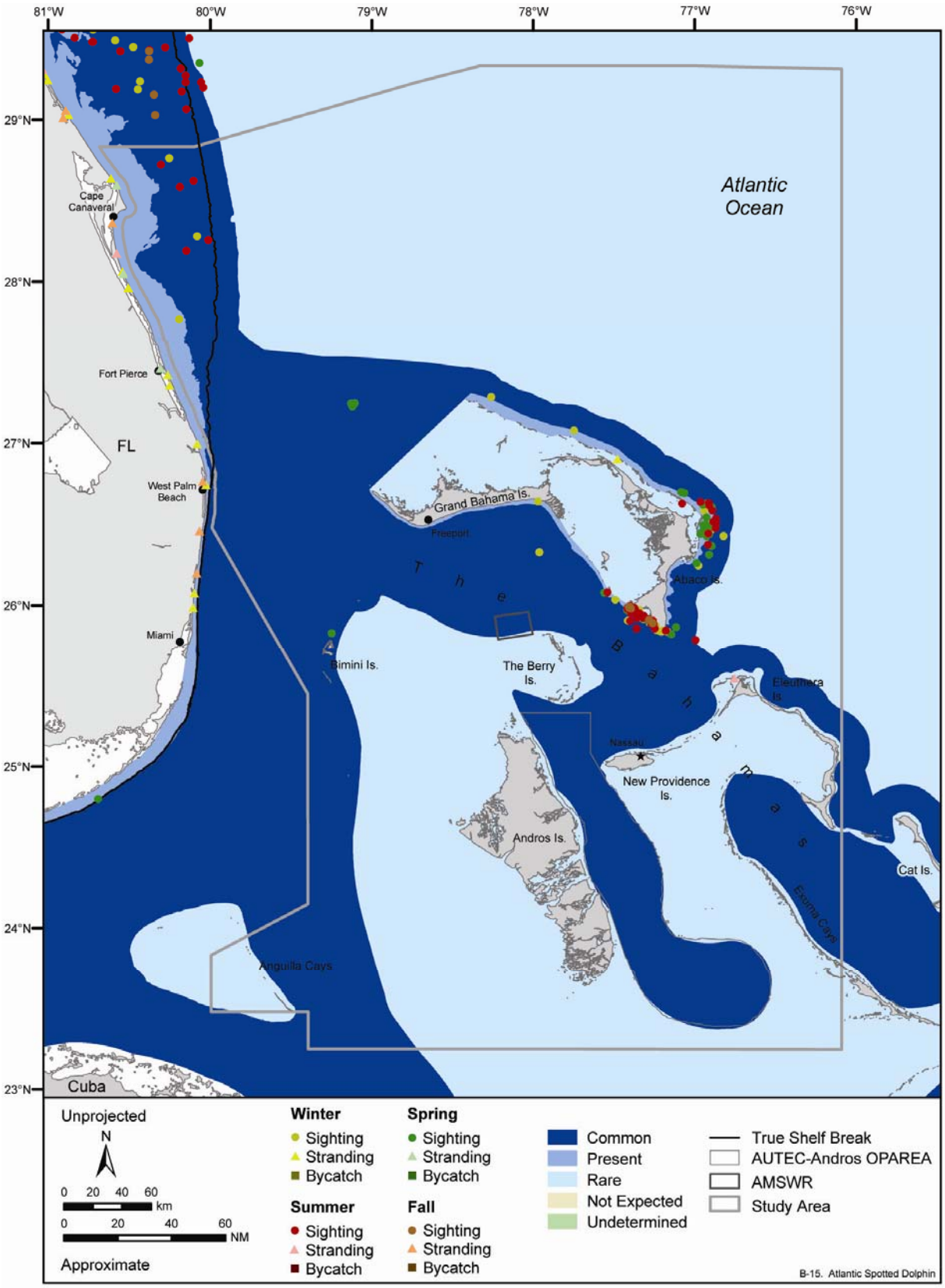


Figure B-15. Occurrence of the Atlantic spotted dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

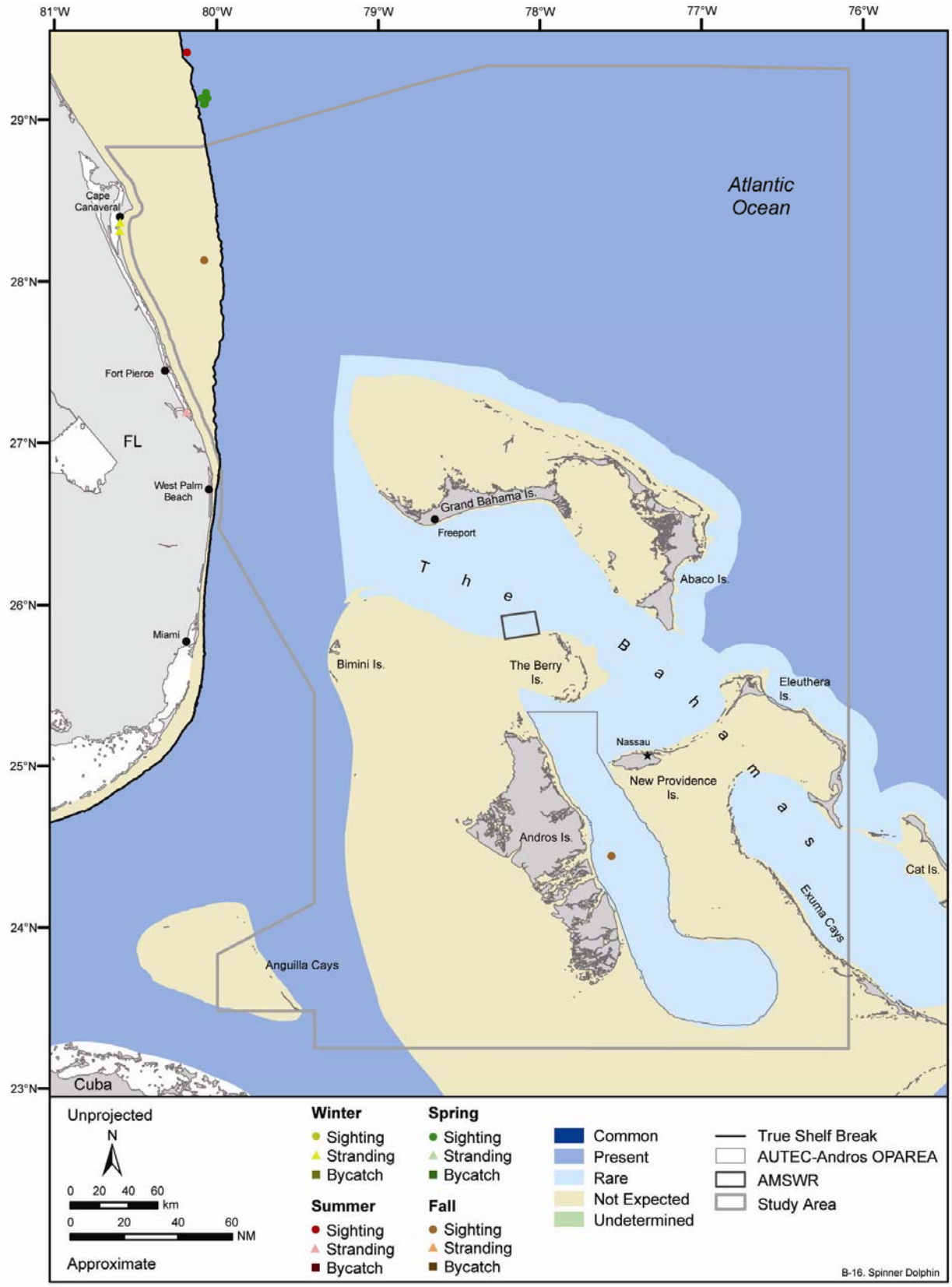


Figure B-16. Occurrence of the spinner dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

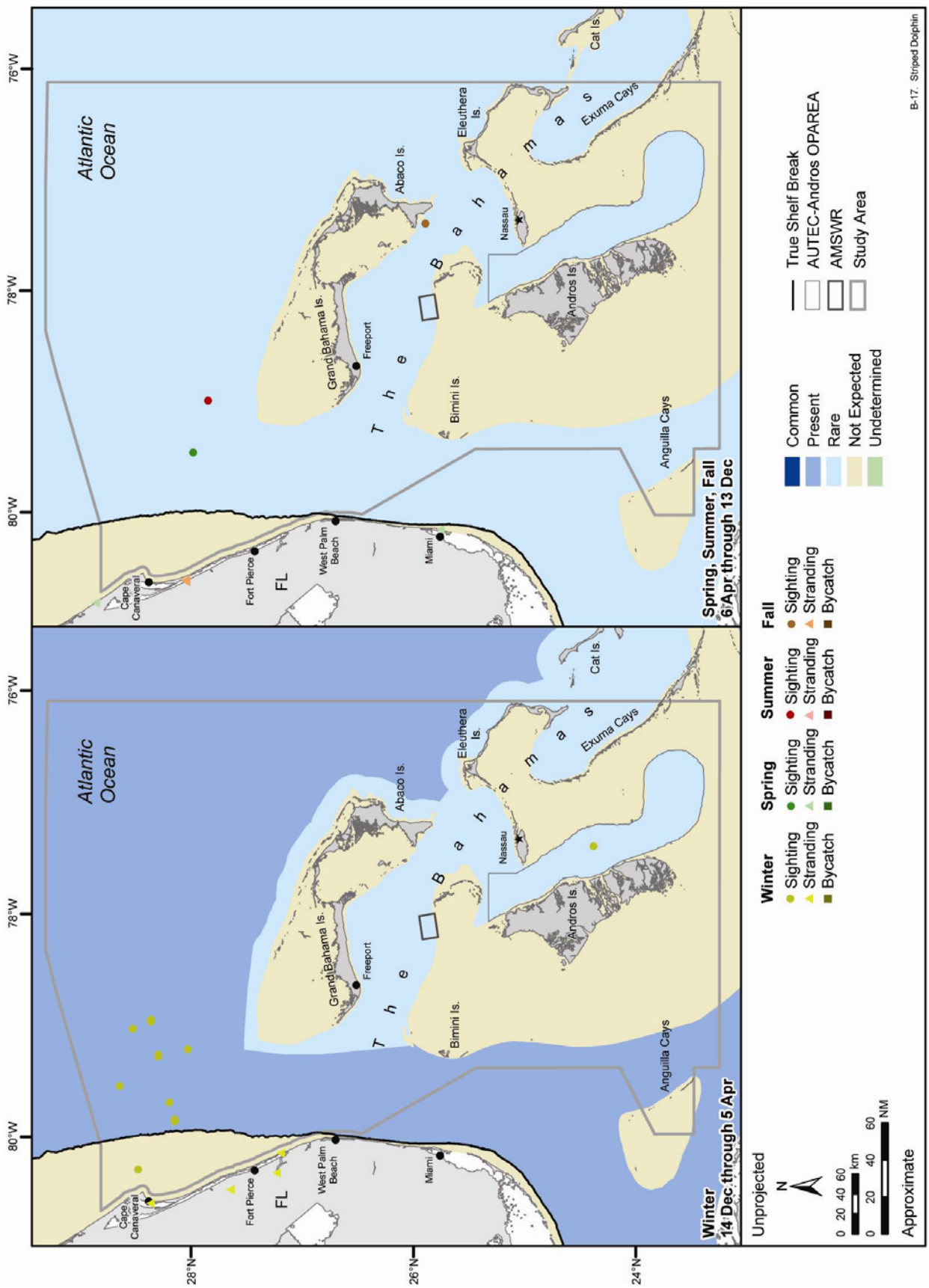


Figure B-17. Occurrence of the striped dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

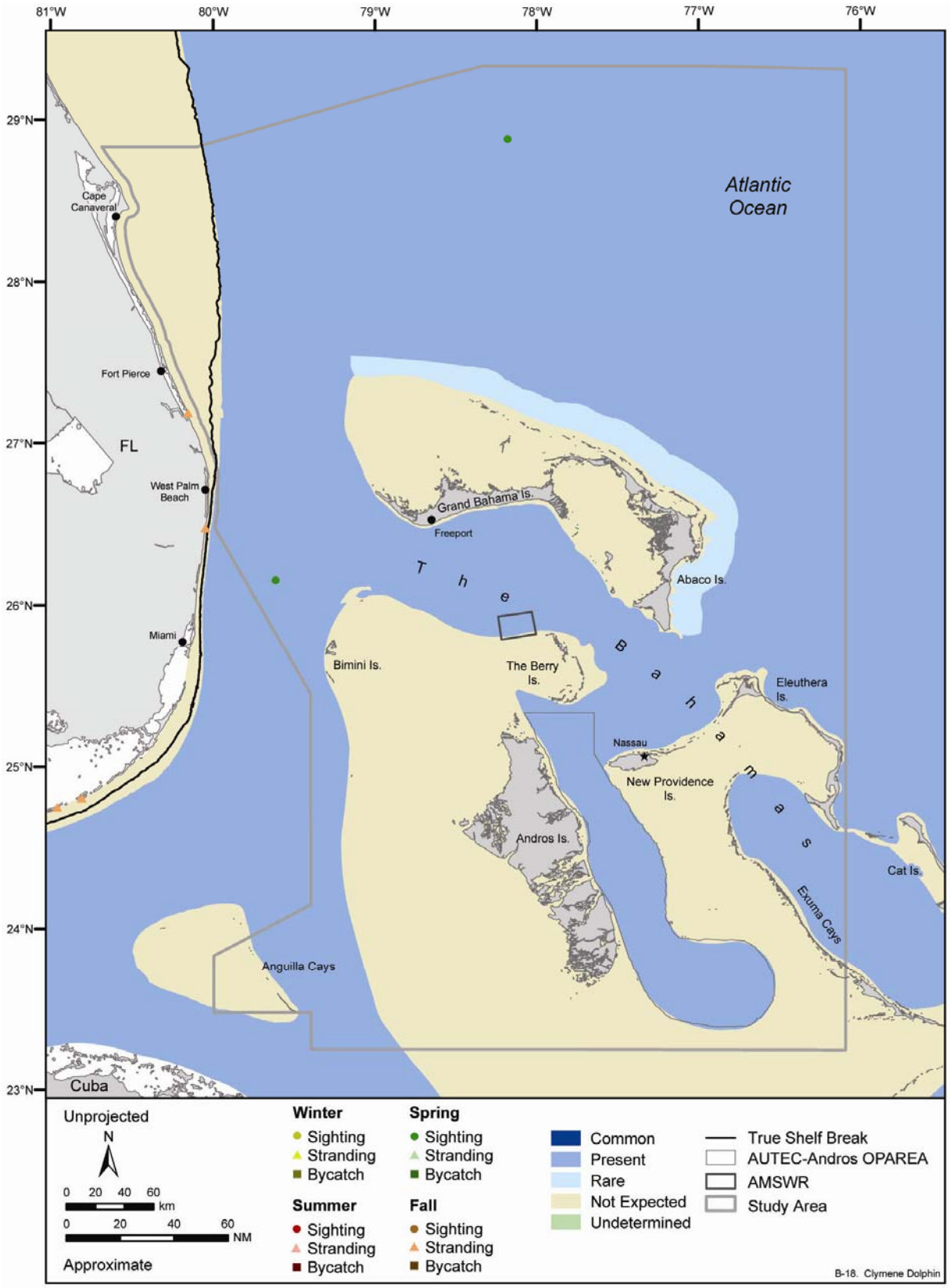


Figure B-18. Occurrence of the Clymene dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

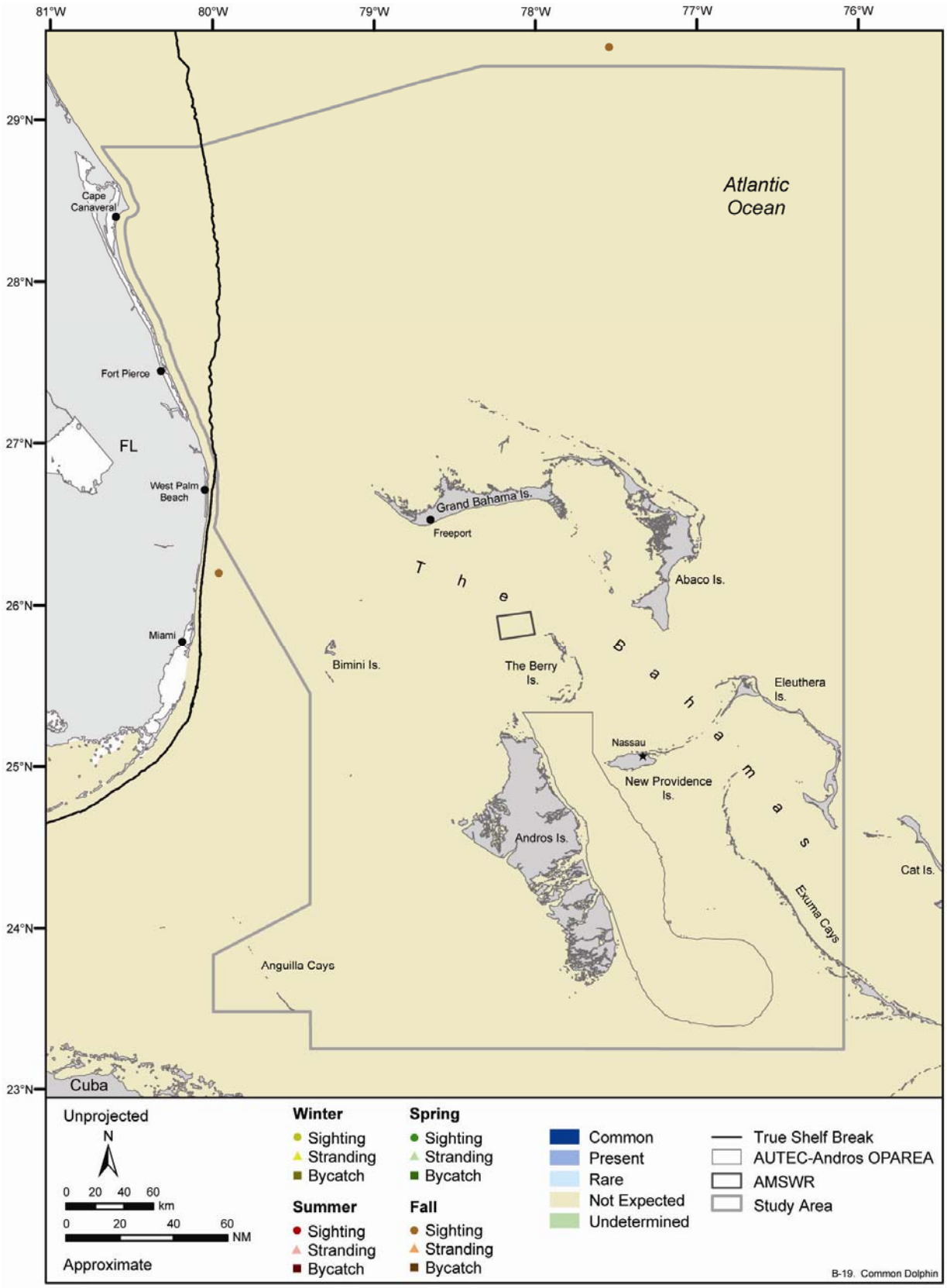


Figure B-19. Occurrence of the common dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

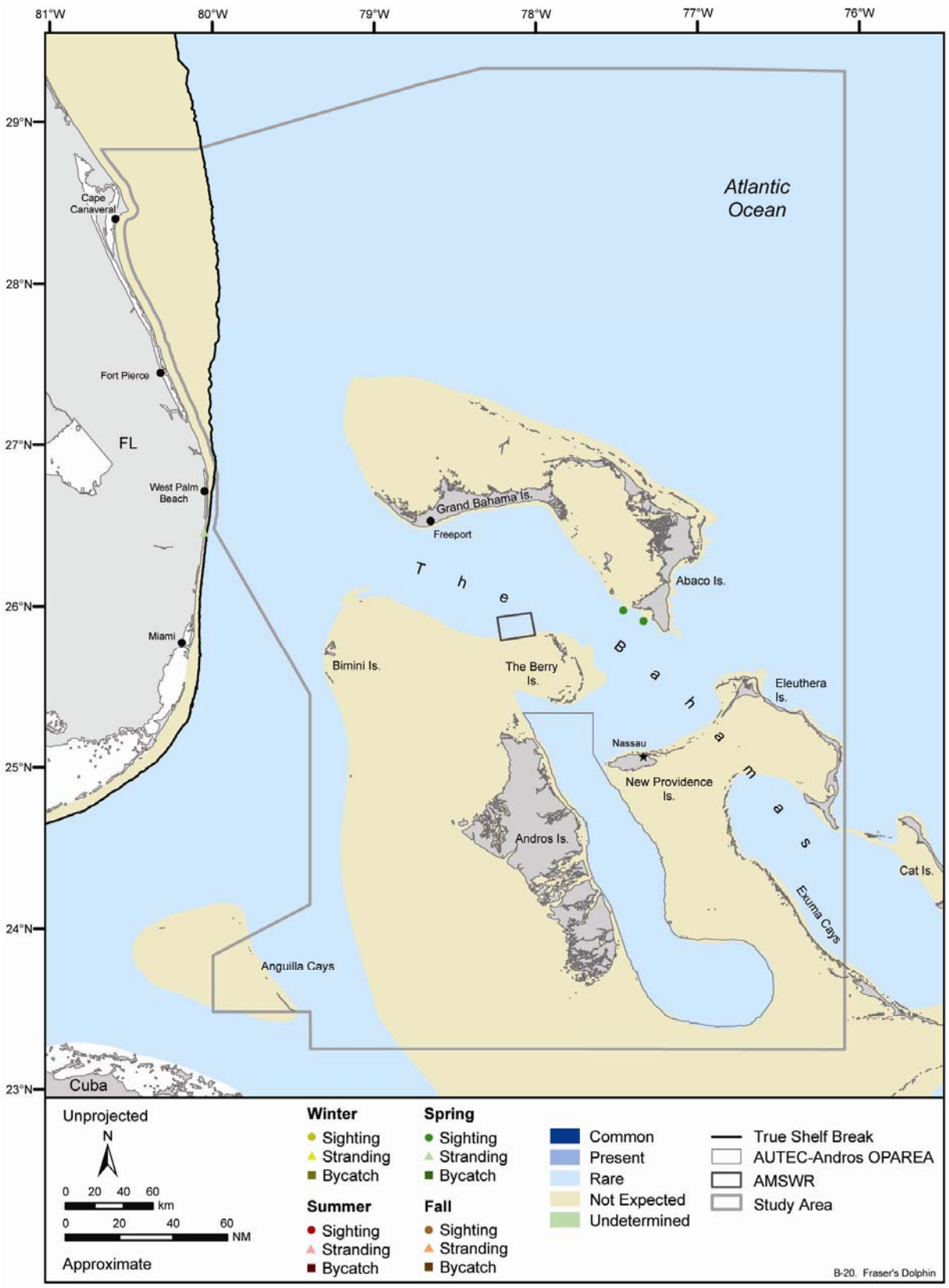


Figure B-20. Occurrence of the Fraser's dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

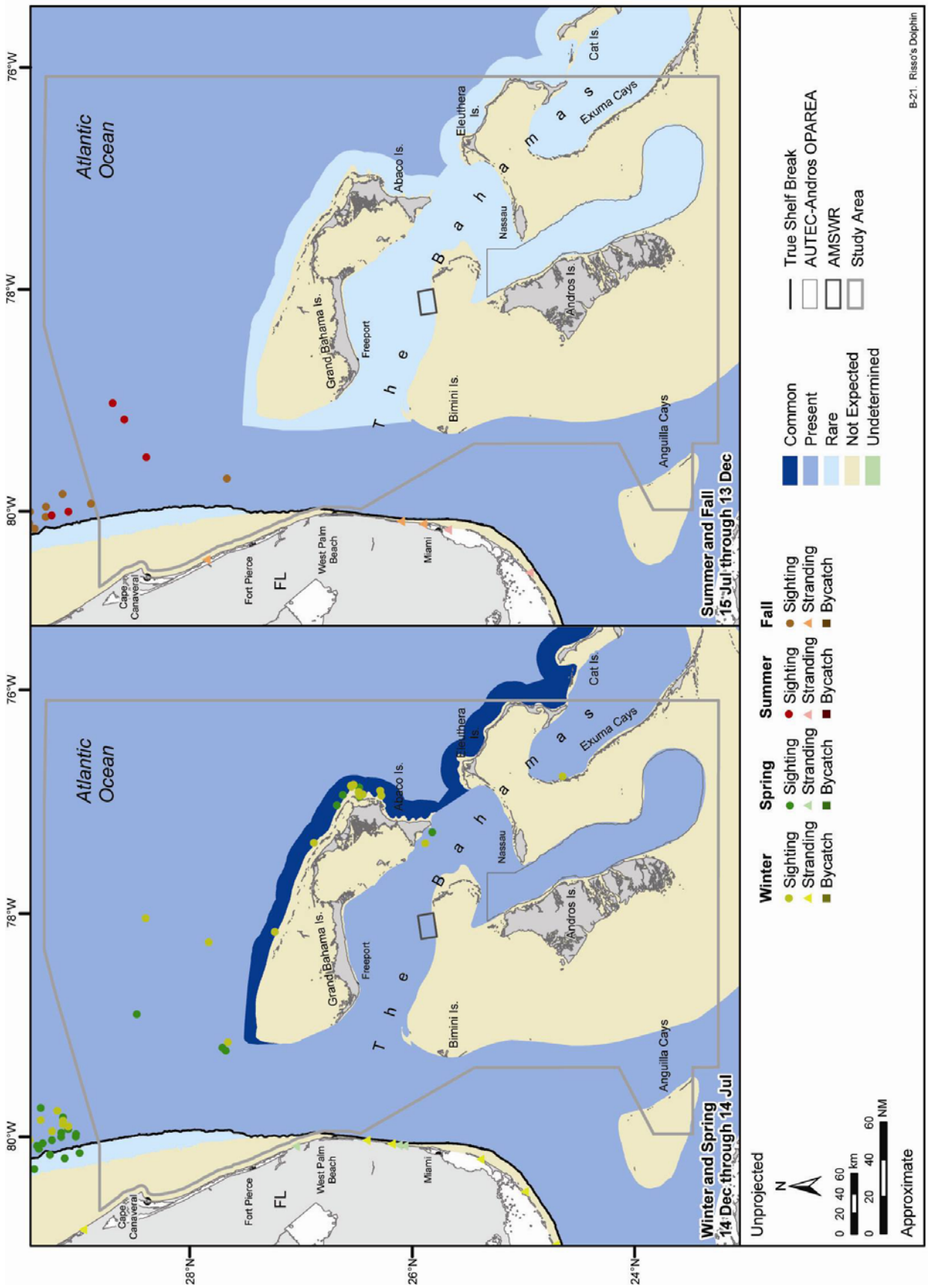


Figure B-21. Occurrence of the Risso's dolphin in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

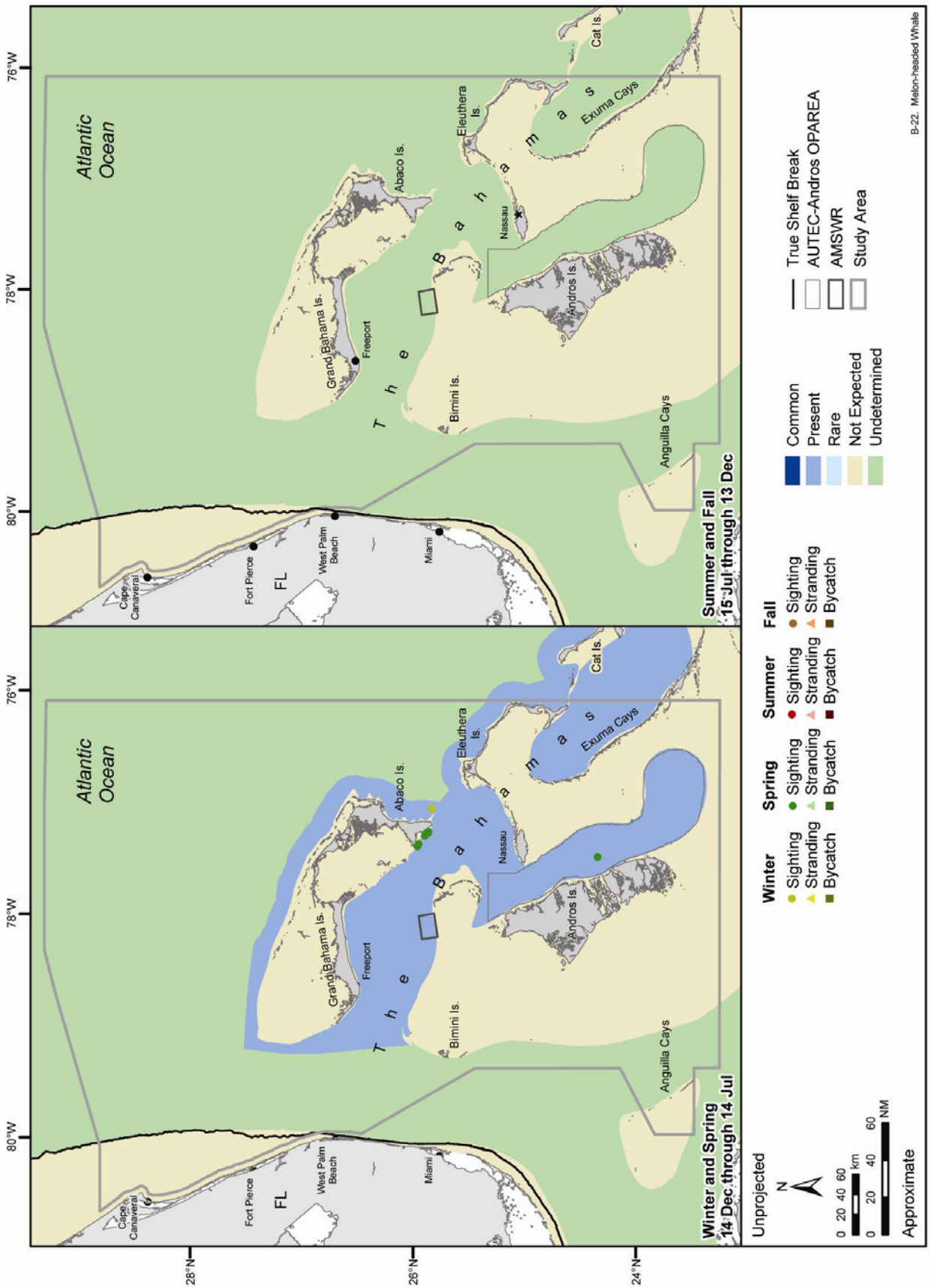


Figure B-22. Occurrence of the melon-headed whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

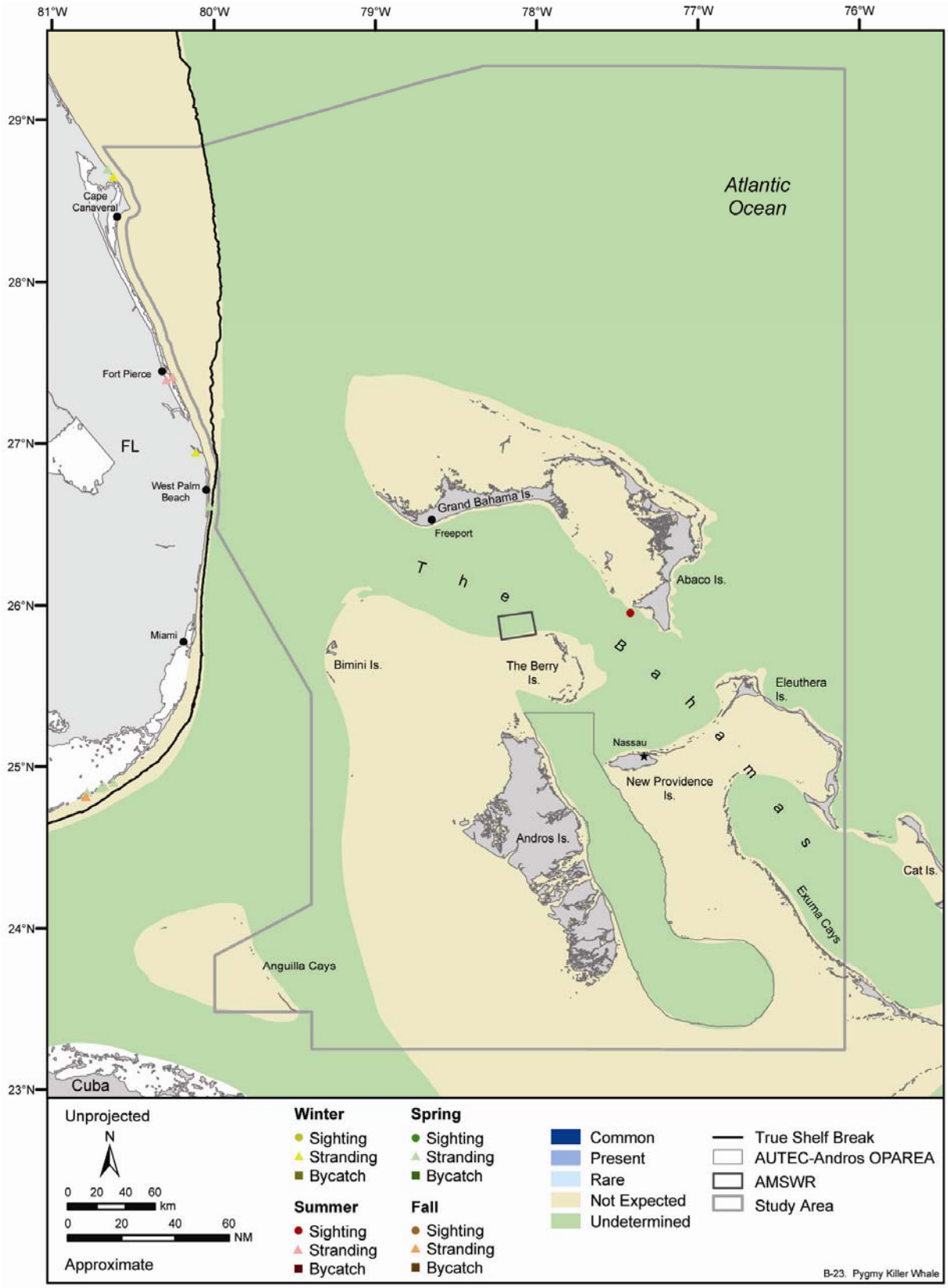


Figure B-23. Occurrence of the pygmy killer whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

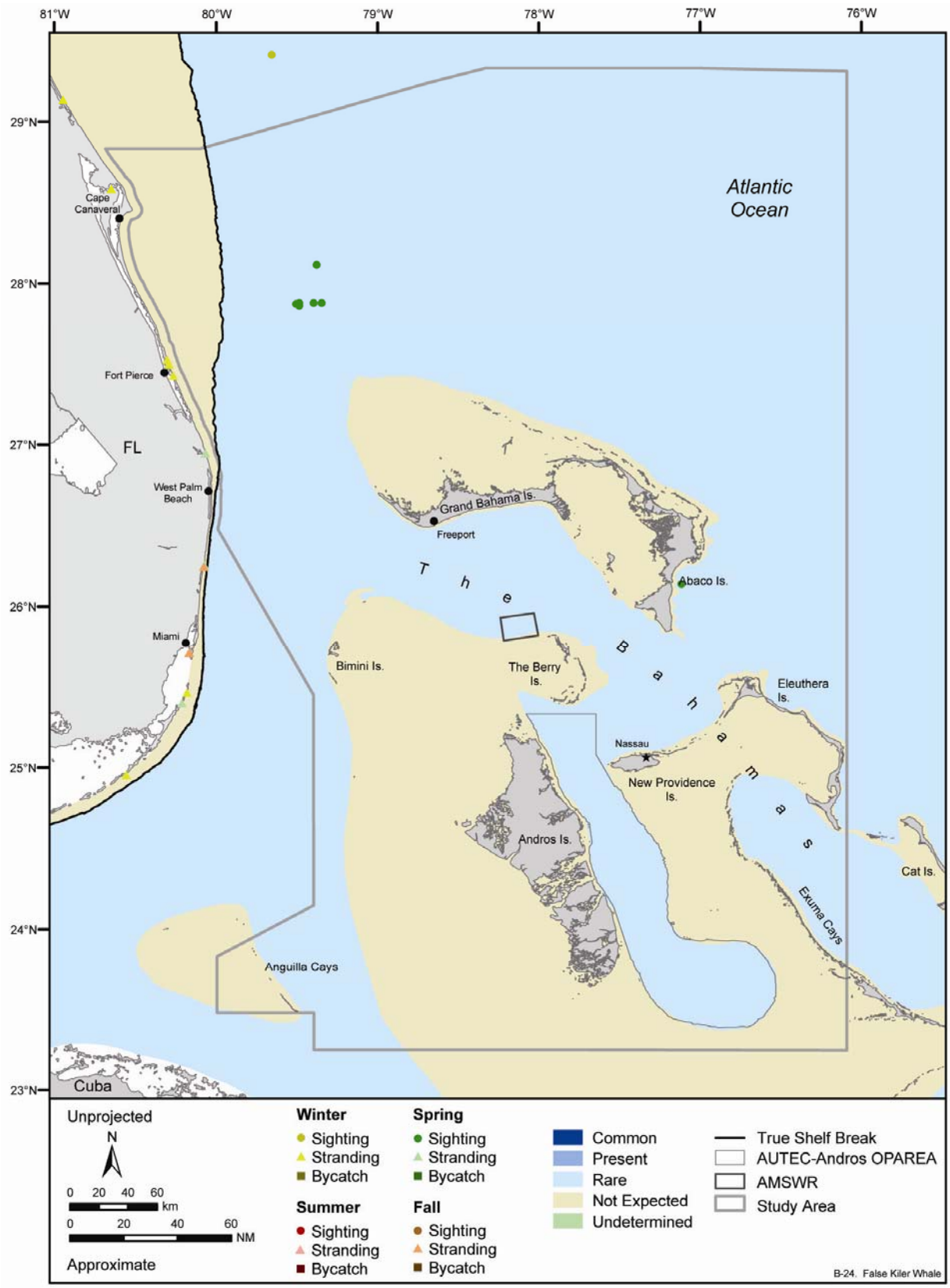


Figure B-24. Occurrence of the false killer whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.

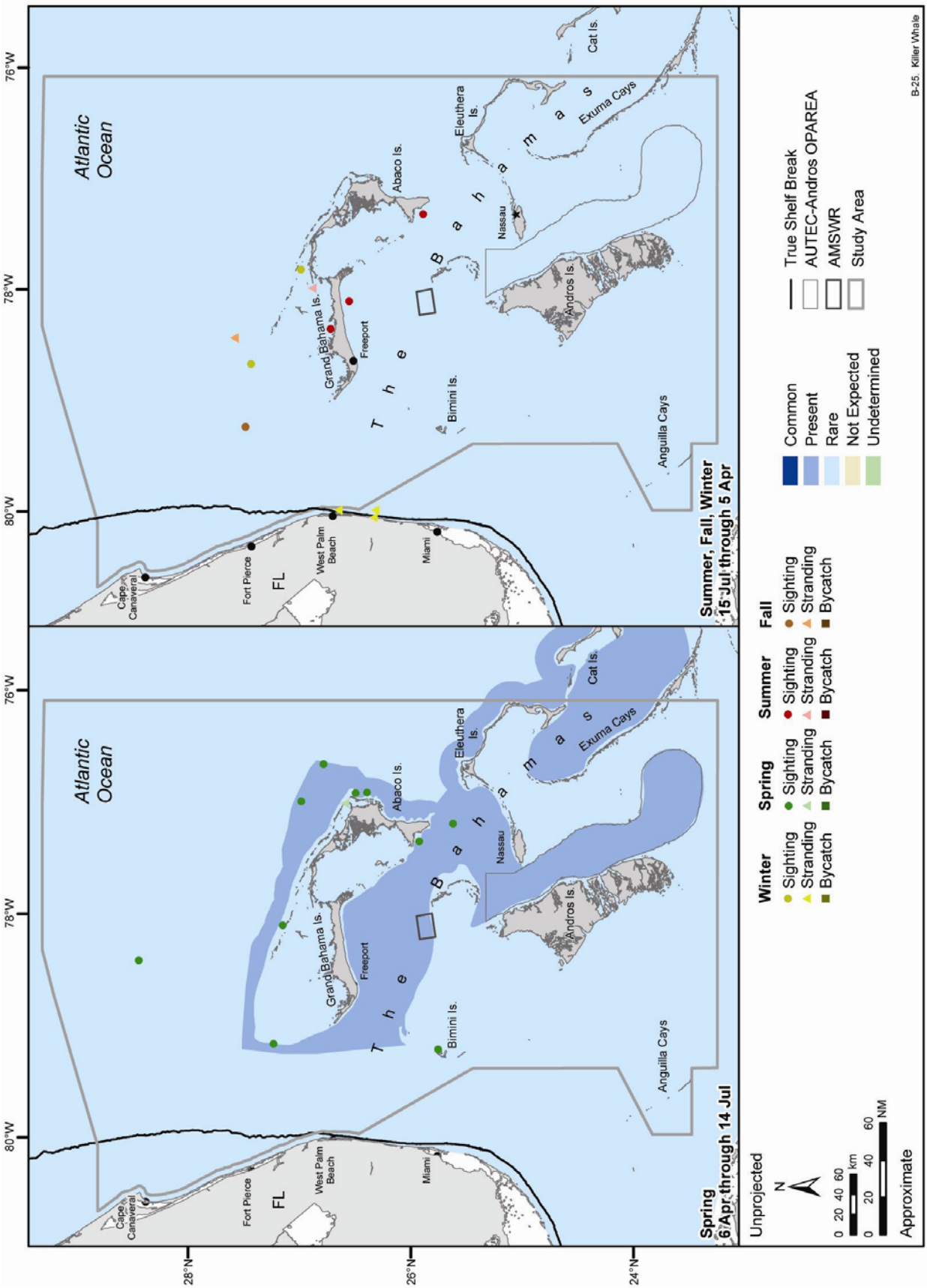
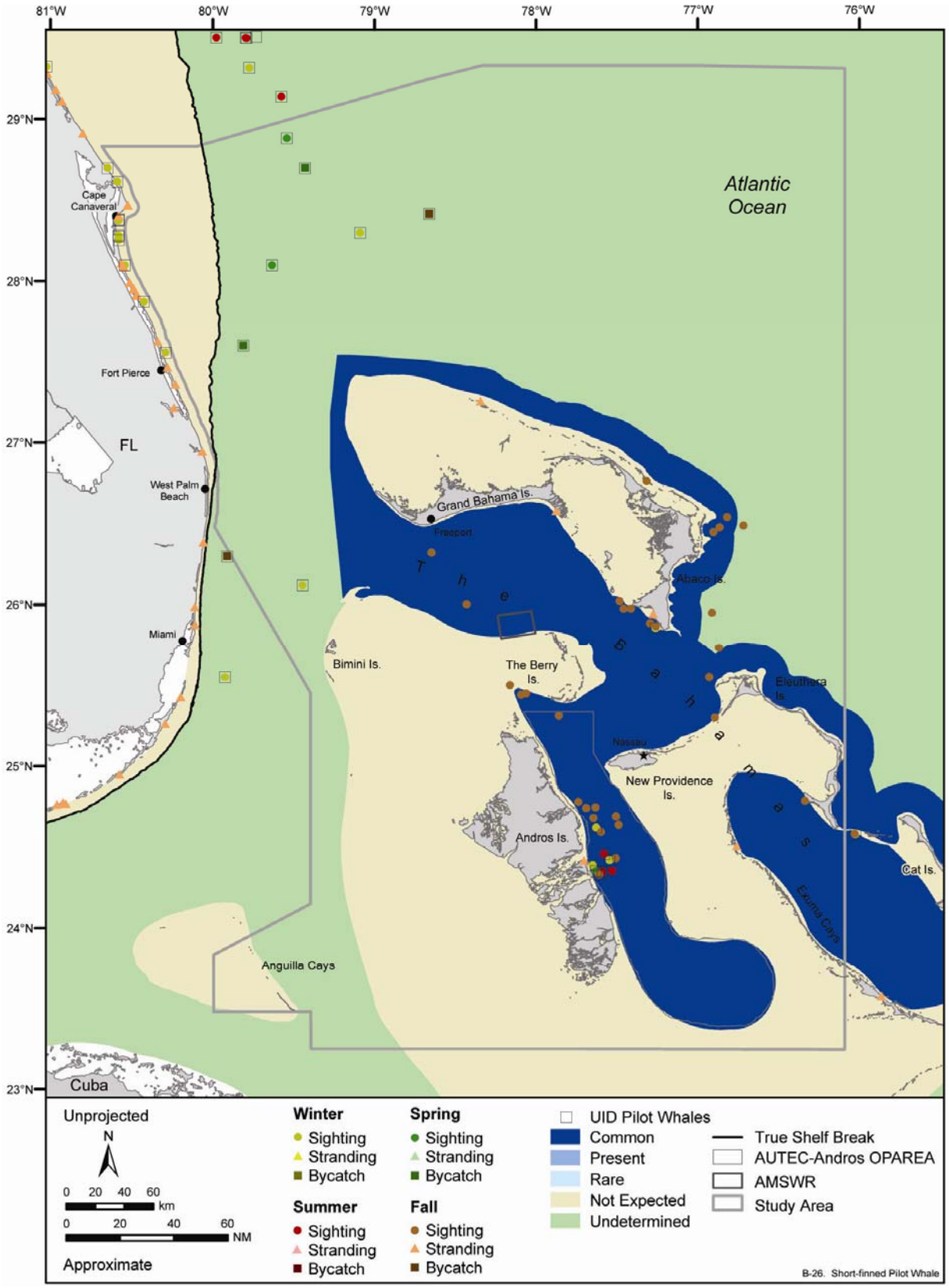


Figure B-25. ccurrence of the killer whale in the study area for the Southeastern Florida and the AUTEC-Andros MRA. Source data: refer to Table A-1.



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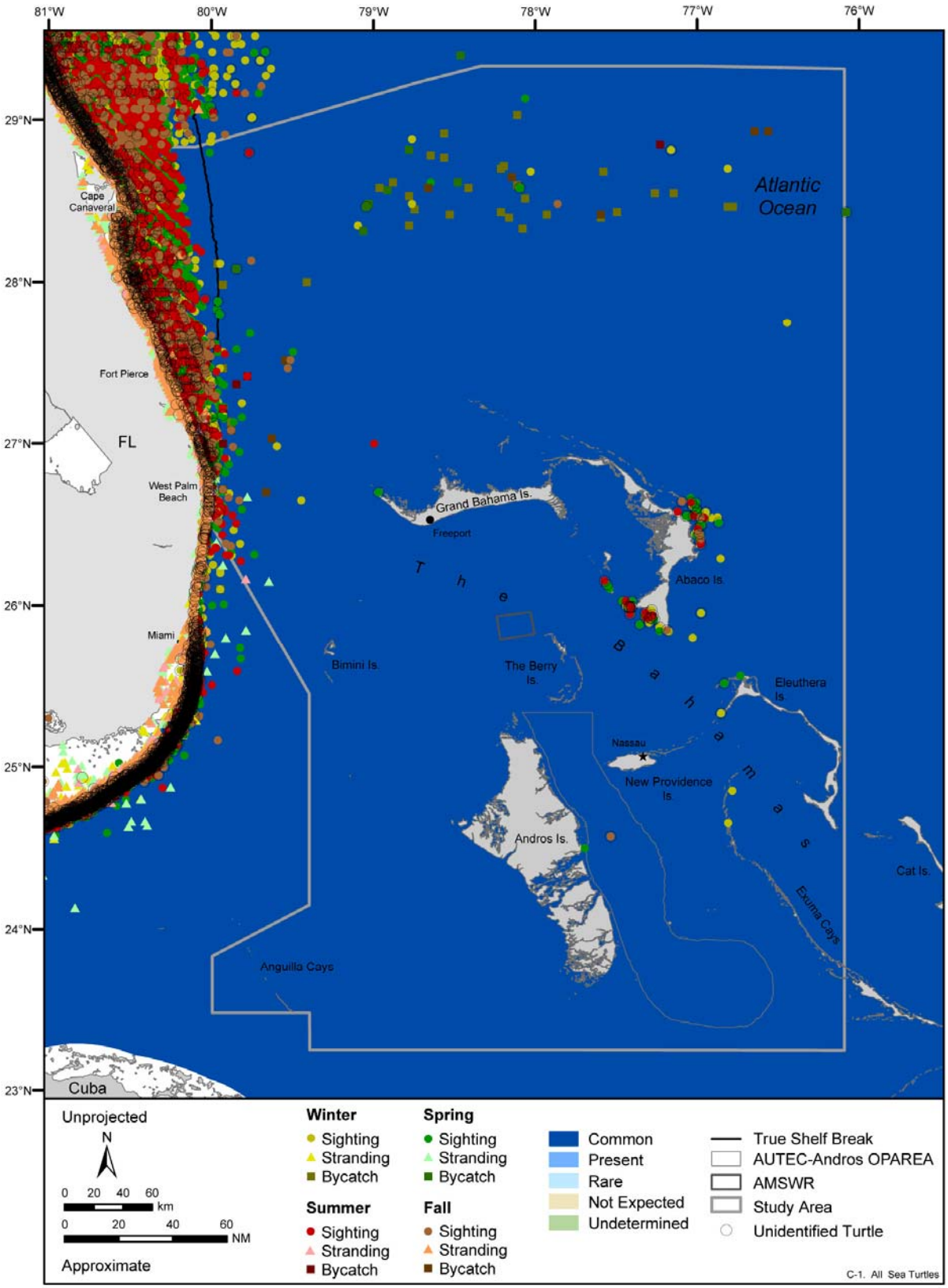
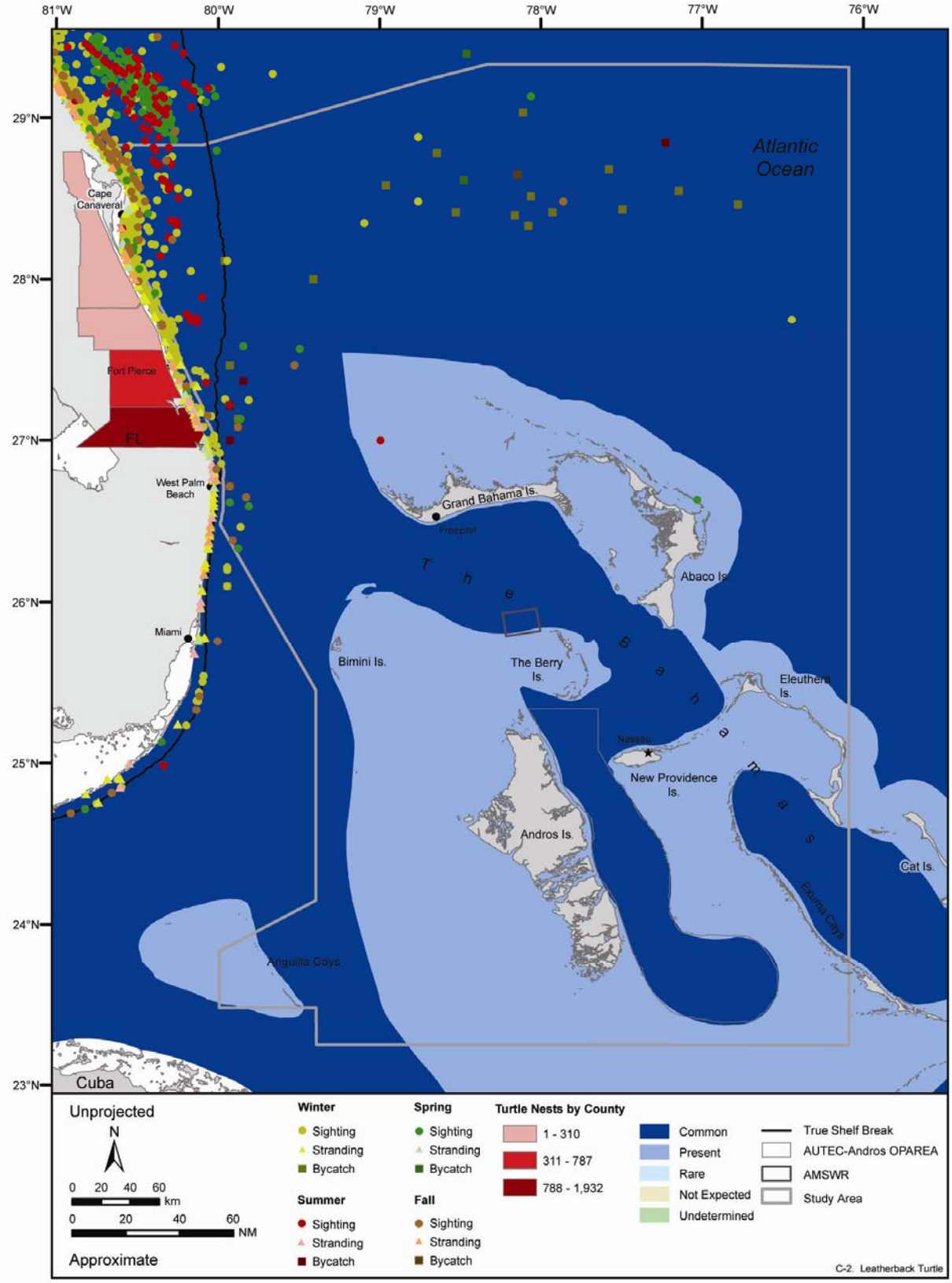


Figure C-1. Occurrence of all sea turtles in the study area for the Southeastern Florida and AUTEC-Andros MRA. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.



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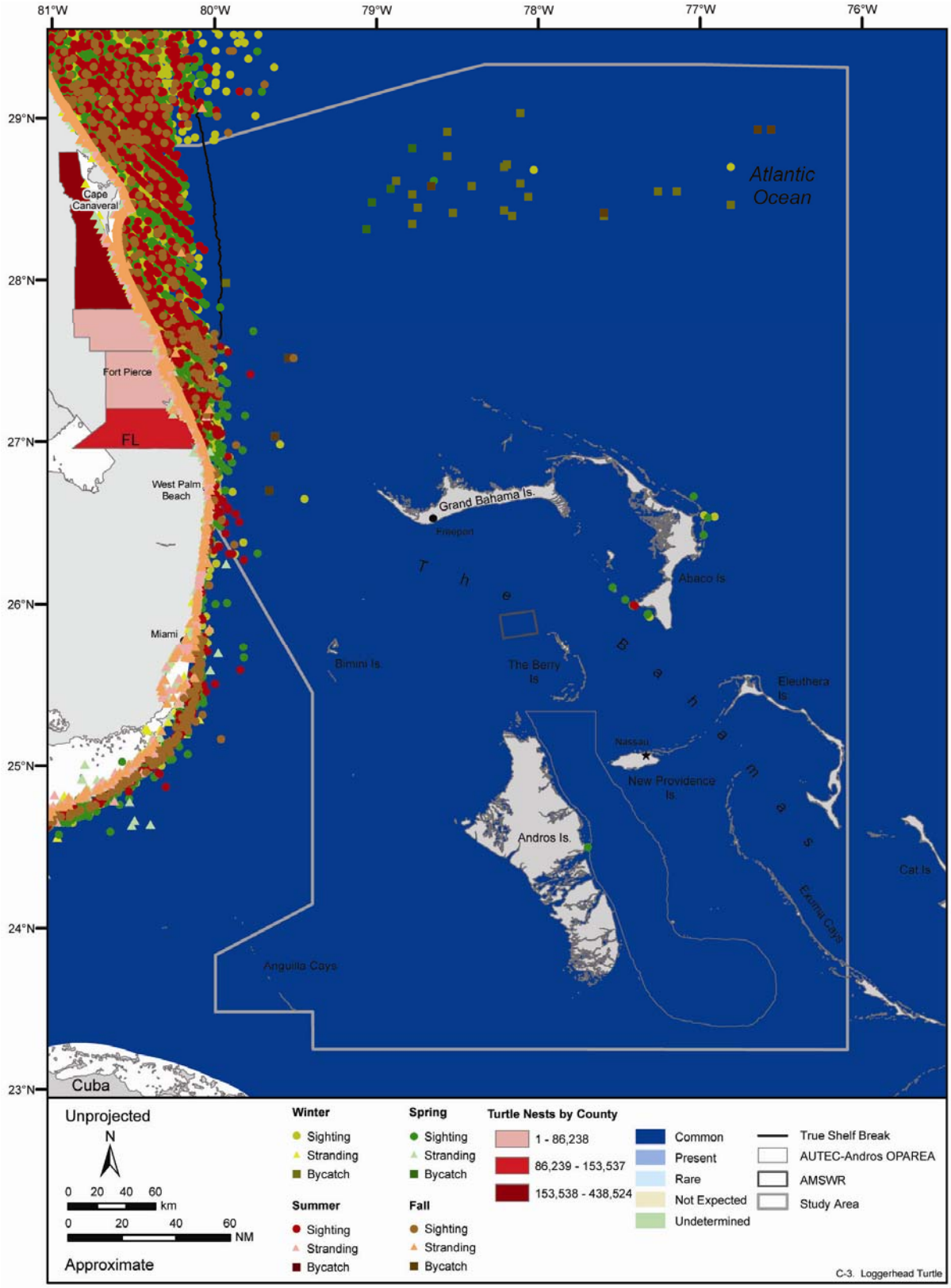

Figure C-3. Occurrence of the loggerhead turtle in the study area for the Southeastern Florida and AUTEC-Andros MRA. Available sighting, stranding, nesting, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

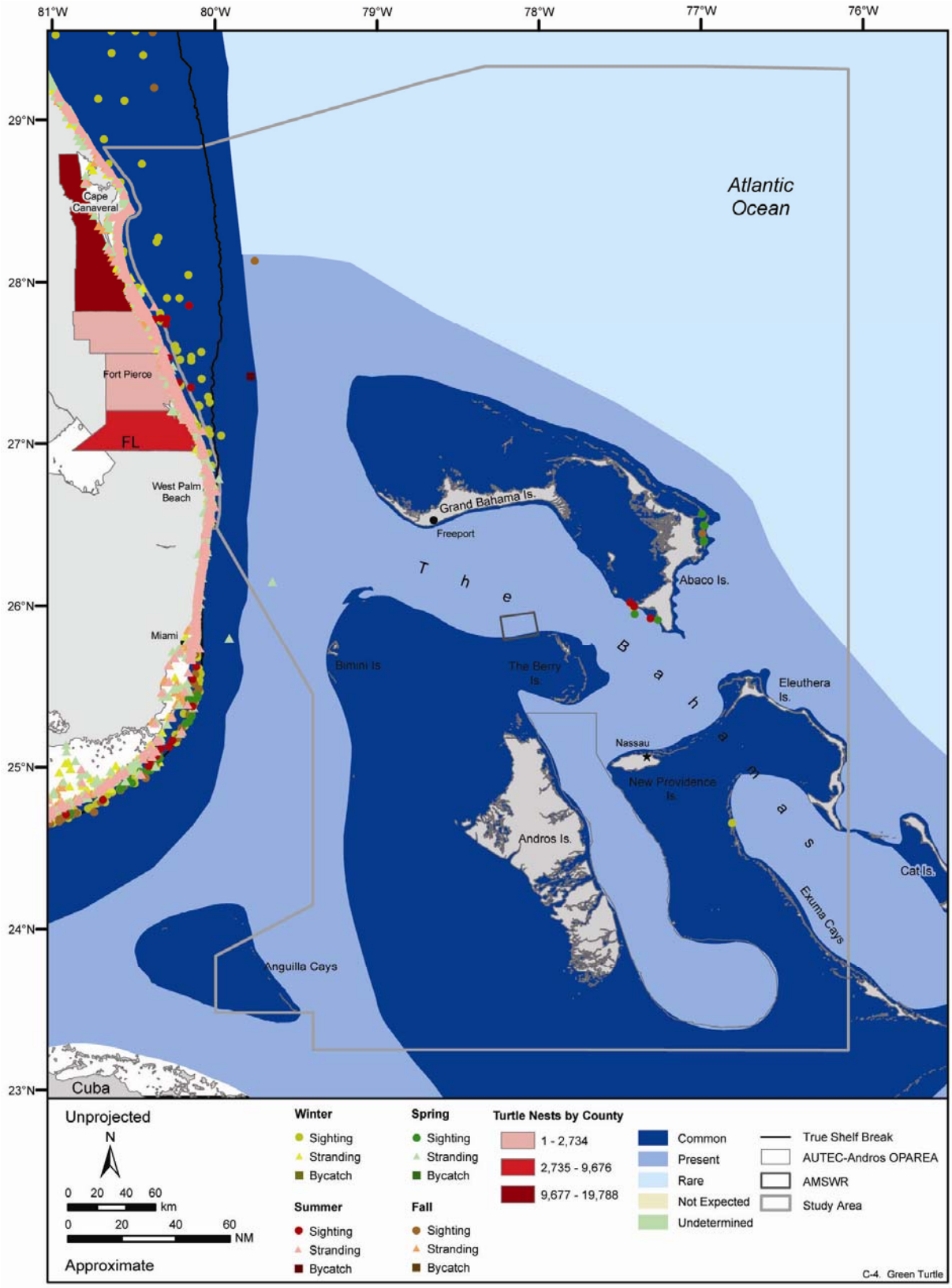

Figure C-4. Occurrence of the green turtle in the study area for the Southeastern Florida and AUTEC-Andros MRA. Available sighting, stranding, nesting, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

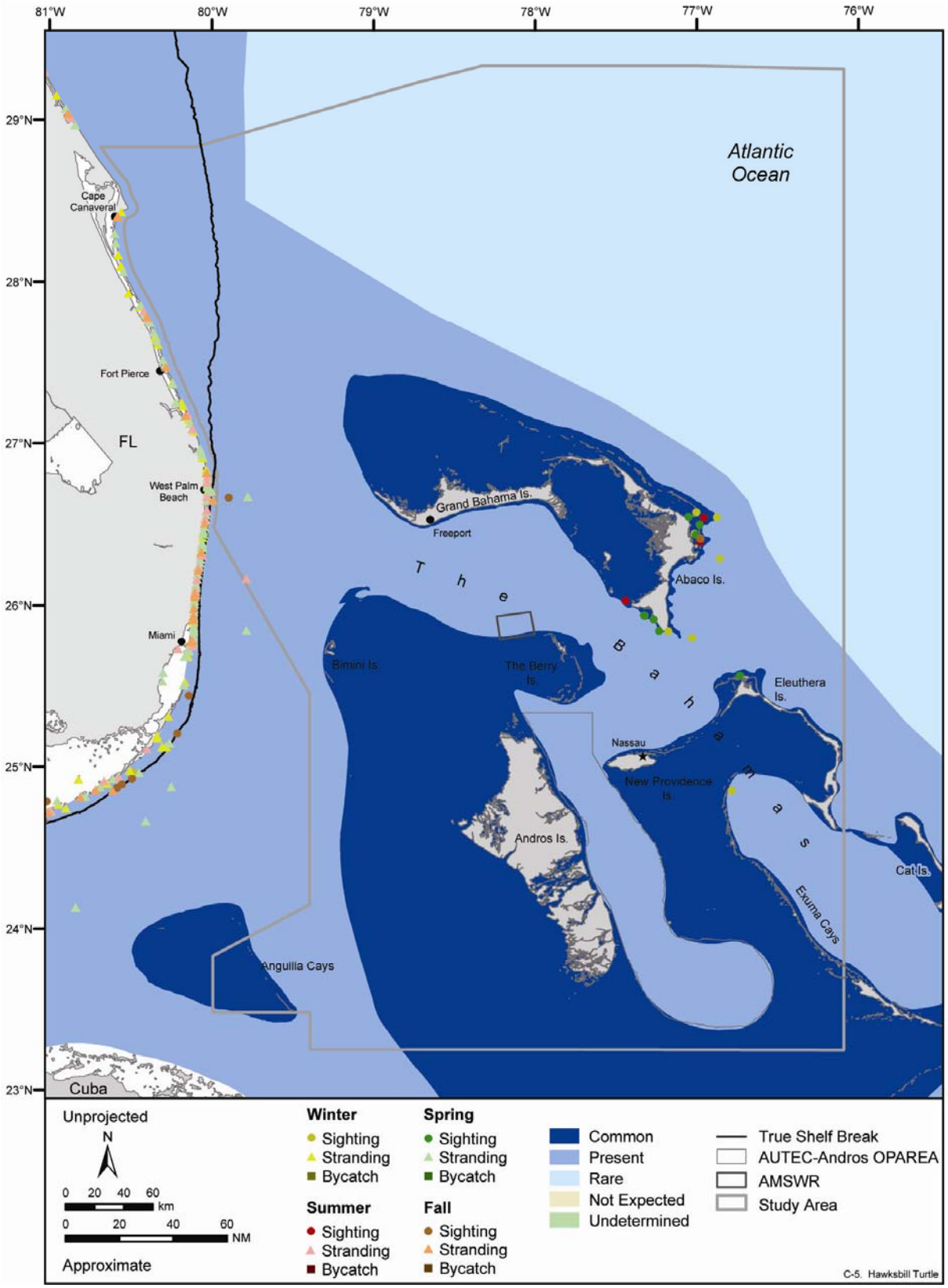

Figure C-5. Occurrence of the hawksbill turtle in the study area for the Southeastern Florida and AUTEC-Andros MRA. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

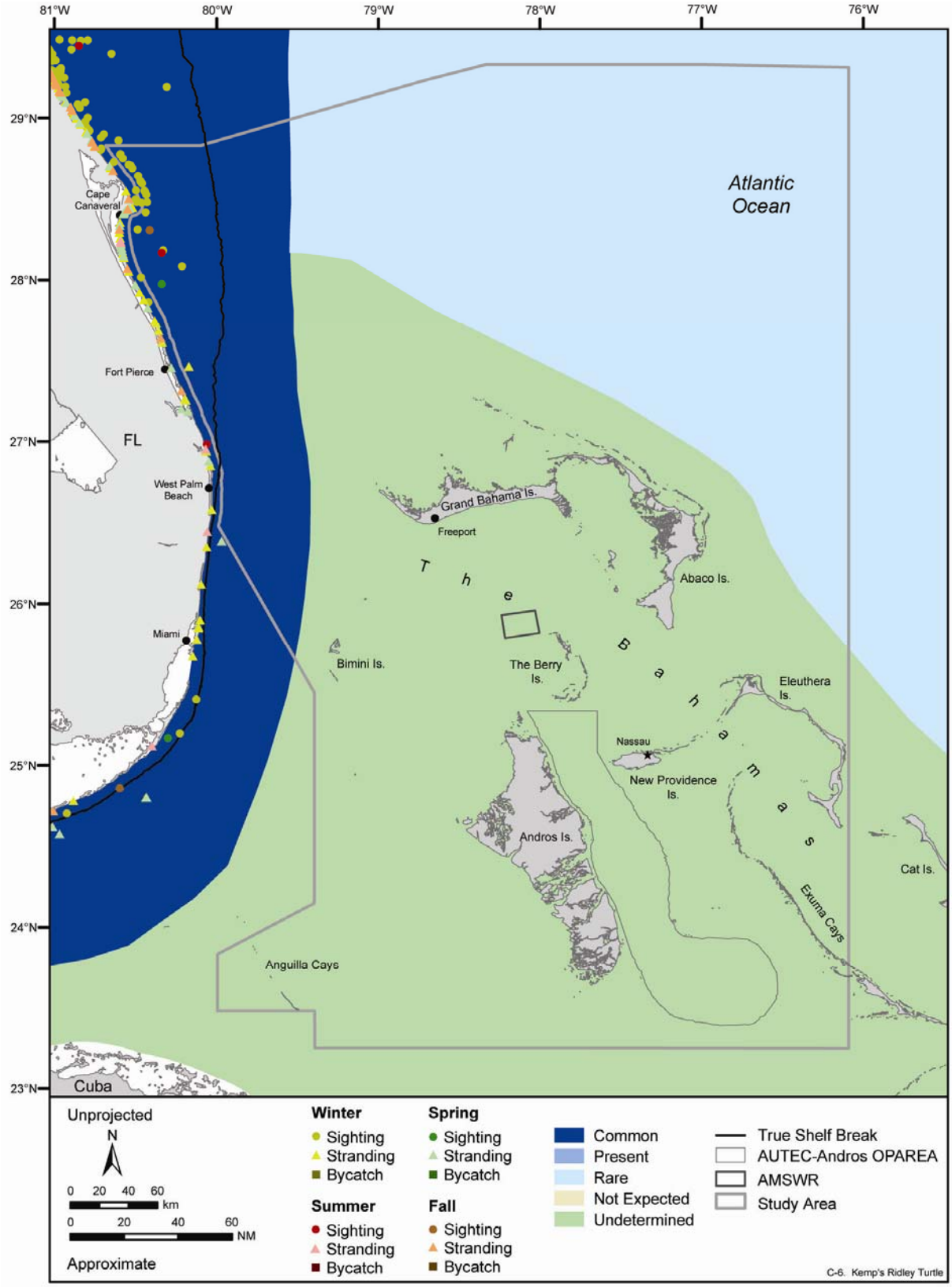

Figure C-6. Occurrence of the Kemp's ridley turtle in the study area for the Southeastern Florida and AUTEC-Andros MRA. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

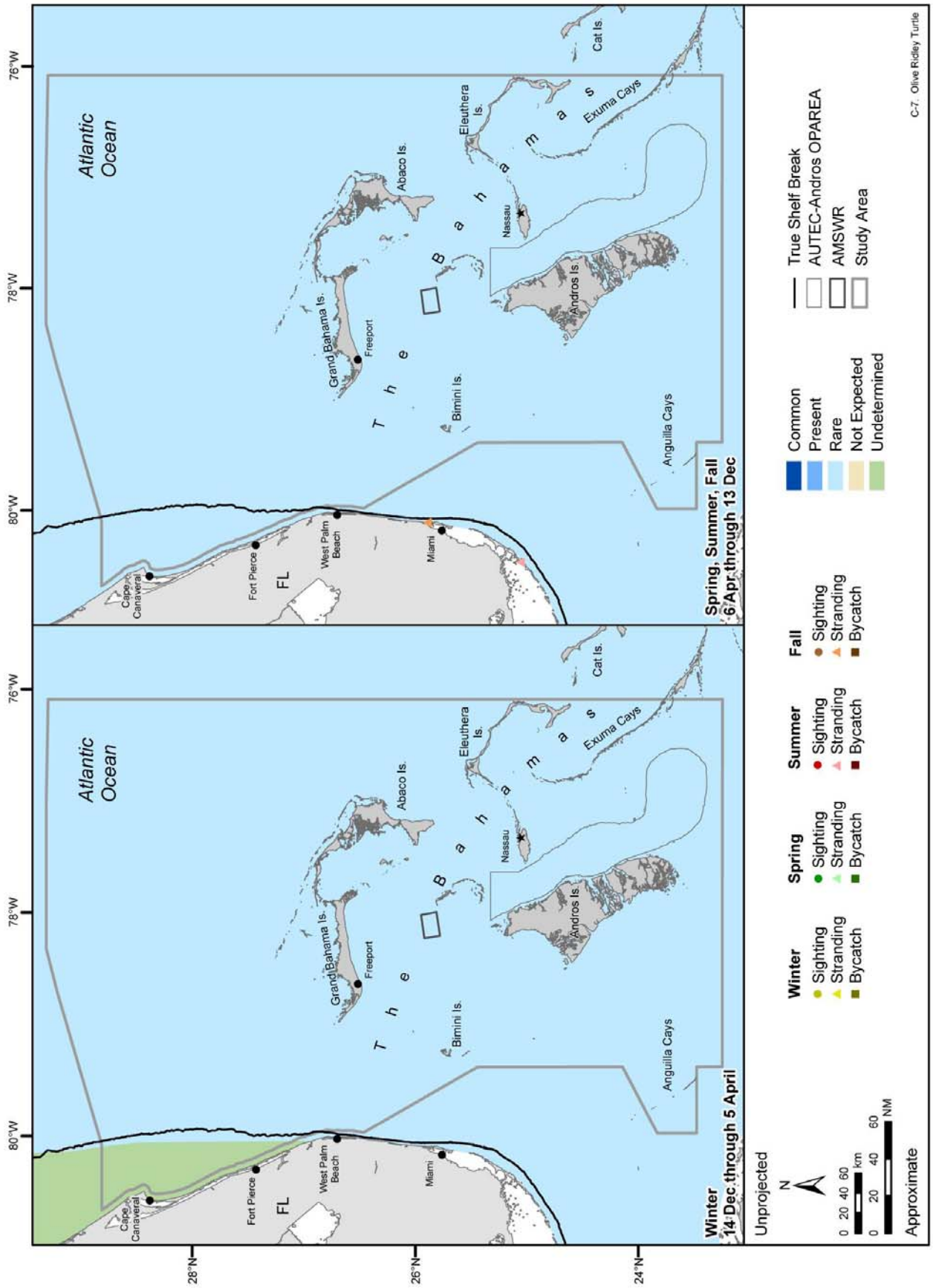

Figure C-7. Occurrence of the olive ridley turtle in the study area for the Southeastern Florida and AUTEC-Andros MRA. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Table A-1.

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APPENDIX D: ESSENTIAL FISH HABITAT

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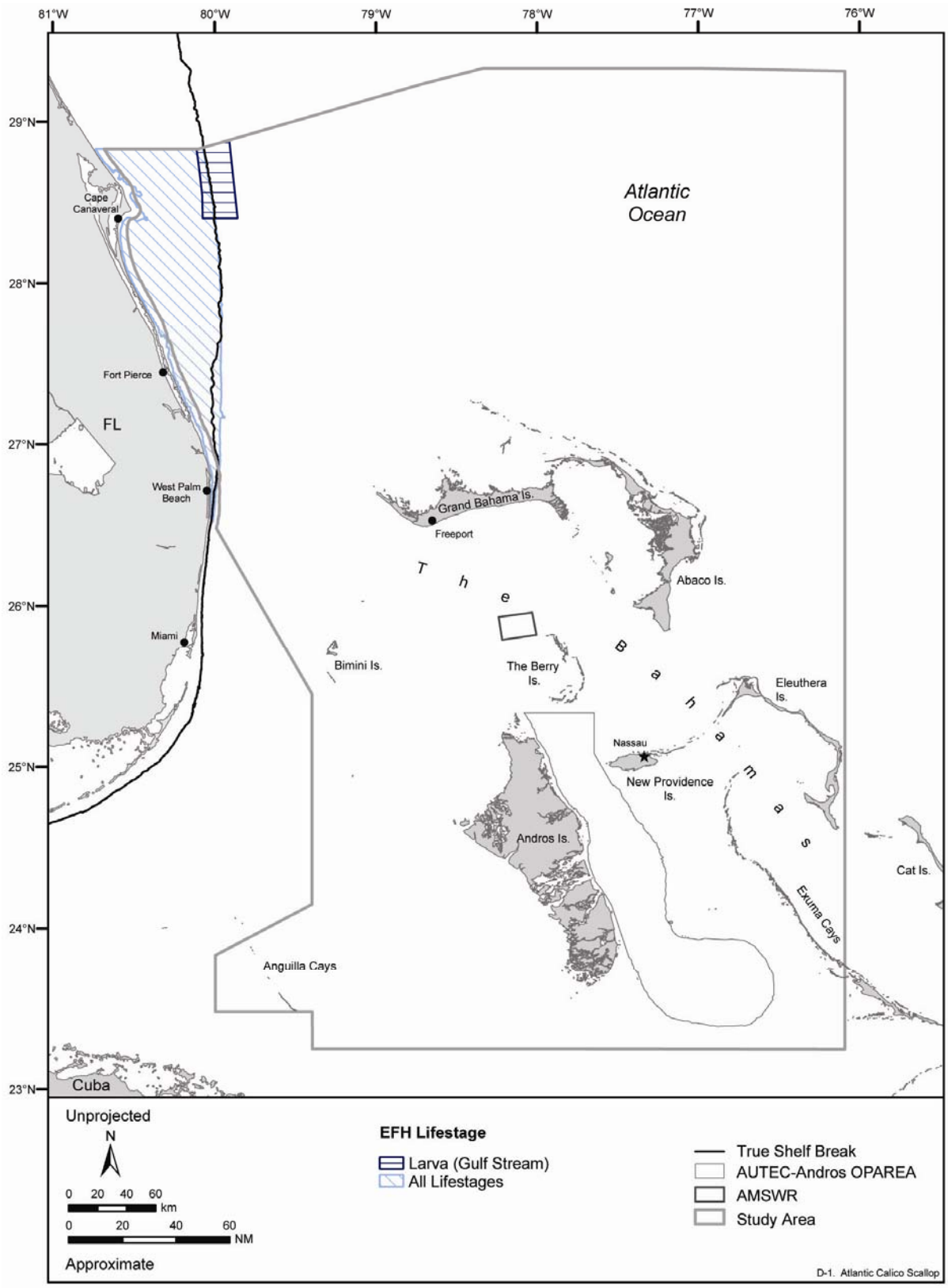


Figure D-1. Essential fish habitat (EFH) for all lifestages of the Atlantic calico scallop designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: USGS (2000) and GDAIS (2005). Source map (scanned): General Oceanics, Inc. (1986).

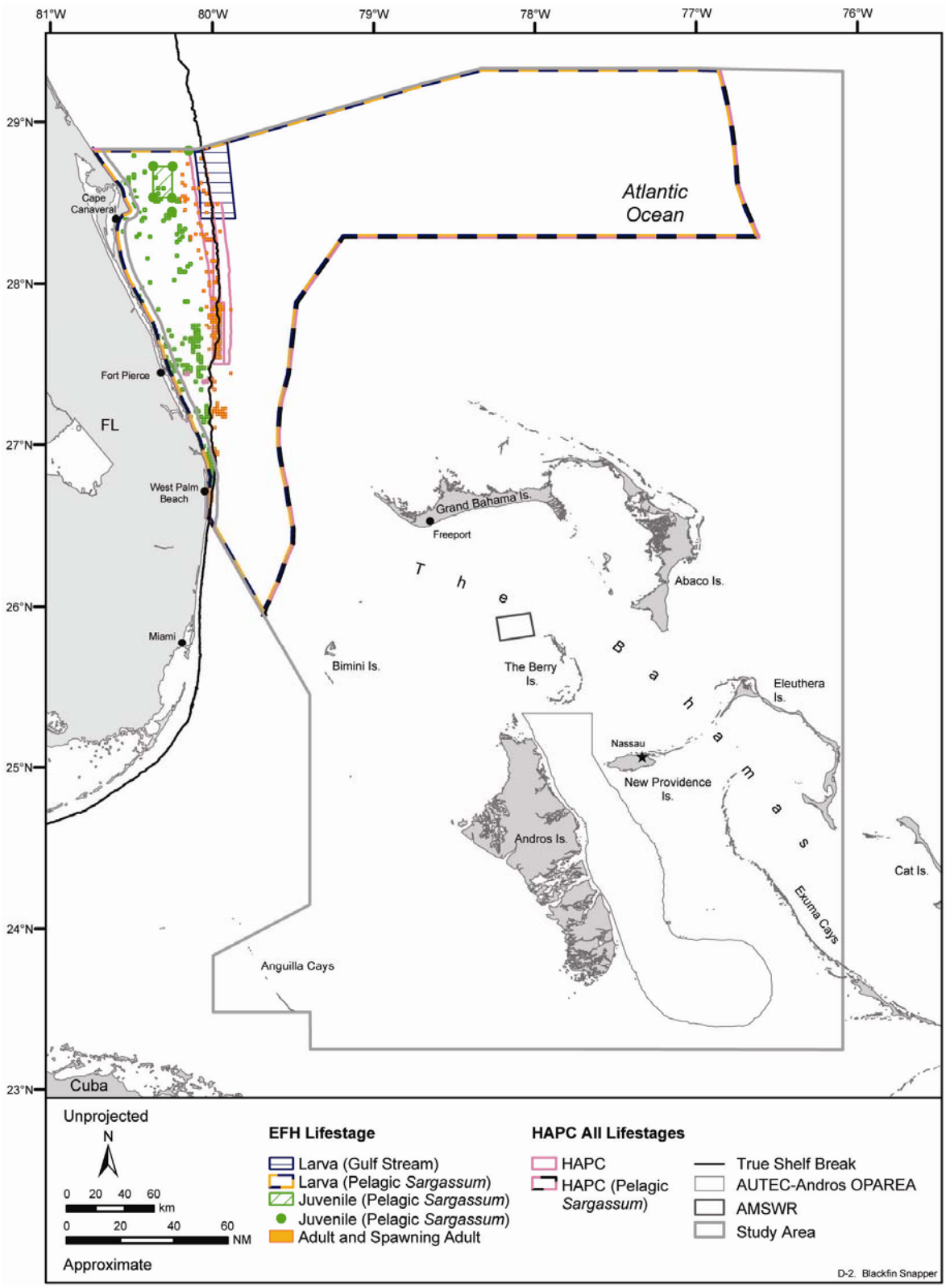


Figure D-2. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the blackfin snapper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2005), GDAIS (2005), and Reed et al. (2005). Source maps (scanned): BLM (1976) and General Oceanics, Inc. (1986).

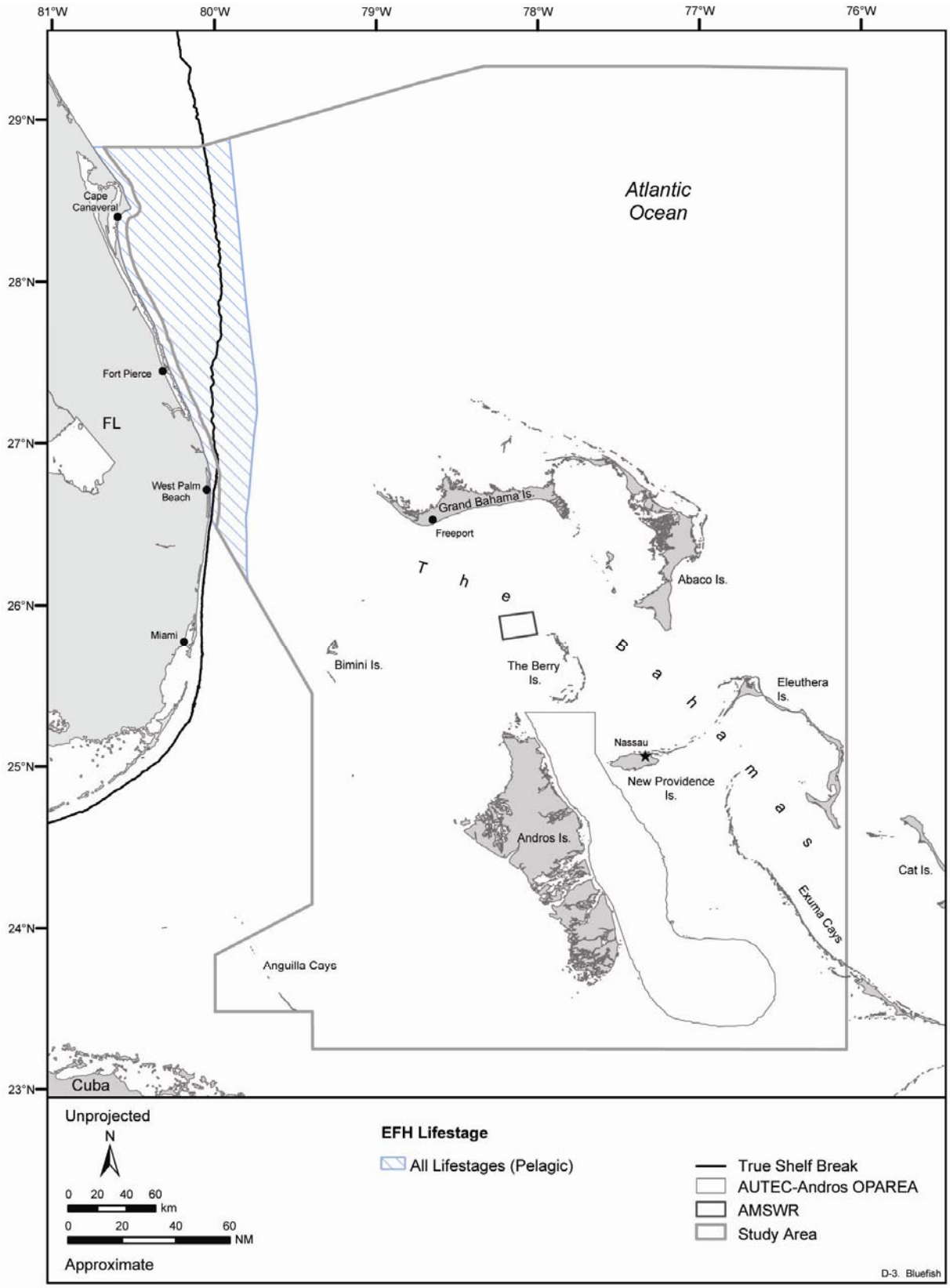


Figure D-3. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the bluefish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: GDAIS (2005). Source map (scanned) General Oceanics, Inc. (1986).

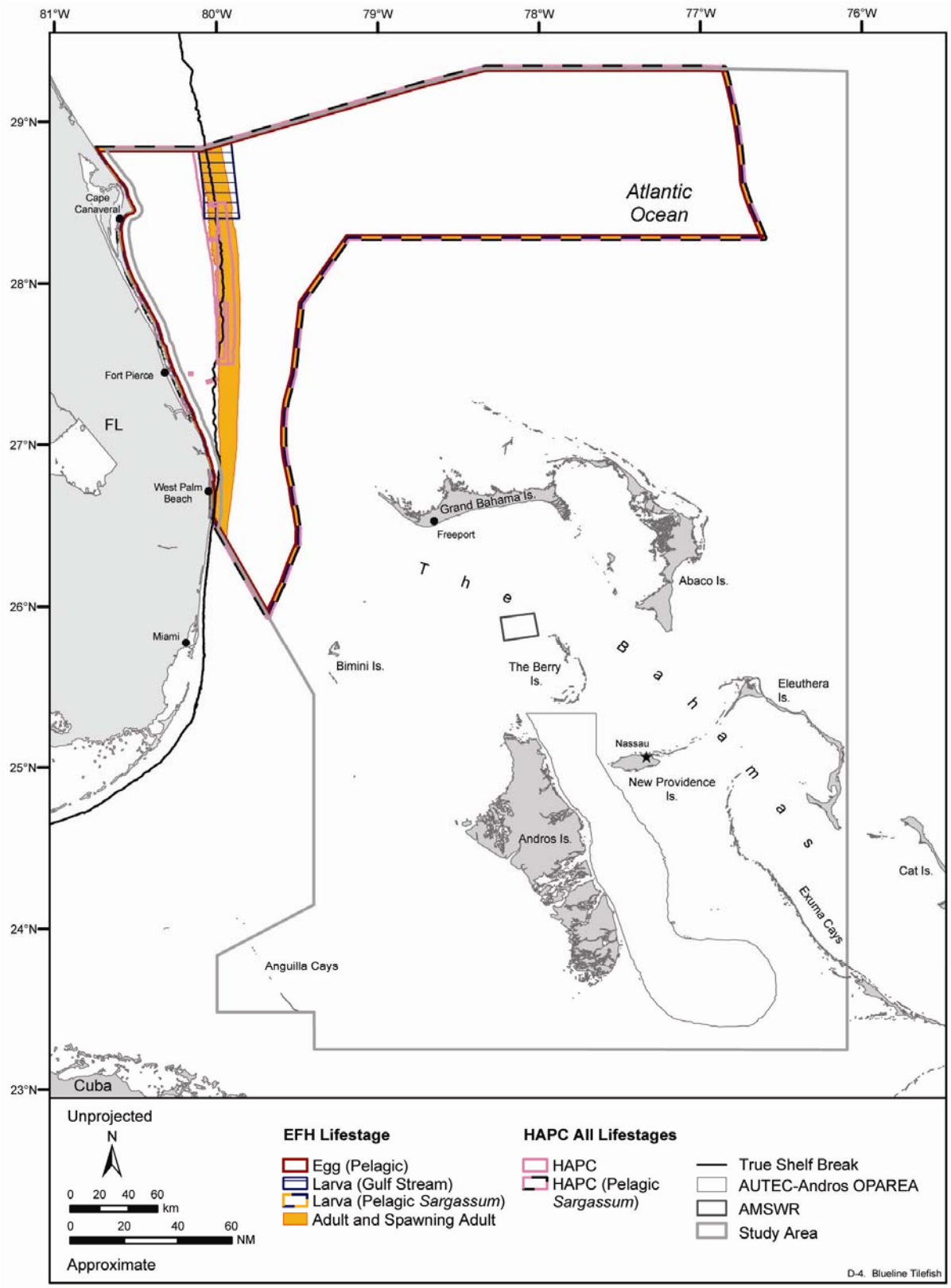


Figure D-4. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the blueline tilefish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: NOAA-CSC (2002, 2005), GDAIS (2005), and Reed et al. (2005). Source map (scanned): General Oceanics, Inc. (1986).

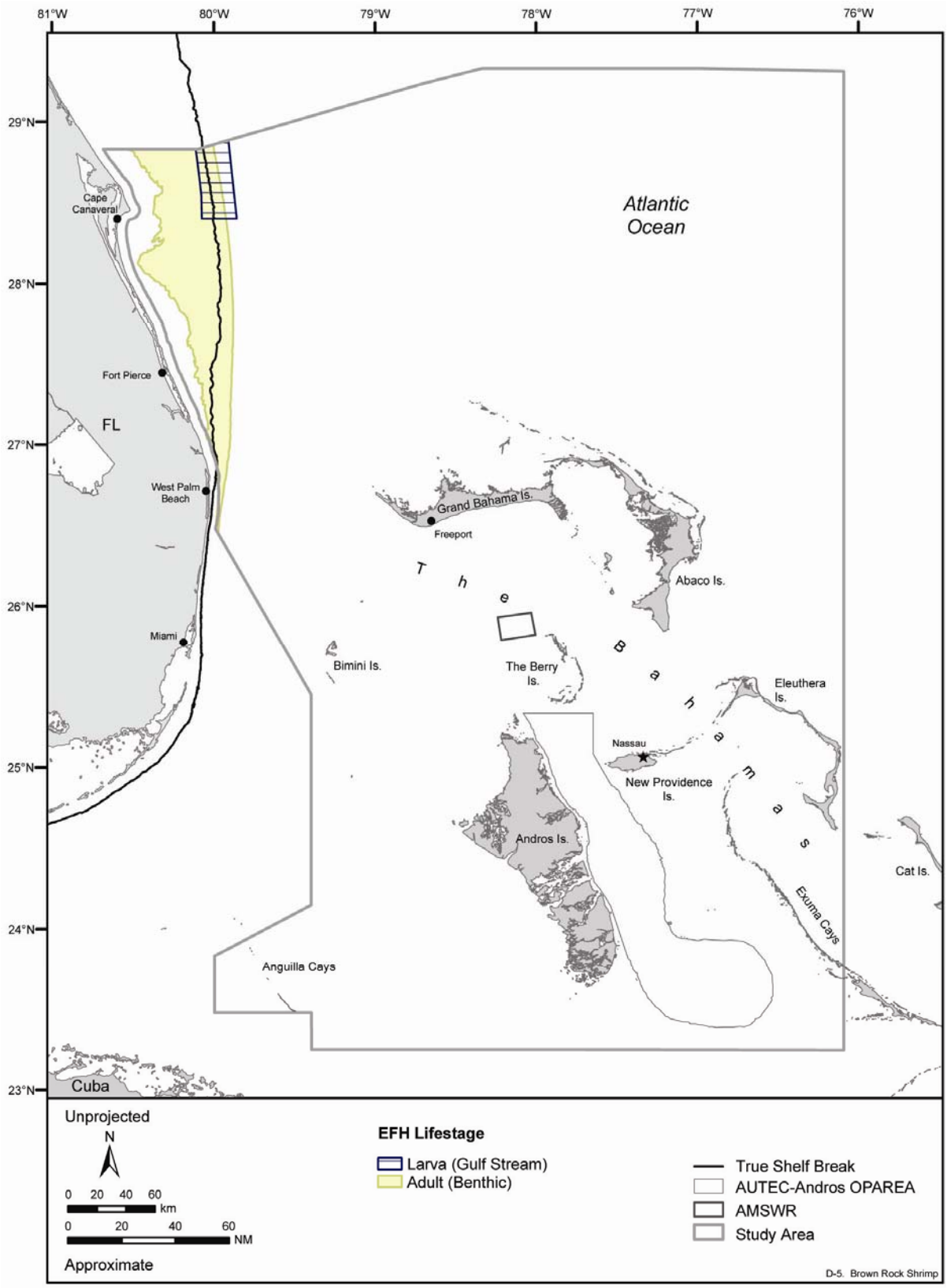


Figure D-5. Essential fish habitat (EFH) for all lifestages of the brown rock shrimp designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: USGS (2000) and GDAIS (2005). Source map (scanned): General Oceanics, Inc. (1986).

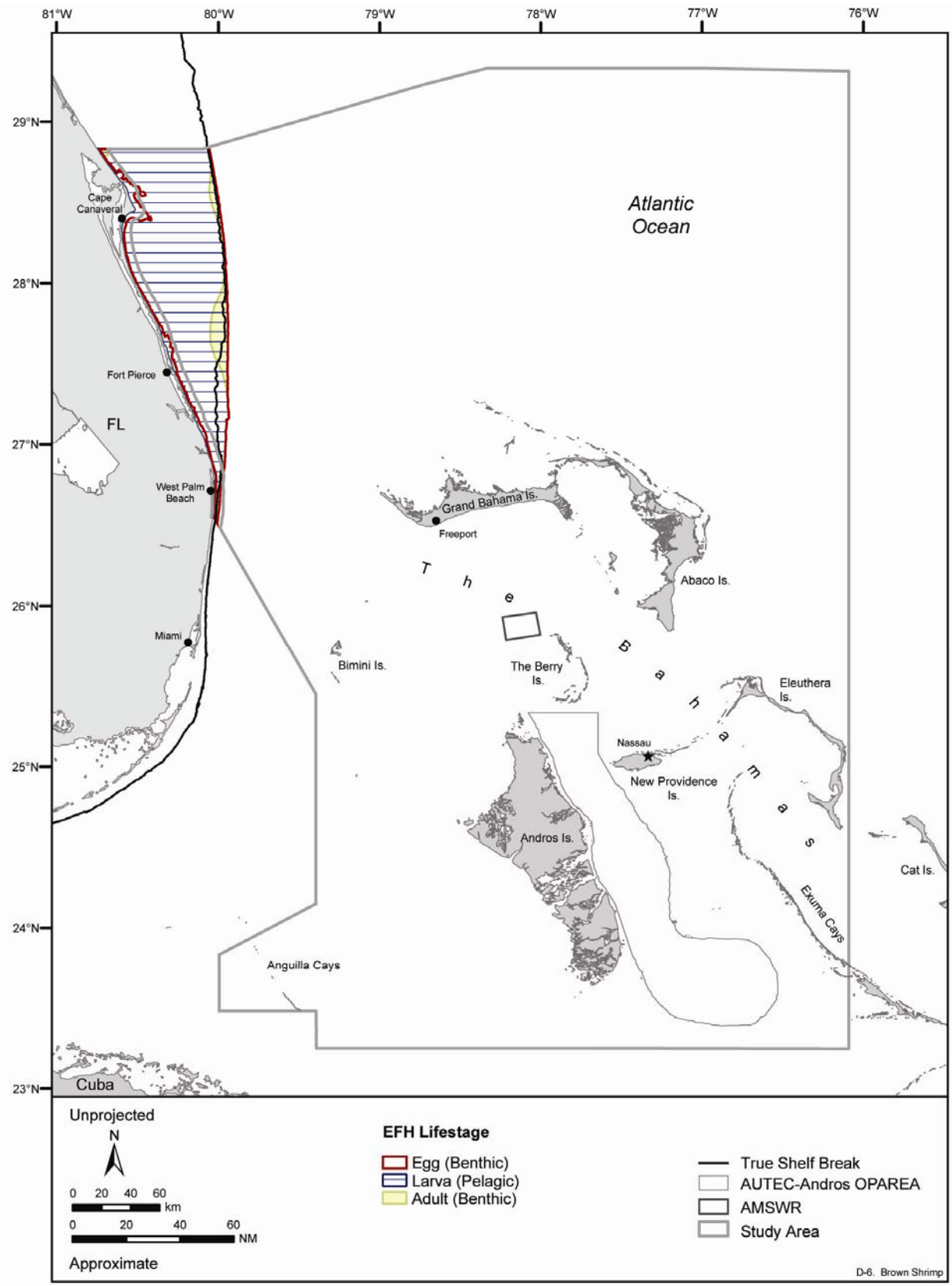


Figure D-6. Essential fish habitat (EFH) for all lifestages of the brown shrimp designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: USGS (2000) and GDAIS (2005).

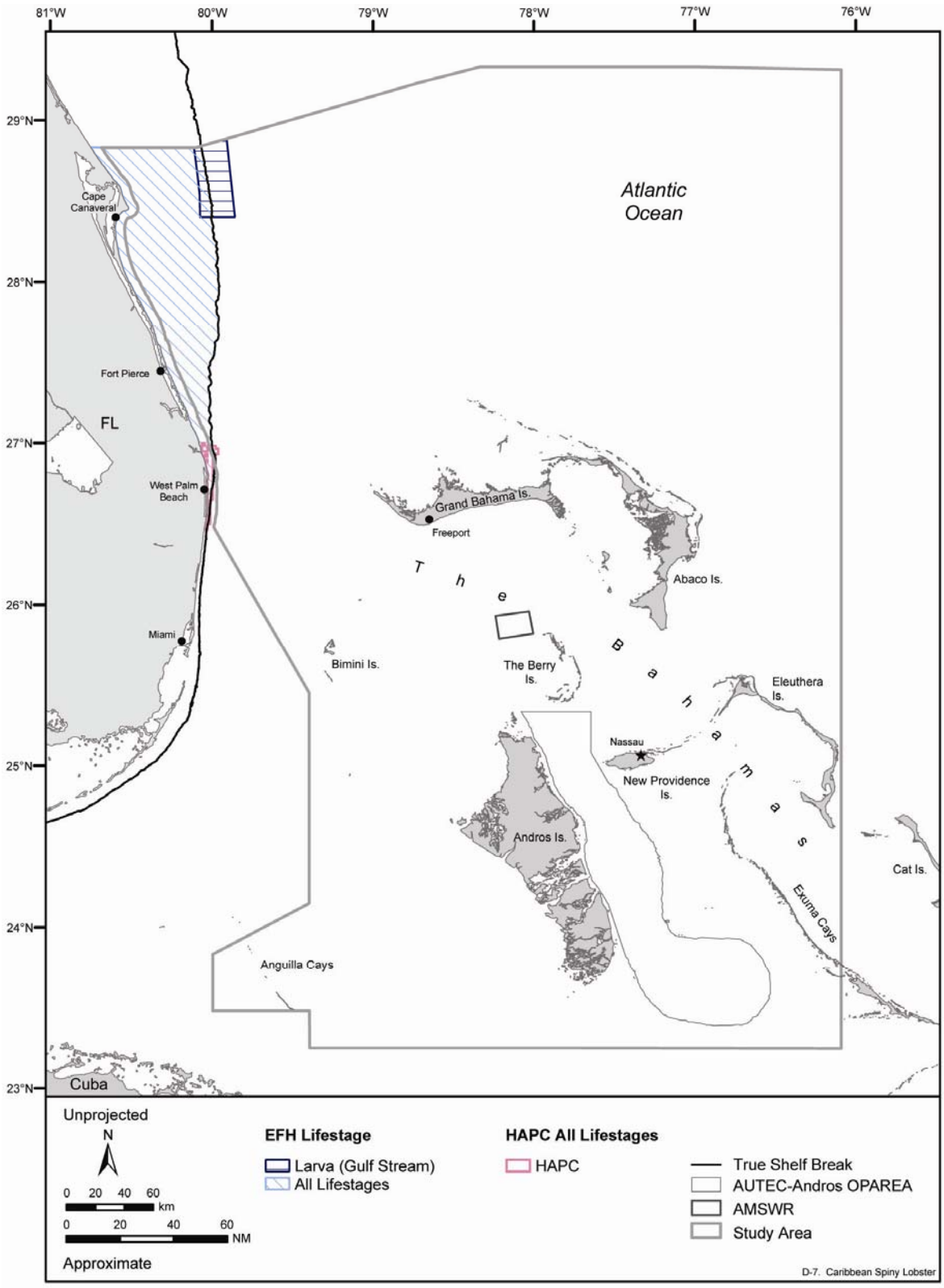


Figure D-7. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the Caribbean spiny lobster designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Sponges are also designated as EFH for all lifestages but could not be depicted. Source data: USGS (2000), SEAMAP (2001a), Reed (2005), and GDAIS (2005). Source maps (scanned): BLM (1976) and General Oceanics, Inc. (1986).

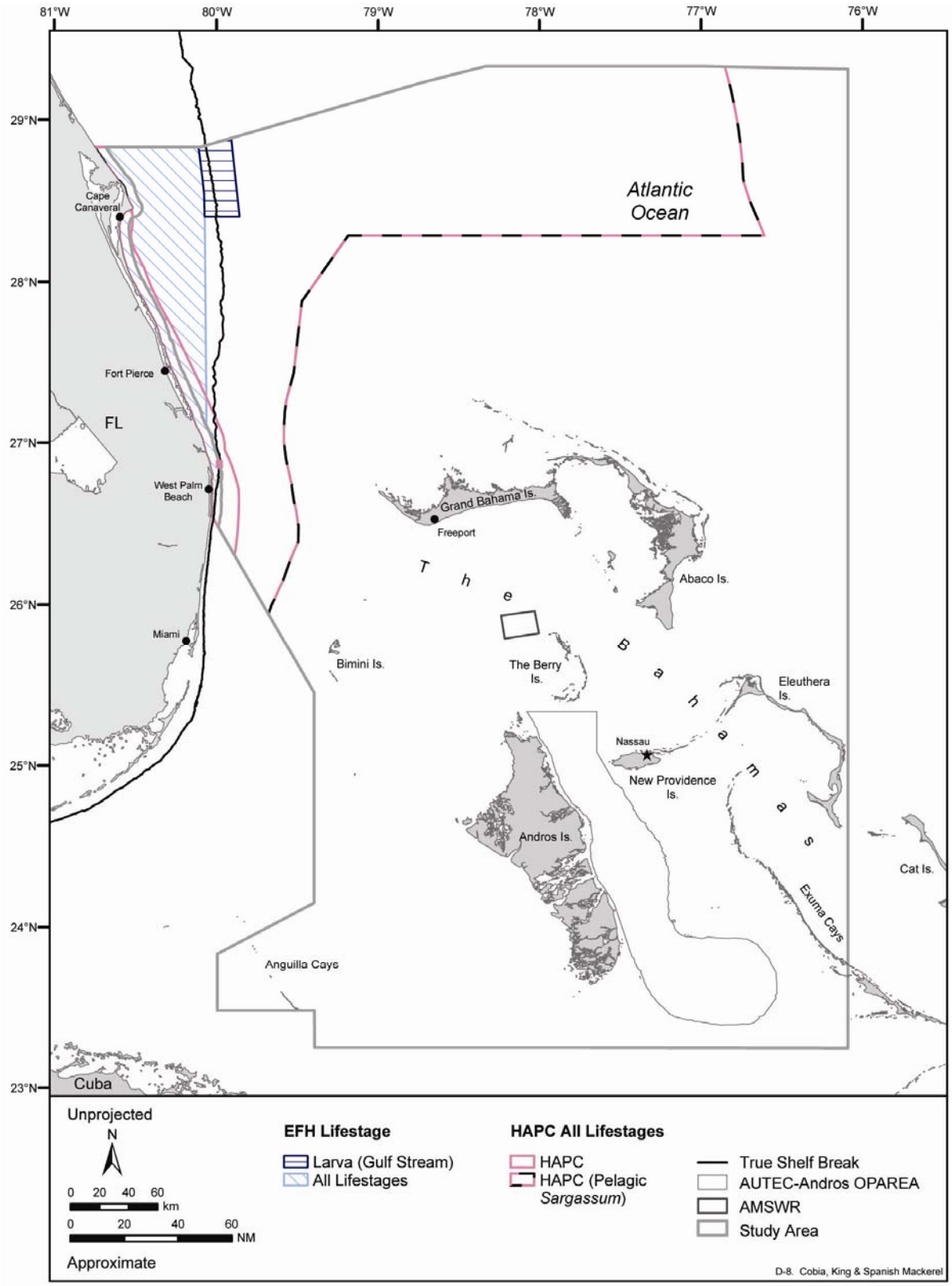


Figure D-8. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the cobia, king mackerel, and Spanish mackerel designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: GDAIS (2005) and SAFMC (2005). Source map (scanned): General Oceanics, Inc. (1986) and Zale and Merrifield (1989).

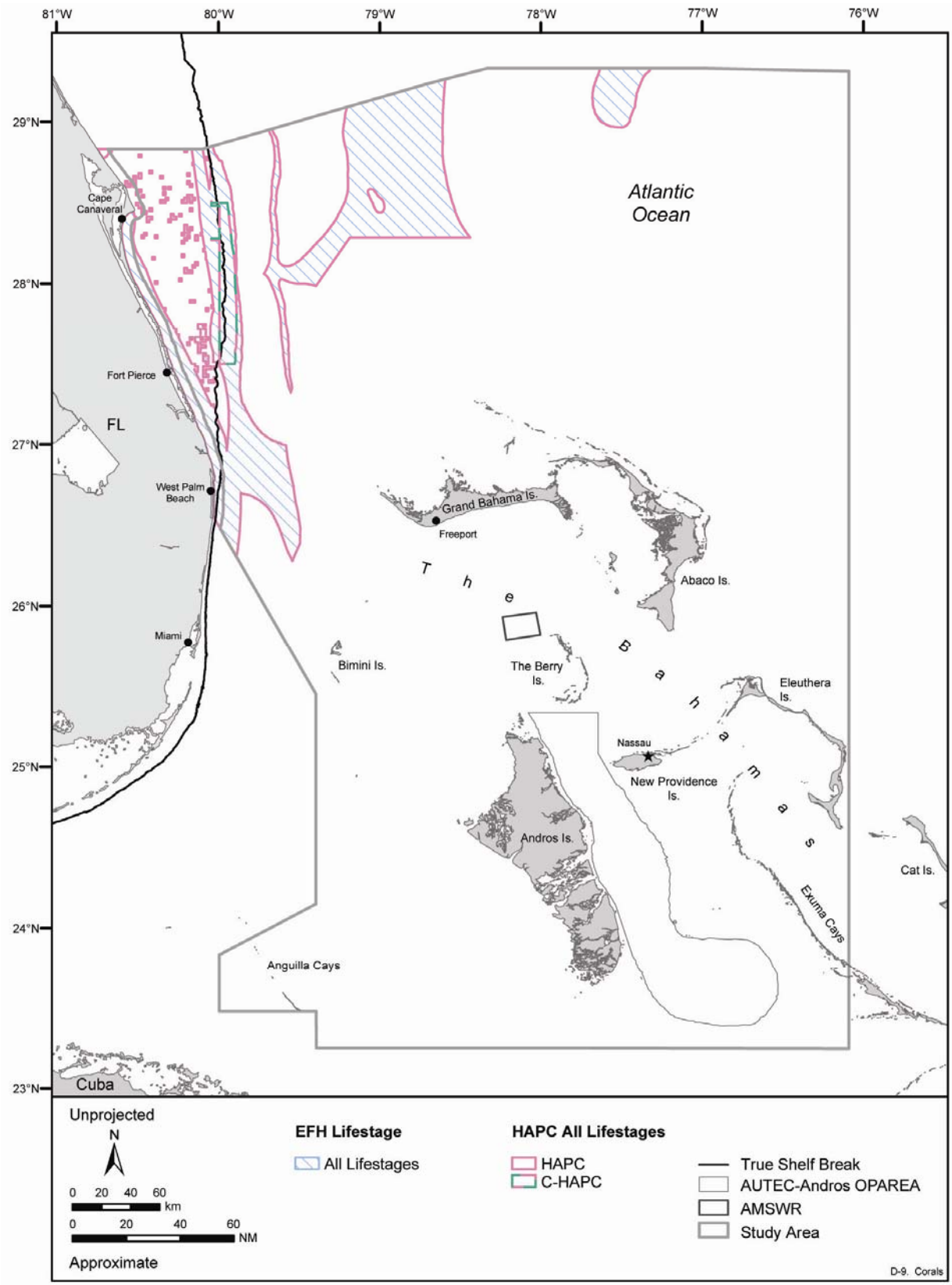


Figure D-9. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of corals and coral reefs designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: SEAMAP (2001a), GDAIS (2005), and Reed et al. (2005). Source map (scanned): Zale and Merrifield (1989).

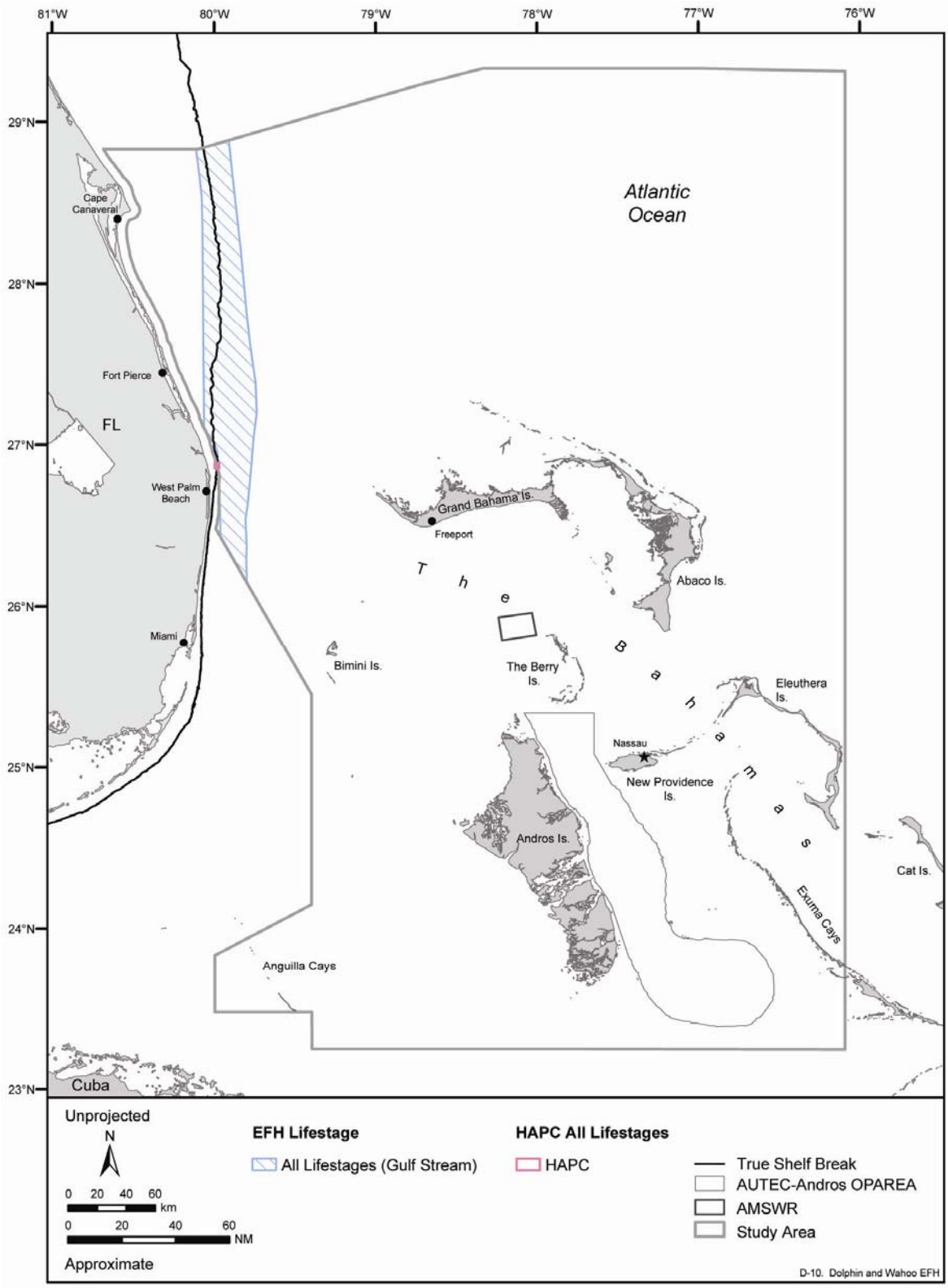


Figure D-10. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the wahoo, dolphinfish, and pompano dolphinfish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Gulf Stream/Florida Current associated gyres and eddies are also designated as EFH for all lifestages of the wahoo, dolphinfish and pompano dolphin but could not be mapped due their dynamic nature. Source data: SAFMC (2005). Source map (scanned): General Oceanics, Inc. (1986).

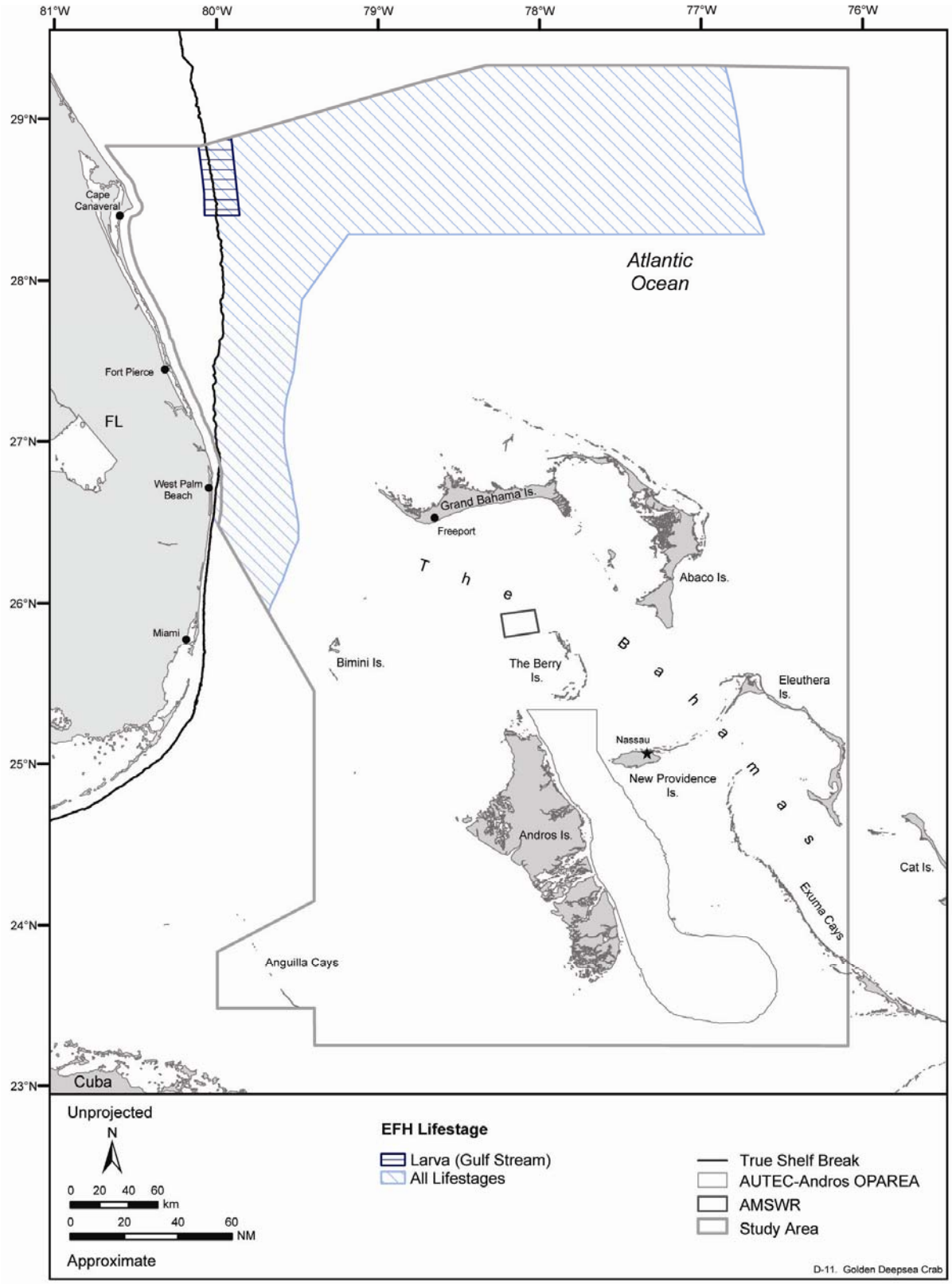


Figure D-11. Essential fish habitat (EFH) for all lifestages of the golden deepsea crab designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Seven unique benthic habitats designated as EFH are not included on this map as the aerial extent of the habitats was not designated. Source data: GDAIS (2005). Source map (scanned): General Oceanics, Inc. (1986).

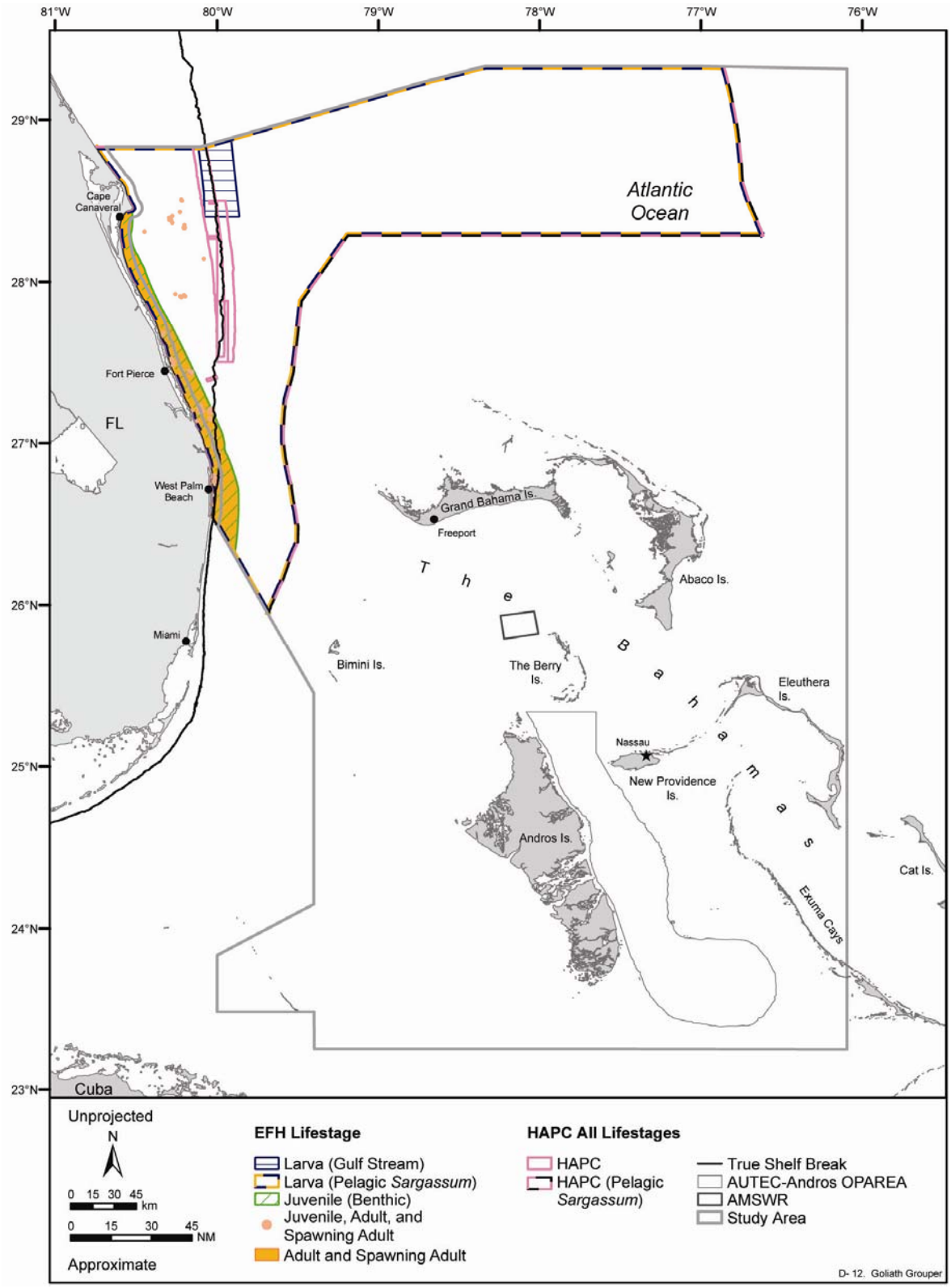


Figure D-12. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the goliath grouper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: NOAA-CSC (2002, 2005), FFWCC (2005a), GDAIS (2005), and Reed et al. (2005). Source maps (scanned): General Oceanics, Inc. (1986) and Zale and Merrifield (1989).

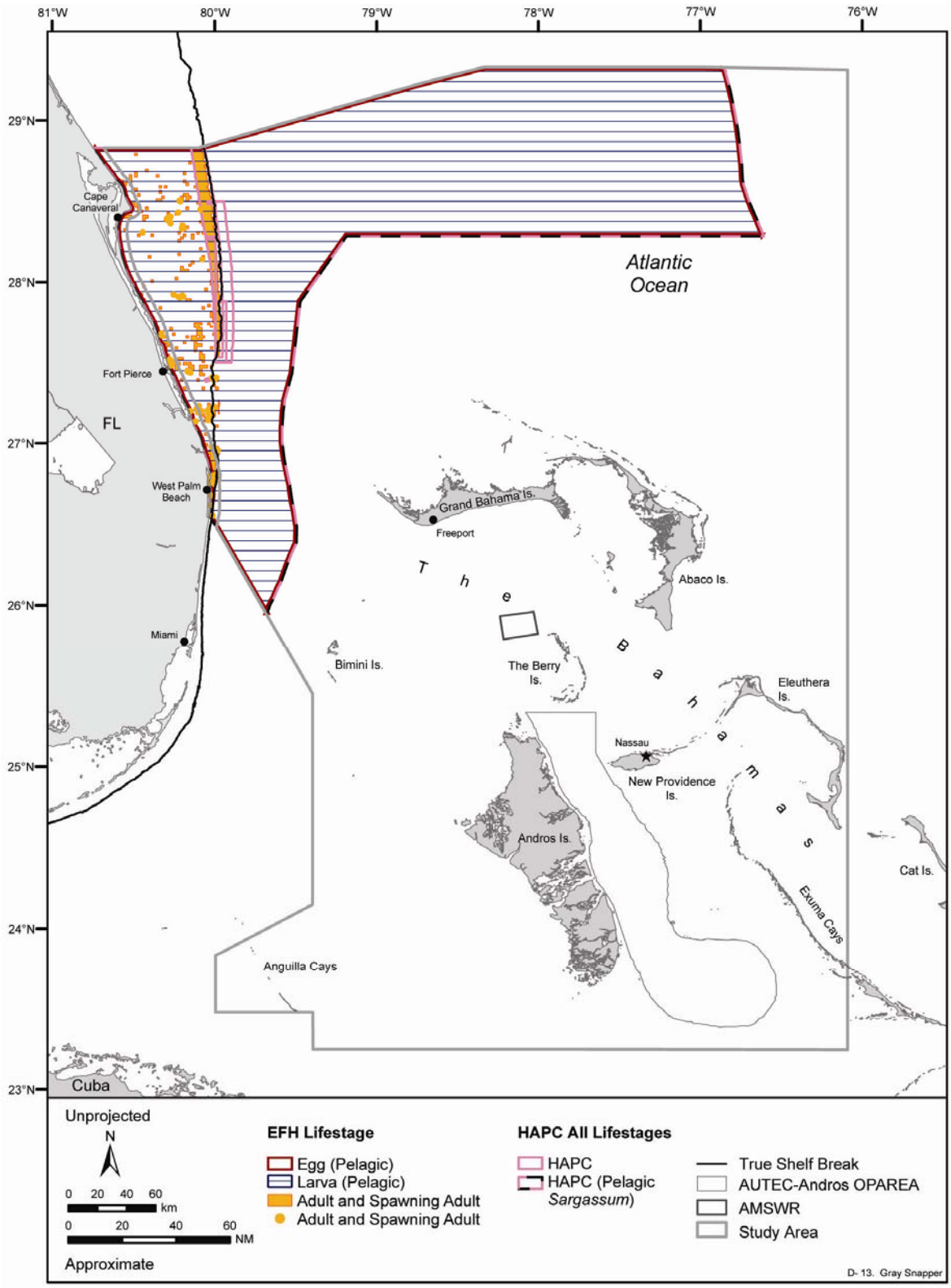


Figure D-13. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the gray snapper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Sponges are also designated as EFH for juveniles in the SAFMC's jurisdiction but could not be depicted. Additionally, *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), FFWCC (2005a), GDAIS (2005), and Reed et al. (2005).

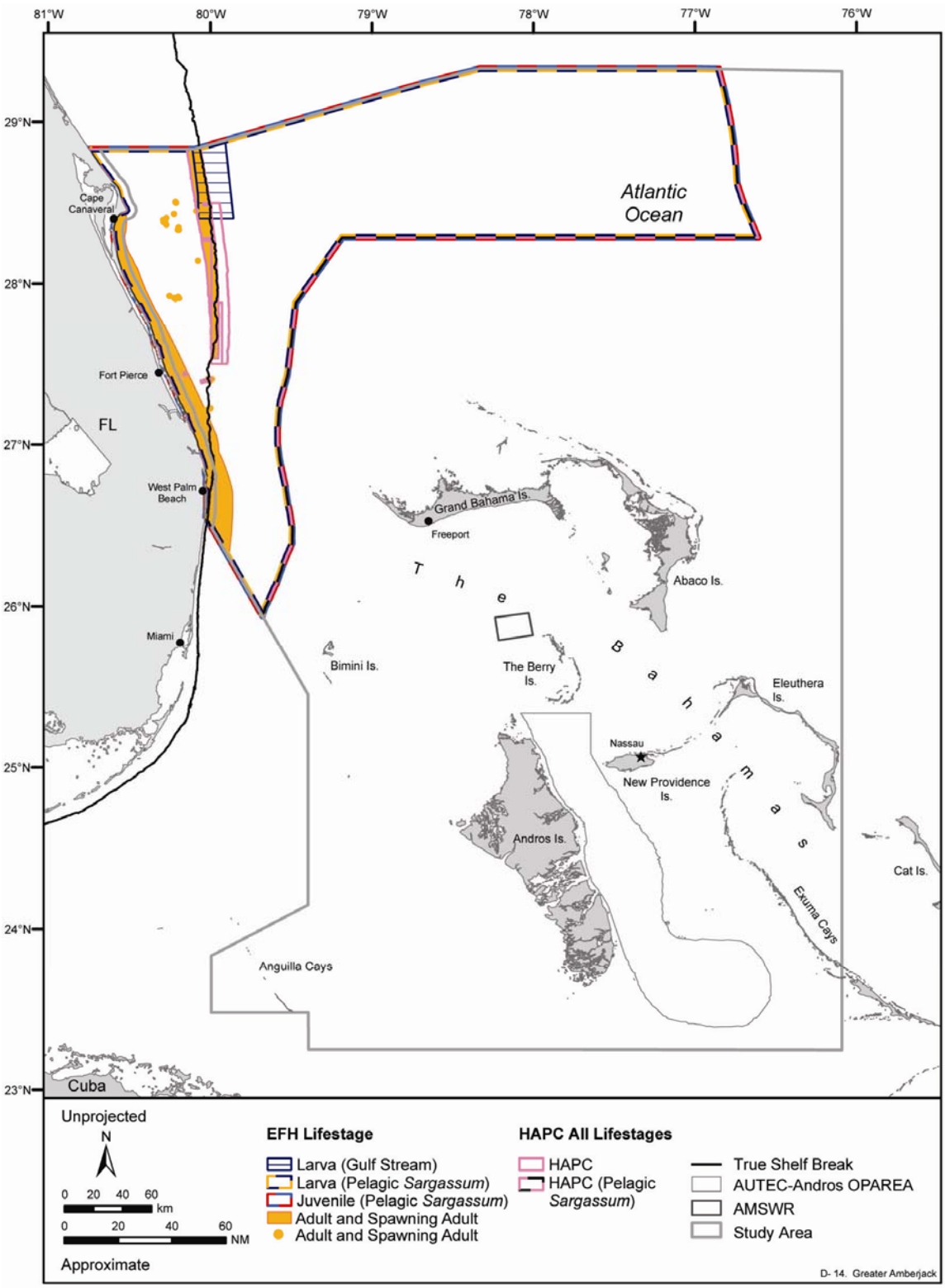


Figure D-14. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the greater amberjack designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Floating debris is designated for juveniles in the SAFMC jurisdiction but was impossible to depict on the map. Additionally, *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: NOAA-CSC (2002, 2004), FFWCC (2005a), GDAIS (2005), and Reed et al. (2005). Source maps (scanned): General Oceanics, Inc. (1986) and Zale and Merrifield (1989).

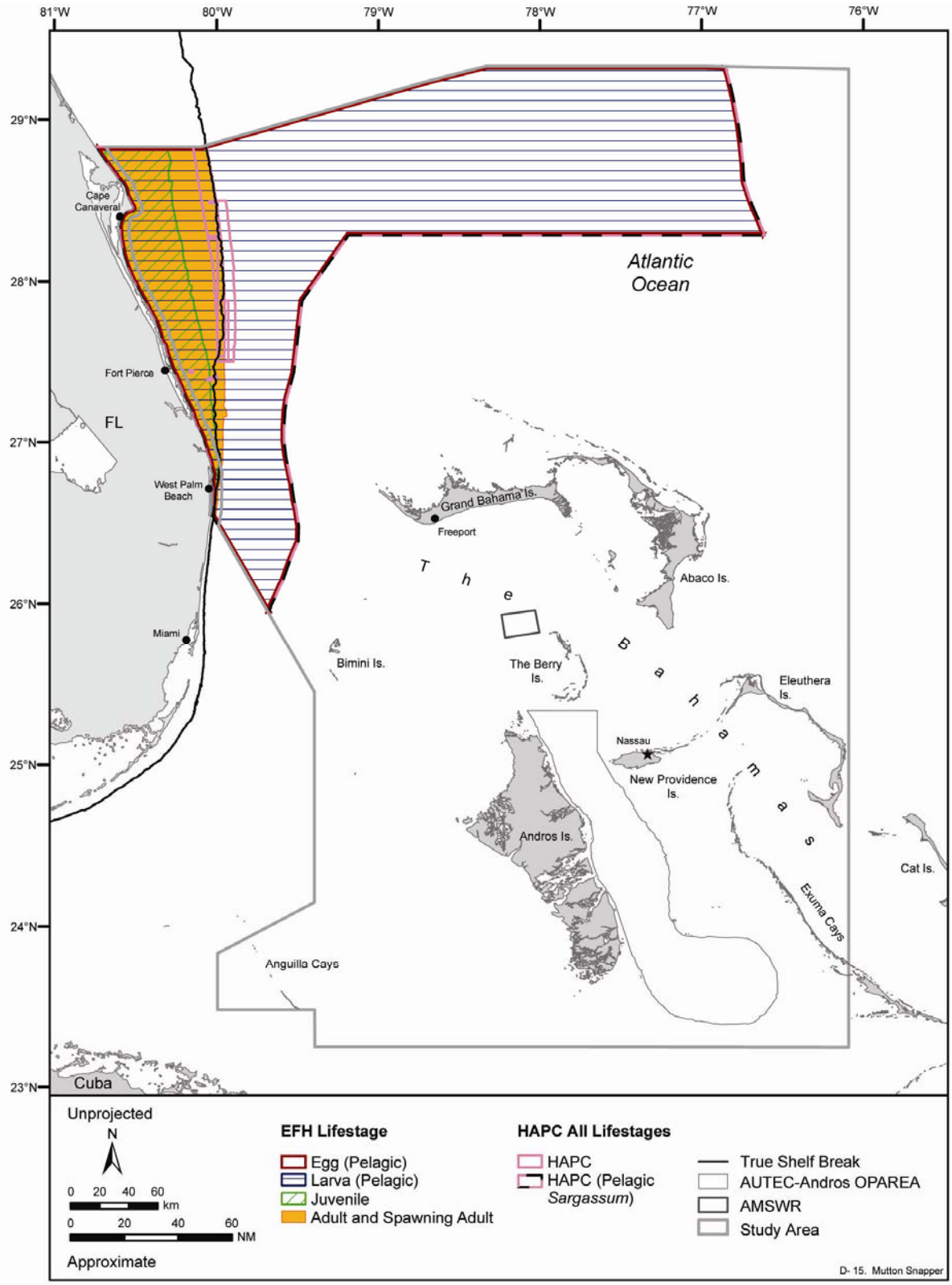


Figure D-15. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the mutton snapper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: USGS (2000), SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005). Source map (scanned): Zale and Merrifield (1989).

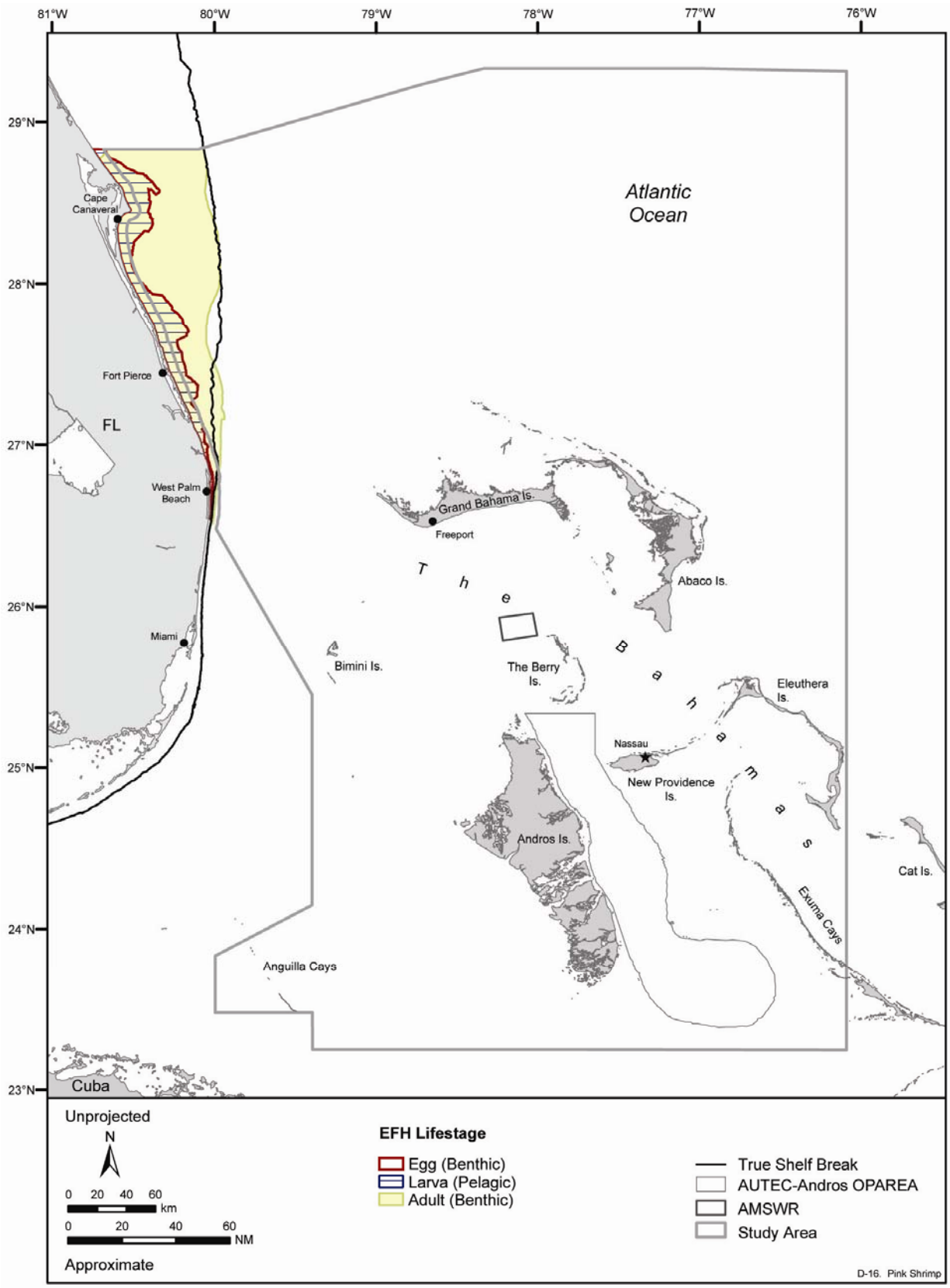


Figure D-16. Essential fish habitat (EFH) for all lifestages of the pink shrimp designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: GDAIS (2005) and USGS (2000).

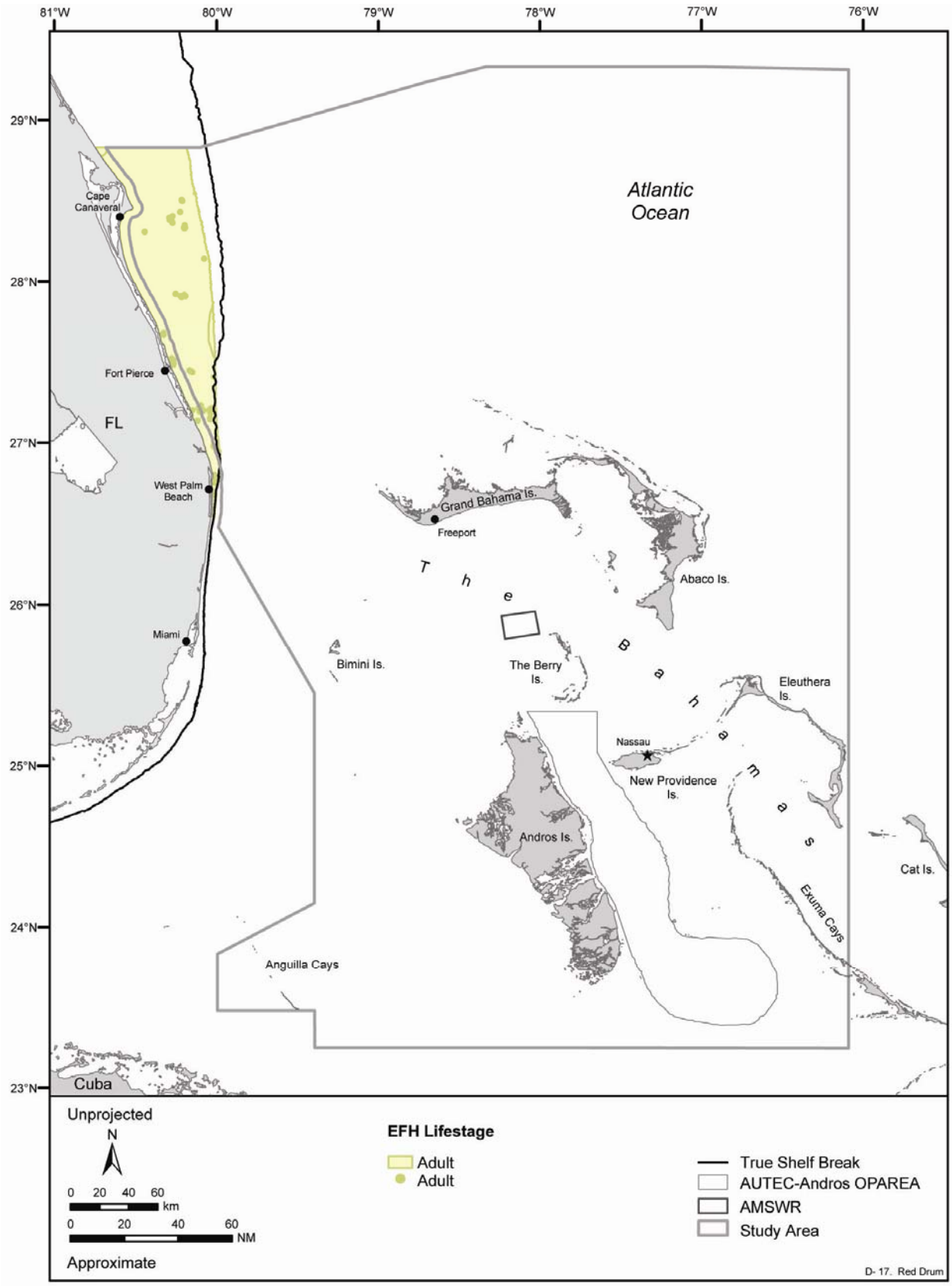


Figure D-17. Essential fish habitat (EFH) for all lifestages of the red drum designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: USGS (2000) and FFWCC (2005a).

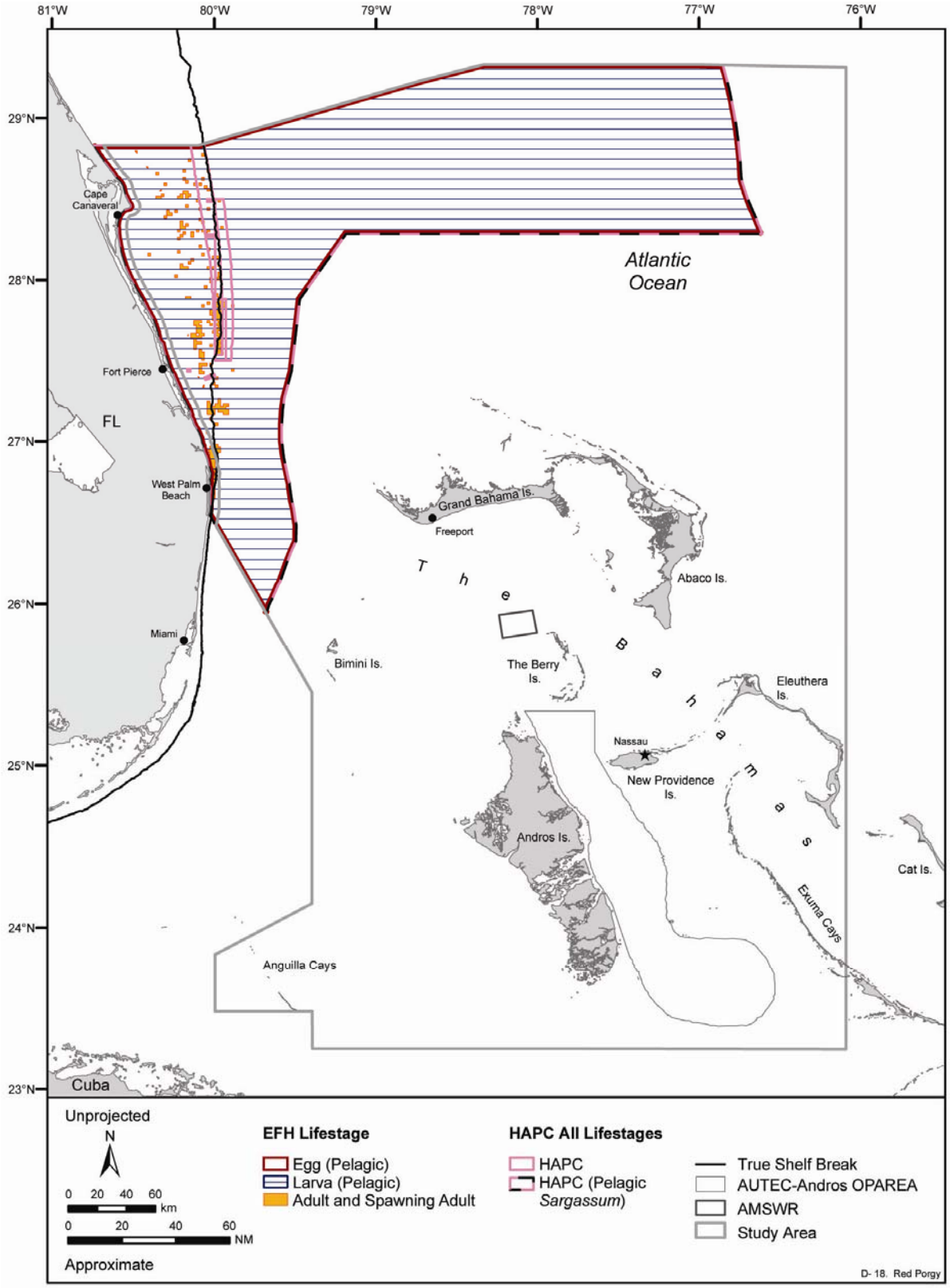


Figure D-18. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the red porgy designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005).

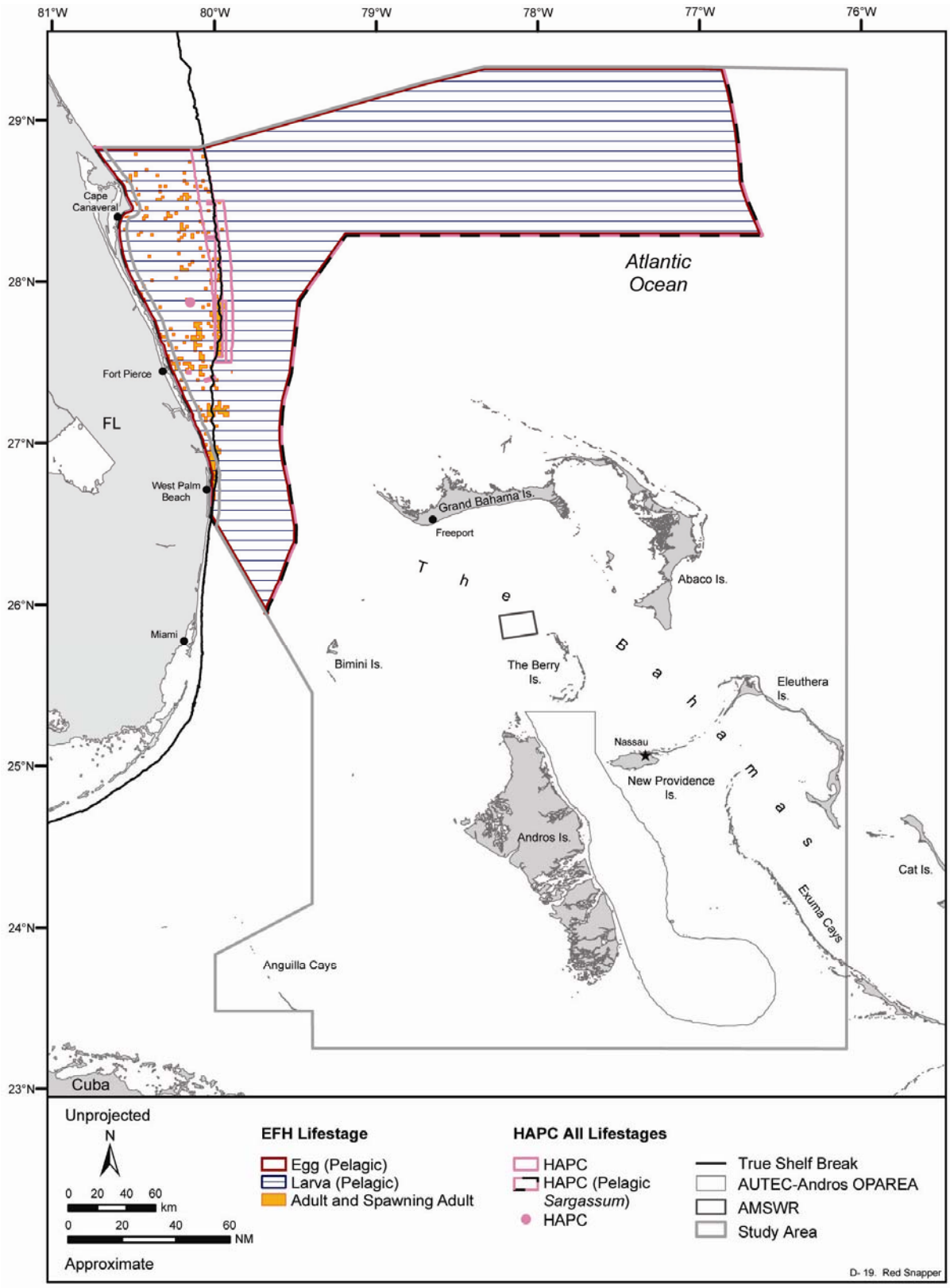


Figure D-19. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the red snapper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), Reed et al. (2005), and Sedberry (2005).

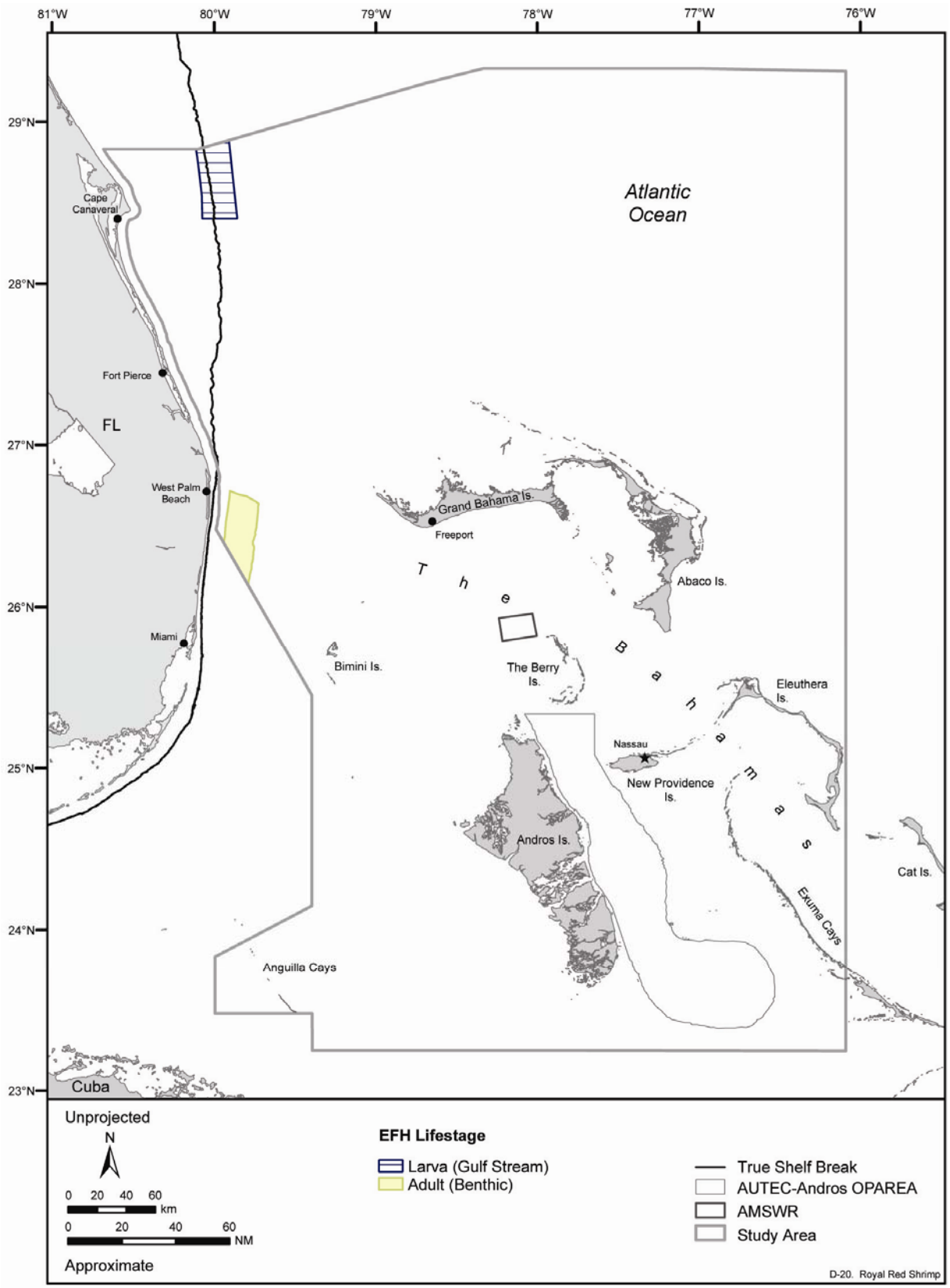


Figure D-20. Essential fish habitat (EFH) for all lifestages of the royal red shrimp designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data USGS (2000) and GDAIS (2005). Source map (scanned): General Oceanics, Inc. (1986).

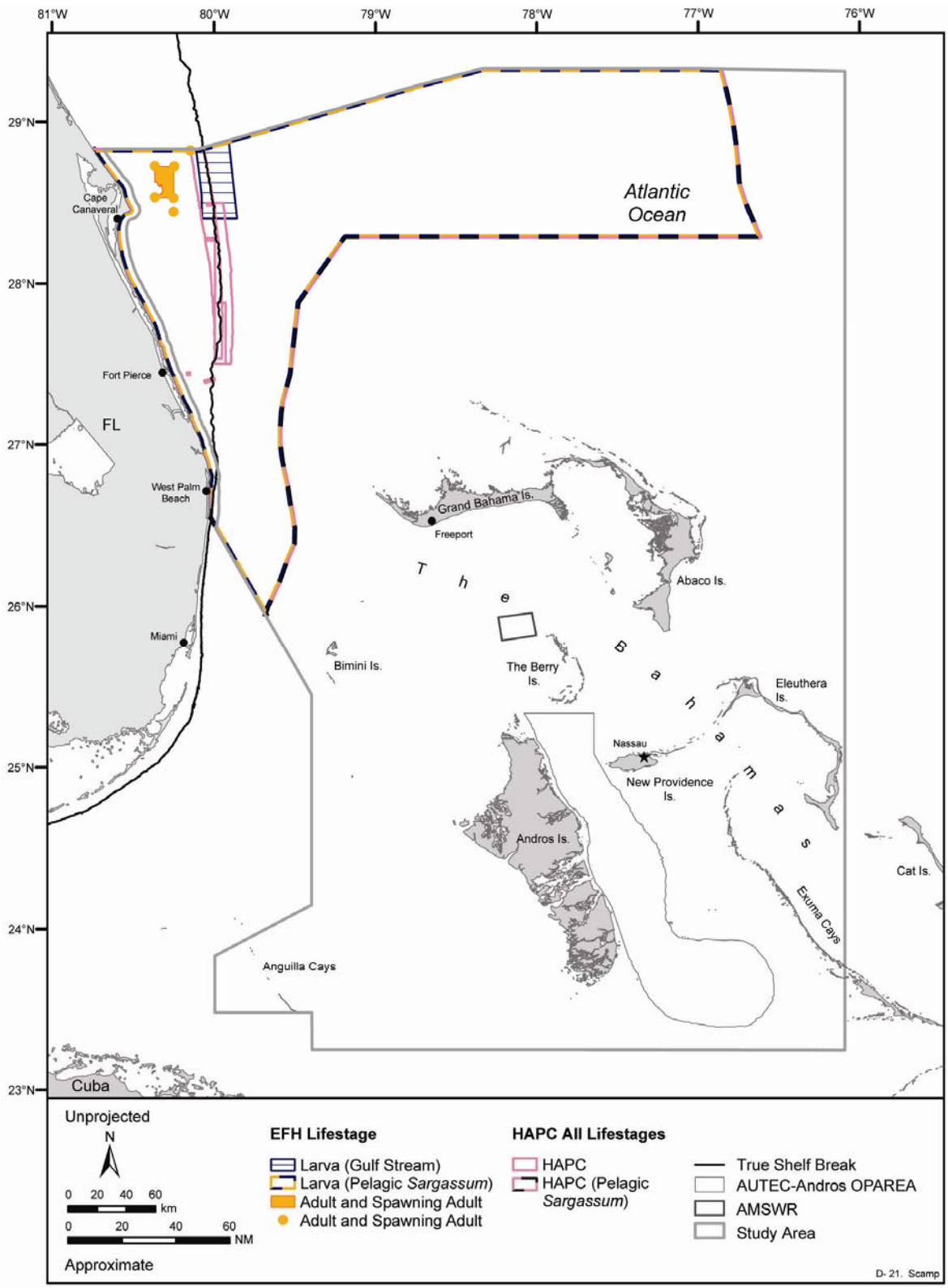


Figure D-21. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the scamp designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005). Source maps (scanned): BLM (1976) and General Oceanics, Inc. (1986).

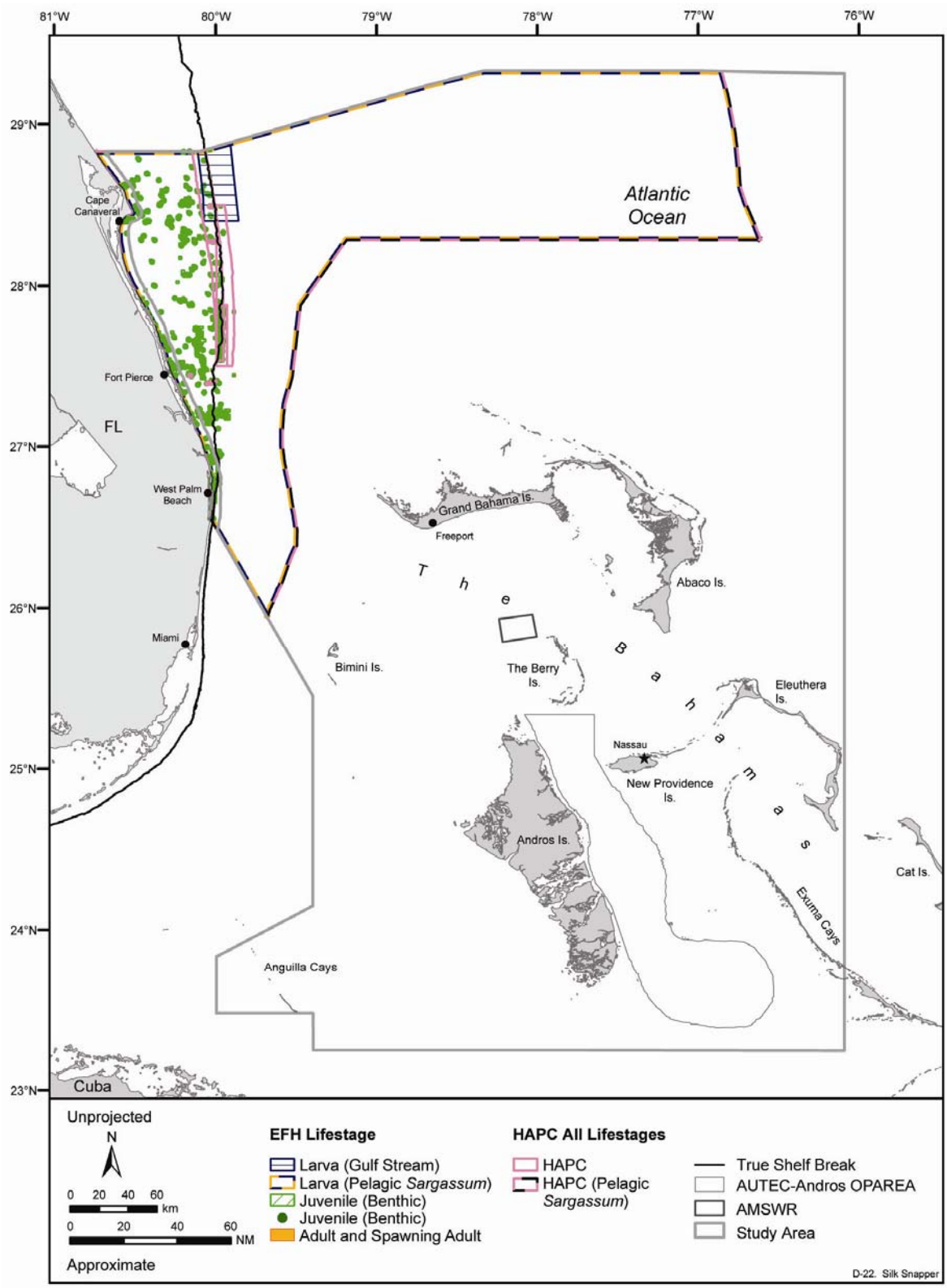


Figure D-22. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the silk snapper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), FFWCC (2005a), GDAIS (2005), and Reed et al. (2005). Source map (scanned): General Oceanics, Inc. (1986).

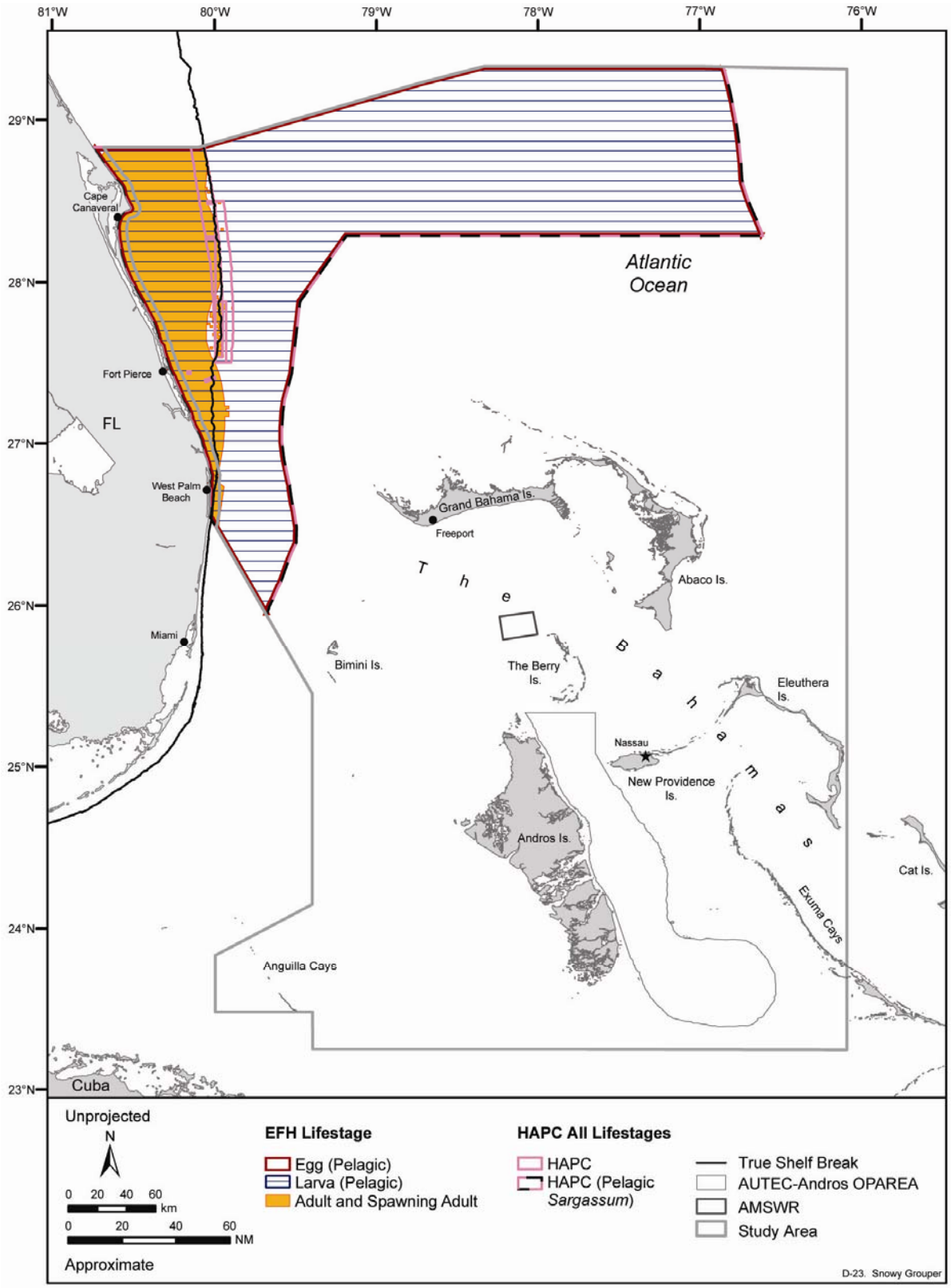


Figure D-23. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the snowy grouper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: USGS (2000), SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005).

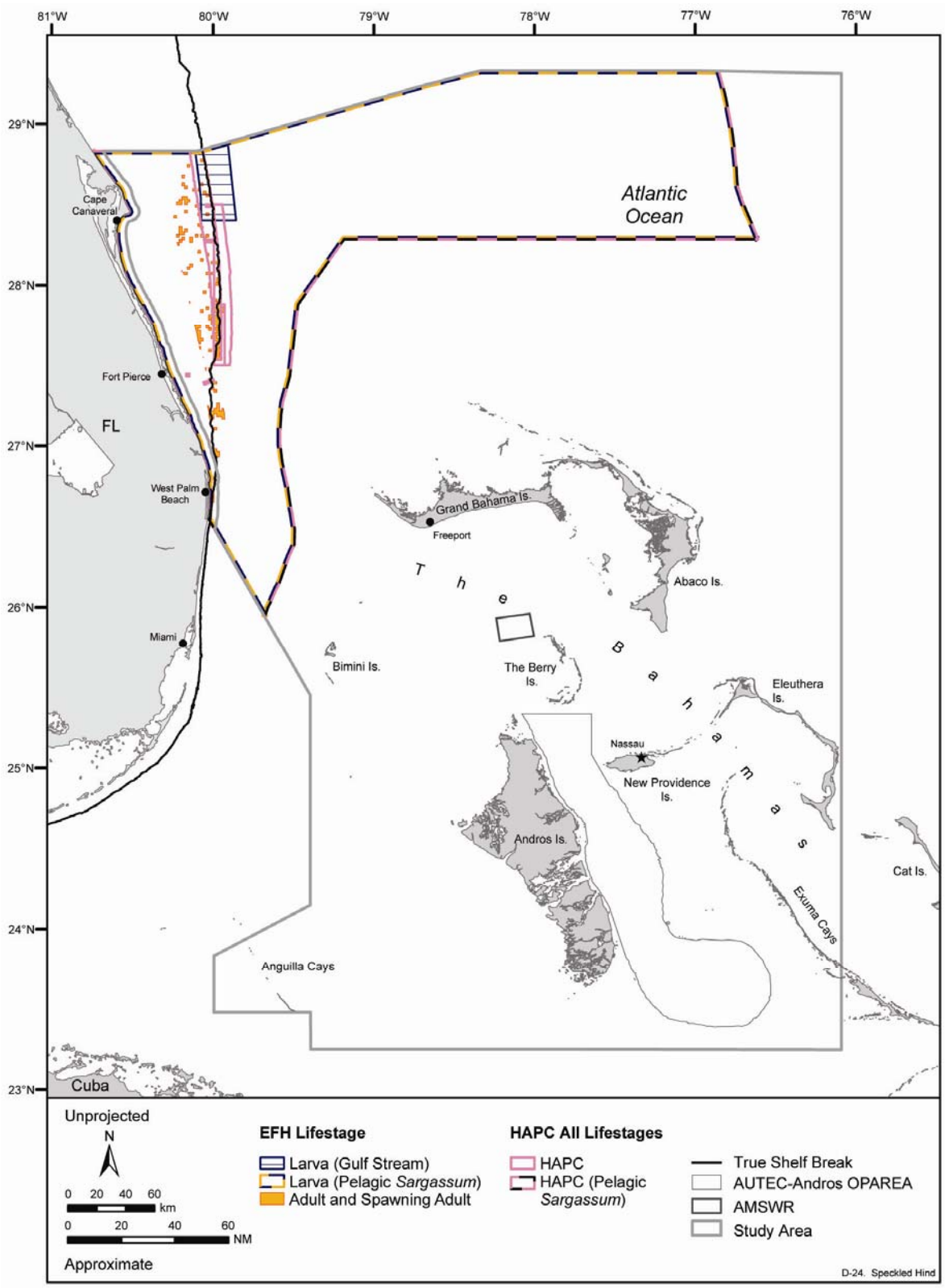


Figure D-24. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the speckled hind designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005). Source map (scanned): General Oceanics, Inc. (1986).

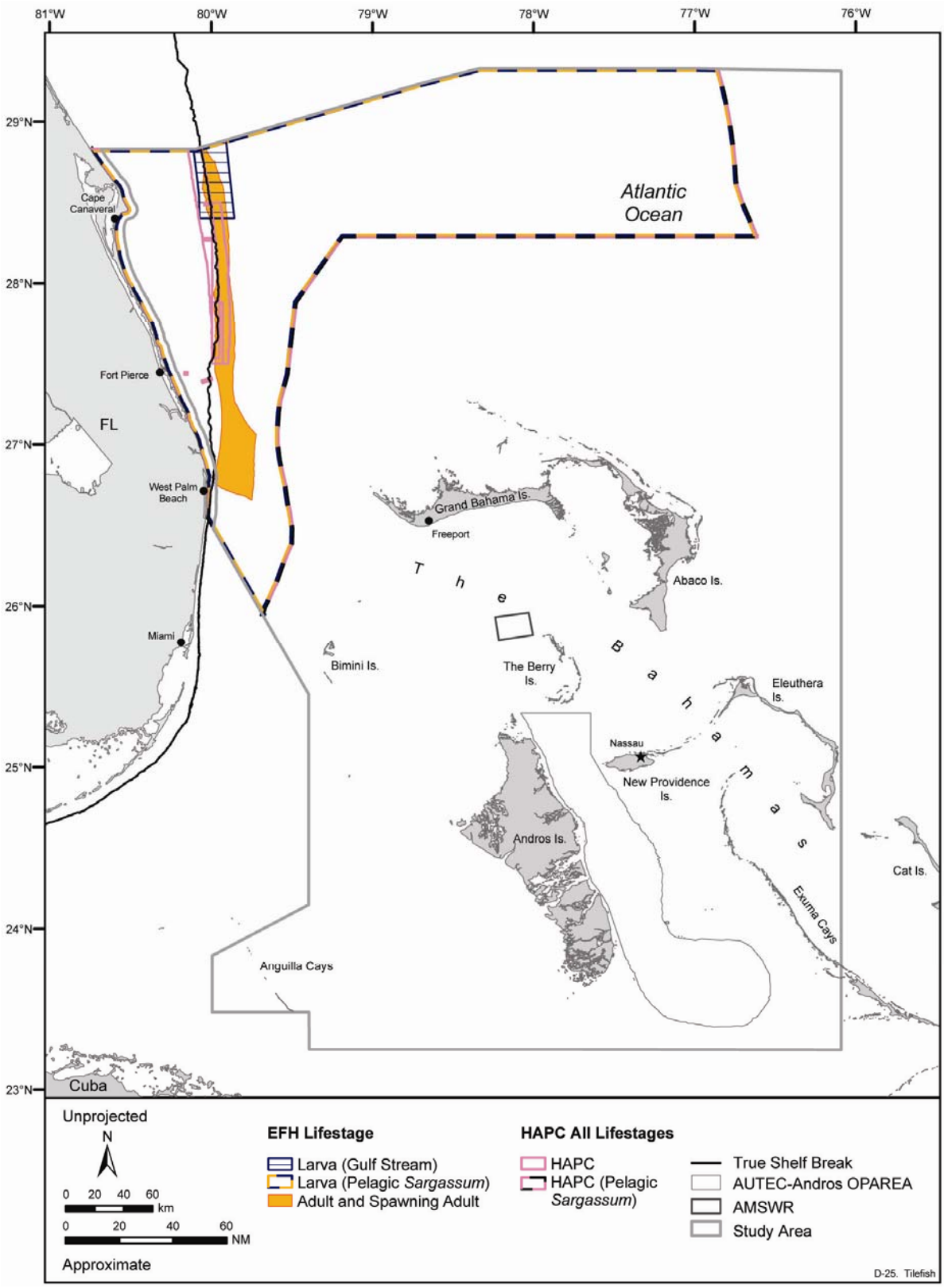


Figure D-25. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the tilefish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: USGS (2000), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005). Source map (scanned): General Oceanics, Inc. (1986).

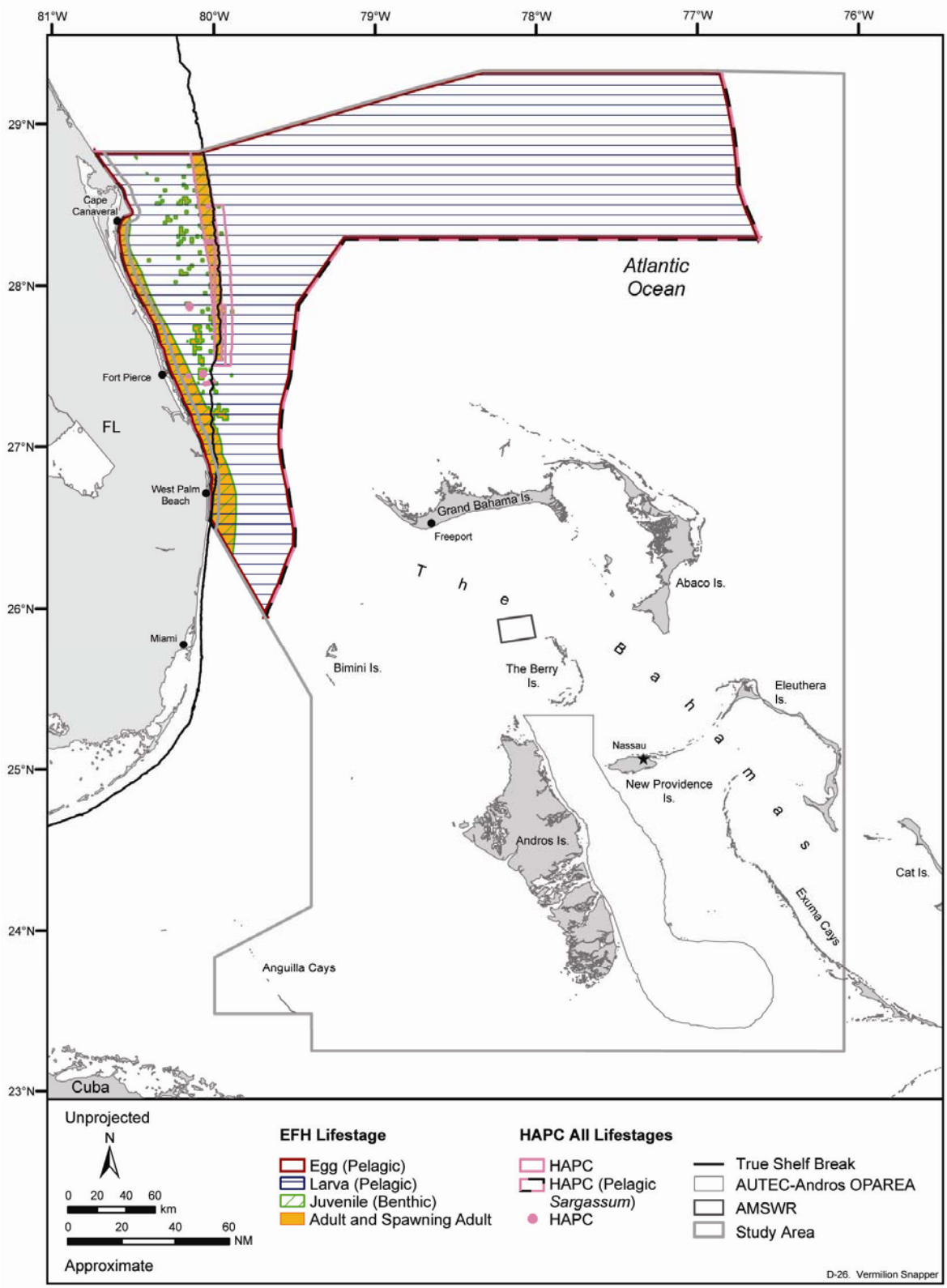


Figure D-26. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the vermilion snapper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), Reed et al. (2005), and Sedberry (2005). Source map (scanned): Zale and Merrifield (1989).

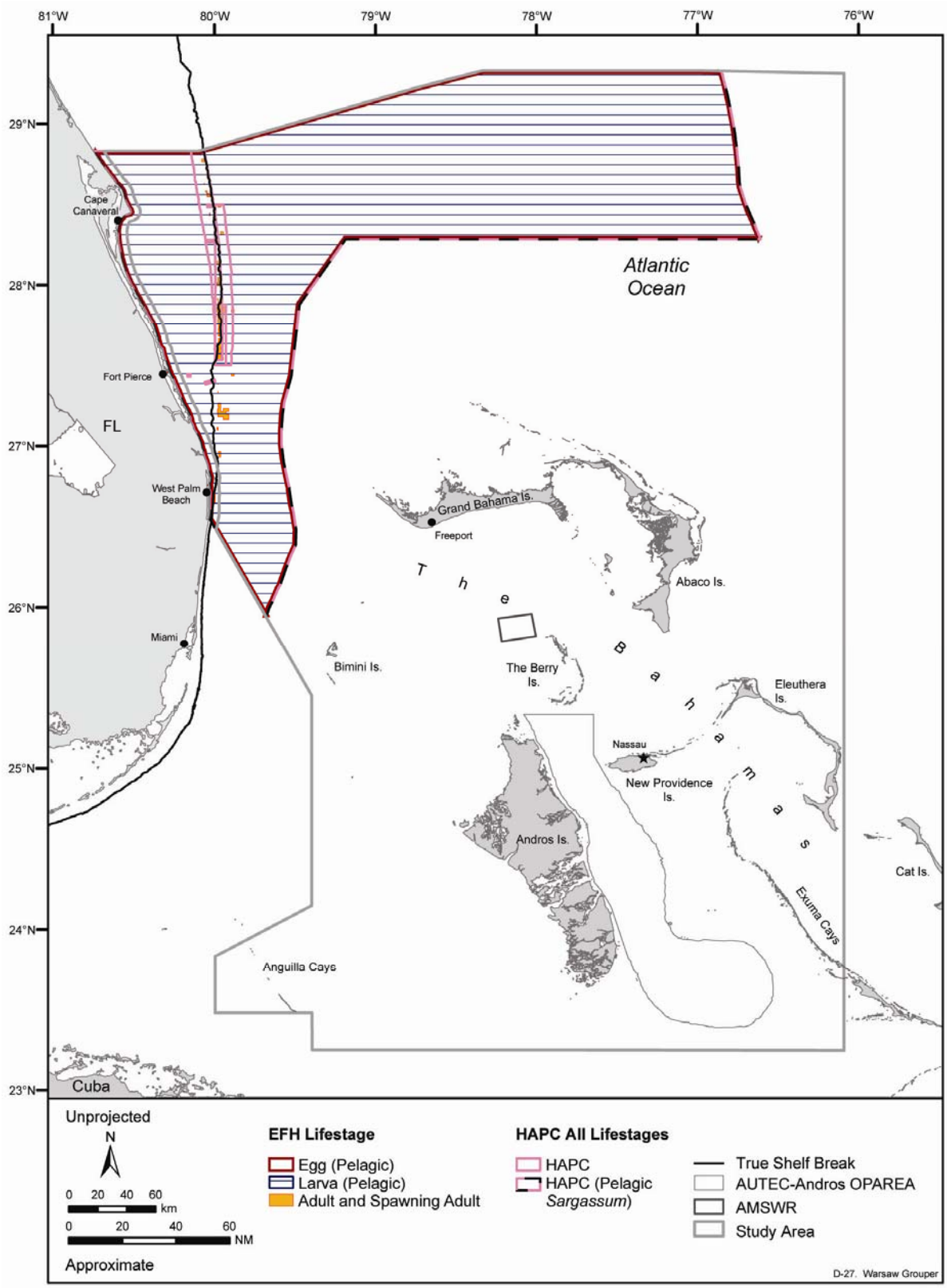


Figure D-27. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the warsaw grouper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005).

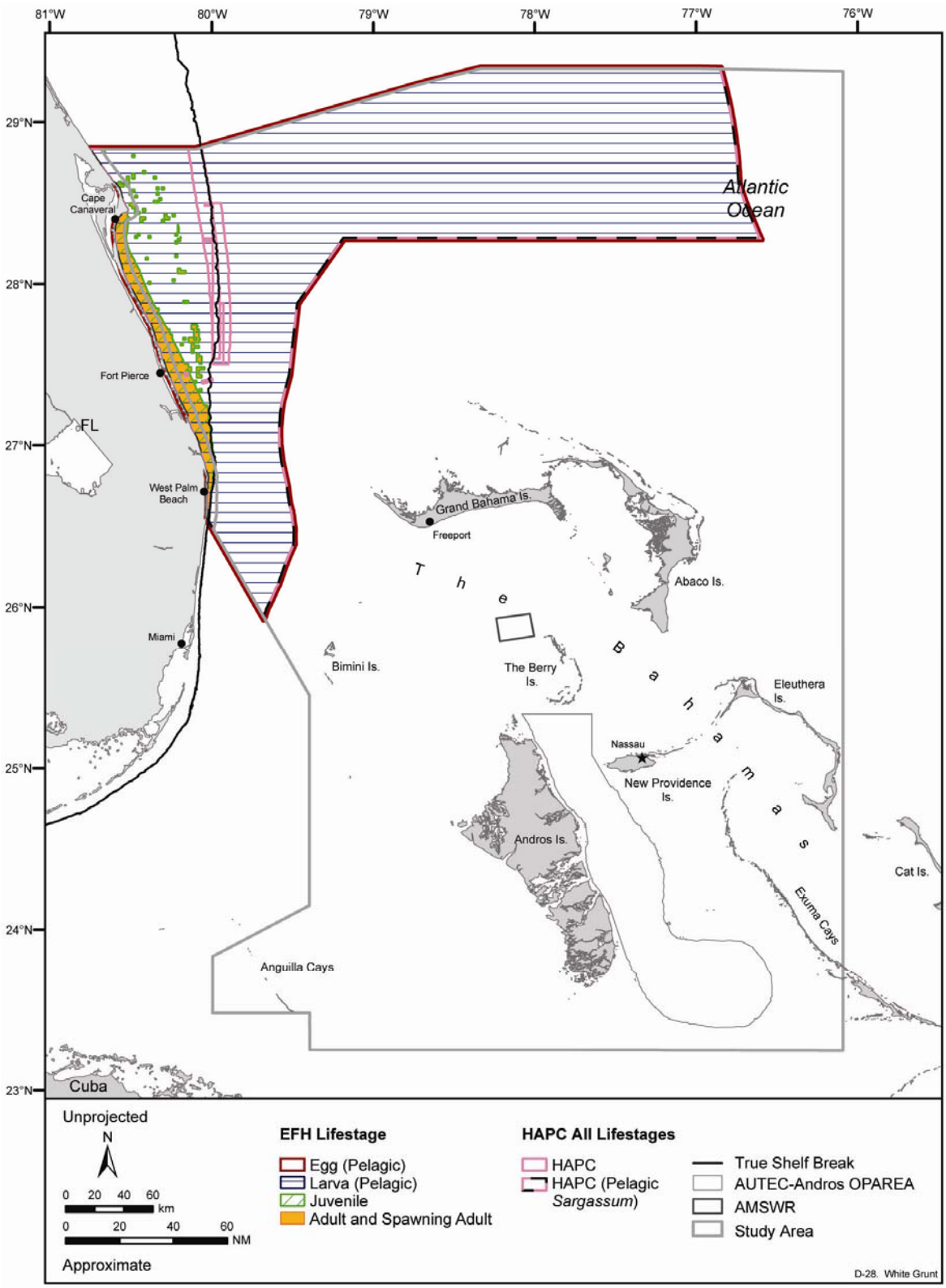


Figure D-28. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the white grunt designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005). Source map (scanned): Zale and Merrifield (1989).

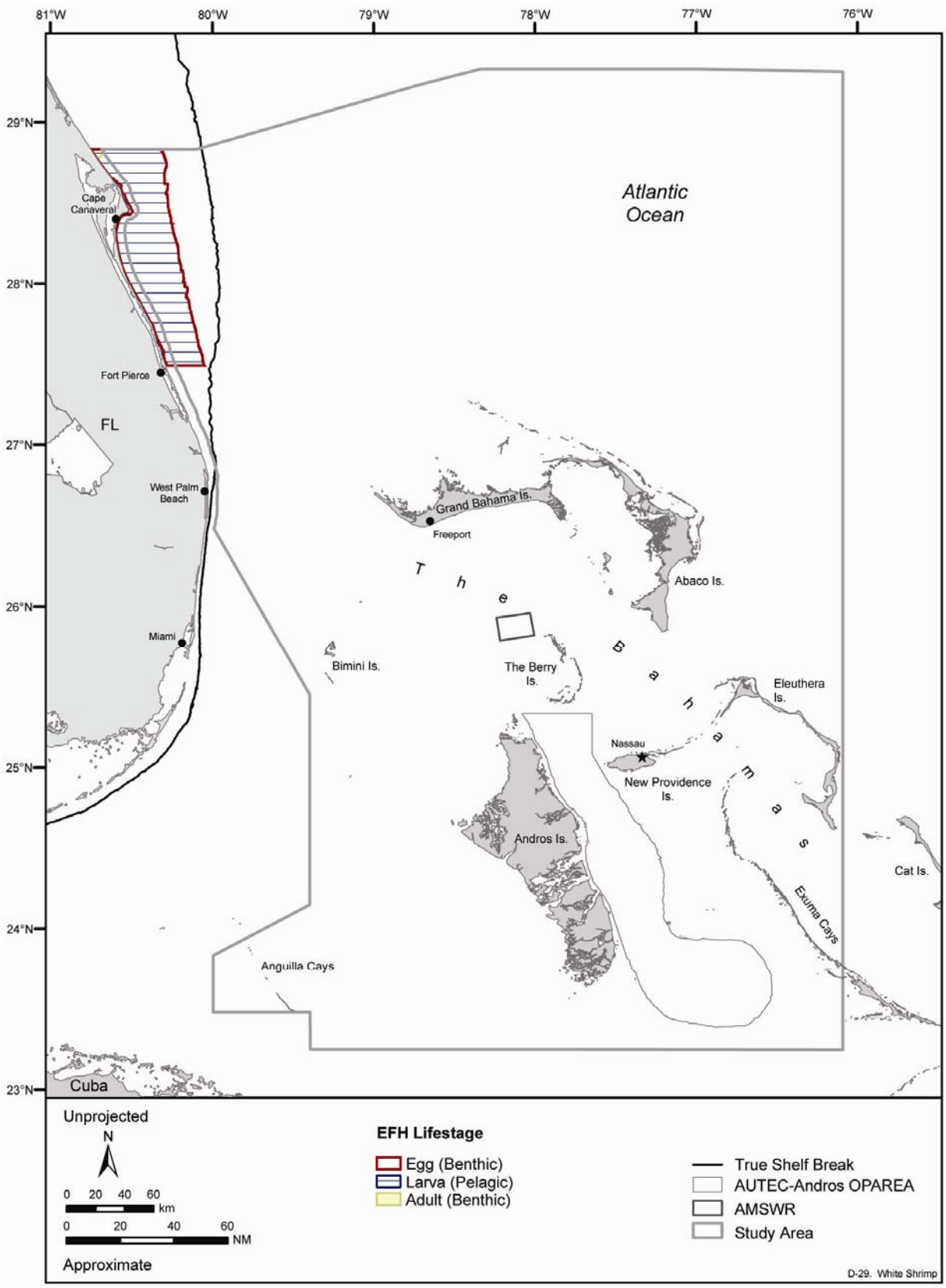


Figure D-29. Essential fish habitat (EFH) for all lifestages of the white shrimp designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: USGS (2000) and GDAIS (2005).

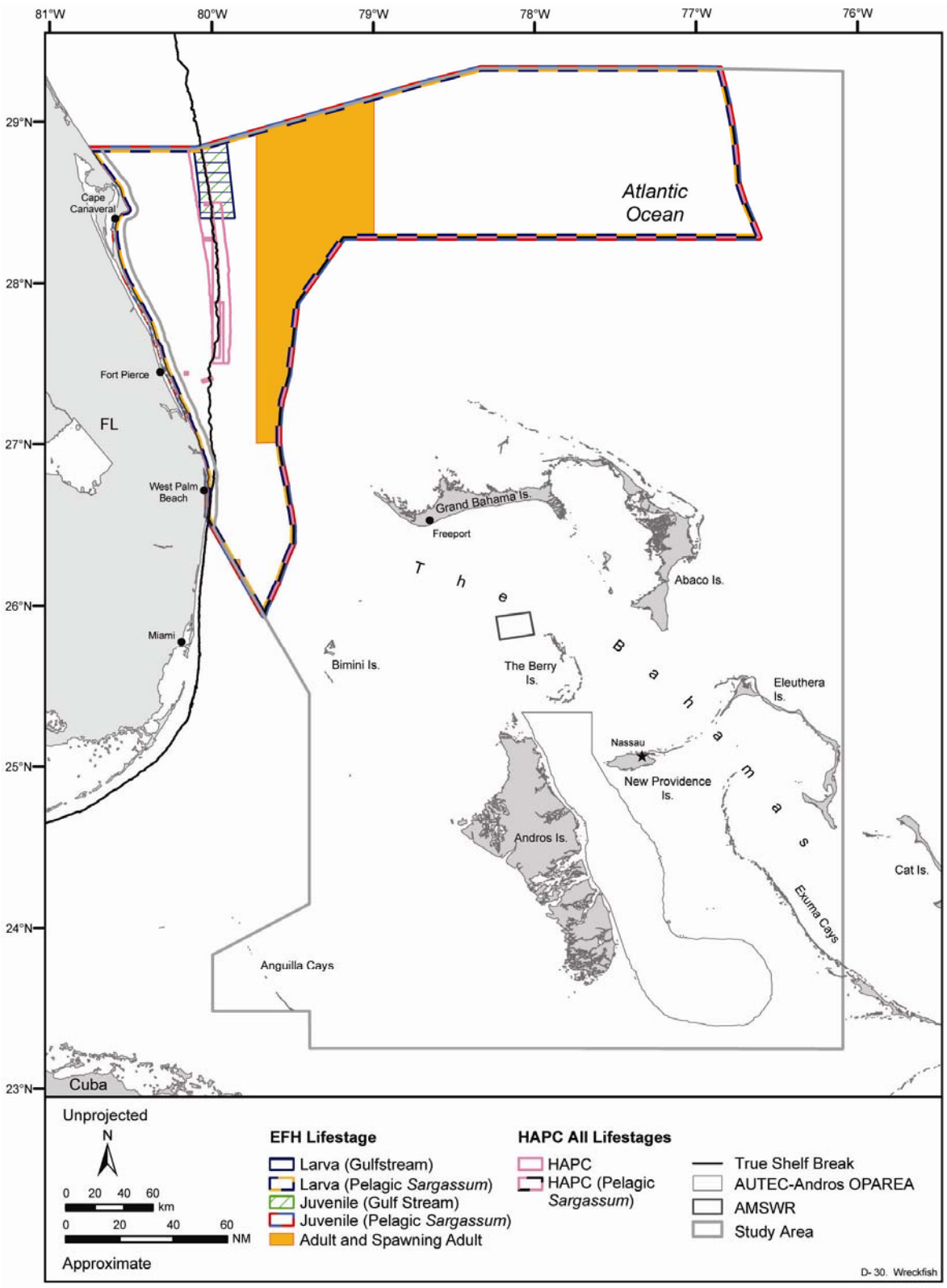


Figure D-30. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the wreckfish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: NOAA-CSC (2002, 2004), FFWCC (2005b), GDAIS (2005), and Reed et al. (2005). Source map (scanned): General Oceanics, Inc. (1986).

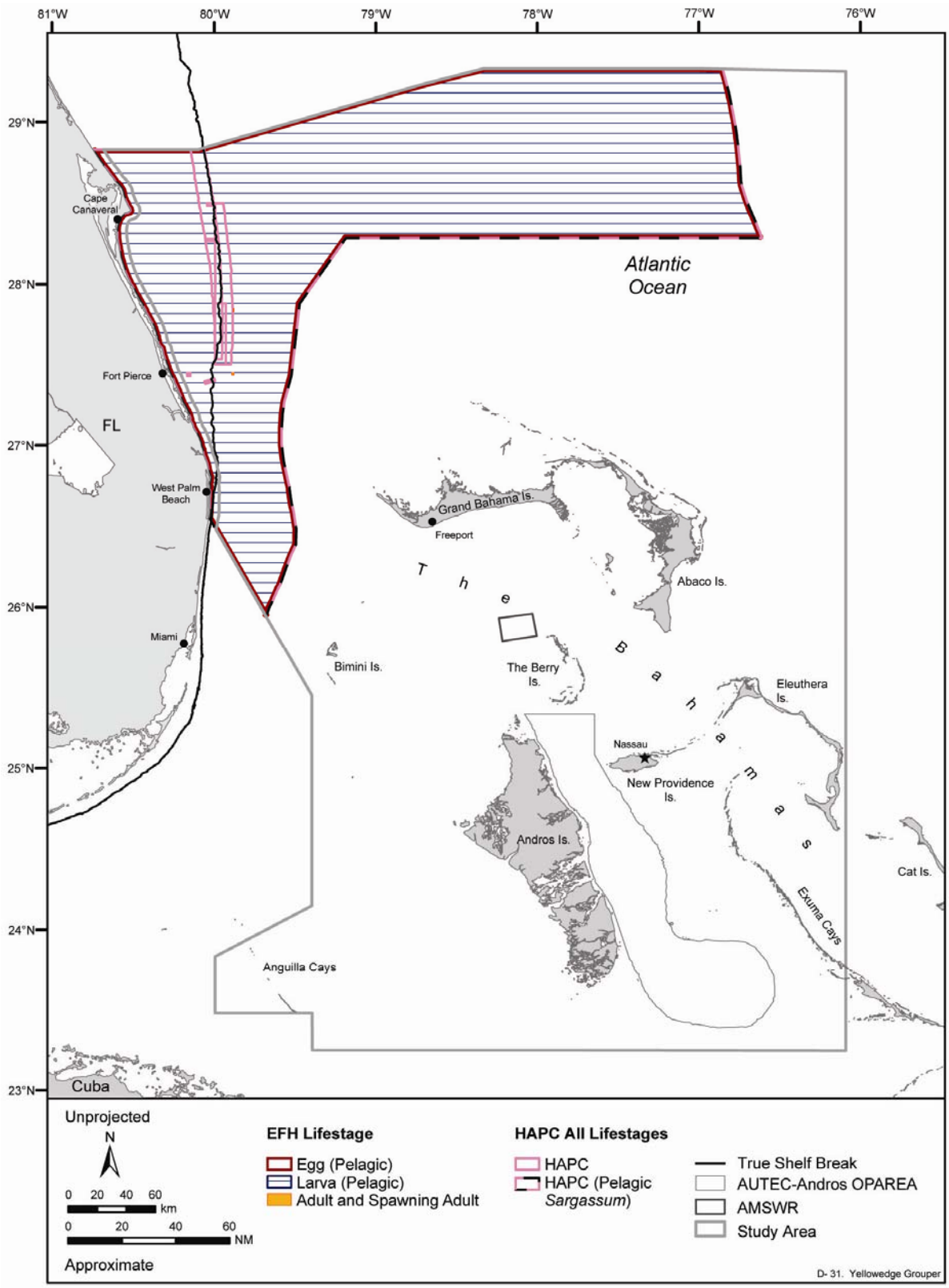


Figure D-31. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the yellowedge grouper designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. *Oculina* patches are designated as HAPC for this species but could not be mapped. Source data: SEAMAP (2001a), NOAA-CSC (2002, 2004), GDAIS (2005), and Reed et al. (2005).

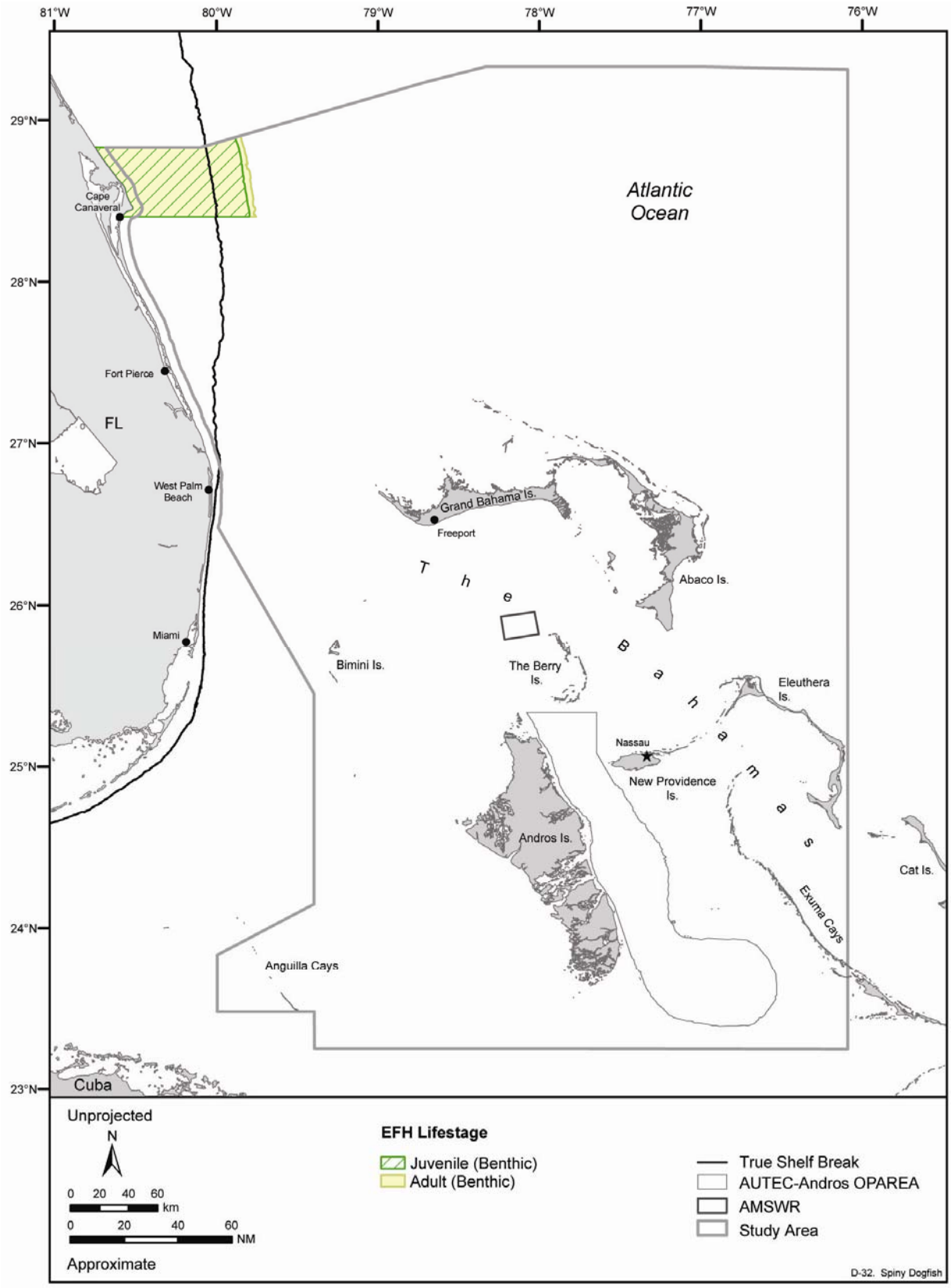


Figure D-32. Essential fish habitat (EFH) for all lifestages of the spiny dogfish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: GDAIS (2005).

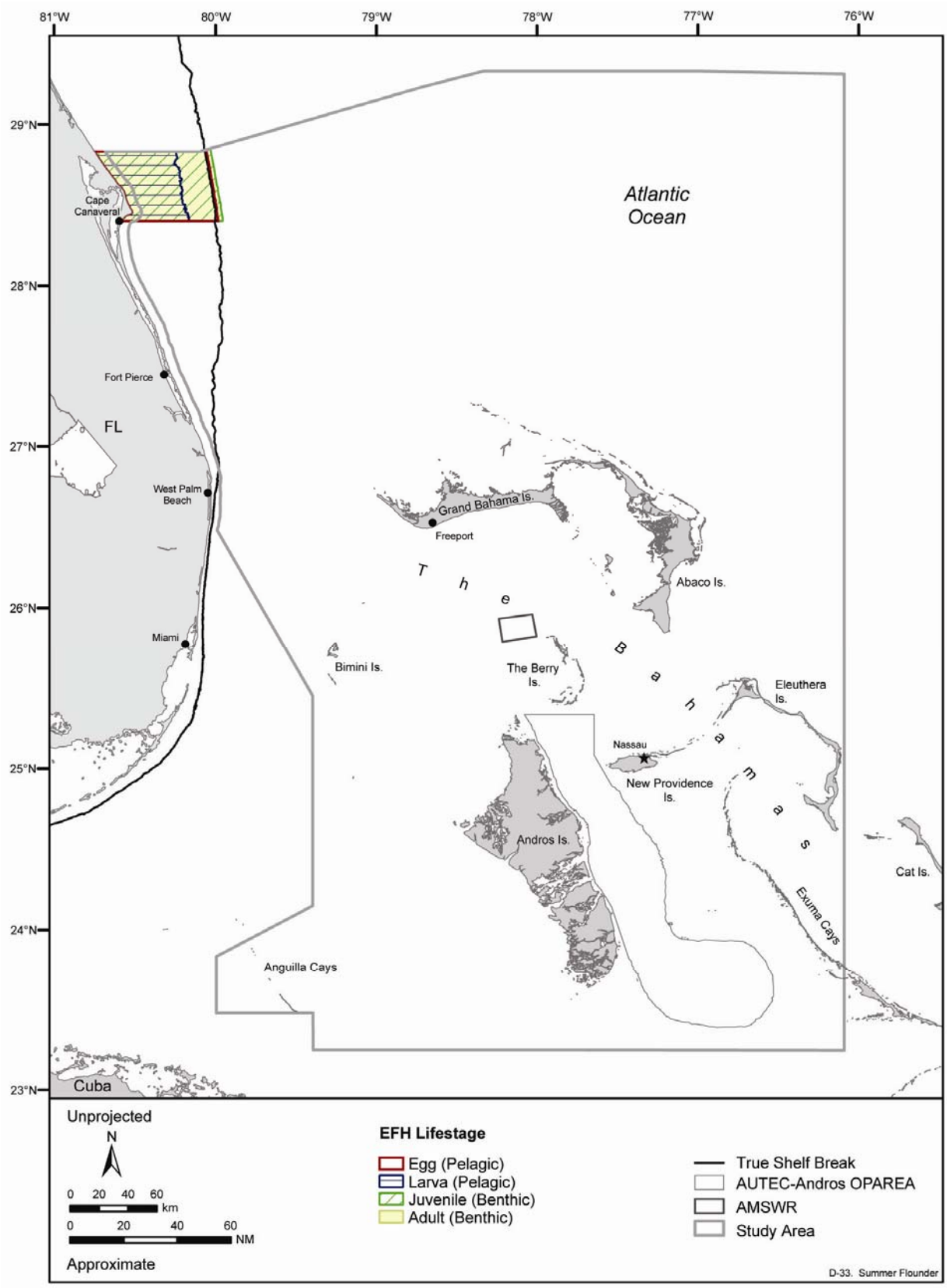


Figure D-33. Essential fish habitat (EFH) and habitat areas of particular concern (HAPC) for all lifestages of the summer flounder designated in the study area for the Southeastern Florida and AUTEC-Andros MRA.

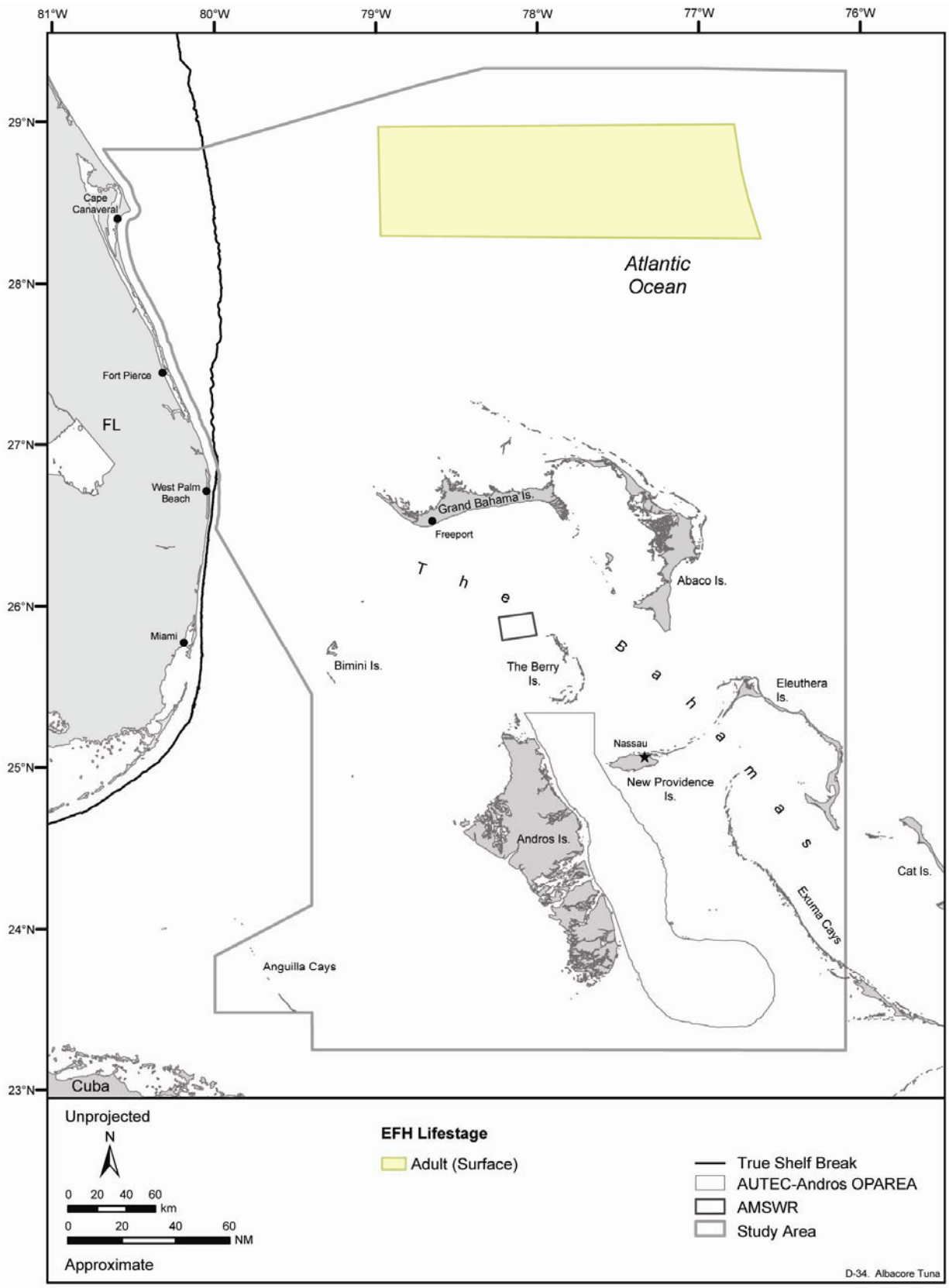


Figure D-34. Essential fish habitat (EFH) for all lifestages of albacore tuna designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e).

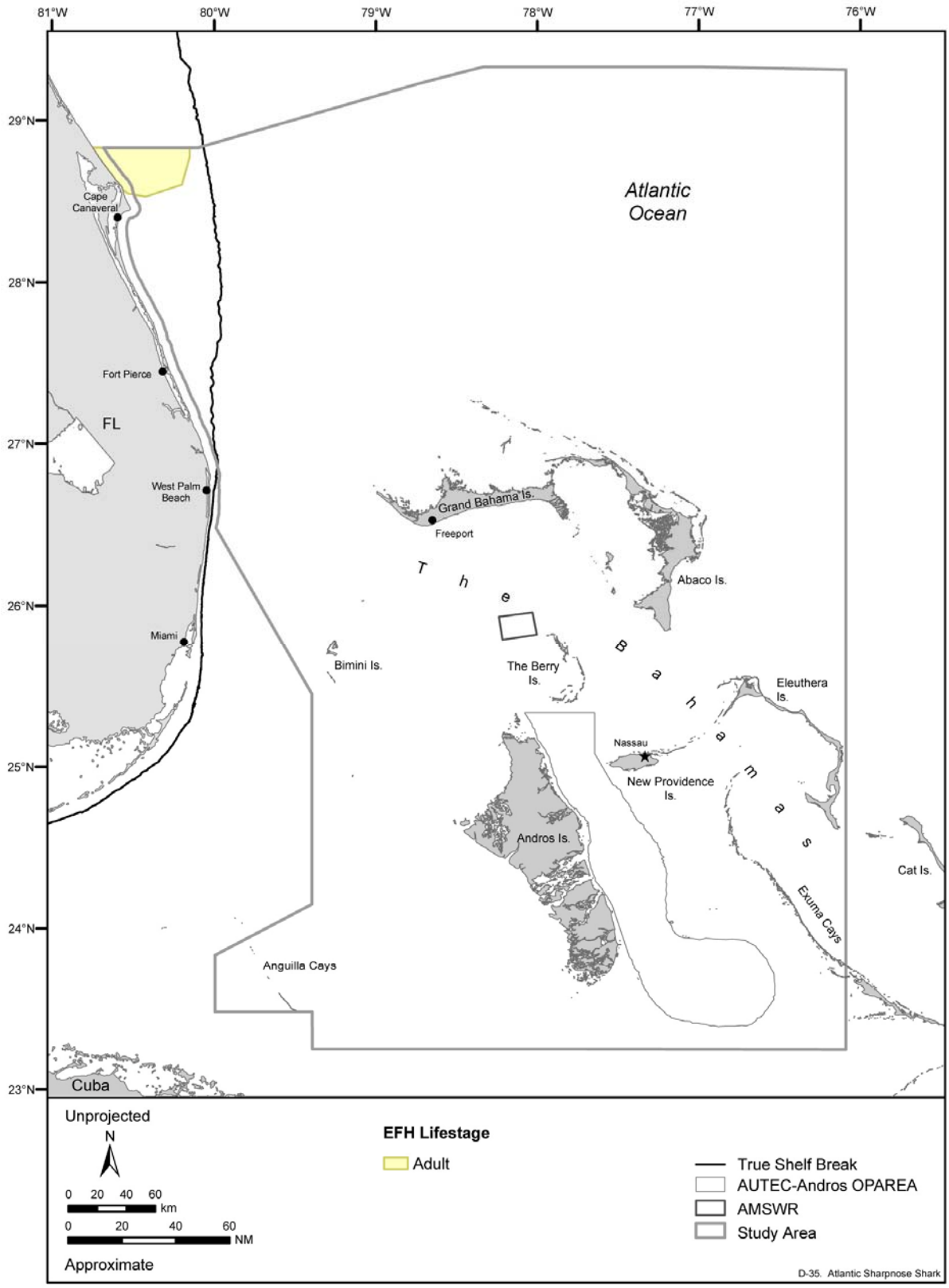


Figure D-35. Essential fish habitat (EFH) for all lifestages of Atlantic sharpnose shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. EFH designations for the neonate and early juvenile lifestage as well as the late juvenile and subadult lifestage depicted here do not match the text designation. Source data: NMFS (1999e).

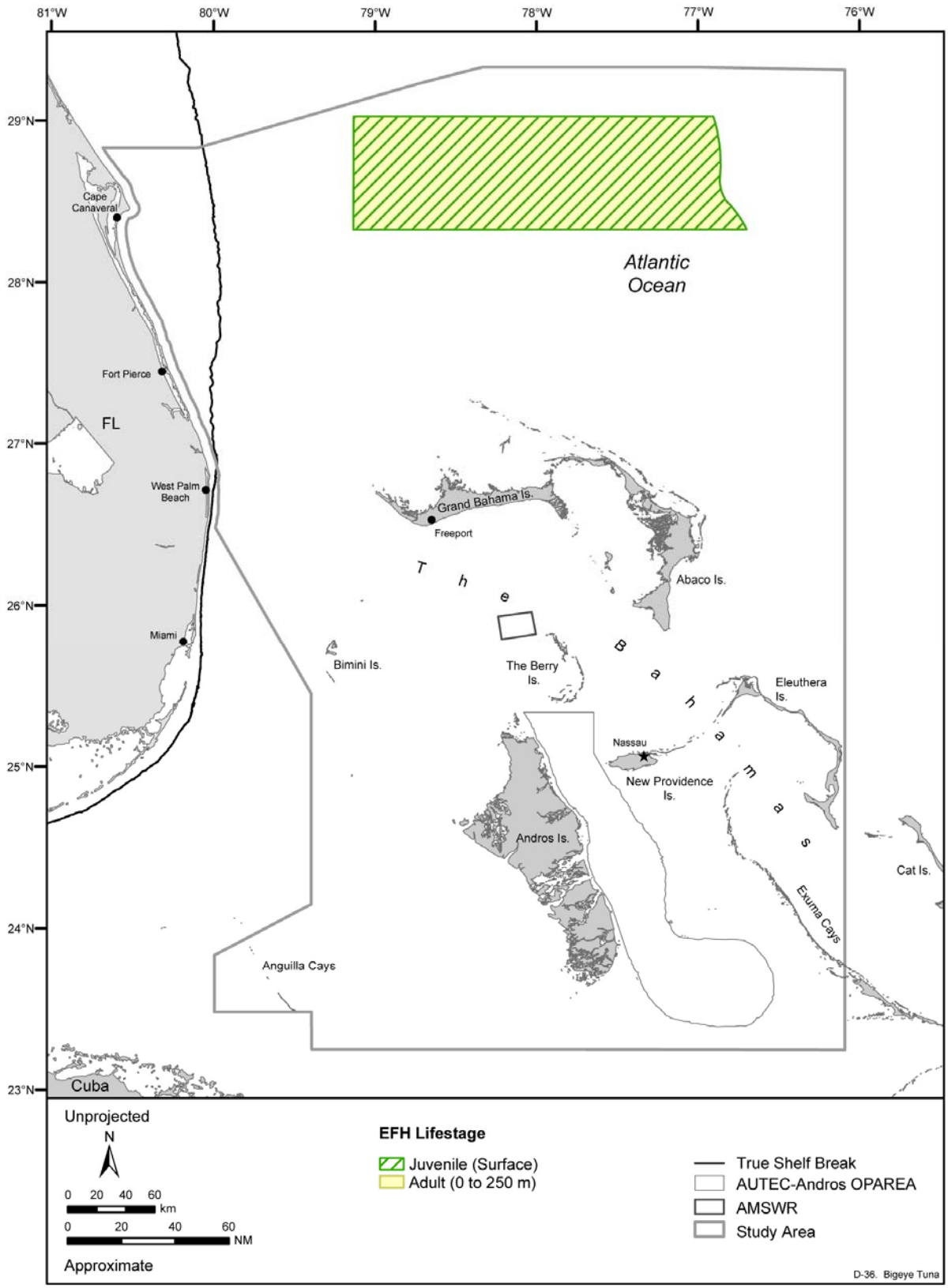


Figure D-36. Essential fish habitat (EFH) for all lifestages of bigeye tuna designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. EFH designation for the adult lifestage depicted here does not match the text designation. Source maps (scanned): NMFS 1999a. Source information: Rilling (2007).

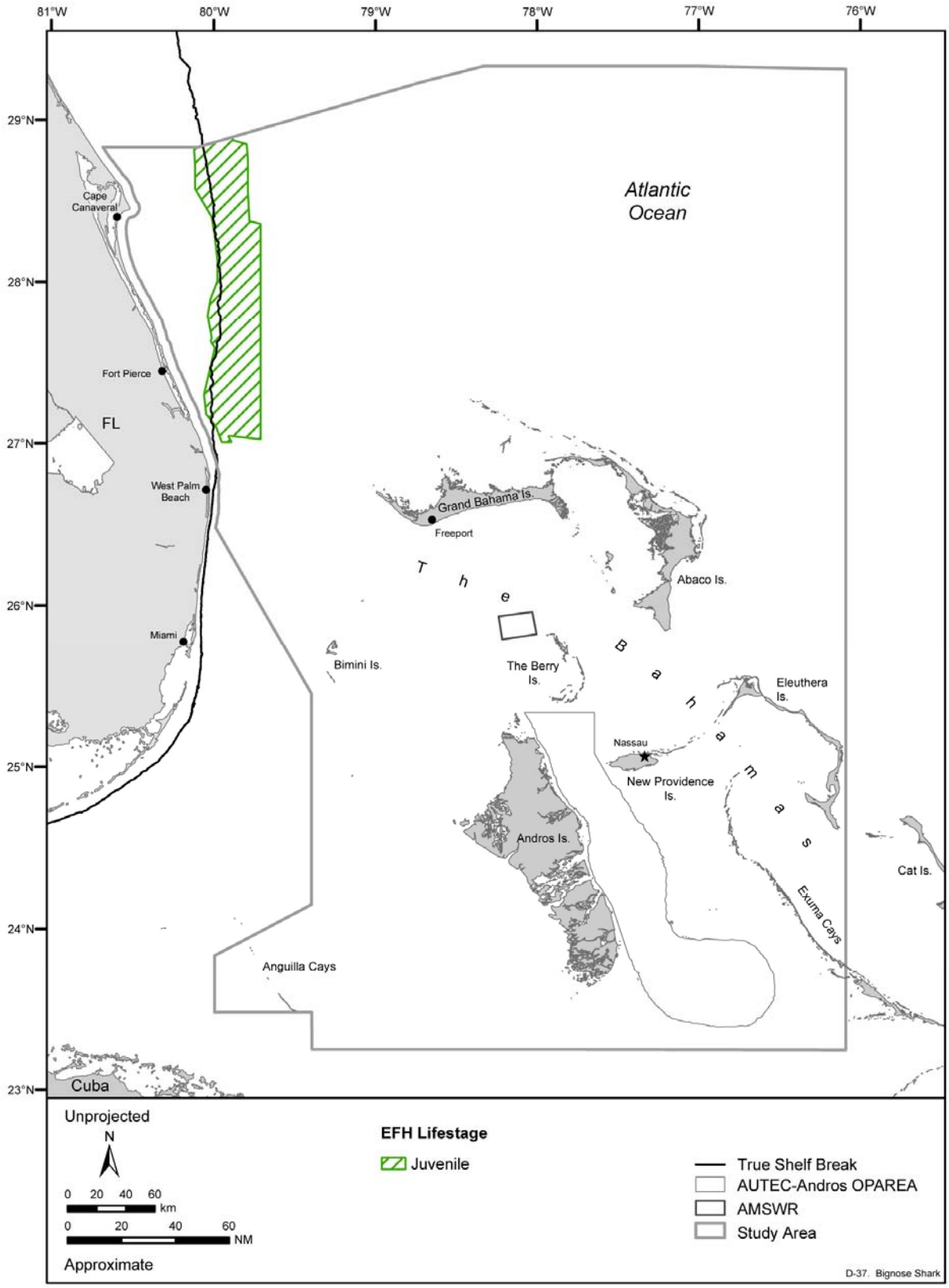


Figure D-37. Essential fish habitat (EFH) for all lifestages of bignose shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

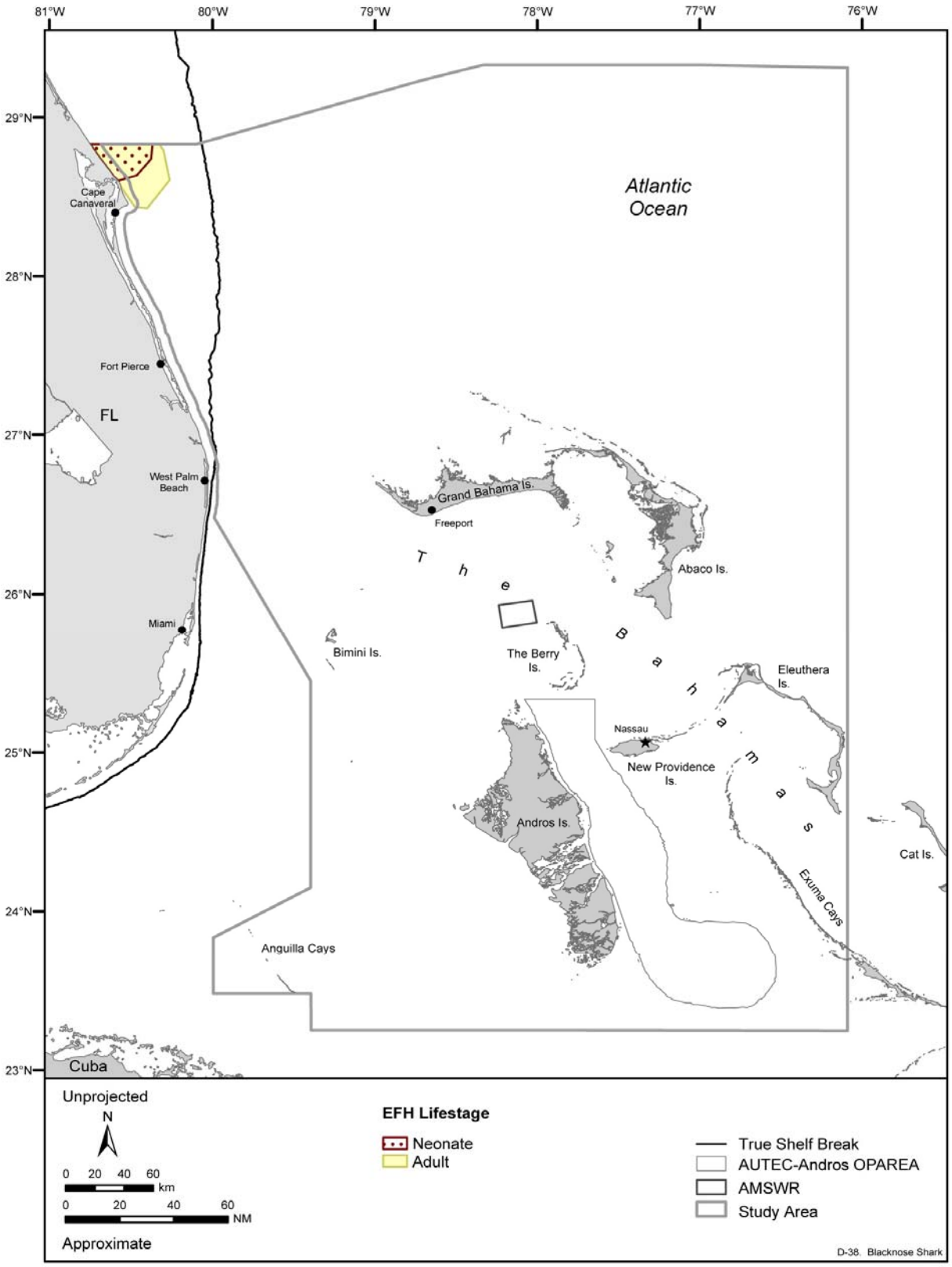


Figure D-38. Essential fish habitat (EFH) for all lifestages of the blacknose shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. No EFH is depicted for the juvenile lifestage within the study area although designated in the FMP text. Source data: NMFS (1999e). Source information: Rilling (2007).

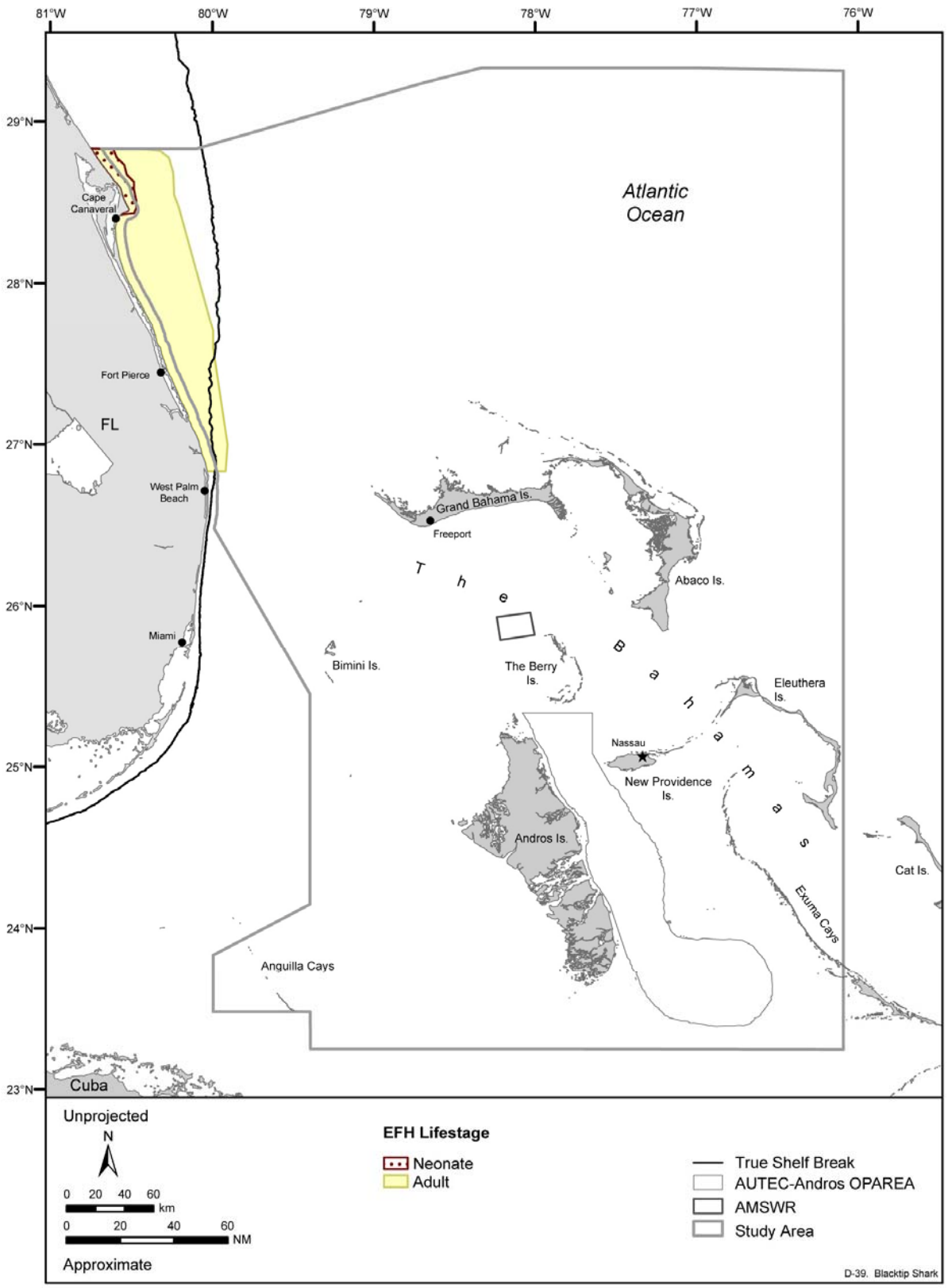


Figure D-39. Essential fish habitat (EFH) for all lifestages of the blacktip shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. The EFH designation for the adult lifestage depicted does not match the FMP text designation. Source data: NMFS (2003b).

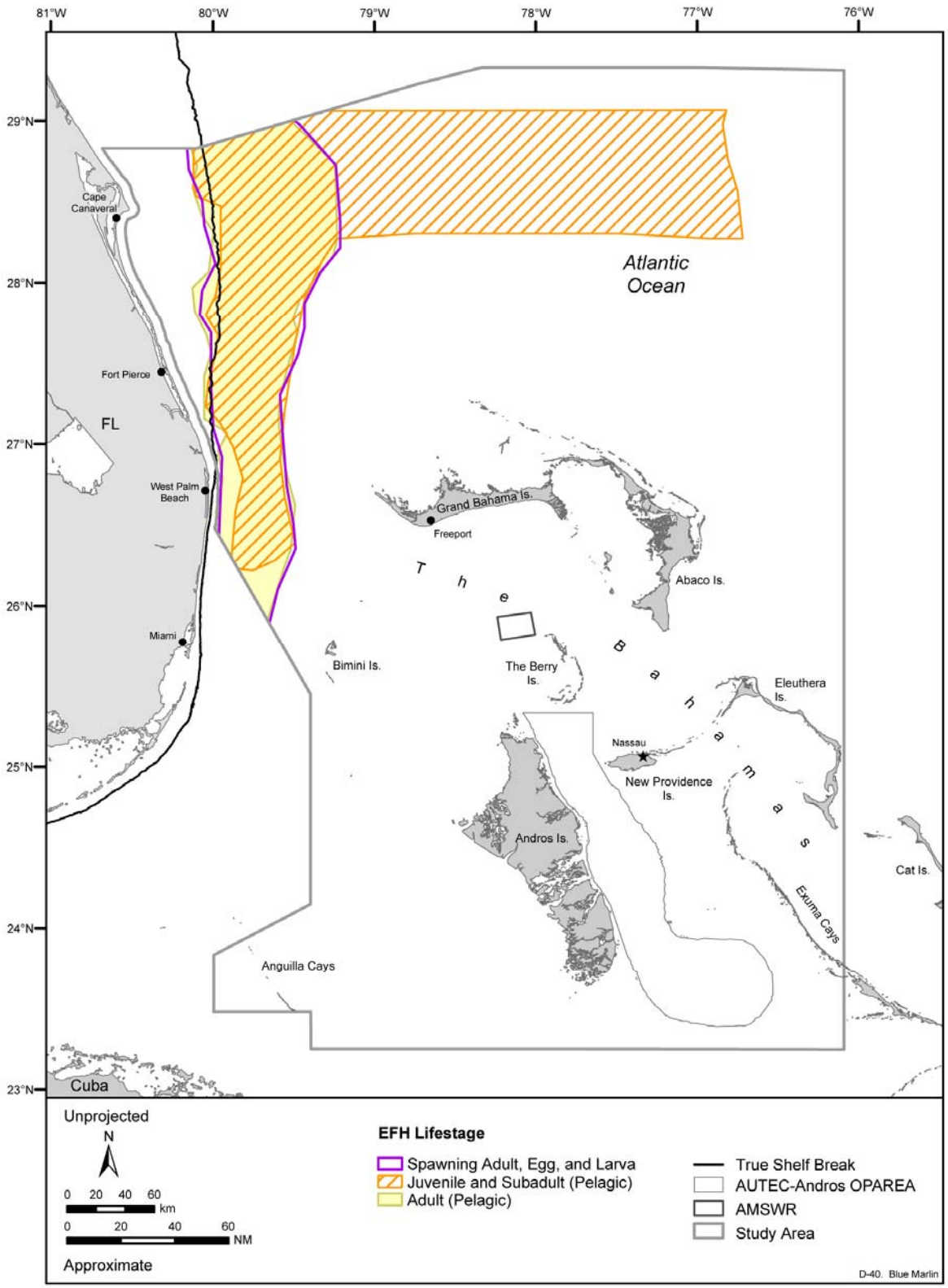


Figure D-40. Essential fish habitat (EFH) for all lifestages of the blue marlin designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. EFH designations for the adult and spawning adult/egg/larva lifestages depicted do not match the respective text designations, which indicates that the EFH is identical. Source data: NMFS (1999e).

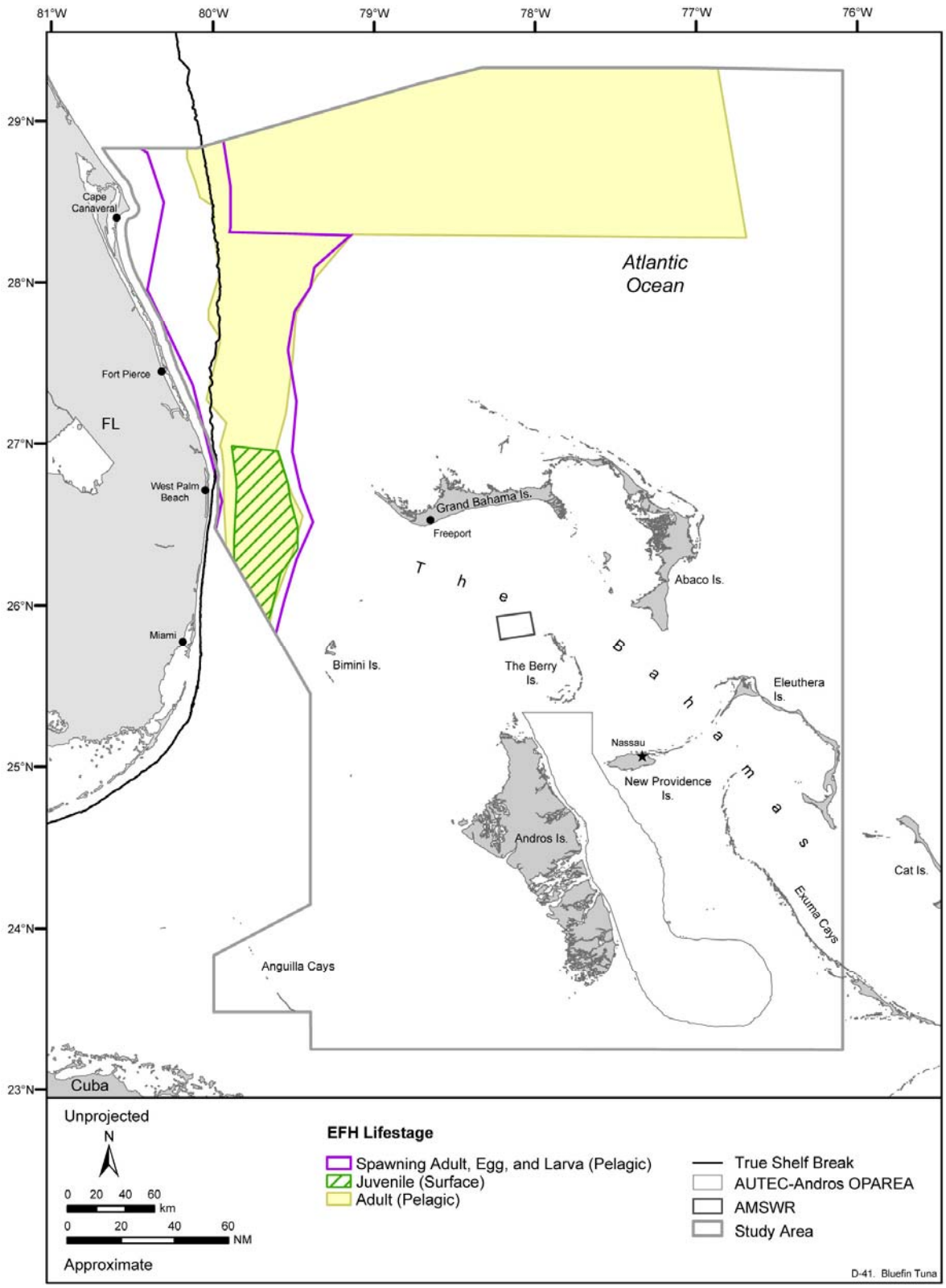


Figure D-41. Essential fish habitat (EFH) for all lifestages of the bluefin tuna designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. The EFH text designation from the FMP lists the outer boundary of all lifestages as the U.S. EEZ, which does not match the NMFS data depicted. Source data: NMFS (1999e). Source information: Rilling (2007).

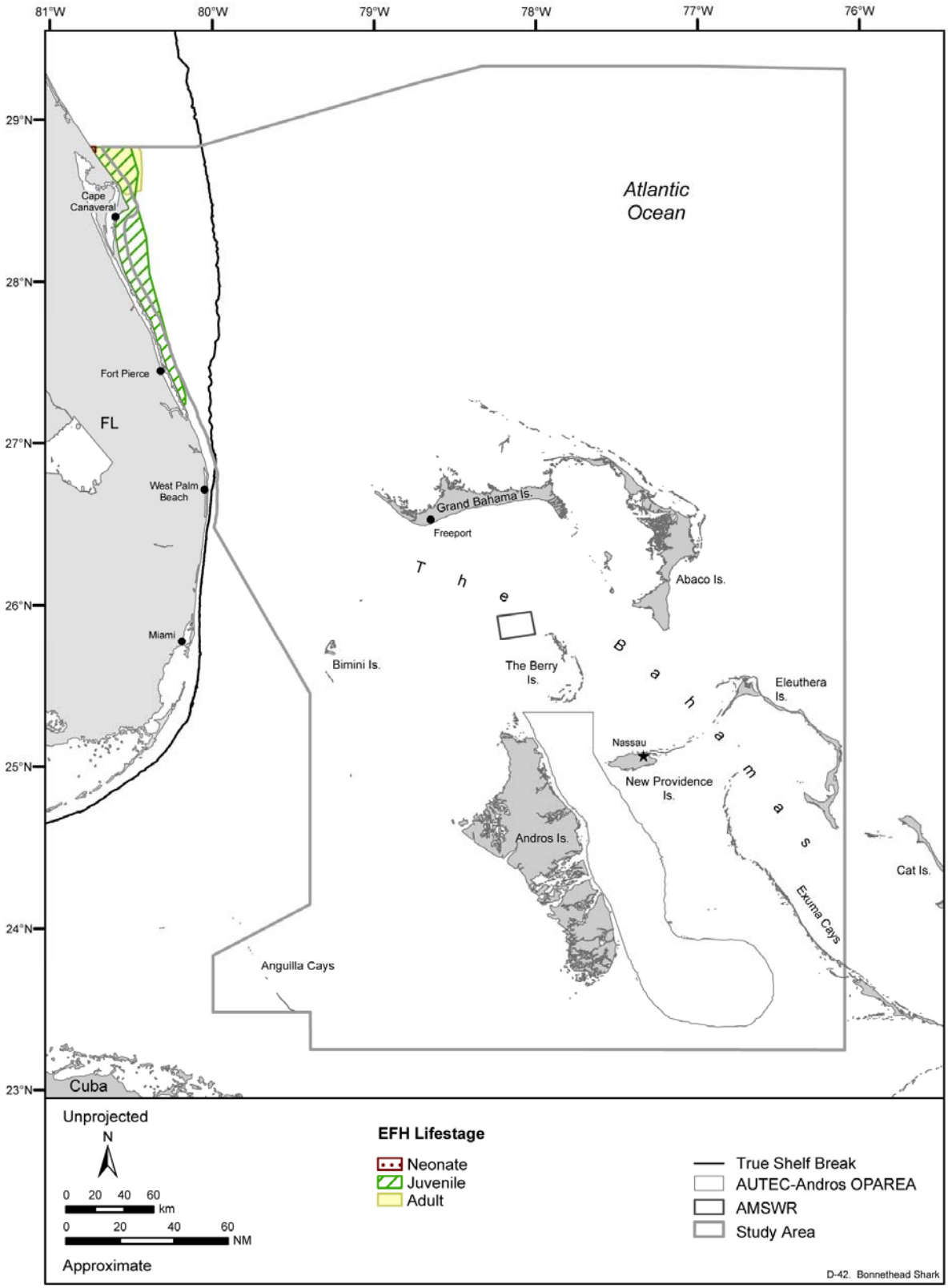


Figure D-42. Essential fish habitat (EFH) for all lifestages of bonnethead shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

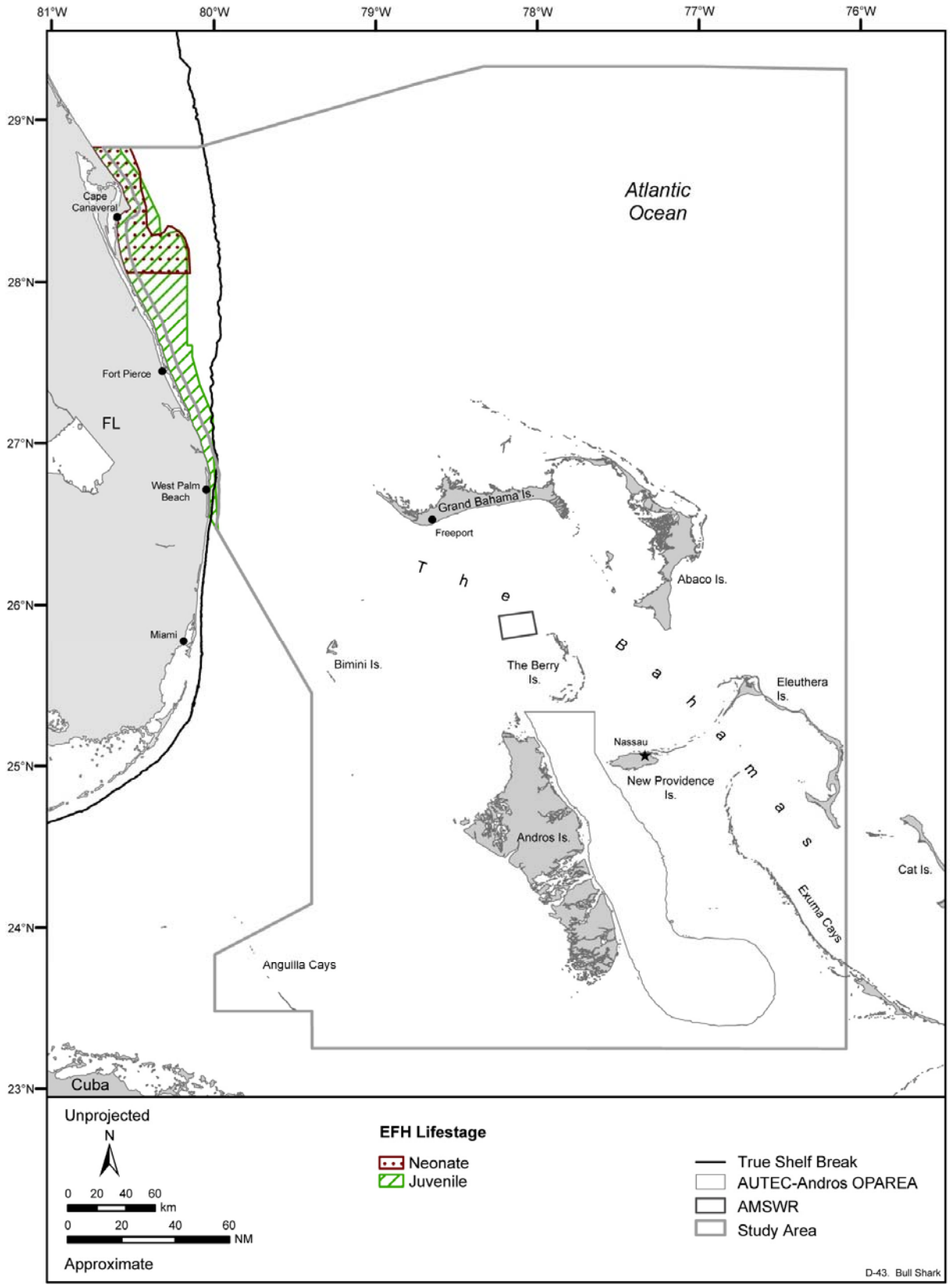


Figure D-43. Essential fish habitat (EFH) for all lifestages of bull shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

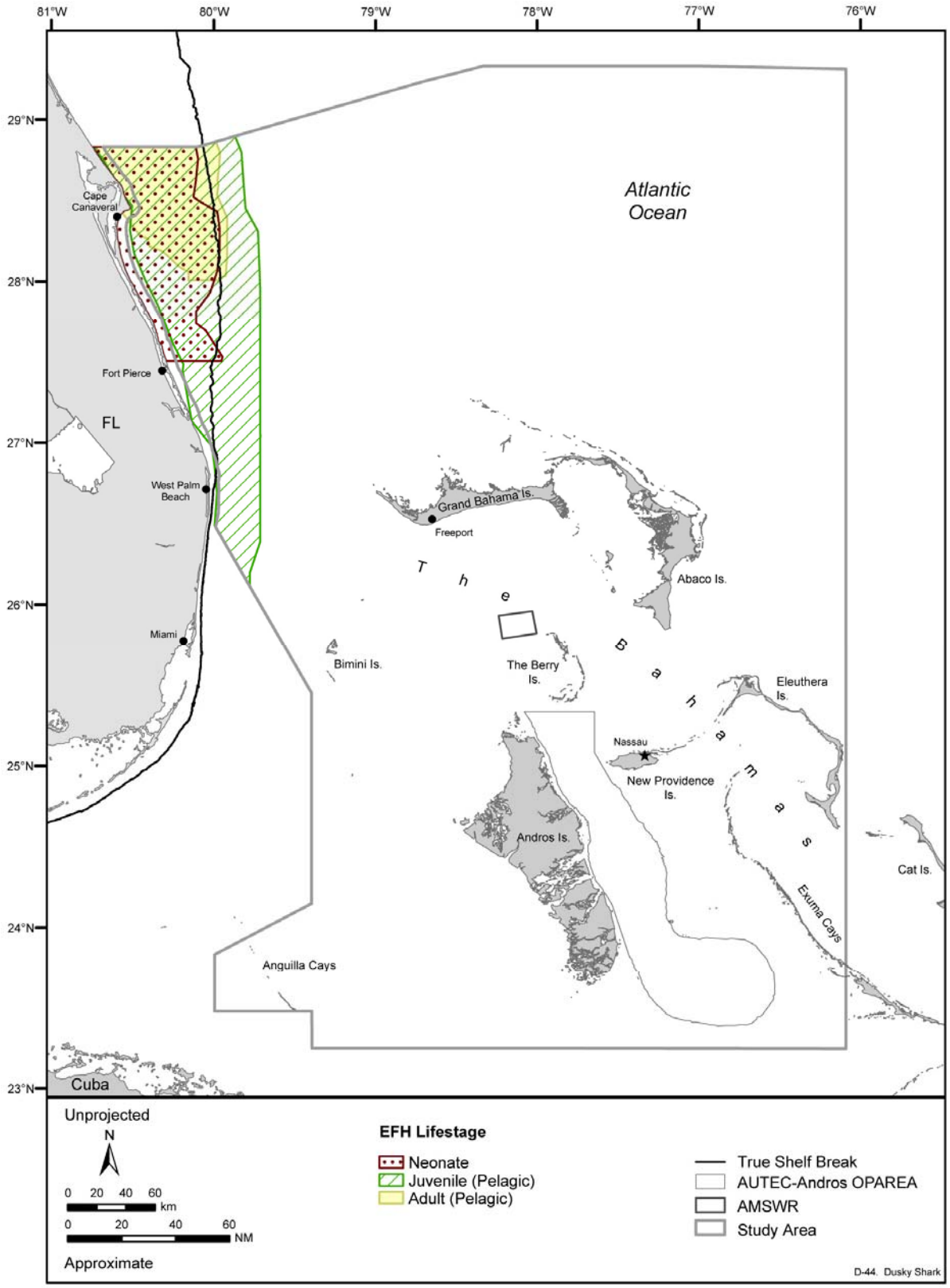


Figure D-44. Essential fish habitat (EFH) for all lifestages of the dusky shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. The EFH depicted for the neonate lifestage does not match the FMP text designation. Source data: NMFS (2003b).

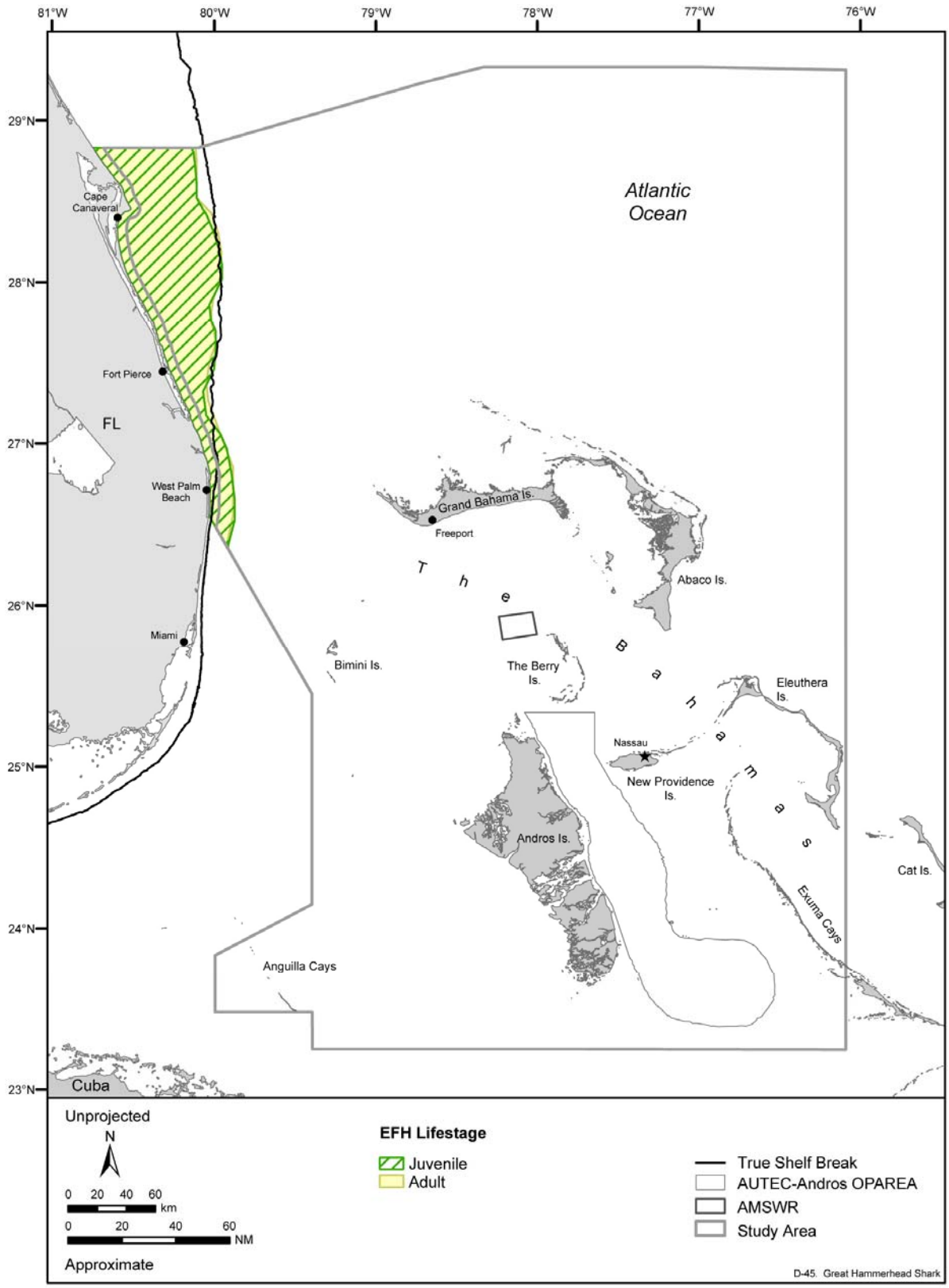


Figure D-45. Essential fish habitat (EFH) for all lifestages of great hammerhead shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

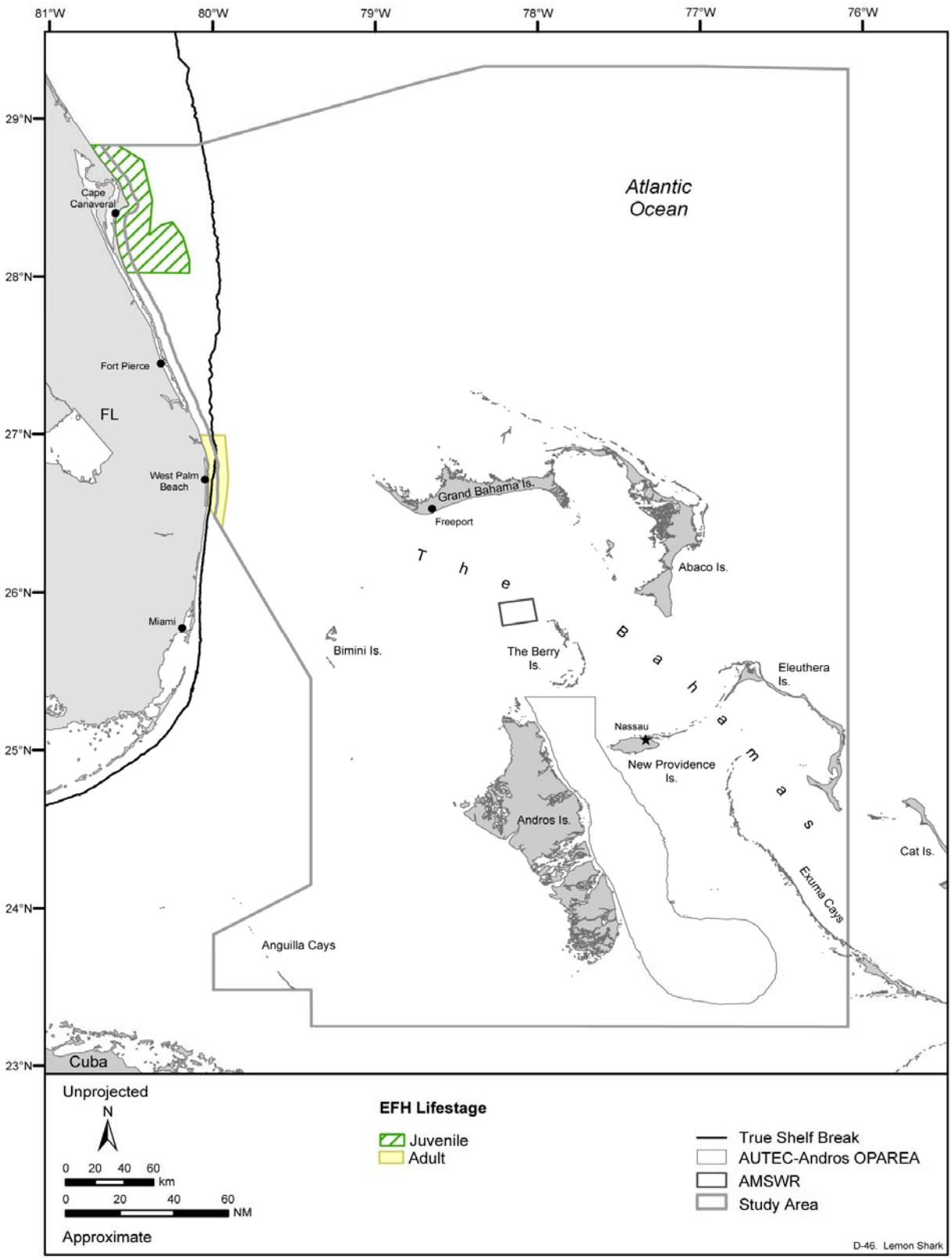


Figure D-46. Essential fish habitat (EFH) for all lifestages of lemon shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

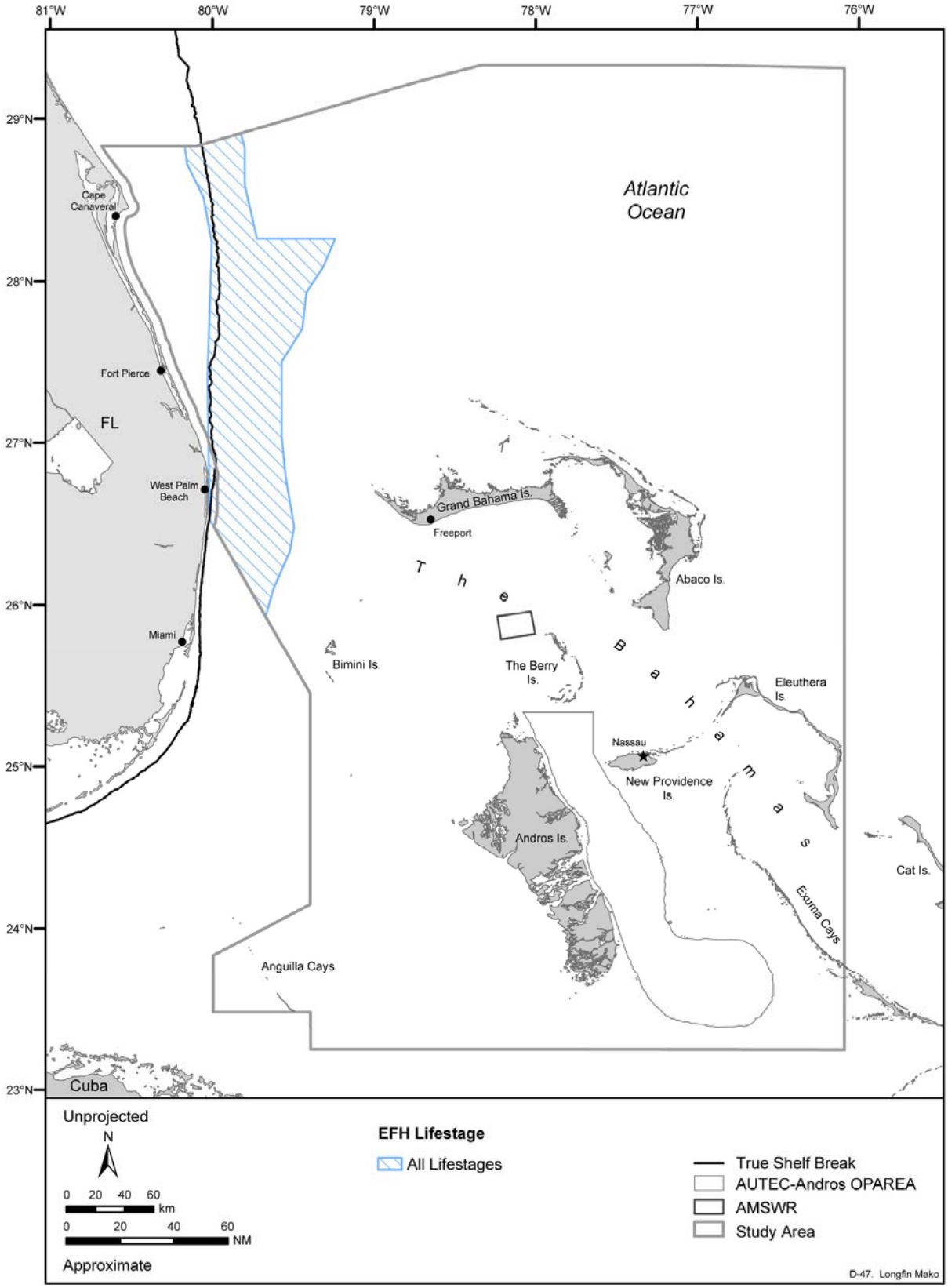


Figure D-47. Essential fish habitat (EFH) for all lifestages of longfin mako shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e).

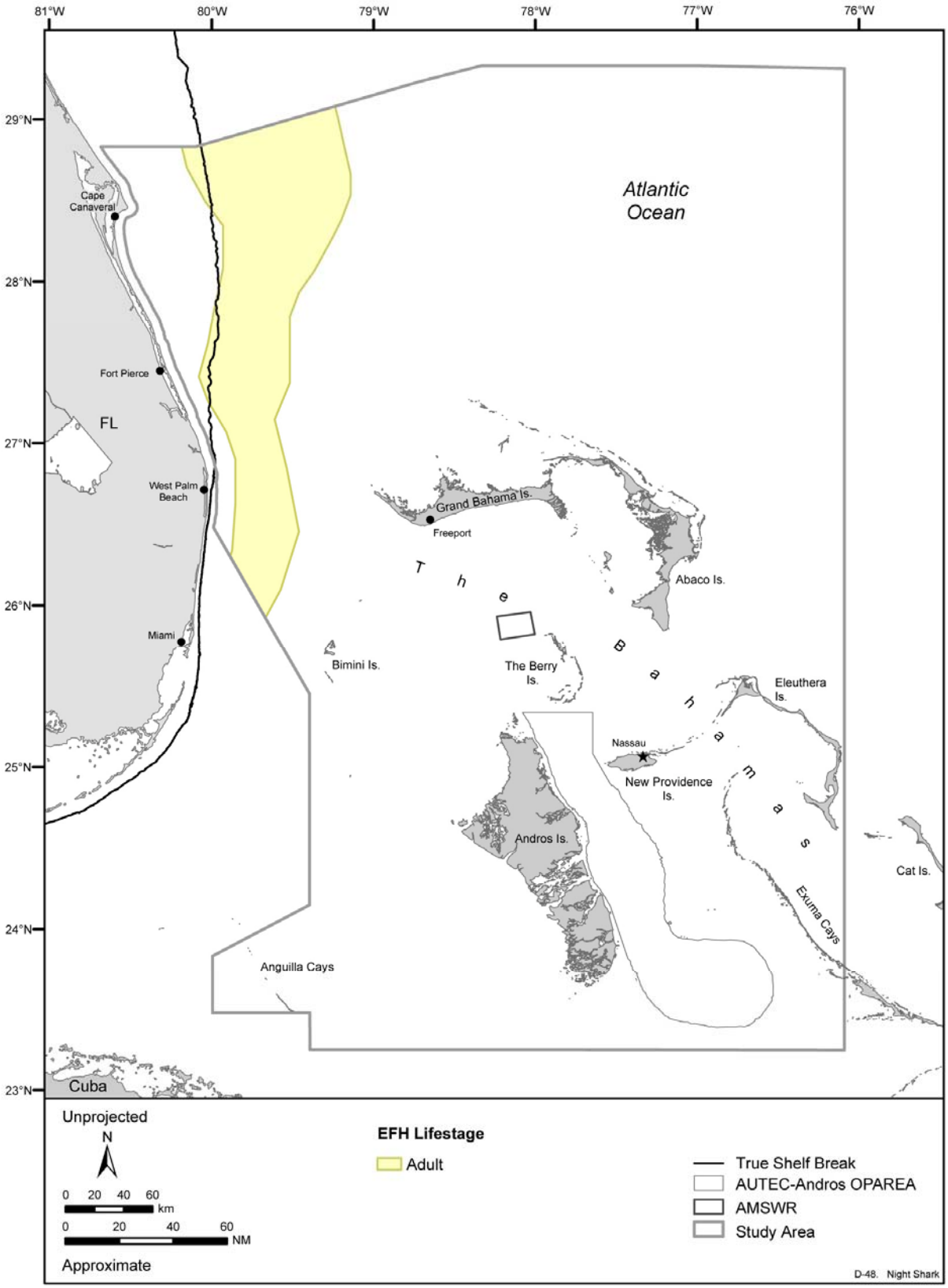


Figure D-48. Essential fish habitat (EFH) for all lifestages of night shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e).

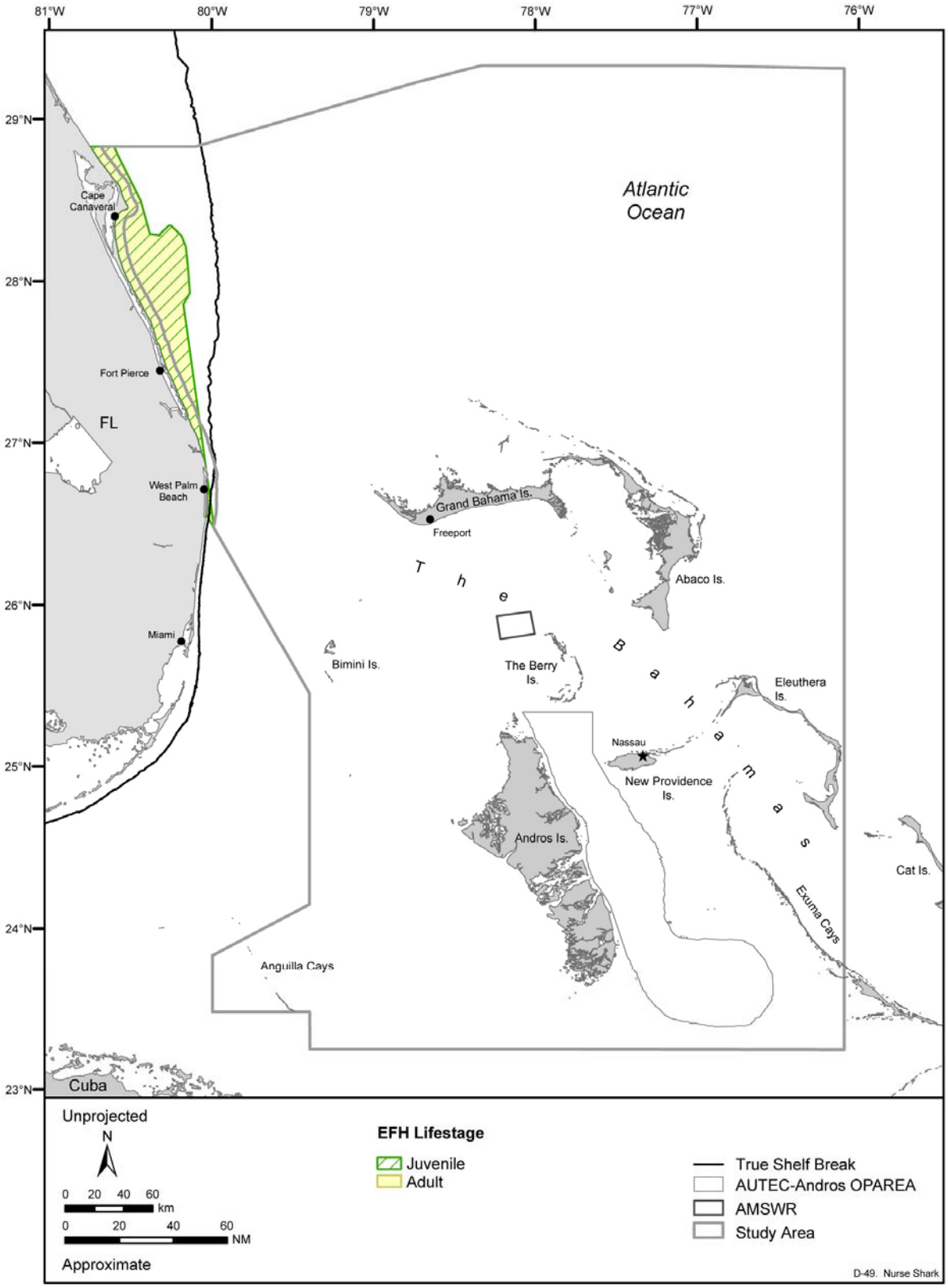


Figure D-49. Essential fish habitat (EFH) for all lifestages of nurse shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. EFH designations for the juvenile and adult lifestages depicted here do not match the text designation. Source data: NMFS (2003b).

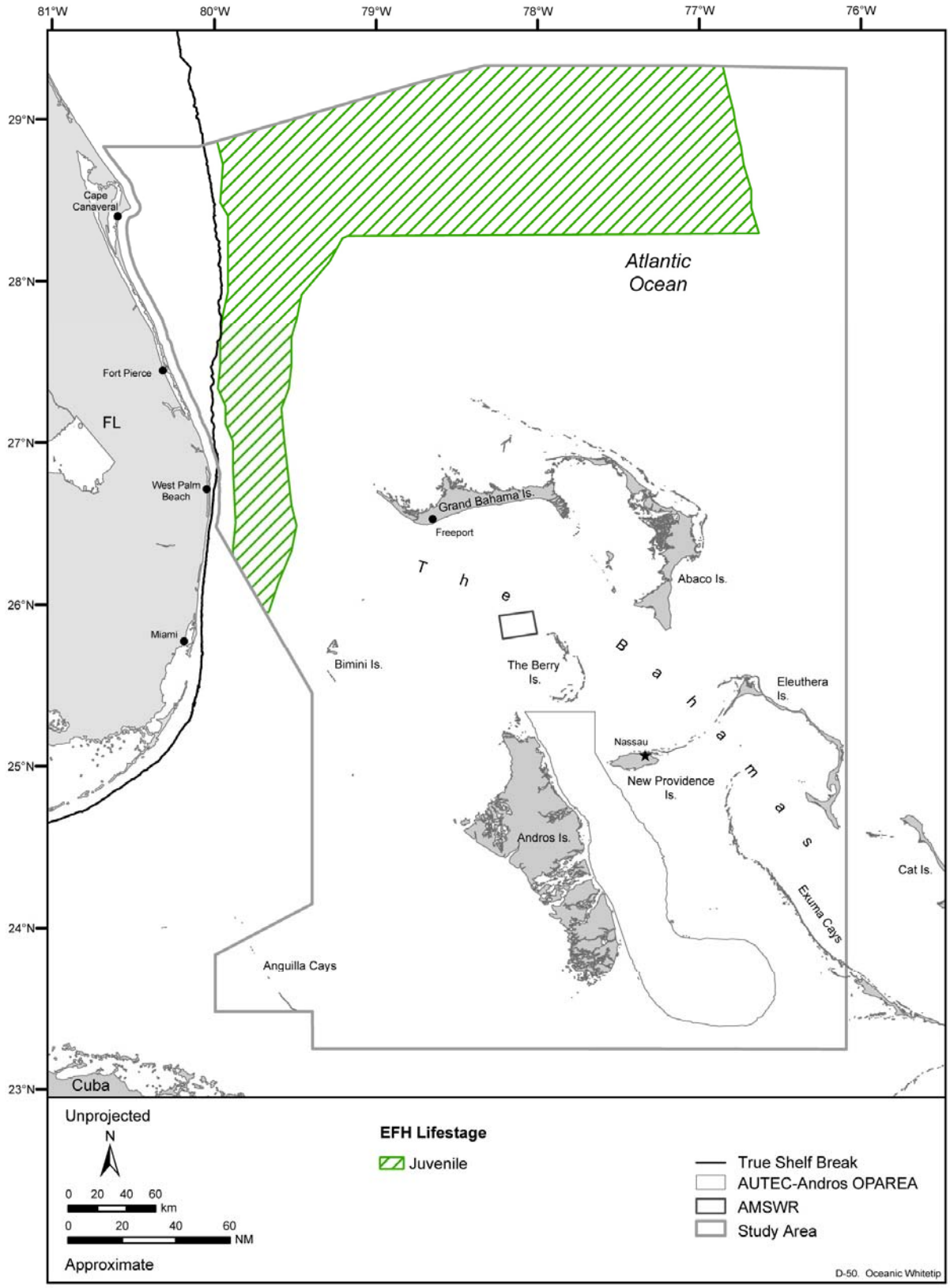


Figure D-50. Essential fish habitat (EFH) for all lifestages of oceanic whitetip shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

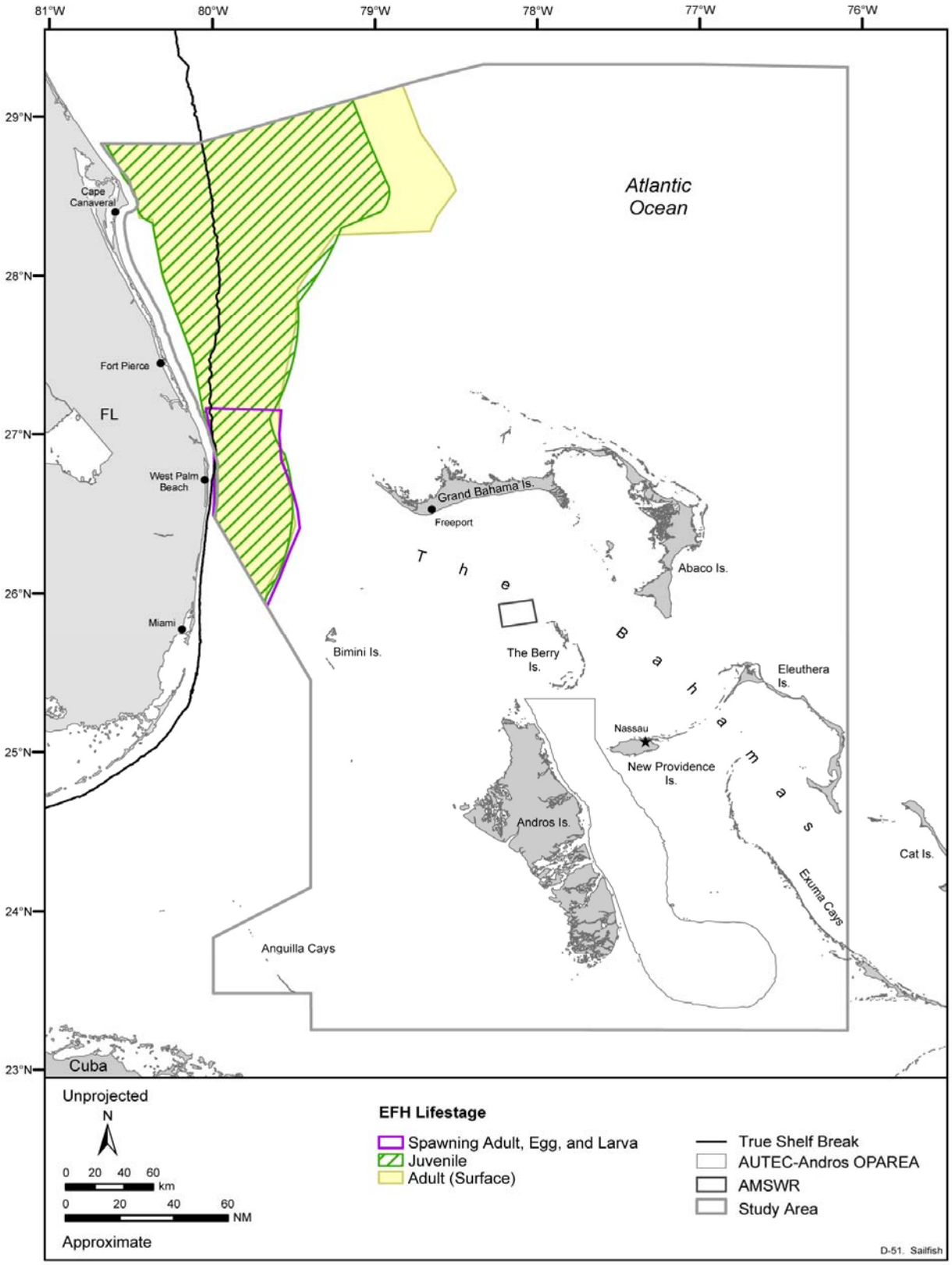


Figure D-51. Essential fish habitat (EFH) for all lifestages of sailfish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. EFH designations for the spawning adult, egg, and larva lifestage depicted here do not match the text designation. Source data: NMFS (1999e). Source map (scanned): NMFS (1999b).

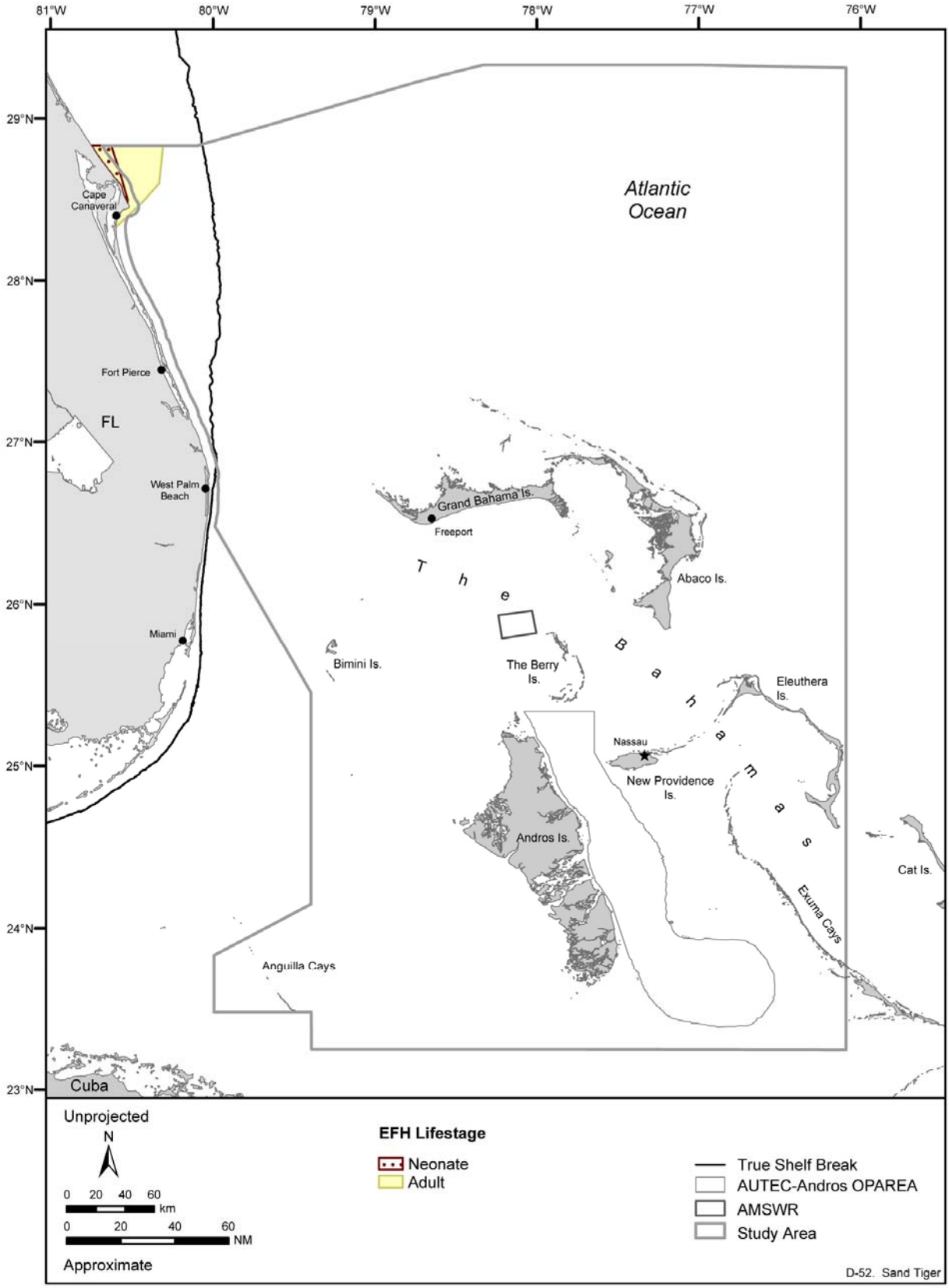


Figure D-52. Essential fish habitat (EFH) for all lifestages of sand tiger shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e).

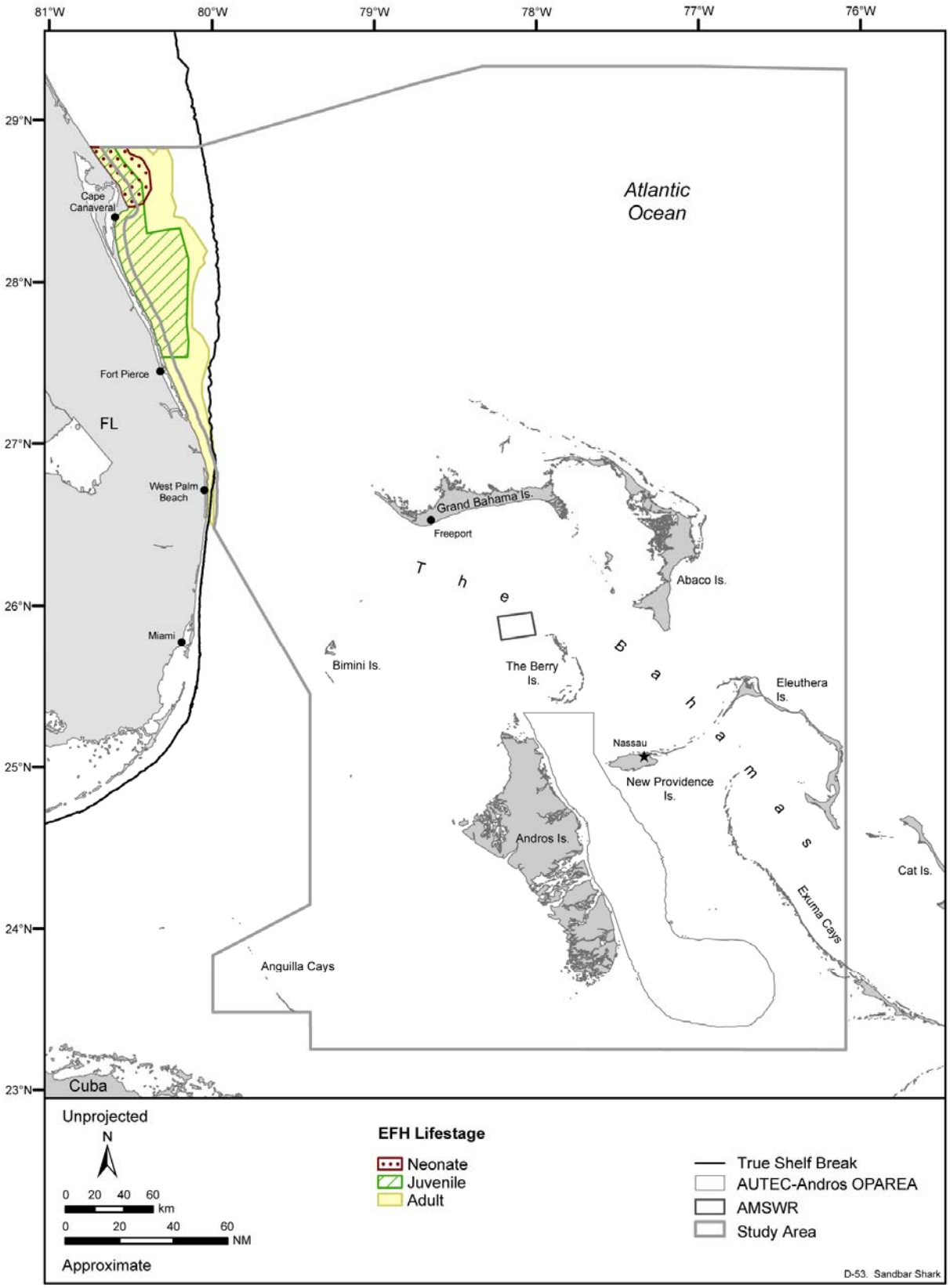


Figure D-53. Essential fish habitat (EFH) for all lifestages of sandbar shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (2003b).

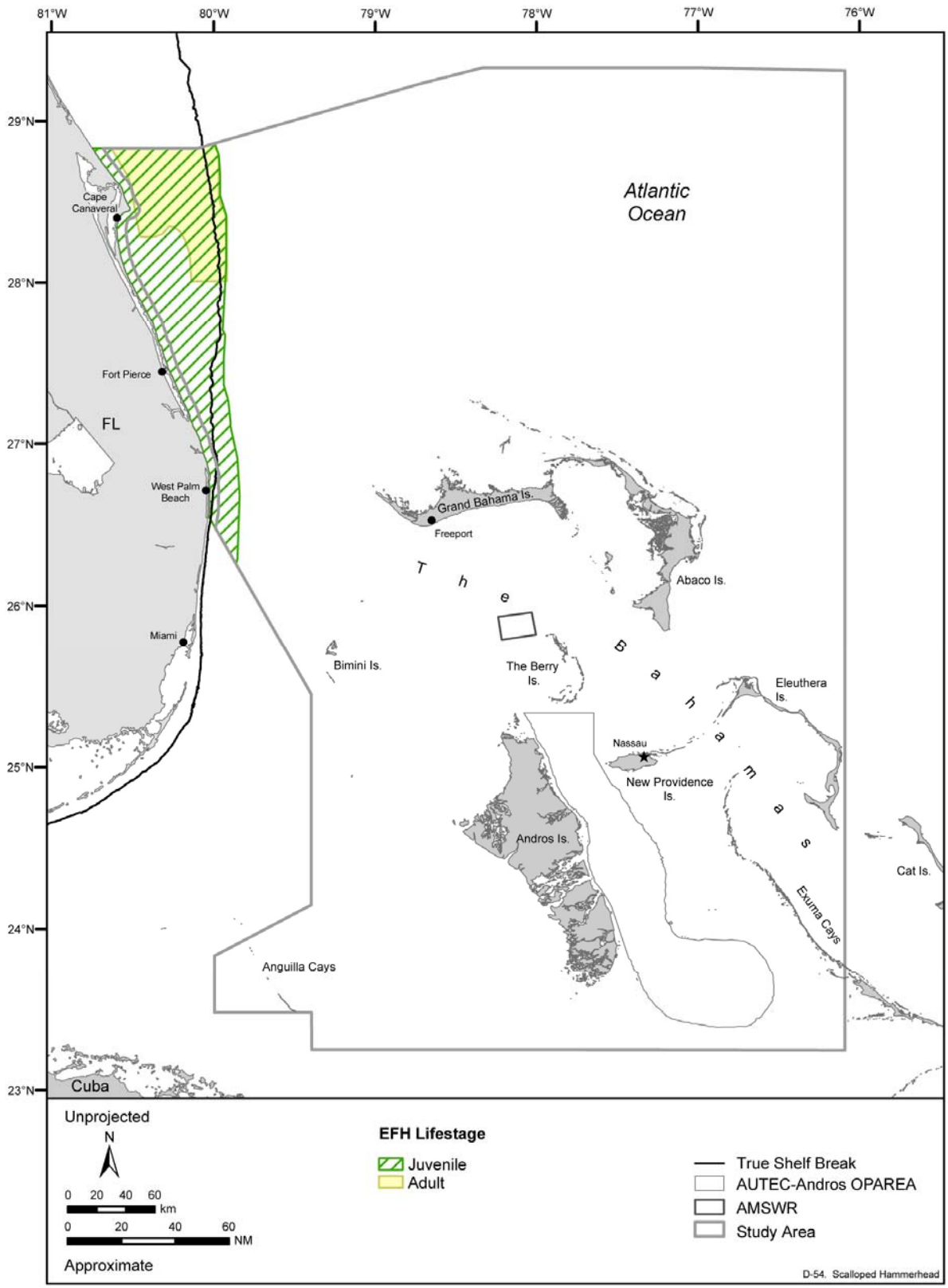


Figure D-54. Essential fish habitat (EFH) for all lifestages of scalloped hammerhead shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

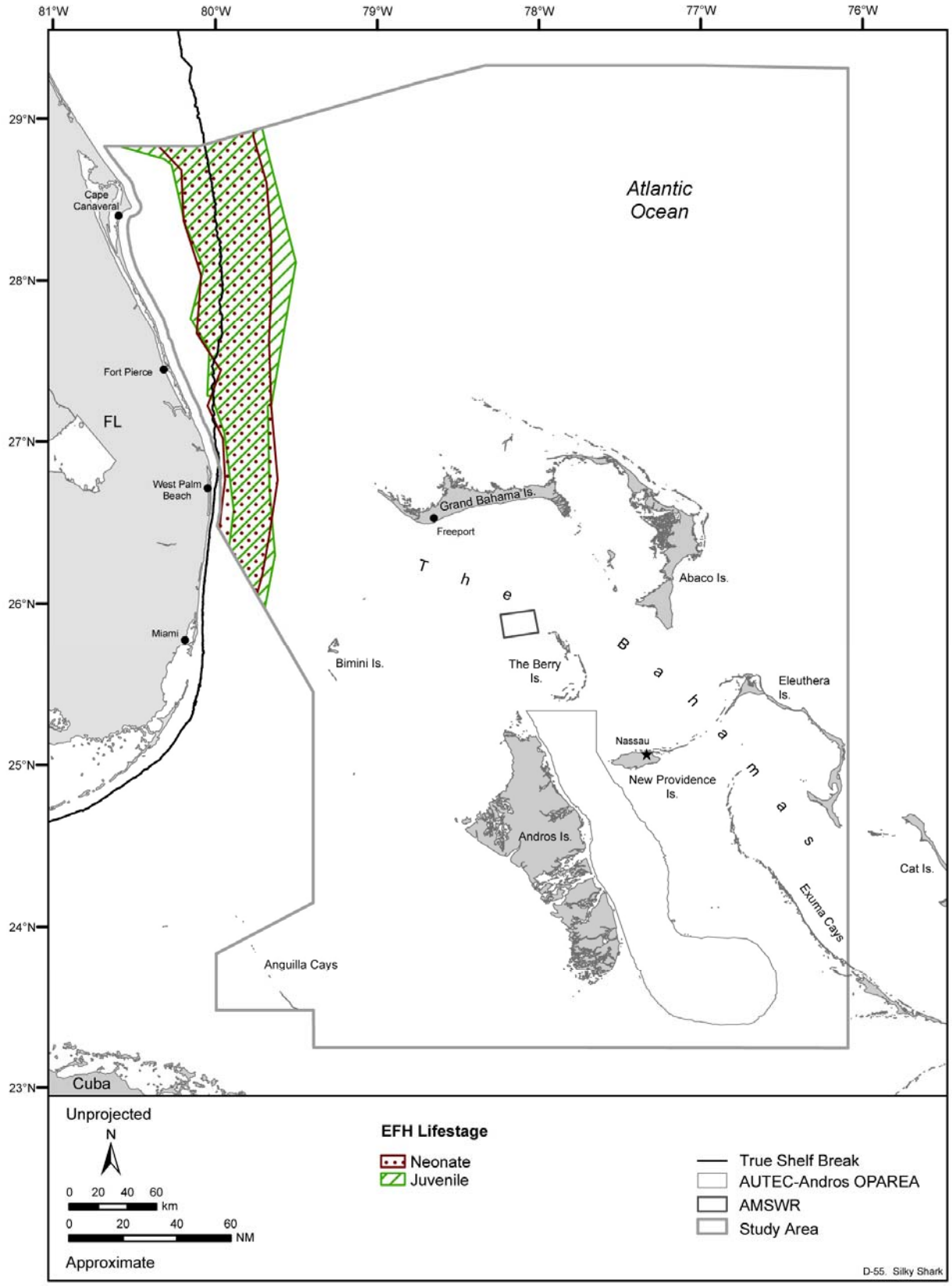


Figure D-55. Essential fish habitat (EFH) for all lifestages of silky shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

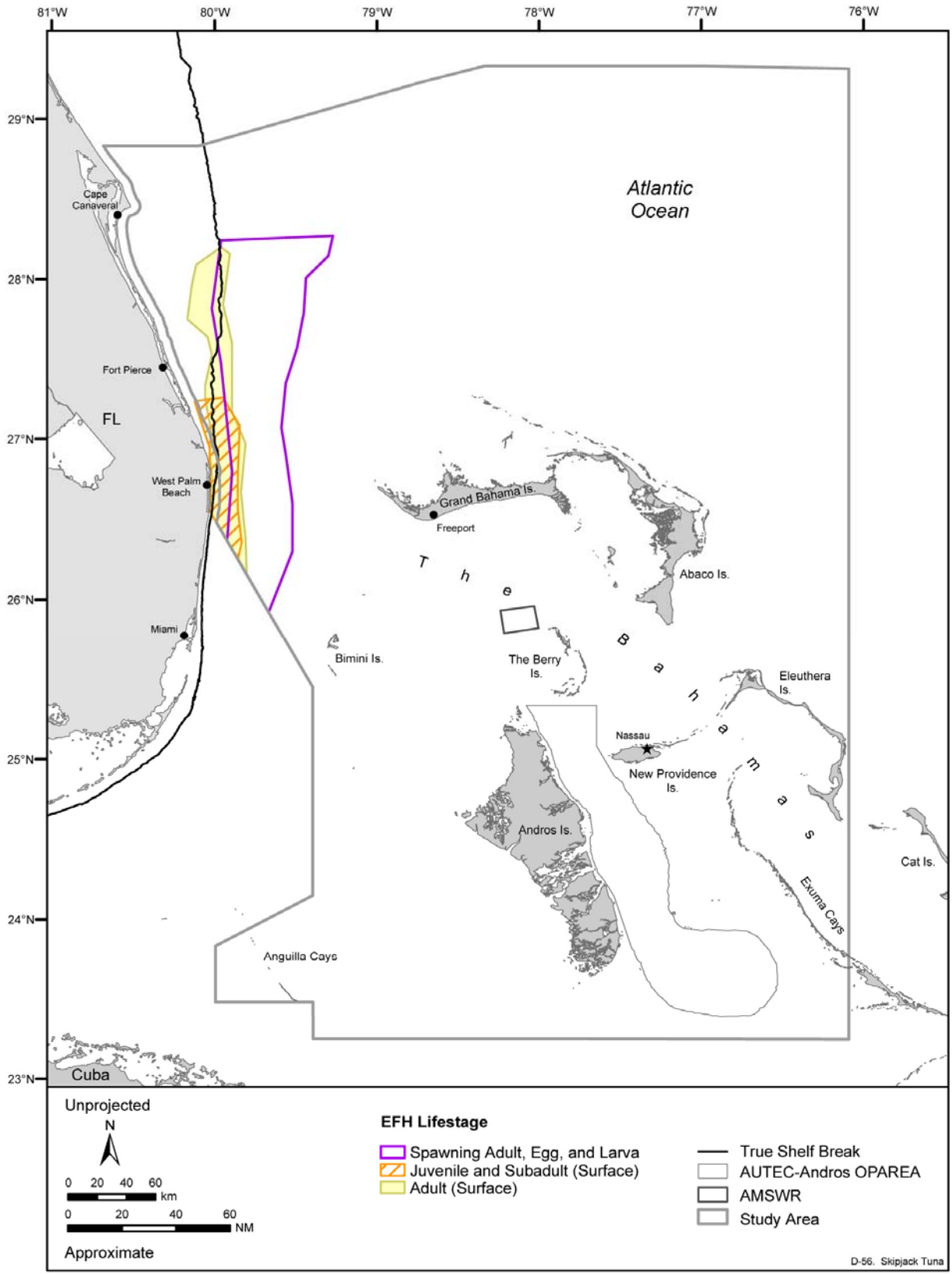


Figure D-56. Essential fish habitat (EFH) for all lifestages of the skipjack tuna designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. The EFH depicted for the adult lifestage does not match the FMP text designation, which indicates no EFH for this lifestage within the study area. Source data: NMFS (1999e).

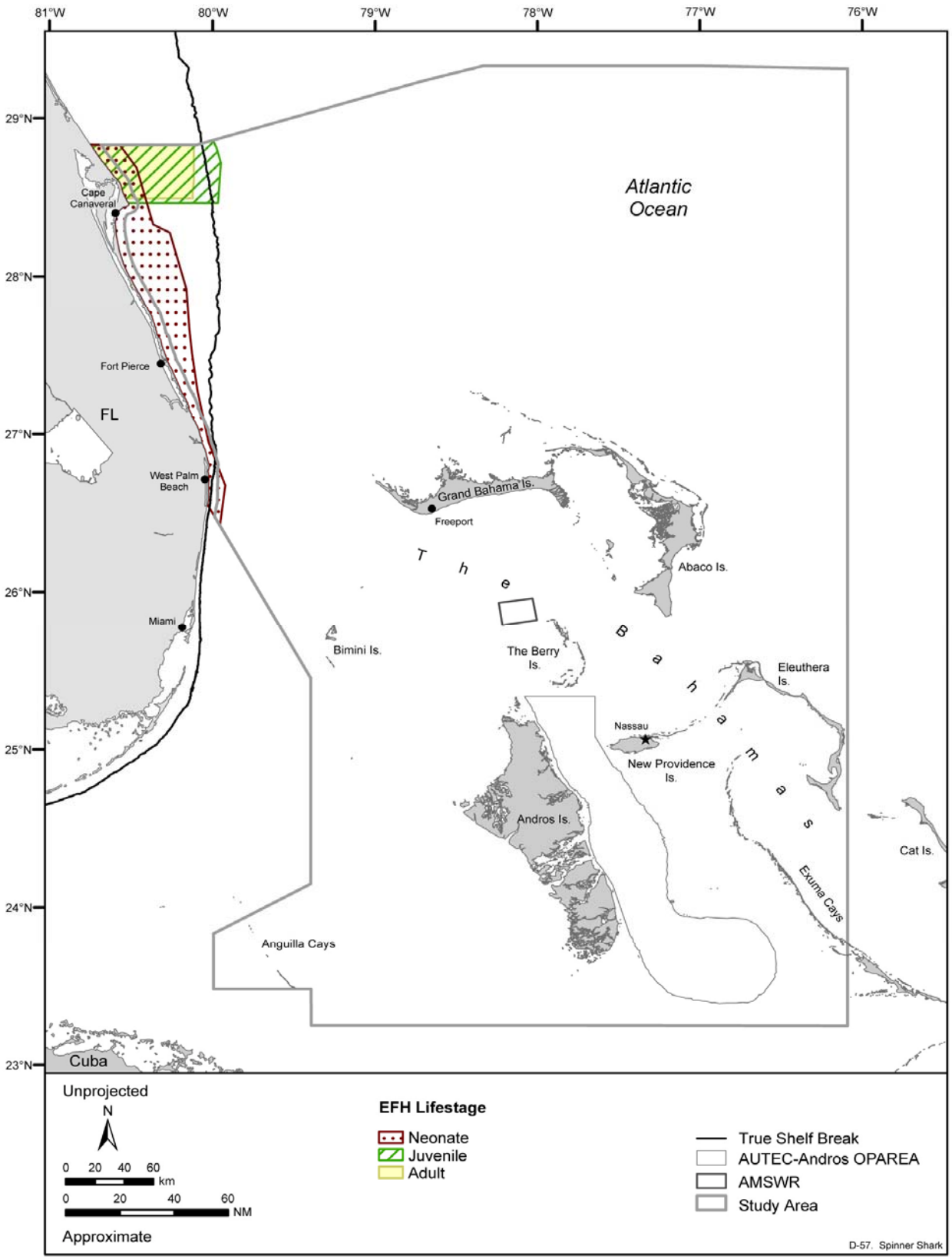


Figure D-57. Essential fish habitat (EFH) for all lifestages of spinner shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

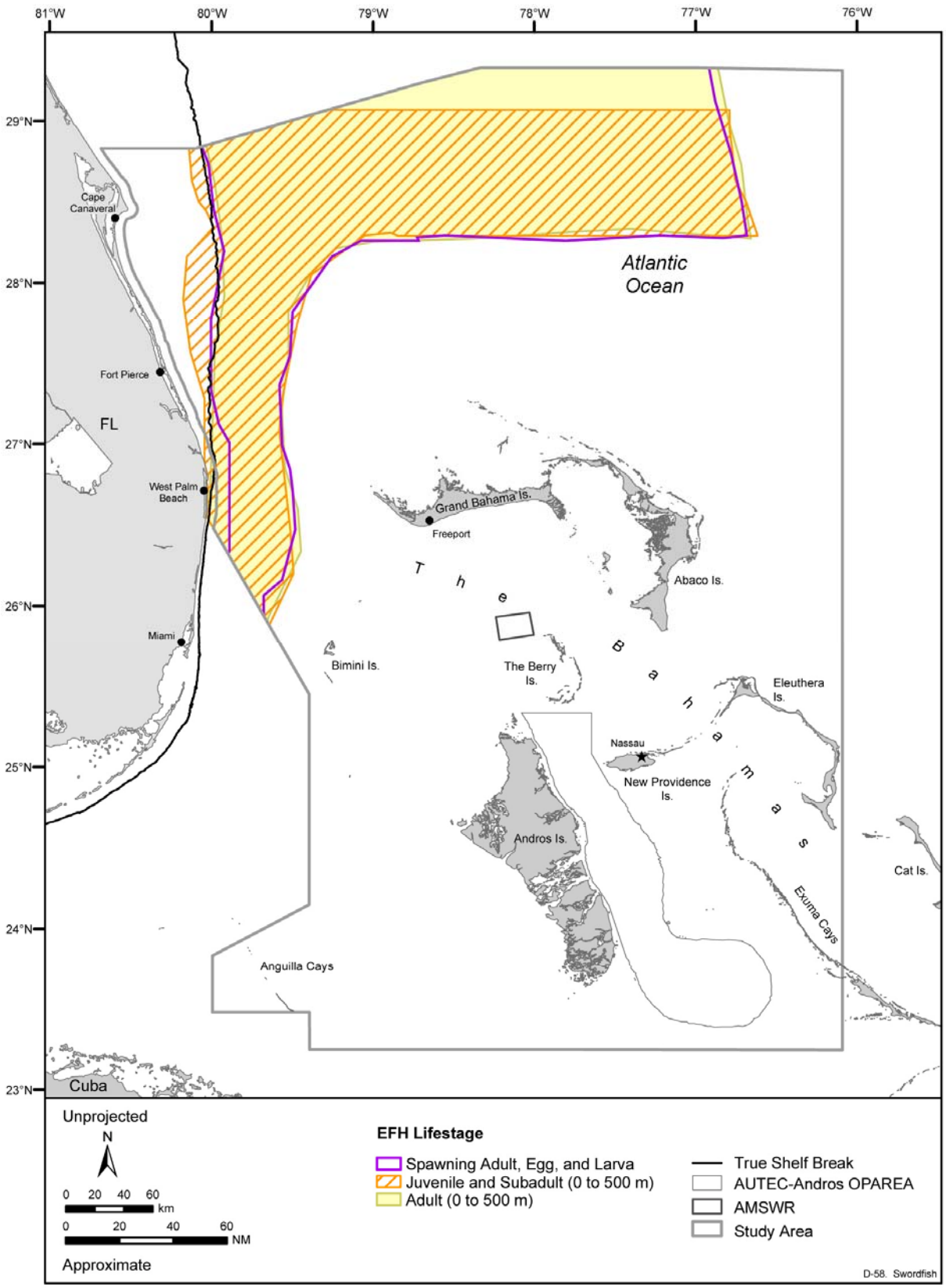


Figure D-58. Essential fish habitat (EFH) for all lifestages of swordfish designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e).

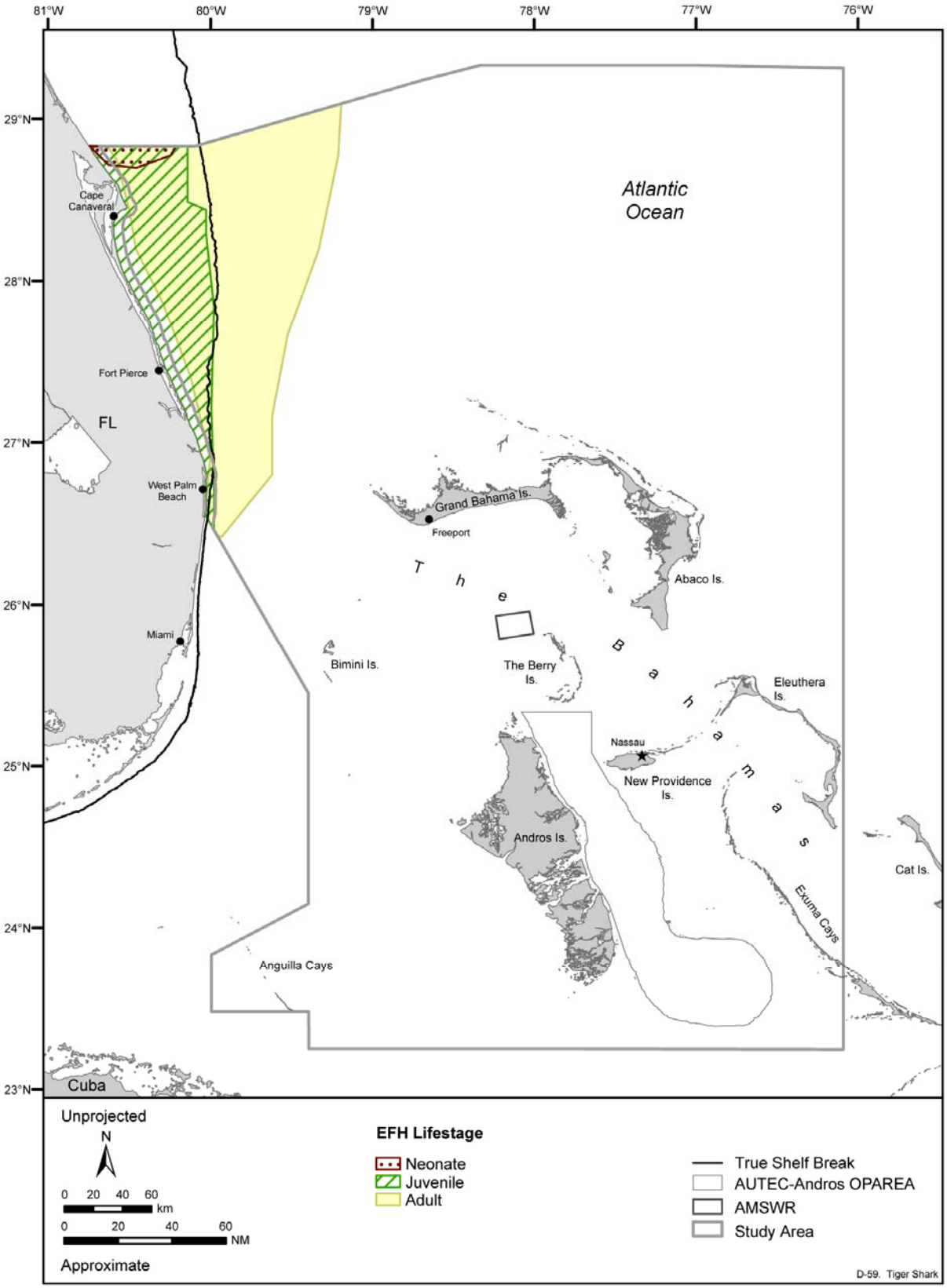


Figure D-59. Essential fish habitat (EFH) for all lifestages of tiger shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. EFH designation for the adult lifestage depicted here does not match the text designation. Source data: NMFS (1999e). Source information: Rilling (2007).

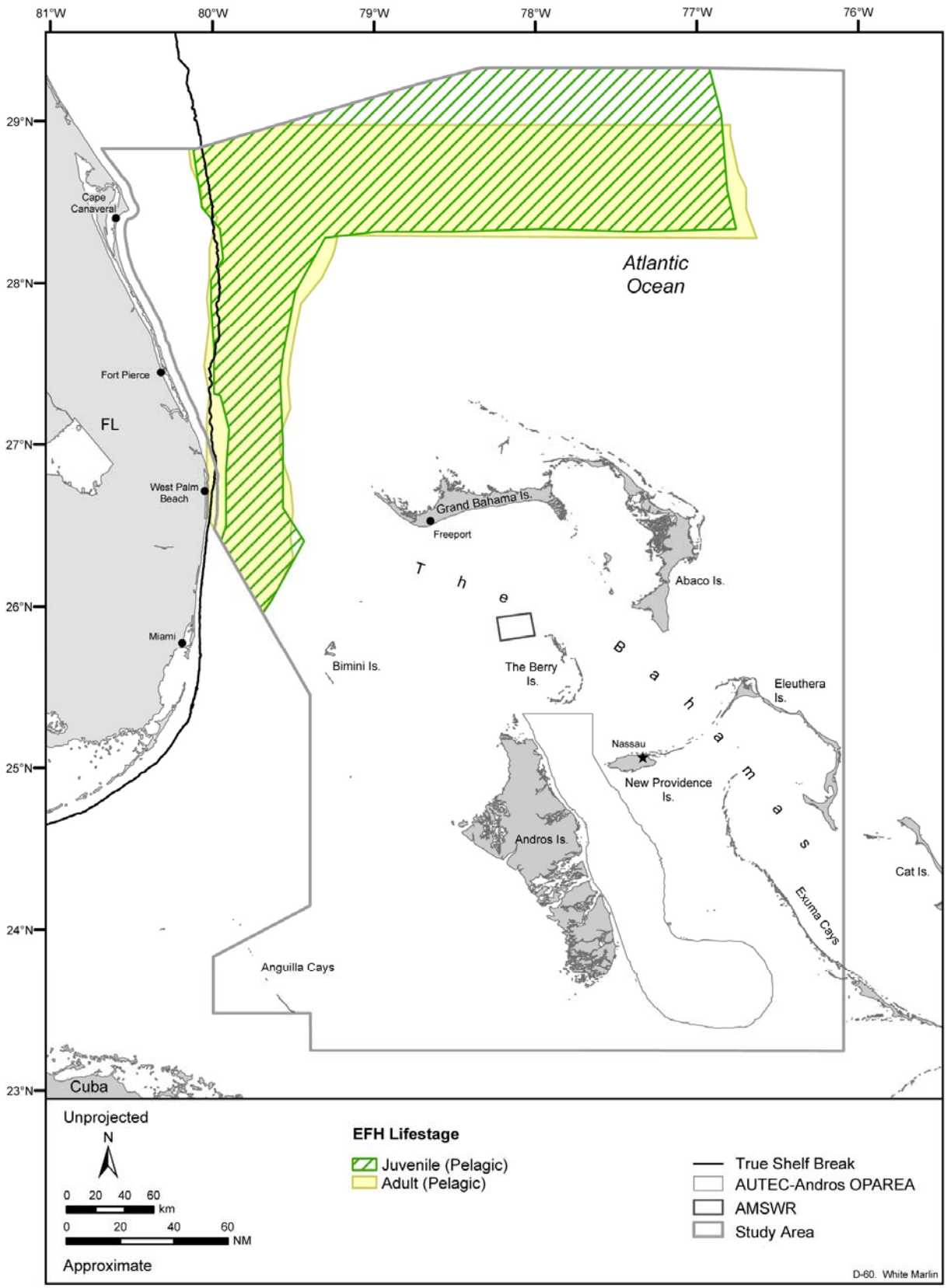


Figure D-60. Essential fish habitat (EFH) for all lifestages of white marlin designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

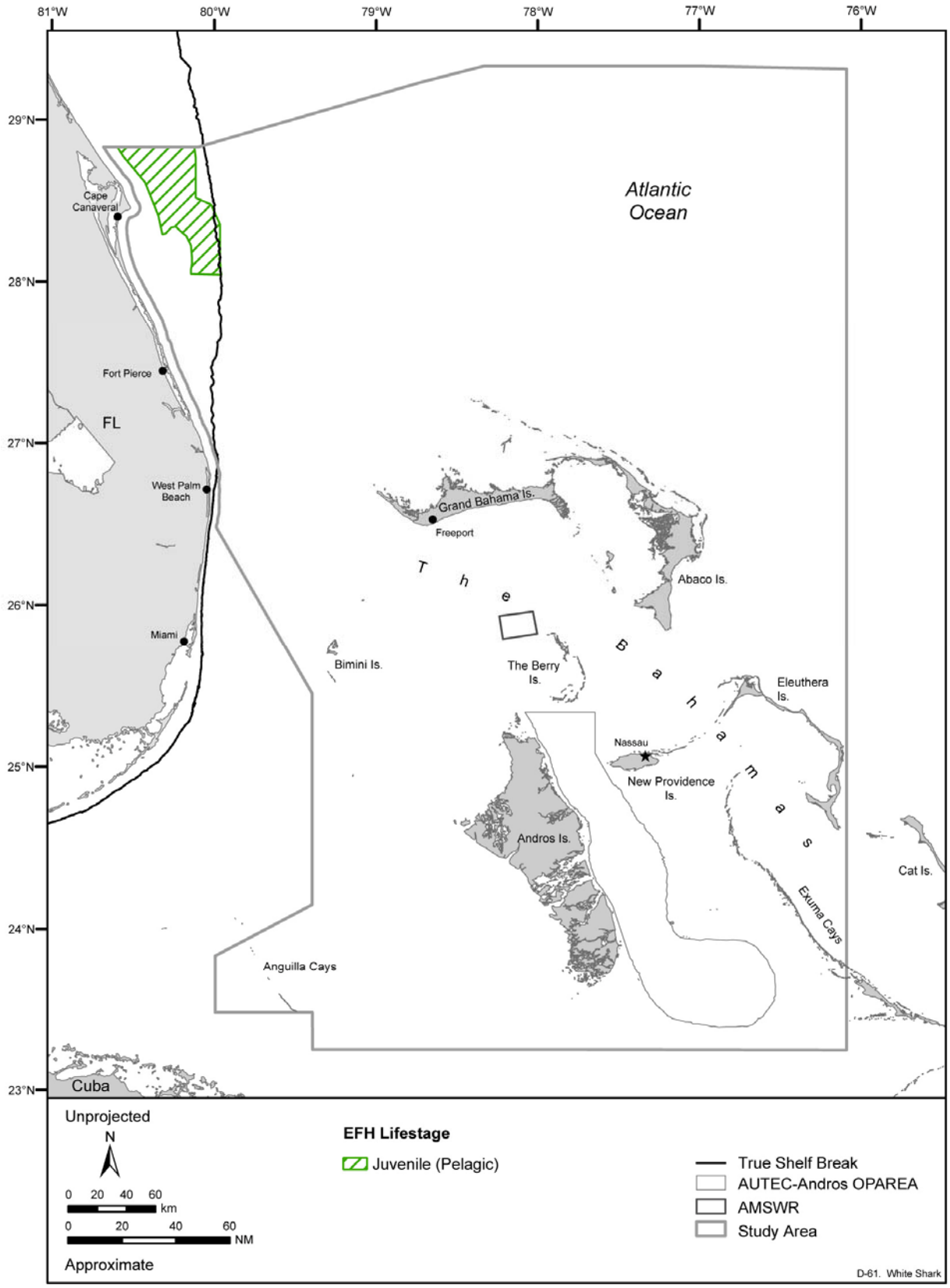


Figure D-61. Essential fish habitat (EFH) for all lifestages of white shark designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e). Source information: Rilling (2007).

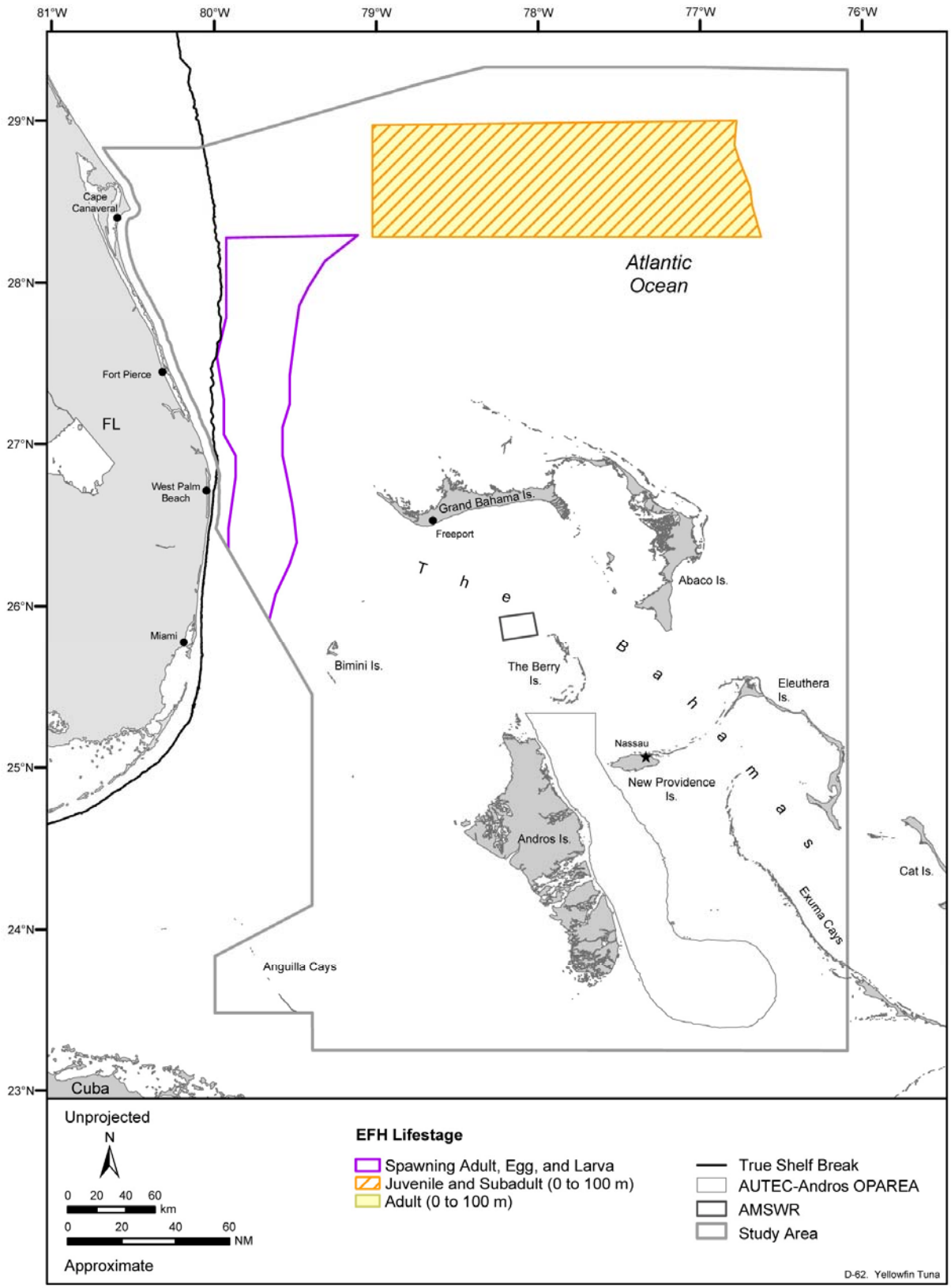
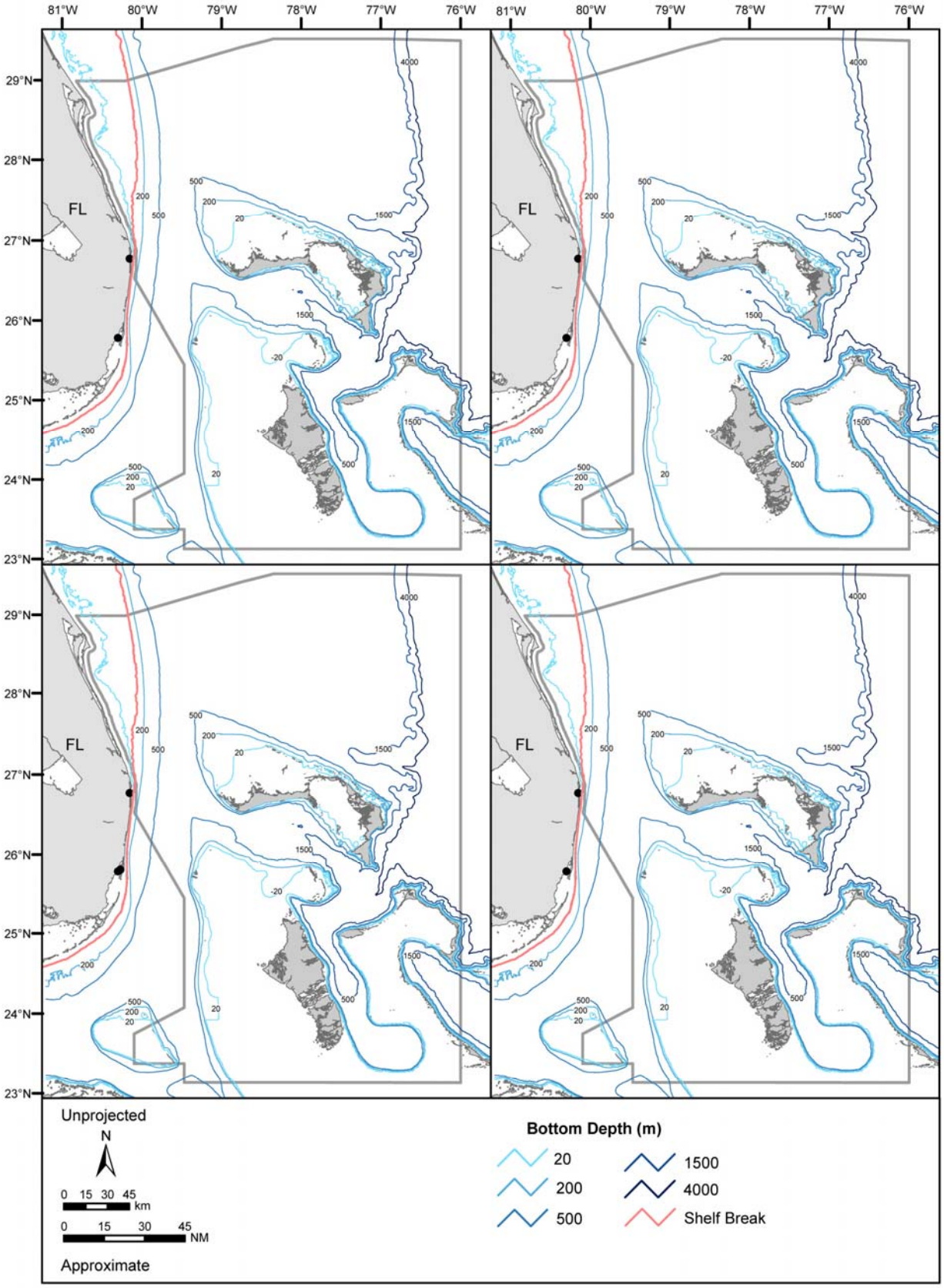


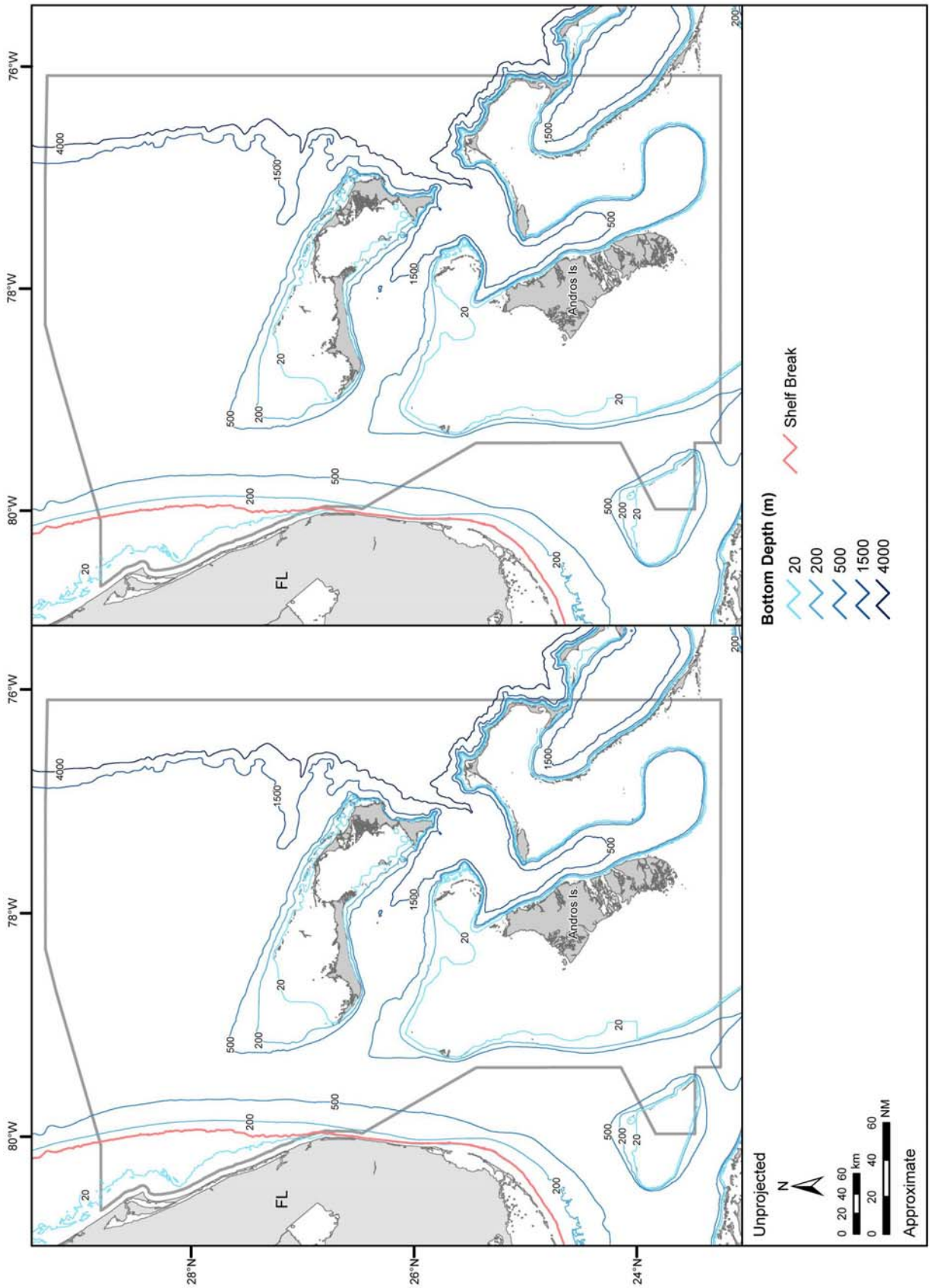
Figure D-62. Essential fish habitat (EFH) for all lifestages of yellowfin tuna designated in the study area for the Southeastern Florida and AUTEC-Andros MRA. Source data: NMFS (1999e).

APPENDIX E: MYLAR TRANSPARENCIES

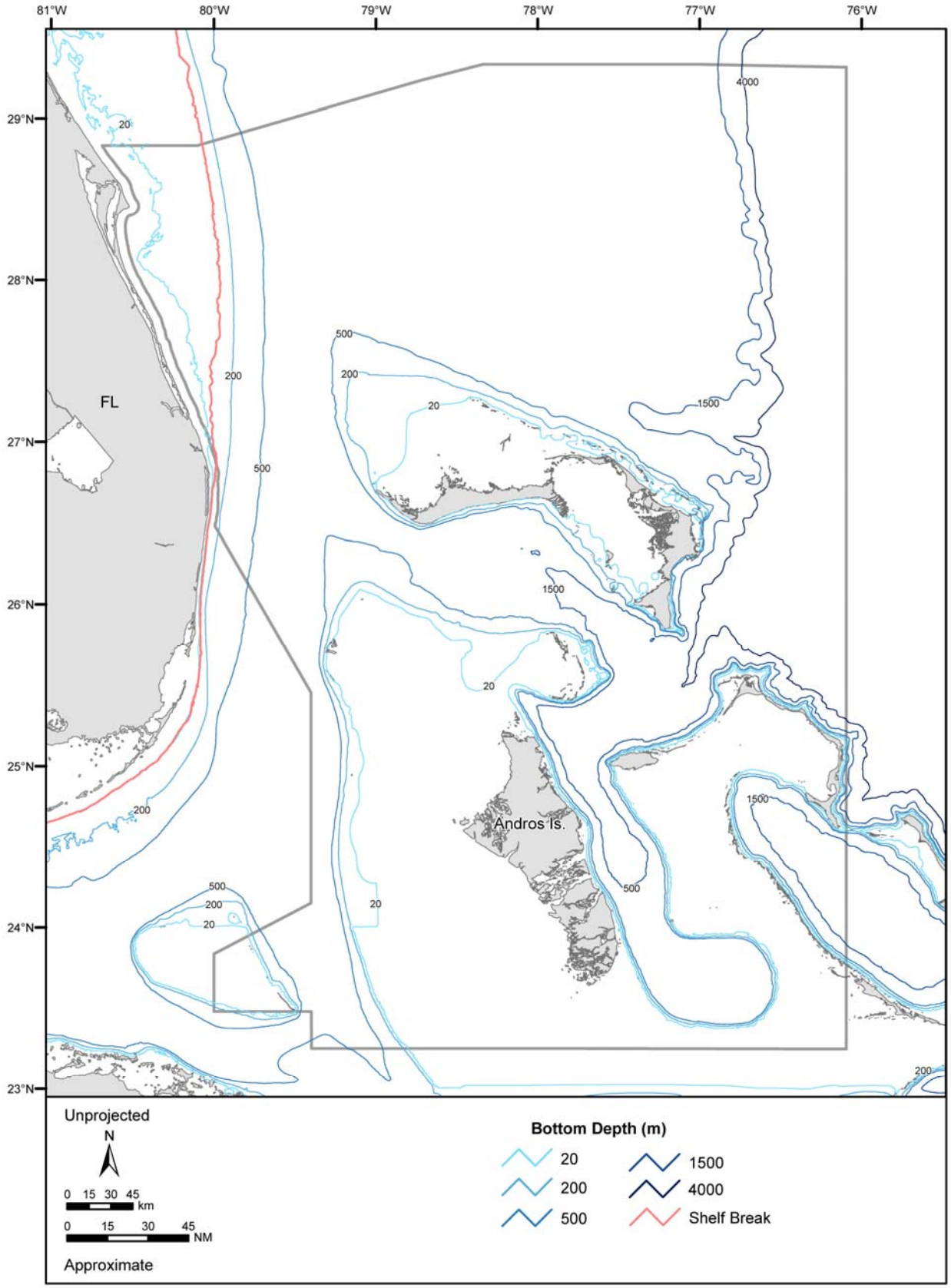
Title
Bathymetry—Selected Isobaths for Four Seasons (Quad Layout)
Bathymetry—Selected Isobaths for Two Seasons (Bi Layout)
Bathymetry—Selected Isobaths for One Season (Mono Layout)
Ocean Currents—One Season (Mono Layout)



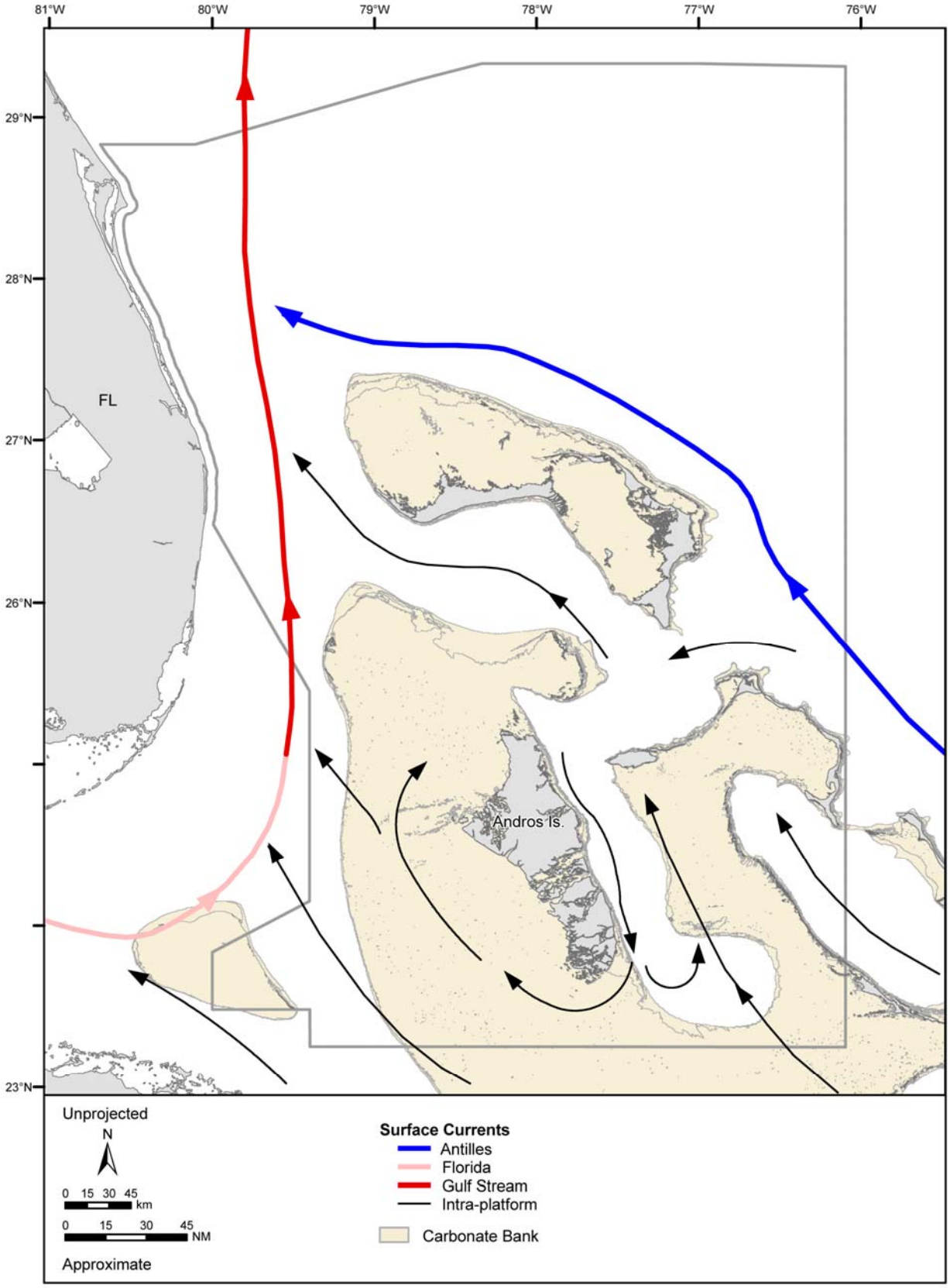
Bathymetry—Selected Isobaths for Four Seasons (Quad Layout).



Bathymetry—Selected Isobaths for Two Seasons (Bi Layout).



Bathymetry—Selected Isobaths for One Season (Mono Layout).



Ocean Currents—One Season (Mono Layout).