MARINE RESOURCES ASSESSMENT UPDATE FOR THE VIRGINIA CAPES OPERATING AREA

FINAL REPORT

OCTOBER 2008

PREPARED FOR:
Department of the Navy,
U.S. Fleet Forces Command

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Task Order: 0056

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ACKNOWLEDGEMENTS

The Department of the Navy (DoN) 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, who provided protected species data for the study area. In particular, we acknowledge the efforts of Drs. Keith Mullin, Lance Garrison, John Bohnsack, Chris Sasso, Ms. Wendy Teas, Ms. Jenny Litz, and Ms. Blair Mase-Gunthrie of the Southeast Fisheries Science Center and Dr. Debra Paulka of the Northeast Fisheries Science Center. Data for the study area from the NMFS North Atlantic Right Whale Consortium database were furnished by Dr. Robert Kenney. Dr. David Hyrenbach of Duke University provided access to marine mammal and sea turtle sighting data. Bill McLellan provided access to marine mammal sighting data. Michael Coyne of Duke University provided Kemp's ridley sea turtle habitat suitability maps. Matthew Godfrey of the North Carolina Wildlife Resources Commission provided sea turtle nesting data. Mike Arendt, Sally Murphy, and DuBose Griffin of the South Carolina Department of Natural Resources and Catherine McClellan of Duke University provided sea turtle tracking 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. Information on the locations of deep water coral was contributed by Dr. Steve Ross, University of North Carolina at Wilmington. High resolution sea surface temperature data was provided by the Institute of Marine and Coastal Sciences at Rutgers University.

For technical assistance with and review of the protected species material in this MRA, we would like to thank Dr. Robert Kenney (North Atlantic Right Whale Consortium). We have attempted to acknowledge the contributions of everyone who assisted in the completion of this MRA, but recognize that we may have inadvertently neglected to mention one or two names; the oversight was not intentional nor was the assistance any less appreciated.

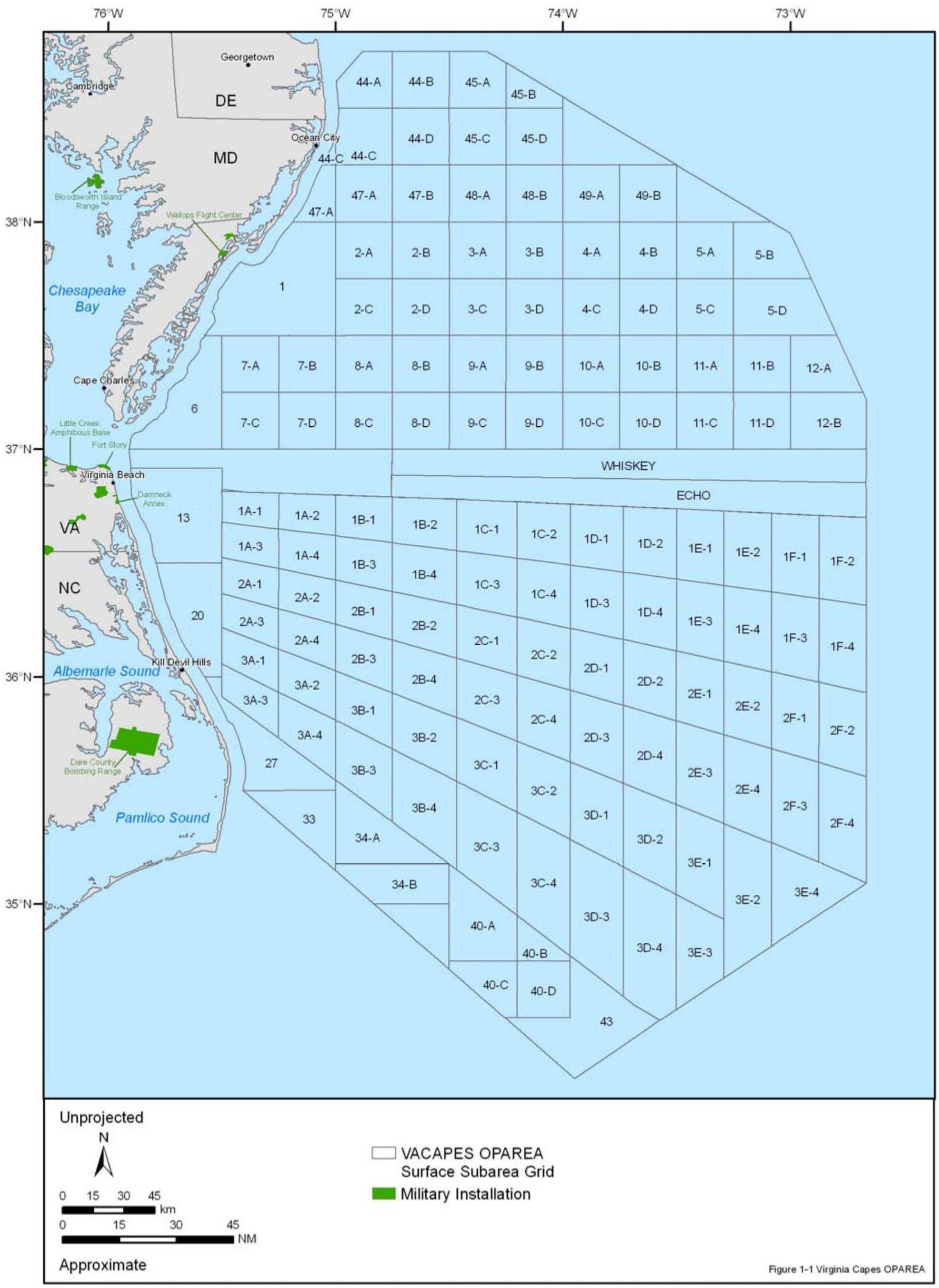
EXECUTIVE SUMMARY

The Department of the Navy (DoN) is committed to environmental stewardship in the execution of its national defense mission. The Navy is responsible for compliance with a variety of complex federal, environmental and natural resources laws and regulations that apply to the marine environment. These include 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 among others. The Commander, U.S. Fleet Forces Command (FFC) implemented the Marine Resource Assessment (MRA) program to develop a comprehensive data and literature compilation of protected and managed marine resources within its various operating areas (OPAREAs). The information that this MRA update provides 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.

The original MRA for the Virginia Capes (VACAPES) OPAREA was published in October of 2001. This document provides an update detailing the marine resources within and adjacent to the VACAPES OPAREA adding recent data and relevant research information.. An overview of the VACAPES OPAREA marine environment describes the important physical parameters that likely influence the occurrence and distribution of protected and managed marine species and habitats. Characteristics and life histories of protected species, including marine mammals, sea turtles, and fishes, that occur in the VACAPES OPAREA are included. Seasonal occurrence patterns of these protected species are identified, mapped, and described along with likely associated factors (e.g., behavioral, climatic, or oceanographic). Oceanic benthic communities including coral, live/hard bottom, and artificial habitats are investigated and mapped. An overview of the fish assemblages in the VACAPES OPAREA and information on the seasonal distribution of fishing activities, both commercial and recreational, has been provided. Detailed summaries and the associated graphical depiction of essential fish habitat (EFH) for those fish and invertebrate species with EFH in the VACAPES OPAREA are provided. Each EFH write-up includes a overview of the status, distribution, and EFH designations by lifestage. Additional considerations include relevant information on the locations of federal maritime boundaries, navigable waters, marine managed areas, recreational SCUBA dive sites, and weather buoy locations in the VACAPES OPAREA.

Thorough literature and data searches were conducted to verify and expand upon information previously related in the original VACAPES MRA. Available sighting, stranding, incidental fisheries bycatch, satellite-tracking, and nest data for marine mammals, sea turtles, and fish were compiled and analyzed to assess occurrence patterns of these protected species in the VACAPES OPAREA. Marine mammal and sea turtle seasonal occurrence predictions are based on sightings-per-unit-effort calculations derived from appropriate line-transect survey data.

Geographical representations of marine resource occurrences in the VACAPES OPAREA are a major feature of this MRA. A geographic information system (GIS) was used to enter, store, manipulate, analyze, and visualize the spatial data and information accumulated for the original VACAPES MRA and data collected for this update. Over 190 GIS-generated map figures are included in this update. Data layers associated with these maps consist of bathymetry, sea-surface temperature, protected and managed species' occurrences, fishing grounds, Navy OPAREAs, and EFH, as well as many others. Metadata, or documentation of GIS data, were also prepared for each GIS figure.



The Virginia Capes OPAREA with surface subarea grid and nearby military installations.

REPORT ORGANIZATION

This MRA consists of nine major chapters and associated appendices:

- **Chapter 1 Introduction**—contains background information on the project, an explanation of its purposes and need, a review of relevant environmental legislation, and a description of methodologies in the preparation of the assessment;
- **Chapter 2 Physical & Biological Environment**—describes the physical environment of the VACAPES OPAREA, 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**—discusses the protected marine mammals, sea turtles, and fish (i.e., the shortnose sturgeon) found in the VACAPES OPAREA, with detailed narratives of their morphology, status, habitat associations, distribution, behavior, life history, acoustics, and hearing;
- **Chapter 4 Habitats of Concern**—details the occurrence of *Sargassum*, corals, hard bottom communities, and artificial habitats located in the VACAPES OPAREA;
- **Chapter 5 Fish and Fisheries**—investigates fish assemblages, EFH, and fishing activities (commercial and recreational) that occur within the VACAPES OPAREA;
- **Chapter 6 Additional Considerations**—provides information on maritime boundaries, navigable waters, marine managed areas, recreational diving locations, and weather data buoys;
- **Chapter 7 Recommendations**—suggests future research activities identified during this project that would clarify anemic data from biological or oceanographic aspects within the VACAPES OPAREA and prioritizes research needs from a cost/benefit approach;
- **Chapter 8 List of Preparers**—lists all individuals who prepared the VACAPES MRA update;
- **Chapter 9 Glossary**—defines terms used in this MRA;
- **Appendix A**—provides 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 efforts;
- **Appendix B**—provides marine mammal occurrence maps;
- **Appendix C**—illustrates sea turtle occurrence maps; and
- **Appendix D**—presents map sources and EFH maps.

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	Three-dimensional
ºC	Degrees Celsius
ºF	Degrees Fahrenheit
µm	Micrometer(s)
µPa	Micropascal(s)
AA	Aggregation Area
AABW	Antarctic Bottom Water
ABR	Auditory Brainstem Response
ACCSP	Atlantic Coastal Cooperative Statistics Program
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
ARPA	Advanced Projects Research Agency
ASMFC	Atlantic States Marine Fisheries Commission
AVHRR	Advanced Very High Resolution Radiometer
BLM	Bureau of Land Management
BTS	Bureau of Transportation Statistics
C	Carbon
CA	Closed Area
$CaCO_3$	Calcium Carbonate
CBRA	Coastal Barrier Resources Act
CCL	Curved Carapace Length
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CHA	Critical Habitat
C-HAPC	Coral Habitat Area of Particular Concern
CHPT	Cherry Point
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
CORMP	Coastal Ocean Research and Monitoring Program
CR	Critically Endangered
CSC	Coastal Services Center
CWA	Clean Water Act
CZCS	Coastal Zone Color Scanner
CZMA	Coastal Zone Management Act
dB	Decibel
dB re 1µPa-m	Decibels at the Reference Level of One Micropascal at One Meter Distance
DCM	Deep Chlorophyll Maximum
DSCS	Deep-Sea Coral and Sponge
DN	Pixel Value (Digital Number)
DNM	Deployed Noise and Measurement
DNR	Department of Natural Resources
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

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

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
EFH	Essential Fish Habitat
EFS	East Florida Shelf
EIS	Environmental Impact Statement
ENSO	El Niño/Southern Oscillation
EO	Executive Order
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
FHCZ	Fisheries Habitat Conservation Zone
FKNMS	Florida Keys National Marine Sanctuary
FL	Florida
FMNH	Florida Museum of Natural History
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
GEBCO-SCUFN	General Bathymetric Chart of the Oceans-Sub-Committee on Undersea Feature Names
GIS	Geographic Information System
GMFMC	Gulf of Mexico Fishery Management Council
GMI	Geo-Marine, Inc.
GSMFC	Gulf States Marine Fisheries Commission
HAPC	Habitat Areas of Particular Concern
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

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

IOC	Intergovernmental Oceanographic Commission
ISOW	Iceland-Scotland Overflow Water
IUCN	International Union for Conservation of Nature
IUCN-WCPA	International Union for Conservation of Nature-World Commission on Protected Areas
IWC	International Whaling Commission
kg	Kilogram(s)
kHz	Kilohertz
km	Kilometer(s)
km^2	Square Kilometers
l	Liter(s)
LC	Location Class
LAT	Latitude
LIW	Labrador Intermediate Water
LON	Longitude
m	Meter(s)
m^2	Square meters
m^3	Cubic Meters
MAB	Mid-Atlantic Bight
MAFMC	Mid-Atlantic Fishery Management Council
MARAD	U.S. Maritime Administration
MARMAP	Marine Resources Monitoring Assessment and Prediction
MATS	Mid-Atlantic *Tursiops* Surveys
MCALF	Marine Corps Auxiliary Landing Field
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCOLF	Marine Corps Outlying Field
MFCMA	Magnuson Fishery Conservation Management Act
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
MNR	Managed Nature Reserve
MPA	Marine Protected Area
MPH	Mile(s) per hour
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

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

NC	North Carolina
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NFEA	National Fishing Enhancement Act
NGDC	National Geophysical Data Center
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
NSIP	National Implementation Support Partnerships
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
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
PL	Public Law
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
SCDNR	South Carolina Department of Natural Resources
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

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

SFA	Sustainable Fisheries Act
SL	Standard Length
SOSUS	Sound Surveillance System
sp.	Species
spp.	Species (plural)
SMZ	Special Management Zone
SST	Sea Surface Temperature
STSSN	Sea Turtle Stranding and Salvage Network
SUW	Subtropical Underwater
SV	Sverdrup (1,000,000 m^3/sec)
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
TTS	Temporary Threshold Shift
U.N.	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environmental Progamme
UNEP-WCMC	United Nations Environment Programme-World Conservation Monitoring Centre
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
VA	Virginia
VACAPES	Virginia Capes
VU	Vulnerable
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 Resources Assessment (MRA) was contracted by the United States (U.S.) Navy's (Navy) U.S. Fleet Forces (USFF) to update data and information concerning the protected and commercial marine resources found in the Virginia Capes Operating Area (VACAPES OPAREA; Figure 1-1). This document serves as an update to the original MRA for the VACAPES OPAREA published in October of 2001.

1.1 PURPOSE AND NEED

This MRA describes and documents the marine resources in the VACAPES OPAREA and vicinity, including both protected and commercially important marine species, and provides a compilation of the most recent data and information on resource distribution and occurrence. A synopsis of environmental data for the VACAPES OPAREA and vicinity and in-depth discussions of the species and habitats of concern found in the region are included. The locations of essential fish habitat (EFH) and fishing grounds (recreational and commercial) as well as other areas of interest (such as marine managed areas and scuba diving sites), are also addressed. Finally, important data gaps are identified and recommendations for future VACAPES OPAREA research are suggested.

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 Navy's Integrated Long-Range Planning Process and represents an important component in 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 are considered in this assessment.

Exhaustive searches and reviews of relevant literature and data were conducted to summarize marine features pertinent to the VACAPES OPAREA and vicinity, protected species occurrence patterns, and distributions of important marine habitats and fishes occurring in the region. To describe the physical environment of the VACAPES OPAREA and vicinity, physiographic, bathymetric, geologic, hydrographic, and oceanographic data are presented. Comprehensive sighting, stranding, incidental fisheries bycatch, tagging, satellite tracking, and nest data for protected marine mammals and sea turtles were compiled, analyzed, and interpreted to predict occurrence patterns. Seasonal variations in occurrence patterns are identified, mapped, and described along with associated factors (behavioral, climatic, or oceanographic). Characteristics of protected species, such as their behaviors and life histories, relevant to the evaluation of potential impacts of Navy operations, are included. Locations of benthic communities (live/hard bottom communities and corals), artificial habitats (artificial reefs and shipwrecks), and EFH are also addressed. To supplement these key aspects, information and data regarding fishing activities (recreational and commercial), U.S. maritime boundaries, navigable waters, marine managed areas, and scuba diving sites in the VACAPES OPAREA and vicinity are also discussed.

1.2 LOCATION OF OPAREA

The VACAPES OPAREA is located in the coastal and offshore waters of the western North Atlantic Ocean adjacent to Delaware, Maryland, Virginia, and North Carolina (Figure 1-1) and covers 101,414 kilometers square (km^2) (39,156 square miles [mi^2]). The northernmost boundary of the VACAPES OPAREA is located 60 km (37 nautical miles [NM]) off the entrance of Delaware Bay at latitude 38° 45' N, the farthest point of the eastern boundary is 296 km (184 NM) east of Chesapeake Bay at longitude 72° 41' W, and the southernmost point is 169 km (105 NM) southeast of Cape Hatteras, North Carolina, at latitude of 34° 19' N. From north to south, the OPAREA covers 494 km (307 mi) and east to west the area covered is 298 km (185 mi). The western boundary of the VACAPES OPAREA lies approximately 5.56 km (3 NM) off the coastline in the territorial waters of the United States (U.S.). The area for which

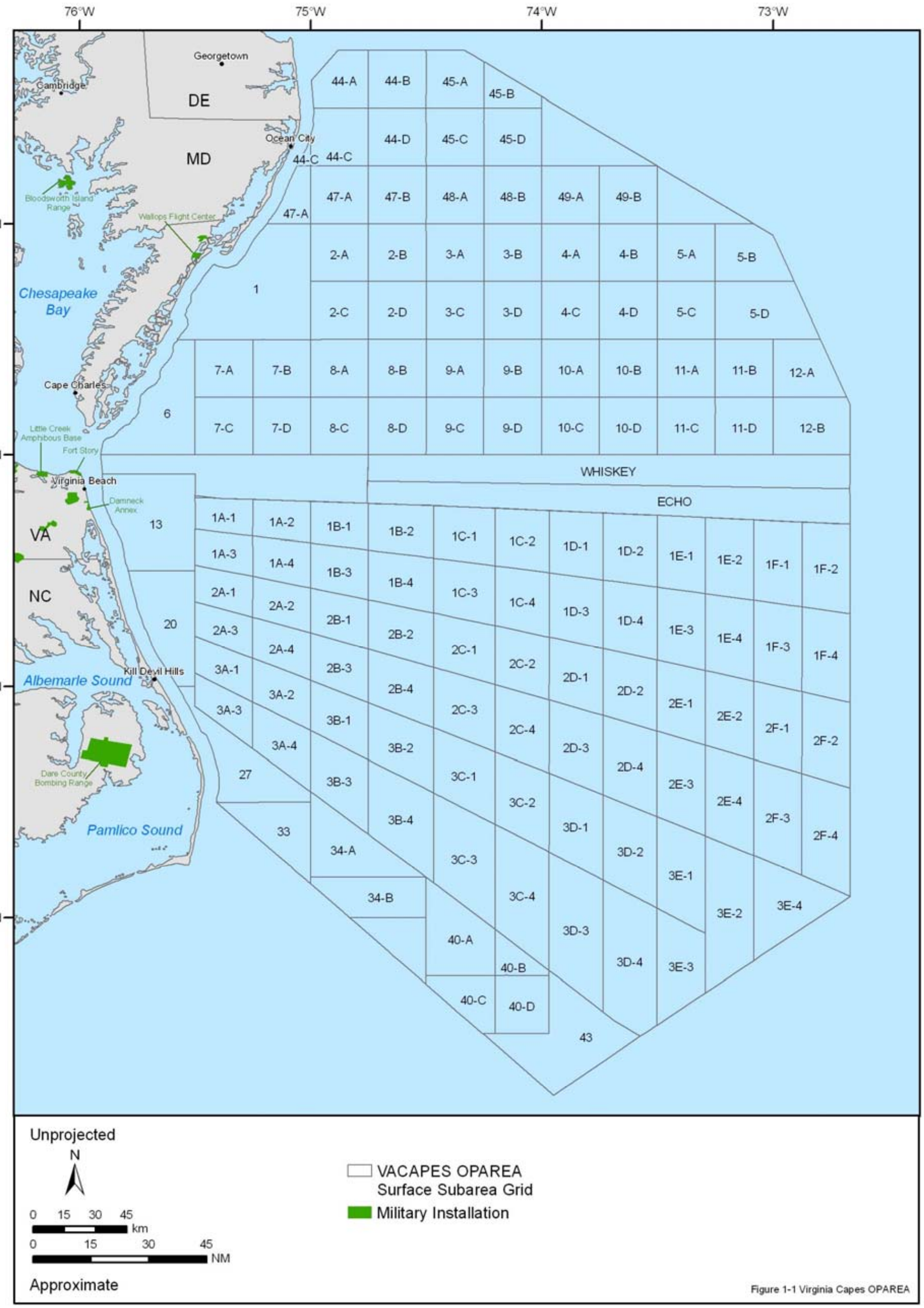

Figure 1-1. The Virginia Capes OPAREA is located along the U.S. Atlantic coast off the states of Delaware, Maryland, Virginia, and North Carolina. Source data: SRS Technologies (2003).

comprehensive data were collected is defined by the shoreward or western boundary of the VACAPES OPAREA. Although some data are shown on the maps beyond that boundary, those data are not necessarily complete.

The Gulf Stream is the dominant oceanographic feature of the VACAPES OPAREA and divides the southeastern portion of the VACAPES OPAREA as it turns east from Cape Hatteras. The northern edge of the Gulf Stream forms the boundary between temperate and subtropical regions in this part of the North Atlantic Ocean. This strong contrast prevents description of the VACAPES OPAREA as a homogeneous region. Even though the northern edge of the Gulf Stream forms a sharp southern limit to the normal range of many temperate marine species, it does not form as sharp a northern limit to the range of subtropical marine species. The ecology of this portion of the Mid Atlantic Bight (MAB) is believed to be related to the dynamics of the region and the high productivity of the waters east of Cape Hatteras, North Carolina. Productive conditions here are facilitated by the convergence of the Gulf Stream and the Western Boundary Under Current (Milliman and Wright 1987). The mouths of two large bays, the Chesapeake and Delaware, open into the VACAPES OPAREA on its western and northern sides, respectively. These bays influence the physical environment of the OPAREA with fresh and brackish water input as well as providing an entrance into the OPAREA for commercial shipping traffic, fishermen, and other marine traffic.

Figure 1-1 shows the surface operations grid, the outer boundary of which is used throughout the report on all marine mammal, sea turtle, and essential fish habitat map figures to represent the VACAPES OPAREA. The map figure also illustrates the locations of some important geographic locations included in the report.

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. The following sections are chronological lists of the many laws and regulations that the Navy must consider when conducting maritime operations in the VACAPES OPAREA 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 U.S. Thus, environmental factors must be given appropriate consideration in all decisions made by federal agencies.

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

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

  Future studies and/or actions 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 "takes" in waters or on lands under U.S. jurisdiction. The MMPA defines a "take" as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S. Code [U.S.C.] 1362[13]). It also prohibits the importation into the U.S. of any marine mammal or parts or products thereof, unless it is for the purpose of scientific research or public display, as permitted by the Secretary of the Interior or the Secretary of Commerce. In the 1994 amendments to the MMPA, two levels of "harassment" were defined. Harassment is defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A), or any act that has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to migration, breathing, nursing, breeding, feeding, or sheltering (Level B). In 2003, the National Defense Authorization Act for fiscal year 2004 altered the MMPA's definition of 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 2003).

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 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 2004). 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 2004).

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: the identification of threatened and endangered species; the identification of critical habitats for these species; the implementation of research programs and recovery plans for these species; and 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 seven marine mammals and five sea turtles listed as threatened or endangered in the VACAPES OPAREA and vicinity (Table 1-1). Of the marine mammals, the NMFS has jurisdiction over cetaceans and pinnipeds while the USFWS has jurisdiction over the West Indian manatee in U.S. territorial waters. The NMFS has jurisdiction over sea turtles while they are in the water, and the USFWS has jurisdiction over nesting individuals.

- The Fishery Conservation and Management Act of 1976, later renamed 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.

Table 1-1. The Endangered Species Act (ESA) designated species with potential occurrence in the Virginia Capes OPAREA. Marine mammal taxonomy follows Rice (1998) for the West Indian manatee and the IWC (2005) for cetaceans except for the North Atlantic right whale, which was revised by Rosenbaum et al. (2000). Sea turtle taxonomy follows Pritchard (1997).

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

[1] Although this species as a whole is listed as threatened, the Florida and Mexican Pacific nesting stocks of green turtles are listed as endangered.

- 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 establishes 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 U.S., 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 (i.e., those designated by the EPA's National Estuary Program), 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 5 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 1998).

- 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 (NMS). 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. NMS, 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

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.

  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

Exhaustive and systematic searches for relevant scientific literature and data were conducted. Once information vital to the production of this MRA report was identified, the information, 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 location data (geographic coordinates) on the occurrence of marine resources within the VACAPES OPAREA and vicinity.

To investigate the physical environment of the VACAPES OPAREA and vicinity; to summarize the occurrence patterns of marine mammals and sea turtles; to determine the locations of benthic communities, artificial habitats, and EFH, as well as recreational and commercial fishing grounds; and to ascertain the distribution of maritime boundaries, shipping routes, marine managed areas, and diving sites, information was collected from the following sources:

- Academic and educational/research institutions: College of William and Mary, Duke University, Los Angeles County Museum*,* New England Aquarium, Old Dominion University, Rutgers University, Texas A&M University, University of Rhode Island, and Virginia Institute of Marine Science [VIMS];

- University on-line databases: Ingenta, Web of Science;

- Online resources, including various databases and related websites: National Oceanic and Atmospheric Administration (NOAA)-Coastal Services Center, NMFS, Ocean Biogeographic Information System (OBIS), U.S. Geological Survey (USGS), Mid-Atlantic Fishery Management Council (MAFMC), South Atlantic Fishery Management Council (SAFMC), New England Fishery Management Council (NEFMC), Atlantic States Marine Fisheries Commission (ASMFC), Gulf of Mexico Fishery Management Council (GMFMC), WhaleNet, Blackwell-Science, FishBase, Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute, Food and Agriculture Organization, Federal Register, Marine Turtle Newsletter, Proceedings of the Annual Sea Turtle Symposium, Caribbean Conservation Corporation, and Seaturtle.org;

- Federal agencies: the Navy, SAFMC, GMFMC, ASMFC, MAFMC, NEFMC, NMFS Highly Migratory Species (HMS) Division, NMFS Southeast Fisheries Science Center (NMFS-SEFSC), NMFS Southwest Fisheries Science Center (NMFS-SWFSC), NMFS Southeast Regional Office, NMFS Northeast Fisheries Science Center (NMFS-NEFSC), NMFS Northeast Regional Office, NMFS Office of Habitat Protection, NMFS Office of Protected Resources; NOAA: Marine Managed Areas Inventory, USFWS Ecological Services Field Offices; Bureau of Land Management (BLM), and other state/regional agencies (e.g., Florida Fish and Wildlife Conservation Commission [FFWCC], Florida Marine Research Institute [FMRI]); and

- Marine resource specialists and subject matter experts.

1.4.2 Spatial Data Representation—Geographic Information System

The geographical representation of marine resource occurrences in the VACAPES OPAREA and vicinity is a major constituent of this MRA report. The marine resources data and information accumulated for this project were obtained 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 VACAPES OPAREA and vicinity. 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 VACAPES OPAREA 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 the CHPT 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.

Often source data were not in a standard format, there was no standard naming convention 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 kilometers and nautical miles. The majority of maps in this report are in one of two formats: a portrait display that includes a full-page map and a landscape display that includes four seasonal maps on a single 11x17 inch page. Maps of each display type are presented at the same approximate scale; most full-page portrait maps are at the approximate scale of 1:2,758,831 and each of the landscape maps are at the approximate scale of 1:12,237,810.

1.4.2.1 Maps of the Physical Environment—Oceanography

- *Bathymetry*—The bathymetry data used in this MRA represent two levels of sampling resolution. Raster depth data, usually shallower than 200 m, from NOAA's (2001a, 2001b) National Geophysical Data Center were sampled at 3-arcsecond resolution. The data were extracted at 15-arcsecond 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 2-arcminute resolution (Figure 1-2). Highly detailed vector bathymetry (i.e., isobaths) were prepared with contour intervals of 10 m for depths shallower than 200 m and with contour intervals of 100 m for depths greater than 200 m. 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 VACAPES OPAREA and vicinity, triangular irregular networks (TINs), which linearly interpolate intermediate data values between data points, were created in the ArcView® 3D Analyst extension using the combined bathymetry data. For this process, the NOAA bathymetry data were extracted at 30-arcsecond resolution. The NOAA data were then combined with the lower resolution Smith and Sandwell data to create the TIN. The TINs were added to the ArcView® 8.3 ArcScene™ extension to achieve the full 3D display (Figure 2-1). ArcScene® allows the 3D display to be manipulated (rotated and tilted) and the vertical dimension to be exaggerated so that key physiographic features are emphasized in the 3D image. 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 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 shelf break utilized high-resolution (3 arc-second) bathymetry data available from the NOAA for the U.S. coast, published information on the seaward gradients of the shelf, slope, and the shelf break in the VACAPES OPAREA and vicinity, and analyses completed in the GIS environment (ArcView® version 8.3) to map the true shelf break. Thus, the shelf break line presented on the map figures in this report represents the actual geographic area where the seafloor gradient changes. The bottom depths this line represents range from ~20 to 70 m. The gradient at which the shelf break occurs is >1.2° throughout most of the

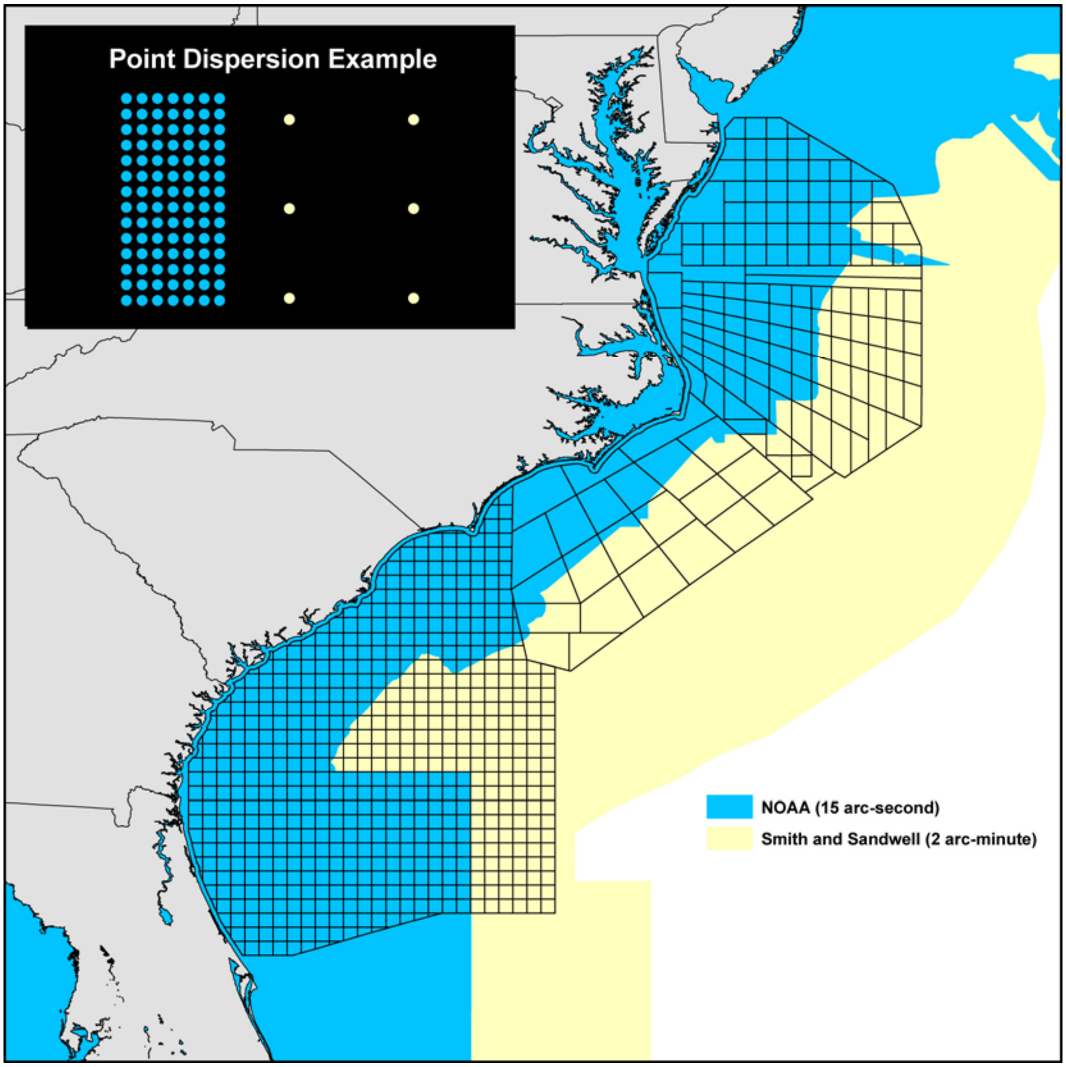

Figure 1-2. Spatial coverage of bathymetric datasets used for the SE OPAREAs, the resolution of each dataset, and a scale model example of spatial distribution of the data points associated with each dataset.

VACAPES OPAREA and vicinity and >1.5° north of Cape Hatteras. This calculation is based primarily on an analysis of the bathymetry data and is corroborated with published bathymetry maps depicting the shelf break in the region (Emery and Uchupi 1972; Shepard 1973; Jones et al. 1985).

Using ArcView® GIS software, the bathymetry data for the U.S. Atlantic east coast shelf and slope provinces 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 southeast U.S. coast, including the VACAPES OPAREA. 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 B-spline algorithm in the GIS environment to produce a geographic representation of the true shelf break.

- *Sea Surface Temperature (SST) and Seasonal Delineation*—Maps of seasonal SST were created from data available through the Physical Oceanography Distributed Active Archive Center (PODAAC) that is sponsored jointly by the National Aeronautics and Space Administration (NASA) and the NOAA (PODAAC 2004). SST data were compiled from weekly averaged Advanced Very High-resolution Radiometer (AVHRR), version 5.0, satellite data, which contain multi-channel SST pixel data (NASA 2000).

Data for the VACAPES OPAREA and vicinity 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:

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

where DN is the 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 single mean SST value representing a region comprised of the three southeast U.S. OPAREAs (CHPT, Virginia Capes [VACAPES], and Charleston and Jacksonville [JAX/CHASN]) 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. 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 VACAPES OPAREA and vicinity were associated with a color gradient ranging from blue to red that represents cooler to warmer surface water temperatures (in °C), respectively. All seasonal SST maps reference the identical color bar to facilitate comparison.

The resulting seasons used throughout this report are defined as winter (6 December through 5 April), spring (6 April through 13 July), summer (14 July through 16 September), and fall (17 September through 5 December). Although the dates each of the seasons represents may be different than the standard calendar seasonal definitions we are accustomed to, 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.

The SST data used to depict surface currents in the VACAPES OPAREA and vicinity was provided by Rutgers University (Rutgers University 2006). Rutgers' Coastal Ocean Observation Lab independently acquires 1 km x 1 km resolution AVHRR data and processes the data to create high quality images of SST in coastal regions. The data were cropped from their original extent to focus on the VACAPES OPAREA and vicinity. The color bar used with this map is different from the color bar used in the seasonal SST maps and is based on the range of temperatures found in the map extent.

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

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

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 smoother image. The seasonal range of chlorophyll *a* concentrations (in milligrams per cubic meter [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

Marine mammal and sea turtle occurrence data were accumulated from available sources and provided comprehensive coverage of the OPAREA (Appendix A-3). Occurrence data records of aerial and shipboard (visual/sighting) surveys, opportunistic and historical sightings, strandings, incidental fisheries bycatch, satellite-tagging programs, turtle nest counts, and other available sources were acquired (Appendix Table A-1). Data represented on the marine mammal and sea turtle maps were vital to the determination of seasonal occurrence patterns for protected species known to inhabit the waters of the OPAREA.

Sighting data from aerial and shipboard surveys were obtained from the NMFS-SEFSC, NMFS-NEFSC, and other sources (Appendix A). In addition to collecting marine mammal and sea turtle data directly from agencies and institutions, miscellaneous sighting data from technical reports and other scientific literature were also amassed and incorporated into this MRA. The marine mammal stranding data used in this report were acquired from the Smithsonian Institution and the Southeast Marine Mammal Stranding Network. Sea turtle nesting and stranding data were obtained for North Carolina from the North Carolina Wildlife Resources Commission. Incidental fisheries bycatch data for marine mammals and sea turtles were also obtained from the NMFS-SEFSC.

While working with the marine mammal and sea turtle observation data, several assumptions were made. First, it was assumed that the species identifications given in the original datasets were correct. Since the reliability of species identifications from one dataset to the next was usually not known, it was necessary to make this assumption. The reliability of marine mammal and sea turtle species identification is of greater importance when calculating densities or estimating a species' abundance in a particular area. Although it was assumed that the species identifications were correct, the accuracy of the geographic coordinates given in the dataset could not be assumed. Problems were often encountered when the original data coordinates were plotted and animal's positions were shown to occur in unexpected locations. This was especially true of the marine mammal stranding data. For example, the geographic coordinates of several strandings often indicated that they occurred well out to sea or far inland. In such cases, the stranding record was moved as close to the original geographic description as possible. If no geographic description was available, the stranding was moved to the nearest shoreline at an accuracy scale of 1:250,000. If the stranding record was too far offshore or inland to estimate an accurate shore position, the record was deleted.

For the purposes of this MRA report, most categories of unidentified species were merged into a category called unidentified marine mammals or unidentified turtles, which were plotted on the all marine mammal and all turtle map figures along with the associated identified species (Figures B-1, and C-1, respectively).

Tracklines (line features) and transect coordinates (point features) were plotted for all aerial and shipboard sighting surveys within the OPAREA and vicinity (Appendix A, Figures A-1 through A-4). To visualize those areas of the VACAPES OPAREA and vicinity where no survey effort occurred, a grid was created that covered the entire OPAREA. Each grid cell was 0.1667 x 0.1667 decimal degrees (i.e., 10 minutes) in size. The grid was clipped to the map extent,and populated with the survey tracklines or transect-coordinates, one cell at a time. Grid cells that intersected with a trackline or transect coordinate were designated as "present" while those with no tracks or coordinates were designated as "absent". The "absent" grid cells were colorized and visualized to depict the sections of the OPAREA where no surveys of any type occurred (Figure 7-1). No numerical values are associated with the grid cells for this map.

A 10-minute grid covering the OPAREA was also used to depict the amount of line-transect survey effort in km-per-grid cell that occurred throughout the OPAREA. Each grid cell was populated with a numerical value representing the total amount of survey effort that occurred over time in that cell. The resulting values of effort for line-transect surveys were divided into quarters, which were used as the effort level categories (Figure A-5).

- Sighting Effort—A common problem with the interpretation of distribution or occurrence patterns based on sighting data is the likelihood of bias introduced by an uneven pattern of survey coverage (or "effort"). It is difficult to know if an observed concentration of sightings is associated with high-use habitat or simply due to a concentration of survey effort in a particular area of the ocean. Conversely, when few or no sightings appear in a geographic area, it can be nearly impossible to understand if that paucity is attributable to the actual rarity of a species or is simply due to sparse or absent survey effort. One method to address this potential bias is to quantify sighting effort and then to correct sighting frequencies for differences in effort, producing an index which can be termed an encounter rate, sighting rate, or sightings-per-unit-effort (SPUE). The unit for the SPUE value used in this report is the number of animals sighted per pre-defined length of survey track. Length was selected as more representative than time for quantifying effort when combining aerial and shipboard surveys that utilize very different platform speeds. To standardize the SPUE data even further, the survey data that were used for SPUE computations are usually limited to only a subset of the available survey tracklines that meet some pre-defined criteria for "acceptability." If the SPUE values are computed for consistent spatial units, they can be mapped to show effort-corrected distribution patterns. SPUE values also can be statistically compared across areas, seasons, and years. Development of this method was begun during the Cetacean and Turtle Assessment Program (CETAP) (CETAP 1982), and has been used in a variety of published analyses (Kenney and Winn 1986; Winn et al. 1986; Kenney 1990; Hain et al. 1992; Shoop and Kenney 1992; Kraus et al. 1993; Mitchell et al. 2002).

  Survey data vary widely in the range of data variables that are included in datasets and the rigor with which the data are collected. The most rigorous surveys are line-transect surveys (that are used to estimate densities and abundances of marine mammals and sea turtles). Line-transect survey data must be carefully standardized. Data to be used in density estimation are restricted to sightings collected during defined census tracks (i.e., "on-effort"). Sightings collected during transits to or from a survey area, on cross-legs between census tracks, or while the ship or aircraft has left a census track to investigate a sighting, are considered to be "off-effort", even if the observers were on watch and recording data at the time. For more information concerning each of the surveys used in the SPUE calculations, see Appendix A-3.

  For the calculation of effort and SPUE values, all of the line-transect survey data from the OPAREA that met minimum standards for available data were pooled. To be included in the SPUE analysis, a dataset had to have data fields allowing assessment of the sighting conditions encountered during each segment of the survey track, including visibility, sea state, and observer watch status, as well as altitude for aerial surveys. There also had to be sufficient records (time and position) for the survey track, in addition to the sighting locations, to adequately reconstruct the platform track. Only track segments completed with at least one observer on watch, clear visibility of at least 2 NM, Beaufort sea state of less than or equal to three, and altitude of less than 366 m were included as acceptable effort. The analysis area was defined as all Atlantic Ocean waters off the southeastern U.S. that were encompassed in the following area: between 39.3563ºN and 28.5ºN and between 71.5ºW and 82.0470ºW. The analysis area was covered with a grid of 10-minute by 10-minute cells (a compromise as smaller cells provide finer resolution while larger cells are more likely to have enough effort to be useful) to provide a geographic unit index for the effort and subsequent SPUE values.

- SPUE Calculation—It is important to note that there are inter-platform differences between shipboard and aerial surveys, specifically in the detectability of marine mammals and sea turtles from each platform. However, information relating to sighting distances, which are necessary to calculate the probability of detection functions for each species, were not available. In the absence of the data necessary to quantify the differences between sighting platforms, the SPUE values were calculated based on the assumption of no inter-platform, inter-species (including group size) differences in detectability. This assumption has been made by other researchers (e.g., Shoop and Kenney 1992) and allowed the pooling of shipboard and aerial data for use in calculating the SPUE values for each species.

Effort was quantified as length of track surveyed. The great-circle distance (*D*, in km) between any two latitude/longitude positions can be calculated by:

$$D = 111.12*\arccos[\sin(LAT1)*\sin(LAT2)+\cos(LAT1)*\cos(LAT2)*\cos(LON2-LON1)] \quad \text{(Equation 3)}$$

where LAT = latitude, LON = longitude, and 1 and 2 identify the two positions.

Great-circle and rhumb-line distances between two points 10 km apart differ by less than 1 m. For a track segment with both ends within the same 10-minute grid cell, the length (i.e., effort) is directly assigned to that cell. When the segment crosses more than one cell, however, the effort must be partitioned across all appropriate cells. The method by which this can be resolved involves simultaneous solution of the equations for the trackline and the cell boundary(ies) to insert new position(s) for the intersection(s), then calculation of the lengths of the sub-segments within each cell.

All acceptable effort within each cell and season was summed across all years (1979 through 2005). Grid cells with less than 5 km of valid effort within a season across all combined years were considered not to have been sampled sufficiently to produce reliable data and were eliminated from the analysis (i.e., treated as Effort = 0). The total valid survey effort in the OPAREA between 1979 and 2005 was 1,318,793 km; there were 1482 cells meeting the 5 km minimum criterion (Table 1-2; Figure A-5). Effort was highest during the winter and lowest in summer.

Table 1-2. Seasonal summaries of survey effort (km) used to calculate SPUE for the Southeast OPAREAs (Virginia Capes, Cherry Point, and Charleston/Jacksonville) per 10-minute grid cell.

Season	N	Mean	Median	Maximum	Total Effort
Winter	955	1,124	90	43,228	1,073,069
Spring	856	80	58	1,085	68,327
Summer	1,175	80	227	931	93,521
Fall	639	131	17	3,861	83,876
All Seasons	3,625	364	49	43,228	1,318,793

Only animals sighted (*n*) during acceptable effort were included and summed within species across all years. Finally, the number of animals sighted was divided by effort to generate the SPUE index, in units of animals sighted per 1,000 km of valid effort:

$$SPUE = 1{,}000 * n / \text{Effort} \quad \text{(Equation 4)}$$

The factor of 1,000 was included simply to upwardly scale the SPUE values to avoid very small decimal values. For each cell that was sampled with at least 5 km of effort within a season (i.e., had associated survey effort), there was a corresponding SPUE value calculated for each species (many cells contained a value of zero) (Figure 1-3; Appendix A-3). For mapping purposes, SPUE values were geographically located in the center of each grid cell. Therefore, the locations of sighting records may not match the location of an associated SPUE value.

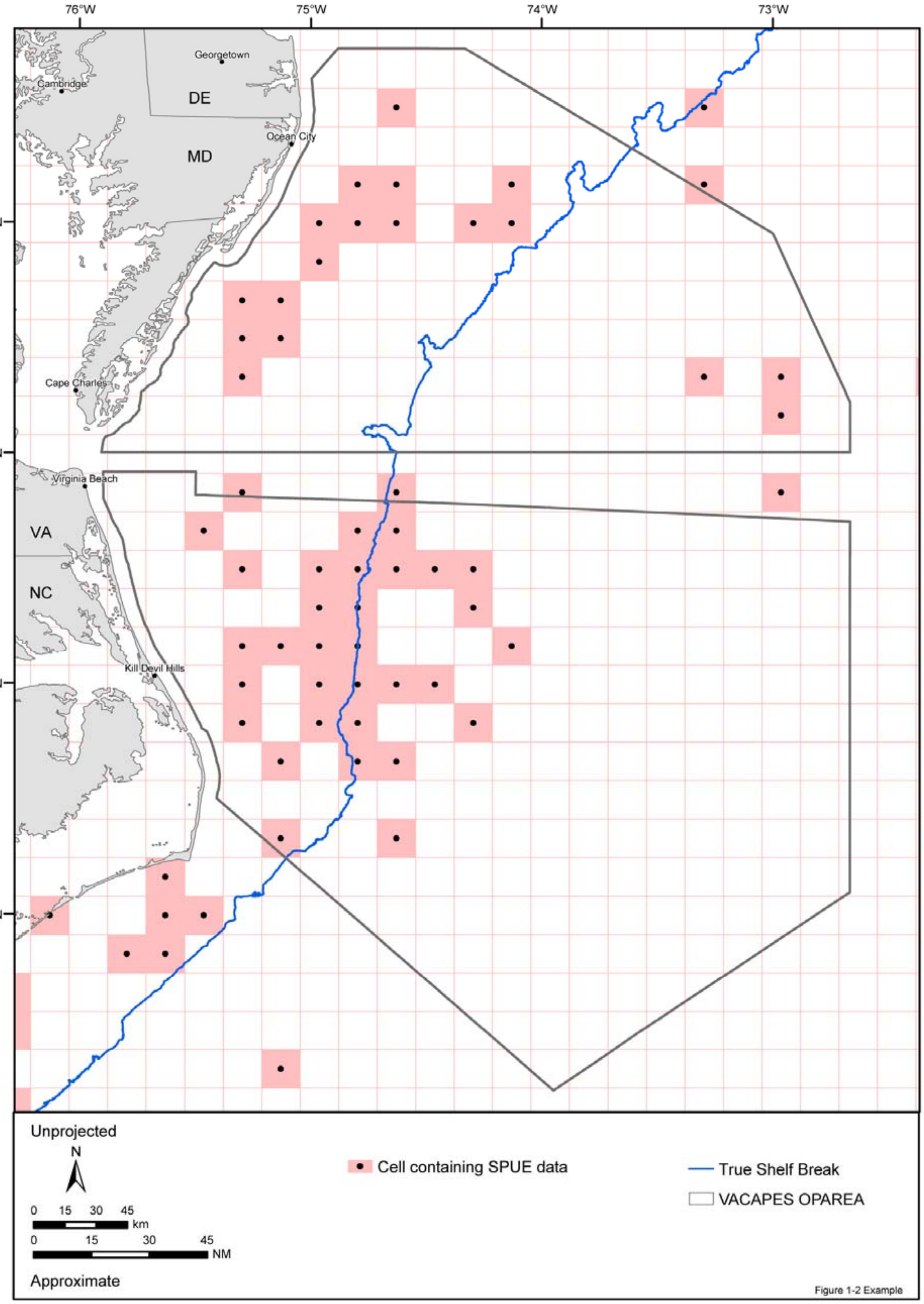

Figure 1-3. Example of the grid in 10-minute cells used for survey effort and sightings per unit effort (SPUE) calculations. SPUE data values are assigned to the center point of each grid cell.

- Geostatistical Modeling of Occurrences—The seasonal observations of protected species were modeled by interpolating the SPUE data with Kriging, a geospatial interpolation method using ESRIs Geostatistical Analyst® extension of their GIS software. The only regions of the OPAREA modeled with Kriging were those regions where sufficient survey effort had occurred (e.g., Effort ≥ 5 km); the grid cells in the regions of the OPAREA where no survey effort occurred were combined and smoothed (splined) to represent a uniform region of “No Survey Effort".

  Kriging is a statistical interpolation method that predicts the values at unsampled locations, creating a model of geospatial data (Johnston et al. 2001). Kriging was chosen for the purpose of creating occurrence models instead of other inverse distance weighted (IDW) interpolation methods because it develops a more accurate model. IDW interpolation methods use a simple algorithm that weights the model based solely on distance while Kriging uses a complex algorithm that develops an interpolation model weighted by several parameters, including the distance between measured points and the prediction location, as well as the overall spatial arrangement among the measured points and their values (Johnston et al. 2001). To create a continuous surface, interpolations or predictions are made for the unsampled locations in the analysis area based on the interpolation function and spatial arrangement of the measured values that are nearby (nearest neighbor analysis).

  There are several types of Kriging techniques, each of which is based on different data assumptions and criteria. At the onset of the analysis, it was unclear whether any significant trends were present in the data. To account for these potential trends, the universal Kriging technique was selected due to its use of local means as a sum of low order polynomial functions of the spatial coordinates to model the data (Krivoruchko 2002). In contrast, ordinary and simple Kriging techniques both assume a constant mean when fitting the data (Johnston et al. 2001; Krivoruchko 2002). In essence, universal Kriging decomposes the data into a deterministic trend component and an autocorrelated random component and Kriging is then performed on the residuals once the trend has been removed. The trend is reapplied to the output surface prior to calculating the final predictions (Johnston et al. 2001). Universal Kriging, with a prediction map output, was used to interpolate the SPUE data values and create an occurrence model for each season and species for which data were sufficient. As a result of applying the universal Kriging technique, no trends were found in the SPUE data for the VACAPES MRA. Subsequent comparisons of the cross-validation results between universal and ordinary Kriging revealed no differences in the model results (i.e., the occurrence polygons).

  The process of creating the occurrence models using the Kriging method involved numerous steps (Figure 1-4). The primary step was the development of the weighted interpolation function. This empirical weighted function was plotted and a curve was generated to ensure that the function best fit the data. A minimum of two, but optimally five, nearest neighbors (SPUE data points) were required to create an occurrence polygon for any occurrence level. Requiring a minimum of two neighbor data points ensures that the resulting models (polygons) represent the likely occurrence of a marine mammal species in the area.

  One of the key parameters in the Kriging method is the selection of a neighborhood search pattern. The neighborhood search pattern affects the level of interpolation and, ultimately, the detail of the model produced. The search pattern selected for these analyses was circular and extended outward from each SPUE value. The circular search pattern was chosen to reduce prediction error and eliminate any bias in search direction or distance. The circular search pattern can be divided equally into one, four, or eight search sectors. The single-sector search pattern (no divisions) produces a very finely detailed model result (polygon), while the eight-sector search pattern produces a much-generalized model result with little detail (Figure 1-5). The four-sector search method was selected as the best compromise, producing occurrence results/polygons that were neither too detailed nor too generalized to limit their usefulness.

  In some instances, the minimum number of nearest neighbor criteria may not be met before the search reaches it maximum distance limit, resulting in the creation of no occurrence model (polygon) (Figure 1-4). This often occurs when few SPUE data values are associated with a species or species

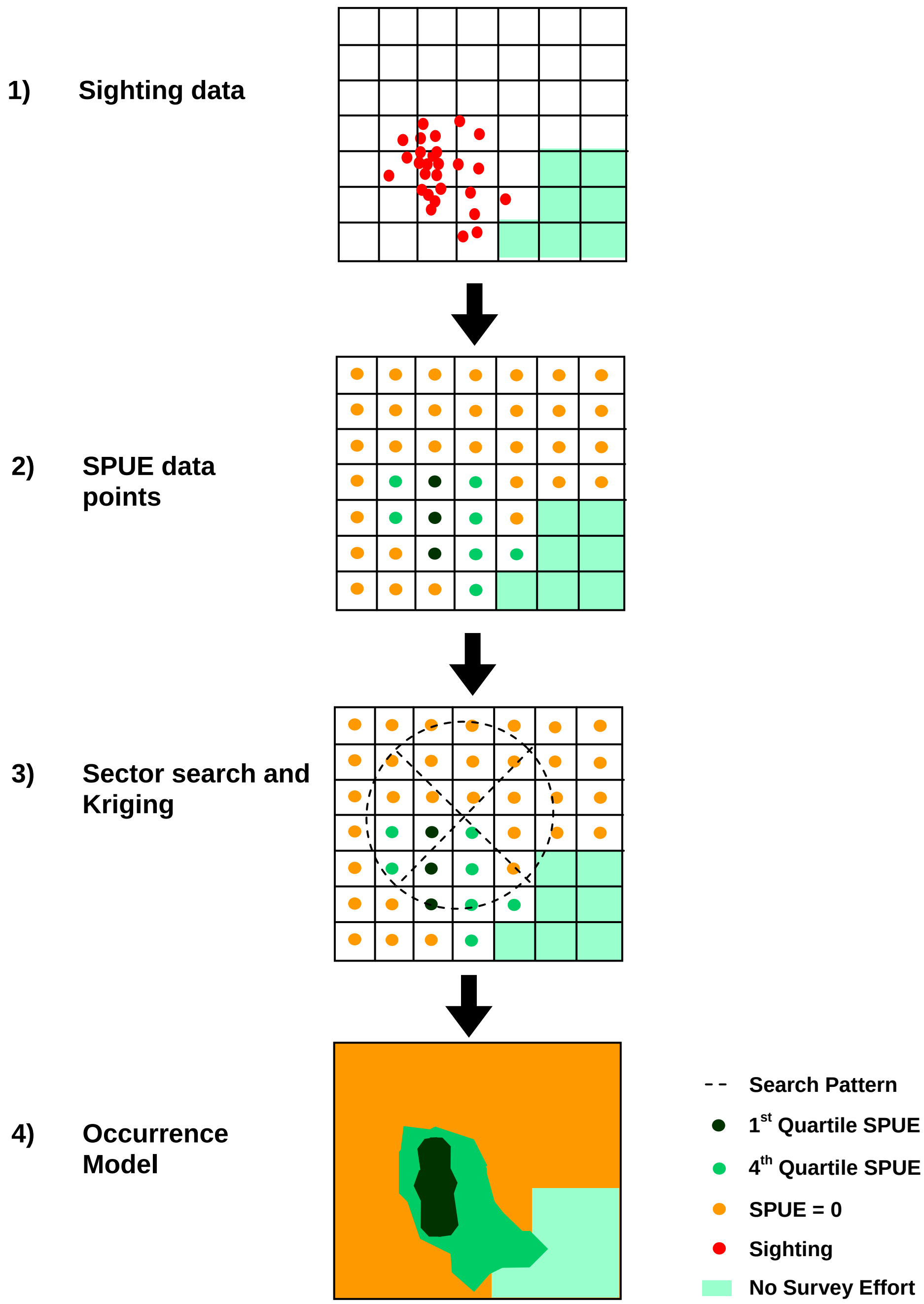

Figure 1-4. Example of the SPUE/Kriging process. Sighting data that met specific criteria (1) were used to calculate sightings-per-unit-effort (SPUE) values for each 10-minute by 10-minute grid cell (2). Each SPUE value is located in the center of a grid cell. During the Kriging process, a four-sector search pattern was used to locate a minimum of two nearest neighbors to create the occurrence estimate polygons (3). The final output is the occurrence model of the SPUE data values (4). Note that Kriging can predict the occurrence beyond the limit of the SPUE data due to the numerous weighting functions and presence of nearest neighbor values.

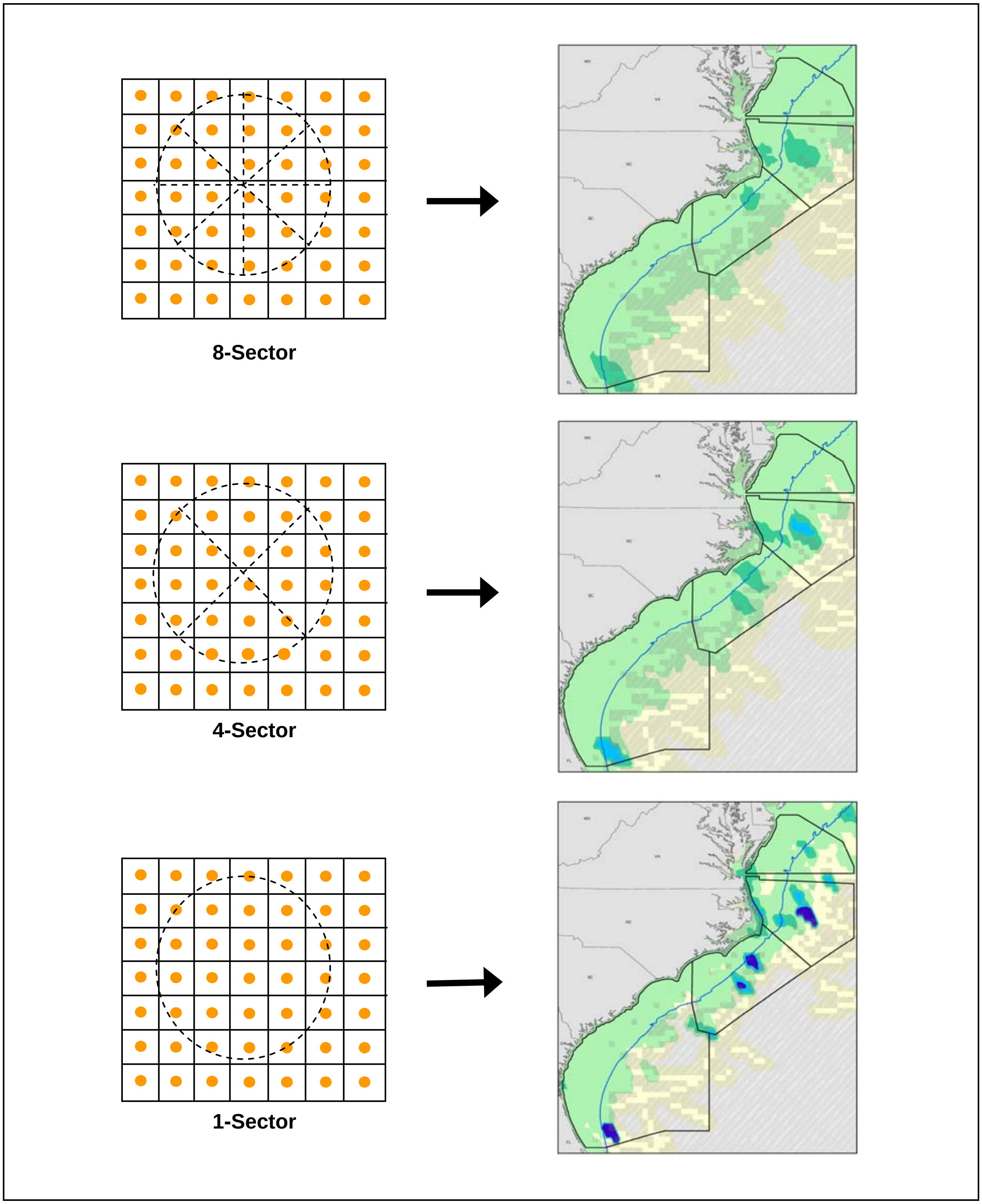

Figure 1-5. Example of sector search type on the detail of the model produced. The 8-sector search pattern provides the most generalized model, while the 1-sector search pattern provides the most detailed model. The 4-sector search pattern was used from the analysis in this report.

group or when the SPUE data are sparsely located throughout the analysis area for each quarter level. The result is that for some species, not all occurrence or quarter levels are represented. The last parameter of the model to be enabled is the anisotropy. Anisotropy is a property of a spatial process or data where spatial dependence (autocorrelation) changes with both the distance and the direction between two locations. The cause of the anisotropy (directional influence) in the semivariogram is not usually known, so it is modeled as random error. Anisotropic influences can still be quantified and accounted for if the cause is not known (Johnston et al. 2001).

For classification purposes, the predicted SPUE values obtained from the applied Kriging model were divided into quarters for each individual species and for several pooled species categories (e.g., common dolphins or beaked whales). In some cases, there were insufficient observations for reliable classification. All SPUE values greater than zero for a particular species (or pooled species category) for all four seasons were compiled into a discrete dataset and then separated into quarters (defined as 1st, 25th, 75th, and 100th percentiles in this analysis) representing the highest, second highest, second lowest, and lowest quarters of the total range of the SPUE values for each species/species category. For the purpose of this analysis, quarters are defined as:

- Highest quarter or 1st Quarter SPUE (between 76% and 100% of the SPUE range);
- Second highest quarter or 2nd Quarter SPUE (between 51% and 75% of the SPUE range);
- Second lowest quarter or 3rd Quarter SPUE (between 26% and 50% of the SPUE range); and
- Lowest quarter or 4th Quarter SPUE (between 1% and 25% of the SPUE range).

An additional occurrence level is SPUE = 0, indicative of areas where survey effort occurred (Effort ≥ 5 km) but no sightings were recorded. In all cells with Effort < 5 km (or 0), the occurrence area was defined as 'No Survey Effort'; in these areas the likelihood of a protected species occurring is not known because no adequate surveys have been completed in that area. Since all four seasons were pooled before the quarter classification for each species or category, the occurrence classifications within a species/category are directly comparable and quantitatively equivalent across seasons.

The final step in the creation of occurrence models is their visualization in the GIS environment. If sufficient data were available to calculate SPUE values for a species or species group, then occurrence models were produced. Two map figures have been produced for each season for each species or species group for which there were sufficient data to model occurrences. One map shows all data, including the occurrence records (sighting data points) as well as the model results, while the second map only depicts the occurrence model results (polygons) for clarity. The sighting records depicted on these maps are divided visually into those data used in the computation of effort and SPUE (and thus are the basis for the occurrence model estimates) and those not used in the calculations (such as strandings and bycatch records). The SPUE/kriging methodology is currently being prepared for peer review and publication.

1.4.2.3 Habitat Resource Maps—Habitats of Concern

- *Coral Mapping*—Mapping shelf coral in the VACAPES OPAREA was depicted through interpreting SEAMAP (2001) and Watling et al. (2003) hard bottom data and using previously scanned benthic habitat maps provided from sources in previous MRAs such as BLM (1976) and Wigley and Theroux (1981). Although this region is important for commercial and recreational fish species, the isolated coral and sponge habitats have not been fully documented and specific coral and sponge data are not readily accessible. This is not the case for deep sea corals (i.e., *Lophelia pertusa*), which are receiving considerable attention from the NMFS and the SAFMC due to their significant role of providing habitat for various commercial fish species (i.e., snappers and groupers). The deep sea coral (*Lophelia pertusa*) data depicted in this MRA were derived from data provided by the FFWCC in conjunction with the SAFMC and acquired from various exploration cruises led by Dr. Steve Ross of the University of North Carolina at Wilmington (UNCW). Both shelf coral and deep sea coral are mapped together in this chapter to fully depict the association of hard bottom with coral habitat at various depths.

1.4.2.4 Biological and Habitat Resource Maps—Fisheries and Essential Fish Habitat

- *Commercial Fisheries*—Data illustrating commercial fishing effort in the region were acquired from the Atlantic Coastal Cooperative Statistics Program (ACCSP 2006). Data were provided by gear type with effort displayed as average number of trips. Closures relevant to specific commercial fisheries were included with the fishing effort and were mapped using data from various sources, including the MPA database (NOAA and DOI 2006).

- *Essential Fish Habitat and Habitat Areas of Particular Concern*—EFH designated outside the VACAPES OPAREA 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 OPAREA. The EFH species maps do not have any seasonal designations as the FMPs presented the EFH information according to life history stages.

  EFH designations can include the entire water column, 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 environment partition is indicated after the lifestage, then EFH is designated for the entire water column and seafloor.

  - Temperate Species: MAFMC Designations—To create a more uniform graphical (visual) format for the gridded EFH data prepared by the NEFMC and MAFMC, each of the EFH source maps were scanned and geo-referenced. A 10-minute template grid was created and overlain on each scanned image in ArcView® to replicate the FMC grids. Template 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 out and then buffered back in 10 NM on all sides to create a more smoothed shape without compromising its 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 maps included in Appendix D.

  - 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 only text designations (SAFMC 1998) or information from the NMFS EFH Mandate (NMFS 2002b). 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 2002b). 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 2002b]). 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.

  Also, 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 the SAFMC EFH designations for coral, so EFH was assumed to be designated for all lifestages of coral.

- *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 VACAPES OPAREA and vicinity. 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.

- *Gulf Stream Current:* The Gulf Stream is designated as EFH for numerous species in the VACAPES OPAREA and vicinity (e.g., snappers groupers, coastal migratory pelagic species, dolphinfishes, and wahoo). The Gulf Stream is a dynamic oceanographic feature whose path and boundaries vary temporally and spatially.

- *Habitat Areas of Particular Concern:* Since HAPC are not required to be legally designated by individual species or lifestage, these areas can be designated for individual species, an individual species lifestage, or by MU. For the members of the snapper grouper MU, HAPC are designated as a MU, not by individual species. Thus, for some species in this MU, HAPC are located outside the areas designated as EFH on the map figures (Ruebsamen 2005). Furthermore, if HAPC are designated for a MU, the HAPC are relevant only for those species that also have EFH designated.

- *Manganese Outcroppings on the Blake Plateau:* These benthic deposits are designated as HAPC for members of the snapper grouper MU but the locations or geographic extent of the habitat were not provided in any of the SAFMC's FMPs. To most accurately map these regions, scientific literature and subject area experts were consulted. Based on sidescan sonar surveys, the USGS delineated the only known areas of manganese outcroppings off the southeast U.S. (USGS 1993), and this information was used to depict this habitat area for the relevant species for which this habitat area was designated as EFH. Additional manganese outcropping may occur on the Blake Plateau but have not been mapped.

- *Nearshore Areas:* As defined by the SAFMC, nearshore areas are all state waters extending from estuaries to three nautical miles from shore (Brouwer 2005). These nearshore areas are not within the VACAPES OPAREA 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 2005). However, pelagic *Sargassum* was approved as EFH or HAPC for other managed species (e.g., snapper grouper MU) (NMFS 2002b; Ruebsamen 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 2005).

- *Southeast Area Monitoring and Assessment Program (SEAMAP) Data:* These data (SEAMAP 2001) 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.

- *Spawning Adults:* Species in the snapper grouper MU have EFH designated for the spawning adult lifestage as the water column above the adult habitat. These designations are not shown separately on the EFH maps but instead are included as part of the adult depiction.

- *The Point, Ten Fathom Ledge, and Big Rock:* Prior to the SAFMC FMP for the dolphin and wahoo in 2003, only text designations were provided by the SAFMC for The Point, Ten Fathom Ledge, and Big Rock as HAPC. The updated 2003 FMP provides coordinates for these areas, which are intended to be applied to all managed species for which these areas were designated as HAPC (i.e., snapper grouper MU, corals, and coastal migratory pelagic MU) (Brouwer 2005).

Information used to map the various habitat types (e.g., bottom substrates and corals) and HAPC were derived from a variety of literature sources or from GIS data (SEAMAP 2001; Sedberry 2005).

- *Highly Migratory Species*—The GIS shapefiles of the EFH and HAPC for highly migratory species (tuna, sharks, swordfish, and billfish) obtained from the NMFS required some GIS processing during which the GIS data were clipped to the shoreline of the VACAPES OPAREA. Therefore, inshore EFH is not graphically depicted and the text narrative should be consulted directly for EFH beyond the shoreline or outside of the VACAPES OPAREA. Differences exist between the EFH text designations and NMFS GIS data for several species (e.g., the adult lifestage of bigeye tuna, and adult lifestage of blacktip shark). For example, GIS data either depict more or less EFH than described by in the text designation or a species might have more than one lifestage with identical text designations but the GIS data are different for the lifestages (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 2007); 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 2006e). These discrepancies are noted in the text descriptions in Chapter 5 as well as on the corresponding map figures.

1.4.2.5 Maps of Additional Considerations

Information regarding U.S. maritime boundaries, navigable waterways, marine managed areas (MMAs), scuba diving sites, and weather buoys and light towers located in or in the vicinity of the VACAPES OPAREA was gathered from a wide array of sources; however much of the data used to create the maps were available for downloading from U.S. internet websites.

For both the federal and state MMA maps, only sites that were listed in the MMA inventory as of 26 May 2006 were included on each map. The MMA inventory is being updated on a nearly daily basis, particularly with new information on state designated MMAs, which necessitated setting a cut-off date for acquiring new data. Not all state designated MMAs are identified by a number and in the inset table on the state MMA map, because there were simply too many to so in an organized and readable format; however all state MMAs discussed in the text are identified on the state MMA map. The MMA inventory (http://www3.mpa.gov/exploreinv/explore.aspx) should be checked frequently for the latest information on MMAs (and ultimately marine protected areas [MPAs]) in the VACAPES OPAREA and vicinity.

Recreational scuba diving sites in the OPAREA and vicinity were depicted using a variety of sources including geographic data, 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 Marine Sighting Survey Data Bias

Sighting data from shipboard or aerial platforms can provide a powerful indicator of species' occurrence. However, it is necessary to first recognize inherent biases associated with each survey type. A primary drawback of marine surveys is that shipboard and aerial surveys count only the number of animals at or near the water's surface; a region 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 surveys under sample (under estimate) 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 mammals and sea turtles observation are problematic in being dissimilar in sampling efficiency between these groups. Since most sighting surveys target multiple species, the sampling designs, although likely cost- and labor-efficient, cannot be considered optimal for each species (Scott and Gilbert 1982). The altitude at which marine mammal aerial surveys are flown is much higher than is desirable to sight sea turtles (which are typically much smaller than cetaceans). Shipboard surveys designed for sighting marine mammals are adequate for detecting larger sea turtle species but usually not smaller sea turtles. Their 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. For example, the operating cost for a research vessel is approximately $10,000 per day (Forney 2002).

In addition, marine survey data does 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 Interpretation of Stranding Data

Marine mammal and sea turtle strandings are not generally considered accurate representations of distribution. Sick animals may strand 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 shoreline monitoring 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 proximity to coastline, stranding frequencies should not be used when attempting to compare the occurrence of a coastal versus an oceanic stock in a particular 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's 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*. As a result of these issues and limitations, care should be taken when interpreting the stranding record to support evaluation of distribution and abundance.

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 and Biological Environment**—describes the physical environment of the VACAPES OPAREA and vicinity, including climate, marine geology (physiography, bathymetry, and bottom sediments), physical oceanography (circulation and currents), hydrography (surface temperature and salinity), and biological oceanography (plankton and primary productivity);

- **Chapter 3 Protected Species**—ccovers all protected species found in the VACAPES OPAREA and vicinity, including marine mammals and sea turtles. For these species, detailed narratives of their morphology, status, habitat associations, 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 VACAPES OPAREA and vicinity;

- **Chapter 5 Fish and Fisheries**—investigates fishes, EFH, and fishing activities (commercial and recreational) that occur within the VACAPES OPAREA and vicinity;

- **Chapter 6 Additional Considerations**—provides information on U.S. maritime boundaries, navigable waterways and commercial shipping lanes, MMAs 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;

- **Chapter 8 List of Preparers**—lists all individuals who prepared the VACAPES MRA Update;

- **Chapter 9 Glossary**—defines terms used in this MRA;

- **Appendix A**—provides 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 efforts;

- **Appendix B**—contains occurrence map figures that are described or referenced in the marine mammal section of Chapter 3 (3.1);

- **Appendix C**—contains occurrence map figures that are described or referenced in the sea turtle section of Chapter 3 (3.2); and

- **Appendix D**—includes maps for all species for which EFH/HAPC has been designated within the VACAPES OPAREA and vicinity.

This report is written in a format and reference style that follows *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.

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2.0 PHYSICAL & BIOLOGICAL ENVIRONMENT

2.1 INTRODUCTION

The VACAPES OPAREA is located off the U.S. Atlantic coast, and includes the nearshore waters from just south of the mouth of Delaware Bay to north of Cape Hatteras, North Carolina (Figure 2-1). Beyond the shelf break, the OPAREA extends southeast to approximately 34°12' N (its southern most point) and east to approximately 72°40' W where water depths exceed 4,000 m. The surface area encompassed within the OPAREA covers approximately 94,925 km^2. Cape Hatteras marks the transition between the oceanic provinces of the South-Atlantic Bight (SAB), to the south, and the Mid-Atlantic Bight (MAB) to the north. The SAB encompasses the marine environment from Cape Hatteras south to the Florida Straits whereas the MAB extends from Cape Hatteras northward to Cape Cod, Massachusetts (Brown et al. 1987; Schmitz et al.1987; Churchill et al. 1993; NOAA 2005a). The waters off of Cape Hatteras are known for their complex, often turbulent surface and deep water circulation as well as for widely varying physical properties (e.g., temperature and salinity). The mechanism driving these often dramatic changes in the physical characteristics of the region is the collision of the warm, tropical waters moving north in the Gulf Stream Current with the cool, temperate waters of the MAB residing over the continental slope. The Gulf Stream separates from the coast at Cape Hatteras and flows northeastward into the North Atlantic.

The majority of the VACAPES OPAREA is located in the MAB, but the southernmost section of the OPAREA extends into the northernmost reaches of the SAB. Thus, the distinctly different features of both oceanic provinces influence the physical environment of the VACAPES OPAREA. Broad, gently sloping, physiography shaped by the scouring effects of the Gulf Stream characterize the marine geology of the SAB, while thick sediment layers, steeper gradients, and submarine canyons are some of the most prominent features of the MAB.

Fronts or boundaries between water masses with distinctly differing physical properties (e.g., temperature or salinity) are prominent features in the region which can affect both the flow of water masses (i.e., currents) as wells as the distribution of the plankton. Two large estuaries, Chesapeake Bay and Delaware Bay, are the most prominent coastal features adjacent to the VACAPEA OPAREA and both significantly influence surface, and to a lesser extent, deep water circulation over the continental shelf.

2.2 CLIMATE AND WEATHER

The climate in the VACAPES OPAREA is influenced by several factors including prevailing winds, warm Gulf Stream waters, and oscillating atmospheric pressure systems. Oceanographic and atmospheric phenomena are interrelated and combine to create the long term climate and short term weather patterns that characterize the OPAREA. When viewed over appropriate time scales, any given atmospheric event is coupled in some way with a related oceanographic occurrence, and together the two components combine to form a larger ocean-atmosphere system (Gill 1982).

Three atmospheric pressure systems govern the wind patterns and climate in this region: the Icelandic Low, the Bermuda-Azores High, and the Ohio Valley High (Blanton et al. 1985). The Bermuda-Azores High is a semi-permanent, high-pressure system centered over the island of Bermuda in summer and fall and over the Azores in the eastern North Atlantic in winter and spring (NOAA 2005b). The anticyclonic (clockwise) circulation associated with the Bermuda-Azores High dominates the climate from approximately May through August producing southeasterly winds (<6 meters/second [$m\ s^{-1}$]) and hot, humid weather over much of the southeastern U.S. In winter (approximately November through March) the Icelandic Low and weak Ohio Valley High combine to generate west-northwesterly winds (8 to 10 $m\ s^{-1}$) and drier weather conditions in the region (Adams et al. 1993; NOAA 2005b).

A long-term record of atmospheric and oceanographic conditions at several sites within the VACAPES OPAREA is available from oceanographic buoys maintained by the NOAA's National Data Buoy Center (NDBC 2006). Air temperature measured over a 17 year period in the northern part of the OPAREA, 48

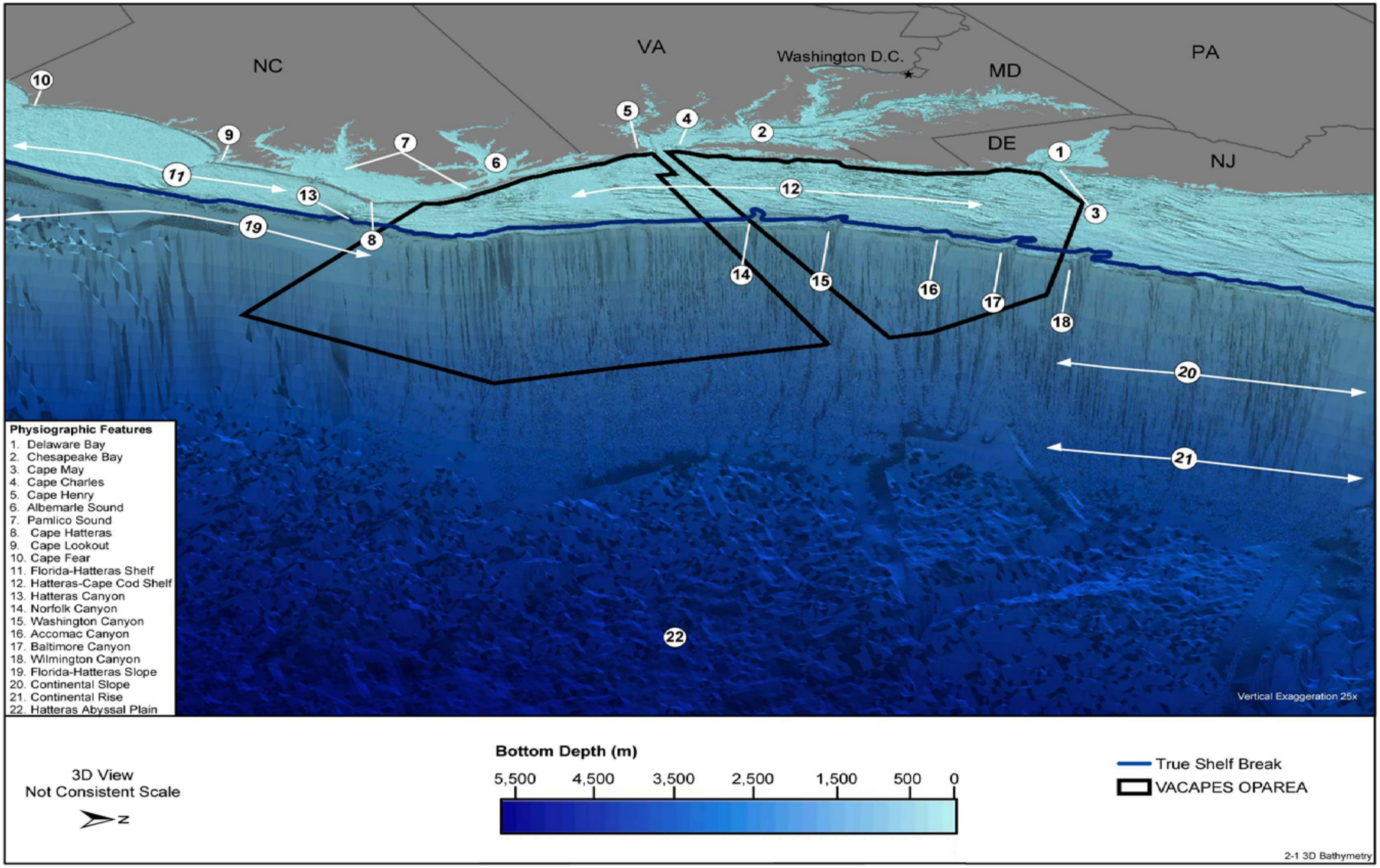

Figure 2-1. Three-dimensional bathymetry and major physiographic features located along the southeastern U.S. coast in or in the vicinity of the Virginia Capes OPAREA. Source data: Smith and Sandwell (1997), NOAA (2001a and 2001b). Source Information: Emery and Uchupi (1972), NGDC and IOC (2003), and GEBCO-SCUFN (2005).

km southeast of Cape May, New Jersey, averaged 23.3°C in August and 3.6°C in February, the warmest and coldest months, respectively (NDBC 2003a). Near the southern extent of the OPAREA a buoy located 278 km east of Cape Hatteras recorded mean monthly air temperatures of 26.1°C in August and 14.9°C in January over a concurrent 25 year period (NDBC 2003b). The significant difference between the average summertime and wintertime temperatures at the southern and northern ends of the OPAREA is undoubtedly a result of the warm Gulf Stream waters that flow through the southern half of the OPAREA but separate from the coast and move eastward before entering the northern half of the OPAREA. Cooler waters originating from the northern North Atlantic reside over the continental margin in the northern half of the OPAREA and demonstrate how significant the moderating effect of the Gulf Stream is on local air temperature, particularly in winter.

Precipitation also varies significantly between the northern and southern halves of the OPAREA. Total annual precipitation averaged 115 cm from 1948 through 2005 in Lewes, Delaware, which is adjacent to the northern boundary of the OPAREA (SRCC 2006a). However, at Cape Hatteras, near the southern extent of the OPAREA, total precipitation averaged an additional 30 cm per year (145 cm) between 1957 and 2006 (SRCC 2006b). Precipitation in the form of snow or freezing rain occurs more frequently in the north. Annual snowfall in Lewes averaged 33 cm between 1948 and 2005 with monthly means exceeding 10 cm in both January and February (SRCC 2006c). At Cape Hatteras, frozen precipitation is far less common. The average annual snowfall was less than 5 cm from 1956 through 1996, and snowfall was only recorded during the months of December through March; during which the mean monthly snowfall was less than 1.5 cm (SRCC 2006d). Differences in the total and frozen precipitation observed across the OPAREA can also be attributed to the warm, moist air transported through the southern half of the OPAREA by the Gulf Stream.

Weather systems pass rapidly through the southeastern U.S. approximately every 2 to 5 days throughout the year, and their effects are superimposed on the seasonal cycling of the Bermuda Azores High (Joyce 1987). The proximity of the Gulf Stream to the southeast U.S. coast has a strong effect in the generation of cyclonic, extra-tropical storms in winter as cold, dry continental air meets the warm, moist air over Gulf Stream waters (Adams et al. 1993). Thunderstorms and major storm systems occur in the region most often during summer and fall as hot, humid air masses collide with passing fronts (Joyce 1987).

2.2.1 Tropical Storms and Hurricanes

Most major storms, including hurricanes, occur in the VACAPES OPAREA during the North Atlantic hurricane season which occurs annually from June through November. Tropical cyclones form in warm, equatorial waters of the North Atlantic Ocean and Caribbean Sea and often move northward along the southeastern U.S. coast following the path of the Gulf Stream (Adams et al. 1993; Buchan 2000). Since 1944, when reliable data on storm systems were recorded, 655 named storms have occurred over the North Atlantic; 162 of these storms were major hurricanes (i.e., category 3, 4, or 5 on the Saffir/Simpson scale) (NCDC 2006a). From 1950 through 2005, 27 hurricanes made first landfall between Cape Canaveral, Florida and Cape Hatters with just two hurricanes, Carol (1954) and Emily (1993), striking the coast between Cape Hatteras and Long Island, New York (NCDC 2006b). Hurricanes Carol and Emily made landfall in North Carolina just north of Cape Hatteras. Even though the coast adjacent to the VACAPES OPAREA has experienced only two hurricane first landfalls over the past 55 years, a number of powerful tropical storms and hurricanes have passed through the OPAREA, including, most recently, hurricanes Isabel (2003), Alex (2004), and Ophelia (2005) (NOAA 2006a). Furthermore, the Atlantic hurricane seasons of 2004 and 2005 were particularly active. The 2005 season produced a record number of named storms (28), a record number of hurricanes (15) including four category 5 hurricanes, and a record number (4) of major hurricanes impacting the U.S. (NOAA 2006b).

The strength and number of named storms (including hurricanes) developing in the North Atlantic and potentially impacting coastal regions of the U.S. and Caribbean nations has remained above average since 1995, and this trend is forecast to continue at least through the 2007 season, sustained by decadal-scale atmospheric patterns (NASA 2005a; NOAA 2006c). Atmospheric and oceanic phenomena combine to create conditions favorable for the formation of storm systems. 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. Reduced cloud cover over Hurricane Alley increases the exposure of ocean waters to the warming rays of the sun. Warmer waters fuel the formation of tropical storm systems, and an increase in ocean surface 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

Two large-scale, multi-decadal climactic phenomena: the North Atlantic Oscillation (NAO) and the El Niño/Southern Oscillation (ENSO) have a significant influence on the climate of the North Atlantic Basin as well as the global climate (Conlan and Service 2000; Stenseth et al. 2003; Boyles and Raman 2003).

The NAO is regarded as the dominant mode of decadal-scale variability in weather and climate in the North Atlantic region (Hurrell 1995; Hu and Huang 2006). 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 marine ecosystems and the terrestrial environments of North America and Europe (Open University 2001; Stenseth et al. 2003; Menzel et al. 2005). The NAO is a continual oscillation in the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores and the subpolar low-pressure center over Iceland (Curry and McCartney 2001; Stenseth et al. 2003). When the atmospheric pressure at sea level increases in Iceland it decreases in the Azores and vice-versa (Open University 2001; Stenseth et al. 2003). Although the NAO primarily affects the climate and oceanography of the northern North Atlantic Ocean, its influence also extends into the mid-Atlantic region and the VACAPES OPAREA (Hurrell et al. 2001).

The variability of the NAO is measured by an index, which indicates the departure from the mean atmospheric pressure difference between the Azores High and the Iceland Low. However, there are different NAO indices available using different reference stations and/or base-line time periods. Since the known effects of the NAO are most pronounced in winter (Taylor and Stephens 1998), the NAO index most often used is the winter index, which is the average over four or five months—December through March or April (Hurrell 1995). Typical conditions expected during the two phases (positive and negative) of the NAO index include:

- *Positive or Strong Phase*
  - Both the Iceland Low and Azores High intensify (i.e., there is a larger difference between the two pressure centers)
  - Westerly winds strengthen resulting in a jet stream that flows primarily from west to east; meandering of the jet stream is reduced
  - Air temperatures in eastern and central North America are warmer than normal
  - Europe is warmer and wetter than normal
  - Greenland and the northern North Atlantic are colder than average
  - The Mediterranean Sea and surrounding area is colder and drier than average
- *Negative or Weak Phase*
  - Both the Iceland Low and Azores High are weaker than average (i.e., there is a smaller difference between the two pressure centers)
  - Meridional flow dominates; the jet stream meanders strongly
  - Eastern North America is colder and drier than normal
  - Europe is colder and drier than normal
  - Greenland and the northern North Atlantic are warmer than normal
  - 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 On average, the NAO was positive from 1900 to 1950, negative in the 1960s and 1970s, and has been positive since 1970 (Hurrell et al. 2001); although, recently the NAO index has declined rapidly resulting in a weak to nonexistent trend in the index when averaged over the past 30 years (Cohen and Barlow 2005).

Since ocean circulation is wind and density driven, it is not surprising to find that the NAO appears to have a direct effect on the position and strength of currents in the North Atlantic Ocean. The NAO influences the latitude of the Gulf Stream and accounts for a great deal of the interannual variability in the location of the current. In years following a positive NAO index, the latitude of the "north wall" of the Gulf Stream Current (i.e., the northern boundary of the current east of Cape Hatteras) is located farther north than usual (Taylor and Stephens 1998; Open University 2001). In addition, the NAO is capable of affecting the strength of the Gulf Stream and its end-member, the North Atlantic Current. During the predominantly negative NAO years of the 1960's, the Gulf Stream shifted southward and weakened. During the subsequent 25-year period when the NAO index was predominantly positive, the Gulf Stream intensified reaching a record peak in transport in the 1990s that was 25 to 33% above average (Curry and McCartney 2001). The location and strength of the Gulf Stream is critical, because the current is an essential part of the North Atlantic atmospheric-oceanographic system, moderating local climate and weather from the U.S. to the Mediterranean, including the climate in the VACAPES OPAREA (Buchan 2000; Open University 2001).

2.2.3 El Niño/Southern Oscillation

The ENSO is an oceanic and atmospheric phenomenon most closely associated with the Pacific Ocean rather than the Atlantic Ocean; however, effects on climate resulting from the ENSO are observed on a global scale (Conlan and Service 2000). During non-El Niño (normal) years, steady trade winds blowing from east to west in the tropical Pacific maintain the transport of warm surface waters into the western Pacific basin. A steeply inclined thermocline sloping upward from west to east is present across the Pacific, and upwelling frequently occurs along the coast in the eastern Pacific (Conlan and Service 2000; Open University 2001). During El Niño conditions, the atmospheric pressure difference between the eastern and western tropical Pacific decreases causing the northeasterly trade winds to weaken, which results in warm equatorial waters moving into the central and eastern tropical Pacific (Open University 2001). The depth of the thermocline increases in the eastern Pacific and upwelling along the coasts of North and South America is drastically reduced. Monsoon rains normally occurring in Indonesia and India occur instead over the central Pacific, which leads to an increase in the number of storms impacting the west coasts of North and South America (Conlan and Service 2000). El Nino events have also been linked to abnormally cold winters in North America and Europe (Open University 2001). A pattern of atmospheric pressure systems over the North Pacific and the North American continent during El Niño years causes the westerlies to meander to the north and south as they traverse the U.S. such that more cold, Arctic air out of the north is brought over the U.S. east coast. The unusually northerly winds may also be associated with a persistent low pressure system over the region, which increases the probability of snowfall (Mann and Lazier 1996).

La Niña is the companion phase to El Niño in the ENSO cycle. La Niña conditions are generally opposite those experienced during El Niño events and include stronger than average easterly trade winds and enhanced upwelling along the eastern Pacific coast (Open University 2001). Although El Niño events are most closely associated with negative environmental impacts, strong La Niña events can also have severe environmental consequences. During strong La Niña years, the number and intensity of hurricanes occurring in the North Atlantic and potentially impacting the U.S. east coast increases (NOAA 2006c). The abnormally high number of early-season storms that formed in 2005 and contributed to a devastating hurricane season are partially attributed to La Niña conditions in the equatorial Pacific Ocean.

2.3 MARINE GEOLOGY

A continental margin is the zone of transition from a continent to the adjacent ocean basin and can be described as either passive for active. Along a passive continental margin the continent and adjacent ocean floor are on the same tectonic plate. Passive continental margins, such as the one found along the U.S. Atlantic coast, are characterized by subsidence, erosion, and thick sediment accumulations that have led to the development of the classic continental margin sequence: continental shelf, continental slope, and continental rise (Kennett 1982). The section of the U.S. continental shelf between Cape Hatteras and Cape Cod is referred to as the Hatters-Cape Cod Shelf and makes up nearly half of the seafloor lying beneath the VACAPES OPAREA. Two large bays, Delaware Bay and Chesapeake Bay, and two major sounds, Albemarle Sound and Pamlico Sound, are prominent features along the shoreward boundary of the OPAREA. Chesapeake Bay is the largest estuary in the U.S., and the mouth of the Bay opens directly onto the western border of the OPAREA, bisecting the OPAREA in the longitudinal direction. The peninsula located between Chesapeake Bay and Delaware Bay is comprised of land from three states: Delaware, Maryland, and Virginia and is often referred to as the DELMARVA Peninsula.

2.3.1 Physiography and Bathymetry

Characteristics of the MAB seafloor include a terraced continental shelf indicative of previous sea level stands, glacially formed moraines at its northern extent, and numerous named and unnamed canyons which incise the continental slope throughout the MAB. By comparison, south of Cape Hatteras, in the SAB, submarine canyons are all but nonexistent, and erosion by the Gulf Stream has been the dominant process shaping the physiography. Four major submarine canyons incise the continental slope in the VACAPES OPAREA and continue as deep sediment-filled channels onto the continental rise. The deepest areas of the OPAREA overlay the lower continental rise and the Hatteras Abyssal Plain (Figure 2-2).

2.3.1.1 Continental Margins

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 2-3). 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 the three provinces of the continental margin is largely dictated by a change in the seaward gradient of the sea floor along the expanse of the continental margin.

The continental shelf is considered the submarine extension of the continent. A gentle 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. Heezen et al. (1959) established a minimum gradient defining the shelf break in the North Atlantic of 1:40 or 1.4°, which has generally remained accepted. The average depth of the shelf break usually coincides with the deepest waters found on the continental shelf (Shepard 1973; Pickard and Emery 1990).

Four ancient shorelines indicating the progression of sea level rise since the Pleistocene Era (1.8 million to about 12,000 years ago) give the Hatteras-Cape Cod Shelf a terraced structure. From shallowest to deepest, the shorelines, which appear as linear features running approximately parallel to the present day coastline, are named the Block Island, Fortune, Franklin, and Nicholls shores (Emery and Uchupi 1972). All but the Fortune Shore is found in the VACAPES OPAREA. The Block Island Shore stretches for about 800 km (nearly the length of the entire MAB) and varies in depth from 36 to 48 m. The Franklin Shore is about 700 km long and rises from a depth of 140 m in the northeast to 85 m at its southwestern end. The Nicholls Shore parallels the Franklin Shore, extending for 570 km southwestward and between depths of 160 and 120 m. Identifying the ancient shorelines is complicated by the presence of modern sand ridges and recent sediment deposition which are also prominent features on the continental margin (Emery and Uchupi 1972).

Several elongated, ancient stream channels cross the Hatteras-Cape Cod Shelf approximately perpendicular to the shoreline, the most prominent of which are the Block Island Channel, Hudson Channel, and the Delaware Channel. The Delaware Channel runs through the central Delaware Bay onto the shelf and is visible to about the 30 m isobath; beyond this depth it is covered by sand waves and sand ridges (Figure 2-1). A fourth channel extending from the mouth of Chesapeake Bay is covered by recently

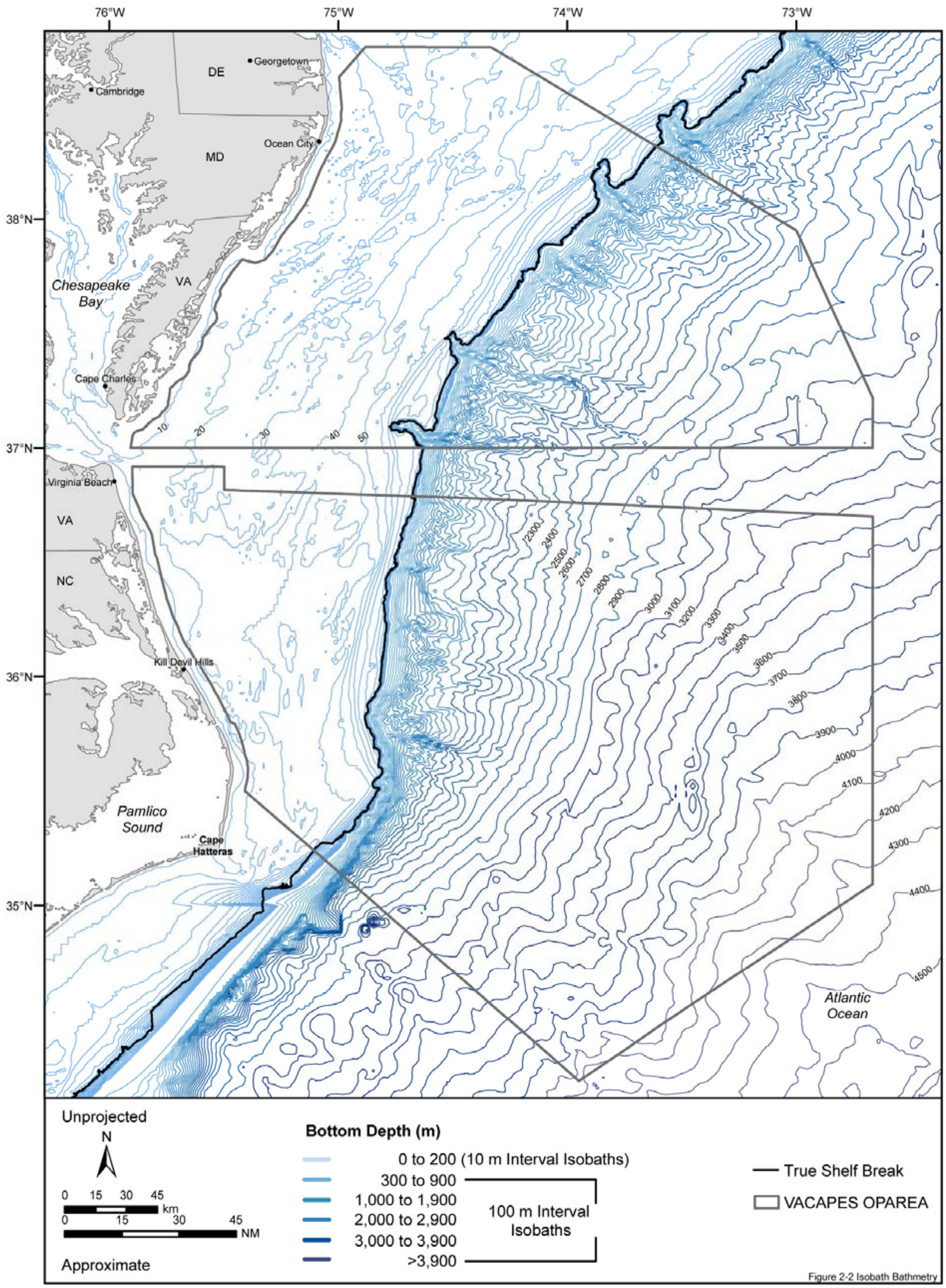

Figure 2-2. Bathymetry in the Virginia Capes OPAREA and vicinity. Source data: Smith and Sandwell (1997), NOAA (2001a and 2001b).

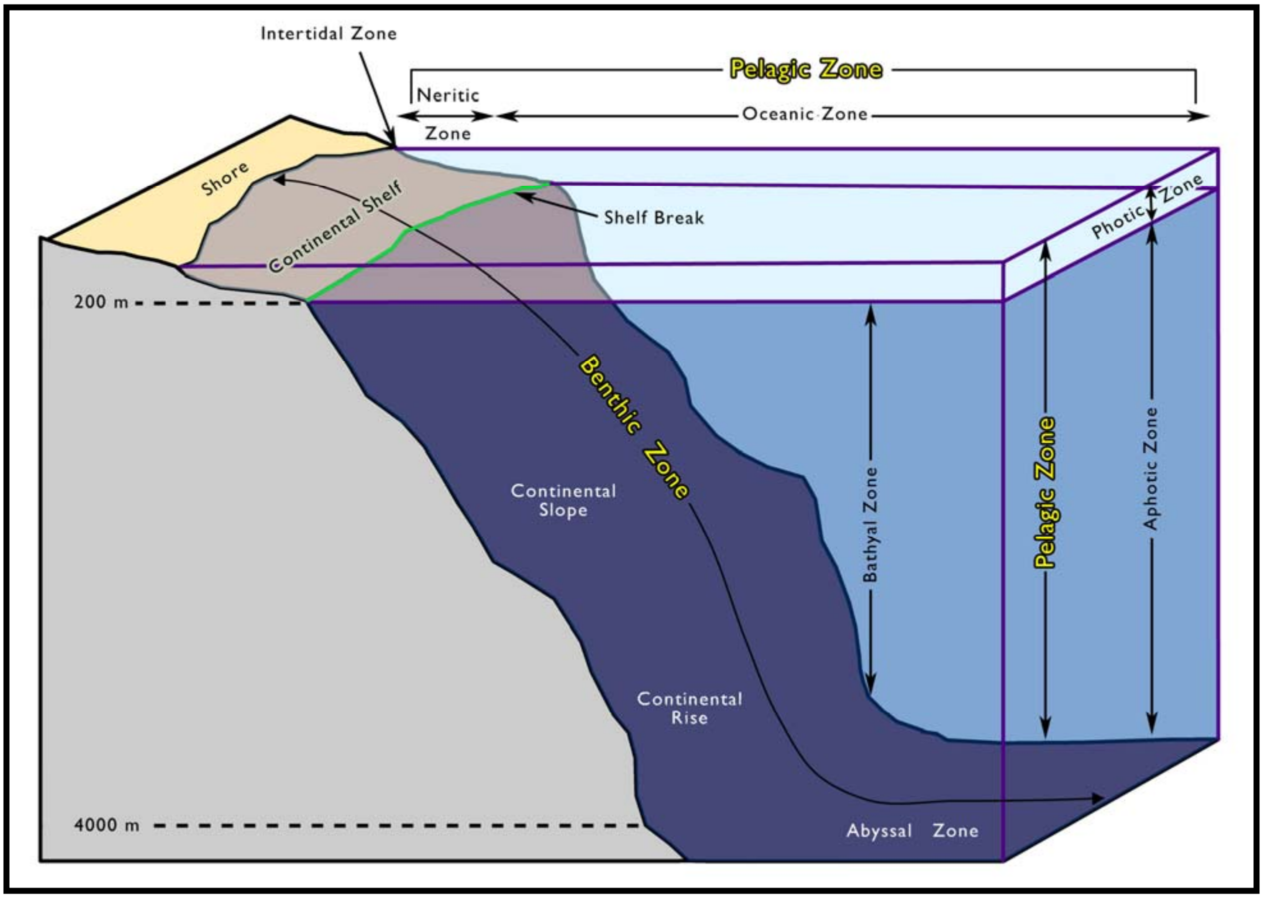

Figure 2-3. Generic three-dimensional representation of the continental margin and the major submarine zones referred to in the MRA. The continental margin includes the continental shelf, shelf break, continental slope, and continental rise, where each province is defined primarily by its seaward gradient. 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.

deposited sediments and is observable only on seismic surveys (Emery and Uchupi 1972). Only the Delaware and Chesapeake Bay channels extend into the VACAPES OPAREA. Sand waves and ridges are present over the entire Hatteras-Cape Cod Shelf and are usually oriented at an angle to the shoreline rather than parallel to it (McBride and Moslow 1991). The morphology of nearshore sand waves off of capes and at the mouths of bays, such as Chesapeake Bay and Delaware Bay, are heavily influenced by longshore and cross-shelf currents as well as tidal fluctuations (Emery and Uchupi 1972; McBride and Moslow 1991; Murray and Thieler 2004).

The shelf break in the northern MAB, off of New York, lies between depths of 120 and 160 m and is coincident in some locations with the ancient shorelines described above (Emery and Uchupi 1972). At the northern extent of the VACAPES OPAREA, off of Delaware Bay, the shelf break occurs near the 90 m isobath and at a gradient of about 3 to 5° (Figure 2-2; Heezen et al. 1959; McAdoo et al. 2000). Off of Norfolk, Virginia the shelf break occurs where the seafloor gradient increases abruptly to about 1:10 or 5.7° which coincides with a depth of approximately 120 m (Hollister 1973). Farther to the south, a similar increase in the seafloor gradient from less than 1:900 (or <0.1°) to 5.7° marks the location of the shelf beak about 45 km off of Cape Hatteras (Newton et al 1971).

Worldwide, the 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 (Heezen et al. 1959; Fairbridge 1966; Sverdrup et al. 1970; Eisma 1988). The gradient on the continental slope in the MAB ranges widely in localized areas from 1 to about 15° with an average gradient of approximately 8° over the steepest areas (Emery and Uchupi 1972; Tucholke 1987). The width of the continental slope in the MAB varies between 10 and 50 km with an average of approximately 30 km.

The most obvious characteristic of the continental slope in the MAB is the presence of at least 34 named and numerous smaller, unnamed submarine canyons, many of which dissect the continental slope at the shelf break and continue as sediment filled channels on the continental rise (Emery and Uchupi 1972; Tucholke 1987; Alperin et al 2002; USGS 2006). Four major submarine canyons, Norfolk, Washington, Accomac, and Baltimore are found within the VACAPES OPAREA, and two additional canyons, Wilmington and Hatteras, are located just to the north and south of the OPAREA, respectively (Figures 2-1 and 2-2). Canyons with canyon heads incising the continental slope at the shelf break, as opposed to farther down the slope, are thought to be much older and to have been filled with sediments and flushed-out multiple times. These deeply incised canyons (e.g., Wilmington Canyon) follow a more sinuous path down the continental slope (Emery and Uchupi 1972; Tucholke 1987). The walls of submarine canyons in the MAB have gradients ranging from 6° to 30° with an average of about 14°. Canyons often merge either on the lower continental slope or upper continental rise forming channels or gullies distinguished by walls with gentler gradients (10° on average) (Tucholke 1987).

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 abyssal plain). Worldwide, 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 (0.08 to 0.06°) with low relief (Kennett 1982). The continental rise is usually covered with thick layers of sediments that have been transported down the continental slope from the continents.

The continental rise in the MAB begins at the base of the continental slope at a depth of approximately 2,000 m ± 200 to 300 m and continues to over 5,000 m where it merges with one of three deep-sea basins: the Hatteras Abyssal Plain (between 33°N and 35°N), the western most part of the Bermuda Rise (between 35°N and 37°N) and the Sohm Abyssal Plain (north of 37°N) (Tucholke 1987). Seafloor gradients on the continental rise average 0.5° for the first 4,000 m with gentler gradients below 4,000 m. Between Cape Hatters and Long Island, a terrace-like region has formed between about 4,000 and 4,600 m with gradients of less than 0.15°. Sediments deposited by the southeasterly flowing Western Boundary Undercurrent (WBUC) created the Hatteras Outer Ridge, a dam-like feature along the seaward edge of the terrace. The Ridge inhibits slope sediments from continuing to the lower continental rise causing them to build-up behind the Ridge and creating the deep-sea terrace found just seaward of the OPAREA (Tucholke 1987). The most easterly portions of the VACAPES OPAREA overlie the continental rise and the Hatteras Abyssal Plain (Emery and Uchupi 1972).

2.3.2 Bottom Substrate

Bottom sediments found on the continental margin of the VACAPES OPAREA and surrounding areas are derived from four primary sources: rivers, glaciers, terrigenous and submarine outcrops of older rocks, and biogenic productivity (Tucholke 1987). Deposition of sediments onto the Hatteras-Cape Cod Shelf by modern rivers is minimal and is limited primarily to near-shore regions and estuaries (Hollister 1973). Relict sediments deposited on the continental shelf by receding glaciers consist mainly of terrigenous sediments eroded by ancient rivers and carbonate detritus. In addition, the high-energy current and tidal systems of the region transport sediments off of the shelves into deeper waters (Riggs et al 1998). Because of this lack of input, the continental shelves of the western North Atlantic are considered to be sediment starved.

Bottom sediments found on the continental margin of the MAB are well sorted by grain size with sands and localized areas of gravelly sand distributed over the continental shelf and finer grained silts and clays transported shoreward by tidal currents into the estuaries or seaward by turbidity currents onto the continental slope and rise (Hollister 1973; Tucholke 1987). Shelf sands in the MAB consist mostly of quartz and feldspar, and the average size of sand gains usually increases toward the shelf break (Figure 2-4; Hollister 1973; Tucholke 1987).

By contrast, the layers of sand and gravel found on the Florida-Hatteras Shelf and Slope are much thinner than those found north of Cape Hatteras due primarily to the erosion and suspension induced by the Gulf Stream. Sediments on the shelf in the SAB also contain much greater amounts of calcium carbonate (>50%) than shelf sediments in the MAB, which on average contain less than 5% calcium carbonate (Tucholke 1987). Sediments found on the continental slope and rise consist mostly of resuspended and reworked fine-grained sediments from the continental shelf that are transported seaward by bottom currents as well as detritus derived from biological sources (Tucholke 1987).

An accumulation of silty clay located on the upper continental rise off the coasts of New Jersey and Maryland is deposited in a relatively calm region located between a slow moving water mass, referred to as slope water, that flows south over the continental slope and the more energetic Deep Western Boundary Current (DWBC) which flows south over the continental rise. The relatively lethargic deep water currents in the region allow fine grained sediments to accumulate rather than being entrained towards areas of the lower continental rise and the ocean basin (Hollister 1973). Several large debris flows, which are mass movements of sediment down the continental slope and onto the continental rise, have been documented in acoustic reflection profiles of the seafloor (Tucholke 1987). The random structure of sediment types on the seafloor that result following a massive slumping of sediments characterize debris flows and give them a unique signature on acoustic profiles. The largest debris flow within the VACAPES OPAREA is located on the continental rise east of Albemarle Sound (~36°N); covering an area of approximately 11,000 km^2 and extending to a depth of nearly 4,300 m (Tucholke 1987).

Tropical cyclones and other major storm systems can have a significant effect on the distribution and resuspension of bottom sediments, particularly on sediment-starved continental shelves. In 2003 hurricane Isabel made landfall on the Outer Banks of North Carolina just south of the OPAREA. Over a 4.5 day period as Isabel approached and passed through the region, bottom currents and sediment resuspension in Onslow Bay, North Carolina increased dramatically and resulted in a net southwest transport of fine and medium grained sediment in the Bay (Wren and Leonard 2005). Sudden and rapid transport of massive quantities of bottom sediments can have a significant impact on the exposure of hard bottom substrate and ultimately on all components of the benthic environment (Wren and Leonard 2005).

2.4 WATER MASSES, CURRENTS, AND CIRCULATION

The water column can be divided into essentially three separate layers or water masses: a surface water layer, a deep water layer, and an intermediate layer called the thermocline that resides between the two other layers. The thermocline is defined as the area where water temperature changes rapidly from the warmer, surface water to the colder, deep water. In the North Atlantic Ocean approximately 67% of the water is found in the deep layer, 25% is found in thermocline layer, and 8% is composed of the warmer surface waters (Schmitz et al. 1987).

The two primary forces that drive circulation, or currents, in these water masses are the wind and differences in water density. Surface currents are primarily driven by the drag of the wind over the surface of the water which causes the water to move and form currents. Wind-driven circulation, as it is called, affects primarily the upper 100 m of the water column. Variations in temperature and salinity result in differences in water density; these differences 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 generally dominated wind-drive circulation at the surface (Pickard and Emery 1990).

2.4.1 Surface Currents

Prevailing winds, the Coriolis effect, and the presence of landmasses cause surface waters to move in a circular fashion, that is, as a rotating gyre in ocean basins. In the North Atlantic Ocean, this gyre system is

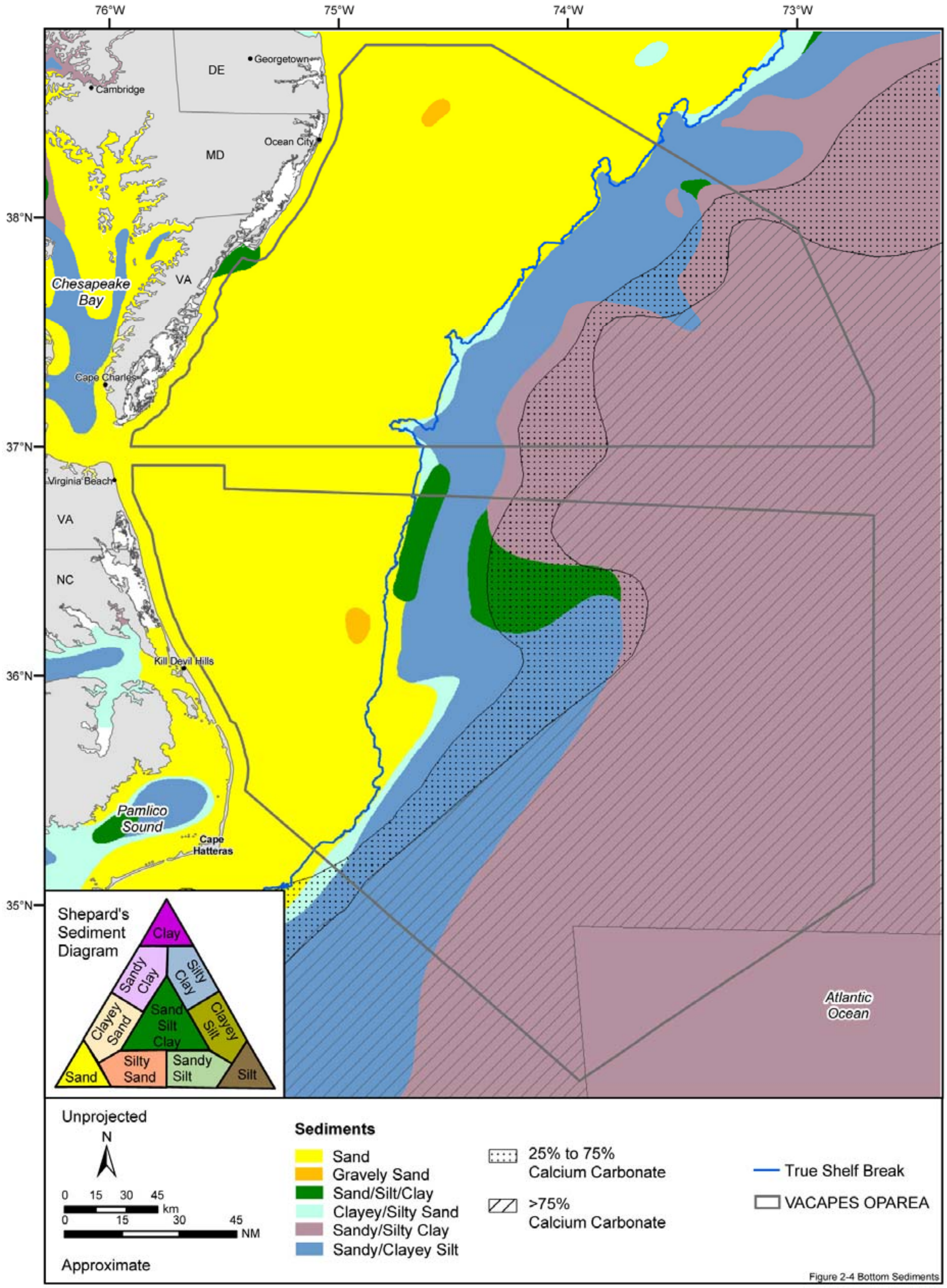

Figure 2-4. Seafloor sediment types occurring in the Virginia Capes OPAREA and vicinity and (where available) the percentage of calcium carbonate ($CaCO_3$) contained in sediments. Source data: Amato (1994) and USGS (2000). Source information: MGS (2005).

composed of the Gulf Stream, North Atlantic, Canary, and North Equatorial currents (Emery and Uchupi 1972). Together the Florida Current and Gulf Stream Current form the western boundary current within the North Atlantic Gyre. Western boundary currents exist along the western boundaries of the world's oceans and are known for high transport rates, high current velocities (~2 m s^{-1}), and relatively narrow, well-defined widths (~100 km) (Open University 2001).

The Gulf Stream often refers not just to the Gulf Stream Current, but to the complex system of surface currents that flows from the Caribbean Sea into the Gulf of Mexico and ultimately to the northeastern Atlantic Ocean (Pickard and Emery 1990). The Antilles Current, which originates from the North Equatorial Current and flows northwestward along the eastern edge of the Bahamas, contributes to the Gulf Stream when it joins the Florida Current off the east coast of Florida. The Gulf Stream flows northward along the U.S. southeast coast, and is the dominant surface current in the western North Atlantic, SAB, and VACAPES OPAREA.

In addition to the Gulf Stream, which flows through the southern half of the VACAPES OPAREA immediately after diverging from the coast off of Cape Hatteras, currents originating from the outflow of both Chesapeake Bay and Delaware Bay influence the surface circulation in the OPAREA (Figure 2-5). The Chesapeake Bay plume flows seaward from the mouth of the Bay and then turns south to form a coastal jet that can extend as far as Cape Hatteras. Similarly, the Delaware Coastal Current initiates in Delaware Bay and flows southward along the DELMARVA Peninsula before being entrained into the Chesapeake Bay plume (see below for more details on both currents).

On average, surface currents over the Florida-Hatteras Shelf move slowly to the northeast, and surface currents over the Hatteras-Cape Cod Shelf move to the southwest until a confluence of the two water masses occurs just north of Cape Hatteras (Emery and Uchupi 1972; Pickard and Emery 1990). However, reversals in the direction of flow over the shelves have been observed and tend to coincide with changes in the direction of the prevailing winds and low river discharge (Emery and Uchupi 1972). The Gulf Stream and its meanders strongly influence the general flow of currents over the Florida-Hatteras Shelf, whereas remnants of the southeasterly flowing Labrador Current, located upstream of the VACAPES OPAREA, direct the flow of the cold, temperate waters over the Hatteras-Cape Cod Shelf, as well as the slope water found just beyond the shelf break (Emery and Uchupi 1972; GoMOOS 2005).

- Gulf Stream Current—The western continental margin of any ocean basin, particularly in the Northern Hemisphere, is the location of intense boundary currents, and the Gulf Stream is the western boundary current in the North Atlantic Ocean (Figures 2-5 and 2-6). The Gulf Stream Current is one member of the larger Gulf Stream System and is preceded upstream by the Yucatan Current and the Loop Current in the Gulf of Mexico and the Florida Current in the Florida Straits. The Gulf Stream is a powerful surface current that carries warm equatorial waters into the cooler North Atlantic (Pickard and Emery 1990; Verity et al. 1993). It is usually sharply defined along its western and northern sides or walls but much less so on its eastern and southern walls (Pickard and Emery 1990) due primarily to sharp temperature gradients found only across the western/northern wall.

  The Gulf Stream flows roughly parallel to the coastline from the Florida Straits to Cape Hatteras, where it is deflected from the North American continent and flows northeastward past the Grand Banks. The width of the Gulf Stream varies from about 80 km at 27°N to 120 km at 29°N as it emerges from the Florida Straits and gradually broadens to 145 km in the North Atlantic at 73°W (Gyory et al 2005). Surface velocity ranges from 1 to 2.6 m s^{-1} with temperature ranging from 25° to 28°C (Mann and Lazier 1996). Average transport off of Cape Hatteras is estimated to be between 50 and 65 Sv (Sv ≡ 10^6 m^3 s^{-1}) and increases to about 145 Sv at 60°W (Schmeits and Dijkstra 2000; Gyory et al 2005). The position of the Gulf Stream is variable due to a number of oceanographic and atmospheric influences including water column stratification, the NAO, and instability in the mean flow past Cape Hatteras (Taylor and Stephens 1998; Schmeits and Dijkstra 2000; Pershing et al. 2001).

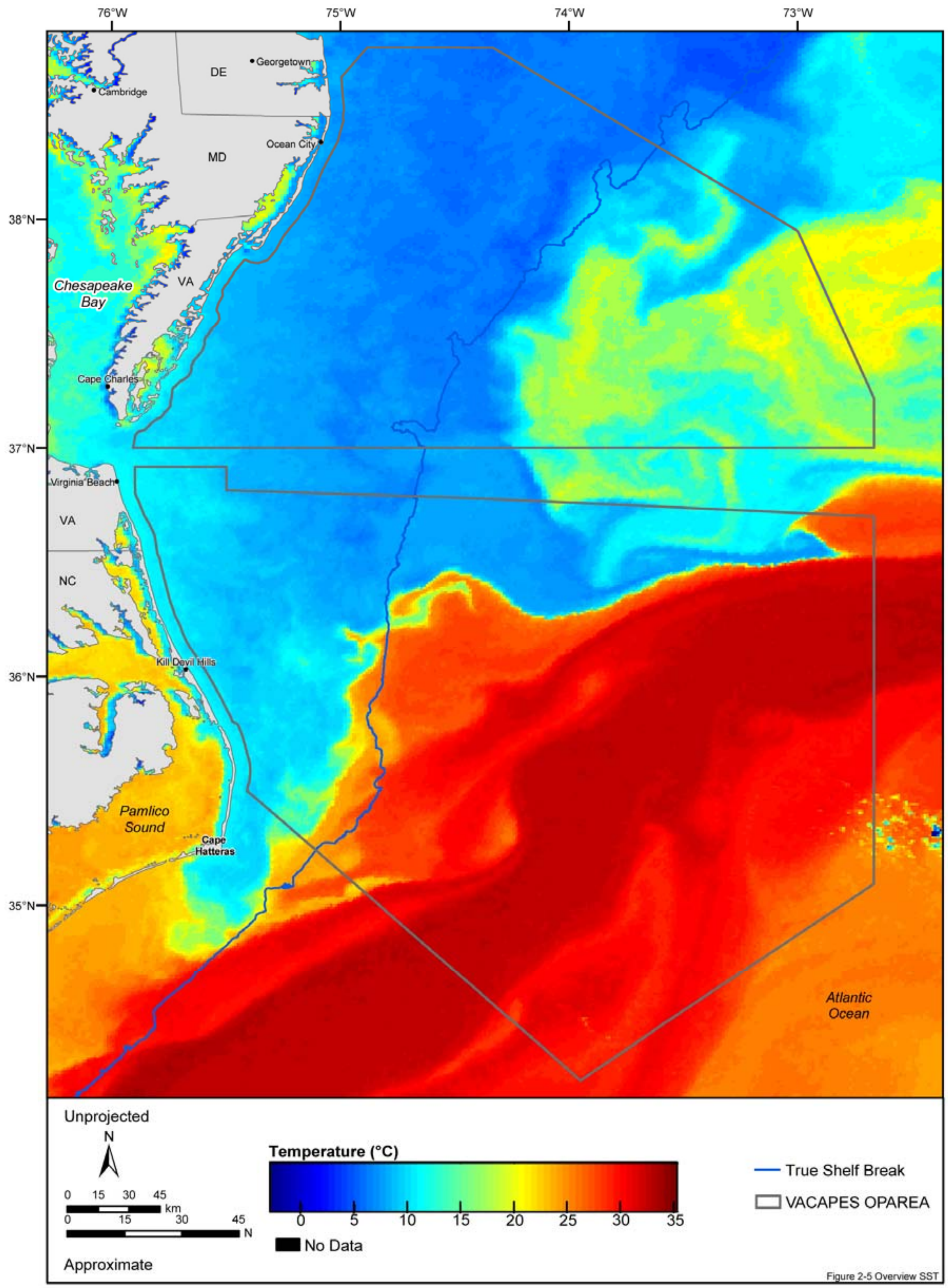

Figure 2-5. Surface circulation in the Virginia Capes OPAREA and vicinity revealed by a sea surface temperature (SST) image on 20 April 2006. Warm waters transported north by the Gulf Stream Current are clearly visible and dominate surface circulation in the OPAREA. Colder water moving south from Chesapeake Bay and off of the northeast coast converges with the Gulf Stream waters off of Cape Hatteras. Source data: Rutgers University (2007).

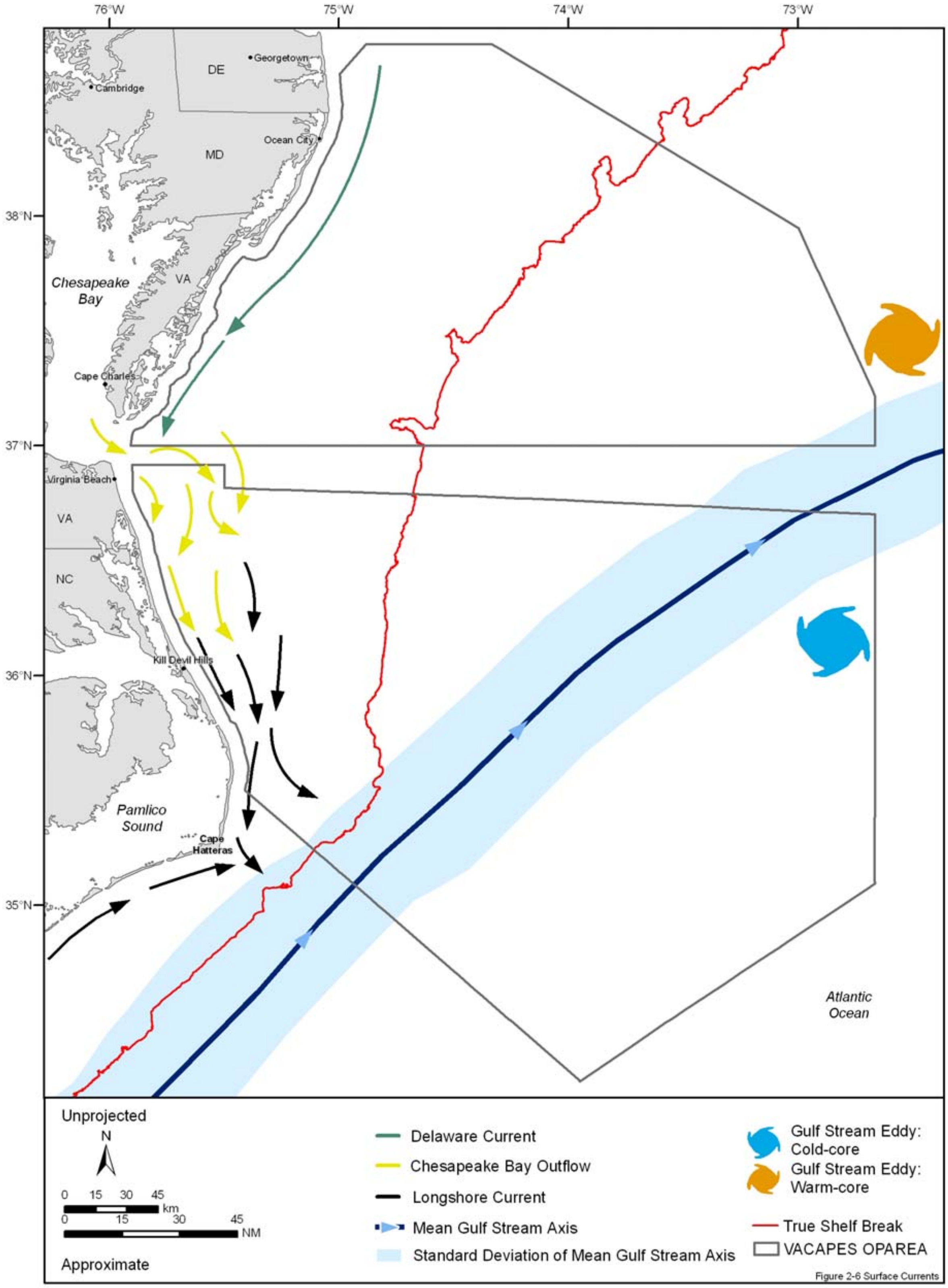

Figure 2-6. Surface circulation in the Virginia Capes OPAREA and vicinity including the dominant Gulf Stream Current and major coastal and shelf currents. Source map (scanned): General Oceanics, Inc. (1986). Source Information: Emery and Uchupi (1972), Shen et al. (2000), Marmorino et al. (2002), Dzwonkowski and Yan (2005), Park and Wells (2005).

Meandering of the current begins to occur south of Cape Hatteras before the current separates from the coastline; however farther downstream meanders tend to increase in amplitude by as much as ten fold (Savidge 2004). South of Cape Hatteras, meanders typically form frontal eddies that remain attached to the Gulf Stream while north of Cape Hatteras meanders usually pinch off to form small gyres that become separated from the Gulf Stream as either warm- or cold-core rings (Mann and Lazier 1996). On average, these meanders form at one to two week intervals and persist for over a year (Atkinson and Targett 1983). The formation of warm- and cold-core rings does not appear to be correlated with seasonality but rather appears to be driven by localized flow dynamics of the Gulf Stream. Warm-core rings are anticyclonic meanders of warm Sargasso Sea water that pinch off to the north of the Gulf Stream (Mann and Lazier 1996; Brooks 1996); on average 22 warm-core rings are formed per year, each measuring approximately 100 km in diameter and 1,000 m in the vertical dimension (Gyory et al 2005). Having lifetimes that range anywhere from 11 to 399 days, warm-core rings drift in a south to southwesterly direction (generally west of 50°W and north of 30°N) eventually dissipating or merging with the Gulf Stream again (Pickard and Emery 1990; García-Moliner and Yoder 1994).

Cold-core rings form when a meander pinches off the Gulf Stream, resulting in a cyclonic (counterclockwise rotating) ring of cool continental slope water surrounded by the warmer waters of the Sargasso Sea (Pickard and Emery 1990; Mann and Lazier 1996). On average 35 cold-core rings are shed by the Gulf Stream per year (Gyory et al 2005). Cold-core rings have diameters between 100 and 350 km, vertical dimensions of 3,000 m, and may persist up to two years (Pickard and Emery 1990). Newly formed cold-core rings also drift in a south-southwesterly direction west of 50°W and north of 30°N and eventually dissipate in the Sargasso Sea or merge with the Gulf Stream.

Frontal eddies occur approximately once ever 2 weeks along the U.S. Atlantic coast south of Cape Hatteras (Yoder et al. 1981). These eddies often take the form of finger-like extensions that protrude onto the shelf, folding back to enclose a cold, nutrient-rich core of water upwelled from deep within the Gulf Stream (Mann and Lazier 1996). The transient upwelling associated with frontal eddies results in localized areas of high surface primary productivity. Water temperature and salinity are vertically stratified within the Gulf Stream, with density increasing and temperature decreasing with depth (Yoder et al. 1981; Adams et al. 1993). The isopycnals (surfaces of equal density) are strongly inclined throughout the water column in the Gulf Stream; from the shoreward to offshore edges of the Gulf Stream the isopycnals deepen by approximately 800 m (Adams et al. 1993). This steep inclination is what gives rise to the high velocity of the Gulf Stream Current (Pond and Pickard 1983), and also defines the “front” or the “north wall” (boundary) of the Gulf Stream (Adams et al. 1993). Surface temperatures can vary seasonally by as much as 3 to 4°C within the upper 100 to 200 m of the Gulf Stream (Adams et al. 1993).

- Chesapeake Bay Outflow—Outflow from the mouth of the Chesapeake Bay, which is located at the center of the shoreward boundary of the VACAPES OPAREA, takes the form of a plume characterized by colder, less saline waters than the adjacent shelf waters (Figure 2-5). The less dense plume waters flow over top of the denser shelf waters resulting in steep oceanographic fronts in both temperature and salinity that are indicative of the magnitude and spatial extent of the plume (Marmorino et al 2000). Transient upwelling, downwelling, and enhanced primary productivity often occur along the frontal boundaries induced by the intrusion of plume waters. Under the influence of the Coriolis effect, and at times enhanced by local winds, a current associated with the plume is directed southward and contributes to a longshore current flowing adjacent to the Virginia and North Carolina coast with a velocity that can exceed 0.5 m s^{-1} (Dzwonkowski and Yan 2005; Gangopadhyay et al. 2005).

  Recent studies measuring current velocities using land-based and aerial radar systems have provided near real-time data on the highly variable, wind-driven circulation on the shelf (Shen et al. 2000; Marmorino et al 2002; Gangopadhyay et al. 2005). Offshore rip currents (also referred to as “rip tides”) are frequently associated with persistent longshore currents (Park and Wells 2005). Rip currents occur where opposing longshore currents converge and form a high-speed jet that flows seaward for over 100 m (NOAA 2005c). Currents on the shelf fluctuate seasonally and are predominantly wind driven but can also be influenced by tides, transient storm systems, changes in density caused by fresh water input, and intrusion by Gulf Stream waters (Shen et al. 2000; Marmorino et al 2002; Lentz et al. 2003).

- Delaware Coastal Current—Outflow from Delaware Bay located just north of the VACAPES OPAREA contributes to the formation of the southerly flowing Delaware Coastal Current. This longshore, buoyancy-driven current remains adjacent to the coastline and flows through the northern half of the VACAPES OPAREA along the coast of the DELMARVA Peninsula until it reaches the mouth of Chesapeake Bay where it merges with the Chesapeake Bay plume (Münchow and Garvine 1993; Sanders and Garvine 1996). The Delaware Coastal Current is a persistent offshore current, unlike the Hudson Coastal Current to the north and longshore currents off of the coast of the Carolinas, and it appears to maintain a mean velocity of approximately 10 cm s^{-1} (Münchow and Garvine 1993). Wind direction and speed are factors that influence the current, but only strong upwelling-favorable winds (i.e., blowing to the north at >7 m s^{-1}) coupled with moderate to low riverine discharge result in a reversal of the current flow and a dispersion of the plume over the mid and outer continental shelf (Münchow and Garvine 1993; Whitney and Garvine 2005). Downwelling-favorable winds augment the southward flow of the current and cause it to narrow into a well-defined jet that can extend through the entire water column (~30m) (Whitney and Garvine 2005).

2.4.2 Deepwater Currents/Water Masses

Bottom currents on the Hatters-Cape Cod Shelf and, in particular, within the VACAPEAS OPAREA tend to be directed shoreward throughout most of the year consistent with basic estuarine circulation associated with Chesapeake and Delaware bays (Emery and Uchupi 1972). Transport within the water column particularly in the vicinity of Cape Hatteras is often variable and complex. Kim et al. (2001) report observations of near bottom currents east of Cape Hatteras as predominantly offshore whereas southeast of Cape Henry (a short distance to the north) bottom currents are predominantly onshore. Similar differences in the direction of mid-level and surface currents between Cape Hatteras and Cape Henry were observed (Kim et al. 2001).

The Deep Western Boundary Current (DWBC) flows southward in the western North Atlantic towards the equator along bathymetric contours, typically from 800 to 4,000 m of water depth (Adams et al. 1993; Dengler et al. 2004). The current is comprised of several cold, deep water masses, each with a characteristic temperature and salinity. The DWBC may be thought of as a 200 km wide mass of water that hugs the continental slope and rise and flows beneath the Gulf Stream before being deflected eastward by Blake Plateau, which interrupts the continental slope off Cape Hatteras. Driven by density gradients rather than wind, the DWBC has an average transport of 16 Sv and velocities ranging between 9 and 18 cm s^{-1} (Schmitz et al. 1987; Bryden et al. 2005). The DWBC is thought to play a significant role in completing the Sverdrup recirculation in the North Atlantic; however, the exact processes that take place are not fully understood (Meinen et al. 2004; Bryden et al. 2005; Johns et al. 2005). Three deep-water masses combine in the northern North Atlantic Ocean and ultimately move southward as the DWBC: Antarctic Bottom Water, Labrador Intermediate Water, and North Atlantic Deep Water (Schmitz et al. 1987; Adams et al. 1993).

- Antarctic Bottom Water (AABW)—AABW is formed by wintertime convection in the Southern Ocean and is distinguished by a salinity maximum of 34.9 practical salinity units (psu) (Schmitz et al. 1987). As sea ice forms in the Weddell Sea, salt is concentrated into the already cold (<1.8°C) surrounding water, which increases its density and causes it to sink to the ocean bottom (Schmitz et al. 1987). As it flows north into the Atlantic Ocean, AABW gradually mixes with the warmer, more saline North Atlantic Deep Water (NADW) overlying it (see below). As AABW reaches the U.S. continental slope, it can be distinguished from the NADW by its elevated silicate concentration (Schmitz et al. 1987). Most of the AABW in the North American basin of the Atlantic Ocean is found in waters deeper than 4,000 m. The very deepest waters in the VACAPES OPAREA likely contain AABW (Kennett 1982; Schmitz et al. 1987; Pickard and Emery 1990).

- Labrador Intermediate Water (LIW)—LIW forms in the southern Labrador Sea (located southwest of Greenland), where relatively warm, saline waters from the Irminger Current combine with colder, fresher water from the Labrador Current. Winter winds out of the northwest cool the waters in the Labrador Sea which then sink to depths of 1,400 to 2,000 m (Schmitz et al. 1987; Mann and Lazier 1996). The depth to which water sinks is dependent on atmospheric conditions; when warmer winds blow over the Labrador Sea convection cooling and subsequent sinking is reduced (Mann and Lazier 1996). LIW primarily spreads to the east; however, some water flows around the Grand Banks and travels south along the continental shelf where it merges with slope water residing on the North American continental slope. LIW has been traced as far south as 20°N (Schmitz et al. 1987).

- North Atlantic Deep Water (NADW)—The most abundant deep water mass in the North Atlantic Ocean is NADW, which is a mixture of water from several sources and makes up 70% of all deep water in the North Atlantic (Schmitz et al. 1987). 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). Mediterranean Sea outflow, characterized by high salinity (>35 psu), intrudes into the North Atlantic as far as the western continental rise and down to a depth of 2,000 m, ultimately contributing to the NADW (Pickard and Emery 1990; Reid 2005). Once this water mass reaches the continental slope it is defined as the DWBC.

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 the southern portion of the OPAREA. 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 (Blanton et al 1981; Lee et al. 1991; Savidge 2004). In the northern portion of the OPAREA, seasonal upwelling of denser slope water onto the continental shelf is largely wind-driven with upwelling favorable winds out of the south or southwest initiating the seaward transport of surface waters, which allows the slope water to move shoreward (Flagg et al. 1994; Hu and Huang 2006). Intrusions of the denser, saltier slope water occur in the bottom half of the water column below the seasonal thermocline and most frequently in summer when the thermocline is well established. The speed of upwelling currents has been observed as high as 20 cm s^{-1}. Upwelling events often occur rapidly and last for relatively short time periods (~hours) (Flagg et al. 1994). Upwelling events occurring over the continental shelf in the SAB and the southern MAB play a critical role in the distribution of phytoplankton biomass in shelf waters as well controlling the timing of phytoplankton blooms (Signorini et al. 2005).

2.5 HYDROGRAPHY

Freshwater input from rivers into the SAB and southern MAB is mitigated by coastal bays and an extensive system of estuaries and salt marshes which filter riverine outflow and reduce total discharge onto the shelf (Newton et al 1971; Edwards et al. In press). Along the North Carolina coast, Pamlico and Albemarle sounds and a chain of barrier islands limit freshwater input to offshore areas. Freshwater input from the Pamlico, Neuse, Chowan, and Alligator rivers is mixed with higher salinity, brackish water in the sounds and has little impact on the salinity of shelf waters within the southern VACAPEAS OPAREA (Newton et al. 1971). Hydrography along the Virginia and DELMARVA coasts is dominated by the outflow from both Chesapeake Bay and Delaware Bay. Nearly all major rivers in the region, including the Susquehanna, Potomac, Rappahannock, and the James empty into Chesapeake Bay where the lower salinity water is mixed with brackish bay waters before being discharged as a buoyant plume onto the continental shelf. Similarly, just to the north of the OPAREA, freshwater entering Delaware Bay, 60% of which is from the Delaware River, is mixed with the mesohaline waters in the Bay before flowing along the inner shelf and entering the VACAPES OPAREA as a buoyant coastal current (Sanders and Garvine 1996).

2.5.1 Sea Surface Temperature

During most of the year, there is a clear gradient of increasing sea surface temperature (SST) from north to south in the VACAPES OPAREA; this trend is less obvious in summer when the range in surface water temperatures is smallest (Figure 2-7). Water temperatures in the OPAREA reach a minimum in winter with a well defined thermal convergence of cold, northern waters and warm Gulf Stream waters off of Cape Hatteras. The effects of the Gulf Stream are most noticeable in the southern portion of the OPAREA where seasonal SST ranges from a low of approximately 21°C in winter to 31°C in summer. Just north of Cape Hatteras the Gulf Stream separates from the coast, and waters on the continental shelf near the mouth of Chesapeake Bay undergo a much wider seasonal cycle ranging between 8 and 26°C.

Long term measurements of oceanographic conditions at several locations within the VACAPES OPAREA are made by buoys operated and maintained by the NOAA (NDBC 2006). SST measured over a 17 year period in the northern part of the OPAREA, 48 km southeast of Cape May, averaged 23.5°C in August and 4.8°C in February (NDBC 2003a). Near the southern extent of the OPAREA a buoy located 278 km east of Cape Hatteras recorded mean monthly SST extremes of 27°C in August and 19.5°C in March over a 25 year period (NDBC 2003b). The significant difference between the average summer and winter SST at the southern and northern ends of the OPAREA is undoubtedly attributable to the warm waters of the Gulf Stream that flow only through the southern half of the OPAREA. Off of Cape May, the lowest daily temperature recorded was 1.1°C in February, 1985 and the highest was 28.4°C in July of 2001 (NDBC 2003a). Off of Cape Hatteras, daily temperature extremes of 32.8°C and 16.9°C were recorded in August of 2000 and March of 1998, respectively (NDBC 2003b).

As late spring progresses into early summer, a seasonal thermocline is established in the waters throughout the region. Waters over the continental shelf become highly stratified in both temperature and salinity as relatively warm, buoyant estuarine waters from the bays protrude seaward as plumes overtop of cooler, saltier pelagic waters. In fall, decreasing SST coupled with increased wind-driven mixing combine to break down the thermocline and deepen the mixed layer (Open University 2001). By winter, the water column is well mixed over the shelf and the thermal convergence zone is well defined just north of Cape Hatteras.

2.5.2 Bottom Water Temperature

Near-bottom shelf waters are about 5°C off Cape Hatteras in winter and increase seaward to about 10°C and southward to as high as 20°C (Newton et al. 1971). In summer, bottom waters range from about 10° to 25°C, with temperature gradually increasing shoreward along the shelf. Bottom temperatures along the shelf break just north of Cape Hatteras range from about 9° to 11°C in winter with significantly colder

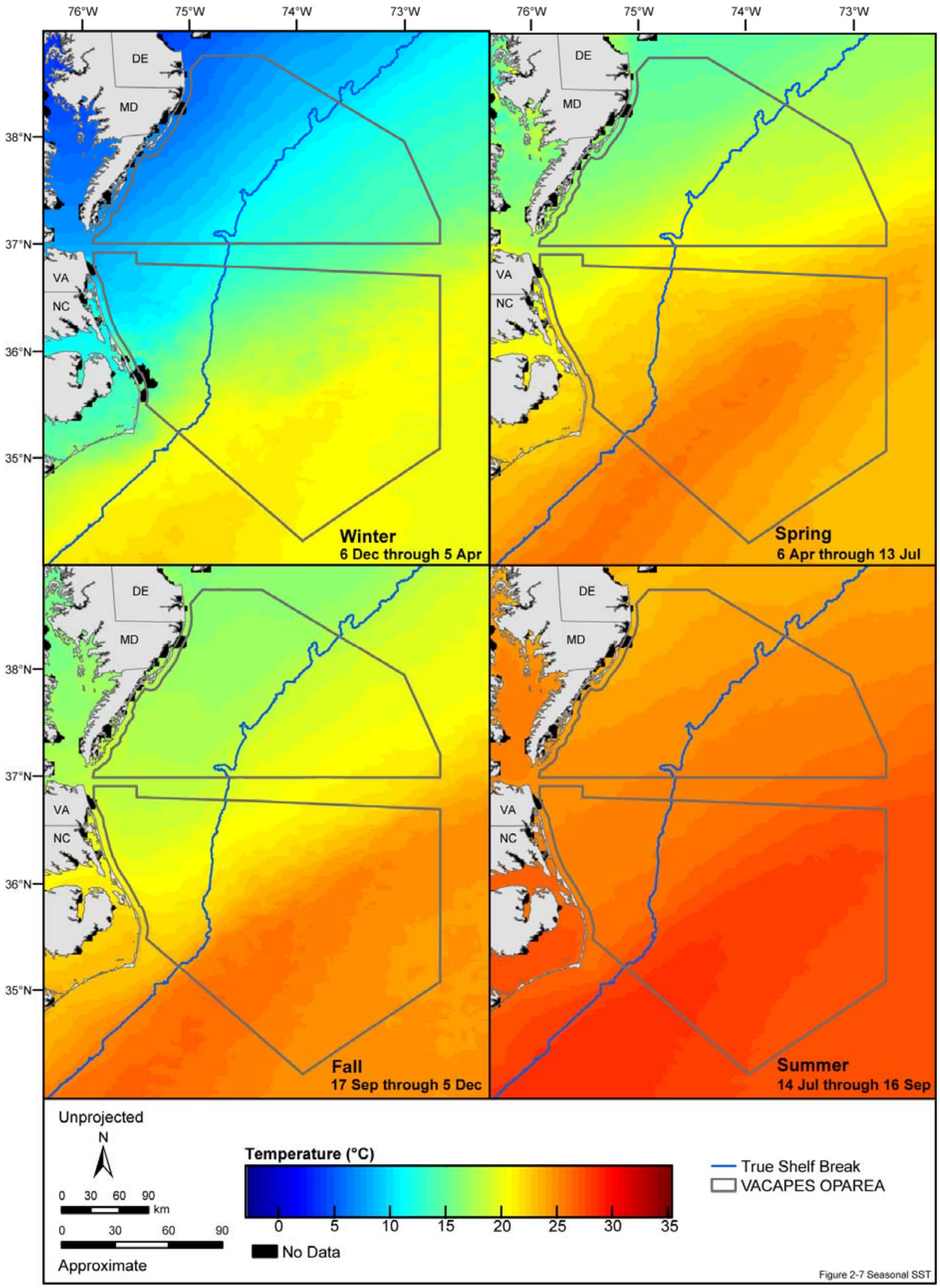

Figure 2-7. Mean seasonal sea surface temperature (SST) occurring along the southeastern U.S. coast and in the Virginia Capes OPAREA from 1985 through 2004. Source data: PODAAC (2004).

(2° to 6°C) bottom waters found inshore over the shelf (Cook 1988). Bottom temperatures on the inner shelf in the OPAREA typically reach a maximum of approximately 24°C in September and October with warmest temperatures occurring south of Chesapeake Bay (Weinberg 2005). On the outer shelf and slope bottom temperatures decrease seaward to as low as 5°C during fall (Weinberg 2005). A recent study on the abundance and distribution of Atlantic surfclams suggests that water temperature along the entire east coast has increased by as much as 2° to 3°C over the last century contributing to the observed seaward shift in the distribution of the surfclams (Weinberg 2005).

2.5.3 Salinity

Salinity over the southern Hatteras-Cape Cod Shelf ranges between 30 and 35 practical salinity units (psu) throughout most of the year with variability dependent on several factors including, freshwater input, wind stress and whether winds are downwelling-favorable or upwelling-favorable, transient storm systems, and the position of the Gulf Stream (Kim et al 2001; Emery and Uchupi 1972). Increases in salinity over the shelf are often associated with persistent southerly upwelling-favorable winds (i.e., winds out of the south); although intrusions of higher salinity (>35 psu) water from beyond the shelf break cannot wholly be attributed to the effects of wind stress (Flagg et al. 1994). Cross-shelf currents with speeds of 20 cm s^{-1} have been observed at the frontal boundary between saltwater intrusions and the fresher shelf water resulting in the onset of instabilities along the front and mixing between the two water masses. Intrusions typically initiate rapidly and persist for only a short period of time (~hours), and in addition to upwelling-favorable winds, may also result from Gulf Stream meanders and warm-core eddies (Flagg et al. 1994; Kim et al. 2001).

Ship transect measurements in the Delaware Coastal Current, which flows south from Delaware Bay into the VACAPES OPAREA, indicate that surface salinity along the inner shelf and within the current can vary from approximately 24 to 32 psu (Whitney and Garvine 2006). Similar measurements taken from within the Chesapeake Bay plume and across a salinity front indicate that salinity can range from less than 22 psu within the plume to over 28 psu in the so called Virginia Coastal Water trapped between the plume and the coast (Marmorino et al. 2000).

2.6 BIOLOGICAL OCEANOGRAPHY

The oceanic environment in which all marine organisms exist can be divided into two primary marine zones, the pelagic zone and the benthic zone. 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 VACAPES OPAREA and vicinity, such as marine mammals, sea turtles, fish species, and 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 organisms that float or drift and cannot maintain their direction against the movement of currents (Parsons et al. 1984). 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 these organisms are macroscopic, with some jellyfish reaching 3 m in diameter. Many zooplankton migrate hundreds of meters in the water column on a daily basis, which can place them under the influence of different currents than occur at the surface, allowing them to indirectly control their lateral movement; however, like all plankton, they cannot migrate against the prevailing current (Lalli and Parsons 2000).

2.6.1.1 Phytoplankton

Phytoplankton are single-celled organisms that are similar to plants because they photosynthesize using sunlight and chlorophyll to generate energy. Phytoplankton are often referred to as primary producers, because, like terrestrial plants, they are able to fix carbon, create their own energy, and are at the base of the marine food chain making them essential to the overall productivity of the ocean. Phytoplankton distribution is patchy, occurring in environments that have optimal light, temperature, and nutrient conditions. 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 lesser degree, other factors such as pH and salinity also affect the growth of phytoplankton (Parsons et al. 1984). When one of these essential factors is in short supply, growth is said to be limited by that factor. In general, the concentration of phytoplankton will be higher in nearshore areas where nutrients are discharged from land sources, such as rivers and areas of urban runoff. The principal nutrients phytoplankton use for growth and photosynthetic processes are dissolved nitrogen (nitrate/nitrite/ammonia), phosphorous (phosphate), and silica (silicate). Phosphorous limitation is typical of freshwater systems whereas marine systems are more likely to be nitrogen limited.

Most major river systems adjacent to the VACAPES OPAREA discharge either into Chesapeake Bay or Delaware Bay where freshwater from the rivers is mixed with brackish estuarine water before reaching the offshore waters of the OPAREA. Nutrient input from these rivers enhances primary productivity within the estuaries and has lead to well publicized occurrences of eutrophication, particularly in Chesapeake Bay (Boesch et al. 2001). Although primary productivity is enhanced by nutrient input from rivers and runoff, increased turbidity associated with fluvial discharge into coastal regions can reduce light penetration into the water column to the point where it actually inhibits primary production (Signorini et al. 2005).

A deep chlorophyll maximum appears to be a seasonal feature of summer vertical profiles as far north as 45°N. South of 40°N a deep chlorophyll maximum has been described at depths of 100 to 150 m. This feature appears to be permanent in oceanic waters as far south as the tropics (Parsons et al. 1984). In continental slope waters off of the U.S. Atlantic coast, a deep chlorophyll maximum peak is located at about 75 m in fall, while in the northern Sargasso Sea the deep chlorophyll maximum reaches approximately 85 m by mid summer. The concentration of chlorophyll is much greater in slope waters than in the oligotrophic Sargasso Sea throughout the year. However, differences in chlorophyll concentrations between the two regions may be attributable to grazing pressure by zooplankton which are known to form larger aggregations in the Sargasso Sea than in slope waters (Wiebe et al. 1987).

Phytoplankton communities change in response to changing environmental conditions on several different scales. For example, 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. In the North Atlantic, the water column is well mixed in winter when solar radiation is lowest. This causes phytoplankton growth to be light limited (Ryan et al. 1999a). Cells are circulated to the full depth of the mixed layer and hence spend a large proportion of their time in regions where there is not sufficient light for growth. In the spring, the mixed layer is shallower, light limitation is overcome, and phytoplankton bloom or grow at exponential rates (Parsons et al. 1984; Mann and Lazier 1996; Ryan et al. 1999a). Increasing stratification of the water column during spring suppresses the vertical mixing that replenishes nutrients, leading to nutrient limitation of phytoplankton growth in the upper 20 to 30 m of the water column by approximately May. Moore et al. (2006) suggest that phytoplankton growth in the central North Atlantic may also be limited by iron concentrations in the mixed layer. A major source of iron is dust blown into open waters from the continents (i.e., western Africa in this case), which may affect the initiation, duration, and magnitude of the spring phytoplankton bloom. As the seasons change from winter (light-limited growth) to spring (nutrient-limited growth), the composition of phytoplankton assemblages changes from netphytoplankton (>20 μm) to nanophytoplankton (<20 μm) (Ryan et al. 1999b).

The composition of phytoplankton communities varies both temporally and spatially in the North Atlantic. In general, the total number of species and individual cells decreases seaward from the coast as estimated by satellite measurements of ocean color (Signorini et al. 2005; Figure 2-8). Chlorophyll concentration has been measured from satellite based detectors for over 20 years; however, the ability to distinguish individual species groups has only recently been successfully demonstrated (Alvain et al. 2005). Although only four major groups are distinguished using this technique, the method does hold promise for using remote sensing as a tool for identifying phytoplankton species distribution on a global scale. Certain difficulties still need to be resolved to improve the accuracy of satellite based estimates of chlorophyll concentrations. Harding et al. (2005) demonstrated that the satellite based SeaWiFS (Sea-viewing Wide Field-of-view Sensor) tends to overestimate chlorophyll *a* concentrations in Chesapeake Bay and adjacent MAB waters primarily due to three factors: (1) inadequate assessment of the effects of non-pigmented dissolved particulate matter in the water column, (2) underestimation of the reflectance caused by atmospheric aerosols, and (3) lack of sensitivity in waters with high absorption (e.g., turbid waters). However, despite these shortcomings, SeaWiFS was found to accurately represent seasonal and interannual fluctuations in phytoplankton biomass (Harding et al. 2005).

Large-scale surveys of phytoplankton species composition conduced in the late 1970’s and early 1980 have identified over 900 species in waters from the Gulf of Maine to the Florida Straits (Wiebe et al. 1987). The largest groups included 277 diatoms, 247 pyrrhophyceans, 54 coccolithophores, 9 silicoflagellates, and 6 cyanophyceans (Wiebe et al. 1987). Seventy-six percent of all species identified in the initial survey (Marshal 1971) occurred in only one of three distinct regions, the Gulf Stream, the Sargasso Sea, or the waters over the continental shelf (Wiebe et al. 1987). The distribution and diversity of phytoplankton species has been observed to differ with locally varying salinity and temperature gradients along the North Carolina and Virginia coasts where the plume waters from Chesapeake Bay create strong frontal boundaries (Lohrenz et al. 2003). An assortment of haptophytes, dinoflagellates (e.g., genus *Ceratium*), and chrysophytes dominates species composition in warmer, higher salinity shelf waters in this region that likely originate from the Gulf Stream, SAB, and over the continental slope. Phytoplankton species within the cooler, lower salinity plume waters are composed primarily of cyanobacteria, cryptophytes (e.g., *Chryptomonas* spp.), prasinophytes, and large diatoms (e.g., genera *Haslea* and *Skelotonema)* (Lohrenz et al 2003). Generally, greater abundance or biomass and lower diversity characterize plume waters in comparison to offshore shelf and slope waters of the southern MAB (Lohrenz et al. 2003).

Off of Cape Hatteras, primary production over the continental shelf is influenced by intrusions of high-nutrient Gulf Stream waters which can result in phytoplankton blooms along frontal boundaries between shelf and Gulf Stream waters (Lohrenz et al. 2002). A number of other factors can enhance the position of the front between shelf, slope, and Gulf Stream waters just north of Cape Hatteras including the presence of upwelling-favorable winds, early spring shoaling of the mixed layer near the shelf break, and summertime stratification of shelf waters. In this particularly survey, springtime in situ chlorophyll concentrations were measured at greater than 10 mg m^{-3} at the shelf break with highest concentrations found below the surface; most phytoplankton were greater than 8μm in size. Later in the year, summertime chlorophyll concentrations dropped to less than 10 mg m^{-3} and the greatest contribution to primary production on the shelf came from phytoplankton smaller than 8μm in size (Lohrenz et al. 2002).

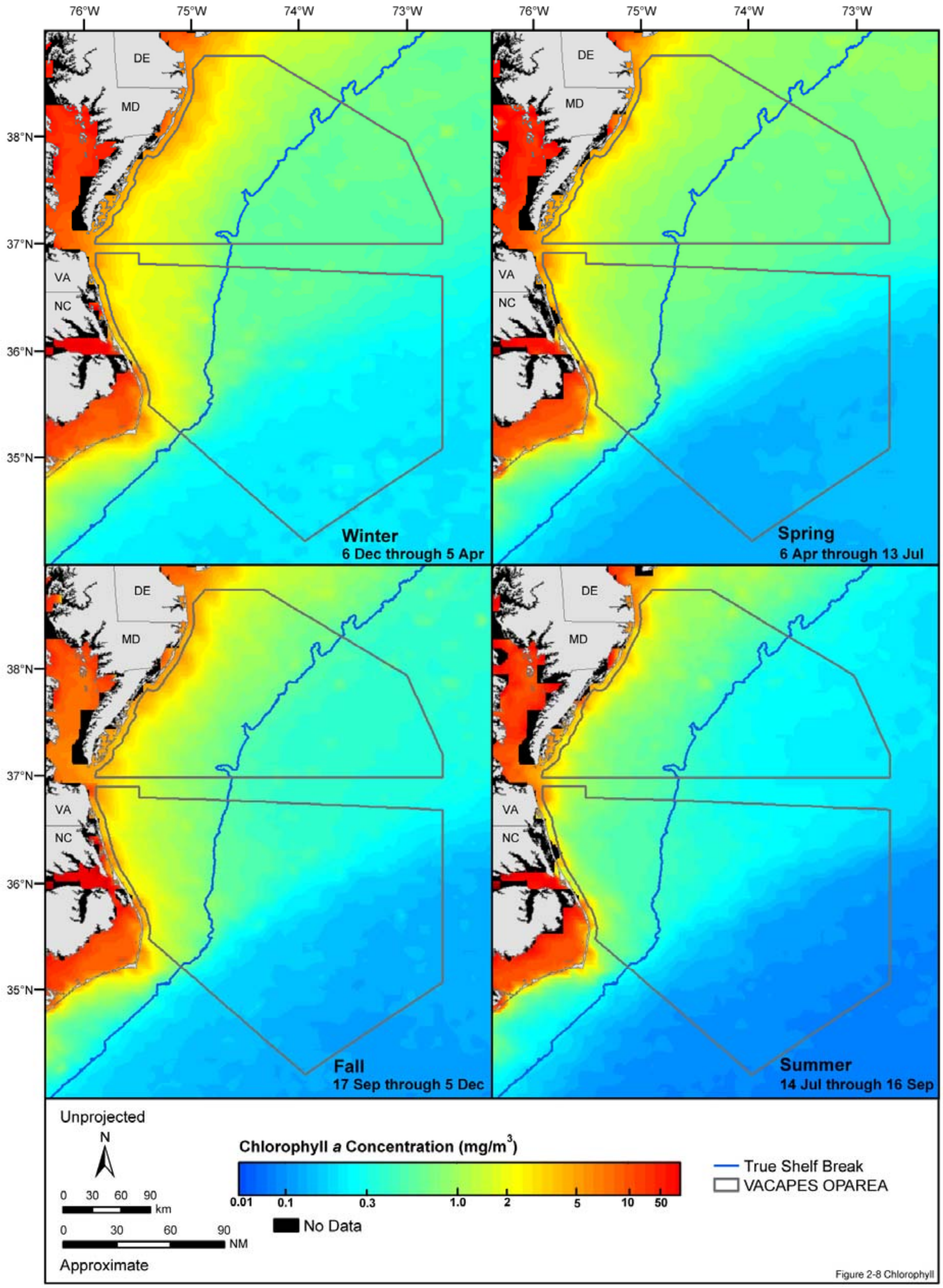

Figure 2-8. Mean seasonal chlorophyll *a* concentrations occurring in surface waters along the southeastern U.S. coast and in the Virginia Capes OPAREA from September 1997 through October 2005. Source data: NASA (2005b).

2.6.1.2 Zooplankton

Zooplankton are aquatic animals that, like all plankton, are unable to migrate against the prevailing current and whose distribution is therefore essentially determined by their physical environment (Wiebe et al. 1987). The size of zooplankton found in the worlds oceans ranges widely from microscopic protozoans (<200μm) to the largest jellyfish (~3 m in diameter) (Lalli and Parsons 2000). Although many zooplankton perform diel vertical migrations of hundreds of meters to feed and avoid predators, large-scale horizontal distribution is primarily determined by surface and deep water currents (Wiebe et al. 1987; Mann and Lazier 1996). For example, zooplankton assemblages are likely to be concentrated in areas of increased primary productivity such as along frontal boundaries and eddy peripheries associated with the Gulf Stream (Oschlies and Garcon 1998).

Zooplankton biomass is influenced by seasonal fluctuations in hydrography and phytoplankton abundance. In general, zooplankton biomass is as much as four times higher in waters over the continental slope than in the Sargasso Sea, and biomass shows stronger seasonality in slope waters than in the Sargasso Sea (Allison and Wishner 1986; Wiebe et al. 1987). An increase in zooplankton biomass occurs in spring 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.

Salps are found in the surface and near surface waters of the VACAPES OPAREA and represent one of the larger types of zooplankton. Individual salps have a cylindrically shaped, gelatinous body between 1 and 30 cm in length with openings at either end. Salps have the ability to pump water through their bodies to allow some locomotion and to filter out a variety of food particles, including phytoplankton, zooplankton, bacteria, and detritus (Lalli and Parsons 2000; Vargus and Madin 2004). Known for their extremely rapid growth rates, salps often form long chains (~15 m in length) of several hundred individuals during their asexual reproductive stage and can significantly impact both primary and secondary production in the MAB (Lalli and Parsons 2000). Impacts to secondary production occur both through grazing as well as through competition for phytoplankton as a food source (Vargus and Madin 2004). Three species of salps commonly found in the MAB are *Thalia democratica*, *Cyclosalpa affinis*, and *Salpa Cylindrica*; all three have been observed to feed indiscriminately on the most abundant food source available at any given time (in nearly all instances observed this was dinoflagellates). (Vargus and Madin 2004).

The Gulf Stream region is ecologically important in that it acts as a boundary for the distribution of some animals and a dispersal mechanism for others. The northern wall of the Gulf Stream Current marks the southern limit for cold-water species and the northern limit for many warm-water species (Wishner et al. 1988). The surface water of the Gulf Stream tends to have a species composition and seasonal variability similar to those of the Sargasso Sea, although differences in absolute and relative species abundances can occur. In deeper water, there are similarities in faunal composition between continental slope and Sargasso Sea waters in the western North Atlantic (Wishner et al. 1988). Within the Gulf Stream, copepod species have distinct patterns of distribution that are related to oceanic habitat characteristics and that change with depth along sloping isopycnals (Wishner et al. 1988). Transport of zooplankton species across the Gulf Stream is only likely for those species occurring in the surface mixed layer. Species occurring in deeper sections of the Gulf Stream are likely to be transported farther downstream and dispersed in offshore waters of the North Atlantic (Wishner et al. 1988).

2.6.1.3 Meroplankton

Meroplankton describe those zooplankton species that spend only a portion of their life history as plankton. Certain lifestages of bivalves, fish, and arthropods are spent as plankton; however in each of these cases the adult lifestage is not (Lalli and Parsons 2000). The larval lifestage of the blue crab (*Callinectes sapidus*) is spent in the surface waters of the MAB before returning to Chesapeake Bay and developing into the well recognized adult (Lalli and Parsons 2000).

Ichthyoplankton (a subset of the meroplankton) consist of the larvae and eggs of fish species. Large frontal eddies associated with Gulf Stream meandering can transport ichthyoplankton normally associated with Gulf Stream waters into mid-shelf waters (Powell et al. 2000; Quattrini et al. 2005). The survival and recruitment success of shelf-spawned estuarine larva are likely tied to oceanographic conditions on the inner shelf such as upwelling and downwelling as well as to wind-driven mechanisms (Reiss and McConaugha 1999; Garland and Zimmer 2002; Shanks et al. 2003). Ichthyoplankton species known to be present in plume waters of Chesapeake Bay and to undergo some level of disbursement over the continental shelf include: *Anchoa* spp. (anchovies), *Micropogonias undulates* (Atlantic croaker), *Etropus microstomus* (smallmouth flounder), and *Centropristis striata* (black seabass) (Reiss and McConaugha 1999).

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3.0 PROTECTED SPECIES

This chapter provides detailed information on the protected marine species potentially occurring in the VACAPES OPAREA. Protected species in the OPAREA include 40 marine mammal and five sea turtle species. Marine mammals are the taxon group with the largest number of federally protected species in the OPAREA. All marine mammals are protected by the MMPA, but the manatee and six large whales are also listed as endangered and, therefore, are afforded additional protection under the ESA. The five sea turtle species known to occur in the OPAREA are all listed as threatened or endangered under the ESA.

Section 3.1 of this chapter provides information on the marine mammal species occurring in the OPAREA. The marine mammal species are discussed in taxonomic order, beginning with the endangered species. An overview of the taxon and a brief introduction to acoustics and hearing are included. A detailed narrative has been prepared for each marine mammal species and consists of a species' description, status, habitat associations, distribution (including a focus on the OPAREA), behavior and life history, as well as an account of vocalizations and hearing capabilities (when available). Map figures showing critical habitat, migration routes, and movement patterns of some tagged marine mammals are included in this section. Additional map figures depicting the seasonal occurrence records and the estimated occurrences (predicted by an effort-based geostatistical model) for each species in the OPAREA are found in Appendix B (Figures B-1-1 through B-29).

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 OPAREA is described in detail by its physical description, status, habitat associations, distribution (including an emphasis on the OPAREA), and behavior and life history. Map figures showing the movements of tagged turtles in the OPAREA are included in this section. Additional map figures depicting occurrence records, nest locations, and occurrence estimates as predicted by an effort-based geostatistical model are included in Appendix C (Figures C-1-1 through C-6-2).

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 two 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 species of marine mammals occur worldwide (Rice 1998). The term “marine mammal” is purely descriptive and refers 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).

Most of the 40 marine mammal species that are documented to occur within the VACAPES OPAREA are cetaceans (whales, dolphins, and porpoises). Cetaceans are divided into two major suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales). Toothed whales are generally smaller and have teeth that are used to capture prey. Baleen whales use baleen to filter their prey from the water. In addition to contrasts in feeding methods, there are life history and social organization differences (see Tyack 1986).

Pinnipeds are divided into three families: Phocidae (the “true” or earless seals); Otariidae (sea lions and fur seals); and Odobenidae (walruses). Of the pinnipeds, only phocids are expected to occur in the OPAREA. Some of the more obvious phocid attributes are a lack of external ears, inability to rotate the pelvic flippers under the body (leading to a “galumphing” motion on land), use of pelvic flippers for underwater propulsion, and small pectoral appendages for underwater steering (Riedman 1990).

Four living sirenian species are classified into two families: Trichechidae, with three species of manatees, and Dugongidae, the dugong. Sirenians are the only completely herbivorous marine mammals. Of the sirenians, only the West Indian manatee occurs along the U.S. Atlantic coast.

3.1.1.1 Adaptations to the Marine Environment: Sound Production and Reception

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

Marine mammal vocalizations often extend both above and below the range of human hearing; vocalizations with frequencies lower than 18 Hertz (Hz) are labeled as infrasonic (Leventhall 2007) and those higher than 20 kiloHertz (kHz) as ultrasonic (Leighton 2007). Baleen whales primarily use the lower frequencies, producing both amplitude-modulated and tonal (frequency-modulated) sounds in the range of 14 to 3,000 Hz depending on the species. Most mysticete sounds can be characterized as moans, simple (pulsed) or complex calls, and songs (Wartzok and Ketten 1999). 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, passively listening to received echoes to navigate and orient relative to physical features of the ocean. The toothed whales produce a wide variety of sounds that are commonly grouped into three general categories: these sounds include species-specific, amplitude-modulated (AM) broadband “clicks” with peak energy between 10 and 200 kHz, individually variable “burst pulse” click trains, and constant frequency or frequency-modulated (FM) whistles ranging from 1 to 20 kHz (Wartzok and Ketten 1999). The general consensus is that the tonal vocalizations (whistles) produced by toothed whales play an important role in social activity, e.g., communication, maintenance of contact between dispersed individuals, etc., while broadband clicks are used during echolocation (Wartzok and Ketten

1999; Tyack 2000; Tyack 2002). However, several species of toothed whale (e.g., sperm whales (Whitehead 2003), Commerson's dolphins (Dawson 1991), and dusky dolphins (Yin et al. 2001) produce only click sounds, which are used for both communication and echolocation. Burst pulses, trains with repetition rates ranging from 100's to 1000's of cicks per second, are used to share information between individuals by species that whistle and those that do not. Burst pulses have been documented during playful interactions (e.g., Herzing 1996; Blomqvist et al. 2005) agonistic encounters (McCowan and Reiss 1995) and other socializing. These sounds have been suggested to represent "emotive" signals in a broader sense, possibly representing graded communication signals (Herzing 1996). Echolocation, or sonar, is produced by all toothed whales studied to-date and is used during foraging (e.g., Janik 2000), short-range navigation (Au 1993) and during communication (Reynolds III and Rommel 1999; Perrin et al. 2002): recent evidence has been shown that dolphins are capable of echoic eavesdropping ((e.g., Xitco Jr. and Roitblat 1996; e.g., Gőtz et al. 2005; Gregg et al. 2008), which could represent another avenue for these animals to share information. (Echoic eavesdropping refers to one animal listening to the click production and return echoes from a second dolphin to gain useable information.)

Pinnipeds are amphibious; they produce both airborne and underwater sounds primarily in the sonic range (i.e., roughly between 20 Hz and 20 kHz, (Thomson and Richardson 1995). Their vocalizations primarily include grunts, barks, rasps, and growls in addition to the moans, whistles and possibly pulsed calls. In general, phocids are far more vocal underwater than are otariids. Phocid calls commonly range between 100 Hz and 15 kHz, with peak energy less than 5 kHz, but can range as high as 40 kHz (Ketten 1998a; Wartzok and Ketten 1999). Otariid calls are somewhat variable with most having a more narrow frequency range (~1 to 4 kHz) than the phocids (Wartzok and Ketten 1999; Frankel 2002). Otariid calls include barks, groans, and grunts, although their vocalizations are assumed less socially complex than those of phocids, which might be related to the differences in their mating strategies. Phocids mate underwater while otariids mate on land and are relatively quiet at sea (Frankel 2002). There is no evidence that pinnipeds echolocate (Schusterman et al. 2000).

Empirical data on the hearing abilities of cetaceans are sparse, particularly for the larger cetaceans such as the baleen whales. The auditory thresholds of some of the smaller odontocetes have been determined in captivity (see Thewissen (2002) for an overview on hearing in marine mammals), and more recently from some free-ranging species (e.g., Nachtigall et al. 2008). It is generally believed that cetaceans should at least be sensitive to the frequencies of their own vocalizations and the new data are confirming this assumption in the species studied. Comparisons of the anatomy of cetacean inner ears and models of the structural properties and the response to vibrations of the ear's components in different species provide an indication of likely sensitivity to various sound frequencies. The ears of small toothed whales are optimized for receiving high-frequency sound, while baleen whale inner ears are best in low to infrasonic frequencies (Ketten 1992, 1997).

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

General reviews of cetacean and pinniped sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), Au et al. (2000), Thewissen (2002); Hildebrand (2005), and Southall et al. (Southall et al. 2007). 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 affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Bjørge 2002; Bowen et al. 2002; Forcada 2002; Stevick et al. 2002). Most information on marine mammal distribution has been obtained from shipboard and aerial observations, which provide a very limited perspective on their life at or near the surface and little insight into their behavior under the water where some species, particularly cetaceans, spend up to 90% of their time (e.g., Costa 1993).

Our knowledge of marine mammal habitats is often quite limited. Poor definition of spatiotemporal scales is the primary cause for confusion and disagreement among studies about factors that associate with marine mammal (particularly 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 whose 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).

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

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

Since most toothed whales do not have the fasting capability of baleen whales, toothed whales are thought to follow seasonal shifts in preferred prey or feed opportunistically on whatever prey are available locally. 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). Bottlenose dolphin distributions may also be influenced by small-scale hydrographic fronts that act as convergence zones. A spatial association has been demonstrated between bottlenose dolphins and surface features of tidal intrusion fronts. This may result in an accumulation of prey in the frontal region leading to increased dolphin foraging efficiency (Mendes et al. 2002). Such a front exists near Cape Henry, Virginia, because of outflow from the Chesapeake Bay (Marmorino et al. 2000). Cetacean movements have also been associated with indirect indicators of prey movements, such as sea-surface temperature variations, sea-surface chl *a* concentrations, and bathymetry (Fiedler 2002). In addition, diet similarity between two or more predators in the same habitat will affect the level of competition between these predators for limited prey resources. This can result in the competitive exclusion of one or more predator species from a specific habitat. Competitive exclusion may lead to niche segregation. MacLeod et al. (2003) and MacLeod and Zuur (2005) suggest that this may occur between *Mesoplodon* spp. beaked whales, northern bottlenose whales (*Hyperoodon*), and Cuvier's beaked whales (*Ziphius cavirostris*). *Hyperoodon* and *Ziphius* appear to have similar diets but are geographically segregated, with *Hyperoodon* occurring in polar to cold-temperate waters and *Ziphius* in warm-temperate to tropical waters.

Fluctuations in food availability may also influence the occurrence of extralimital observations of cetaceans or shift the habitats in which they normally occur. Several studies have correlated changes in the distribution of some baleen and toothed whale populations in the Gulf of Maine with ecological shifts in prey patterns after intense commercial fishing (Payne et al. 1986; Payne et al. 1990a; 1990b; Kenney et al. 1996). A similar shift in humpback whale distribution from offshore Grand Banks feeding areas to nearshore Newfoundland waters was attributed to the collapse of offshore capelin stocks due to overfishing (Whitehead and Carscadden 1985). 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.

The abundance and quality of prey, as well as its seasonal distribution, is also important to long-range pinniped movements (Forcada 2002). Phocids appear to migrate more than otariids as a result of a more variable environment (i.e., ice cover) in their higher-latitude distributions (Bowen and Siniff 1999). As with cetacean migrations, variations in timing exist and may be influenced by age classes (Forcada 2002). Pinniped movements are also associated with transient (thermal discontinuities) or non-transient physical features that concentrate prey (Field et al. 2001). McConnell and Fedak (1996) hypothesized that seals in open oceans follow mesoscale frontal systems that locally enhance prey abundance. Thompson et al. (1991) observed that spatial and temporal occurrences of feeding harbor seals were in response to fish distributions. These same fish distributions also shifted spatially and temporally with concentrations over trenches and holes more than 10 m deep during daylight hours.

All pinnipeds periodically leave the water to haul out (come ashore) on land or ice to molt, rest, mate, warm themselves, or avoid marine predators (Riedman 1990). Additionally, pinniped reproductive biology requires individuals to return to land or ice to pup (give birth), nurse, and rear their offspring. However, seasonal changes in oceanographic and ice cover conditions affect pinniped distribution on the pack ice (Forcada 2002). Hauling out by pagophylic pinnipeds seems to be influenced by both weather and time of day during breeding and molting periods (Moulton et al. 2000). For harbor seals, tidal stage also has a significant effect on haulout behavior (Schneider and Payne 1983). The incidence, significance, and controlling factors of hauling out during other times, when temperatures are coldest, are essentially unknown (Moulton et al. 2000).

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 recent winters, hooded seals have occurred in the Gulf of Maine in larger numbers than 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 (*Boreogadus saida*) (Tynan and DeMaster 1997).

Climatic fluctuations have produced a growing concern about the effects of climate change on marine mammal populations (MacGarvin and Simmonds 1996; IWC 1997; Evans 2002; Würsig et al. 2002; Le Boeuf and Crocker 2005). 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 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 global warming and the subsequent rise in ocean temperature may lead to increased climatic variability and more severe fluctuations in the NAO Index. Such fluctuations would be expected to cause dramatic shifts in the reproductive rate of critically endangered North Atlantic right whales (Drinkwater et al. 2003; Greene et al. 2003) and possibly a northward shift in the location of right whale calving grounds (Kenney 2007a). More details on the NAO and climate variability in the North Atlantic Ocean may be found in Chapter 2.

3.1.2 Marine Mammals of the VACAPES OPAREA

Forty marine mammal species have confirmed or potential occurrence in the VACAPES OPAREA (Table 3-1). These species include 35 cetaceans, four pinnipeds, and one sirenian. Although it is possible that 40 species of marine mammals may occur in the OPAREA, only 23 of those species are expected to occur regularly in the region. Some cetacean species are resident in the OPAREA year-round (e.g., bottlenose dolphins and beaked whales), while others (e.g., northern right and humpback whales) occur seasonally as they migrate through the area. Only extralimital occurrences of the West Indian manatee are anticipated in the OPAREA. Gray, harp, and hooded seals are extralimital while harbor seals are considered rare in this area, which is well south of this species' typical ranges.

Based on stranding records, waters off North Carolina appear to have the greatest cetacean diversity along the eastern seaboard (Webster et al. 1995). Cape Hatteras is generally considered to be a boundary between temperate and tropical species in the western North Atlantic and an area of overlap for many marine species (Ekman 1953; Briggs 1974; Garrison et al. 2003b). This area harbors two warmer-water and two colder-water *Mesoplodon* (beaked whale) species in the western North Atlantic (MacLeod 2000b). Stranding records indicate that many marine mammals in North Carolina waters are year-round residents, but others migrate into inshore waters during summer/fall and winter/spring months (Webster et al. 1995). Some closely related species that occupy the same ecological niche, such as long-finned and short-finned pilot whales, have shifting distributions relative to the positions of cold-water and warm-water currents (Payne and Heinemann 1993).

Table 3-1. Marine mammal species of the Virginia Capes OPAREA and their status under the Endangered Species Act (ESA). Naming convention matches that used in the NOAA stock assessment reports.

	Scientific Name	Status	Occurrence[1]
Order Cetacea			
Suborder Mysticeti (baleen whales)			
Family Balaenidae			
North Atlantic right whale	*Eubalaena glacialis*	ENDANGERED	Regular
Family Balaenopteridae (rorquals)			
Humpback whale	*Megaptera novaeangliae*	ENDANGERED	Regular
Minke whale	*Balaenoptera acutorostrata*		Regular
Bryde's whale	*Balaenoptera edeni/brydei**		Rare
Sei whale	*Balaenoptera borealis*	ENDANGERED	Rare
Fin whale	*Balaenoptera physalus*	ENDANGERED	Regular
Blue whale	*Balaenoptera musculus*	ENDANGERED	Rare
Suborder Odontoceti (toothed whales)			
Family Physeteridae			
Sperm whale	*Physeter macrocephalus*	ENDANGERED	Regular
Family Kogiidae			
Pygmy sperm whale	*Kogia breviceps*		Regular
Dwarf sperm whale	*Kogia sima*		Rare
Family Ziphiidae			
Cuvier's beaked whale	*Ziphius cavirostris*		Regular
True's beaked whale	*Mesoplodon mirus*		Regular
Gervais' beaked whale	*Mesoplodon europaeus*		Regular
Blainville's beaked whale	*Mesoplodon densirostris*		Regular
Sowerby's beaked whale	*Mesoplodon bidens*		Rare
Northern bottlenose whale	*Hyperoodon ampullatus*		Extralimital
Family Delphinidae			
Rough-toothed dolphin	*Steno bredanensis*		Regular
Bottlenose dolphin	*Tursiops truncatus*		Regular
Pantropical spotted dolphin	*Stenella attenuata*		Regular
Atlantic spotted dolphin	*Stenella frontalis*		Regular
Spinner dolphin	*Stenella longirostris*		Regular
Striped dolphin	*Stenella coeruleoalba*		Regular
Clymene dolphin	*Stenella clymene*		Regular
Short-beaked common dolphin	*Delphinus delphis*		Regular
Fraser's dolphin	*Lagenodelphis hosei*		Rare
White-beaked dolphin	*Lagenorhynchus albirostris*		Extralimital
Atlantic white-sided dolphin	*Lagenorhynchus acutus*		Rare
Risso's dolphin	*Grampus griseus*		Regular
Melon-headed whale	*Peponocephala electra*		Rare
Pygmy killer whale	*Feresa attenuata*		Rare
False killer whale	*Pseudorca crassidens*		Rare
Killer whale	*Orcinus orca*		Regular
Long-finned pilot whale	*Globicephala melaena*		Regular
Short-finned pilot whale	*Globicephala macrorhynchus*		Regular
Family Phocoenidae			
Harbor porpoise	*Phocoena phocoena*		Regular
Order Carnivora			
Suborder Pinnipedia (seals, sea lions, walruses)			
Family Phocidae (true seals)			
Harbor seal	*Phoca vitulina*		Rare
Gray seal	*Halichoerus grypus*		Extralimital
Harp seal	*Pagophilus groenlandicus*		Extralimital
Hooded seal	*Cystophora cristata*		Extralimital
Order Sirenia			
Family Trichechidae			
West Indian manatee	*Trichechus manatus*	ENDANGERED	Extralimital

[1] **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

* Includes more than one species, but nomenclature is still unsettled

Oceanographic features, such as eddies associated with the Gulf Stream, are important factors determining cetacean distribution since their prey are attracted to the increased primary productivity associated with some of these features (Biggs et al. 2000; Wormuth et al. 2000; Davis et al. 2002). The warm Gulf Stream moves rapidly through the Florida Straits and extends northeast along the continental shelf. This current is the single most-influential oceanographic feature of the region and influences water temperature, salinity, and nutrient availability. These factors, in turn, are important in regulating primary productivity associated with phytoplankton growth in the region and the subsequent secondary productivity of zooplankton and other animal life that provide prey for marine mammals.

There is also an association between cetaceans and cold-core and warm-core rings (Griffin 1999; Biggs et al. 2000; Waring et al. 2001). Both ring types are eddies that detach from the Gulf Stream; it is possible to find either near the VACAPES OPAREA, increasing the likelihood of higher cetacean presence for the duration of these mesoscale hydrographic features. It is likely that the upwelling associated with cold-core rings permits greater feeding efficiency by cetaceans on mesopelagic squids and fishes. Cetacean species that typically occur on the continental shelf or along the shelf break might be less affected by the eddies (rings) since they are outside the major influences of these features. Sperm whales and several *Stenella* spp. have been documented to occur along the periphery of eddies (Biggs et al. 2000; Waring et al. 2001).

Along the Virginia and North Carolina shoreline, upwelling and downwelling events are not limited to Gulf Stream or deep-sea canyon geography. Wind patterns and outflow from the Chesapeake Bay cause upwelling and downwelling features along the continental shelf on a regular basis (Cudaback and Largier 2001), potentially increasing regional productivity and thereby enhancing local cetacean abundance. Disturbances, such as hurricanes, atmospheric frontal systems, and shifts in current patterns can also increase the before-mentioned oceanographic conditions to enhance local productivity. For example, increased sediment and nutrient loads are present in freshwater systems following heavy and prolonged rainfall, similarly enhancing primary productivity along the continental shelf near the system's effluence.

The modeled occurrence of a species in a given portion of the study area is based upon a geo-statistical sightings-per-unit-effort (SPUE) analysis and is presented for each season (winter=6 December through 5 April; spring=6 April through 13 July; summer=14 July through 16 September; fall=17 September through 5 December) in Appendix B. A listing and description of 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 Section 1.4.2.2. An occurrence record does not reflect the number of animals; due to the social nature of cetaceans, multiple individuals of a species are often sighted at the same time and at the same location. It should be noted that the number of marine mammal observations in this area is partially a function of the level of effort to collect this information rather than the actual marine mammal abundance in the area.

On the map figures, various shading and terminology designate the occurrence of marine mammals in the study area. Species' occurrence levels were defined as SPUE values within the: highest quartile (1^{st} Quartile SPUE) in areas shaded in purple, second highest quartile (2^{nd} Quartile SPUE) in areas shaded in blue, second lowest quartile (3^{rd} Quartile SPUE) in areas shaded in dark green, and lowest quartile (4^{th} Quartile SPUE) in areas shaded in light green. An additional occurrence level of SPUE = 0 (shaded in yellow), is indicative of areas where survey effort occurred (effort ≥ 5 km) but no sightings were recorded. In all cells with effort <5 km (or 0), the occurrence area was defined as "No Survey Effort" (stipple pattern); in these areas the likelihood of a protected species occurring is not known because no line-transect surveys have been completed in that area or were not available for inclusion in the analysis. Due to a lack of survey data available for certain species, occurrence models could not be calculated for every species known to occur in the study area.

Each marine mammal species below is listed with its description, status, habitat association, distribution (including location and seasonal occurrence in the VACAPES OPAREA), behavior and life history, and information on its acoustic and hearing abilities. Threatened and endangered marine mammals appear first. Remaining species follow the taxonomic order presented in Table 3-1.

Waters off North Carolina have the greatest cetacean diversity along the eastern seaboard (Webster et al. 1995). Cape Hatteras is generally considered to be a boundary between temperate and tropical species in the western North Atlantic and an area of overlap for many marine species (Ekman 1953; Briggs 1974; Garrison et al. 2003a). This area harbors two warmer-water and two colder-water *Mesoplodon* (beaked whale) species in the western North Atlantic (MacLeod 2000a). Many marine mammals along North Carolina waters are year-round residents, but others migrate into inshore waters during summer/fall and winter/spring months (Webster et al. 1995). Some closely related species that occupy the same ecological niche, such as long-finned and short-finned pilot whales, have shifting distributions relative to the positions of cold-water and warm-water currents (Payne and Heinemann 1993).

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Along the Virginia and North Carolina shoreline, upwelling and downwelling events are not limited to Gulf Stream or deep-sea canyon geography. Wind patterns and outflow from the Chesapeake Bay cause upwelling and downwelling features along the continental shelf on a regular basis (Cudaback and Largier 2001), potentially increasing regional productivity and thereby enhancing local cetacean abundance. Disturbances, such as hurricanes, atmospheric frontal systems, and shifts in current patterns can also increase the before-mentioned oceanographic conditions to enhance local productivity. For example, increased sediment and nutrient loads are present in freshwater systems following heavy and prolonged rainfall, similarly enhancing primary productivity along the continental shelf near the system's effluence.

The distribution of marine mammal occurrence records (sightings, strandings, and fisheries bycatch) and occurrence estimates based on geostatistical modeling (kriging) of the line-transect sighting data records are presented for each season (winter=6 December through 5 April; spring=6 April through 13 July; summer=14 July through 16 September; fall=17 September through 5 December) in Appendix B. A listing and description of 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 Section 1.4.2.2. An occurrence record does not reflect the number of animals; due to the social nature of cetaceans, multiple individuals of a species are often sighted at the same time and at the same location. It should be noted that the number of marine mammal observations in this area is partially a function of the level of effort to collect this information rather than the actual marine mammal abundance in the area.

On the map figures, various types of shading and terminology designate the occurrence of marine mammals in the OPAREA. The occurrence of a species in a given portion of the OPAREA is based on sightings-per-unit-effort (SPUE) in that area. For SPUE values to be calculated for a given area there must be at least 5 km of valid survey effort. Species' occurrence levels were parsed into quartiles or four divisions as defined by the range in the SPUE values associated with each species. The SPUE/modeled occurrence levels are: 1st or highest quartile, 2nd or second highest quartile, 3rd or second lowest quartile, and 4th or lowest quartile. An additional occurrence level is “SPUE = 0”, indicative of areas where survey effort occurred (effort ≥ 5 km) but no sightings were recorded. In all cells with effort < 5 km (or 0), the occurrence area was defined as “No Survey Effort”; in these areas the likelihood of a protected species occurring is not known because no line-transect surveys have been completed in that area. Due to a lack of survey data available for certain species, occurrence models could not be calculated for every species known to occur in the OPAREA.

Each marine mammal species below is listed with its description, status, habitat preference, distribution (including location and seasonal occurrence in the VACAPES OPAREA), behavior and life history, and information on its acoustic and hearing abilities. Threatened and endangered marine mammals appear first. Remaining species follow the taxonomic order presented in Table 3-1.

3.1.2.1 Threatened and Endangered Marine Mammals

Seven marine mammal species with records in the VACAPES OPAREA are listed as endangered under the ESA. These include five baleen whales (northern right, humpback, sei, fin, and blue), one toothed whale (sperm whale), and one sirenian (West Indian manatee). The West Indian manatee is considered extralimital to the VACAPES OPAREA and is not included in the model for T/E marine mammals due to the lack of survey data.

The sperm whale is driving the model output for T/E cetaceans in the OPAREA (Figures B-1-1 and B-1-2). The areas of increased occurrence reflect concentrations of sperm whales and are identical to the model output predicted for this species. Occurrences of fin, humpback, and North Atlantic right whales explain the nearshore portion of the predicted occurrence for T/E cetaceans (Figures B-1-1 and B-1-2). Humpback and North Atlantic right whales occur in the OPAREA every season except summer when these species should be on their feeding grounds farther north.

- North Atlantic Right Whale (*Eubalaena glacialis*)

  Description—Until recently, right whales in the North Atlantic and North Pacific were classified together as a single species, referred to as the “northern right whale.” Genetic data indicate that these two populations represent separate species: the North Atlantic right whale and the North Pacific right whale *(Eubalaena japonica)* (Rosenbaum et al. 2000; NMFS 2008).

  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. 1986b).

  Status—The North Atlantic right whale is one of the world’s most endangered large whale species (Clapham et al. 1999; Perry et al. 1999; IWC 2001a). North Atlantic right whales are classified as endangered under the ESA (NMFS 2008) and, therefore, considered to be a strategic stock (Waring et al. 2008). According to the North Atlantic right whale report card released annually by the North Atlantic Right Whale Consortium, approximately 393 individuals are thought to occur in the western North Atlantic (NARWC 2007). The most recent NOAA stock assessment report states that in a review of the photo-id recapture database for June 2006, 313 individually recognized whales were known to be alive during 2001 (Waring et al. 2008). This is considered the minimum population size.

  No best population estimate is available for this stock.

  This species showed a decline in survival during the 1990’s (Best et al. 2001; Waring et al. 2008). In recent years, there has been in increase in the number of catalogued individuals (Waring et al. 2008);

however, Kraus et al. (2005) noted that the recent increases in birth rate were insufficient to counter the observed spike in human-caused mortality that has recently occurred.

One calving and two feeding areas in U.S. waters are designated as critical habitat for North Atlantic right whales (NMFS 1994; NMFS 2005; 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 North Atlantic 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. 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 2006b). These routes are voluntary at this time and are included on the updated NOAA nautical charts (http://www.noaa.gov/charts.html) (NOAA 2006b).

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 2006a). 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 2006d).

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, the typical reaction is 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 (northern right, fin, humpback, and minke) due to incidental interaction with commercial fishing activities (NMFS 1999). 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/.

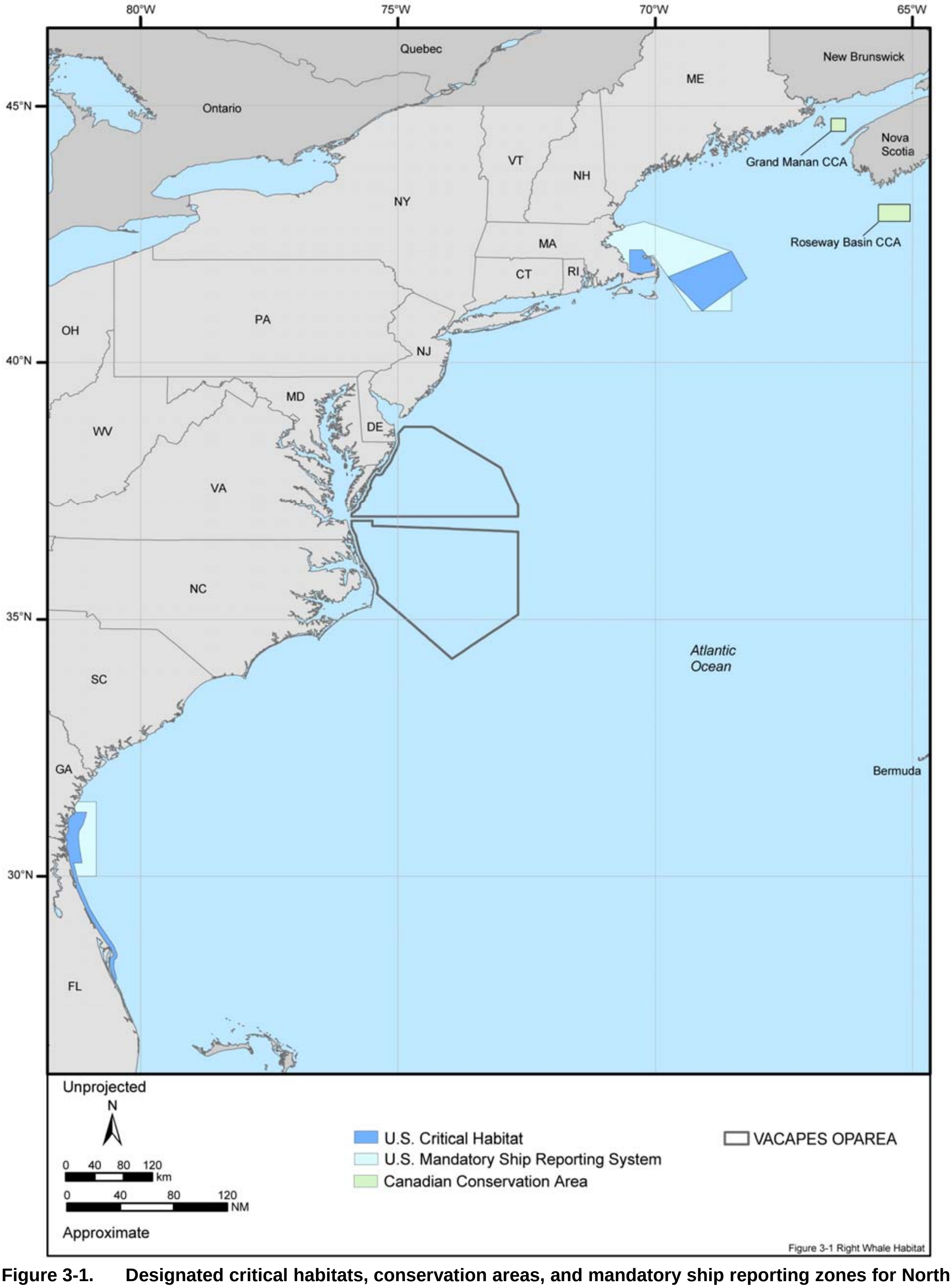

Figure 3-1. Designated critical habitats, conservation areas, and mandatory ship reporting zones for North Atlantic right whales. Source information: NMFS (1994), USCG (1999), and DFO (2003a).

Habitat Associations—North Atlantic 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), North Atlantic 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). North Atlantic 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, 2007a). For example, the near absence of North Atlantic 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 the copepod, *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, 2007a). Some preliminary research has attempted to use remotely-sensed oceanographic data to predict North Atlantic 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 North Atlantic 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 North Atlantic 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. The North Atlantic right whale was historically widely distributed, ranging from latitudes of 60°N to 20°N, prior to serious declines in abundance due to intensive whaling (e.g., NMFS 2006c; Reeves et al. 2007). 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 (Winn et al. 1986). Right whales typically migrate within 65 km of shore, but individuals have been observed farther offshore (Knowlton 1997). In fact, trans-Atlantic migrations of North Atlantic right whales between the eastern U.S. coast and Norway have been documented (Jacobsen et al. 2004) which suggests a possible offshore migration path.

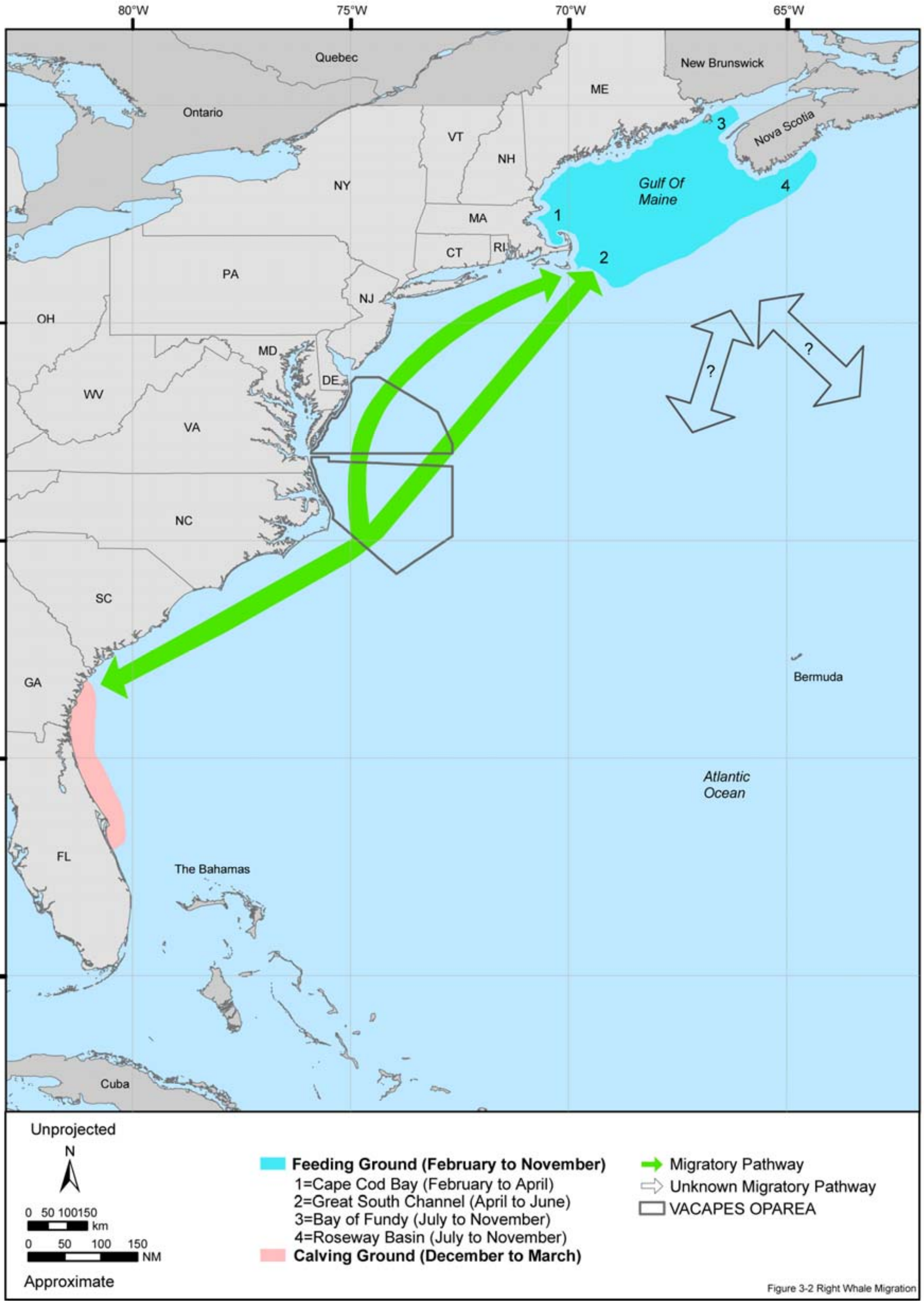

Figure 3-2. North Atlantic right whale migration patterns. This species migrates in at least two separate pathways, though some whales may remain in the feeding grounds throughout the winter. Pregnant females and some juveniles migrate to the calving grounds in late fall to winter, returning northward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

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 as well as 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; Figure 3-1).

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). 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. 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. 1986a).

The coastal waters of the Carolinas are suggested to be a migratory corridor for the North Atlantic 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 North Atlantic right whale (Winn et al. 1986).

Until better information is available on the geographic and temporal extent of the North Atlantic right whale's migratory corridor, it has been recommended that ships transit along the coast in waters deeper than 20 fathoms (37 m). This would bring ship traffic between 15 and 30 nm (24 and 48 km) from shore and minimize possible encounters with right whales (Knowlton 1997). Based on a recent analysis of sightings data collected in the mid-Atlantic from northern Georgia to southern New England between 1974 and 2002, Knowlton et al. (2002) found that the majority of right whale sightings occurred within approximately 9 km (5 nm) from shore, and 94% of all sightings were within 56 km (30 nm) from shore. This finding provides support for the previous ship traffic recommendation but also suggests that limiting ship traffic within 30 nm from shore would likely provide even more protection for right whales.

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). One individually identified North Atlantic 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). 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).

Of note is the unusual movement of a cow-calf pair in 2007. The calf was supposedly born in northeast waters; the cow was first sighted with the calf on June 2, 2007 in the Great South Channel. On July 17, this cow-calf pair was sighted southeast of Mayport, Florida. Two months later, the same cow-calf pair was sighted in the Bay of Fundy (Neuhauser 2007).

- Information Specific to the VACAPES OPAREA—The coastal waters of the Carolinas are part of a migratory corridor for the right whale (Winn et al. 1986; Knowlton et al. 2002). 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 can depend on a number of factors such as its previous reproductive history; nutritional, health, age, and social status; and/or environmental conditions of the current season. To demonstrate differences in migratory movements by North Atlantic right whales, two individuals with contrasting movement patterns are discussed. In 2000, Dr. Bruce Mate satellite-tagged a North Atlantic right whale, "Piper," whose southbound migration hugged the U.S. coastline and traversed the westernmost sections of the VACAPES OPAREA (a plot of this whale's movements can be seen at: http://oregonstate.edu/groups/marinemammal/Piper.htm). In early January 1996, an adult female right whale, "Metompkin," was found swimming and entangled in lobster-pot buoys off Jacksonville. By late January, "Metompkin" was off Charleston Harbor, and the New England Aquarium was able to equip the whale with a satellite tag and later remove the lines and buoys from the whale. "Metompkin" moved into deep waters when she traveled through the southeastern portion of the VACAPES OPAREA and then east to nearly the middle of the Atlantic (Figure 3-3).

  North Atlantic right whale sightings in very deep offshore waters of the western North Atlantic are infrequent (Knowlton et al. 2002). However, there is limited evidence suggesting that a regular offshore component exists to their distributional and migratory cycle. This evidence includes a rare occurrence off Bermuda, offshore excursions by satellite-tracked individuals (Mate et al. 1997), disappearance of North Atlantic right whales from most coastal habitats in winter, genetic and sighting data indicating additional summer grounds, and North Atlantic right whales sighted past the continental shelf break off Florida. There have also been opportunistic sightings of right whales in deep waters of the VACAPES OPAREA (Figures B-2-1 and B-2-2). There is also a lack of survey effort for North Atlantic right whales in offshore waters (specifically in the VACAPES OPAREA).

  - Winter—Knowlton (1997) estimated that 84% of the North Atlantic right whales sighted in the mid-Atlantic are seen between November and April, with peaks in December and March through April. During the winter (as early as November and through March), right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida (Winn et al. 1986). Sightings data support this observation with more right whales sighted during the winter than the other seasons (Figures B-2-1 and B-2-2). The model output predicts areas of occurrence in coastal waters of the OPAREA. A small area of increased occurrence is predicted along the shelf break near the Virginia/North Carolina border; however this is likely more a product of relatively few observations rather than a

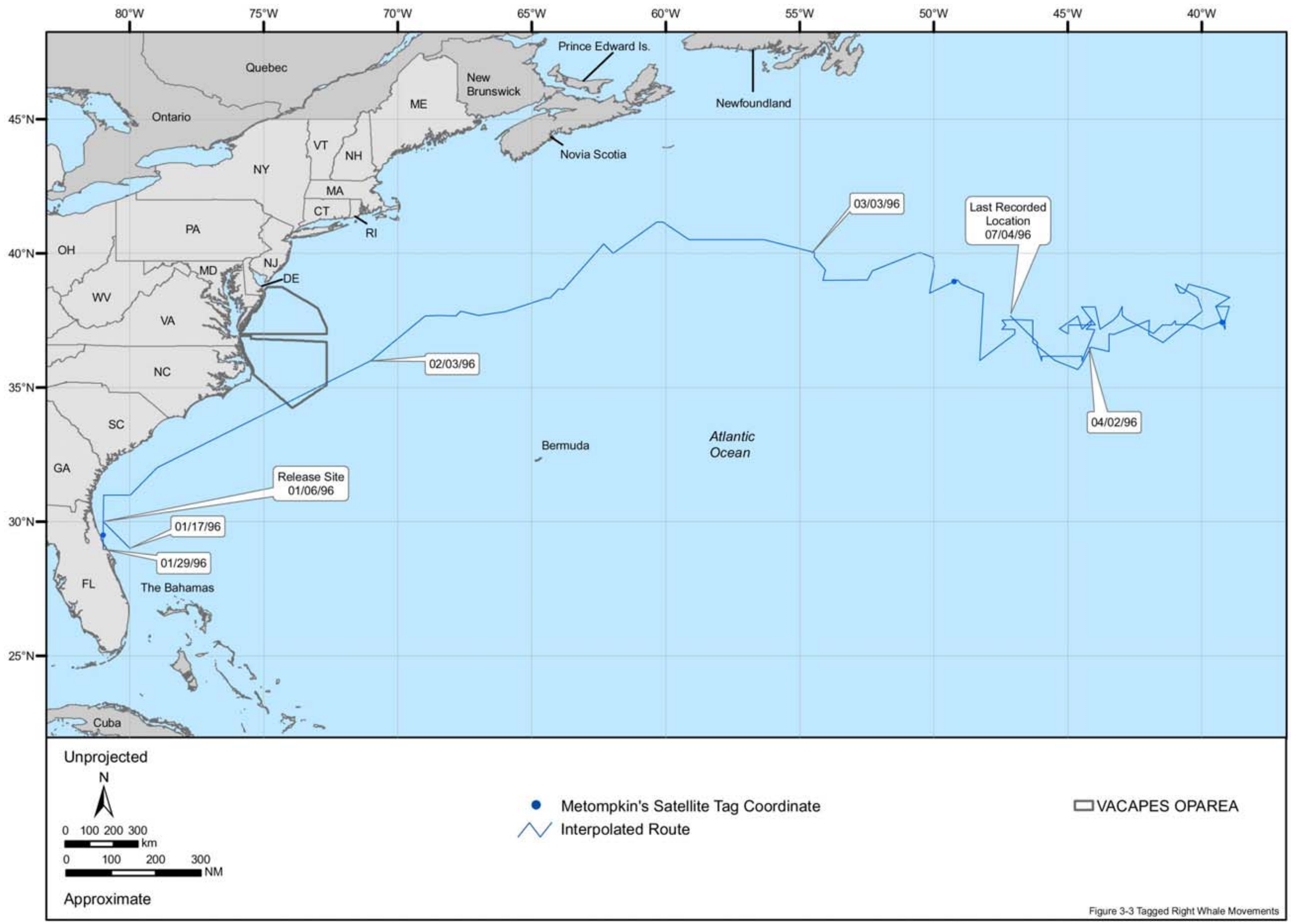

Figure 3-3. Movements of the satellite-tagged North Atlantic right whale "Metompkin" from January 1996 through July 1996. Five geographic coordinates were received while "Metompkin" was in the Charleston/Jackson OPAREA. The presumed track of the whale's movement through the Cherry Point OPAREA resulted from connecting available coordinates with a straight line. Source data: WhaleNet (1998).

true area of concentration. The patchy nature of the model out put is most likely a result of the extremely small population size and limited survey effort. Strandings and off-effort/opportunistic sightings help to supplement the model and give a more complete representation of right whale distribution throughout this region. Right whales are expected to occur inshore of the shelf break throughout this area as reflected in the distribution of off-effort sightings throughout the shelf waters of the OPAREA. The lack of on-effort sighting data is likely due to less survey effort during this time of year and the extremely low abundance of this population of right whales.

- Spring—The model output predicts no occurrence for the species in the OPAREA during this season although a small area of increased occurrence extends into shelf waters in the extreme northern tip of the OPAREA. The presence of this species in the rest of the OPAREA is recognized based on sparse sighting and stranding records (Figures B-2-1 and B-2-2). Off-effort sightings are recorded in nearshore and slope waters. As noted by Gaskin (1982), North Atlantic right whales might be seen anywhere off the Atlantic U.S. throughout the year. Sightings observed during spring are likely of right whales transiting the area on their migrations to and from breeding grounds farther south or feeding grounds farther north. Therefore, North Atlantic right whales would be expected to occur throughout the nearshore waters of the OPAREA during this season.

- Summer—The model output predicts no occurrence for the species in the OPAREA. Right whales should primarily occur farther north on their feeding grounds during this time of year and are not expected in the OPAREA. However, right whales can occasionally occur here during summer as evidenced by the few sighting and stranding records near the OPAREA (Figures B-2-1 and B-2-2).

- Fall—The model output predicts no occurrence for the species in the OPAREA during this season; however, the presence of this species here is recognized based on sparse sighting and stranding records (Figures B-2-1 and B-2-2). Off-effort sightings are recorded in nearshore and shelf waters in the OPAREA and vicinity. As noted by Gaskin (1982), North Atlantic right whales might be seen anywhere off the Atlantic U.S. throughout the year. Sightings observed during fall are likely of right whales transiting the area on their migrations to and from breeding grounds farther south or feeding grounds farther north. This is a time of a year with less survey effort than some other seasons (specifically summer).

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). Three puzzling population biology factors for the North Atlantic right whale population are the variation in interannual calf production; consistently low reproductive rates; and the number of adult females who have never been known to give birth. Genetic variability and inbreeding, potential effects of pollutants, and food supply limitations are all possible driving factors for these observations (Kraus et al. 2007).

North Atlantic right whales feed on zooplankton, particularly large calanoid copepods such as *Calanus* (Kenney et al. 1985; Beardsley et al. 1996; Baumgartner et al. 2007). The food resource in the Great South Channel and the Bay of Fundy is believed to be composed almost exclusively of *Calanus finmarchicus*, while in Cape Cod Bay, their food resource is more diverse, consisting of *Centropages typicus*, *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 North Atlantic right whales (DeLorenzo Costa et al. 2006).

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

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

***Acoustics and Hearing*—**North Atlantic right whales produce a variety of sounds, including moans, screams, gunshots, blows, upcalls, downcalls, and warbles that are often linked to specific behaviors (Matthews et al. 2001; Laurinolli et al. 2003; Vanderlaan et al. 2003; Parks et al. 2005; Parks and Tyack 2005). Sounds can be divided into three main categories: (1) blow sounds; (2) broadband impulsive sounds; and (3) tonal call types (Parks and Clark 2007). Blow sounds are those coinciding with an exhalation; it is not known whether these are intentional communication signals or just produced incidentally (Parks and Clark 2007). Broadband sounds include non-vocal slaps (when the whale strikes the surface of the water with parts of its body) and the "gunshot" sound; data suggests that the latter serves a communicative purpose (Parks and Clark 2007). Tonal calls can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls (Parks and Clark 2007). Most of these sounds range in frequency from 0.02 to 15 kHz (dominant frequency range from 0.02 to less than 2 kHz; durations typically range from 0.01 to 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 (decibels at the reference level of one micropascal at one meter) (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). Vocalization rates of North Atlantic right whales are also highly variable, and individuals have been known to remain silent for hours (Gillespie and Leaper 2001). Baumgartner et al. (2005) noted that downsweep calls by North Atlantic right whales in the 16 to 160 Hz frequency band exhibited a diel pattern (fewer calls at night) that corresponded strongly to the diel vertical migration of zooplankton.

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; Parks et al. 2007). Nowacek et al. (2004) observed that exposure to short tones and down sweeps, ranging in frequency from 0.5 to 4.5 kHz, induced an alteration in behavior (received levels of 133 to 148 dB re 1 µPa-m), but exposure to sounds produced by vessels (dominant frequency range of 0.05 to 0.5 kHz) did not produce any behavioral response (received levels of 132 to 142 dB re 1 µPa-m).

- Humpback Whale (*Megaptera novaeangliae*)

Description—Adult humpback whales are 11 to 16 m in length and are more robust than other rorquals. The body is black or dark gray, with very long (about one-third of the body length) flippers that are usually at least partially white (Jefferson et al. 1993; Clapham and Mead 1999). The head is larger than in other rorquals. The flukes have a concave, serrated trailing edge; the ventral side is variably patterned in black and white. Individual humpback whales may be identified using these patterns (Katona et al. 1979). 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. 2008). An estimated 11,570 humpback whales occur in the entire North Atlantic (Stevick et al. 2003a). The International Whaling Commission (IWC) considers the “feeding stock” to be the appropriate unit for management of humpback whales in the North Atlantic (COSEWIC 2003). Humpback whales in the North Atlantic are thought to belong to five different feeding stocks: Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland. There appears to be very little exchange between these separate feeding stocks (Katona and Beard 1990). The best estimate of abundance for the Gulf of Maine Stock is 847 individuals and is based on the results of line transect surveys in 2006; the minimum population estimate is 549 individuals (Waring et al. 2008). There is no designated critical habitat for this species.

Habitat Associations—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. 1990b; 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 deepwater during migration (Clapham and Mattila 1990; Calambokidis et al. 2001).

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.

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 associations 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. 1990b; 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; Figure 3-4). 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. 2008). A humpback whale was also sighted in the Tongue of the Ocean (Bahamas) during marine mammal surveys (Mobley 2004). There are also reports of humpback whales in the Gulf of Mexico, particularly near the Panhandle region of Florida, during this time of year (Weller et al. 1996a; MMS 2001; Pitchford 2006). None of these occurrences are fully understood. They might be due to distribution shifts, increased sighting effort, or habitat that is becoming increasingly important for juveniles (Wiley et al. 1995). 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 VACAPES OPAREA—Humpback whales occur on the continental shelf and in deep waters of the VACAPES OPAREA in fall, winter, and spring during migrations between calving grounds in the Caribbean and feeding grounds off the northeastern U.S. During the summer, humpback whales are found primarily farther north of the OPAREA at the feeding

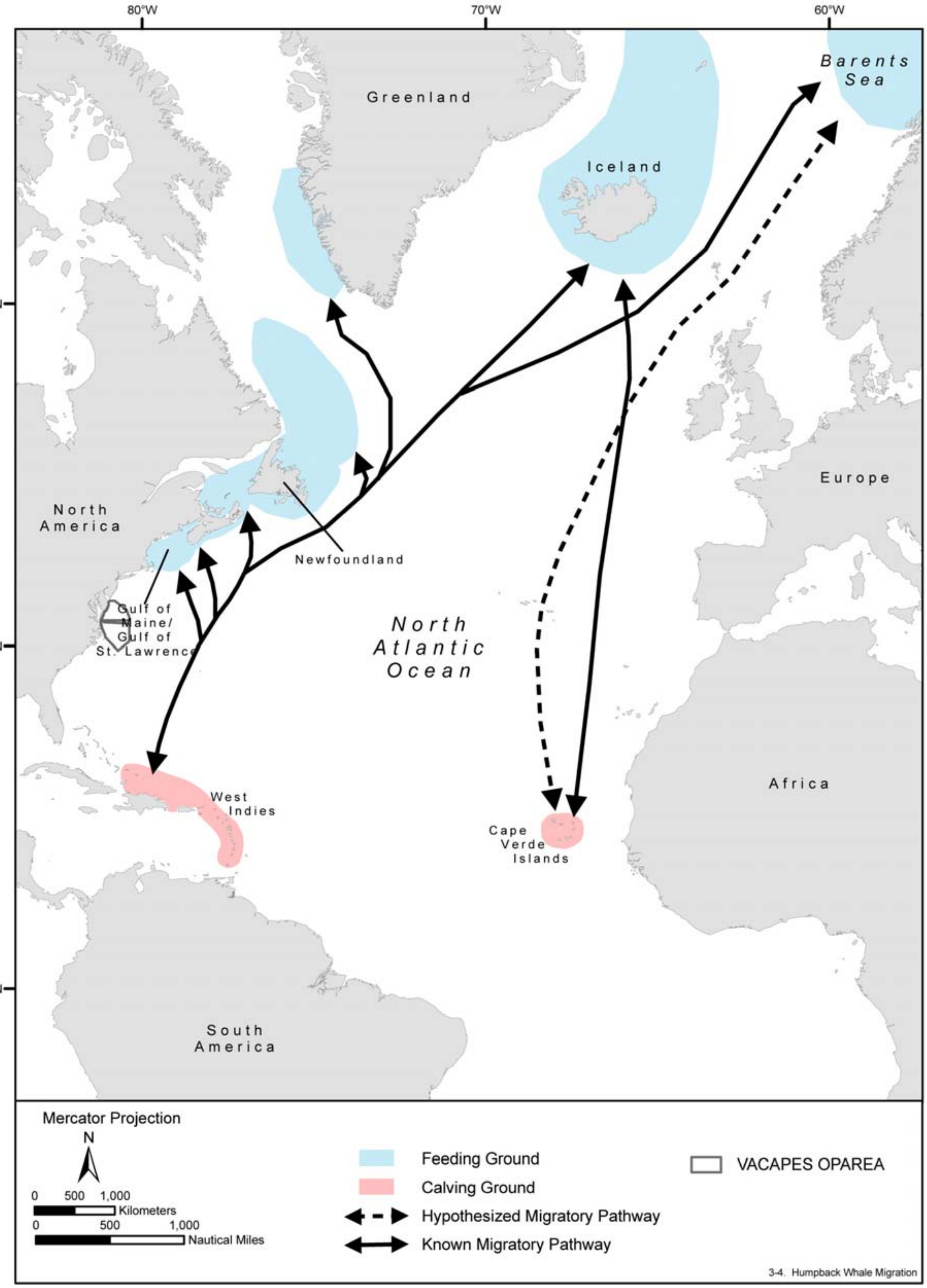

Figure 3-4. Current knowledge of the migration pathways of humpback whales in the North Atlantic Ocean. Current feeding and calving grounds and general migratory pathways are depicted. Note that humpback whales also occur outside these areas. Source information: Stevick et al. (1998), Jann et al. (2003), and Stevick et al. (2003b).

grounds. There is an increasing occurrence of humpback whale sightings and strandings during the winter (particularly January through April) 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). Sightings of humpback whales migrating through this area are likely not well-represented here due to the lack of complete survey effort in offshore waters of the OPAREA.

- Winter—Occurrence is predicted throughout much of the nearshore and shelf waters of the OPAREA. The area of greatest concentration includes shelf and slope waters off the coast of the Virginia/North Carolina border, as well as nearshore and shelf waters near Cape Hatteras, and reflects the increased use of this region during the winter months. The greater number of humpback whale observations in this region may represent individuals that have chosen to stay in higher latitudes rather than migrating south to the breeding grounds (Barco et al. 2002). The concentration of whales here also supports the hypothesis that the mid-Atlantic region may be a supplemental winter feeding ground for humpbacks (Barco et al. 2002). Primary productivity is enhanced near the northern end of the Outer Banks where the Gulf Stream collides with the colder Labrador Current, resulting in an upwelling of nutrient rich water and localized areas of prey concentration. Primary production is also enhanced by the intrusion of plume waters from Chesapeake Bay which may explain the increased occurrence predicted from near the mouth of the bay to slope waters just beyond the shelf break. It is also possible that sightings in the OPAREA during this time of year are of individuals enroute to the wintering grounds. The model output does not reflect the occurrence of this species in deep waters of the OPAREA which may be due to limited survey effort in offshore waters. However, occurrence here is supported by the off-effort sightings recorded in deep waters over the continental rise in the southeastern portion of the OPAREA (Figures B-3-1 and B-3-2).

- Spring—The model output predicts occurrence primarily in shelf/slope waters of the OPAREA. Increased concentrations are predicted near the mouth of the Chesapeake Bay; occurrence here is likely influenced by the enhanced primary productivity from the nutrient-rich plume from the bay. Several opportunistic sightings are recorded in deep waters of the OPAREA during this time of year. Humpback whales are expected to occur on the shelf, as well as farther offshore, during migrations at this time of the year(Figures B-3-1 and B-3-2).

- Summer—The model output predicts no occurrence for humpback whales in the OPAREA. Only one sighting is recorded in the OPAREA during summer; humpback whales are not expected to occur here during this season since they should be farther north on their feeding grounds (Figures B-3-1 and B-3-2).

- Fall—The model output predicts no occurrence for humpback whales in the OPAREA. Several opportunistic sightings and strandings are documented in and near the OPAREA. Sightings are mostly inshore of the shelf break; however, one sighting is documented in deep waters of the continental rise. Humpback whales are expected to occur on the shelf, as well as farther offshore, during migrations at this time of the year. Occurrence in the fall may be underrepresented due to limited survey effort (Figures B-3-1 and B-3-2).

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 five min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min; dives of greater than 30 min have been recorded (Clapham and Mead 1999). Although humpback whales have been recorded to dive as deep as 500 m (Dietz et al. 2002), on the feeding grounds they spend the majority of their time in the upper 120 m of the water column (Dolphin 1987; Dietz et al. 2002). Recent 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. 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 meausured between 151 and 189 dB re 1 µPa-m and high-frequency harmonics extending beyond 24 kHz (Au et al. 2001; Au et al. 2006). Songs have also been recorded on feeding grounds (Mattila et al. 1987; Clark and Clapham 2004). The main energy lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz. "Feeding" calls, unlike song and social sounds, are highly stereotyped series of narrow-band trumpeting calls. They are 20 Hz to 2 kHz, less than 1 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). Feeding calls have not been reliably documented in the North Atlantic.

While no measured data on hearing ability is available for this species, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Houser et al. (2001) produced the first humpback whale audiogram (using a mathematical model), which was u-shaped and conformed to the typical mammalian presentation. The area of best hearing, or sensitivity, was observed between frequencies from 700 Hz to 10 kHz but the maximum range of hearing was identified between 200 Hz to 14 kHz.. Au et al. (2006) noted that if the popular notion that animals generally hear the totality of the sounds they produce is applied to humpback whales, this suggests that its upper frequency limit of hearing is as high as 24 kHz.

- Sei Whale (*Balaenoptera borealis*)

Description—Adult sei whales are up to 18 m in length and are mostly dark gray in color with a lighter belly, often with mottling on the back (Jefferson et al. 1993). 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 stock structure of sei whales in the North Atlantic is uncertain. Both the NMFS and the IWC recognize a minimum of two stocks, although there may be at least one other (Donovan 1991; Perry et al. 1999; Waring et al. 2008). The Nova Scotia Stock occurs in U.S. Atlantic waters (Waring et al. 2008). The current minimum population estimate of this stock is 128 individuals (Waring et al. 2008). The best estimate of abundance for this stock is 207 individuals; however, this is considered conservative due to uncertainties in population structure and movements between surveyed and unsurveyed areas (Waring et al. 2008). 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 Associations—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 deepwater, and land station catches were usually taken from along or just off the edges of the continental shelf.

Distribution—Sei whales have a worldwide distribution but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 1987). Sei whales are also known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades (Horwood 1987; Schilling et al. 1992; Clapham et al. 1997; Gregr et al. 2005).

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 1998b). 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 1998b). 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 VACAPES OPAREA—There are insufficient data to model the predicted occurrence of sei whales in the OPAREA. Sightings and strandings are documented in or near the OPAREA throughout the year (Figure B-4). Sightings are documented in continental shelf and slope waters as well as farther offshore (Figure B-4). The winter range of most rorquals (blue, fin, sei, and minke whales) is hypothesized to be in offshore waters (Kellogg 1928; Gaskin 1982). Although this species is considered rare within the OPAREA, any occurrences would be expected throughout the OPAREA year-round based on known habitat associations and documented sightings in the OPAREA. During the summer, sei whales are generally farther north on feeding grounds around the eastern Scotian Shelf or Grand Banks; however, sightings within the OPAREA during this time of year may represent individuals making early or late migrations to the feeding grounds.

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 1985b).

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 2006e).

Status—Fin whales are classified as endangered under the ESA (NMFS 2006e) and, therefore, are considered a strategic stock (Waring et al. 2008). The most recent best estimate of abundance is 2,269 in individuals in the western North Atlantic stock while the minimum population estimate is 1,678 (Waring et al. 2008). No critical habitat is designated for this species.

Habitat Associations—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. 1992). 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. 1990b; Kenney et al. 1996; 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). 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). Waring et al. (1992) reported sighting fin whales along the edge of a warm core eddy and a remnant near Wilmington Canyon, along the northern wall of the Gulf Stream. Clark and Gagnon (2004) determined that vocalizing fin whales show strong associations, even during summer months, with shelf breaks, seamounts, or other areas where food resources are known to occur.

Distribution—Fin whales are broadly distributed throughout the world's oceans, usually in temperate to polar latitudes and less commonly in the tropics (Jefferson et al. 2008). In general, fin whales are more common north of about 30ºN than they are in tropical zones (NMFS 1998b). 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 1985a; NMFS 1998b). 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). 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 deepwater hydrophone arrays in the North Atlantic (Clark 1995).

Based on passive acoustic detection using Navy Sound Surveillance System (SOSUS) hydrophones in the western North Atlantic (Clark 1995), fin whales are believed to move southward in the fall and northward in spring. The location and extent of the wintering grounds are poorly known (Aguilar 2002). Fin whales have been seen feeding as far south as the coast of Virginia (Hain et al. 1992).

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).

- <u>Information Specific to the VACAPES OPAREA</u>—Fin whales are more commonly encountered north of Cape Hatteras (CETAP 1982; Hain et al. 1992; Waring et al. 2008). The dynamics of the Gulf Stream in the Cape Hatteras region probably play a role in the zoogeography of fin whales throughout much of the year. Fin whales may occur in both continental shelf and offshore waters of the OPAREA year-round. Preliminary results from the Navy's deepwater hydrophone arrays indicate a substantial deep-ocean component to fin whale distribution (Clark 1995).

- Winter—The model predicts occurrence throughout most of the nearshore and shelf waters of the OPAREA, as well as steeply sloping waters over the shelf break (Figures B-5-1 and B-5-2). This occurrence accounts for the predominance of fin whales over the continental shelf (CETAP 1982). Upwelling that forms along the western perimeter of the Gulf Stream likely influences fin whale occurrence here. Fin whales are known to associate with warm core rings in this region and along the northern wall of the Gulf Stream off North Carolina (Waring et al. 1992). Stranding data suggest that calving may take place near Cape Hatteras during this season (particularly December and January) (Hain et al. 1992).

- Spring—The greatest fin whale abundance and occurrence occurs in spring off the northeast U.S. (Hain et al. 1992); this is also the season with the most fin whale sightings documented in the VACAPES OPAREA. The model output for this season is probably most indicative of the true distribution of fin whales in the OPAREA; fin whales are anticipated to occur throughout nearshore, shelf, and slope waters (Figures B-5-1 and B-5-2) which accounts for migratory movements into waters over the continental shelf. Occurrence also extends into deep (3,000 m) offshore waters; it is possible that not all fin whales make inshore/offshore migratory movements, which could account for some fin whales occurring in deeper OPAREA waters.

- Summer—Predicted occurrence is similar to the winter and spring seasons but appears to be more limited to deeper shelf waters (Figures B-5-1 and B-5-2). Sightings are mostly recorded along the shelf break and in the northern portion of the OPAREA which may reflect greater survey effort, possible feeding ground presence, and changes in prey distribution.

- Fall—The relatively low number of sightings throughout the OPAREA may be due to limited survey effort during this season. Sightings are predominantly over the continental shelf; however, a few offshore observations are documented in deep waters over the continental rise (Figures B-5-1 and B-5-2). Depending on the timing of inshore/offshore migratory movements, it is probable that fin whales travel to offshore waters prior to winter. It has been suggested that calving takes place near the MAB from October through January (Hain et al. 1992). Therefore, it is likely that some VACAPES sightings during this season are of mother/calf pairs.

Behavior and Life History—Fin whales feed by “gulping” where up to 50% of the animal’s body volume in seawater enters the mouth and distends pleats along the throat (Pivorunas 1979; Orton and Brodie 1987; Lambertsen et al. 1995). They prey upon a wide variety of small, schooling prey (especially herring, capelin, and sand lance) including squid and crustaceans (krill and copepods) (see review in Kenney et al. 1985; NMFS 2006e). Single fin whales are most common, but they do gather in groups at times, especially when good sources of prey are aggregated. Fin whales are frequently observed in large, multi-species feeding aggregations with humpback whales, minke whales, and Atlantic white-sided dolphins (CETAP 1982).

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; however, the location of breeding grounds is unknown. Weaning may occur at six months (Boyd et al. 1999). Calving intervals in northeastern U.S. waters range from two to six years (Agler et al. 1990).

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 1998a). At least two discrete populations are found in the North Atlantic. One population ranges from West Greenland to New England and is centered in eastern Canadian waters; the other includes individuals found in Icelandic waters and south to northwest Africa (Sears et al. 1990; Ramp 2006). There are no current estimates of abundance for the North Atlantic blue whale (Waring et al. 2008). However, the 308 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. 2008). There is no designated critical habitat for this species in the North Atlantic.

Habitat Associations—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 associations with 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 associations, even during the summer months, with shelf breaks, seamounts, or other areas where food resources are known to occur.

Distribution—Blue whales are distributed from the ice edge to the tropics and subtropics in both hemispheres (Jefferson et al. 1993). The longest documented migration for this species is between Iceland and Mauritania at an estimated 5,200 km (Sears et al. 2005). Stranding and sighting data suggest that blue whale occurrence in the Atlantic extended south to Florida and the Gulf of Mexico; however, the southern limit of this species' range is unknown (Yochem and Leatherwood 1985). 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). Sightings in the Gulf of Maine and U.S. EEZ have been made in late summer and early fall (August and October) (CETAP 1982; Wenzel et al. 1988). Researchers using the Navy-integrated undersea surveillance system (IUSS) resources detected blue whales throughout the open Atlantic south to at least the Bahamas (Clark 1995), suggesting that all North Atlantic blue whales may comprise a single stock (NMFS 1998a).

- Information Specific to the VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. In the OPAREA there is only one blue whale record, a sighting made between the 3,000 and 4,000 m isobaths which was noted in the pre-survey CETAP historical data collection (Figure B-6). The blue whale is primarily a deepwater species but is occasionally found in shallow, shelf waters. Winter range of most rorquals (blue, fin, sei, and minke whales) is hypothesized to be in offshore waters (Kellogg 1928; Gaskin 1982). Although this species is considered rare within the OPAREA, any occurrences would be expected in waters seaward of the 50 m isobath throughout the OPAREA during fall, winter, and spring based on known habitat associations. Blue whales are not expected to occur in the OPAREA during summer when they should primarily occur farther north in their feeding ranges.

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). Breeding grounds are thought to be located in tropical/subtropical waters; however, exact locations are unknown (Jefferson et al. 2008).

Blue whales spend greater than 94% of their time below the water’s surface (Lagerquist et al. 2000). Not much is known about blue whale diving behavior in the western North Atlantic. In the eastern North Pacific, 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. Blue whales produce both long- and short-duration calls: one set of 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 1998a; Mellinger and Clark 2003). These calls are presented in series and are referred to as “songs.” Short-duration sounds are transient, frequency-modulated (“B”-type) or frequency-constant (“A”-type) calls that have a higher frequency range and shorter duration than song notes and also more often sweep 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). Short-duration sounds are less than 5 sec (A-type) or about 11 sec (B-type) 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 1998a; 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). Additionally from the North Atlantic blue whales, Mellinger and Clark (2003) present data on two tonal signals – one sound with slightly shorter duration than A or B type calls and a second call type with an inflection and frequenc range up to 70 Hz followed by a return to 25 Hz. 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 2006a) although as a species, the sperm whale is not immediately threatened (Reeves et al. 2003). Due to ESA listing, this is a strategic stock (Waring et al. 2008). The current combined best estimate of sperm whale abundance from Florida to the Bay of Fundy in the western North Atlantic is 4,804 individuals (Waring et al. 2008). The minimum population estimate for the western North Atlantic sperm whale is 3,539 (Waring et al. 2008). Stock structure for sperm whales in the North Atlantic is unknown (Dufault et al. 1999). No critical habitat is designated for this species.

Habitat Associations—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 association by sperm whales. Most tagged sperm whales in the Gulf of Mexico had strong associations with 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 (Mate 2003). 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). 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 “whaling grounds” are usually correlated with areas of increased primary productivity caused by upwelling (Jaquet et al. 1996). 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). These eddies are mesoscale features which produce upwelling of nutrients that enhance local plankton growth (Wormuth et al. 2000). Data from the Gulf of Mexico suggest that sperm whales adjust their movements to stay in or near these cold-core eddies (Davis et al. 2002), which demonstrate that sperm whales can shift their movements in response to prey density.

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

Distribution—Sperm whales are found from tropical to polar waters in all oceans of the world between approximately 70°N and 70°S (Rice 1998). Females use a subset of the waters where males are regularly found. Females are normally restricted to areas with SST greater than approximately 15°C, whereas males, and especially the largest males, can be found in waters as far poleward as the pack ice with temperatures close to 0° (Rice 1989). The thermal limits on female distribution correspond approximately to the 40° parallels (50° in the North Pacific; Whitehead 2003). Photo-identification data analyzed by Jaquet et al. (2003) revealed that seven female sperm whales moved into the Gulf of California from the Galápagos Islands, traveling up to 3,803 km; these are among the longest documented movements for female sperm whales.

Sperm whales are the most-frequently sighted whale seaward of the continental shelf off the eastern U.S. (CETAP 1982; Kenney and Winn 1987; Waring et al. 1993). In Atlantic EEZ waters, sperm whales appear to have a distinctly seasonal distribution (CETAP 1982; Scott and Sadove 1997). In winter, sperm whales are primarily concentrated east and northeast of Cape Hatteras. However, in spring, the center of concentration shifts northward to off Delaware and Virginia and is generally widespread throughout the central MAB and southern Georges Bank. Summer distribution is similar to spring but also includes the area northeast of Georges Bank and into the Northeast Channel region as well as shelf waters south of New England. Fall sperm whale occurrence is generally south of New England over the continental shelf, with a remaining contingent over the continental shelf break in the MAB. Despite these seasonal shifts in concentration, no movement patterns affect the entire stock (CETAP 1982). Although concentrations shift depending on the season, sperm whales are generally distributed in Atlantic EEZ waters year-round.

- Information Specific to the VACAPES OPAREA—Worldwide, sperm whales exhibit a strong affinity for deep waters beyond the continental shelf break (Rice 1989). The recorded observations of sperm whales in the OPAREA and vicinity support this trend, with sightings consistently recorded in waters seaward of the shelf break (Figures B-7-1 and B-7-2).

  - Winter—Sightings are distributed throughout slope and deep waters of the OPAREA. Survey effort during this season, especially in the deep waters of the OPAREA, is low and may explain the paucity of sighting records when compared to spring and summer in particular. The predicted occurrence of sperm whales during this season includes waters just inshore and seaward of the shelf break (Figures B-7-1 and B-7-2). This region includes steeply sloping areas and waters over Norfolk, Washington, Accomac, and Baltimore canyons which are localized areas of prey concentration. Gulf Stream features are thought to be high-use habitat for sperm whales because they are regions of enhanced productivity (Waring et al. 1992). Therefore, this area of occurrence is also likely influenced by the path of the Gulf Stream; sperm whales are often found along the edges of the Gulf Stream and within warm-core rings (Waring et al. 1993; Jaquet et al. 1996; Griffin 1999). Sperm whales likely associate with warm-core rings that separate from the Gulf Stream north of Cape Hatteras. Based on sighting data and deepwater habitat associations, sperm whales are expected to occur seaward of the shelf break throughout the OPAREA.

  - Spring—Spring distribution appears generally more widespread through the central portion of the MAB which is reflected in the distribution of sightings records for this season. The model output predicts occurrence from deeper shelf waters and extending seaward over the abyssal plain (Figures B-7-1 and B-7-2). The areas of greatest concentration are in waters over the continental slope and the continental rise near the center of the OPAREA. As in winter, occurrence of sperm whales in this region is likely influenced by localized prey concentrations due to upwelling associated within the Gulf Stream meanders and eddies, as well as areas of steep bottom topography. Although the model output predicts that this species will occur inshore of the shelf break, occurrence here is not likely based on sighting data and the deepwater habitat associations of this species. Based on sighting data and deepwater habitat associations, sperm whales are expected to occur seaward of the shelf break throughout the OPAREA.

- Summer—The model output for this season is similar to spring with occurrence predicted from deeper shelf waters and extending seaward over the abyssal plain (Figures B-7-1 and B-7-2). Apparent areas of increased occurrence extend over continental slope waters and are likely influenced by the dynamic upwelling features associated with the Gulf Stream's northern wall and the steep bottom topography. Based on sighting data and deepwater habitat associations, sperm whales are expected to occur seaward of the shelf break throughout the OPAREA.

- Fall— Fall is the season with the fewest observations, likely due to limited survey effort (particularly offshore) and high Beaufort sea states that can make sighting cetaceans difficult during this time of year. Predicted occurrence based on the model output is similar to the rest of the year although compressed due to limited data. Despite the lack of a large amount of pobservations, sperm whales should generally be expected to occur seaward of the shelf break throughout the OPAREA.

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; however, the location of specific breeding grounds is unknown. 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 (Fiscus and Rice 1974; Rice 1989; Clarke 1996).

Sperm whales forage during deep dives that routinely exceed a depth of 400 m and a duration of 30 min (Watkins et al. 2002). They are capable of diving to depths of over 2,000 m with durations of over 60 min (Watkins et al. 1993). Sperm whales spend up to 83% of daylight hours underwater (Jaquet et al. 2000; Amano and Yoshioka 2003). Males do not spend extensive periods of time at the surface (Jaquet et al. 2000). In contrast, females spend prolonged periods of time at the surface (1 to 5 hrs daily) without foraging (Whitehead and Weilgart 1991; Amano and Yoshioka 2003). An average dive cycle consists of about a 45 min dive with a 9 min surface interval (Watwood et al. 2006). The average swimming speed is estimated to be 0.7 m/sec (Watkins et al. 2002). Dive descents for tagged individuals average 11 min at a rate of 1.52 m/sec, and ascents average 11.8 min at a rate of 1.4 m/sec (Watkins et al. 2002). North Atlantic sperm whales primarily forage at depths of 500 to 1,100 m but may also take prey in waters as shallow as 300 m (Palka and Johnson 2007).

Acoustics and Hearing—Sperm whales are highly vocal and produce short-duration (generally less than 3 sec), broadband clicks at varying repetition rates that are 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). Generally, most of the acoustic energy is present at frequencies below 4 kHz, although diffuse energy up to 20 kHz has been reported (Thode et al. 2002). The source levels can be up to 236 dB re 1 µPa-m (Møhl et al. 2003). Thode et al. (2002) suggested that the acoustic directivity (angular beam pattern) from sperm whales must range between 10 and 30 dB in the 5 to 20 kHz region. Zimmer et al. (2005b) employed a three-dimensional beam pattern away to confirm the bent-horn hypothesis for the production of regular clicks: early recordings were unable to confirm the directivity of these pulsed sounds which led to the assumption that sperm whales did not echolocate like smaller odontocetes (Watkins 1980). Data from tagged whales in the Ligurian Sea show that sperm whale clicks are composed of three components with differing characteristics, all generated by the phonic lips (below the blowhole) and very directional, thus confirming that these clicks are used in echolocation for foraging (Zimmer et al. 2005b). 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 at 1 m (Teloni et al. 2005).

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).

The anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic frequency sounds (Ketten 1992). 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 manatees around Florida are divided into four relatively discrete management units, each representing a significant portion of the species' range (USFWS 2007). West Indian manatees found along the Atlantic U.S. coast make up two subpopulations: the Atlantic Region and the Upper St. Johns River Region (USFWS 2007). Manatees from the western coast of Florida make up the other two subpopulations: the Northwest Region and the Southwest Region (USFWS 2007). West Indian manatee numbers are assessed by aerial surveys during the winter months when manatees are concentrated in warm-water refuges. Minimum population estimates for each management unit are as follows: Atlantic coast (1,447 individuals), Upper St. Johns River (112 individuals), Northwest (377 individuals), and Southwest (1,364 individuals) (USFWS 2007). The best minimum population estimate for manatees throughout Florida is approximately 3,300 individuals based on the statewide count at warm-water refuges and adjacent areas in January 2001 (USFWS 2007). Although surveys have been conducted since 2001, the 2001 estimate is still considered the best minimum population estimate because the weather conditions for that survey were particularly ideal (USFWS 2007). The most recent aerial surveys were conducted between January 30 and February 1, 2007 and produced a preliminary abundance estimate of 2,812 individuals for Florida (1,400 along Florida's Gulf Coast and 1,412 on the Atlantic coast) (FMRI 2007).

In 1976, critical habitat was designated for the West Indian manatee in Florida (USFWS 1976). The designated area included all of the West Indian 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 been infrequently 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 2002b; USFWS 2002a). 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 2002b; USFWS 2002a).

Habitat Associations—Sightings of West Indian manatees are restricted to warm freshwater, estuarine, and extremely nearshore coastal waters. However manatees may be seen farther from shore where shallow waters extend farther from land (Beck 2006b). Shallow seagrass beds close to deep channels are preferred feeding areas in coastal and riverine habitats (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 West Indian manatees in the Caribbean Sea (Rathbun et al. 1985). West Indian 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 (Fertl et al. 2005).

Distribution—West Indian manatees occur in warm, subtropical, and tropical waters of the western North Atlantic Ocean, from the southeastern U.S. to Central America, northern South America, and the West Indies (Lefebvre et al. 2001). West Indian manatees occur along both the Atlantic and Gulf coasts of Florida. West Indian manatees are sometimes reported in the Florida Keys; these sightings are typically in the upper Florida Keys, with some reports as far south as Key West (Moore 1951a, 1951b; Beck 2006b). During winter months, the West Indian 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) extending into southern Georgia. As water temperatures rise in spring, West Indian 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).

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).

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).

Although West Indian manatees are expected to inhabit nearshore areas, a few individuals have been sighted offshore. A West Indian manatee hit by a boat in Louisiana was determined to be an individual previously photographed in the Tampa Bay, FL area (Fertl et al. 2005). A West Indian manatee photographed in January 2000 in the Bahamas was matched to a West Indian manatee sighted as a juvenile in 1994 on the west coast of Florida, indicating the potential for offshore movements (Reid 2000). Reynolds and Ferguson (1984) reported sightings of two West Indian manatees 61 km northeast of the Dry Tortugas Islands, an area not considered to be part of this species' range. "Mo," a radio-tagged West Indian manatee that had been raised in captivity and released at Crystal River, FL, wandered offshore and then apparently drifted south with offshore currents and was "rescued" in deepwater 37 km northwest of the Dry Tortugas (Lefebvre et al. 2001). Another West Indian 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).

West Indian manatees off the east coast of Florida are also known to occasionally make their way farther 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). Perhaps the most famous long distance movements of any West Indian manatee were exhibited by the animal known as "Chessie," who gained fame when he spent an extended period of time in a Chesapeake tributary in 1994. In 1995, Chessie swam to Rhode Island in the summer, returned to Florida for the winter, and traveled north again to Virginia where he was seen in 1996 (USGS 2001). In early September 2001, "Chessie" was once again sighted in Virginia (USGS 2001). More recently, in August 2006, a West Indian manatee was sighted in waters off Rhode Island, Massachusetts, and in the Hudson River in New York City (Anonymous 2006; Beck 2006a).

- Information Specific to the VACAPES OPAREA—There are several unpublished records and personal observations of manatees throughout this region. Manatees have been reported near the OPAREA as far north as the Potomac River (sighting in August 1980) and Buckroe Beach, Hampton City, Chesapeake Bay (stranding in October 1980) (Rathbun et al. 1982). Over 70 West Indian manatee observations have been reported in North Carolina rivers, estuaries, and open ocean waters (Schwartz 1995). The vast majority of sightings in North Carolina waters are of subadults (Schwartz 1995). It is possible that West Indian manatees may be expanding their range into North Carolina waters (Schwartz 1995). Based on their known habitat associations, manatees could occur throughout the freshwater, estuarine, and nearshore coastal waters in or near the OPAREA year-round. Any occurrences of the West Indian manatee here are considered to be extralimital (Figure B-29).

Behavior and Life History—Two important aspects of the West Indian manatee's physiology influence behavior: nutrition and metabolism. West Indian 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 refuges (Hartman 1979).

West Indian manatees are not gregarious and are most often observed alone (Hartman 1979). West Indian manatees in Florida do, however, aggregate in large, unorganized groups around warm-water sources during the cooler months (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).

West Indian 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 s (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, West Indian 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 33 non-endangered or non-threatened marine mammal species with known or potential occurrence in the VACAPES OPAREA: two baleen whales, 27 toothed whales, and four seal species. For most marine mammal species that occur in the VACAPES OPAREA, there are few records of their occurrence. 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 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 in the North Atlantic Ocean: Canadian East Coast, West Greenland, central North Atlantic, and northeastern North Atlantic (Donovan 1991). 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 45ºW and south to the Gulf of Mexico (Waring et al. 2008). The best estimate of abundance for the Canadian East Coast stock is 3,312 individuals; the minimum population estimate is 1,899 individuals (Waring et al. 2008).

  Habitat Associations—Off eastern North America, minke whales generally remain in waters over the continental shelf, including inshore bays and estuaries (Mitchell and Kozicki 1975; Murphy 1995; Mignucci-Giannoni 1998). 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. 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 within fine-scale eddies; these eddies form around islands during tidal retreat (Johnston et al. 2005a). Ingram et al. (2007) reported minke whales feeding in areas with headland wakes in the Bay of Fundy (functioning similarly to create areas of upwelling and fronts that can aggregate prey).

  Distribution—Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993); they are less common in the tropics than in cooler waters. This species is more abundant in New England waters rather than the mid-Atlantic (Hamazaki 2002). The southernmost sighting in recent NMFS shipboard 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 minke whale occurrence off the northeastern U.S. During 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. 2008). 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 the winter months (November through March) in the western North Atlantic from Bermuda to the West Indies (Winn and Perkins 1976; Mitchell 1991; Mellinger et al. 2000).

- Information Specific to the VACAPES OPAREA—Minke whales are assumed to have a similar life history as the other rorquals, with seasonal offshore/inshore movements and a population shift north into summer feeding grounds. Minke whales generally occupy the continental shelf and are widely scattered in the mid-Atlantic region (CETAP 1982). There is a more common occurrence farther north of the OPAREA. The dynamics of the Gulf Stream in the Cape Hatteras region probably play a role in the zoogeography of minke whales throughout much of the year. Most sightings in the OPAREA and vicinity are recorded over the continental shelf; few are scattered in slope waters just beyond the shelf break (Figures B-8-1 and B-8-2). The paucity of sighting data here is likely due to incomplete survey coverage in the OPAREA, especially during winter and fall.

  - Winter—Few sightings are recorded during this time of year (Figures B-8-1 and B-8-2) although minke whales have been detected (by passive acoustic means) in the southern portion of the western North Atlantic during this time of year (Clark 1995). Minke whales off the U.S. Atlantic Coast are thought to migrate offshore and southward in winter (Mitchell 1991; Mellinger et al. 2000); sightings have been reported in deep waters during this time of year (Slijper et al. 1964; Mitchell 1991). The low number of sightings during this season may be a result of limited survey coverage in offshore waters of the OPAREA. Minke whales may occur in shelf and deep waters north of Cape Hatteras during this time of year. South of Cape Hatteras, minke whales may occur just inshore of the shelf break and seaward of the shelf break in the OPAREA. The change in occurrence patterns just south of Cape Hatteras takes into consideration the steep bathymetric gradient.

  - Spring—This is the season with the most sightings recorded in the OPAREA; the majority of sightings are in waters over the continental shelf. The model output predicts occurrence over the continental shelf and shelf break throughout much of the OPAREA; increased occurrence is anticipated just inshore of the shelf break off northern Virginia and Maryland. During this time of year, minke whales may occur in shelf and offshore waters of the OPAREA, most likely representing early or late migrating individuals. Spring and summer are also the seasons with the most observations of feeding whales in the OPAREA. Therefore, it is possible that VACAPES OPAREA is being used as a supplemental feeding area, particularly in upwelling zones influenced by the Gulf Stream's northern wall (Figures B-8-1 and B-8-2).

  - Summer—There are only two observations within the OPAREA during summer. Minke whales are expected to occur at higher latitudes on their primary feeding grounds during this time of year which likely explains the paucity of sightings in the OPAREA. In addition, minke whales migrate northward through both continental shelf and offshore waters during this season (Stewart and Leatherwood 1985). It is possible that the lack of sightings of minke whales here is due to the limited survey coverage in offshore waters.

- Fall—The model output predicts no occurrence of minke whales in the OPAREA for this season (Figures B-8-1 and B-8-2) although minke whales have been detected by passive acoustic means) in the southern portion of the western North Atlantic during this time of year (Clark 1995). Only one sighting is recorded in slope waters of the OPAREA.

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). Location of specific breeding grounds is unknown though it is thought to be in areas of low latitude (Jefferson et al. 2008). Minke whales reach sexual maturity at an age of five to seven years (Stewart and Leatherwood 1985; Olsen and Sunde 2002). 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), as well as copepods and krill (Horwood 1990). Minke whales tend to feed on whatever food source is most abundant in a given area.

Diel and seasonal variation in surfacing rates are documented for this species; this is probably due to changes in feeding patterns (Stockin et al. 2001). Dive durations of 7 to 380 sec are recorded in the eastern North Pacific and the eastern North Atlantic (Lydersen and Øritsland 1990; Stern 1992; Stockin et al. 2001). Mean time at the surface averages 3.4 sec (S.D.=$\pm$0.3 sec) (Lydersen and Øritsland 1990). Stern (1992) described a general surfacing pattern of minke whales consisting of about four surfacings interspersed by short-duration dives averaging 38 sec. After the fourth surfacing, there was a longer duration dive ranging from approximately 2 to 6 min.

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

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

- Bryde's Whale (*Balaenoptera edeni/brydei*)

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 (Jefferson 2006).

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 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 western North Atlantic (Waring et al. 2008).

Habitat Associations—Bryde's whales are found both offshore and near the coasts in many regions. In the Gulf of Mexico, all Bryde's whale sightings have been near the shelf break in and near DeSoto Canyon (Mullin et al. 1994c; Davis and Fargion 1996b; Jefferson and Schiro 1997; Davis et al. 1998; Davis et al. 2000). Off eastern Venezuela, Bryde's whales are often sighted in the shallow waters between Isla Margarita and Peninsula de Araya, as well as into waters where there is a steep slope, such as the Cariaco Trench (Notarbartolo di Sciara 1982). Along the Brazilian coast, distribution and seasonal movements of the Bryde's whale appear to be influenced by the behavior, distribution, and abundance of Brazilian sardine (*Sardinella brasiliensis*) schools which approach the coast to spawn in shallow waters (Zerbini et al. 1997). The Bryde's whale appears to associate with waters 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 of 40° in the northern hemisphere or south of 40° in the southern 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. 1994c). 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 VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. 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). One Bryde's whale stranding is recorded from the winter of 1927 well within Chesapeake Bay (Mead 1977). A few unidentified Bryde's/sei whale records are also documented near the shelf break off the coast of Virginia (DoN 1995). Although this species is considered rare within the OPAREA, any occurrences would be expected seaward of the shoreline in the OPAREA year-round.

Behavior and Life History—This species is generally seen alone or in pairs (Tershy 1992), although they can be seen 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, and locations of specific breeding areas are unknown. There is a two-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 0.25 sec to several seconds; and they 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 *K. 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 be an Atlantic and a Pacific species of dwarf sperm whales; however, more data are needed to make such a 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 3.8 m and 2.7 m, respectively (Jefferson et al. 2008).

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. 2008). The best estimate of abundance for both species combined in the western North Atlantic is 395 individuals; the minimum population estimate is 285 individuals (Waring et al. 2008). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al. 2008).

Habitat Associations—*Kogia* spp. 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* spp. may associate with frontal regions along the continental shelf break and upper continental slope, where higher epipelagic zooplankton biomass may enhance the densities of squids, their primary prey (Baumgartner et al. 2001). Dwarf sperm whales in The Bahamas were found in waters with bottom depths ranging from 94 to 883 m (MacLeod et al. 2004). In Hawaiian waters, this species was found in waters up to 3,200 m in depth (Baird 2005).

There appear to be some habitat association 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; Plön 2004). However, after first suggesting this, Ross (1984) later indicated that the difference may be more in terms of a difference between juveniles and adults, with juveniles being more coastal, perhaps in both species. Unfortunately, most studies are based on stranding records, which do not provide the best evidence on habitat selection, and they often appear to ignore Ross' (1984) reinterpretation of his own earlier conclusion.

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

In conclusion, although the dwarf sperm whale does appear to prefer more tropical waters, the exact habitat associations 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, stranding records of the pygmy sperm whale have been documented as far north as the northern Gulf of St. Lawrence, New Brunswick, and parts of eastern Canada (Piers 1923; Baird et al. 1996; McAlpine et al. 1997; Measures et al. 2004) and as far south as Colombia and Brazil (de Carvalho 1967; Geise and Borobia 1987; Muñoz-Hincapié et al. 1998). Pygmy sperm whales are also found in the Gulf of Mexico (Gunter et al. 1955; Hysmith et al. 1976; Baumgartner et al. 2001) and in the Caribbean (MacLeod and Hauser 2002).

The northern range of the dwarf sperm whale is largely unknown; however, multiple strandings have been recorded on the eastern coast of the U.S. as far north as North Carolina (Hohn et al. 2006) and Virginia (Potter 1979; Morgan et al. 2002). Records of strandings and incidental captures indicate the dwarf sperm whale may range as far south as the Northern Antilles in the North Atlantic and Brazil in the South Atlantic (Muñoz-Hincapié et al. 1998). Dwarf sperm whales also occur in the Caribbean (Caldwell and Caldwell 1973; Cardona-Maldonado and Mignucci-Giannoni 1999) and the Gulf of Mexico (Jefferson and Schiro 1997; Davis et al. 2002).

- <u>Information Specific to the VACAPES OPAREA</u>—*Kogia* spp. generally occur along the continental shelf break and over the continental slope (e.g., Baumgartner et al. 2001; McAlpine 2002). Few sightings are recorded in the OPAREA which is likely due to limited survey coverage throughout most of the deep waters of this region (especially during winter and fall) as well as generally cryptic behavior and avoidance reactions away from ships (Figures B-9-1 and B-9-2). However, strandings are relatively common, particularly along the North Carolina coast during all seasons and support the likelihood of *Kogia* occurrence in the OPAREA year-round. Although pygmy sperm whales are considered to occur regularly in the OPAREA, only rare occurrences of dwarf sperm whales are anticipated.

  - <u>Winter</u>—The model output predicts no occurrence in the OPAREA during this time of year due to the lack of sighting data (Figures B-9-1 and B-9-2). Winter contains the most stranding records near the OPAREA.

  - <u>Spring</u>— There are only two observation records of *Kogia* in the OPAREA during spring (Figures B-9-1 and B-9-2). Stranding records are concentrated in the southern portion of the region although Kogia are most likelt distributed throughout the OPAREA from the shelf break into deeper waters.

  - <u>Summer</u>—Summer is the season for which most sighting records have been documented. This is likely a reflection of sighting conditions (for example, calm seas) favorable for sighting these cryptic odontocetes, as well as relatively high survey effort. All sightings are recorded in deep waters of the OPAREA as would be expected for this genus. The model results predict areas of occurrence along the shelf break in the extreme northern part of the OPAREA and in slope and offshore waters of the OPAREA (Figures B-9-1 and B-9-2). There appears to be an area of greatest concentration in deep waters (>4,000 m) in the southeast portion of the OPAREA. It is doubtful that this is an actual area of concentration for *Kogia*. It is likely more reflective of a cluster of sightings recorded during one day in an area of low overall survey effort. Or it may possibly be a result of a concentrated food resource at that time. *Kogia* spp. are anticipated to occur seaward of the shelf break throughout the OPAREA.

- Fall—The model output predicts no occurrence in the OPAREA during this time of year due to the lack of sighting data. However, the presence of this genus here is recognized based on strandings recorded inshore of the OPAREA boundaries (Figures B-9-1 and B-9-2). *Kogia* spp. would be expected seaward of the shelf break throughout the OPAREA.

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

Kogia spp. feed on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell 1989; McAlpine et al. 1997; Willis and Baird 1998; Santos et al. 2006). Willis and Baird (1998) reported that whales of the genus *Kogia* make dives of up to 25 min. Dive times ranging from 15 to 30 min (with 2 min surface intervals) have been recorded for a dwarf sperm whale in the Gulf of California (Breese and Tershy 1993). Median dive times of around 11 min are documented for *Kogia* (Barlow 1999). 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—There is little published information on sounds produced by *Kogia* spp, although they are categorized as non-whistling smaller toothed whales. Recently, free-ranging dwarf sperm whales off La Martinque (Lesser Antilles) were recorded producing clicks at 13 to 33 kHz with durations of 0.3 to 0.5 sec (Jérémie et al. 2006). The only sound recordings for the pygmy sperm whale are from two stranded individuals: a stranded individual being prepared for release in the western North Atlantic emitted clicks of narrowband pulses with a mean duration of 119 μsec, interclick intervals between 40 and 70 msec, centroid frequency of 129 kHz, peak frequency of 130 kHz, and apparent source level of up to 175 dB re 1 μPa-m (Madsen et al. 2005a). Another individual found stranded in Monterey Bay produced echolocation clicks ranging from 60 to 200 kHz, with a dominant frequency of 120 to 130 kHz (Marten 2000; Ridgway and Carder 2001).

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

- Beaked Whales *(Family Ziphiidae)*

Description—Based upon available data, six beaked whales are known to occur in the VACAPES OPAREA: Cuvier's beaked whales, northern bottlenose whales, and four members of the genus *Mesoplodon* (True's, Gervais', Blainville's, and Sowerby's beaked whales), which, with the exception of *Ziphius* and *Hyperoodon*, 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). They are presented in one summary due to the paucity of biological information available for each species and the difficulty of species-level identifications for *Mesoplodon* species. *Mesoplodon* spp. are also often termed 'mesoplodonts.'

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).

Northern bottlenose whales are 7 to 9 m in length with rotund bodies, large bulbous heads, and small, well-defined beaks (Mead 1989b). These whales range in color from green-brown to gray with lighter gray-white markings on the body and lighter coloring on the lower part of the flanks and ventral surface (Jefferson et al. 1993). Diatoms are known to grow on some individuals, giving them an added brownish appearance. The head and face are gray and may even appear white. White or yellow blemishes or scars can be present, especially in older animals. Only mature males have erupted teeth. There is marked sexual dimorphism in the melon of northern bottlenose whales, which is enlarged, flattened, and squared off in males (Mead 1989b). Gowans and Rendell (1999) observed head-butting by males and speculated that differences in head shape may be significant in male contests for mates.

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 mesoplodont and Cuvier's beaked whale abundance combined in the western North Atlantic is 3,513 individuals, and the minimum population estimate is 2,154 (Waring et al. 2008). 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, it was not possible for this study to discern finer-scale population differences within the North Atlantic (Dalebout et al. 2005). Using mark-recapture techniques, 133 northern bottlenose whales have been estimated to utilize the Gully (Nova Scotia) (Gowans et al. 2000). It is not possible to obtain any additional species-specific estimates due to the difficulty of individual identification at sea.

The western North Atlantic stocks of the Cuvier's beaked whale and of *Mesoplodon* spp. are considered strategic stocks due to the uncertainty of stock size and the potential for human-induced mortality and serious injury because of acoustic activities (Waring et al. 2008). The western North

Atlantic stock of northern bottlenose whales is not a strategic stock because there are no recent records of fishery-related mortality or serious injury (Waring et al. 2008).

Habitat Associations—Little is known about beaked whale habitat associations. 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).

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 northeast U.S. (including waters off Virginia in this study), beaked whales are seen in waters with a mean bottom depth ranging from 90 to 5,009 m (Ward et al. 2005). Ward et al. (2005) presented information on their attempts to characterize and predict beaked whale habitat in the northeast U.S. using habitat models. The models predicted habitat concentrations along the slope and in deeper waters (Ward et al. 2005). Further work is needed for developing 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 associations 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 deepwater currents, levels of local productivity, and distribution of prey species may influence habitat usage.

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 deepwater 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 24.9ºC and a bottom depth of 500 to 2,000 m (Waring et al. 2003). Sightings of beaked whales have been made near Oceanographer Canyon (southern Georges Bank), between the 200 and 2,000 m isobaths, and did not coincide with a thermal gradient (Waring et al. 1992).

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; Gannier 2000; MacLeod et al. 2004; Claridge 2005; Ferguson 2005). At oceanic islands, both Baird et al. (2004) and MacLeod et al. (2004) reported that Cuvier's beaked whales are found in deeper waters than Blainville's beaked whales. Most ecological information on Blainville's beaked whales comes from the northern Bahamas (MacLeod et al. 2004; Claridge 2005; MacLeod and Zuur 2005). According to Claridge (2005), Blainville's beaked whales in the northern Bahamas are found along shelf waters of canyon walls and in deeper offshore waters. Most time is spent along these walls where bottom depths are less than 800 m (Claridge 2003; MacLeod et al. 2004; MacLeod and Zuur 2005). Adults in The Bahamas are found most often over the continental slope, while subadults are found in even deeper waters (Claridge 2005).

Northern bottlenose whales are concentrated in cold waters seaward of the continental shelf break (Reeves et al. 1993). South of Nova Scotia, northern bottlenose whales are sighted in waters with bottom depths between 500 and 1,500 m and relatively steep topography (Hooker and Baird 1999; Hooker et al. 2002). Small-scale distribution in this area is likely based upon fluctuations in prey availability over different canyon features (Hooker et al. 2002). Northern bottlenose whales have been observed in waters with SST ranging from -2°C to 17°C (Reeves et al. 1993).

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 of 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).

Northern bottlenose whales are restricted to northern latitudes of the North Atlantic. This species is routinely found in the Gully, a submarine canyon off the coast of Nova Scotia, near the southern and western limits of the species' range (Gowans et al. 2000).

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 1989a; 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, North Carolina (note that the latitude provided by Tove is incorrect) (Tove 1995).

The continental shelf margins from Cape Hatteras to southern Nova Scotia were recently identified as known "key areas" for beaked whales in a global review by MacLeod and Mitchell (2006).

- Information Specific to the VACAPES OPAREA—Beaked whales are deepwater species. As mentioned previously, Ward et al. (2005) used habitat models to predict beaked whale habitat and identified waters along the slope and deeper as primary beaked whale habitat in the northeast U.S. Based on the cryptic behavior and similarity in appearance of these species, it is difficult to identify beaked whales to species. Cuvier's, True's, Gervais', and Blainville's beaked whales are the only beaked whale species expected to occur regularly in the OPAREA, with possible occurrence of Sowerby's beaked whales. There is one extralimital stranding record of a northern bottlenose whale inshore of the VACAPES OPAREA. Of note is a mass stranding of four Blainville's beaked whales in North Carolina (unspecified exact location) that occurred subsequent to Hurricane Bonnie in 1998 (Norman and Mead 2001).

    - Winter—Although this is a season with relatively low survey effort, there are a number of sightings in waters seaward of the shelf break. The model output predicts areas of occurrence in offshore waters and extending over the shelf break onto the shelf near the Baltimore and Wilmington canyons as well as south of the OPAREA off the Outer Banks. The area of greatest concentration includes deep (>3,000 m) waters in the eastern portion of the OPAREA (Figures B-10-1 and B-10-2). Increased occurrence here is likely influenced by the path of the Gulf Stream; beaked whales have been sighted in association with warm-core features and the Gulf Stream's northern wall (Waring et al. 1992). Beaked whales should be expected seaward of the shelf break throughout the OPAREA based on known habitat associations.

    - Spring—Sightings are clustered in slope and deep waters of the OPAREA (Figures B-10-1 and B-10-2). The model output suggests patchy occurrence over the shelf and in slope and deeper waters near the Washington, Accomac, and Pamlico canyons. Areas of increased occurrence extend over Pamlico Canyon and offshore of Washington and Accomac canyons and are likely influenced by the upwelling features associated with the Gulf Stream's northern wall and the steep bottom topography in this area. Occurrence should be expected in deep waters throughout the OPAREA based on known habitat associations.

- Summer—Sightings are distributed near the shelf break and seaward into deep waters over the continental rise in the OPAREA (Figures B-10-1 and B-10-2). The large number of beaked whale sightings to the north of the VACAPES OPAREA may reflect greater survey effort, as well as more favorable sighting conditions. The model output predicts occurrence extending seaward from the shelf break to deep, offshore waters across the northeastern portion of the OPAREA and the region near Pamlico Canyon. As for winter and spring, occurrence of beaked whales in this region is likely influenced by localized prey concentrations due to upwelling associated within the Gulf Stream's northern wall, as well as areas of steep bottom topography. Beaked whales are anticipated to occur throughout deep waters of the OPAREA based on known habitat associations.

- Fall—The model output predicts no occurrence for beaked whales during this time of year due to the lack of on-effort sighting records. This is also a time of year with less survey effort, particularly in offshore waters. A few opportunistic sightings and several strandings are recorded in or near the OPAREA during the fall (Figures B-10-1 and B-10-2), suggesting that beaked whales do occur here during this time of year. Beaked whale occurrence is still expected in waters seaward of the shelf break, particularly over the continental slope, based on known habitat associations.

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. Reproductive biology is generally undescribed, and the locations of specific breeding grounds are unknown.

Observed beaked whale group sizes normally range from one to four individuals. Cuvier's beaked whales and *Mesoplodon* spp. are generally found alone or in groups of up to 15 individuals (Mullin et al. 2004; MacLeod and D'Amico 2006). A survey off North Carolina recorded Cuvier's beaked whale group sizes of three to eight individuals, with groups composed of either mature females or mature females accompanied by a single mature male (Cresswell and Walker 2002). 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, based on studies/observations from the northeastern Bahamas. Groups there are usually comprised of females, calves, and/or juveniles. Some groups also include a mature or subadult male (Claridge 2005; MacLeod and D'Amico 2006).

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 deepwater benthic invertebrates (Heyning 1989; Heyning and Mead 1996; Santos et al. 2001; MacLeod et al. 2003). However, based on recent tagging data, Baird et al. (2005b) 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). Northern bottlenose whales feed primarily on squids, particularly the genus *Gonatus*; they also take fish, large decapod crustaceans, sea stars, and sea cucumbers (Benjaminsen and Christensen 1979; Clarke and Kristensen 1980; Bloch et al. 1996). 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. 2005b). Tagged northern bottlenose whales off Nova Scotia were found to dive approximately every 80 min to over 800 m, with a maximum dive depth of 1,453 m for as long as 70 min (Hooker and Baird 1999). Northern bottlenose whale dives fall into two discrete categories: short-duration (mean =11.7 min), shallow dives and long-duration (mean=36.98 min), deep dives (Hooker and Baird 1999). 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. 2004; Baird et al. 2005b). Tagged Blainville's beaked whale dives have been recorded to 1,408 m and lasting as long as 54 min (Baird et al. 2005b). Baird et al. (2005b) reported that several aspects of diving were similar between Cuvier's and Blainville's beaked whales: 1) both dove for 48 to 68 minutes 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. 2005b) (MacLeod and D'Amico 2006; Tyack et al. 2006). Whistle frequencies are about 2 to 12 kHz, while pulsed sounds range in frequency from 300 Hz to 135 kHz; however, as noted by MacLeod and D'Amico (2006), higher frequencies may not be recorded because of equipment limitations. Whistles recorded from free-ranging Cuvier's beaked whales off Greece ranged in frequency from 8 to 12 kHz (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 (Caldwell and Caldwell 1971b). MacLeod (1999) suggested that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication.

Hooker and Whitehead (2002) recorded clicks from northern bottlenose whales off Nova Scotia which consisted of two major categories identified by received amplitude differences. Whales socializing at the surface produced clicks that were loud and rapid, but with short and varied inter-click intervals. Clicks with a lower amplitude were characterized by consistent inter-click intervals and were assumed produced by whales foraging at depth. The loud clicks presented peak frequencies between 2 and 22 kHz, while the lower amplitude clicks had a peak frequency at 24 kHz (Hooker and Whitehead 2002). The latter clicks also had a 3 dB bandwidth at 4 kHz. Hooker and Whitehead (2002) did not record whistles from bottlenose whales even though Winn et al. (1970) recorded sounds from this species that were not only comprised of clicks but also whistles which were attributed to northern bottlenose whales. Hooker and Whitehead (2002) noted that the whistles captured by Winn et al. (1970) were more likely from long-finned pilot whales (*Globicephala melas*). Still, Hooker and Whitehead suggested that more recordings from this species are required while no other animals are present to confirm whether or not bottlenose whales actually produces whistles.

Studies incorporating DTAGs (miniature sound and orientation recording tag) attached to Blainville's beaked whales in the Canary Islands and Cuvier's beaked whales in the Ligurian Sea recorded high-frequency echolocation clicks (duration: 175 µs for Blainville's and 200 to 250 µs for Cuvier's) with center frequencies at around 42 kHz and dominant frequency ranges from about 20 to over 40 kHz (limit of recording system was 48 kHz); these clicks were recorded at depths over 200 m with a hydrophone array (Johnson et al. 2004; Madsen et al. 2005b; Zimmer et al. 2005a; Tyack et al. 2006). The source level of the Blainville's beaked whales' clicks were estimated to range from 200 to 220 dB re 1 µPa-m (Johnson et al. 2004), while they were 214 dB re 1 µPa-m for the Cuvier's beaked whale (Zimmer et al. 2005a). Concurrent anatomical rotational and behavioral data (also collected with the DTAG) indicated that beaked whales use a series of regular clicks (Interclick Interal of 0.2 –

0.4 s, ~250 μs) during the search phase of foraging and shift to a 'buzz' click (i.e., increased repetition rate from regular clicks to ~250 clicks/s) to capture prey (Johnson et al. 2004; Johnson et al. 2008). It is believed that beaked whales employ a dynamic echolocation system during prey detection and capture that is somewhat different from other odontocetes that feed in more shallow water (Johnson et al. 2008).

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

- Rough-Toothed Dolphin (*Steno bredanensis*)

Description—This is a relatively robust dolphin with a cone-shaped head and 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 scratches and spots on the body from cookie-cutter sharks and other rough-toothed dolphins. The rough-toothed dolphin reaches 2.8 m in length (Jefferson et al. 1993).

Status—No abundance estimate is available for rough-toothed dolphins in the western North Atlantic (Waring et al. 2008).

Habitat Associations—The rough-toothed dolphin is regarded as an offshore species that prefers deep waters; however, it can occur in shallow waters as well (e.g., Gannier and West 2005). 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). The rough-toothed dolphin may regularly frequent coastal waters and areas with shallow bottom depths. Off the Florida Panhandle, this species can be found over the continental shelf (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 (Banick and Borger 2005), and in coastal waters off Brazil, including even in a lagoon system (Flores and Ximenez 1997; Lodi and Hetzel 1999).

Tagging data for this species from the Gulf of Mexico and western North Atlantic provide important information on habitat associations. 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 (Wells 2007). The tagged animal moved north as far as Charleston, SC, before returning to the Miami area, remaining in relatively shallow waters (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 (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 (Wells 2007). The last signal placed them northeast of the Lesser Antilles (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 (Wells 2007). The tagging data demonstrated that these individuals proceeded south to a deep trench close to the north coast of Cuba (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 an association with 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 (Miyazaki and Perrin 1994). Rough-toothed dolphins occur in low densities throughout the eastern tropical Pacific where surface water temperatures are generally above 25° C (Perrin and Walker 1975). This species is not a commonly encountered species in the areas where it is known to occur (Jefferson 2002c). Not many records for this species exist from the western North Atlantic, but they 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).

- <u>Information Specific to the VACAPES OPAREA</u>—There are insufficient data to model the predicted occurrence of this species. Several strandings and two sightings have been recorded in or near the OPAREA (Figure B-11). Occurrence would be expected seaward of the shelf break based on this species' association with deep waters. During the winter, the rough-toothed dolphin's occurrence is expected in warmer waters, so occurrence in the OPAREA may follow the western edge of the Gulf Stream.

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, 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).

Seasonality and location of rough-toothed dolphin breeding is unknown. 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 and whistles. Echolocation clicks (duration <250 microseconds [μsec]) typically have a frequency range of 0.1 to 200 kHz, with the dominant energy found at 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 most of the energy can be found in the 2 to 14 kHz range (Miyazaki and Perrin 1994; Yu et al. 2003).

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

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

Status—Two forms of bottlenose dolphins are recognized in the western North Atlantic Ocean: nearshore (coastal) and offshore morphotypes. Each morphotype is referred to as a stock by NMFS. There is a complex mosaic that comprises the coastal stock (NMFS-SEFSC 2001; Waring et al. 2008). The NMFS recognizes the mosaic to be seven discrete management units (MU) (or stocks) that have distinct spatial and temporal components: Northern Migratory MU, Northern North Carolina MU, Southern North Carolina MU, South Carolina MU, Georgia, Northern Florida MU, and Central Florida MU (Waring et al. 2008). Three MUs occur during the summer (May through October) in the VACAPES OPAREA: Northern Migratory, Northern North Carolina, and Southern North Carolina. During the winter (November through April), the Northern Migratory, Northern North Carolina, and Southern North Carolina MUs overlap along the coast of North Carolina and are referred to as the Winter Mixed MU (Waring et al. 2008).

The NMFS provides abundance estimates for each MU by season. During the summer (May through October), the best estimates of abundance for the Northern Migratory, Northern North Carolina, and Southern North Carolina MUs are 17,466, 7,079, and 3,786 individuals, respectively (Waring et al. 2008). The minimum population estimates of these MUs during summer are 14,621, 4,083, and 1,987 individuals, respectively. During the winter (November through April), an estimated 16,913 individuals (13,558 minimum estimate) make up the Winter Mixed MU (Waring et al. 2008). The MUs making up the coastal stock are considered depleted under the MMPA and classified as a strategic stock (Waring et al. 2008).

Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km from the U.S. coastline (Waring et al. 2008). The minimum population estimate for this stock is 70,775 individuals; best population estimate is 81,588 individuals (Waring et al. 2008). This stock is not currently considered a strategic stock.

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 draft 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 the potential biological removal (PBR) level (NMFS 2006b).

Habitat Associations—The bottlenose dolphin lives in coastal areas of all continents, around many oceanic islands and atolls, and over shallow offshore banks and shoals. There are also oceanic populations that range far from land. Risk of predation and food availability influence bottlenose dolphin habitat use (Shane et al. 1986; Wells et al. 1987; Allen et al. 2001; Heithaus and Dill 2002). Predation risk is determined by the number of predators in an area, the ability of predators and prey to detect each other, and the probability of capture after detection; predation risk can be influenced by a suite of habitat attributes, such as water clarity and depth (Heithaus 2001).

Bays, sounds, and estuaries are high-use habitats for bottlenose dolphins due to their importance as nursery and feeding areas (A.J. Read et al. 2003b); individuals may exhibit either resident or migratory patterns in coastal areas (Kenney 1990; Waring et al. 2008).

The MUs of the coastal morphotype show a temperature-limited distribution, occurring in significantly warmer waters than the offshore stock, and having a distinct northern boundary (Kenney 1990). Recent winter aerial surveys reported a lack of sightings north of Chesapeake Bay, corresponding to water temperatures less than 9.5°C (Waring et al. 2008), and a study of the Chesapeake Bay/Virginia coast area showed a much greater probability of sightings with a SST of 16° to 28°C (Armstrong et al. 2005). Surface water temperature may significantly influence seasonal movements of migrating coastal dolphins along the Western Atlantic coast (Barco et al. 1999); these seasonal movements are likely also influenced by movements of prey resources.

The nearshore waters of the Outer Banks serve as winter habitat for coastal bottlenose dolphins (A. Read et al. 2003), particularly for those of the Northern Migratory, Northern North Carolina, and Southern North Carolina MUs. Cape Hatteras represents important habitat for bottlenose dolphins, particularly in winter, as evidenced from concentrations of bottlenose dolphins during recent aerial surveys (Torres et al. 2005).

In the western North Atlantic, the greatest concentrations of the offshore stock are along the continental shelf break (Kenney 1990). Tentative evidence suggests that the offshore stock does not inhabit waters closer than 12 km from shore during summer and 27 km from shore during winter (Garrison and Yeung 2001). During CETAP surveys, offshore bottlenose dolphins generally were distributed between the 200 and 2,000 m isobaths in waters with a mean bottom depth of 846 m from Cape Hatteras to the eastern end of Georges Bank. Geography and temperature also influence the distribution of offshore bottlenose dolphins (Kenney 1990).

Distribution—The overall range of the bottlenose dolphin is worldwide in tropical and temperate waters. This species occurs in all three major oceans and many seas. Dolphins of the genus *Tursiops* generally do not range poleward of 45ºC, 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 and have a relatively continuous distribution southward to Venezuela and Brazil (Wells and Scott 1999). Bottlenose dolphins occur seasonally in estuaries and coastal embayments as far north as Delaware Bay (Kenney 1990) and in waters over the outer continental shelf and inner slope, as far north as Georges Bank (CETAP 1982; Kenney 1990).

Genetic analyses and spatial patterns observed from aerial surveys indicate regional and seasonal distribution differences between the coastal and offshore stocks. North of Cape Hatteras, the coastal stock is thought to be restricted to waters <25 m in depth, while offshore dolphins generally range beyond the 50 m isobath (CETAP 1982; Kenney 1990). Mitochondrial DNA and spatial analyses from dolphins south of Cape Hatteras suggest individuals sighted within 7.5 km of shore are of the coastal form and those beyond 34 km from shore and in waters with a bottom depth greater than 34 m are of the offshore form (Torres et al. 2003). However, Torres et al. (2003) also found an extensive region of overlap between the coastal and offshore stocks between 7.5 and 34 km from shore.

In North Carolina, there is significant overlap between distributions of coastal and offshore dolphins during the summer. North of Cape Lookout, there is a separation of the two stocks by bottom depth; the coastal form occurs in nearshore waters (<20 m deep) while the offshore form is in deeper waters (>40 m deep) (Garrison et al. 2003a). However, south of Cape Lookout to northern Florida, there is significant spatial overlap between the two stocks. In this region, coastal dolphins may be found in waters as deep as 31 m and 75 km from shore while offshore dolphins may occur in waters as shallow as 13 m (Garrison et al. 2003a). Additional aerial surveys and genetic sampling are required to better understand the distribution of the two stocks throughout the year.

Discrete MUs exhibit seasonal migrations regulated by temperature and prey availability (Torres et al. 2005), traveling as far north as New York in summer and as far south as central Florida in winter (Urian et al. 1999). During the summer, the Northern Migratory MU occurs from the New York/New Jersey border to the Virginia/North Carolina border. The Northern North Carolina MU ranges from the Virginia/North Carolina border to Cape Lookout, North Carolina during the summer months, and the Southern North Carolina MU ranges from Cape Lookout, North Carolina to Murrell's Inlet, South Carolina at this time of year. In the winter months, these three MUs overlap along the coast of North Carolina and southern Virginia (Waring et al. 2008).

Coastal bottlenose dolphins along the western Atlantic coast may exhibit either resident or migratory patterns (Waring et al. 2008). Photo-identification studies support evidence of year-round resident bottlenose dolphin populations in Beaufort and Wilmington, North Carolina (Koster et al. 2000); these are the northernmost documented sites of year-round residency for bottlenose dolphins in the western North Atlantic (Koster et al. 2000). A high rate of exchange occurs between the Beaufort and Wilmington sites as well (Waring et al. 2008). Individuals from the Northern Migratory MU may enter these areas seasonally as well, as evidenced by a bottlenose dolphin tagged in 2001 in Virginia Beach who overwintered in waters between Cape Hatteras and Cape Lookout (NMFS-SEFSC 2001).

➢ Information Specific to the VACAPES OPAREA—Bottlenose dolphins are abundant in continental shelf and inner slope waters throughout the western North Atlantic (CETAP 1982; Kenney 1990; Waring et al. 2008). The greatest concentrations of offshore animals are along the continental shelf break and between the 200 and 2,000 m isobaths (Kenney 1990). However, the range of offshore bottlenose dolphins may actually extend into deeper waters (R.S. Wells et al. 1999), possibly even over the Hatteras Abyssal Plain just southeast of the VACAPES OPAREA.

  - Winter—Occurrence is predicted throughout shelf and slope waters during this season. The model results predict an area of increased occurrence in shelf waters around Cape Hatteras just south of the OPAREA (Figures B-12-1 and B-12-2). This area surrounding Cape Hatteras is an important habitat area for bottlenose dolphins which may preferentially use these waters in response to changes in prey distribution or SSTs (Torres et al. 2005). Bottlenose dolphins are known to occur in nearshore waters of North Carolina year-round although they tend to be more concentrated south of Cape Hatteras during the colder months. The large number of sightings along North Carolina is consistent with previous survey data indicating a higher abundance of bottlenose dolphins in coastal waters of North Carolina during winter (Torres et al. 2005). Limited survey effort during the winter months, particularly in deeper waters, may be under-representing occurrence of the offshore stock. Bottlenose dolphnins should be expected throughout the OPAREA during winter.

- Spring—The model results predict occurrence throughout nearshore, shelf, and slope waters of the OPAREA (Figures B-12-1 and B-12-2). Areas of increased occurrence include slope waters offshore of Accomac Canyon and near Pamlico Canyon; concentrated occurrences here appear to follow the path of the Gulf Stream's northern wall and are likely influenced by enhanced upwelling associated with Gulf Stream features and steeply sloping bottom topography. It is well-known that bottlenose dolphins occur in nearshore waters of North Carolina year-round and in Virginia waters seasonally from late April to November (Blaylock 1988; Barco et al. 1999; NMFS-SEFSC 2001).

- Summer—Summer shipboard surveys provide increased opportunity for observations, and these sightings are more widespread through the VACAPES OPAREA than during other seasons; the larger number of bottlenose dolphin sightings in the summer may reflect greater survey effort during this season. As with spring, occurrence during summer is predicted throughout nearshore, shelf, and slope waters (Figures B-12-1 and B-12-2). However, predicted occurrence also extends into deeper, offshore waters. Areas of increased occurrence are distributed over shelf and slope waters in the southern portion of the OPAREA. As with the spring, the pockets of increased occurrence are likely influenced by the path of the Gulf Stream and steeply sloping bottom topography. Additional areas of increased occurrence in nearshore regions would be expected based on the known increase in abundance in coastal waters during this time of year (particularly in August). This is supported by the large number of sightings consistently recorded in nearshore waters from the Delaware Bay area to the Outer Banks.

- Fall—Although this is a season with less survey effort, there are a number of sightings over the continental shelf and shelf break and in slope waters throughout the OPAREA clearly distinguishing the offshore stock. The model results reflect occurrence along shelf and slope waters of much of the OPAREA (Figures B-12-1 and B-12-2). Pockets of increased occurrence are predicted in shelf and slope waters near Washington Canyon and the region around Pamlico Canyon. Concentrated occurrence is anticipated near the mouth of Chesapeake Bay and extending from nearshore waters to slope waters around the Pamlico Canyon region. Bottlenose dolphins are known to utilize the Chesapeake Bay region between September and November (Barco et al. 1999). A recurring nearshore front occurs near Cape Henry in the mouth of the Bay (Marmorino et al. 2000); dolphins may use this area as feeding habitat during this time of year.

Behavior and Life History—Bottlenose dolphins are gregarious and typically found in groups of up to 15 individuals, although groups of 100 or more are reported (Shane et al. 1986; Kerr et al. 2005). Coastal bottlenose dolphins typically exhibit smaller group sizes than larger forms, as water depth appears to be 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 (Shane et al. 1986; Wells et al. 1987). Semi-open or open habitats, however, 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.

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), with individuals forming numerous weak and few strong associations with other individuals. Lasting social bonds occur between mothers and calves; male pair bonds are documented in some resident communities throughout the world (Connor et al. 2000; Owen et al. 2002).

Little is known of offshore bottlenose dolphin behavior as studies of this stock are limited. 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 Atlantic coast of the U.S., where the majority of detailed work on bottlenose dolphins has been conducted, male and female bottlenose dolphins reach physical maturity at 13 years, with females reaching sexual maturity as early as seven years (Mead and Potter 1990). Bottlenose dolphins are flexible in their timing of reproduction. Seasons of birth for bottlenose dolphin populations are likely responses to seasonal patterns of availability of local resources (Urian et al. 1996). Thayer et al. (2003) found bottlenose dolphins in North Carolina to exhibit a strong calving peak in spring, particularly May and June, and a diffuse peak from late spring to early fall. There is a gestation period of one year (Caldwell and Caldwell 1972). Calves are weaned as early as one and a half years of age (Reynolds III et al. 2000), and typically remain with their mothers for a period of three to eight years (Wells et al. 1987), although longer periods are documented (Reynolds III et al. 2000). There are no specific breeding locations for this species.

Bottlenose dolphins are opportunistic feeders that utilize numerous feeding strategies to prey upon a variety of fishes, cephalopods, and shrimps (Shane 1990; Wells and Scott 1999). Along the southeastern U.S., bottlenose dolphins may exploit human fishing effort by feeding in association with shrimp trawlers (Fertl and Leatherwood 1997) or depredating fishing nets (A.J. Read et al. 2003a). Bottlenose dolphins likely detect and orient to fishes by using passive listening (Barros and Myrberg 1987; Gannon and Waples 2004; Gannon et al. 2005). Numerous dietary studies along the southeastern coast have found coastal bottlenose dolphins to prey predominantly on scaenid fishes (Barros and Odell 1990; Gannon and Waples 2004; Fisk et al. 2005); such associations likely result in the numerous documented fishery interactions, as scaenids are targeted by many fisheries (Friedlaender et al. 2001). In North Carolina, bottlenose dolphin diet varies seasonally, although estuarine resident dolphins prey predominantly upon Atlantic croaker while coastal migratory dolphins feed primarily on weakfish (Gannon and Waples 2004). The offshore stock preys on pelagic squids and fishes, especially myctophids (Barros and Odell 1990; Mead and Potter 1995; Gannon and Waples 2004).

Dive durations as long as 15 min are recorded for trained individuals (Ridgway et al. 1969). Typical dives, however, are shallower and have a much shorter duration. Mean dive durations of Atlantic bottlenose dolphins typically range from 20 to 40 sec at shallow depths (Mate et al. 1995) and can last longer than 5 min during deep offshore dives (Klatsky et al. 2005). Offshore bottlenose dolphins regularly dive to 450 m and possibly as deep as 700 m (Klatsky et al. 2005). Bottlenose dolphin dive behavior may correlate with diel cycles (Mate et al. 1995; Klatsky et al. 2005); this may be especially true for offshore stocks, which dive deeper and more frequently at night to feed upon 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 wave 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 1998a). Whistles are primarily associated with communication and can serve to identify specific individuals (i.e., signature whistles) (Caldwell and Caldwell 1965; Janik et al. 2006). Up to 52% of whistles produced by bottlenose dolphin groups with mother-calf pairs have been 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 200 Hz to 160 kHz (Au 1993; Turl 1993), though with exposure during testing some dolphins might receive information as low as 50 Hz (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).

- 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 2006). Adults may reach 2.6 m in length (Jefferson et al. 1993). North and offshore of Cape Hatteras, adults may bear only a few small, dark, ventral spots whereas individuals over the continental shelf become so heavily spotted that they appear nearly white (Perrin and Hohn 1994).

Status—The best estimate of abundance of the western North Atlantic stock of pantropical spotted dolphins is 4,439 individuals while the minimum estimate is 3,010 (Waring et al. 2008). There is no information on stock differentiation for pantropical spotted dolphins in the U.S. Atlantic (Waring et al. 2008).

Habitat Associations—Pantropical spotted dolphins tend to associate with bathymetric relief and oceanographic interfaces. Most sightings of this species in the Gulf of Mexico, Caribbean, and off Brazil occur over the lower continental slope (Davis et al. 1998; Mignucci-Giannoni et al. 2003; Mullin et al. 2004; Moreno et al. 2005). 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). 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). Along the northeastern U.S., Waring et al. (1992) found that *Stenella* spp. were distributed along the Gulf Stream's northern wall. *Stenella* sightings also occurred within the Gulf Stream, which is consistent with the oceanic distribution of this genus and its associations with warm water (Waring et al. 1992; Mullin and Fulling 2003). In the eastern Pacific, the pantropical spotted dolphin is an inhabitant of the tropical, equatorial, and southern subtropical water masses characterized by a sharp thermocline at less than 50 m depth, surface temperatures greater than 25ºC, and salinities less than 34 parts per thousand (ppt) (Au and Perryman 1985).

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

- Information Specific to the VACAPES OPAREA—The pantropical spotted dolphin is a deepwater species (Jefferson et al. 1993). Pantropical spotted dolphins have been sighted along the Florida shelf and slope waters and offshore in Gulf Stream waters southeast of Cape Hatteras (Waring et al. 2008). In the Atlantic, this species is considered broadly sympatric with Atlantic spotted dolphins (Perrin and Hohn 1994). The offshore form of the Atlantic spotted dolphin and the pantropical spotted dolphin can be difficult to differentiate at sea. Therefore, the low number of sightings of pantropical spotted dolphins in offshore waters of the OPAREA may be more of a reflection of survey observers not distinguishing between the two species. Unidentified spotted dolphins were not included in the models for either species but are included in Figure B-13-2.

  There are very few sightings in or near the OPAREA (Figure B-11). However, note that this is a pelagic deepwater species and the waters seaward of the shelf edge generally have very little survey coverage. The model output predicts no occurrence throughout most of the OPAREA, but a small area of occurrence is predicted along the continental shelf and over the shelf break in spring (Figure B-11). Distribution here is likely influenced by the Gulf Stream's northern wall. Sightings of this species are likely not captured here due to incomplete survey coverage in offshore waters as well as the general low survey effort during spring and fall. Based on known habitat associations, pantropical spotted dolphins would be expected seaward of the shelf break throughout the OPAREA.

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).

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). However, breeding times and locations in the western Atlantic are unknown. Pantropical spotted dolphins prey on epipelagic fishes, squids, and crustaceans (Perrin and Hohn 1994; Robertson and Chivers 1997; Wang et al. 2003). Not much is known about the diving behavior of pantropical spotted dolphins in the western North Atlantic. 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 been documented from 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 with the finding that they have a Type II cochlea, like other dephinids, which 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. 1994c; 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. 1994c; 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. 1994c). 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).

  Status—The best estimate of Atlantic spotted dolphin abundance in the western North Atlantic is 50,978 individuals; the minimum estimate is 36,235 individuals (Waring et al. 2008). Recent genetic evidence suggests that there are at least two populations in the western North Atlantic (Adams and Rosel 2006), as well as possible continental shelf and offshore segregations. Atlantic populations are divided along a latitudinal boundary corresponding roughly to Cape Hatteras (Adams and Rosel 2006).

  Habitat Associations—Atlantic spotted dolphins occupy both continental shelf and offshore habitats. The large, heavily-spotted coastal form typically occurs over the continental shelf inshore or near the 185 m isobath, 8 to 20 km from shore (Perrin et al. 1994c; Davis et al. 1998; Perrin 2002a). There are also frequent sightings beyond the continental shelf break in the Caribbean Sea, Gulf of Mexico, and off the U.S. Atlantic Coast (Mills and Rademacher 1996; Roden and Mullin 2000; Fulling et al. 2003; Mullin and Fulling 2003; Mullin et al. 2004). Griffin et al. (2005) proposed that Atlantic spotted dolphins spend more time feeding over the continental shelf in winter than during summer. Atlantic spotted dolphins are found commonly in inshore waters south of Chesapeake Bay as well as over continental shelf break and slope waters north of this region (Payne et al. 1984; Mullin and Fulling 2003). Sightings have also been made along the northern wall of the Gulf Stream and its associated warm-core ring features (Waring et al. 1992).

  Distribution—Atlantic spotted dolphins are distributed in warm-temperate and tropical Atlantic waters from approximately 45ºN to 35ºS; in the western North Atlantic, this translates to waters from northern New England to Venezuela, including the Gulf of Mexico and the Caribbean Sea (Perrin et al. 1987).

  - Information Specific to the VACAPES OPAREA—Atlantic spotted dolphins may occur in both continental shelf and offshore waters (Perrin et al. 1994c); the model results reflect this broad range of distribution in the OPAREA (Figures B-14-1 and B-14-2). In the Atlantic, this species is considered broadly sympatric with pantropical spotted dolphins (Perrin and Hohn 1994). The offshore form of the Atlantic spotted dolphin and the pantropical spotted dolphin can be difficult to differentiate at sea. Unidentified spotted dolphins were not included in the models for either species but are included in Figure B-14-2.

    - Winter—Sightings are distributed over the shelf and shelf break in the southern portion of the OPAREA (Figures B-14-1 and B-14-2). The model results demonstrate occurrence over the continental shelf, along the shelf break, and in steeply sloping waters of this region. Atlantic spotted dolphins would be expected to occur in continental shelf and offshore waters throughout the OPAREA.

- Spring—The larger number of Atlantic spotted dolphin sightings in spring are potentially a reflection of the increased level of survey effort during this time of year. On-effort sightings are clustered along the shelf break south of Chesapeake Bay but are also recorded in deeper, offshore waters. Several opportunistic sightings are scattered throughout the OPAREA, particularly on the continental shelf in the southern portion of the OPAREA (Figures B-14-1 and B-14-2). Sightings of Atlantic spotted dolphins in the northern VACAPES OPAREA are consistent with the Atlantic spotted dolphin's occurrence into cooler waters versus the more tropical pantropical spotted dolphin. Predicted occurrence extends over the continental shelf and shelf break into deep, offshore waters (Figures B-14-1 and B-14-2). Distributions of both coastal and offshore forms are likely represented in the model output. Increased occurrence is anticipated over deep (>2,000 m) waters near Pamlico Canyon in the southern portion of the OPAREA. The northern wall of the Gulf Stream and its associated warm-core ring features likely influences occurrence of Atlantic spotted dolphins here.

- Summer—As with spring, the large number of Atlantic spotted dolphin sightings during summer is potentially a reflection of the increased level of survey effort during this time of year. Sightings are scattered throughout the OPAREA and range from shallow, coastal waters to deep waters over the continental rise (Figures B-14-1 and B-14-2). Sightings of Atlantic spotted dolphins in the northern VACAPES OPAREA are consistent with the Atlantic spotted dolphin's occurrence into cooler waters versus the more tropical pantropical spotted dolphin. Occurrence is predicted in nearshore waters, along the continental shelf and shelf break, and in offshore waters (Figures B-14-1 and B-14-2). An increased area of occurrence in deep waters just north of the Pamlico Canyon appears to coincide with the path of the Gulf Stream and is likely associated with the upwelling features of the northern wall.

- Fall—This is the season with the least amount of recorded sightings, likely due to decreased survey effort and inclement weather conditions that can make sighting cetaceans difficult during this time of year. Although the model output predicts only a small area of occurrence along the shelf break and in steeply sloping waters between the Norfolk and Pamlico canyons (Figures B-14-1 and B-14-2), occurrence is still expected in continental shelf and offshore waters throughout the OPAREA.

Behavior and Life History—Atlantic spotted dolphin groups are normally composed of fewer than 50 individuals (Jefferson et al. 1993). Little life history information for this species is known. Perrin et al. (1994c) present information on female and male sexual maturation relative to body length for individuals in the Gulf of Mexico and western North Atlantic. In The Bahamas, female sexual maturation occurs at about 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); however, breeding times and locations in the western Atlantic are largely unknown.

Atlantic spotted dolphins feed on small cephalopods, fishes, and benthic invertebrates (Perrin et al. 1994c). Atlantic spotted dolphins have been observed feeding on herring and anchovies near St. Augustine, Florida, and on carangid fishes farther from shore (Caldwell and Caldwell 1966) and have been observed chasing and catching flying fish (MacLeod et al. 2004).

The only information on diving depth for this species is from a satellite-tagged individual in the Gulf of Mexico (Davis et al. 1996). This individual made short, shallow dives to less than 10 m and as deep as 60 m, while in waters over the continental shelf on 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 100 Hz 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). Spotted dolphins in The Bahamas were frequently recorded during agonistic/agressive interactions with bottlenose dolphins (and their own species) to produce squawks (200 Hz to 12 kHz broad band burst pulses; males and females), screams (5.8 to 9.4 kHz whistles; males only), barks (200 Hz to 20 kHz burst pulses; males only), and synchronized squawks (100 Hz - 15 kHz burst pulses; males only in a coordinated group) (Herzing 1996).

There has been no data collected on Atlantic spotted dolphin hearing abilities. However, odontocetes are generally adapted to hear high-frequencies (Ketten 1997) and it can be assumed that vocalization frequencies are generally within the hearing range of a species.

- Spinner Dolphin (*Stenella longirostris*)

Description—The spinner dolphin 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—No estimate of abundances are currently available for the western North Atlantic stock of spinner dolphins (Waring et al. 2008). Stock structure in the western North Atlantic is unknown (Waring et al. 2008).

Habitat Associations—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. Along the northeastern U.S. and Gulf of Mexico, they are distributed in waters with a bottom depth greater than 2,000 m (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 associations 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). Distribution in the western North Atlantic is poorly-known (Waring et al. 2008) although stranding records range from the Gulf of Mexico to North Carolina.

- Information Specific to the VACAPES OPAREA—There are insufficient data to model predicted occurrence of spinner dolphins in the OPAREA. Several stranding, sighting, and bycatch records are documented in or near the OPAREA (Figure B-15). Spinner dolphins prefer warm, offshore waters as evidenced by the sighting and bycatch records associated with the Gulf Stream in the winter and spring months. Occurrence is expected from the vicinity of the continental shelf break to eastward of the OPAREA boundary in association with the Gulf Stream's northern boundary. No seasonal differences in occurrence are anticipated.

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 can dive to at least 200 to 300 m (Perrin and Gilpatrick 1994). Based on research in the Hawaiian Islands, 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).

Life history information on spinner dolphins in the Atlantic is limited. 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). Specific locations of breeding are unknown.

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 1998a). Spinner dolphins consistently produce whistles with frequencies as high as 16.9 to 17.9 kHz that have 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 1998a). The burst pulses are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al. 2003). Source levels at 222 dB re 1 μPa at 1 m peak-to-peak have been recorded for spinner dolphin clicks (Schotten et al. 2004).

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

- <u>Striped Dolphin</u> (*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, and the minimum estimate is 68,558 individuals (Waring et al. 2008).

Habitat Associations—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).

Off the northeastern U.S., striped dolphins are distributed along the continental shelf break from Cape Hatteras to the southern margin of Georges Bank, as well as offshore over the continental slope and continental rise in the mid-Atlantic region (CETAP 1982). Continental shelf break sightings were generally centered along the 1,000 m isobath year-round (CETAP 1982). Striped dolphins likely have a northern limit associated with the meanderings of the Gulf Stream (Perrin et al. 1994a; Archer II and Perrin 1999). Striped dolphins are known to associate with the Gulf Stream's northern wall and warm-core ring features (Waring et al. 1992).

Distribution—Striped dolphins are distributed worldwide in cool-temperate to tropical zones. In the western North Atlantic, this species occurs from Nova Scotia southward to the Caribbean Sea, Gulf of Mexico, and Brazil (Würsig et al. 2000).

➢ Information Specific to the VACAPES OPAREA—As noted earlier, the striped dolphin is a deepwater species that is generally distributed north of Cape Hatteras (CETAP 1982), which is supported by the distribution of sightings data in the VACAPES OPAREA (Figures B-16-1 and B-16-2). The southern edge of this species' predicted occurrence appears to be influenced by meanderings of the Gulf Stream. Sightings predominately occur along the Gulf Stream's northern wall, where it travels through the southern part of the VACAPES OPAREA. Occurrence is expected near and seaward of the shelf break throughout the OPAREA year-round.

- Winter—Sighting and bycatch data are scattered seaward of the shelf break throughout much of the OPAREA. Striped dolphins are predicted to occur along the continental shelf and in slope and deep waters of the OPAREA (Figures B-16-1 and B-16-2). A small area of increased occurrence is predicted over steeply sloping waters south of Pamlico Canyon. Occurrence here is likely influenced by the path of the Gulf Stream since striped dolphins are often associated with the Gulf Stream's northern wall and warm-core rings (Waring et al. 1992).

- Spring—The model output predicts occurrence throughout much of the shelf, slope, and deep waters of the OPAREA (Figures B-16-1 and B-16-2). A pocket of increased occurrence in the southern VACAPES OPAREA abuts the Gulf Stream's northern wall. Upwelling here is enhanced by the Gulf Stream features and steep sloping bottom topography.

- Summer—Predicted occurrence extends seaward of the shelf break into deep (>3,500 m), offshore waters throughout much of the OPAREA (Figures B-16-1 and B-16-2). As during winter and spring, occurrence of striped dolphins during summer generally follows the path of the Gulf Stream's northern wall.

- Fall—This is the season with the least amount of recorded sightings, likely due to decreased survey effort and inclement weather conditions that can make sighting cetaceans difficult during this time of year. Sightings are restricted to the northern VACAPES OPAREA during this time of year; however, strandings recorded inshore of the southern portion support the likelihood of striped dolphins occurring throughout the OPAREA (Figures B-16-1 and B-16-2).

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). 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). Breeding times and locations in the western Atlantic are largely unknown.

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. 1994a; 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). Details on clicks, pluses or click trains are not available for striped dolphins.

A single striped dolphin's hearing range, determined by using standard psycho-acoustic techniques, was from 500 Hz to 160 kHz with best sensitivity at 64 kHz (Kastelein et al. 2003). The external and middle ear anatomy of the striped dolphin was recently examined by Sassu and Cozzi (2007), but with more focus on functionality with respect to barotraumas than to hearing.

- Clymene Dolphin (*Stenella clymene*)

Description—Due to similarity in appearance, 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 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 population in the western North Atlantic is currently considered a separate stock for management purposes although there is not enough information to distinguish this stock from the Gulf of Mexico stock(s) (Waring et al. 2008). The best estimate of abundance for the western North Atlantic stock of Clymene dolphins is 6,086 individuals (Mullin and Fulling 2003; Waring et al. 2008). No minimum population estimate is currently available for this stock (Waring et al. 2008).

Habitat Associations—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 and a range out to the 4,500 m isobath (Fertl et al. 2003; Moreno et al. 2005). Biogeographically, the Clymene dolphin is found in the warmer waters of the North Atlantic and is often associated with 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 confluent circulation (Davis et al. 2002). In the western North Atlantic, Clymene dolphins were identified primarily in offshore waters east of Cape Hatteras over the continental slope and are likely to be strongly influenced by oceanographic features of the Gulf Stream (Mullin and Fulling 2003).

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 VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. Most sightings in or near the OPAREA are recorded in offshore waters over the continental slope and follow the path of the Gulf Stream. The oceanographic features of the Gulf Stream likely influence the distribution of Clymene dolphins in this region. Based on confirmed sightings and this species' association with warm, deep waters, Clymene dolphins are expected in waters seaward of the shelf break south of the northern wall of the Gulf Stream. Only two sightings (both during summer) are documented north of the Gulf Stream in the OPAREA. Clymene dolphins may occur north of the Gulf Stream's warm water influence, particularly during summer when water temperatures are generally warmer (Figure B-17).

Behavior and Life History—Very little is known about the biology of the Clymene dolphin (Jefferson 2002b). 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). Seasonality and location of Clymene dolphin breeding is unknown. 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, which were first recorded in 1985 by Watkins and Wartzok (cited in Jefferson and Curry (2003). 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 with an average duration of 0.61 s) (Mullin et al. 1994a). In the Gulf of Mexico, on acoustic surveys, Clymene dolphins were vocal and presented whistles with a mean duration of 0.41 s and frequencies between 9.25 and 13.62 kHz (Mullin et al. 1994a; Norris et al. 2000). Click sounds from Clymene dolphins have not been examined for detail.

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).

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

Description—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 (females) and 2.6 m (males); however, there is substantial geographic variation (Jefferson et al. 1993).

Status—The best estimate of abundance for the western North Atlantic *Delphinus* spp. stock is 120,743 individuals, and the minimum population estimate is 99,975 individuals (Waring et al. 2008). There is no information available for western North Atlantic common dolphin stock structure (Waring et al. 2008).

Habitat Associations—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 2003). 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). Waring et al. (1992) reported short-beaked common dolphin sightings along the northern wall of the Gulf Stream and warm-core rings that coincided with the continental shelf break. Some common dolphin populations appear to preferentially travel along topographic features such as escarpments and seamounts (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—*Delphinus* 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).

Selzer and Payne (1988) described short-beaked common dolphin distribution along the northeastern U.S. This study found that this species is abundant within a broad band paralleling the continental slope from 35ºN to the northeast peak of Georges Bank. Short-beaked common dolphin sightings occurred primarily along the continental shelf break south of 40ºN in spring and north of this latitude in fall. During fall, this species is particularly abundant along the northern edge of Georges Bank (CETAP 1982) but less common south of Cape Hatteras (Gaskin 1992a). Historically, short-beaked common dolphins frequented the northeast Florida coast but have been conspicuously absent since the early 1960's (Caldwell et al. 1971; Leatherwood et al. 1976). The reason for this absence is unknown, although Jefferson and Shiro (1997) speculated that this may be a result of population or distributional fluctuations.

- Information Specific to the VACAPES OPAREA—Common dolphins primarily occur in a broad band along the shelf break from Cape Hatteras to Nova Scotia year-round (CETAP 1982). This species is less common south of Cape Hatteras (Gaskin 1992a); occurrence south of Cape Hatteras is considered questionable (Kenney 2007b).

  - Winter—The areas of greatest concentration are predicted near Pamlico and Accomac canyons near the northern wall of the Gulf Stream where common dolphins are thought to associate with the warm-core rings that coincide with the shelf break (Waring et al. 1992). This is a region of enhanced primary productivity resulting in localized prey concentrations. Predicted occurrence includes waters over the continental shelf and slope as well as nearshore waters (Figures B-18-1 and B-18-2). The lack of offshore sightings is most likely due to limited survey effort in offshore waters during this time of year.

  - Spring—The model output is similar to the winter season and is indicative of the expected occurrence for this species in the OPAREA. The common dolphin is predicted to occur in a broad band along the shelf break throughout the OPAREA; occurrence also extends into some deep, offshore waters (Figures B-18-1 and B-18-2). There is also an area of increased occurrence in deep (>3,500 m) waters over the continental rise in the eastern part of the OPAREA. The model predicts areas of greater occurrence in the Pamlico Canyon region near the northern wall of the Gulf Stream.

  - Summer—Occurrence is predicted in shelf and slope waters throughout much of the OPAREA (Figures B-18-1 and B-18-2). Occurrence in the southern VACAPES OPAREA abuts the northern wall of the Gulf Stream and may reflect a temperature-limited boundary during this time of year.

- Fall—This is the season with the least amount of recorded sightings, likely due to decreased survey effort and inclement weather conditions that can make sighting cetaceans difficult during this time of year. Predicted occurrence is restricted to shelf and slope waters in the northern VACAPES OPAREA due to the lack of on-effort sightings in the southern portion (Figures B-18-1 and B-18-2). However, opportunistic sightings, bycatch, and stranding records in this region support the likelihood of common dolphin occurrence throughout the OPAREA. The model output for winter and spring is more representative of what is generally expected for this species.

Behavior and Life History—The common dolphin is a very gregarious species; group sizes range from several dozen to over 10,000 individuals. 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); however, locations of breeding areas are unknown. Males in the North Atlantic reach sexual maturity at about 9 to 12 years of age (Murphy et al. 2005; Westgate and Read 2007) while females reach maturity at approximately eight years of age (Westgate and Read 2007). Gestation is approximately 11 months and mating occurs primarily during July and August (Westgate and Read 2007).

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). Foraging dives up to 200 m in depth have been recorded off southern California (Evans 1994).

Acoustics and Hearing—Recorded *Delphinus* spp. vocalizations include whistles, chirps, barks, and clicks (Ketten 1998a). Clicks range from 200 Hz 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 500 Hz to 14 kHz, and whistles range in frequency from 2 to 18 kHz (Fish and Turl 1976; Thomson and Richardson 1995; Ketten 1998a; Oswald et al. 2003). Maximum source levels averaged approximately 180 dB 1 μPa at 1m for clicks from a group of about 300 individual common dolphins (Fish and Turl 1976). Around the British Isles, short-beaked common dolphins display a vocal diurnal pattern: more acoustic contact was recorded during early morning and late evening periods (Goold 2000). Ansmann et al. (2007) examined the whistle repertoire of short-beaked common dolphins at two locations around the British Isles and found the frequencies to range from 3.56 to 23.51 kHz lasting from 0.05 to 2.02 seconds.

Popov and Klishin (1998) recorded auditory brainstem responses from a short-beaked common dolphin. The audiogram was U-shaped with a steeper high-frequency branch. This species' hearing range extended from 10 to 150 kHz and was most sensitive from 60 to 70 kHz.

- Fraser's Dolphin (*Lagenodelphis hosei*)

Description—The 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 (Jefferson 2002a). 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 abundance estimate of Fraser's dolphins in the western North Atlantic is available (Waring et al. 2008).

Habitat Associations—Fraser's dolphins are an oceanic species, except in places where deepwater 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. 1994b). 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; Bolaños and Villarroel-Marin 2003).

- Information Specific to the VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species in the OPAREA. Only one sighting is documented in the VACAPES OPAREA (Figure B-19); this sighting was recorded in deep waters (>3,000 m in depth) offshore of Cape Hatteras (NMFS-SEFSC 1999). Although this species is considered rare within the OPAREA, any occurrences would be expected seaward of the shelf break throughout the OPAREA year-round based on known habitat associations.

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, and specific breeding locations are unknown. 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. 1994b). 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). In the southeast Caribbean, both broadband clicks and whistles were recorded from a group of about 60 Fraser's dolphin (Watkins et al. 1994). Concurrent behavioral observations suggest these dolphins use clicks for echolocation and whistles for information sharing; whistle frequencies ranged from 4 to 24 kHz and lasted from 0.1 to 2 seconds (Watkins et al. 1994).

There are no empirical hearing data hearing data available for this species.

- White-beaked Dolphin *(Lagenorhynchus albirostris)*

Description—The white-beaked dolphin is a robust species, reaching lengths of 3.2 m, and weights of up to 354 kg (Jefferson et al. 1993; Reeves et al. 1999c). The back and sides of this species are generally black to dark gray. The short, thick beak is often mottled; Both the beak and most of the belly, are white to light gray (Jefferson et al. 1993). Dark or light flecks may occur between the eye and flipper.

Status—At least two white-beaked dolphin stocks are present in the North Atlantic: one in the eastern and one in the western (Waring et al. 2008). An abundance of 573 white-beaked dolphins was estimated during a 1980 aerial survey between Cape Hatteras, North Carolina and Nova Scotia (CETAP 1982). However, this out-dated count was not corrected for dive time or g(0) and is, therefore, not thought to represent current population size. There are no current estimates of abundance for the western North Atlantic stock (Waring et al. 2008).

Habitat Associations—White-beaked dolphins occupy waters over and beyond the continental shelf (Lien et al. 2001). Sightings are most common in nearshore waters of Newfoundland and Labrador (Lien et al. 2001). During CETAP (1982) surveys, white-beaked dolphins were typically sighted in coastal waters near Cape Cod and along Stellwagen Bank depths between 13 and 748 m.

Distribution—The white-beaked dolphin is found only in cold-temperate and subarctic North Atlantic waters and appears to be more common in eastern rather than western waters (Lien et al. 2001). Studies in the eastern North Atlantic suggest that the white-beaked dolphin has a more coastal feeding habit in contrast to the Atlantic white-sided dolphin which mainly feeds offshore (Das et al. 2003).

In the western North Atlantic, white-beaked dolphins occur from eastern Greenland through the Davis Strait and south to Massachusetts (Lien et al. 2001). White-beaked dolphins are found near the northern limits of their range between spring and late fall; they appear to winter farther south and some may remain there until late spring or early summer (Leatherwood and Reeves 1983). The northward shift that occurs during the summer appears to follow the progression of spawning capelin (Lien et al. 2001).

Off the northeastern U.S., white-beaked dolphins sightings are concentrated in the western Gulf of Maine and around Cape Cod (CETAP 1982). Prior to the 1970s, these dolphins were found primarily over the continental shelf in the Gulf of Maine and over Georges Bank. However, since then, they have occurred primarily in waters over the continental slope and have been replaced by Atlantic white-sided dolphins (Sergeant et al. 1980; Katona et al. 1993). This shift may result from a sand lance increase and herring decline in continental shelf waters (Payne et al. 1986; Payne et al. 1990b; Kenney et al. 1996).

- Information Specific to the VACAPES OPAREA—Any occurrences of the white-beaked dolphin here are considered to be extralimital. One sighting record is documented in the OPAREA along the shelf break during spring (Figure B-20). Based on the habitat associations of this species, the white-beaked dolphin could be found in waters between the shoreline and the 2,000 m isobath.

Behavior and Life History—In the western North Atlantic, white-beaked dolphins are most commonly sighted in small groups numbering 10 to 20 animals (CETAP 1982; Lien et al. 2001). Mean group size off Nova Scotia is estimated at around eight individuals, although groups of up to 25 individuals have been documented (Gowans and Simard 2003). White-beaked dolphins occasionally associate with common dolphins, Atlantic white-sided dolphins, bottlenose dolphins, fin whales, and humpback whales (Lien et al. 2001).

Basic biological parameters are poorly known (Reeves et al. 1999c). A calving peak appears to occur in summer and early fall (Jefferson et al. 1993); breeding locations are unknown. Male white-beaked dolphins become physically mature at 2.8 m in length and 13 years of age. Females reach physical maturity at an average length of 2.6 m and 16 years of age, but there is considerable variation in length at sexual maturity (Hai et al. 1996). The principal prey of white-beaked dolphins are clupeids (herrings), gadids (Atlantic cod, haddock), whiting, hake, and squids (Reeves et al. 1999c). There is no information available on depths to which white-beaked dolphins dive.

Acoustics and Hearing—White-beaked dolphins produce sounds including clicks and squeals. Clicks are presumably used for echolocation (Rasmussen et al. 2002). Maximum click source levels are 219 dB re 1 µPa-m (Rasmussen et al. 2002). Squeals range from 6.5 to 15 kHz (Lien et al. 2001).

There is virtually no other vocalization or hearing data available on this species; however, odontocetes are generally adapted to hear high frequencies (Ketten 1997). Nachtigall et al. (2008) collected the first AEP measurements of two wild white-beaked dolphins (one male, one female): results suggest that individuals of this species follow the typical "U"-shaped audiogram curve for odontocetes. Threshold frequencies at 50 and 64 kHz were recorded from the female (Nachtigall et al. 2008) and a complete audiogram was obtained from the male. The frequency range was 16 to 181 kHz (Nachtigall et al. 2008), which suggests that white-beaked dolphins possess high-frequency hearing comparable to the harbor porpoise.

- Atlantic White-sided Dolphin *(Lagenorhynchus acutus)*

Description—The Atlantic white-sided dolphin has a stocky body with a short thick beak and tall, falcate dorsal fin. Individuals have a complex color pattern consisting of black on the back, top of the beak, flippers and flukes and gray sides (Jefferson et al. 1993). There is a white band below the dorsal fin that connects with a yellow band on the tailstock. Adults reach 2.5 to 2.8 m in length.

Status—Based on the distribution of sightings, strandings, and bycatch records, three stocks have been suggested for Atlantic white-sided dolphins in the western North Atlantic: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka et al. 1997). However, recent mitochondrial DNA analyses indicate no definite stock structure exists (Amaral et al. 2001). The total number of Atlantic white-sided dolphins along the U.S. and Canadian Atlantic coast is unknown. The best estimate of Atlantic white-sided dolphins in the western North Atlantic stock is 63,368 individuals while the minimum estimate of this stock is 50,883 (Waring et al. 2008).

Habitat Associations—The Atlantic white-sided dolphin is found primarily in continental shelf waters up to 100 m deep (CETAP 1982; Selzer and Payne 1988; Mate et al. 1994). Atlantic white-sided dolphin occurrence in the northeastern U.S. probably reflects fluctuations in food availability, as well as oceanographic conditions (Selzer and Payne 1988). Prior to the 1970s, Atlantic white-sided dolphins were primarily found offshore in waters over the continental slope. However, they have more recently occurred primarily in waters over the continental shelf, replacing white-beaked dolphins, which were previously sighted in greater local abundance. This shift may have resulted from sand lance increase herring decrease over the continental shelf (Payne et al. 1986; Payne et al. 1990b; Kenney et al. 1996). Important feeding areas are located near Cape Cod and on the northwest edge of Georges Bank in an area identified as the Great South Channel-Jeffreys Ledge corridor (CETAP 1982).

Selzer and Payne (1988) sighted Atlantic white-sided dolphins more frequently in areas of high seafloor relief and where SSTs and salinities were low. The authors noted that these environmental conditions might only be a secondary influence on dolphin distribution. Seasonal variation in sea-surface temperature and salinity, as well as local nutrient upwelling in areas of high seafloor relief, may affect preferred prey abundances, which in turn regulates cetacean distribution.

Distribution—Atlantic white-sided dolphins are found in cold-temperate to subpolar waters of the North Atlantic, from New England to France, north to southern Greenland, Iceland, and southern Norway (Jefferson et al. 1993). This species is most common over the continental shelf from Hudson Canyon north to the Gulf of Maine (Palka et al. 1997). Virginia and North Carolina appear to represent the southern edge of their range (Testaverde and Mead 1980). Sighting data indicate seasonal shifts in distribution, perhaps a reflection of an inshore/offshore movement (CETAP 1982; Payne et al. 1990a; Northridge et al. 1997). The spatial distribution of Atlantic white-sided dolphin sightings closely parallels sand lance distribution and abundance patterns (Selzer and Payne 1988; Kenney et al.

1996). SST was shown to be the most important variable corresponding to Atlantic white-sided dolphins occurrence west of Scotland (MacLeod et al. 2007).

From January to May, few Atlantic white-sided dolphins may be found from Georges Bank to Jeffreys Ledge (Northridge et al. 1997; Waring et al. 2008). Even lower numbers are found south of Georges Bank (a few strandings have been collected from Virginia and North Carolina beaches) (Payne et al. 1990a; Palka et al. 1997). From June through September, large numbers of Atlantic white-sided dolphins are found from Georges Bank to the lower Bay of Fundy (Payne et al. 1990a; Waring et al. 2008). During this time, strandings occur from New Brunswick, Canada to New York (Palka et al. 1997). From October to December, Atlantic white-sided dolphins occur in intermediate densities from southern Georges Bank to the southern Gulf of Maine. Sightings occur year-round in low densities south of Georges Bank, particularly around Hudson Canyon (CETAP 1982; Payne et al. 1990a; Palka et al. 1997).

Atlantic white-sided dolphins have the ability to move through wide-ranging areas; a rehabilitated individual was tracked over 300 km in less than three days (Mate et al. 1994). Photo-identification work also supports widespread movements (Weinrich et al. 2001).

- Information Specific to the VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. Sightings are recorded mostly in the northern VACAPES OPAREA and vicinity. Strandings and bycatch records are also documented near the OPAREA. Due to this species' association with colder waters, the Gulf Stream may be a southern boundary for Atlantic white-sided dolphin distribution. Although this species is considered rare within the OPAREA, any occurrences would be expected primarily in waters over the continental shelf throughout the OPAREA year-round based on known habitat associations. However, distribution may also range farther offshore which is evidenced by the sighting records offshore in waters over the continental slope in and near the OPAREA (Figure B-21).

Behavior and Life History—A mean of 54.3 individuals per sighting was calculated during CETAP surveys (CETAP 1982). Weinrich et al. (2001) calculated a mean group size of 52.4 individuals, with a range of 2 to 2,500 individuals. Mitochondrial DNA analyses suggests that this species forms small, matrilineal groups, which sometimes combine to form larger herds (Amaral et al. 2001). Weinrich et al. (2001) found group sizes in the Gulf of Maine were significantly higher during August through October.

Little is known about the life history of this species. Age at sexual maturity is around eight to nine years for males and six to eight years for females (Sergeant et al. 1980). Gestation lasts approximately 10 to 12 months and is followed by an 18-month lactation period. The calving interval is between two and three years. Calving appears to be highly seasonal with a strong peak in June and July but may range from May to August (Sergeant et al. 1980; Weinrich et al. 2001). Locations of breeding are unknown.

Atlantic white-sided dolphins feed on pelagic and benthipelagic fishes, such as capelin, herring, hake, sand lance, smelt, and cod, as well as squids (Katona et al. 1978; Sergeant et al. 1980; Kenney et al. 1985; Selzer and Payne 1988; Waring et al. 1990; Weinrich et al. 2001). Atlantic white-sided dolphins in the eastern North Atlantic feed mainly offshore (Das et al. 2003).

There is very little information on the diving behavior of Atlantic white-sided dolphins. Tagging data recorded from a single individual in the Gulf of Maine indicated that the animal spent 89% of its time submerged and had an average dive duration of 38.8 seconds (Mate et al. 1994).

Acoustics and Hearing—The only information available on Atlantic white-sided dolphin vocalizations involves the dominant frequency which is estimated to range from 6 to 15 kHz (Thomson and Richardson 1995).

There is virtually no other vocalization or hearing data available on this species. However, odontocetes are generally adapted to hear high frequencies (Ketten 1997).

- Risso's Dolphin (*Grampus griseus*)

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

Status—The best estimate of Risso's dolphin abundance in the western North Atlantic is 20,479 individuals; the minimum population estimate is 12,920 individuals (Waring et al. 2008).

Habitat Associations—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). Satellite tracking data support these observations; "Rocky", a Risso's dolphin, was tracked along the continental shelf break from Delaware to North Carolina from April to June 2005 (Figure 3-5); WhaleNet 2005). 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 deepwater 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 SSTs 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). In general, U.S. Atlantic Risso's dolphins occupy the mid-Atlantic continental shelf year-round, although they are rarely observed in the Gulf of Maine (Payne et al. 1984). Risso's dolphins are distributed along the continental shelf break from Cape Hatteras north to Georges Bank from March through December (CETAP 1982; Payne et al. 1984). This range extends seaward in the mid-Atlantic Bight from December through February (Payne et al. 1984). 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 VACAPES OPAREA—As mentioned above, Risso's dolphins are most commonly found in areas with steep bottom topography and are often sighted along the northern wall of the Gulf Stream which is a region of enhanced productivity. The model output results for the OPAREA generally follow this pattern of distribution with occurrence predicted along the shelf break and path of the Gulf Stream and including steep portions of the continental slope (Figures B-22-1 and B-22-2).

    - Winter—The model output predicts occurrence along the shelf break and continental slope throughout much of the OPAREA (Figures B-22-1 and B-22-2). Occurrence also extends into deeper, offshore waters in the Gulf Stream. The model output indicates an area of concentrated occurrence over steeply sloping bottom near Norfolk Canyon which would be an area of increased biological productivity. The paucity of sightings in offshore waters is likely a result of incomplete survey effort and inclement weather conditions during this time of year. Risso's dolphins are expected from the shelf break and seaward throughout the OPAREA based on sighting data and the association of this species for deep waters.

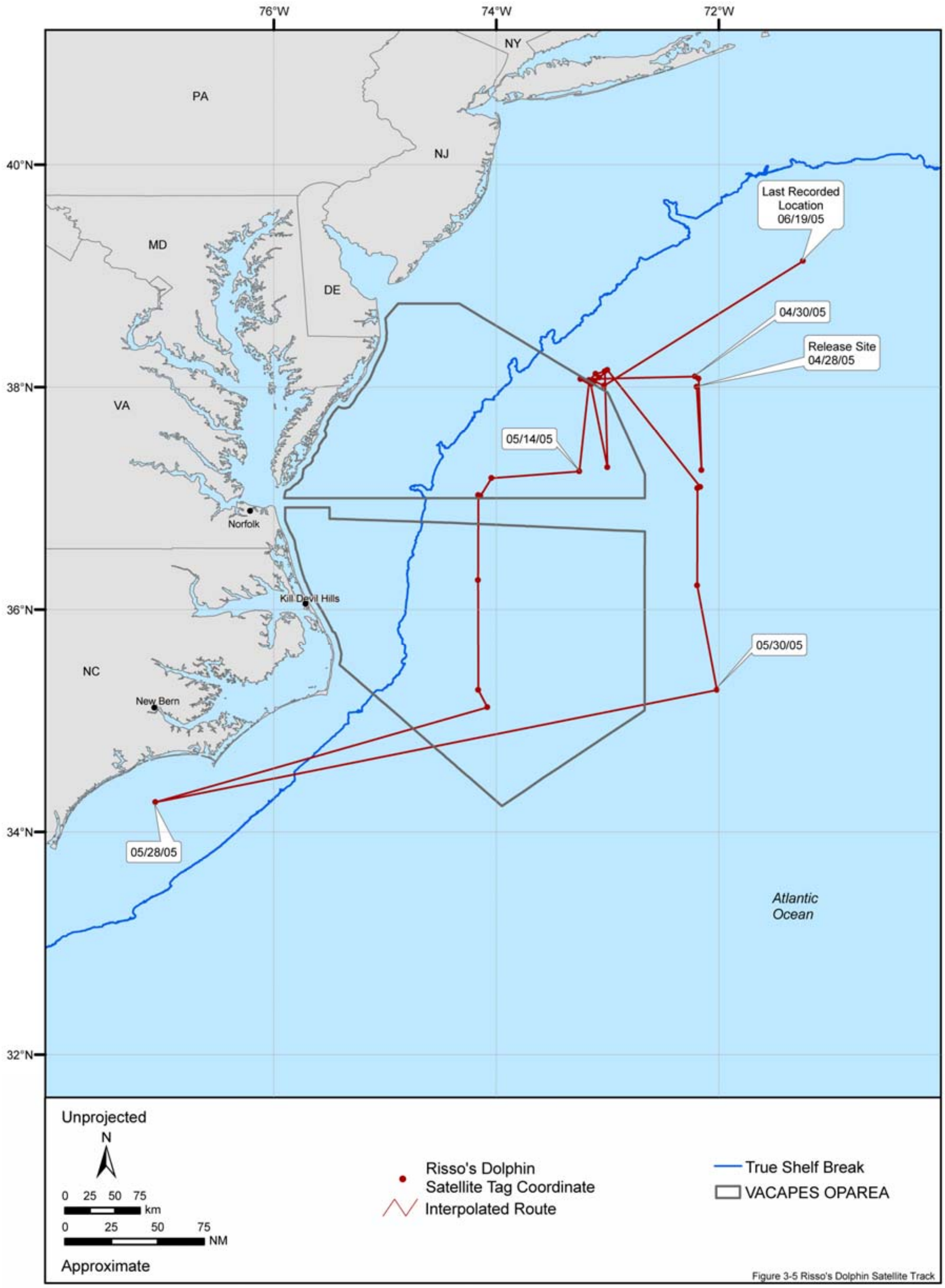

Figure 3-5. Satellite-tracked movements of a rehabilitated Risso's dolphin, "Rocky", from April through June 2005. Rocky moved along the continental shelf break and over the continental rise from southern Delaware to near Cape Hatteras, through the Virginia Capes and Cherry Point OPAREAs. Source data: WhaleNet (2005).

- Spring—Risso's dolphins are predicted to occur along the shelf break and over the continental slope throughout the OPAREA (Figures B-22-1 and B-22-2). The high number of sightings likely reflects greater spring survey effort.

- Summer—Occurrence is similar to the spring; however, sightings are more clustered north of the OPAREA which is likely a reflection of concentrated prey (Figures B-22-1 and B-22-2). Waring et al. (1992) noted an association with Risso's dolphins and the Gulf Stream northwall and warm-core rings during the summer of 1990 and 1991. Occurrence is also expected throughout offshore waters of the OPAREA.

- Fall—This is the season with the least amount of recorded sightings, likely due to decreased survey effort and inclement weather conditions that can make sighting cetaceans difficult during this time of year. The model predicts occurrence along the shelf break and continental slope throughout most of the OPAREA (Figures B-22-1 and B-22-2). Predicted occurrence also extends into nearshore waters off Maryland and Delaware; however, occurrence here is not likely based on the habitat associations of this species. Spring and summer reflect more of the expected distribution patterns of this species.

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), but locations of breeding are unknown. Risso's dolphins are quite social; groups usually average about 30 individuals but can range up to several hundred (Kruse et al. 1999) or even several thousand (Jefferson 2006). 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 400 Hz 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, also called the buzz, was stereotyped, ranged from 2 to 22 kHz with a mean duration of 8 seconds (both sounds together) and appears 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. 2004b).

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 observed at 90 kHz.

- 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 abundance estimates for melon-headed whales in the western North Atlantic (Waring et al. 2008).

Habitat Associations—Melon-headed whales are most often found in offshore waters. Sightings off Cape Hatteras, North Carolina are reported in waters greater than 2,500 m (NMFS-SEFSC 1999; NMFS-SEFSC 2002), and most in the Gulf of Mexico have been well beyond the edge of the continental shelf break (Mullin et al. 1994b; Davis and Fargion 1996a; Davis et al. 2000). 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 occur worldwide in subtropical and tropical waters. There are very few records for melon-headed whales in the North Atlantic (Ross and Leatherwood 1994; Jefferson and Barros 1997). Maryland is thought to represent the extreme of the northern distribution for this species in the northwest Atlantic (Perryman et al. 1994; Jefferson and Barros 1997).

- Information Specific to the VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. Melon-headed and pygmy killer whales can be difficult to distinguish from one another, and on many occasions only a determination of "pygmy killer whale/melon-headed whale" can be made. Records of both species are included in Figure B-23. Two sightings of melon-headed whales are recorded in deep (>2,500 m) offshore waters along the path of the Gulf Stream in the southern VACAPES OPAREA (Figure B-23). Although this species is rare within the OPAREA, any occurrences would be expected seaward of the shelf break throughout the OPAREA year-round based on known habitat associations. Based on warm water associations, melon-headed whale occurrence in the OPAREA during winter is likely influenced by the Gulf Stream.

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).

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). Breeding locations are unknown. 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 frequency 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 frequency 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 estimate of abundances for pygmy killer whales in the western North Atlantic (Waring et al. 2008).

Habitat Associations—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 1996b; Davis et al. 2000) out to waters over the abyssal plain (Jefferson 2006). Pygmy killer whales were sighted in waters deeper than 1,500 m off Cape Hatteras (Hansen et al. 1994). 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 40ºN or south of 35ºS (Jefferson et al. 1993). There are few records of this species in the western North Atlantic (e.g., Caldwell and Caldwell 1971a; Ross and Leatherwood 1994). Most records from outside the tropics are associated with unseasonable intrusions of warm water into higher latitudes (Ross and Leatherwood 1994).

➢ Information Specific to the VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. Pygmy killer and melon-headed whales can be difficult to distinguish from one another, and on many occasions only a determination of “pygmy killer whale/melon-headed whale” can be made. Records of both species are included in Figure B-23. Only one confirmed record, a fall stranding north of Cape Hatteras, is documented for pygmy killer whales in the OPAREA and vicinity. Although this species is rare within the OPAREA, any occurrences would be expected seaward of the shelf break throughout the OPAREA year-round based on known habitat associations. Based on warm water associations, pygmy killer whale occurrence in the OPAREA during winter is likely influenced by the Gulf Stream.

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. Seasonality and location of pygmy killer whale breeding are unknown. 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. 2004a). 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. 2004a). These clicks possess characteristics of echolocation clicks (Madsen et al. 2004a).

There are no empirical hearing data available for this species.

- <u>False Killer Whale</u> (*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 available for this species in the western North Atlantic (Waring et al. 2008).

Habitat Associations—False killer whales are primarily offshore animals, although they do come close to shore, particularly around oceanic islands (Baird 2002). 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 1996b). Inshore movements are occasionally associated with movements of prey and shoreward flooding of warm ocean currents (Stacey et al. 1994).

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).

- <u>Information Specific to the VACAPES OPAREA</u>—There are insufficient data to model the predicted occurrence of this species. False killer whales occur in offshore, warm waters worldwide (Baird 2002). The warm waters of the Gulf Stream likely influence occurrence in the southern VACAPES OPAREA. A small number of sightings and strandings are recorded near the OPAREA; the sightings reflect the association of this species with offshore waters (Figure B-24). Although this species is rare within the OPAREA, any occurrences would be expected seaward of the shelf break throughout the OPAREA year-round based on known habitat associations.

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 or specific locations are known for false killer whales. 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 (*Coryphaena hippurus*) and yellowfin tuna (*Thunnus albacares*) (Ligon and Baird 2001).

Deepwater cephalopods and fishes are their primary prey (Odell and McClune 1999), but large pelagic species, such as dorado, have been taken. False killer whales also take tuna from longlines (e.g., Mitchell 1975; Orsi Relini and Cagnolaro 1996; 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; Jefferson 2006) have been observed.

Acoustics and Hearing—The dominant frequency range of false killer whale whistles is from 4 to 9.5 kHz, and the range 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 1998a). Recently, false killer whales recorded in the Indian Ocean produced echolocation clicks with a dominant frequency of about 40 kHz and estimated source levels of 201-225 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 estimates of abundance for killer whales in the western North Atlantic (Waring et al. 2008). 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 Associations—Killer whales have the most ubiquitous distribution of any species of marine mammal, and they have been observed in virtually every marine habitat from the tropics to the poles and from shallow, inshore waters (and even rivers) to deep, oceanic regions (Dahlheim and Heyning 1999). In coastal areas, killer whales often enter shallow bays, estuaries, and river mouths (Leatherwood et al. 1976). Based on a review of historical sighting and whaling records, killer whales in the northwestern Atlantic are found most often along the shelf break and farther offshore (Katona et al. 1988; Mitchell and Reeves 1988). Killer whales in the Hatteras-Fundy region probably respond to the migration and seasonal distribution patterns of prey species, such as bluefin tuna (*Thunnus thunnus*), herring (*Clupea harengus*), and squids (Katona et al. 1988; Gormley 1990).

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 (2002a) 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). A year-round killer whale population in the western North Atlantic may exist south of around 35° N (Katona et al. 1988).

- Information Specific to the VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. Several killer whale sightings are recorded in both shallow and deep waters of the OPAREA and vicinity. Strandings are also reported along the Outer Banks (Figure B-25). Occurrence would be expected seaward of the shoreline year-round based on sighting data and the diverse habitat associations of this species.

Behavior and Life History—Killer whales have the most stable social system known among all cetaceans. In all areas where longitudinal studies have been carried out, evidence suggests that there are long-term associations between killer whale individuals and limited dispersal from maternal groups (Baird 2000). Killer whales normally occur in small groups in the northwestern Atlantic Ocean; the largest recorded group size was 40 individuals (Katona et al. 1988). In the Atlantic, calving takes place in late fall to mid-winter (Jefferson et al. 2008); however location of killer whale breeding in the North Atlantic is unknown. Reproductive biology information is not available for killer whales in the western North Atlantic. However, among resident killer whales in the northeastern Pacific, females typically give birth for the first time at 11 to 15 years of age (Ford and Ellis 1999). Based on work in captivity, sexually mature males are 13 years and older (Robeck and Monfort 2006).

Killer whales have the widest prey diversity of any marine mammal. Fishes, cephalopods, seabirds, sea turtles, and other marine mammals are known prey (Katona et al. 1988; Jefferson et al. 1991; Visser and Bonoccorso 2003; Pitman and Dutton 2004; Visser 2005). 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.

Diving behavior specific to the western North Atlantic is unknown. The maximum recorded depth for a free-ranging killer whale dive was 264 m off British Columbia (Baird et al. 2005a). 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. 2003b).

Acoustics and Hearing— Killer whales produce a wide-variety of clicks and whistles, but most of the social sounds of this species are pulsed calls, with frequencies ranging from 500 Hz to 25 kHz (dominant frequency range: 1 to 6 kHz) (Thomson and Richardson 1995). Echolocation clicks recorded for Canadian killer whales foraging on salmon have source levels ranging from 195 to 224 dB re: 1 μPa-m peak-to-peak, a center frequency ranging from 45 to 80 kHz, and durations of 80 to 120 μs (Au et al. 2004). Echolocation clicks from Norwegian killer whales were considerably lower than the previously-mentioned study and ranged from 173 to 202 re: 1 μPa-m peak-to-peak. The clicks had a center frequency ranging from 22 to 49 kHz and durations of 31 to 203 μs (Simon et al. 2007). Source levels associated with social sounds have been calculated to range from 131 to 168 dB re 1 μPa-m and have been demonstrated to vary with vocalization type (e.g., whistles: average source level of 140.2 dB re 1 μPa-m, variable calls: average source level of 146.6 dB re 1 μPa-m, and stereotyped calls: average source level 152.6 dB re 1 μPa-m) (Veirs 2004). Additionally, killer whales modify their vocalizations depending on social context or ecological function (i.e., short-range vocalizations [<10 km range] are typically associated with social and resting behaviors and long-range vocalizations [10 to 16 km range] are associated with travel and foraging) (Miller 2006). Likewise, echolocation clicks are adapted to the type of fish prey (Simon et al. 2007).

Pulsed calls are the most frequently observed vocalization from killer whales and can be discrete, variable or abberant (Ford 1989; Holt 2008). The discrete or stereotyped calls are likely used to maintain group cohesion during travel activity or other periods of separation (see Ford 1989; Filatova et al. 2007; Holt 2008). Foote and Nystuen (2008) examined the call structure (for calls between 0 and 10 kHz) of the three sympatric killer whale ecotypes (offshore, trasient and resident) in the Pacific Northwest in relation to ecological variables. Even though different between ecotypes, each group seemed to produce calls or a calling strategy outside the range of their identified prey (Foote and Nystuen 2008). Residents produced calls that overlapped their prey’s hearing sensitivt at the low end but which included peak energy well above the prey’s range. Transient killer whale calls all overlapped the hearing range of their primary prey (whales, porpoise and seals); however, members of this ecotype hunt silently (Barrett-Lennard et al. 1996).

Resident killer whales are very vocal, making calls during all types of behavioral states. Acoustic studies of resident killer whales in the Pacific Northwest have found that their dialects are highly stereotyped, repetitive, discrete calls, which are group-specific and shared by all members of each group (Ford 1991, 2002a). These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely-related whales (Ford 1991, 2002a). Dialects have been documented in northern Norway (Ford 2002b) and southern Alaskan killer whales populations (Yurk et al. 2002) and for resident killer whales in Southeast Kamchatka, Russia (Filatova et al. 2007), and are likely occur in other regions as well. A comparison of the variation in call parameters produced by resident, transient and offshore killer whales indicates significant shifts in minimum frequencies and peak frequency energy between these ecotypes, which likely correseponds to their foraging strategies and distribution (Foote and Nystuen 2008). Residents not need alter their sounds (i.e., frequency or amplitude) when hunting fishes, since most of their prey (i.e., salmonids) are not capable of hearing in this frequency range (i.e., > 20 kHz) (Hawkins and Johnstone 1978; Au et al. 2004). Transient killer whales, conversely, appear to use passive listening as a primary means of locating prey, call less often, and frequently vocalize or use high-amplitude vocalizations only when socializing (i.e., not hunting), trying to communicate over long distances, or after a successful attack, as a result of their prey's ability (i.e., primarily other marine mammal species) to hear or "eavesdrop" on their sounds (Barrett-Lennard et al. 1996; Deecke et al. 2005; Saulitis et al. 2005).

Both behavioral and ABR techniques indicate killer whales can hear a frequency range of 1 to 100 kHz with a range of best sensitivity (±10 dB from lowest threshold) between 18-42 kHz; however, their hearing is most sensitive at 20 kHz, which is one the lowest maximum-sensitivity frequencies known among toothed whales (Szymanski et al. 1999).

- Short-Finned and Long-Finned Pilot Whales (*Globicephala macrorhynchus* and *G. melaena*, respectively)

Description—Pilot whales are among the largest dolphins, with long-finned pilot whales potentially reaching 5.7 m (females) and 6.7 m (males) in length. Short-finned pilot whales may reach 5.5 m (females) and 6.1 m (males) in length (Jefferson et al. 1993). Pilot whales have bulbous heads, with a forehead that sometimes overhangs the rostrum, and little or no beak. The falcate dorsal fin is distinctive; being generally longer than it is high, with a rounded tip and set well forward of the body's mid-length. The flippers of long-finned pilot whales are extremely long, sickle shaped, and slender, with pointed tips, and an angled leading edge that forms an "elbow". Long-finned pilot whale flippers range from 18 to 27% of length. Short-finned pilot whale flippers are sickle shaped. Pilot whales are black, with a light-gray saddle patch behind the dorsal fin in some individuals. There is also a white to light-gray anchor-shaped patch on the chest. Short-finned pilot whales have flippers that are somewhat shorter than long-finned pilot whale at 16 to 22% of the total body length (Jefferson et al. 1993).

Status—The best estimate of pilot whale abundance (combined short-finned and long-finned) in the western North Atlantic is 31,139 individuals, and the minimum estimate is 24,866 individuals (Waring et al. 2008).

Fullard et al. (2000) proposed a stock structure for long-finned pilot whales in the North Atlantic that was correlated with sea-surface temperature. This involved a cold-water population west of the Labrador and North Atlantic current and a warm-water population that extended across the North Atlantic in the warmer water of the Gulf Stream.

Habitat Associations—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, they are also commonly sighted on the continental shelf and inshore of the 100 m isobath, as well as seaward of the 2,000 m isobath north of Cape Hatteras (CETAP 1982; Payne and Heinemann 1993). Long-finned pilot whale sightings extend south to near Cape Hatteras through the VACAPES OPAREA (Abend and Smith 1999) along the continental slope. 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 (Abend and Smith 1999).

Several studies in different regions suggest that pilot whale distributions and seasonal inshore and offshore movements coincide closely with the abundance of their preferred squid prey (Hui 1985; Payne and Heinemann 1993; Waring and Finn 1995; Bernard and Reilly 1999). 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). Short-finned pilot whale occurrence in the Caribbean Sea seems to coincide with the inshore movement of spawning octopus (Mignucci-Giannoni 1998).

Distribution—Long-finned pilot whales are distributed in subpolar to temperate North Atlantic waters offshore and in some coastal waters. 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 50ºN or south of 40ºS (Jefferson et al. 1993). 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 shelf/shelf-edge and slope waters of the northeastern U.S. between 35°N and 38° to 39°N (New Jersey to Cape Hatteras, North Carolina) (Payne and Heinemann 1993). Strandings of long-finned pilot whales have been recorded as far south as Florida (Waring et al. 2008). Short-finned pilot whales are common south of Cape Hatteras (Caldwell and Golley 1965; Irvine et al. 1979). Long-finned pilot whales appear to concentrate during winter along the continental shelf break primarily between Cape Hatteras and Georges Bank (Waring et al. 1990).

Pilot whales concentrate along the continental shelf break from during late winter and early spring north of Cape Hatteras (CETAP 1982; Payne and Heinemann 1993). This corresponds to a general movement northward and onto the continental shelf from continental slope waters (Payne and Heinemann 1993). From June through September, pilot whales are broadly distributed over the continental shelf (Payne et al. 1990a), with the greater percentage of pilot whale sightings along the continental shelf breaks in the northeastern portion of Georges Bank and onto the Scotian Shelf. From May through October, pilot whales predominantly occur on the northern edge of central Georges Bank (Payne et al. 1990a). Movements from June through September continue northward into the Gulf of Maine and into Canadian waters. From September through December, the largest concentrations of pilot whales occur along the southwestern edge of Georges Bank. By December, many pilot whales have already moved offshore and southward (Payne and Heinemann 1993).

Short-finned pilot whales seem to move from offshore to continental shelf break waters and then northward to approximately 39ºN, east of Delaware Bay during summer (Payne and Heinemann 1993). Sightings coalesce into a patchy continuum and, by December, most short-finned pilot whales occur in the mid-Atlantic slope waters east of Cape Hatteras (Payne and Heinemann 1993). Although pilot whales appear to be seasonally migratory, sightings indicate common year-round occurrence in some continental shelf areas, such as the southern margin of Georges Bank (CETAP 1982; Abend and Smith 1999).

- Information Specific to the VACAPES OPAREA—The VACAPES OPAREA is located in the region of range overlap between both pilot whale species (Payne and Heinemann 1993). Identification of pilot whales to species is difficult at sea, and identification is often made to the genus level only. Both species of pilot whale as well as records of unidentified pilot whales are included the model output and associated figures (Figures B-26-1 and B-26-2). All seasons support sighting and bycatch records of unidentified pilot whales (likely short-finned pilot whales) in Gulf Stream waters of the OPAREA due to the tropical nature of this species.

  Throughout the year, the model outputs results show pilot whale occurrence in waters with steep bottom topography (i.e., canyons and steep slope areas) which are likely feeding areas (Figures B-26-1 and B-26-2). Areas of predicted occurrence also follow the path of the Gulf Stream. As mentioned above, pilot whales are often sighted along the northern wall of the Gulf Stream which is a region of enhanced productivity. Throughout most of the deep waters of the OPAREA there is a lack of sufficient survey effort to predict the occurrence patterns of this genus.

- Winter—During this time of the year, the model output predicts occurrence around the shelf break and over the continental slope into deep (>3,500 m) waters over the continental rise (Figures B-26-1 and B-26-2). Increased occurrence is expected in upper slope waters in the Pamlico Canyon region. This area may represent long-finned pilot whales which are known to concentrate between the Virginia/North Carolina border and Cape Hatteras from late winter to early spring (Abend and Smith 1999). Pilot whales are expected seaward of the shelf break throughout the OPAREA. They may also occur between the shore and shelf break which is supported by a few opportunistic sightings and bycatch records. Limited survey effort may be impacting the assessment of pilot whale distribution during winter.

- Spring—The model output predicts occurrence over shelf waters and seaward of the shelf break throughout the OPAREA (Figures B-26-1 and B-26-2). Predicted occurrence in deep, offshore waters is more extensive than during the winter. The model output results generally agree with what is known about the habitat associations of this genus. The cluster of sightings near the Pamlico Canyon region likely represents long-finned pilot whales which are known to concentrate in this area during late winter to early spring (Abend and Smith 1999).

- Summer—Predicted occurrence is similar to the spring season; however, occurrence does not extend as far offshore (Figures B-26-1 and B-26-2). As during the other seasons, summer occurrence is expected to extend into offshore waters throughout the OPAREA.

- Fall—Occurrence is predicted along the shelf break and steep sloping areas of the OPAREA (Figures B-26-1 and B-26-2). Increased occurrence is predicted along the upper continental slope over the Pamlico Canyon region. Concentrations here are likely influenced by high levels of productivity generated by warm-core rings from the Gulf Stream as well as the steep sloping bottom topography of the area. Occurrence should be expected throughout deep, offshore waters of the OPAREA.

Behavior and Life History—Pilot whales are known to be highly social and are found in relatively stable maternal groups of a few to 100s of individuals (Jefferson et al. 1993). Genetic studies of long-finned pilot whales hunted in the Faroese drive fishery suggest that they may live in groups of mixed age and sex in which adult males and females are related and the males do not sire offspring in the group (Amos et al. 1993b; Amos et al. 1993a). In contrast, a recent behavioral study of long-finned pilot whales off Nova Scotia suggests that groups are ephemeral, with short-term associations between individuals over hours to days, and long-term associations with a subset of those individuals over years (Ottensmeyer and Whitehead 2003). This study could not account for the variation in social structure between geographic areas, but recommended genetic sampling of behaviorally studied populations.

Average age at sexual maturity for long-finned pilot whales is six years for females and 12 years for males. Average age at sexual maturity for short-finned pilot whales is nine years for females and 17 years for males. The gestation period for long-finned pilot whales is 15 months, with a mean calving interval of 3.3 years. 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. The calving peak for long-finned pilot whales is from July to September in the northern hemisphere (Bernard and Reilly 1999). Short-finned pilot whale calving peaks in the northern hemisphere are in the fall and winter for the majority of populations (Jefferson et al. 2008). Locations of breeding areas are unknown.

Pilot whales frequently associate with other cetaceans (Bernard and Reilly 1999). CETAP (1982) reported that mixed groups of pilot whales and offshore bottlenose dolphins were the most frequent multi-species association observed in offshore U.S. Atlantic areas. Associations between long-finned pilot whales and Atlantic white-sided dolphins have also been reported (CETAP 1982; Baraff and Asmutis-Silvia 1998).

Pilot whales are deep divers, staying submerged for up to 27 min and routinely diving to 600 to 800 m (Baird et al. 2003a; Aguilar de Soto et al. 2005). Mate (1989) described movements of a satellite-tagged, rehabilitated long-finned pilot whale released off Cape Cod that traveled roughly 7,600 km during the three months of the tag's operation. Daily movements of up to 234 km are documented. Deep diving occurred mainly at night, when prey within the deep scattering layer approached the surface. Tagged long-finned pilot whales in the Ligurian Sea were also found to make their deepest dives (up to 648 m) after dark (Baird et al. 2002). Two rehabilitated juvenile long-finned pilot whales released south of Montauk Point, New York made dives in excess of 26 min (Nawojchik et al. 2003). However, mean dive duration for a satellite tagged long-finned pilot whale in the Gulf of Maine ranged from 33 to 40 sec., depending upon the month (July through September) (Mate et al. 2005).

Both pilot whale species feed primarily on squids but also take fishes (Bernard and Reilly 1999). The long-finned squid (*Loligo pealei*) is a major component of mid-continental shelf and continental shelf break pilot whale diets from December through May (Waring et al. 1990). Overholtz and Waring (1991) and Gannon et al. (1997b; 1997a) found that pilot whales killed during mackerel fishing operations appeared to feed primarily on mackerel and long-finned squid, although Atlantic mackerel were also taken during trawling operations off the northeastern U.S. from December through May (Waring et al. 1990). Pilot whales in the western North Atlantic take Atlantic cod, Greenland turbot, lantern fish, Atlantic herring, silver hake, and spiny dogfish when squids are not available (Waring et al. 1990; Gannon et al. 1997b; Gannon et al. 1997a). 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. 1996b).

Both pilot whale species are known to mass strand; in fact, they are the most frequently-stranded cetaceans worldwide (Nelson and Lien 1996). An unusual mortality event involving short-finned pilot whales recently occurred along the coast of North Carolina during January 2005 (Hohn et al. 2006). During the event, thirty-three short-finned pilot whales stranded near Oregon Inlet on the Outer Banks (Hohn et al. 2006). Stomach contents analyzed from 13 of the mass stranded short-finned pilot whales suggest dietary differentiation between short-finned and long-finned pilot whales (Jordán Sardi et al. 2005). Short-finned pilot whales fed primarily upon oceanic squids (*Brachioteuthis* and *Histioteuthis*) which reside seaward of the continental shelf break, while *Loligo pealei* is found in shallower waters. Dietary evidence also implies alternative distributions in the OPAREA during this time, with short-finned pilot whales occurring farther offshore than long-finned pilot whales.

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 1998a).

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).

- <u>Harbor Porpoise</u> *(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 1992b). The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,054 individuals; the minimum estimate is 60,970 individuals (Waring et al. 2008).

Habitat Associations—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 1992b). Harbor porpoises are generally scarce in areas without significant coastal fronts or topographically-generated upwellings (Gaskin 1992b; Skov et al. 2003). Harbor porpoises occur most frequently over the continental shelf (Read 1999). 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). Records of bycaught individuals from the winter months coupled with a dearth of sightings over the continental shelf during the winter and spring suggest that this shift to offshore distribution may be seasonal in nature and may represent the winter range of harbor porpoises in the western North Atlantic (Read et al. 1996). However, the winter range of this species is very poorly known and there are not enough data to support unequivocally the presence of an offshore distribution (IWC 1996; Read 1999).

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. 1999b).

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 (Palka 2000). 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 (Waring et al. 2008), with some sightings in continental slope and offshore waters (Westgate et al. 1998). 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). A satellite tagged harbor porpoise, “Gus”, was rehabilitated and released off the coast of Maine and followed the continental slope south to near Cape Hatteras between January and March of 2004 (Figure 3-6; WhaleNet 2004). During this time of year, significant numbers of porpoises occur along the mid-Atlantic shore from New Jersey to North Carolina (Waring et al. 2008), where they are subject to incidental mortality in a variety of coastal gillnet fisheries (Cox et al. 1998). Mid-Atlantic porpoise bycatches occur from December through May (Waring et al. 2008). 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. 1999a).

A noteworthy unusual mortality event took place between 1 January and 28 March 2005 during which 38 harbor porpoises stranded along the coast of North Carolina (Hohn et al. 2006; MMC 2006). Most of the stranded individuals were calves and many were emaciated, indicating that the harbor porpoises had difficulty finding food (MMC 2006).

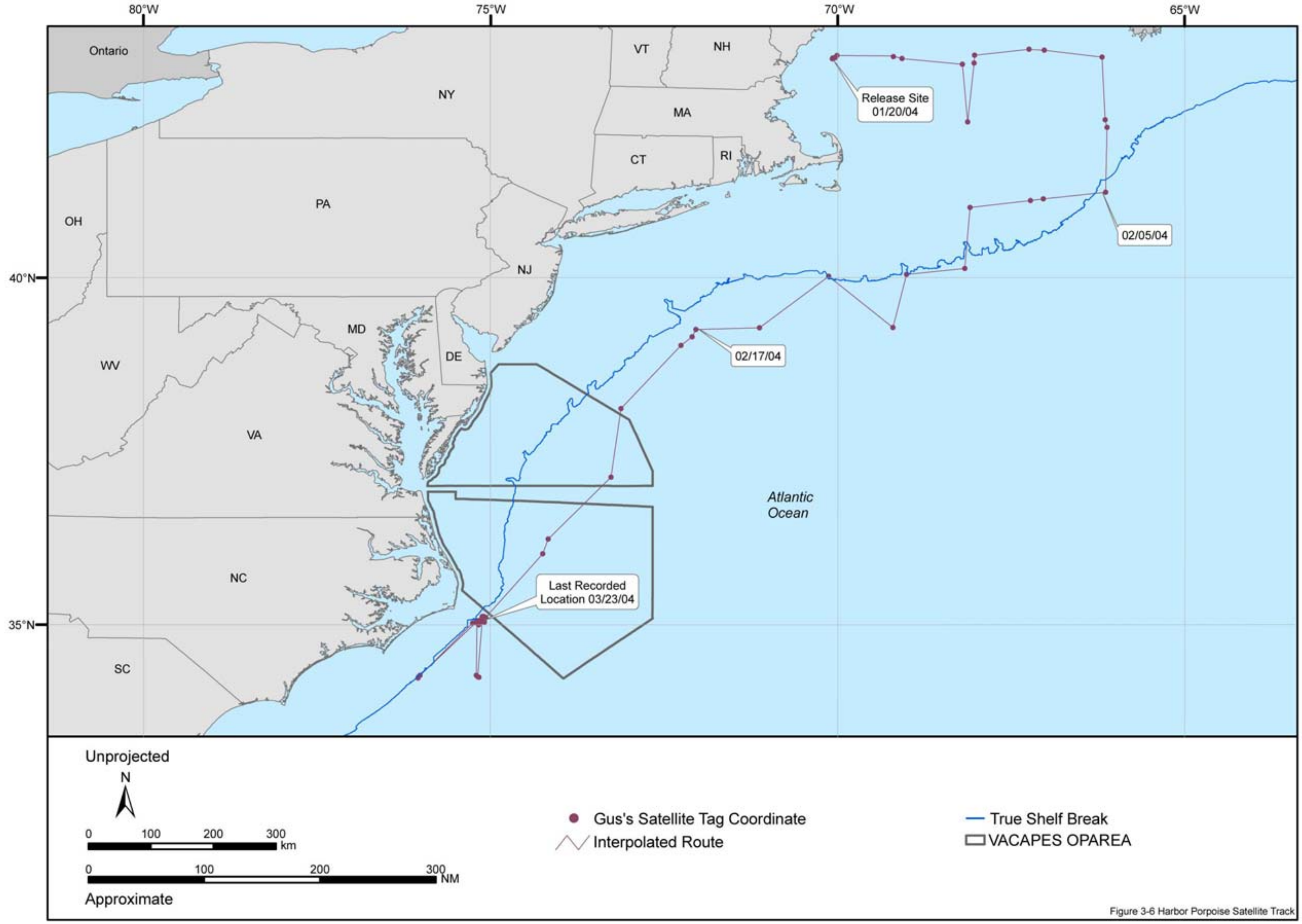

Figure 3-6. Satellite-tracked movements of a rehabilitated harbor porpoise from January through March 2004. This individual traveled south from the Gulf of Maine to Cape Hatteras, into the Virginia Capes and Cherry Point OPAREAs, where it remained for several days before satellite tag failure. Source data: WhaleNet (2004).

- Information Specific to the VACAPES OPAREA—The harbor porpoise primarily occurs on the continental shelf in cool temperate to subpolar waters (Read 1999) that are at higher latitudes than the OPAREA. Occurrences of harbor porpoises in the mid-Atlantic are scattered (CETAP 1982; Northridge 1996). Harbor porpoises are found in coastal waters off North Carolina most commonly during winter (January through March) (Waring et al. 2008).

- Winter—Sightings are distributed over the continental shelf throughout the OPAREA during this time of year (Figures B-27-1 and B-27-2). The concentration of bycatch and stranding records off North Carolina and Delaware/Maryland is likely due to gillnet interactions. Occurrence is predicted over most of the shelf. The areas of greatest concentration are located along the shelf break near the Pamlico Canyon and in shelf waters near Washington Canyon where primary productivity is enhanced near the northern wall of the Gulf Stream. Although sightings indicate that harbor porpoises are limited to shelf waters, they may also occur farther offshore as evidenced by a harbor porpoise caught in a pelagic drift net 75 km east of Nag's Head, North Carolina (Read et al. 1996) and records of the previously-mentioned tagged harbor porpoise that traveled through deep, offshore waters of the OPAREA (Figure 3-6).

- Spring/Summer/Fall—The model output predicts no occurrence for this species in the OPAREA during spring and summer, and only a small area of occurrence is predicted for fall (Figures B-27-1 and B-27-2). A few sighting and bycatch records are documented over the shelf during spring and fall. Several strandings are also recorded inshore of the OPAREA boundaries during spring and fall and support the likelihood of harbor porpoise occurrence during these seasons. Harbor porpoises may occur along the continental shelf in the northern portion of the OPAREA during early spring and fall. During summer, harbor porpoises tend to be concentrated in the northern Gulf of Maine and lower Bay of Fundy region and are not expected to occur as far south as the VACAPES OPAREA.

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 1990b; Read and Hohn 1995). Generally, most calves are born April through August (Jefferson et al. 2008). The location of breeding areas is unknown. Many females are pregnant and lactating simultaneously (Read 1990a; 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 1998a), as well as whistle-like signals (Verboom and Kastelein 1995). The dominant frequency range is 110 to 150 kHz, with source levels between 135 and 205 dB re 1 μPa-m (Ketten 1998b; Villadsgaard et al. 2007). Echolocation signals include one or two low-frequency components in the 1.4 to 2.5 kHz range (Verboom and Kastelein 1995).

A behavioral audiogram of a harbor porpoise indicated the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re 1 μPa-m (Andersen 1970); however, auditory-evoked potential (AEP) studies showed a much higher frequency range of approximately 125 to 130 kHz for best sensitivity (Bibikov 1992). The AEP method suggests that the harbor porpoises have two frequency ranges of best sensitivity depicted in a “W” shaped audiogram (Richardson 1995), while behavioral audiogram studies found the range of best hearing to be 16 to 140 kHz, with a reduced sensitivity around 64 kHz (Kastelein et al. 2002). Behavioral audiograms also presented a “U” shaped audiogram indicating a single peak of best sensitivity (Richardson 1995). Maximum sensitivity occurs between 100 and 140 kHz (Kastelein et al. 2002).

- 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 vitulina* 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 (Temte et al. 1991).

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 (Waring et al. 2008). The minimum population estimate of 91,546 seals is based on corrected total counts along the coast of Maine in 2001 (Waring et al. 2008). 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 Associations—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 (Caldwell and Caldwell 1969; NMFS unpublished data cited in Waring et al. 2008).

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 VACAPES OPAREA—There are insufficient data to model the predicted occurrence of this species. Harbor seal occurrences in the inshore and nearshore waters of the mid-Atlantic region are becoming more frequent in the fall and winter months (Barco 2008). Several strandings near the OPAREA from Delaware to North Carolina are depicted in Figure B-28. Winn et al. (1979) suggested that harbor seals found in this area are likely young individuals that disperse from the north during the winter months. Stranding data support a consistent seasonal occurrence of harbor seals in this region (Harry et al. 2005). Most harbor seal strandings near the OPAREA are documented during winter (Figure B-28). Between 2000 and 2005, at least 71 records of harbor seal strandings were reported for North Carolina and Virginia (Harry et al. 2005). Most of these strandings occurred between November and April and were of young individuals. Sightings and strandings of harbor seals have been documented throughout the year in South Carolina (McFee 2006). Therefore, although harbor seals are considered rare in the OPAREA, they could move south along the coast of North Carolina and occur near the OPAREA any time of the year.

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 and females produce a variety of low-frequency in-air vocalizations including snorts, grunts, and growls, while pups make individually unique calls for mother recognition, which contain multiple harmonics with main energy at 0.35 kHz (Thomson and Richardson 1995). Adult males also produce several underwater sounds such as roars, bubbly growls, grunts, groans, and creaks during the breeding season. These sounds typically range from 0.025 to 4 kHz (duration range: 0.1 sec to 11 seconds) (Hanggi and Schusterman 1994). Hanggi and Schusteman (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 levels of variation (i.e., could represent vocal dialects) between males.

Harbor seals hear nearly as well in air as underwater (Kastak and Schusterman 1998). Harbor seals are capable of hearing frequencies from 1 to 180 kHz (most sensitive at frequencies between 1kHz and 60 kHz using behavioral response testing) 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). Despite the absence of an external ear, harbor seals are capable of directional hearing in-air, giving them the ability to mask out background noise (Holt and Schusterman 2007). Underwater sound localization was demonstrated by Bodson et al. (2006). TTS for the harbor seal was assessed at 2.5 kHz and 3.53kHz, with 80 and 95 dB SL (sensation level, referenced to absolute auditory threshold at center frequency), by Kastak et al. (2005). Data indicated that the range of TTS onset would be between 183-206 dB re: 1μPa^{2}s (Kastak et al. 2005).

- <u>Gray Seal</u> *(Halichoerus grypus)*

Description—Gray seals are large and robust; adult males can reach 2.3 m in length and weigh 310 kg (Jefferson et al. 1993). The sexes are sexually dimorphic (Bonner 1981). The species name *grypus* means “hook-nosed”, referring to the Roman nose profile of the adult male (Hall 2002). In Canada, the gray seal is often referred to as the ‘horse-headed” seal due to the elongated snout of the males (Lesage and Hammill 2001). The head has a wide muzzle, and the nostrils form a distinctive, almost “W” shape (Jefferson et al. 1993). Pelage color and pattern are individually variable, with most gray seals seen in shades of gray, slightly darker above than below (Jefferson et al. 1993). There are usually numerous irregular blotches and spots on the back. Males are generally more uniformly dark when mature whereas females exhibit the more distinct markings on the fur (Hall 2002).

Status—Next to harbor seals, gray seals are the most commonly sighted seal in the northeastern U.S. There are at least three populations of gray seal in the North Atlantic Ocean: eastern North Atlantic, western North Atlantic, and Baltic (Boskovic et al. 1996). The western North Atlantic stock is equivalent to the eastern Canada breeding population (Waring et al. 2008). There are two breeding concentrations in eastern Canada: one at Sable Island and the other on the pack ice in the Gulf of St. Lawrence. These two breeding groups are treated as separate populations for management purposes (Mohn and Bowen 1996). There is an estimated 195,000 gray seals in Canada (DFO 2003b). The herd on Sable Island is thought be growing and may have more than doubled in number, but the Gulf of St. Lawrence population is declining (Bowen et al. 2003). This decline has been attributed to sharp decline in the quantity of suitable ice breeding habitat in the southern Gulf of St. Lawrence possibly due to climate change (Hammill et al. 2003). Small breeding colonies have also been documented along the coast of Maine and Massachusetts (Katona et al. 1993; Rough 1995).

Present data are insufficient to calculate the minimum population estimate for gray seals in U.S. waters (Baraff and Loughlin 2000; Waring et al. 2008). However, gray seal abundance appears to be increasing in the U.S. Atlantic EEZ (Waring et al. 2008). The minimum population estimate for Canadian gray seals is between 125,541 and 169,064 seals (Trzcinski et al. 2005).

Habitat Associations—The gray seal is considered to be a coastal species (Lesage and Hammill 2001). Gray seals may forage far from shore but do not appear to leave the continental shelf regions (Lesage and Hammill 2001). Gray seals haul out on ice, exposed reefs, or beaches of undisturbed islands (Lesage and Hammill 2001). Haulout sites are often near rough seas and riptides (Katona et al. 1993). Remote, uninhabited islands tend to have the largest gray seal haulout sites (Reeves et al. 1992). Weather (strong currents and storms) may change the configuration of haulout sites and result in distribution shifts (Barlas 1999). Gray seals in the Baltic Sea were found to select habitat on the basis of bottom depth or bathymetric features such as slope gradients, which likely correlate with prey availability, yet remain in the vicinity of a specific haulout site for extended periods (Sjöberg and Ball 2000). Foraging areas of gray seals in the North Sea are often localized areas characterized by a gravel/sand sediment, which is the preferred burrowing burrow of the sand lance, an important prey item of the gray seal (McConnell et al. 1992).

Distribution—The gray seal is found throughout temperate and subarctic waters on both sides of the North Atlantic Ocean (Davies 1957). In the western North Atlantic Ocean, the gray seal population is centered in the Canadian Maritimes, including the Gulf of St. Lawrence and the Atlantic Coasts of Nova Scotia, Newfoundland, and Labrador. The largest concentrations are found in the southern half of the Gulf of St. Lawrence (where most seals breed on ice) and around Sable Island (where most seals breed on land) (Davies 1957; Hammill and Gosselin 1995; Hammill et al. 1998).

Gray seals were historically distributed along the northeastern U.S. from Maine to Connecticut (Waters 1967; Rough 1995; Wood et al. 2003). It is thought they were extirpated during the 17th century, possibly due to Native American exploitation, European colonization/exploitation, and/or climate change (Waters 1967; Wood et al. 2003). Gray seals currently range into the northeastern U.S., with strandings as far south as North Carolina (Hammill et al. 1998; Waring et al. 2008). Small numbers of gray seals and pupping have been observed on several isolated islands along the central coast of Maine and in Nantucket Sound (the southernmost breeding site is Muskeget Island) (Andrews and Mott 1967; Rough 1995; Waring et al. 2008). Resident colonies and pupping has been observed in Maine since 1994, on a few islands (Seal and Green) in Penobscot Bay (Waring et al.

2008). Spring and summer sightings off Maine are primarily on offshore ledges of the central coast of Maine (Richardson 1976). In the late 1990s, a breeding population of at least 400 animals was documented year-round on outer Cape Cod and Muskeget Island (Barlas 1999; Waring et al. 2008). Hoover et al. (1999) reported sighting as many as 30 adult gray seals at one haulout site in New York. There are also gray seal sightings and strandings on Long Island Sound.

From December to February, gray seals in the western North Atlantic Ocean aggregate into two main breeding colonies located on Sable Island and in the southern Gulf of St. Lawrence. Post-breeding, gray seals disperse widely; they remain offshore until the spring molt (May to June) (Rough 1995; Lesage and Hammill 2001). After the molt is completed, there is a second dispersal; the destination of these dispersals off eastern Canada is varied and depends on the originating population (Sable Island versus non-Sable Island). In November to December, gray seals return to the southern Gulf of St. Lawrence or to Sable Island for the breeding season. Some gray seals found breeding in the northeastern U.S. bear brands and tags indicating that they had been born on Sable Island (Wood et al. 2003).

- Information Specific to the VACAPES OPAREA—Any occurrences of the gray seal here are considered to be extralimital. Gray seal occurrences in the inshore and nearshore waters of the mid-Atlantic region are becoming more frequent in the fall and winter months (Barco 2008). Strandings near the OPAREA are depicted in Figure B-28 during the winter and spring seasons. In the eastern U.S., gray seal strandings have been recorded from Maine south to North Carolina (Waring et al. 2008). WhaleNet (2006) mentions a gray seal named “Rusty” that was transported to the Marine Mammal Stranding Center in Riverhead, New York due to increasing temperatures in Virginia; it appears that the seal was first sighted there. A female pupped at Assateague Island, Virginia, in 1986; another birth was reported at the same place in 1989 (Katona et al. 1993). Harry et al. (2005) reported eight strandings of gray seals in Virginia and North Carolina between 2000 and 2005. Although there are relatively few gray seal records near the OPAREA, Harry et al. (2005) suggested that strandings are consistent in Virginia and North Carolina, supporting a long-term occurrence of this species in the region.

Behavior and Life History—Gray seals are gregarious during breeding, molting, and while resting in groups; they are thought to be solitary when feeding (Reeves et al. 2002). Gray seals are observed spending long periods of time resting submerged in the water next to haul out sites (D. Thompson et al. 1991). Gray seals coexist with harbor seals in many non-breeding sites in the northeastern U.S., often hauling out in close proximity (DeHart 2002). Gray seals haul out for molting, beginning in early April in Nantucket Sound (Rough 1995).

In the western North Atlantic population, females give birth to a single pup from late December through early February in eastern Canada, on land or on shifting pack ice (Lesage and Hammill 2001). Gray seals breed from January to February in Nantucket Sound (Barlas 1999). Weaning occurs after 15 to 16 days, and mating begins soon after the pup is weaned and the female come into estrus (Lesage and Hammill 2001). Gray seals have delayed implantation (Hall 2002). Males compete for access to females, but do not defend discrete territories (Hall 2002). Breeding adult gray seals of both sexes fast during pupping.

Gray seals feed on a variety of fish species and cephalopods; they are largely demersal or benthic feeders (Bonner 1981; D. Thompson et al. 1991; P.M. Thompson et al. 1991; Hall 2002). Herring (*Clupea harengus*), Atlantic cod (*Gadus morhua*), and sand lance are among the most important prey items (Lesage and Hammill 2001). The only prey information for gray seals in U.S. waters is from Muskeget Island; prey consumed included windowpane flounder, silver hake, sand lance, skates, and gadids (Rough 1995). While at sea, gray seals do not swim at the water’s surface (Thompson and Fedak 1993). Gray seals are able to dive to depths up to 400 m; however, the majority of dives are 40 to 100 m deep (Goulet et al. 2001; Lesage and Hammill 2001). The maximum dive duration is 32 min (Thompson and Fedak 1993; Goulet et al. 2001). Surface intervals between dives are most often 1.2 min (Boyd and Croxall 1996).

Acoustics and Hearing—Underwater vocalizations can be classified into seven call types, ranging in frequency from 1 to 3 kHz (Asselin et al. 1993). Grey seals vocalize at frequencies of 0.1 to 16 kHz (Ketten 1998a); the maximum energy is between 0.1 to 10 kHz (Asselin et al. 1993; Ketten 1998a).

The hearing ability of the gray seal has been studied using auditory evoked potential methods. In water, gray seals are most sensitive at frequencies of 20 or 25 kHz. Gray seals have in-air hearing sensitivities at 4 kHz (Ridgway and Joyce 1975).

- Harp Seal *(Pagophilus groenlandicus)*

Description—These medium-sized phocid seals reach a size of 1.7 m and 130 kg; females are slightly smaller (Lavigne 2002). Adults typically have a light gray pelage, a black face, and a black saddle behind the shoulders. This black saddle extends in a lateral band on both sides toward the pelvis, forming a pattern that resembles a harp. Some adults are sparsely spotted, with the harp pattern not completely developed (Reeves et al. 2002). Newborn pups, called “whitecoats” have a long, white coat that is replaced soon after weaning (at about 3 to 4 weeks) by a short, silver pelage with scattered, small dark spots.

Status—The harp seal is the most abundant pinniped in the western North Atlantic Ocean (Hammill and Stenson 2005). The 2004 Canadian population is estimated at around 5.9 million seals and has changed little since 1996 (DFO 2005). The total population of harp seals is divided among three separate breeding stocks in the White Sea, the Greenland Sea between Jan Mayen and Svalbard, and the western North Atlantic (Reeves et al. 2002). The western North Atlantic stock is the largest; it is divided into two breeding herds: The “Front” herd breeds off the coast of Newfoundland and Labrador, while the “Gulf” herd breeds near the Magdalen Islands (Reeves et al. 2002; Waring et al. 2008). The best estimate of abundance for the western North Atlantic stock is 5.9 million seals; data are insufficient to calculate the minimum estimate for this stock (Waring et al. 2008).

In addition to subsistence hunts in the Canadian Arctic and Greenland, harp seals are harvested commercially in the Gulf of St. Lawrence and off the coast of northeast Newfoundland and Labrador (DFO 2003b).

Habitat Associations—Harp seals are closely associated with drifting pack ice on which they breed and molt; they forage in the surrounding waters (Ronald and Healey 1981; Lydersen and Kovacs 1993). Harp seals prefer rough pack ice that is at least 0.25 m thick; they maintain holes in the ice for easy access to the water (Ronald and Healey 1981; Ronald and Gots 2003). Harp seals make extensive movements over much of the continental shelf within their winter range in the waters off Newfoundland (Bowen and Siniff 1999).

Distribution—Harp seals are distributed in the pack ice of the North Atlantic and Arctic oceans, from Newfoundland and the Gulf of St. Lawrence to northern Russia (Reeves et al. 2002). Most of the western North Atlantic harp seals congregate off the east coast of Newfoundland-Labrador (the Front) to pup and breed. The remainder (the Gulf herd) gather to pup near the Magdalen Islands in the Gulf of St. Lawrence (Ronald and Dougan 1982). Females reach the breeding grounds at the Gulf of St. Lawrence by mid-February and at the Front by early March (Ronald and Dougan 1982). During the early period of pupping, males are found in separate concentrations. Once mating has ended, harp seals move to more northerly ice in preparation for the annual molt, leaving the newly weaned pups at the breeding grounds. In April, juveniles of both sexes and adult males form dense molting concentrations on the pack ice at the Front. Adult females join these concentrations in late April. By mid-May, most of the population follows the retreating ice edge north. After molting in April, harp seals leave the drifting ice and move north along the east coast of Canada toward their Arctic summering grounds, spending this time in the open water among the ice floes of the Eastern Canadian Arctic or along the west coast of Greenland. Harp seals arrive in June when capelin (an important prey item) concentrate to spawn (Bowen and Siniff 1999). With the formation of new ice in September, harp seals begin their southward movements along the Labrador coast, usually reaching the entrance to the Gulf of St. Lawrence by early winter (Waring et al. 2008). There, the population then splits into the two breeding groups, one moving into the Gulf of St. Lawrence and the other remaining off the coast of Newfoundland. During January and February, adult harp seals disperse widely throughout the Gulf of St. Lawrence and over the continental shelf off Newfoundland to fatten in preparation for reproduction. Not all juvenile harp seals make the southward mass movement; some remain in the Arctic along the southwestern coast of Greenland (Bowen and Siniff 1999). The large-scale movements of harp seals represent an annual round trip of more than 4,000 km (Bowen and Siniff 1999).

The number of sightings and strandings of harp seals off the northeastern U.S. has been increasing (McAlpine and Walker 1990; Rubinstein 1994; Stevick and Fernald 1998; McAlpine et al. 1999a; McAlpine et al. 1999b; Harris et al. 2002). Sightings are usually during January through May (Harris et al. 2002), when the western North Atlantic stock of harp seals is at its most southern point in distribution (Waring et al. 2008). Occurrences as far south as South Carolina are reported (McFee 2006).

- Information Specific to the VACAPES OPAREA—Any occurrences of the harp seal here are considered to be extralimital. Harp seal occurrences in the inshore and nearshore waters of the mid-Atlantic region are becoming more frequent in the fall and winter months (Barco 2008). Several strandings of harp seals near the OPAREA from Delaware to North Carolina are depicted in Figure B-28 during winter, spring, and fall. Harry et al. (2005) reported 16 strandings of harp seals in Virginia and North Carolina between 2000 and 2005. Harp seal records in this region date back to 1945 when Goodwin (1954) documented a harp seal stranding at Cape Henry, Virginia in March. Harp seal strandings have been recorded as far south as South Carolina; on 22 August 1997, a harp seal was sighted at Garden City Beach, South Carolina (McFee 2006). Although there are relatively few harp seal records near the OPAREA, Harry et al. (2005) suggested that strandings in Virginia and North Carolina are consistent, supporting a long-term occurrence of this species in the region.

Behavior and Life History—Harp seals are gregarious by nature, hauling out in dense herds to give birth and to molt. Pupping occurs on ice during February and March; weaning occurs after only 9 to 12 days followed shortly by the adult females coming into estrus and breeding (Ronald and Healey 1981; Lydersen and Kovacs 1993). Mating usually takes place in the water (Ronald and Dougan 1982; Lavigne 2002). Harp seals have delayed implantation (Ronald and Dougan 1982).

Haulout behavior is not restricted to breeding and molting periods; harp seals frequently haul out on ice in other seasons (Moulton et al. 2000). Haul-out durations observed in the Gulf of St. Lawrence averaged 21 minutes (Lydersen and Kovacs 1993). Solar radiation influences haulout behavior of harp seals during the molting period, perhaps in part since heating of the skin accelerates the molting process (Moulton et al. 2000).

Harp seals feed on a variety of prey with which vary with age, season, location, and year (Lavigne 2002). Prey-preference studies have revealed that harp seals prefer small fish (such as capelin) to pelagic crustaceans (Lindstrøm et al. 1998). Contrary to popular belief, harp seals rarely eat commercially important Atlantic Cod (Lavigne 2002). Most foraging occurs at depths of less than 90 m, although dives as deep as 568 m have been recorded (Lydersen and Kovacs 1993; Folkow et al. 2004). Harp seals feed intensively during the winter and summer, and less so during the spring and fall migrations or during pupping and molting (Ronald and Healey 1981).

Acoustics and Hearing—The harp seal's vocal repertoire consists of at least 27 underwater and two aerial call types (Serrano 2001). Harp seals are most vocal during the breeding season (Ronald and Healey 1981). Serrano (2001) found that calls of low frequency and with few pulse repetitions were predominantly used outside the breeding season, while calls of high frequency and with a high number of pulse repetitions predominated in the breeding season. Terhune and Ronald (1986) measured source levels of underwater vocalizations of 140 dB re 1 µPa-m. Vester et al. (2001)

recorded ultrasonic clicks with a frequency range of 66 to 120 kHz, with the main energy at 93$\pm$22 kHz and average source levels of 143+ dB re 1 μPa-m in conjunction with live fish hunting.

Behavioral audiograms have been obtained for harp seals (Terhune and Ronald 1972). The harp seal's ear is adapted for better hearing underwater. Underwater, hearing has been measured between 760 Hz to 100 kHz, with areas of increased sensitivity at 2 and 22.9 kHz (Terhune and Ronald 1972). In air, hearing is irregular and slightly insensitive with the audiogram being generally flat (Terhune and Ronald 1971).

- 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 world's hooded seal population consists of three separate stocks which are identified with a specific breeding site: Northwest Atlantic, Greenland Sea ("West Ice"), and White Sea ("East Ice") (Waring et al. 2008). The Western North Atlantic stock is divided into three breeding herds: the Front herd breeds off the coast of Newfoundland and Labrador, the Gulf herd breeds in the Gulf of St. Lawrence, and the other breeding area is in the Davis Strait (Waring et al. 2008). The other two stocks represent separate breeding herds. Recent genetic studies indicate that the world's hooded seals comprise a single panmictic genetic population; therefore, the four breeding herds are not genetically isolated (Coltman et al. 2007).

The best estimate of abundance for western North Atlantic hooded seals is 592,100 (Waring et al. 2008). Based on the 2005 pup survey of all three whelping areas in the Northwest Atlantic, the minimum population estimate for hooded seals in the western North Atlantic is 512,000 seals; however, data are insufficient to estimate the population in U.S. waters (Waring et al. 2008). 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).

Habitat Associations—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).

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 area 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. 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). 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 2006c).

- Information Specific to the VACAPES OPAREA—Any occurrences of the hooded seal here are considered to be extralimital. Strandings have been recorded along the North Carolina coast since 1944 when one hooded seal stranded on Bogue Banks, North Carolina in September (Goodwin 1954). Harry et al. (2005) reported 10 strandings of hooded seals in Virginia and North Carolina between 2000 and 2005. Several hooded seals have been found along the coast of Virginia near Virginia Beach, Accomack County, and Assateague Island (Iliff and Brinkley 2001). Strandings near the OPAREA are depicted in Figure B-28 for the winter, summer, and fall. Although there are relatively few records of hooded seals in the VACAPES OPAREA and vicinity, Harry et al. (2005) reported strandings as consistent in Virginia and North Carolina, supporting a continuous occurrence of this species in the region.

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 deepwater 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). 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.

There are no direct measurements of the hearing abilities of the hooded seal (Kastelein 2007; Southall 2007). Composite Arctic seal hearing data is considered here in the absence of such information as recommended by the NMFS (Southall 2007). The range of underwater hearing for the ringed seal (*Pusa hispida*) ranges from 2.8 to 45 kHz, while in-air, they hear best in the range of 3 to 10 kHz (Terhune and Ronald 1975). The harp seal's (*Pagophilus groenlandicus*) underwater hearing range is from 1 to 40 kHz, with increased sensitivity at 2 and 22.9 kHz (measured from 760 Hz to 100 kHz) (Terhune and Ronald 1972). In-air, they hear from 1 to 32 kHz with greatest sensitivity at 29 dB at 4 kHz (Terhune and Ronald 1971).

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3.2 SEA TURTLES

Sea turtles are long-lived, slow growing reptiles found throughout the world's tropical, sub-tropical, and temperate seas (Lutz and Musick 1997). There are seven living species of sea turtles from two distinct families, the Cheloniidae (hard-shelled sea turtles; six species) and the Dermochelyidae (leatherback sea turtle, one species). These two families can be distinguished from one another on the basis of their carapace structure (upper shell) and other morphological features. 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).

Sea turtles are an important marine resource that provide economic (consumptive and non-consumptive) and ecological (existence and intrinsic) value to humans (Witherington and Frazer 2003). Over the last few centuries, 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. 1997).

3.2.1 Introduction

Modifications to the body and limbs from the basic turtle design make sea turtles highly adapted to the marine environment. Sea turtles possess powerful, modified forelimbs (or flippers) that enable them to swim continuously for extended periods of time (Wyneken 1997). They have compact and streamlined bodies that help reduce drag. Additionally, sea turtles are among the longest and deepest diving of the air-breathing vertebrates, spending as little as 3 to 6% of their time at the water's surface (Lutcavage and Lutz 1997). These physiological traits and behavioral patterns allow for highly efficient foraging and migrating. Sea turtles often migrate thousands of kilometers between their nesting beaches, mating areas, nursery habitats, and feeding grounds, which would not be possible without the aforementioned suite of adaptations (Meylan 1995). Sea turtle traits and behaviors also help protect them from predation. Sea turtles have a tough outer shell and grow to a large size as adults; mature leatherback turtles, for example, 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 (2003).

3.2.1.1 Sea Turtle Life History

Although specialized for life at sea, sea turtles begin their lives on land. Aside from this brief terrestrial period, sea turtles are rarely encountered out of the water. Sexually mature females return to land in order to nest and certain species in the Hawaiian Islands, Australia, and the Galapagos Islands haul out on land in order to bask (Carr 1995; Spotila et al. 1997). Basking allows sea turtles to thermoregulate, elude predators, avoid harmful mating encounters, and possibly accelerate the development of their eggs (Spotila et al. 1997). On occasion, sea turtles unintentionally end up on land if they are dead, sick, injured, or cold-stunned. These events, also known as strandings, can be caused by either biotic (e.g., predation and disease) or abiotic (e.g., water temperature) factors.

Female sea turtles nest in tropical, subtropical, and warm-temperate latitudes, often in the same region where they were born (Miller 1997). Sea turtles nest every two to three years, with the possible exception of Kemp's ridley turtles (*Lepidochelys kempii*) which may nest in consecutive years (Marquez-M. 1994;

Ehrhart 1995). During the nesting season, sea turtles lay several clutches containing 50 to 200 eggs (Witzell 1983; Dodd 1988; Hirth 1997). Internesting intervals range from 9 to 28 days depending on the species (Hirth 1980; Miller 1997). Most sea turtles re-nest in close proximity to the original nesting beach during subsequent nesting attempts. The leatherback turtle is a notable divergence from this pattern. Leatherbacks nest primarily on high-energy beaches with little reef or rock offshore where stochastic erosion can reduce the probability of survival. To compensate, leatherbacks scatter their nests over larger geographic areas and lay, on average, twice as many clutches as other species (Eckert and Sarti-M. 1997). At times, sea turtles may fail to nest after emerging from the ocean. These non-nesting emergences, known as false crawls, can occur if sea turtles are obstructed from laying their eggs (by debris, rocks, roots, or other obstacles), are distracted by surrounding conditions (such as noise, lighting, or human presence), or are uncomfortable with the consistency or moisture of the sand (Proffitt et al. 1986; Miller 1997).

Most nesting and hatchling emergence events occur at night as daytime beach temperatures could be lethal (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 crawl in the direction of the brightest light, which on most beaches is towards the ocean/sky horizon (Ernst et al. 1994; Witherington and Martin 2003). Artificial beachfront lighting that appears brighter than the seaward horizon may disorient hatchlings, reducing their chance for reaching the ocean (Witherington and Bjorndal 1991). Newly emerged hatchlings are also easy prey for a variety of scavengers including seabirds, crabs, and mammals (Ehrhart 1995; Miller 1997). It is estimated that only one out of every 1,000 hatchlings survives long enough to reproduce (Frazer 1986).

3.2.1.2 Sea Turtle Distribution and Behavior

Hatchlings spend the first few years of their lives in offshore waters, drifting in convergence zones or *Sargassum* rafts where they find food (mostly pelagic invertebrates) and refuge in flotsam (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). Sea turtles will spend several years growing in this "early juvenile nursery habitat" before migrating to neritic feeding grounds that comprise as the "later juvenile developmental habitats" (Musick and Limpus 1997). Juvenile sea turtles in this later juvenile developmental habitat change from surface to benthic feeding and begin to feed upon larger items such as crustaceans, mollusks, sponges, coelenterates, fishes, and seagrass (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). A sea turtle's diet varies according to its feeding habitat and its preferred prey. For example, green turtles possess a serrated jaw, specialized for their diet of mainly seagrass (Ernst et al. 1994). Upon moving from the later juvenile developmental habitat to the adult foraging habitat, sea turtles may demonstrate further changes in prey preference, dietary composition, and feeding behavior (Bjorndal 1997; Musick and Limpus 1997).

Sea turtles undergo complex seasonal movements, influenced by changes in ocean currents, turbidity, salinity, and food availability, and perhaps most importantly, water temperature (Epperly et al. 1995c; Davenport 1997; Musick and Limpus 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 when rapid temperature drops occur. Migrating to warmer waters is one cold water avoidance strategy that has been observed for turtles in the northeastern U.S. (Musick and Limpus 1997). Alternatively, some green and loggerhead turtles have been observed brumating (burying into bottom sediments to hibernate) in North American waters (Ogren and McVea 1995; Hochscheid et al. 2005). The preferred temperature ranges of sea turtles vary across age classes and species as well as seasons. The leatherback turtle has a wider range of preferred water temperatures than other species due to its ability to maintain a warm body temperature in temperate waters and avoid overheating in tropical waters (Spotila et al. 1997).

Climatic fluctuations have produced a growing concern about the effects of climate change on various marine species, including sea turtles. Responses of sea turtles to climate change are difficult to interpret due to the confounding effects of natural responses and human influences. Global warming will likely increase the foraging range of leatherback turtles farther into temperate and boreal waters as isotherms shift (M.C. James et al. 2006; McMahon and Hays 2006). Large-scale climatic events may affect turtles by loss of nesting beaches as sea levels rise (Vagg and Hepworth 2006). Nesting biology of sea turtles is strongly affected by temperature both in timing and in the sex-ratio of hatchlings. The effects of climate change may upset the natural ratio of male to female hatchlings, as higher temperatures during incubation tend to produce more females (Hays et al. 2003; Hawkes et al. 2007). Earlier nesting and longer nesting seasons are also being correlated with warmer SSTs (Weishampel et al. 2004; Hawkes et al. 2007). In the Pacific Ocean, productivity and prey abundance are associated with cooler ocean temperatures. Rising SSTs could lower prey abundance which could lead to lowered breeding capacity (Chaloupka et al. 2008). In fact, scientists have documented an inverse relationship between SST and the number of loggerhead and leatherback nests in the Pacific Ocean (Saba et al. 2007; Chaloupka et al. 2008).

3.2.1.3 Sea Turtle Sensory Adaptations

Knowledge of sea turtle sensory biology is limited to a few studies for each sense (vision, olfaction, and hearing). Sea turtles have a spherical lens which is ideal for underwater vision as the refractive index of their cornea is nearly identical to that of sea water (Bartol and Musick 2003; Levenson et al. 2004). Sea turtles have the visual acuity to detect relatively small objects within the marine environment. They are also able to see in color, primarily in the shorter wavelengths (450 to 620 nm), with peak sensitivity for loggerhead and green turtles occurring at 580 nm (yellow) (Bartol and Musick 2003; Levenson et al. 2004). Leatherback spectral sensitiviy is primarily at shorter wavelength with a peak in sensitivity between 400 and 500 nm (violet and blue) (Crognale et al. In press). On land, sea turtle vision is highly myopic (nearsighted). Visual cues on land are restricted to diffuse images and brightness levels (Bartol and Musick 2003).

Several behavioral studies have illustrated that sea turtles are able to smell underwater, an unusual ability for an air-breathing vertebrate. Manton et al. (1972a) observed loggerheads moving the floor of the mouth up and down with the nostrils flared open in response to the introduction of a chemical cue. The throat movements appear to be a means to pump water through the nasal cavities so the turtle can smell underwater (Manton et al. 1972a). Upon a chemical release, flipper movements increased and approaches towards the cue were quite violent (Manton et al. 1972a). Constantino and Salmon (2003) also found that turtles have responses to chemical stimuli and will orient themselves into currents towards the stimuli when the food is not directly visible. However, when food is visible, sea turtles ignore the chemical stimuli and head towards the food object. This would illustrate that chemical cues are important for detecting prey at distance, but then visual cues would take over. Studies have also shown that sea turtles have the capacity to recognize one water mass from another by olfaction. It has been suggested that this may contribute to the species finding waters off their natal beaches (Owens et al 1986; Manton et al. 1972a, 1972b; Grassman et al. 1984).

Sea turtle reception of sound occurs through bone conduction, with the skull and shell acting as receiving structures (Lenhardt et al. 1983). A few preliminary investigations using adult green, loggerhead, and Kemp’s ridley turtles suggest that sea turtles are most sensitive to low-frequency sounds (Ridgway et al. 1969; Lenhardt et al. 1983; Bartol 1999; Moein Bartol and Ketten 2006). Typically, sea turtles hear frequencies from 30 to 2,000 Hz and have a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969; Lenhardt 1994). Green turtle hearing sensitivity peaks at 300 to 400 Hz (Ridgway et al. 1969), loggerhead turtle hearing sensitivity peaks at 400 to 500 Hz (Lenhardt 2002), and Kemp’s ridleys are most sensitive to sounds between 100 and 200 Hz (Moein Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still potentially usable to the animal (Lenhardt 1994). A recent study of juvenile green turtle hearing showed that the species was able to detect levels below 50 Hz underwater (Eckert, S.A., WIDECAST, pers. comm. 7 April 2008). Sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB re 1 µPa-m (Lenhardt 1994).

Sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB re 1 μPa-m (Lenhardt 1994). Adult loggerheads have been observed to initially respond to (i.e., increase swimming speeds) and avoid air guns when received levels range from 151 to 175 dB re: 1 μPa, but eventually habituate to these sounds (Lenhardt 2002). One turtle in study exhibited a temporary threshold shift (TTS) for up to two weeks after exposure (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; McCauley et al. 2000). 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 $μPa^2s$ and 166 dB re: 1 $μPa^2s$ respectively (McCauley et al. 2000). Although auditory data has never been collected for the leatherback turtle, there has been anecdotal evidence that this species responds to boat motor sounds (ARPA 1995).

3.2.2 Sea Turtles of VACAPES OPAREA

Five species of sea turtles have been documented as occurring within the VACAPES OPAREA. These include the leatherback, loggerhead, green, hawksbill, and Kemp's ridley (Table 3-2). Of these, the loggerhead and Kemp's ridley are the most common. No critical habitats for sea turtles have been designated within the OPAREA.

Each sea turtle species is listed below with its physical description, status, habitat associations, distribution (including location and seasonal occurrence in the VACAPES OPAREA), and behavior and life history. Species appearance within the text follows the taxonomic order as presented in Table 3-2.

Table 3-2. Sea turtle species of the Virginia Capes OPAREA, their status under the Endangered Species Act (ESA), and occurrence within the OPAREA. Taxonomy follows Pritchard (1997).

	Scientific Name	Status	Occurrence[1]
Order Testudines			
SuborderCryptodira (hidden-necked turtles)			
Family Dermochelyidae			
Leatherback turtle	*Dermochelys coriacea*	Endangered	Regular
Family Cheloniidae (hard-shelled turtles)			
Loggerhead turtle	*Caretta caretta*	Threatened	Regular
Green turtle	*Chelonia mydas*	Threatened[2]	Regular
Hawksbill turtle	*Eretmochelys imbricata*	Endangered	Rare
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered	Regular

[1] 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

[2] Although the species as a whole is listed as threatened, the Florida and Mexican Pacific nesting stocks of the green turtle are listed as endangered. Since the nesting area for green turtles encountered at sea cannot be determined, a conservative approach to management suggests the assumption that all green turtles found in the study area are from the endangered population.

Several important features regulate the distribution or habitat use of the sea turtles in the VACAPES OPAREA. These features include oceanographic or circulation features such as major surface currents, the Gulf Stream, and eddies. The Gulf Stream (see description in Chapter 2) is a transportation vector for early life stages of sea turtles as well as and overwintering habitat for juveniles and adults. Hatchlings may enter the Gulf Stream upon departing nesting beaches along the U.S. east coast, usually from Florida north to Virginia or, in the case of Kemp's ridleys, enter the Gulf Stream System (the Loop or

Florida Currents) in the Gulf of Mexico and congregate in *Sargassum* rafts (Carr 1987; Musick and Limpus 1997) (see description of *Sargassum* habitat in Chapter 4). Hatchlings may be concentrated in *Sargassum* rafts in areas such as Florida, where local small-scale eddies stream off the Gulf Stream onto the continental shelf of Florida and may restrain hatchings 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). Satellite-tracked juvenile and adult sea turtles have been observed traveling to overwinter in the warm waters at the western edge of the Gulf Stream (Dodd and Byles 2003; Hawkes et al. 2007). Due to the warm surface water temperatures, these waters are available to sea turtles on a year-round basis.

The waters off the Virginia and North Carolina coasts are important transitional habitat for juvenile sea turtles. Juvenile sea turtles along the U.S. Atlantic Coast exhibit seasonal foraging movements, migrating north along the coast in the early spring to coastal development habitats and south in the fall (Morreale and Standora 2005). Coastal waters of Virginia, particularly the Chesapeake Bay, serve as developmental habitat for juvenile loggerhead and Kemp's ridley sea turtles that take up residency during the summer months (Lutcavage 1981; Lutcavage and Musick 1985; Mansfield and Musick 2006a). The presence of juvenile sea turtles in the Chesapeake Bay area and Virginia coastal waters peaks from May through early November (Lutcavage 1981). As waters cool in the fall, most sea turtles emigrate out of the Chesapeake Bay and Virginia coastal waters to travel southward at least as far as Cape Hatteras, North Carolina to avoid cold stunning; many turtles that overwinter off North Carolina remain near the edge of the Gulf Stream during the winter months of January and February (Epperly et al. 1995b; Musick and Limpus 1997). As waters warm again in the spring, sea turtles migrate back inshore and expand their range northward.

Sea turtles are known to nest along Virginia's eastern shore, the Virginia Beach oceanfront, and coastal North Carolina, including the Outer Banks (Mansfield 2006), although nesting events have been documented north of these areas including Maryland, Delaware, and New Jersey (Brandner 1983; (Dodd 1988; Rabon et al. 2003). Back Bay National Wildlife Refuge has monitored sea turtle nesting in Virginia Beach, VA since 1970 (Cross et al. 2001). During the 2005 nesting season, 6 loggerhead nests and one green turtle nest were documented at Back Bay NWR (USFWS 2005a). In 2006, 7 loggerhead nests were documented on Assateague Island (Boettcher et al. 2007). In North Carolina, adult loggerhead and green sea turtles are known to nest on ocean facing beaches in the summer (Schwartz 1989) although the most common North Carolina nesting beaches are located south of the VACAPES OPAREA at Cape Hatteras and Cape Lookout National Seashores (Hopkins and Richardson 1984; Schwartz 1989). From 1969 to 1979, the U.S. Fish and Wildlife Service conducted an experimental loggerhead egg translocation project in which eggs were moved from Cape Island, SC to Chincoteague NWR, Accomack County, VA, Back Bay NWR, Virginia Beach, VA, and Pea Island NWR, Dare County, NC (Boettcher et al. 2007). The purpose of this study was to extend the loggerhead nesting range north along the U.S. Atlantic coast. Since 1970, approximately 102 loggerhead nests have been documented at these sites, with more nesting and greater hatchling survival occurring on the mainland beach sites, such as Back Bay NWR, than barrier island sites, such as Assateague Island (Boettcher et al. 2007). It is likely that a percentage of females nesting in this area have entered these nesting populations through the egg translocation project (Boettcher et al. 2007).

In Virginia, sea turtles are susceptible to mortality from the Virginia pound net fishery (Lutcavage and Musick 1985). Offshore the mid-Atlantic coast, loggerheads and leatherbacks are caught as bycatch in the pelagic longline fishery (Garrison and Richards 2004).

The distribution of available sea turtle occurrence records in the VACAPES OPAREA and vicinity by season is presented in Appendix C, Figures C-1-1 and C-1-2. The distributions of available sea turtle records by season for individual species are presented in Figures C-2-1 through C-6-2. Sea turtle occurrence records include sightings from NMFS aerial and shipboard surveys, sightings from other sources (non-NMFS surveys and opportunistic encounters), strandings, incidental bycatch records from fisheries, and incidental encounters within the study area and vicinity. It should be noted that the number of sea turtle records in a given season or portion of the OPAREA is often a function of the source or type of data, level of effort, and sighting conditions. Unidentified sea turtles (individuals that could not be identified to species) account for a large number of occurrence records, particularly sightings at sea. The hard-shelled sea turtles (loggerhead, green, Kemp's ridley, and hawksbill) are often difficult to distinguish to species, particularly when they are young (i.e., small size classes), during aerial surveys, and/or when observers do not have a high level of experience (Henwood and Epperly 1999). Species identification is also less reliable when individuals from the general public (e.g., commercial and recreational fishermen, beachgoers) sight sea turtles.

The modeled occurrence of a species in a given portion of the study area is based upon a geo-statistical sightings-per-unit-effort (SPUE) analysis and is presented for each season (winter=6 December through 5 April; spring=6 April through 13 July; summer=14 July through 16 September; fall=17 September through 5 December) in Appendix C. A listing and description of 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 Section 1.4.2.2.

On the map figures, various shading and terminology designate the occurrence of sea turtles in the study area. Species' occurrence levels were defined as SPUE values within the: highest quartile (1st Quartile SPUE) in areas shaded in purple, second highest quartile (2nd Quartile SPUE) in areas shaded in blue, second lowest quartile (3rd Quartile SPUE) in areas shaded in dark green, and lowest quartile (4th Quartile SPUE) in areas shaded in light green. An additional occurrence level of SPUE = 0 (shaded in yellow), is indicative of areas where survey effort occurred (effort ≥ 5 km) but no sightings were recorded. In all cells with effort <5 km (or 0), the occurrence area was defined as "No Survey Effort" (stipple pattern); in these areas the likelihood of a protected species occurring is not known because no line-transect surveys have been completed in that area or were not available for inclusion in the analysis. Due to a lack of survey data available for certain species, occurrence models could not be calculated for every species known to occur in the study area.

The occurrence model outputs and available occurrence data, which include survey sightings, strandings, and bycatch events, indicate that sea turtles occur in the OPAREA year-round (Figures C-1-1 through C-6-2). The greatest numbers of sea turtle strandings in states adjacent to the OPAREA occur during the spring, with the exception of Delaware (Figure 3-7). Delaware and Maryland typically experience lower numbers of strandings than Virginia or North Carolina and, since 2001, have not recorded strandings during the winter months. This is likely due to the sea turtle use of overwintering habitat further south.

- Information Specific to VACAPES OPAREA—The occurrence patterns for all sea turtle species appear in Figures C-1-1 and C-1-2. Sea turtle occurrences in the OPAREA peak during spring and fall, indicating the greatest concentrations of sea turtles during these times. Sea turtles are present in the OPAREA during the summer yet in lower concentrations; the lowest concentrations of sea turtles are expected to occur during the winter.

  - Winter—Along the southeast coast, sea turtle occurrence is greatest in shelf waters off southern Georgia and northern Florida. These areas represent overwintering habitat for species such as loggerheads and Kemp's ridleys. During the winter, sea turtles are concentrated within the southern shelf waters of the VACAPES OPAREA; greater concentrations occur further south in North Carolina. The coastal waters of northern VACAPES are typically too cold for most species of sea turtles (with the exception of the leatherback) to overwinter. Cape Hatteras, just south of the OPAREA, represents the approximate northernmost range for most year-round resident turtles. Stranding records that line the shoreline adjacent to VACAPES may represent cold-stunned individuals, common in Delaware, Maryland, and Virginia during this time of year. Sea turtles may also overwinter along the western edge of the Gulf Stream (Renaud 1995; Hawkes et al. 2007). Scattered sightings west of the shelf break suggest such a trend, yet occurrences may be under-represented due to lack of survey effort in this area during the winter.

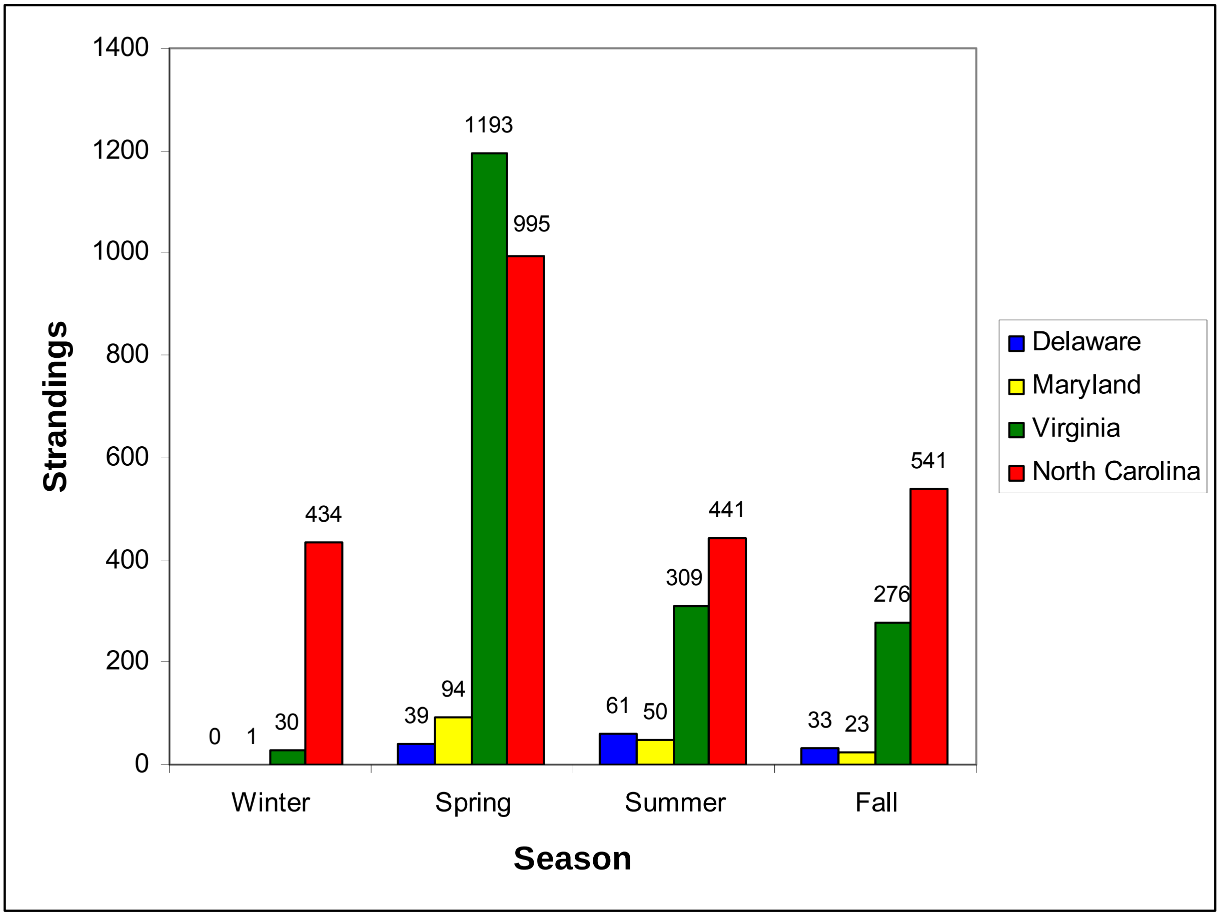

Figure 3-7. Sea turtle strandings reported in Delaware, Maryland, Virginia, and North Carolina by season between 2001 and 2005. Source data: MERRINS (2006); NMFS-SEFSC (2006).

- Spring—High concentrations of sea turtles occur within shelf waters off the eastern shore of Maryland and southern Virginia; such areas represent migratory pathways for juvenile and adult sea turtles traveling north to summer foraging habitat. During the spring, migratory loggerhead, green, and Kemp's ridley juveniles travel as far north as Long Island, NY to seek coastal developmental habitats. Juveniles commonly use the Chesapeake Bay as developmental habitat; their presence in the bay may be evidenced by numerous strandings along Maryland and Virginia bay shoreline. Adults may use coastal or offshore waters of the OPAREA as foraging habitat (Hawkes et al. 2007). The loggerhead sea turtle drives the occurrence trend during the spring.

- Summer—During the summer, the model output predicts high concentrations of sea turtles offshore Maryland and New Jersey although concentrations of sea turtles occur throughout shelf waters of the southeast Atlantic. Within the OPAREA, occurrences are concentrated in shelf waters although many observations have been made beyond the shelf break. The model output in the OPAREA is driven by the presence of juvenile loggerhead, green, and Kemp's ridley turtles using coastal and inshore developmental habitat, particularly the Chesapeake Bay, adult loggerheads and leatherbacks using Atlantic foraging habitat, and adult loggerheads using Atlantic internesting habitat and North Carolina, Virginia, and potentially, Maryland and Delaware nesting beaches. Post-nesting loggerheads may also use the Chesapeake Bay as internesting habitat and Delaware Bay post-nesting, transiting the OPAREA the access these locations (Hopkins-Murphy et al. 2003).

- Fall—High sea turtle concentrations in the OPAREA during the fall likely reflect the southward movement of juveniles and adults to overwintering habitat. The model output shows occurrence to be greatest offshore southern Virginia/northern North Carolina; this high concentration likely reflects a confluence of individuals migrating south from New York, New England, New Jersey, and Delaware coastal waters and the Chesapeake Bay (Morreale and Standora 2005). Migrating individuals include loggerheads, Kemp's ridleys, leatherbacks, and greens; it is therefore not uncommon for large concentrations of sea turtles to occur within these migratory pathways during the fall. Sea turtles may also occur offshore during the fall, as evidenced by numerous bycatch records east of the shelf break. Individuals may migrate east to the western edge of the Gulf Stream for overwintering purposes (Renaud 1995; Hawkes et al. 2007).

- Leatherback Turtle *(Dermochelys coriacea)*

Description—The leatherback turtle is the largest living sea turtle. Adult leatherbacks average between 200 and 700 kg with carapace lengths ranging from 119 to 176 cm (NMFS and USFWS 1992). This species is placed in a separate family from all other sea turtles, in part because of its unique carapace structure. The leatherback'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 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. Scientists use this marking to identify specific individuals (McDonald and Dutton 1996).

Status—Leatherback turtles are listed as endangered under the ESA (NMFS and USFWS 1992). Counts of nesting females typically provide the best available index of leatherback sea turtle population status; the largest leatherback populations are located in the Western Atlantic Ocean and Caribbean Sea regions (Spotila et al. 1996). Long term monitoring of index beaches (mainly Trinidad, Suriname, Guyana, Puerto Rico, and Florida) for the last 2 to 3 decades indicate increases in the nesting population (TEWG 2007). Spotila (1996) estimated a global population of 34,500 adult females. However, recent population estimates for adult leatherbacks range from 34,000 to 94,000 in North Atlantic waters alone (NMFS 2007a; TEWG 2007). Leatherback nesting that was once considered rare in Florida has increased over time and is now a significant nesting population in the North Atlantic (Meylan et al. 2006). Populations nesting in Culebra, Puerto Rico, and St. Croix, U.S. Virgin Islands (USVI) are also believed to be increasing due to heightened protection and monitoring of the nesting habitat over the past 20 years (Hillis-Starr et al. 1998; Fleming 2001; Thompson et al. 2001; Dutton et al. 2005).

Due to the high potential for interactions between leatherbacks and shrimp trawlers along the southeastern U.S. coast, especially during the spring migration period, a leatherback conservation zone was established by the Leatherback Contingency Plan in 1995 (NMFS 1995; 2000). The leatherback conservation zone protects leatherbacks from being caught as bycatch in the shrimp fishery and extends from Cape Canaveral, Florida to the North Carolina-Virginia border, from coastal waters up to 10 NM offshore (NMFS 1995). When leatherback turtle concentrations approach pre-determined abundance levels within this area, NMFS retains the authority to temporarily close shrimping areas for two weeks; all shrimp trawlers whose nets are not equipped with NMFS-approved TEDs (Turtle Excluder Devices) and modified TED escape openings for leatherbacks are prohibited from shrimping during this time (NMFS 1995; 2000).

Leatherback turtles frequently interact with the pelagic longline fishery in the Western Atlantic and the Gulf of Mexico (Garrison and Richards 2004). An observer program and management regulations under the jurisdiction of NMFS are currently in effect to reduce bycatch from the Western Atlantic pelagic longline fishery (Garrison and Richards 2004).

Habitat Associations—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). However, scientists are relatively certain these individuals do not associate with *Sargassum* or other flotsam, as is the case for the other five sea turtle species found in U.S. waters (NMFS and USFWS 1992). Juveniles up to 100 cm in curved carapace length (CCL) are generally restricted to waters greater than 26°C. The transition at 100 cm is relatively abrupt, with leatherbacks as small as 107 cm CCL having been observed in waters as cold as 12°C (Eckert 2002b). Upwelling areas, such as the Equatorial Convergence Zones, serve as nursery grounds for post-hatchling and early juvenile leatherbacks; these areas also provide a high biomass of gelatinous prey (Musick and Limpus 1997).

Late juvenile and adult leatherback turtles are known to range from mid-ocean to continental shelf and nearshore waters (Schroeder and Thompson 1987; Shoop and Kenney 1992; Grant and Ferrell 1993). Juvenile and adult foraging habitats include both coastal feeding areas in temperate waters and offshore feeding areas in tropical waters (Frazier 2001). Adults may also feed in cold waters at high latitudes (M.C. James et al. 2006). The movements of adult leatherbacks appear to be linked to the seasonal availability of their prey and the requirements of their reproductive cycle (Collard 1990b; Davenport and Balazs 1991; Luschi et al. 2006). Leatherbacks in the Chesapeake Bay area are commonly sighted in the lower bay and along the Atlantic coast (Barnard et al. 1989); this pattern is suggested to be due to the abundance of prey floating out of the Chesapeake Bay and into adjacent waters (Barnard et al. 1989).

Distribution—The leatherback turtle is distributed circumglobally in tropical and subtropical waters throughout the year and into temperate waters during late summer and early fall (NMFS and USFWS 1992; James et al. 2005c). Leatherbacks are the most oceanic sea turtle species and have the widest distribution range (Boulon et al. 1988). In the North Atlantic Ocean, leatherbacks 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 wide distribution range is a result of highly evolved thermoregulatory capabilities. Leatherbacks can maintain body core temperatures well above the ambient water temperature. For example, a leatherback caught off Nova Scotia, Canada had a body temperature of 25.5°C in water that was 7.5°C (Frair et al. 1972). As a result, they are more capable of surviving for extended periods of time in cool temperate and boreal waters than the hard-shelled sea turtles (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 traveled of 2,168 km (Keinath and Musick 1990). Leatherbacks tagged on Caribbean nesting beaches travel great distances across the North Atlantic Ocean and vary 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).

According to aerial survey data, there is 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 larger numbers off the coasts of Georgia and the Carolinas (NMFS 1995; NMFS 2000). In late spring/early summer, leatherbacks 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, remaining in the northeast from approximately May through October (CETAP 1982; Shoop and

Kenney 1992; Thompson et al. 2001; Wyneken et al. 2005). Leatherback strandings in the Chesapeake Bay area peak during the months of May and July (Barnard et al. 1989), suggesting peak abundances during this time as well. Leatherbacks may also exhibit east-west movement patterns, migrating seasonally from coastal waters to offshore in the late summer; leatherbacks may be observed in the mid-Atlantic Bight during this time (Eckert 2006). Eckert et al. (2006b) found leatherback foraging areas in the western Atlantic to be located on the continental shelf (30 to 50°N) as well as offshore (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. 2006b).

Leatherbacks commonly nest on wide sandy beaches which are inclined and backed with vegetation (Eckert 1987; Hirth and Ogren 1987). 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). In the United States, the densest nesting is in Florida along the Atlantic coast from Jensen Beach south to Palm Beach (Stewart and Johnson 2006). Sporadic nesting occurs in Georgia, South Carolina, and as far north as North Carolina (Rabon et al. 2003). 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).

Leatherback nesting is rare along the coast adjacent to the VACAPES OPAREA, although several published and unpublished nesting events exist. North Carolina represents the northernmost limit for leatherback nesting (Rabon et al. 2003); the majority of leatherback nesting in North Carolina is concentrated on beaches between Cape Lookout and Cape Hatteras. Seven nesting reports have been confirmed during the 1998, 2000, and 2002 nesting seasons at Cape Lookout National Seashore and Cape Hatteras National Seashore (Schwartz 1989; Rabon et al. 2003). However, many nest monitoring programs in North Carolina do not correlate well with the leatherback nesting season as programs typically begin monitoring in May/June and leatherbacks may nest as early as late February. Therefore, observed nesting reports may underestimate actual leatherback nesting activity in North Carolina (Rabon et al. 2003). One documented nesting emergence exists on Assateague Island National Seashore, MD, although an actual nest could not be confirmed (Rabon et al. 2003).

- Information Specific to the VACAPES OPAREA—Leatherbacks are found year-round in the OPAREA with the greatest occurrence during the summer. As evidenced by a combination of sighting and bycatch records, this species may occur in OPAREA shelf waters or offshore waters just beyond the shelf break (Figures C-2-1 and C-2-2). The greatest concentrations of leatherbacks expected to occur in the OPAREA vary seasonally by location. For example, leatherback presence is expected to peak off Virginia from May through July and in North Carolina from mid-April through mid-October (Keinath et al. 1996b). Seasonal movements of large subadult and adult leatherbacks have been documented by aerial surveys along the U.S. Atlantic Coast; yet, leatherbacks are likely not constrained by seasonal temperature variations. Leatherback occurrence is seasonal along the U.S. Atlantic coast, with the number of sightings along the northern area of the coast increasing from winter to summer.

    - Winter—The model output shows the occurrence trend to the southern shelf waters of the U.S. east coast with the highest leatherback concentrations off South Carolina/Georgia. Few strandings along the southern region of the coast adjacent to the VACAPES OPAREA suggest minimal leatherback presence in OPAREA although foraging individuals may be present later in the season (Eckert et al. 2006a). During the winter months of December through February, leatherback foraging areas shift offshore (Eckert et al. 2006a). Scattered sighting and bycatch records in the OPAREA just beyond the shelf break suggest the presence of foraging leatherback in offshore OPAREA waters although Eckert et al. (Eckert et al. 2006a) found leatherback foraging areas to extend further offshore (42°N, 65°W). Leatherback presence in offshore OPAREA waters may be underestimated due to limited survey effort. Presence of leatherbacks along the U.S. Atlantic coast is also strongly influenced by nesting habitat (Shoop and Kenney 1992); leatherback nesting along the U.S. coast takes place from May through July (NMFS and USFWS 1992). Although rare in the VACAPES OPAREA (Rabon et al. 2003), nesting may still occur towards the end of winter season; individuals may transit OPAREA waters to access nesting beaches, likely in North Carolina (Rabon et al. 2003).

- Spring—By spring, leatherback foraging areas are expected to have shifted from offshore to shelf waters (Eckert 2006); the model output supports this trend as increased observations of leatherbacks occur in shelf waters of the OPAREA as well as further north along the coast. Strandings along the coast adjacent to the OPAREA and into the Chesapeake Bay also suggest the use of shelf and coastal waters by foraging leatherbacks; leatherbacks may forage, particularly, at the mouth of the Chesapeake Bay on jellyfish floating into the ocean (Barnard et al. 1989). Scattered sighting and bycatch records just beyond the shelf break suggest the continued presence of leatherbacks in offshore OPAREA waters as well; however, leatherback presence in eastern OPAREA waters may not be well represented due to limited survey effort in this area.

- Summer—Summer represents the most abundant season for leatherbacks in the VACAPES OPAREA although the occurrence trend along the U.S. east coast is to the shelf waters off South Carolina/Georgia. During the summer, abundant jellyfish prey may influence the concentrated occurrence observed near the coast; cannonball jellyfish are commonly found in along the southeast Atlantic coast from May through November (Grant and Ferrell 1993). Off eastern Canada, James and Herman (James and Herman 2001) found leatherback occurrence to correspond with jellyfish presence from July through September. The model output and sighting records show leatherback occurrence to range throughout the OPAREA shelf waters as well as beyond the shelf break. Leatherback presence during this time is likely driven by foraging sub-adults and adults. Bycatch records along the shelf break in the northern OPAREA waters suggest leatherback presence offshore as well. During late summer, Eckert et al. (Eckert et al. 2006a) found leatherbacks to migrate from coastal areas to offshore waters in areas such as the Mid-Atlantic Bight.

- Fall—The model output shows lower leatherback occurrence in the VACAPES OPAREA although bucatch, starndings, and additional observations appear to suggest a significant presence at least to waters over the shelf break. (Figures C-2-1 and C-2-2). Although leatherbacks are not constricted by water temperature variations as other sea turtle species are, leatherbacks do exhibit seasonal migrations along the coast. Leatherbacks that seasonally migrate in a north/south direction are typically observed in northern habitats through October, northern concentrations are likely a reflection of individual leatherbacks that have not yet left the area for the winter. Eckert et al. (Eckert et al. 2006a) found optimal foraging areas to occur in shelf waters of the U.S. Atlantic coast through November. Strandings along the coast adjacent to the OPAREA further support the continued use of shelf waters as well. Sighting and bycatch records around the shelf break within the OPAREA indicate leatherbacks continue to use these areas into the fall, possibly for foraging purposes (Eckert 2006).

Behavior and Life History—Leatherback turtles primarily feed 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, a strata of vertically migrating zooplankton (primarily siphonophores, salps, and jellyfish) that is concentrated below the 600 m during the day and moves to the surface at night (S.A. Eckert et al. 1989). Leatherbacks have been observed congregating at the entrance to the Chesapeake Bay, likely to feed upon the influx of jellyfish flowing out of the bay's mouth (Barnard 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. Seasonal prey availability likely influences depth and duration of dives (Sale et al. 2006). Leatherbacks make shallower dives and do not exhibit diel diving patterns in colder water, likely due to the shallower distribution and lack of vertiacal migration of the prey in these areas (M. C. James et al. 2006). During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 5 m of the surface (Eckert 2002a; Eckert, S.A., WIDECAST, pers. comm., 28 June 2005).

The leatherback is the deepest diving sea turtle. Leatherbacks in open ocean environments frequently exhibit V-shaped dive patterns (in which they descend to a certain depth and then immediately ascend to the surface), whereas leatherbacks in shallow water 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 ranged from 35 to 122 m, with estimated maximum depths of over 1,000 m (S.A. Eckert et al. 1989; 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 (Eckert et al. 1996). On average, day dives tended to be deeper, longer, and less frequent than those at night.

Mating was thought to occur prior to or during the migration from temperate to tropical waters (Eckert and Eckert 1988). However, the presence of males near nesting colonies suggest that mating may also occur near those colonies. Males have been satellite tracked from foraging areas in the North Atlantic to Caribbean nesting colonies, where the males reside until the peak of the nesting season (James et al. 2005b). 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 2004). The nesting season in the western North Atlantic is mainly from March to July (NMFS and USFWS 1992). Female nesters lay between one and 11 clutches in a single season at 9 to 10 day intervals (NMFS and USFWS 1992). Typical clutches range in size from 50 to over 150 eggs, with the incubation period lasting around 65 days. Females remain in the general vicinity (e.g., within 50 km) of the nesting habitat during inter-nesting intervals, with the 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 to three years. However, remigration intervals (the number of years between successive nesting seasons) between one and five years have been recorded (Boulon et al. 1996; Saba et al. 2007).

- Loggerhead Turtle *(Caretta caretta)*

Description—The loggerhead turtle is a large, hard-shelled sea turtle named for its proportionately large head and powerful jaws. Adult loggerheads weigh between 100 and 150 kg with average carapace lengths ranging from 90 to 95 cm (Dodd 1988; NMFS and USFWS 1991b). Adult loggerheads usually possess a reddish-brown carapace with scutes that are bordered with yellow (NMFS and USFWS 1991b).

Status—Loggerhead turtles are listed as threatened under the ESA (NMFS and USFWS 1991b). The loggerhead is the most abundant sea turtle occurring in U.S. waters. In the continental United States there are four 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, and (4) Dry Tortugas (Witherington et al. 2006b). Bowen et al. (1995) noted that under a conventional interpretation of the nuclear deoxyribonucleic acid (DNA) data, all breeding populations in the entire southeastern United States would be regarded as a single management unit, yet the mitochondrial DNA data indicate multiple isolated populations, and further suggest this complex population structure mandates a different management strategy at each life stage. The South Florida nesting subpopulation is the largest loggerhead rookery in the Atlantic

Ocean (and the second largest in the world), followed by the Northern, Florida Panhandle, and Dry Tortugas subpopulations (Ehrhart et al. 2003; Witherington et al. 2006b). The south Florida nesting subpopulation produced between 43,500 and 83,400 nests between 1992 and 2002 (USFWS and NMFS 2003). Nesting trends indicated that the number of nesting females associated with the south Florida subpopulation was increasing (Epperly et al. 2001). However, recent data suggests that this nesting population has actually been decreasing at a rate of 1.9% a year since 1995 (Witherington et al. In review). This subpopulation also contributes significantly to loggerheads off the Carolinas (66%) and in North Carolina's Albemarle-Pamlico Estuarine Complex (Epperly et al. 2001).

Adult loggerheads within the VACAPES OPAREA experience mortality due to interactions with the western Atlantic pelagic longline fishery (Garrison and Richards 2004). NMFS management regulations and an observer program are currently in effect to reduce loggerhead bycatch (Garrison and Richards 2004).

Habitat Associations—The loggerhead turtle occurs worldwide in habitats ranging from coastal estuaries, bays and lagoons to pelagic waters (Dodd 1988). The generalized life history model of loggerheads consists of different life stages including the early juvenile nursery habitat, later juvenile developmental habitat, adult foraging habitat, and adult internesting or breeding habitat (Musick and Limpus 1997). Early juvenile loggerheads are primarily oceanic, occurring in pelagic convergence zones where they are transported throughout the ocean by dominant currents, such as the North Atlantic Gyre (Caldwell 1968; Carr 1987; Witherington 1994a; Bolten and Balazs 1995). Post-hatchling and early juvenile loggerhead turtles from southeastern Atlantic nesting populations have been found in the waters surrounding the Azores and Maderia, the Great Banks (Newfoundland, Canada) and the Mediterranean Sea (Bolten et al. 1994; Bolten et al. 1998; Bowen et al. 2004). Once North Atlantic juvenile loggerheads reach approximately 40 cm in length (approximately 8.2 years), they migrate back towards the western Atlantic Ocean to neritic feeding grounds near their natal beach of origin (Carr 1987; Musick and Limpus 1997; Bjorndal et al. 2000a; Bowen et al. 2004). 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. 1983) which provide an abundance of prey as well as sheltered locations (Rosman et al. 1987).

Based on growth models, juvenile loggerheads may occupy coastal feeding grounds for 20 years before their first reproductive migration (Bjorndal et al. 2001). Late juveniles and adult loggerheads most often occur on the continental shelf and along the shelf break of the U.S. Atlantic and Gulf coasts as well as coastal estuaries and bays (CETAP 1982; Shoop and Kenney 1992). Sub-adult and adult loggerhead turtles tend to inhabit deeper offshore feeding areas, up to 100 m deep, along the western Atlantic coast from mid-Florida to New Jersey, most likely foraging on benthic prey (Hopkins-Murphy et al. 2003; Roberts et al. 2005; Hawkes et al. 2007).

Distribution—The loggerhead turtle is a circumglobal species found in subtropical and temperate waters throughout the world (NMFS and USFWS 1991b). Loggerhead turtles can be found along the U.S. Atlantic coast from Cape Cod to the Florida Keys during any season; from the shore to the shelf break (CETAP 1982; Shoop and Kenney 1992). Loggerhead distribution along the U.S. Atlantic coast is determined by seasonal water temperatures. Loggerheads prefer water temperatures between 13.3°C and 28°C (Mrosovsky 1980), becoming lethargic between 13 and 15°C and adopting a stunned floating posture in water around 10°C (Mrosovsky 1980). These cold-stunning events typically occur between December and February (Schwartz 1989). Some loggerheads are believed to escape cold conditions by burying themselves in the bottom sediment and hibernating (or brumating); (Carr et al. 1980; Ogren and McVea 1995; Hochscheid et al. 2005).

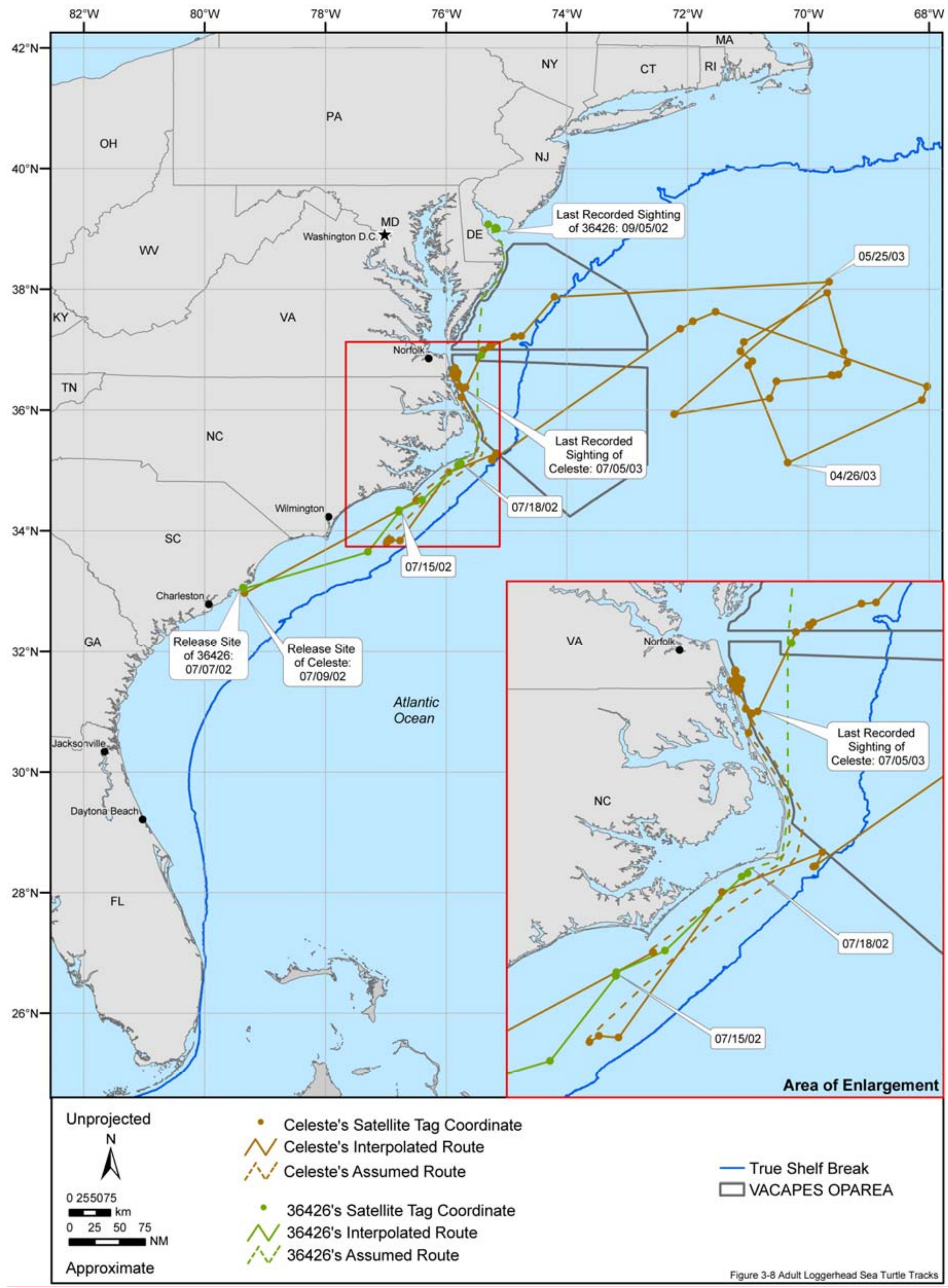

Figure 3-8. Seasonal movement patterns of adult loggerhead sea turtles in the western North Atlantic. Both turtles were satellite tagged and released from South Carolina. "36426" exhibited a typical pattern, moving north along the Atlantic coast during summer. "Celeste" traveled north from South Carolina and entered the Gulf Stream before returning to the coast. Source data: SCDNR (2006b).

Adults may transit the VACAPES OPAREA as evidenced by a post-nesting female, tagged in 1998, traveling into Chesapeake Bay and Delaware Bay after nesting at Back Bay National Wildlife Refuge in Virginia (Bartol and Musick 1998). Seasonal loggerhead migrations take place in both an inshore/offshore and north/south direction (Hopkins-Murphy et al. 2003), and adult loggerheads may pass through North Carolina, Virginia, Maryland, and Delaware en route to summer foraging areas or overwintering grounds (Hawkes et al. 2007). The route of “36426,” an adult female tracked by the South Carolina Department of Natural Resources (SCDNR) in summer 2002, represents a common example of adult loggerhead movements during the summer (Murphy 2006) (Figure 3-8). Between June and September, loggerheads may stay within a mile or two of shore, although individuals may be found far offshore, entering and traveling within the Gulf Stream (Keinath et al. 1996a). Favorable temperature and depth regimes for loggerheads occur along the western edge of the Gulf Stream throughout winter in the vicinity of Cape Hatteras and southward throughout the South Atlantic Bight (Epperly et al. 1995c).

Post-nesting females satellite-tagged on North Carolina nesting beaches may overwinter offshore in the mid-Atlantic (Hawkes et al. 2007). In addition to serving as an overwintering area, the Gulf Stream may also be used by juvenile or adult loggerheads to access mid-Atlantic foraging grounds (Murphy 2006; Hawkes et al. 2007). Dodd and Byles (2003) tracked an adult female from a Florida nesting beach who traveled as north as the shelf edge offshore Cape Hatteras, NC before returning south to overwinter offshore the North Carolina-South Carolina border. Another loggerhead female tracked by the SCDNR, “Celeste”, traveled northeast to the Gulf Stream during the spring (April and May) (Figure 3-8). Hawkes et al. (2007) also tracked a female who traveled into the Gulf Stream and over deep oceanic waters from March through approximately June, potentially using this area as foraging habitat.

In early spring, juvenile loggerheads over-wintering in southeastern U.S. waters begin to migrate north to developmental feeding habitats (Morreale and Standora 2005). Migrating juvenile loggerheads appear in North Carolina waters in April, in Virginia waters during May, and New York and New England waters during June. juvenile loggerheads use estuaries, bays, and sounds as development feeding habitat during the summer months. Individuals will disperse throughout the sounds during the summer, and leave as water temperatures cool in the late fall (Epperly et al. 1995a). Larger benthic juveniles typically forage over the continental shelf (Hopkins-Murphy et al. 2003). Turtles previously tagged and released off North Carolina either moved offshore to deeper waters, traveled nearshore to Florida, or over-wintered on the west side of the Gulf Stream, off North Carolina (Epperly et al. 1995c; Keinath et al. 1996a). A juvenile loggerhead released off Charleston, South Carolina was tracked seasonally; this individual remained off Charleston during the summer and fall, yet overwintered in the Gulf Stream (Figure 3-9).

Departure from Chesapeake Bay developmental habitat is likely influenced by water temperature (Lutcavage and Musick 1985; Byles 1988; Mansfield 2006). Mansfield (2006) found seasonal migrations of loggerheads to occur out the Chesapeake Bay when water surface temperatures dropped below 20°C; the temperature threshold for loggerhead southward migration occurs approximately late May and October each year (Byles 1988). Southward migration for loggerheads tends to be nearshore and along the coast (Keinath et al. 1996a).

Turtles may either move offshore to deeper waters, travel along the shore to Florida, or over-winter on the west side of the Gulf Stream, as evidenced by turtles previously tagged and released off North Carolina and South Carolina (Epperly et al. 1995c; Keinath et al. 1996a). Through offshore movements, individuals may enter or transit through the VACAPES OPAREA. In June through September, loggerheads tend to stay within a mile or two of shore, although individuals may be found far offshore, entering and traveling within the Gulf Stream (Keinath et al. 1996a). Mature male loggerheads occur more often in areas south of Virginia (Lutcavage and Musick 1985).

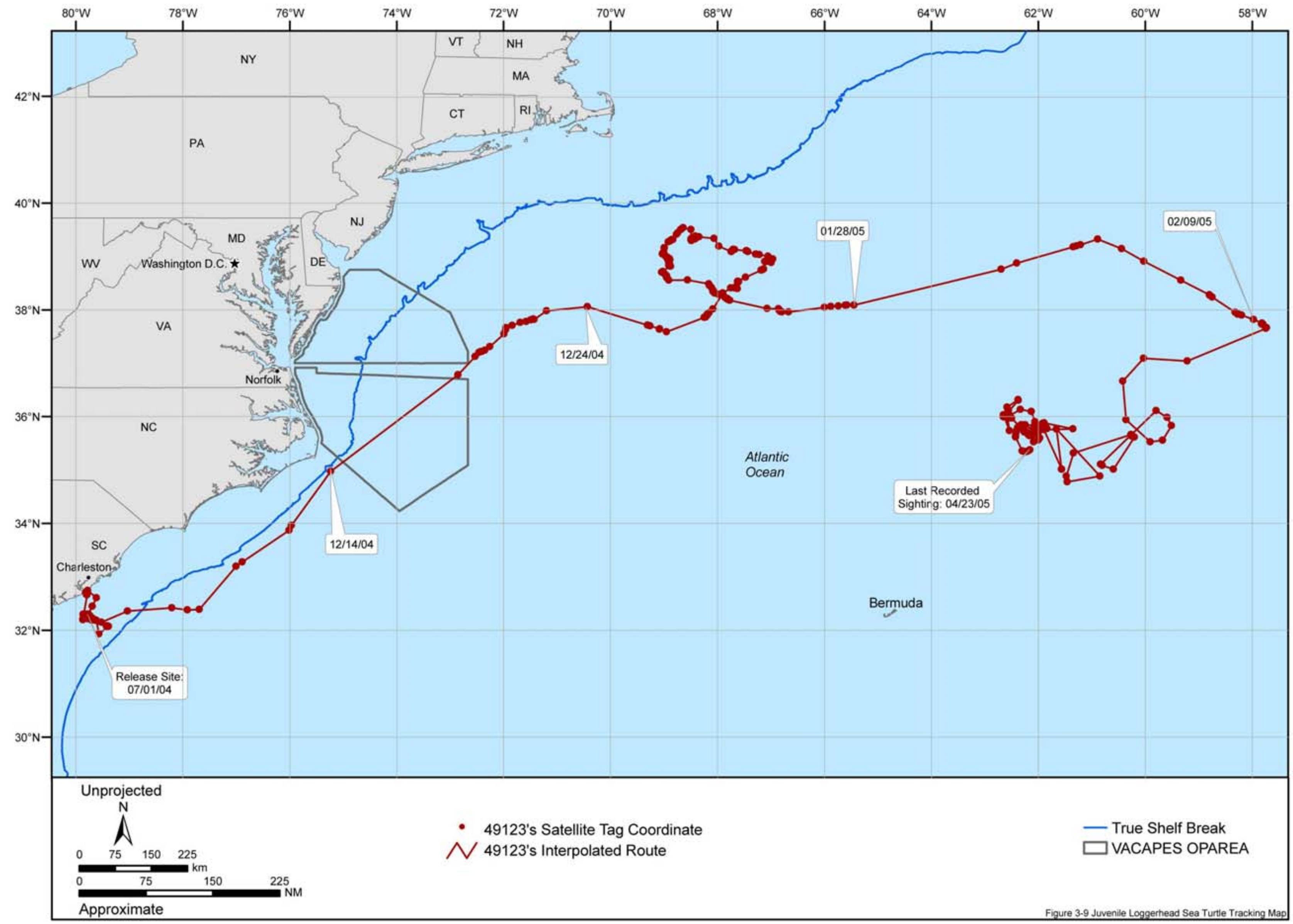

Figure 3-9. Seasonal movement pattern of a juvenile loggerhead sea turtle in the western North Atlantic. "49123" was satellite tagged and released from South Carolina, traveled north, and entered the Gulf Stream. "49123" overwintered in the mid-Atlantic, a possible juvenile foraging habitat. Source data: SCDNR (2006a).

Genetic evidence has indicated that benthic-feeding immature loggerhead assemblages on foraging grounds comprise a mix of subpopulations (Sears et al. 1995; TEWG 1998; Epperly et al. 2001). At least three of the western North Atlantic subpopulations intermingle on foraging grounds off the northeast U.S. coast (Rankin-Baransky 1997). Many of the loggerheads feeding offshore in the Northeast Florida- North Carolina foraging areas are derived from the Florida nesting assemblage (65%) and the nearby Northeast Florida- North Carolina nesting assemblage (19.1%) (Roberts et al. 2005). Epperly et al. (2001) reported that the northern nesting subpopulation (Northeast Florida to North Carolina) accounts for 46% of the loggerheads in Virginia but only 25 to 28% of the loggerheads off the Carolinas. The south Florida subpopulation also contributes significantly to loggerheads off the Carolinas (66%) and in North Carolina's Albemarle-Pamlico Estuarine Complex (Epperly et al. 2001).

Loggerheads typically nest on high-energy beaches close to reef formations and adjacent to warm-temperature currents (Dodd 1988; TEWG 2000). Nesting beaches facing the open ocean or situated along narrow bays are preferred (NMFS and USFWS 1991b). 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 typically return their natal beaches or nearby areas to nest (Comer 2002). Intraseasonal nesting patterns for females vary; some females may nest only once a season while others may nest several times (Webster and Cook 2001). Southeastern Florida represents the principal nesting site for loggerheads along the U.S. Atlantic coast (NMFS and USFWS 1991b). Loggerhead nesting within the VACAPES OPAREA has been reported in areas such as Back Bay National Wildlife Refuge (BBNWR) and Virginia Beach, VA (Norggard 1995; Bartol and Musick 1998; Cross et al. 2001; USFWS 2001; Mansfield 2006), the Virginia/Maryland Eastern Shore (Boettcher et al. 2007), Ocean City, Maryland (Dodd 1988), and Delaware Seashore State Park, Delaware (Dodd 1988). Nest monitoring has occurred at Back Bay NWR since 1970 from the months of May though August (Cross et al. 2001); during the 2005 nesting season, 6 loggerhead nests were documented on the refuge (USFWS 2005a).

- Information Specific to the VACAPES OPAREA—Loggerheads occur year-round in the VACAPES OPAREA using waters of the OPAREA for foraging and transit to nesting beaches. Seasonal water temperatures influence loggerhead occurrence within the OPAREA. The model output shows the occurrence most concentrated in shelf waters throughout the year although limited survey effort in deeper waters could contribute to a significant bias. A high concentration of loggerheads occurs in shelf waters offshore Maryland during the spring and northern North Carolina during the fall (Figures C3-1 and C3-2). During spring and fall, loggerheads are likely transiting the OPAREA to access summer foraging or overwintering habitats.

  - Winter—The occurrence during the winter is primarily in the shelf waters off southern Georgia/northern Florida, likely due to loggerheads overwintering in these areas. Loggerheads are not typically expected north of southern Virginia in coastal waters, as these waters are likely below the temperature at which cold-stunning occurs (10°C; Mrosovsky 1980). However, loggerheads may be expected to range north of southern Virginia in offshore waters of the OPAREA, along the western edge of the Gulf Stream. The model output and bycatch records suggest this trend is more common in the southern OPAREA waters. Strandings that line the coast adjacent to the southern waters of the OPAREA may be the result of cold-stunned individuals.

  - Spring—The model output shows the occurrence throughout shelf waters of the OPAREA during the spring. Migrating loggerheads move north in the spring, expanding their range into the northern warming waters (Hopkins-Murphy et al. 2003; Hawkes et al. 2007). High loggerhead concentrations within shelf waters offshore Maryland likely represent juveniles and adults migrating to northern foraging habitat; individuals are also likely using these shelf waters as summer foraging habitat. A high concentration of loggerheads just offshore the shelf break in northeastern VACAPES may suggest the use of adult foraging habitat in this area as well. The model output shows the loggerhead range to extend furthest offshore during the spring. Strandings are heavily concentrated along the coast adjacent to the

OPAREA; spring season also represents a time when smaller juvenile loggerheads migrate inshore to developmental habitats in bays and sounds as well as encompasses the beginning of loggerhead nesting in adjacent to the OPAREA. Although more common in North Carolina, loggerheads may nest in Virginia, Delaware, or Maryland (Dodd 1988; USFWS 2005a), and transit the OPAREA to access these nesting beaches.

- Summer—During the summer, the model output shows the loggerhead range within the OPAREA to encompass shelf waters and expand beyond the shelf break. High concentrations of loggerheads still occur offshore Maryland and southern Delaware yet are not as pronounced as during the spring. Juvenile and adult loggerheads use coastal and OPAREA waters as foraging habitat during the summer. Adult loggerheads may also nest on the beaches of Delaware, Maryland, Virginia, and North Carolina during this time; post-nesting females may travel north along the coast (Plotkin and Spotila 2002) or access more inland waters such as the Chesapeake or Delaware Bay (Hopkins-Murphy et al. 2003). Scattered occurrence records beyond the shelf break suggest the use offshore habitat by foraging loggerheads and the need for additional survey effort in these areas.

- Fall—The model output shows the highest loggerhead concentrations along the east coast to occur in shelf waters off southern Virginia/northern North Carolina. During the fall, juveniles and adults are typically migrating from developmental habitats and northern foraging habitats, respectively, and transverse the OPAREA during this time. Individuals may migrate south to access overwintering habitat, south of Cape Hatteras, NC, or east to overwinter in warm waters just west of the Gulf Stream. The high loggerhead concentrations within the OPAREA shelf waters likely represent a confluence of juveniles and adults migrating to overwintering habitat. Emigration from summer developmental habitats along the east coast typically begins in October (Morreale and Standora 2005). Strandings that line the coast adjacent to the OPAREA may suggest the continued occurrence of juveniles using Chesapeake Bay and coastal developmental habitat into the fall season and subsequent cold-stunning episodes.

Behavior and Life History—The diet of a loggerhead turtle changes with age and size. The gut contents of post-hatchlings found in masses of *Sargassum* contained parts of *Sargassum*, zooplankton, jellyfish, larval shrimp and crabs, insects, and gastropods (Carr and Meylan 1980; Richardson and McGillivary 1991; Witherington 1994b). Late juvenile loggerhead turtles are omnivorous, foraging on pelagic crabs, mollusks, jellyfish, and vegetation captured at or near the surface (Dodd 1988). Adult loggerheads are generally carnivorous, often choosing to forage on benthic invertebrates (mollusks, crustaceans, and coelenterates), and sometimes fish in nearshore waters (Dodd 1988). In the Chesapeake Bay area, loggerheads consume horseshoe crabs, blue crabs, spider crabs, rock crabs, and various fish species, although the predominant loggerhead prey has shifted over time (Lutcavage and Musick 1985; Seney and Musick 2007). Originally foraging on horseshoe crabs, loggerhead prey shifted to blue crabs in the late 1980s and fish, such as menhaden and croaker, in the mid-1990s (Seney and Musick 2007).

Western Atlantic loggerheads reach sexual maturity 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 1995). 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 1995). Most nesting in the U.S. occurs between April and September. Seasonal and regional variation in nest environments influences loggerhead hatchling sex and size along the U.S. Atlantic coast (Stokes et al. 2006). Beach and nest incubation temperatures determine the sex of loggerhead hatchlings (Mrosovsky 1980). An equal number of males and females are produced at an approximate temperature of 29.0°C; male hatchlings are produced by cooler temperature while female hatchlings are produced by warmer temperatures (Mrosovsky 1980, 1988). Atlantic loggerhead populations exhibit a female sex-bias, likely due to the predominance of South Florida loggerheads originating from beach temperatures warmer than the northern east coast beaches

(TEWG 2000). The male-to-female sex ratio of hatchlings entering the ocean is expected to be 1:6 along the U.S. Atlantic coast (Hopkins-Murphy et al. 2003).

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 172 min (Byles 1988; Sakamoto et al. 1990; Renaud and Carpenter 1994). Diving behavior of adult loggerheads off the U.S. east coast differs between foraging and overwintering habitats, with dives at overwintering habitats being significantly longer than at summer foraging habitats (Hawkes et al. 2007). Loggerheads off the U.S. east coast also exhibit seasonal differences in surfacing behavior and many vary time spent at the surface throughout the year (Mansfield 2006). Loggerheads off the U.S. east coast exhibit seasonal differences in surfacing behavior and many vary time spent at the surface throughout the year (Mansfield and Musick 2006b). In the Chesapeake Bay and coastal Virginia waters, Mansfield (2006) found loggerheads to spend approximately 9.9% of time at the surface in the spring and 25% of time at the surface in the summer. Individuals may spend more time at the surface in areas where a strong thermocline is present (Keinath et al. 1996a); Mansfield (2006) found loggerheads to have higher surfacing times in the deeper and cooler waters of the Chesapeake Bay. Mansfield (2006) found loggerheads in the Chesapeake Bay and coastal Virginia waters to travel at an average speed ranging from 2.3 to 4.2 km/hr.

- Green Turtle *(Chelonia mydas)*

Description—The green turtle is the largest hard-shelled sea turtle. Adult green turtles commonly weigh over 100 kg and are greater than 100 cm in length (NMFS and USFWS 1991a). Hatchlings are distinctively black on the dorsal surface and white on the ventral. Adult carapaces range in color from solid black to gray, yellow, green, and brown in muted to conscious patterns; the plastron is a much lighter yellow to white (NMFS and USFWS 1991a). Green turtles in the Atlantic exhibit a slower growth rate than Pacific green turtles (Bjorndal et al. 2000b).

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 1991a). From 2001 to 2005, an average 5,055 green turtles nested in Florida; this estimate suggests Florida to have the second largest green turtle nesting population in the wider Caribbean (Meylan et al. 2006). Juvenile green turtles are the second most abundant sea turtle species in North Carolina summer developmental habitats (Epperly et al. 1995a). Recent population estimates for green turtles in the western Atlantic area are not available (NMFS 2006).

Habitat Associations—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; Witherington and Hirama 2006). 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 green turtles reach a carapace length of 20 to 25 cm (7.9 to 9.8 inches), they migrate to shallow nearshore areas (<50 m deep) in Florida and the Caribbean, where they spend the majority of their lives as late juveniles and adults (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 in bottom depth), with abundant submerged aquatic vegetation and in close proximity to nearshore reefs or rocky areas (Holloway-Adkins and Provancha 2005; Witherington et al. 2006a). Green turtles may forage in either deep waters or in shallow seagrass beds (Hirth 1997); in Hawaii, green turtles forage in waters as deep as 20 to 50 m (Brill et al. 1995). Along the east coast of Florida, juvenile green turtles use high wave-energy nearshore reef environments as developmental habitats; these areas support an abundance of macro-algae and are less than 2 m in depth (Holloway-Adkins 2006).

Distribution—Green turtles are distributed worldwide in tropical and subtropical waters and prefer temperatures above 20°C (NMFS and USFWS 1991a). Green turtles found in U.S. waters come from nesting beaches widely scattered throughout the Atlantic (Witherington et al. 2006a). In U.S. Atlantic waters, greens are found around the U.S. Virgin Islands, Puerto Rico, and the continental U.S. from Texas to Massachusetts (NMFS and USFWS 1991a). Juvenile green turtles utilize estuarine waters along the U.S. Atlantic coast as summer developmental habitat, as far north as Long Island Sound, Chesapeake Bay, and North Carolina sounds (Epperly et al. 1995b; Epperly et al. 1995a; Musick and Limpus 1997). As adults, green turtles are restricted to more southern latitudes (Epperly et al. 1995a), and are only occasionally are found north of Florida. During non-breeding periods, adults and juvenile distributions may overlap in coastal feeding areas (Hirth 1997). The waters off the North Carolina coast serve as important neritic developmental habitat for benthic-stage green turtles, especially Pamlico and Core sounds (Epperly et al. 1995b; Epperly et al. 1995a). Schwartz (1989) found green turtles to be the second most abundant sea turtle species in the state's waters; they are also the second most numerous species incidentally captured by North Carolina's commercial fishermen (Epperly et al. 1995c). In Virginia, however, loggerheads and Kemp's ridleys are the more likely to occur than greens (Mansfield 2006).

Nearshore water temperatures play a major role in determining green turtle distribution along the Atlantic and Gulf coasts of the United States (Musick and Limpus 1997; Witherington et al. 2006a). 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. Adults are predominantly tropical and are only occasionally found north of southern Florida. Most sightings of individuals north of Florida occur between late spring and early fall, and are juveniles (Lazell 1980; CETAP 1982; Burke et al. 1992; Epperly et al. 1995a). Small numbers of these age classes regularly occur as far north as Long Island, New York from June through October, when the waters are warm enough to support green turtles (Morreale et al. 1992). The highest proportions of green turtles in North Carolina waters are observed in the fall (Epperly et al. 1995a), in conjunction with the southward migration of juvenile greens moving to warmer waters for the winter (Mendonça 1983).

Green turtles nest on both island and continental beaches between 30ºN and 30ºS (Witherington et al. 2006a). The major Atlantic nesting colonies are located at Ascension Island (in the South Atlantic Ocean, about mid-way between South America and Africa), Aves Island (in the Caribbean Sea, about 180 km west of Guadaloupe), and on the beaches of Costa Rica and Suriname (in central and South America, respectively) (NMFS and USFWS 1991a). Although Florida is near the northern extent of the green turtle's Atlantic nesting range, it hosts a significant proportion of green turtle nesting (Witherington et al. 2006a). Green turtle nesting in Florida has occurred in every coastal county except those bordering the Big Bend area (Meylan et al. 1995; Witherington et al. 2006a). Approximately 99% of the green turtle nesting in Florida occurs on the Atlantic coast, with Brevard through Broward counties hosting the greatest nesting activity (Meylan et al. 1995) (Witherington et al. 2006a). There are scattered nesting records in Georgia, and the Carolinas (Peterson et al. 1985; Schwartz 1989; NMFS and USFWS 1991a). Green turtle nesting in North Carolina has been documented at Onslow Beach, Caswell Beach, Bald Head Island, and near Cape Hatteras (Schwartz 1989). The first ever green turtle nest in Virginia was documented in 2005 at Back Bay National Wildlife Refuge (USFWS 2005a). Green turtles rank second behind loggerheads in the number of nests laid on U.S. beaches per year (Dodd 1995; Meylan et al. 1995).

- Information Specific to the VACAPES OPAREA—Green turtles may occur throughout the OPAREA from spring through fall, and are least common within the OPAREA during the winter (Figures C-4-1 and C-4-2). Summer represents the peak time for green turtle occurrence in the OPAREA due to the presence of summer developmental foraging habitat along the coast

(Figures C-4-1 and C-4-2). During the winter, the highest concentration of greens occurs just north of Cape Canaveral, FL, a known overwintering area for juveniles (Figure C-4-1).

- Winter—The model output shows the occurrence trend to northern Florida and Georgia shelf waters during the winter (Figure C-4-1). Although the model output does not show green turtle occurrence within the OPAREA during this time, juveniles that have not migrated south to overwintering habitat. Strandings along the coast of the Chesapeake Bay and northern Outer Banks may represent cold-stunned individuals (Figure C-4-2). During the winter, shelf sea surface temperatures within the OPAREA are near the green turtle's threshold for cold-stunning (10°C); these waters are likely not favorable to greens during this time and may be avoided. Overwintering greens may remain offshore in the Gulf Stream, yet minimal survey effort exists in the area during the winter (Figures C-4-1 and C-4-2; Figure 2-7).

- Spring—During the spring, juvenile greens migrate north to developmental habitats along the U.S. Atlantic coast. Although the model output does not show occurrence in shelf waters, with the exception of waters off northern Delaware, sighting and stranding records indicate the presence of green turtles in the OPAREA during this time (Figures C-4-1 and C-4-2). As juveniles typically arrive at developmental habitats in June, the model output may be a reflection of juveniles having not arrived at habitat in the OPAREA during the majority of spring season (Figures C-4-1 and C-4-2).

- Summer—The model output shows the occurrence trend to the shelf waters of the OPAREA, with the greatest concentration of green turtles predicted along the east coast during the summer. During the summer, juveniles use developmental habitats along the coastal United States, and towards the end of the season, begin their migration south to overwintering grounds. The predicted concentrations of greens within the OPAREA are likely driven by the presence of juveniles using developmental habitat, such as the Chesapeake Bay, or sub-adults using coastal neritic foraging habitat within shelf waters (Barnard et al. 1989; Epperly et al. 1995c; Epperly et al. 1995a). The highest concentration of greens occurs in shelf waters off northern North Carolina although greens may be expected to use developmental or neritic foraging habitat throughout shelf waters of the OPAREA (Figures C-4-1 and C-4-2). Juveniles may occur in developmental habitats as far north as Long Island, NY from June through October (Morreale et al. 1992). Strandings that line the southern coast adjacent to the OPAREA suggest the transit of greens in and out of the Chesapeake Bay and North Carolina sounds (Figure C-4-2). Although not as common as loggerheads, green turtles may also nest on beaches adjacent to the OPAREA; summer represents peak nesting time for greens in the United States (Coston-Clements and Hoss 1983). Individuals may transit the OPAREA to access nesting beaches, such as Back Bay NWR, VA (USFWS 2005a).

- Fall—During the fall, juvenile and sub-adult greens within the OPAREA migrate south to overwintering habitat off Florida or east to the western edge of the Gulf Stream. Sightings data within the OPAREA for green turtles during this season are sparse and therefore, the model prediction may be biased towards those sightings. However, the model output predicts the highest occurrence of greens along the U.S. east coast to be offshore northern North Carolina, beyond the shelf break (Figure C-4-1). A lower occurrence of greens is predicted in shelf waters off the Maryland Eastern Shore (Figures C-4-1 and C-4-2). Clustered strandings from the Chesapeake Bay mouth south to the Outer Banks (Figure C-4-2) may represent individuals becoming cold-stunned after remaining in developmental and neritic foraging habitats after the water temperature drops.

Behavior and Life History— Early juvenile green turtles 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). Late juvenile and adult green turtles feed primarily on seagrasses (e.g., turtle grass, manatee grass, shoal grass, and eelgrass), macro algae, and reef-associated organisms (Burke et al. 1992; Bjorndal 1997). Observations of foraging adult green turtles in Hawaiian Islands suggest they lie down on the sea bottom to feed and crawl or swim to other sites when the nearby food source has been depleted (Hochscheid et al. 1999). Along the eastern U.S. coast, green turtles are known to feed on various species of seagrass and algae (Bjorndal 1997; Musick and Limpus 1997; Holloway-Adkins 2006). Juvenile green turtles off the cost of Palm Beach, Florida were found to forage continuously throughout the day (Makowski et al. 2006).

Green turtles take between 27 and 50 years to reach maturity, the longest age to maturity for any sea turtle species (Frazer and Ehrhart 1985). Approximate size of nesting females in Florida is 101.5 cm straight carapace length. 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 1991a). Females remain in close proximity to their nesting beaches during inter-nesting intervals (Meylan 1995). Green turtles lay between 110 and 145 eggs at a time, and the incubation period is 50 to 60 days long. 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).

Green turtle diving behavior is likely influenced by turtle age class and depth of prey assemblages (Salmon et al. 2004). Green turtles typically make dives shallower than 30 m (Hochscheid et al. 1999; Hays et al. 2000), although they 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). 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). Juvenile green turtles have exhibited deeper dives during the night than during the day with more frequent dives during daylight hours (Makowski et al. 2006). Individuals also differed in dive profile type between diurnal and nocturnal periods, displaying V-shaped active dives during the day and U-shaped resting dives at night (Makowski et al. 2006). Juvenile green turtles may also 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 typically weigh around 80 kg with carapace length ranging from 65 to 90 cm (Witzell 1983; NMFS and USFWS 1993). Hawksbills are distinguished from other sea turtles by 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 classified as endangered under the ESA and are second to the Kemp’s ridleys in terms of endangerment (NMFS and USFWS 1993; Bass 1994). The most recent estimate of hawksbill abundance in the Atlantic Ocean was 3,072 to 5,603 nesting females (this number is compiled from historical and recent estimates of nesting colonies from around the Atlantic basin (NMFS and USFWS 2007b). Declines in nesting females have been recorded at some nesting beaches while increases have been recorded at others (NMFS and USFWS 2007b). In the Caribbean, there is designated critical habitat for hawksbills at Mono and Monito islands, Puerto Rico (NMFS and USFWS 1993).

Habitat Associations— Early juveniles are known to inhabit oceanic waters where they are sometimes associated with drift lines and 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). Shallow seagrass beds may also serve as important developmental habitats for late juvenile hawksbills (Bjorndal and Bolten 1988; Diez et al. 2003).

Coral reefs are recognized as optimal habitat for juvenile, sub-adult, and adult hawksbill turtles. Preference for these habitats is likely related to the presence of sponges, a favored prey item which comprises as much as 95% of their diet (NMFS and USFWS 1993; Diez et al. 2003). Ledges, caves, and root systems, which are often interspersed among these habitats, provide 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).

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). 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).

Distribution— Hawksbill turtles are circum-tropical in distribution, generally occurring from 30°N to 30°S within the Atlantic, Pacific, and Indian oceans (NMFS and USFWS Witzell 1983; 1993). 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). 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, U.S. Virgin Islands (Van Dam and Diez 1996; Starbird et al. 1999).

The hawksbill is rare north of Florida (Plotkin 1995), although sightings and strandings have been recorded in Massachusetts, Virginia, North Carolina, and Georgia (Lee and Palmer 1981; Morreale et al. 1989; Keinath et al. 1991 ; Parker 1995; Godfrey 2003). There are four published records of hawksbills in North Carolina waters, including one 20 miles east of Oregon Inlet (Lee and Palmer 1981). Unpublished reports include a young hawksbill stranding cold-stunned on the Outer Banks of North Carolina in 2001 (Mazzarella 2001) and a yearling hawksbill stranding near the North Carolina/Virginia border in 2003 (Godfrey 2003). In 1990, a hawksbill was captured in Virginia at the mouth of the James River (Keinath et al. 1991), and in 2000, another individual stranded live at Virginia Beach (USFWS 2001).

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). 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).

Hawksbill turtles prefer to nest on the same tropical high-energy beaches as green turtles. Although hawksbills exhibit a wide tolerance for nesting substrate type, they prefer undisturbed, deep-sand beaches underneath vegetative cover (NMFS and USFWS 1993; Comer 2002). The hawksbill's small size and agility allows it to access nesting sites atop narrow and steeply sloped beaches as well as across fringing reefs, areas that are rarely accessible to other sea turtle species (NMFS and USFWS 1993; Comer 2002).The largest nesting aggregation in the Caribbean occurs along the Yucatán Peninsula, Mexico (NMFS and USFWS 1993). 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). Nesting has been documented at Jupiter Island, Biscayne National Monument, and the Canaveral National Seashore on the eastern Florida coast (Lund 1985).

- Information Specific to the VACAPES OPAREA— Although rare, hawksbills have been recorded within or adjacent to the VACAPES OPAREA in all seasons (Figure C-5). Based upon limited data, occurrences are expected to be more common within shelf waters or along the shelf break). As this species is typically tropical, any occurrences within the OPAREA should likely be considered extralimital. Most hawksbill strandings adjacent to the OPAREA, primarily to the south, have been small juveniles (Frick 2001; Mazzarella 2001; Godfrey 2003) suggesting individuals may enter the OPAREA from pelagic juvenile habitat. Sightings and bycatch records along the shelf break may support this (Figure C-5). However, OPAREA waters do not offer optimal developmental habitat for juvenile or foraging habitat for adults (NMFS and USFWS 1993; Diez et al. 2003), and individuals would not be expected to remain in the OPAREA.

Behavior and Life History—Early juveniles hawksbills are believed to utilize pelagic Sargassum or other flotsam as a developmental habitat, but little is known about their diets during this stage (Witzell 1983). Upon recruitment to benthic feeding habitats, hawksbills become omnivorous and feed on encrusting organisms such as sponges, tunicates, bryozoans, algae, mollusks, and a variety of other items such as crustaceans and jellyfish (Bjorndal 1997). Older juveniles and adults feed 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).

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. Mean time at the surface was about 2 min. Average dives during the day ranged from 34 to 65 min, while those at night were between 42 and 74 min. Juvenile hawksbills in the Cayman Islands were found to dive to a mean depth of 6 m and maximum depth of 91 m (Blumenthal et al. 2006). 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. This study, in combination with a more recent habitat utilization study in the Seychelles, indicates that juvenile hawksbills display alternating patterns of short, shallow foraging dives followed by deeper, longer resting dives (Van Dam and Diez 1996; Houghton et al. 2003). Hawksbill diving behavior may be affected by daily and seasonal changes in water temperature; Storch et al. (2005) found an increase in nocturnal dive duration as water temperatures decreased during the winter. Below 27.8°C, the influence of water temperature on dive duration was more pronounced.

Hawksbill turtles often nest in multiple, small, scattered colonies. The nesting season takes place primarily from May through August in the western North Atlantic (Witzell 1983). At tropical latitudes, nesting is most often nocturnal on beaches with sufficient vegetative cover. A female nests an average of 4 to 5 times per season with an inter-nesting interval of about 14 days (NMFS and USFWS 1993). The typical remigration interval is two to three years. Clutch sizes are relatively large at approximately 140 eggs in the U.S. and Caribbean. Incubation time is approximately 60 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 shallow waters adjacent to the nesting beach.

- Kemp's RidleyTurtle *(Lepidochelys kempii)*

Description—The Kemp's ridley is the smallest living sea turtle. This species has a straight carapace length of approximately 60 to 70 cm (with shell length and width being nearly equal) and weigh about 45 kg (USFWS and NMFS 1992; Gulko and Eckert 2004). The carapace is round to somewhat heart-shaped and distinctly light gray.

Status—The Kemp's ridley turtle is classified as endangered under the ESA and is considered the world's most endangered sea turtle (USFWS and NMFS 1992). The worldwide population declined from tens of thousands of nesting females in the late 1940s to approximately 300 nesting females in 1985 (TEWG 2000). From 1985 to 1999, the number of nests at Rancho Nuevo increased at a mean rate of 11.3% per year (TEWG 2000). Positive trends in 2005 were recorded in Rancho Nuevo (6,947 nests), Barra del Tordo (701 nests), and Barra de Tepehuajes (1,610 nests) (USFWS 2005b). Nesting levels at Padre Island National Seashore 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 (Shaver and Wibbels 2007). There are an estimated 3,900 to 8,100 juvenile Kemp's ridleys that utilize developmental habitats annually along the western North Atlantic coast (Seney and Musick 2005).

There are an estimated 3,900 to 8,100 juvenile Kemp's ridleys that utilize developmental habitats annually along the western North Atlantic coast (Seney and Musick 2005); adults in that region number in the hundreds (Keinath et al. 1994). In 1993, approximately 311-464 juvenile Kemp's ridleys were estimated to use the Chesapeake Bay area annually each summer (Keinath et al. 1994). A decline in blue crab populations within the Chesapeake Bay area may have implications for the numerous foraging Kemp's ridley juveniles in Virginia waters (Seney and Musick 2005).

Habitat Associations—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 (Morreale and Standora 2005). 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 and Ogren (1987) 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 1989). 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). Within the OPAREA and vicinity, Kemp's ridleys utilize developmental habitats in coastal Delaware (May/June through October), Maryland (May/June through October), Virginia (May through November), and North Carolina (April through October) (Morreale and Standora 2005). Kemp's ridleys utilize the Chesapeake Bay and coastal Virginia waters, in particular, as summer developmental habitat (Lutcavage and Musick 1985). Individuals may prefer the shallow seagrass habitats in the bay and adjacent waters due to the presence of their preferred prey in this region, the blue crab, (*Callinectes sapidus)* (Lutcavage and Musick 1985; Keinath et al. 1994). Also favored are warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where preferred food occurs (Lutcavage and Musick 1985; Landry and Costa 1999; Seney and Musick 2005).

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). The habitat suitability for Kemp's ridleys within the VACAPES OPAREA and vicinity varies seasonally (Figures 3-

10, 3-11, and 3-12). From July to September, shelf waters of the OPAREA exhibit habitat factors optimal for Kemp's ridleys (Figures 3-10 and 3-11). Habitat is still suitable for Kemp's ridleys in shelf waters during the months of May, June, and October; habitat suitability increased towards the south of the OPAREA. From November to April, the majority of the OPAREA is expected to be unsuitable for Kemp's ridley due to sea surface temperatures ranging below the known Kemp's ridley preferences. Year-round, offshore waters are expected to be unsuitable for Kemp's ridleys.

Distribution—The Kemp's ridley is restricted to the North Atlantic Ocean (Marquez-M. 1994). Oceanic transport of hatchling Kemp's ridleys is controlled primarily by hydrography in the Gulf of Mexico (Collard 1990a). Upon leaving the nesting beach of Rancho Nuevo, hatchling Kemp's ridleys enter the Mexican Current, and are swept eastward into the northern Gulf of Mexico (Musick and Limpus 1997). Many juveniles are retained in the northern Gulf until they migrate inshore to demersal habitat. Others may be carried south from the northern Gulf into the Loop Current, where they are swept into the Florida Current and, subsequently, the Gulf Stream (Musick and Limpus 1997). Once they reach a size of approximately 20 to 30 cm, or 2 years of age, they actively migrate to neritic developmental habitats along the U.S. Atlantic Coast (Musick and Limpus 1997). 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). Movements by adult females in the Gulf of Mexico are expected to be more extensive than those of males, and likely influenced by foraging and reproductive needs (Renaud and Williams 2005). Adult male Kemp's ridleys exhibit small range movements and may reside offshore nesting beaches year-round due to prey availability and mating opportunities (Shaver et al. 2005).

Environmental conditions play a major role in determining the number of Kemp's ridleys in an area. A decrease in air and surface water temperature in the fall likely triggers Kemp's ridley seasonal migrations (Renaud and Williams 2005). During the winter months, individuals along the U.S. Atlantic coast may leave northern developmental habitats and migrate south to warmer waters in Florida (Marquez-M. 1994). Kemp's ridleys seem to have a lower tolerance to cold temperatures than other sea turtle species, withstanding cold waters in Cape Cod Bay for a lesser amount of time. In temperatures less than 13°C Kemp's ridleys become cold-stunned, and may tend to float, make awkward movements (Marquez-M. 1994), or even die (Burke et al. 1991). In the spring, juveniles, and occasionally adults migrate north from overwintering grounds in the southeastern U.S. as water temperatures increase (Henwood and Ogren 1987). Kemp's ridleys appear in waters off North Carolina from April through October and in Virginia in May through November (Morreale and Standora 2005). Some juveniles may migrate as far north as New York and New England, arriving in these areas around June and leaving to travel south in early October (Morreale and Standora 2005). Individuals are known to overwinter in areas south of Cape Hatteras, NC, although the majority of Kemp's ridleys stay in Florida near Cape Canaveral (Henwood and Ogren 1987; Renaud 1995; Morreale and Standora 2005). A juvenile Kemp's ridley, tagged and released off Southern Virginia in mid-August, immediately traveled south post-release to central Florida where it remained from January through July (Mansfield 2006). Individuals that stay the winter in southern North Carolina may subsequently move into warmer waters, such as the Gulf Stream or areas of South Carolina (Renaud 1995; Morreale and Standora 2005). Seasonal movements continue until turtles reach sexual maturity, at which time, they return to breeding grounds in the Gulf of Mexico (Henwood and Ogren 1987).

Migrations tend to take place in nearshore waters along the mid-Atlantic Coast; juvenile and adults typically travel within the 18-m depth contour (Renaud and Williams 2005). Concentrations of Kemp's ridleys increase during fall and spring migrations, especially near Cape Hatteras, NC, where the migration corridor becomes constricted (Morreale and Standora 2005). This migratory corridor is a narrow band running within continental shelf waters, possibly spanning the entire length of the U.S. Atlantic Coast (Morreale and Standora 2005).

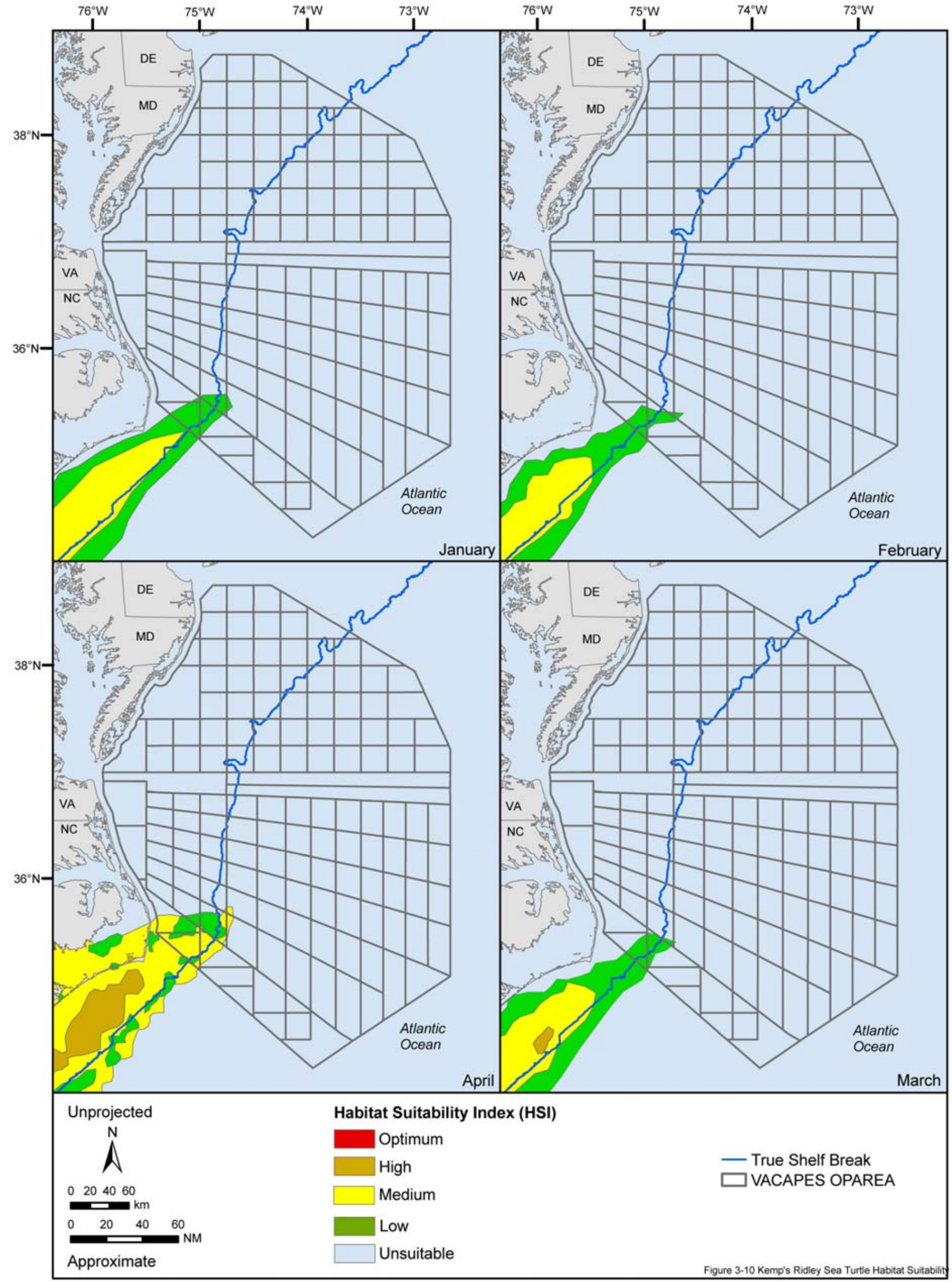

Figure 3-10. The habitat suitability index of waters in the Virginia Capes OPAREA and vicinity for the kemp's ridley sea turtle from January to April. Source maps (scanned): Coyne et al. (1998), used with primary author's permission.

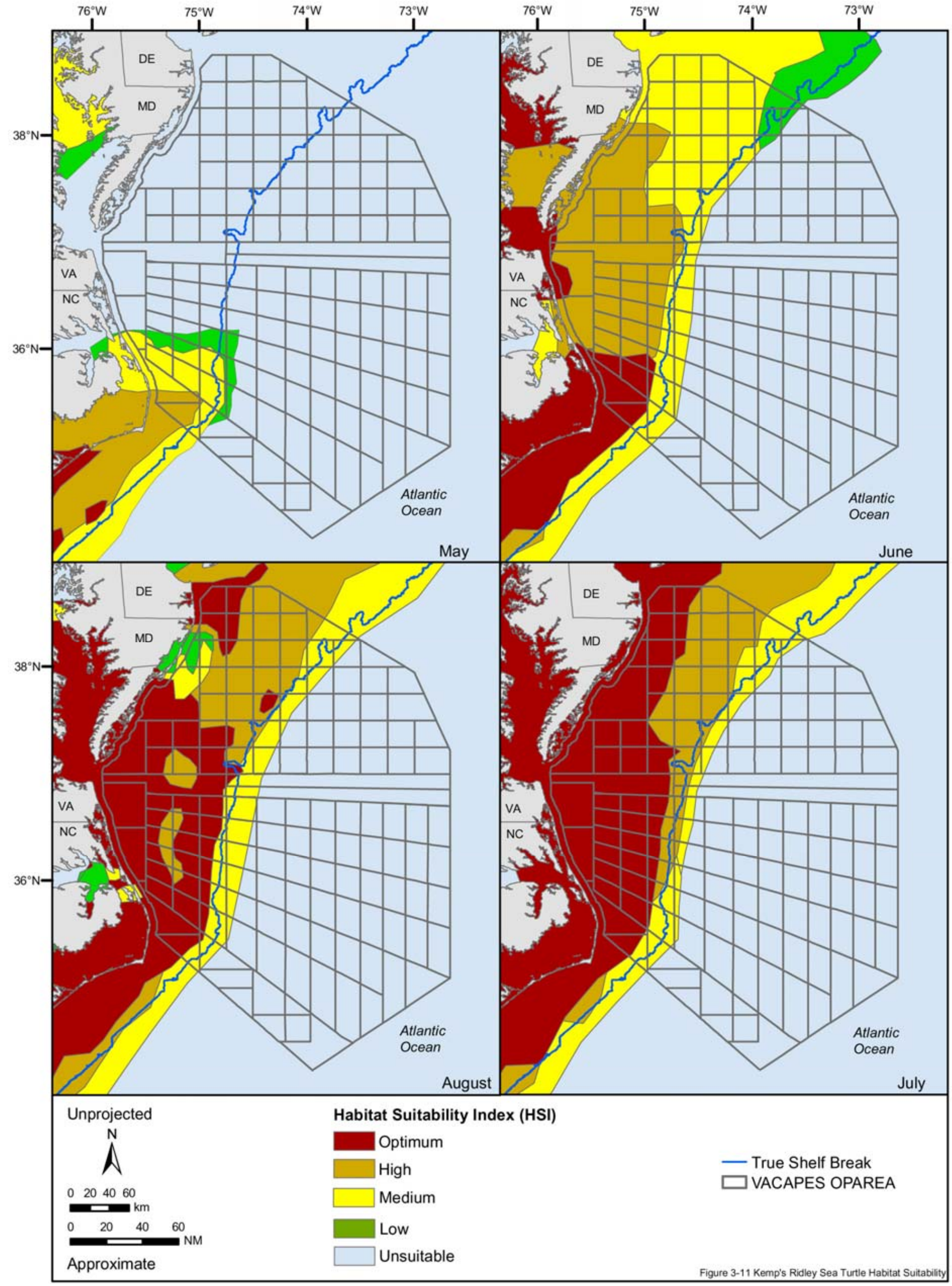

Figure 3-11. The habitat suitability index of waters in the Virginia Capes OPAREA and vicinity for the kemp's ridley sea turtle from May to August. Source maps (scanned): Coyne et al. (1998), used with primary author's permission.

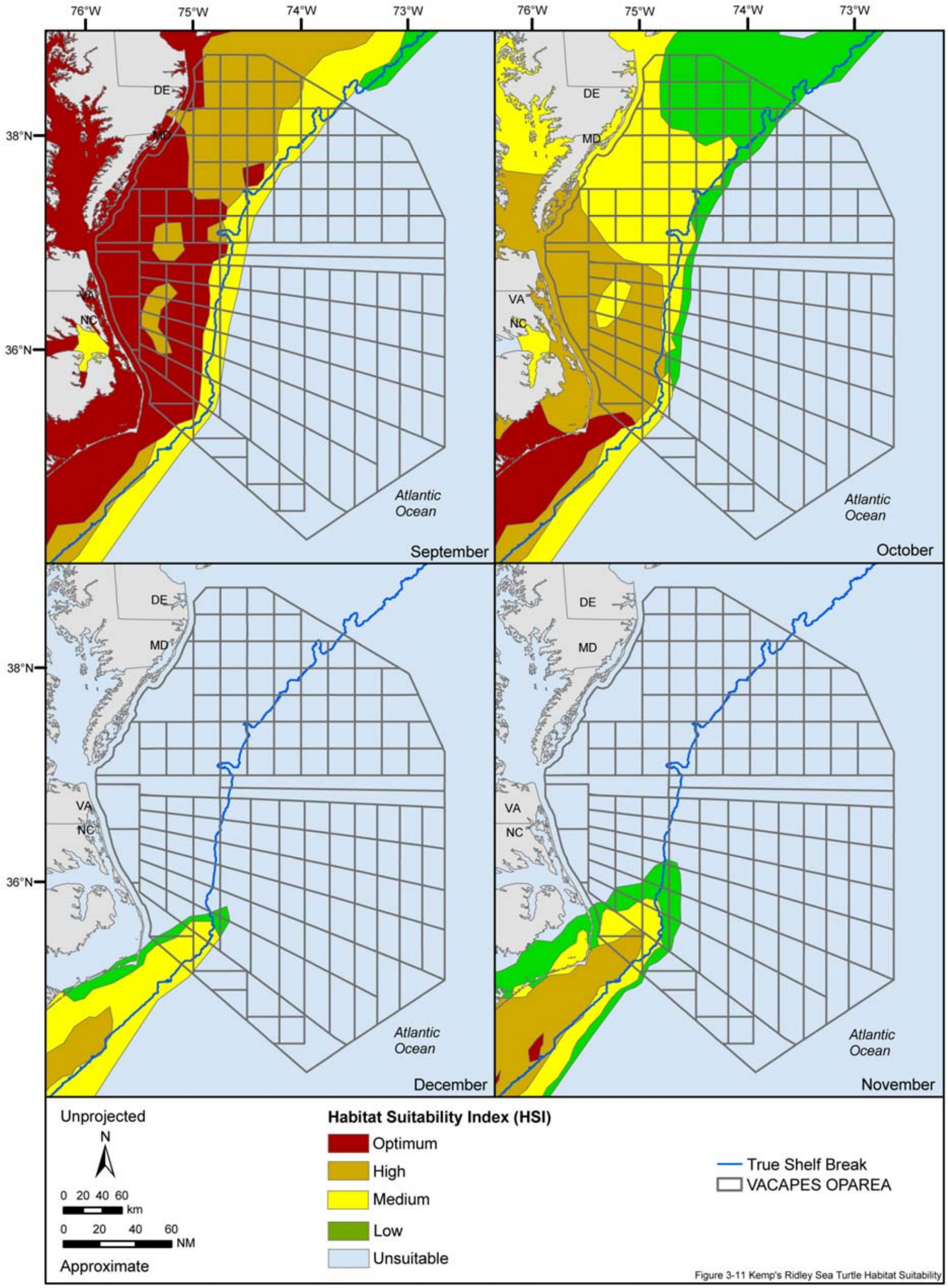

Figure 3-12. The habitat suitability index of waters in the Virginia Capes OPAREA and vicinity for the kemp's ridley sea turtle from September to December. Source maps (scanned): Coyne et al. (1998), used with primary author's permission.

Nesting occurs primarily on a single nesting beach at Rancho Nuevo, on the eastern coast of Mexico (USFWS and NMFS 1992), with a few additional nests in Texas, Florida, South Carolina and North Carolina (Meylan et al. 1990; Weber 1995; Godfrey 1996; Foote and Mueller 2002; NPS 2003). Kemp's ridley nesting in North Carolina is extremely rare, although the National Park Service (NPS) documented a female Kemp's ridley nesting at Cape Lookout National Seashore in June 2003 (NPS 2003). In 1978, a head-starting and imprinting program for Kemp's ridleys was initiated on South Padre Island, TX, in order to establish a nesting beach in this area. Between 1978 and 2002, approximately 28,456 hatchlings have been captive-reared and released from South Padre Island (Márquez-M. et al. 2005). Since 1998, adult Kemp's ridleys have been nesting in small, but steadily increasing, numbers at this beach as well.

- Information Specific to the VACAPES OPAREA—Kemp's ridleys occur within the VACAPES OPAREA year-round although occurrence is most common spring through early fall. Although this may not be reflected in the model output due to a lack in sightings, greater amounts of strandings in the spring and fall support this (Figure C-6-2). Water temperature is likely the most influential factor in the seasonal occurrence of Kemp's ridleys within the OPAREA. Juvenile Kemp's ridleys are the second most common, after loggerheads, to use Virginia developmental habitat (Mansfield 2006). Although not represented by the model output, Kemp's ridley hatchlings may occur offshore near the eastern edge of the OPAREA and Gulf Stream in *Sargassum* (Figure 4-1).

  - Winter—The model output shows the occurrence trend to the shelf waters of North Carolina south through central Florida during the winter. Waters in the VACAPES OPAREA are typically not suitable for Kemp's ridleys during the time mainly due to water temperatures below their preferred range (Figure 2-7; Figures 3-10, 3-12). During the winter, Kemp's ridley juveniles overwinter in warmer waters from Cape Hatteras, NC south through eastern Florida. Individuals overwintering in North Carolina waters may also migrate east to the western edge of the Gulf Stream; such migrations typically take place mid-winter, such as during January (Renaud 1995).

  - Spring—During the spring, juvenile Kemp's ridleys migrate north along the U.S. Atlantic coast to coastal developmental habitats, such as the Chesapeake Bay, appearing in coastal waters of the OPAREA during April (North Carolina), May (Virginia), and June (Maryland, Delaware) (Morreale and Standora 2005). Despite the lack of occurrence model output for the spring, Kemp's ridleys may be present in the OPAREA shelf waters during the spring, transiting to and using developmental habitat. Abundant strandings along the coast and sightings records not included in the model suggest Kemp's ridley presence during this time. Lack of survey effort may underestimate Kemp's ridley occurrence during this season.

  - Summer—The highest concentration of Kemp's ridleys occurs within shelf waters off northeastern Florida although the model output shows Kemp's ridleys to also occur throughout the shelf waters of the OPAREA. The model also predicts occurrences along the shelf waters of the VACAPES OPAREA. These occurrences are likely driven by the presence of juvenile Kemp's ridleys using summer developmental habitat, especially the Chesapeake Bay. By this time, it is expected the majority of individuals have arrived in developmental habitats although there may be occasional transiting through OPAREA waters to access habitats in areas such as the Chesapeake or Delaware Bay.

  - Fall—During the fall, the Kemp's ridley range contracts to Georgia/northern Florida as juveniles migrate south to overwintering habitats. Although not shown by the model output, Kemp's ridley juveniles may transit through the OPAREA on southward migrations during the fall. Juveniles are expected to leave developmental habitats within the OPAREA in October and November; individuals traveling south from more northern developmental habitats may pass through the OPAREA as well, with the greatest concentration of migrating juveniles expected to occur off Cape Hatteras, NC (Morreale and Standora 2005). The fall encompasses the majority of the peak time for Kemp's ridley cold-stunning along the U.S. Atlantic coast (09 November to 20 December, Still et al. 2005) which is supported by the stranding record along the VA and NC coast.

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 (Marquez-M. 1994). Blue crabs and spider crabs (Libinia spp.) are important prey species for the Kemp's ridley in Virginia waters (Lutcavage and Musick 1985; Seney and Musick 2005). This species may also feed on shrimp fishery bycatch (Landry and Costa 1999).

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 and 33 min (Mendonça and Pritchard 1986; Renaud 1995). Dive times may vary by turtle size as well, ranging from an average 5.6 min for small turtles to 33.4 min for large turtles. Kemp's ridleys may stay submerged between 92 and 96% of the time (Byles 1989; Renaud and Williams 2005). Surfacing behavior of Kemp's ridleys may also vary by season. Mansfield (2006) found individuals in the Chesapeake Bay and coastal Virginia waters to spend approximately 36.5% of time at the surface in the spring and 45.7% of time at the surface in early summer. Overall, Mansfield (2006) found the mean time spent at the surface of be as high as 59.8% of time.

Kemp's ridleys reach sexual maturity between 10 and 20 years with an average length of 60 cm CCL (Shaver et al. 2005). Unlike all other species of sea turtle except the olive ridley, the Kemp's ridley is known for nesting en masse during daylight hours. This type of nesting activity is known as an *arribada* (Spanish for "arrival"). During an *arribada*, hundreds of breeding turtles congregate in the waters in front of the nesting beach and then emerge from the sea in unison (Márquez-M. 1990; Weber 1995; Witzell et al. 2005). The peak of the nesting season occurs between mid-April and mid-July (Rostal 2005). Individuals nest approximately every two years (Rostal 2005). A typical female produces about three clutches averaging 110 eggs at 20 to 28 day intervals (Miller 1997), although larger turtles may produce larger clutches (Witzell et al. 2005). Incubation time from deposition to emergence is 46 to 57 days (Witzell et al. 2005).

3.2.3 Literature Cited

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4.0 HABITATS OF CONCERN

4.1 MACROALGAE—*SARGASSUM*

Brown algae (*Phaeophyceae*) of the genus *Sargassum* are 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 dominant 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 that 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 2002). *Sargassum fluitans* makes up the remaining 10% of the drift *Sargassum* in the North Atlantic (Dooley 1972; Figure 4-1). Both species have leafy blades, a densely branched thallus (stem), and berry-like pneumatocysts (air bladders), and can grow to a height of up to two feet (Gosner 1978). Accumulations of *Sargassum* are important sources of protection and food for various marine fauna and flora (Dooley 1972; Coston-Clements 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 contribution of 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 sea surface, 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 2002). Four species of sea turtles (see Chapter 3 for more information) and numerous marine birds utilize *Sargassum* as habitat (SAFMC 2002). 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 sea turtle nesting beaches are likely places where both hatchling sea turtles and *Sargassum* occur.

Juvenile fishes are by far the dominant vertebrate inhabitants of pelagic *Sargassum* mats, yet adults of many large pelagic fish species (i.e., Crevalle jacks [*Carranx hippos*], mackerel scad [*Decapterus macarellis*], dolphinfish [*Coryphaena hippurus*], and billfishes [Istiophoridae]) 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 is both dependant on mat morphology and age (i.e., more species recorded under large mats than small clumps) (Moser et al. 1998).

4.1.1 Status of Sargassum

Sargassum distribution and abundance is difficult to sample, 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 found 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 (1983) data 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).

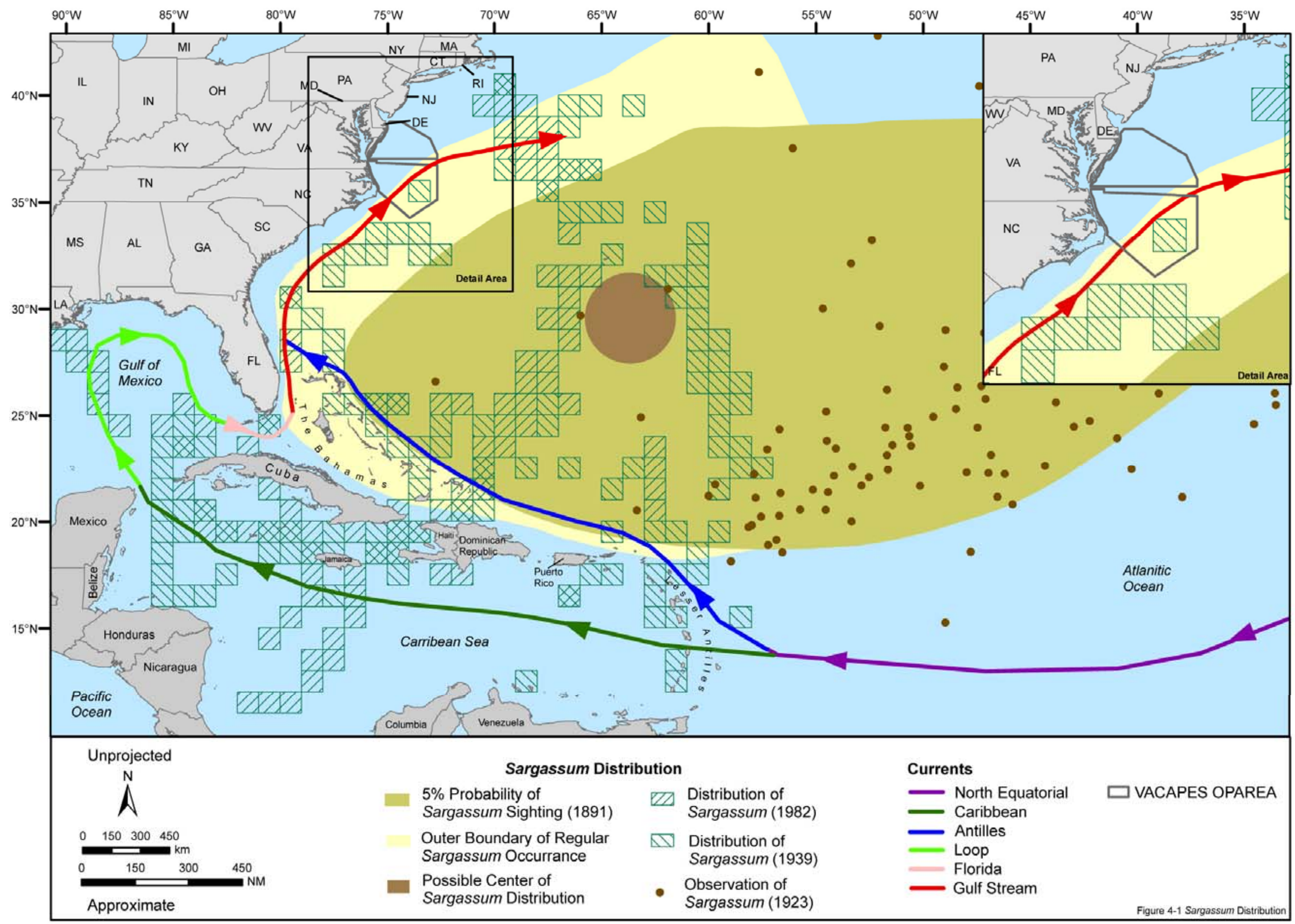

Figure 4-1. Historical Distribution of pelagic *Sargassum* and the major surface currents in the Caribbean, Gulf of Mexico and North Atlantic Ocean. Source data: Butler et al. (1983), Dooley (1972), General Oceanics (1986), Pickard et al. (1982).

Sargassum is susceptible to various pollution sources. Ocean pollution, such as petroleum from ships creating oil slicks which form within the *Sargassum* “windrows”, 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. Aqua-10 Laboratories in the past harvested from the South Atlantic Exclusive Economic Zone (EEZ) off North Carolina from 1976 to 1997 (SAFMC 2002). 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 NMFS (NMFS 2003) 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” (Figure 4-2). 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 2002). 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).

4.1.2 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 30°W and the western edge of the Gulf Stream, a region known as the Sargasso Sea (SAFMC 2002). 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 (Dooley 1972; SAFMC 2002). Some exchange occurs between the *Sargassum* populations of the Caribbean Ocean, Gulf of Mexico, and the 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 Bahamas Banks and Cuba (Dooley 1972). Currents within the Sargasso Sea are typically calm but are surrounded by strong currents, (Florida, Gulf Stream, Canary, North Equatorial, Antilles, and Caribbean currents), thus effectively separating the Sargasso Sea from the rest of the Atlantic. All drift material in the area eventually converges into the Sargasso Sea and remains trapped amidst the expansive *Sargassum* mats.

4.2 BENTHIC COMMUNITIES

Benthic habitats are comprised of a variety of sediments, substrates, and marine life (infauna/flora, epifauna/flora, and demersal organisms) that are commercially and economically valuable. Benthic organisms including crustaceans, echinoderms, anthozoans, annelids, mollusks, and ground fish play a major role in altering underlying benthic substrates and in breaking down organic material which provides sustenance for economically important species of pelagic fish (Sumich 1988).

Benthic communities are influenced by natural and human disturbances. Excessive sedimentation caused by storms, currents, and waves has negative impacts on benthic communities. Cold-water influxes from storms and red tides can also have negative impacts. Other naturally-occurring factors influencing benthic communities include seasonal variations of seawater temperature (4 to 12°C in the winter and 20 to 28°C in the summer) (NMFS 2005), sediment grain size, and seafloor topography (Cutter et al. 2000). While hurricanes and winter storms can alter the shallow shelf topography considerably, impacted benthic fauna will efficiently re-colonize suitable habitat following these disturbances (Cutter et al. 2000). Human-induced impacts on benthic communities include coastal development, dredging, runoff, and fishing (Jones et al. 1985; Rogers 1990; Liddell et al. 1997).

Deep sea coral communities are particularly vulnerable to human impacts including trawling by modern fishing vessels, hydrocarbon exploration, seabed extraction, cable laying, ocean dumping, and mining (Puglise et al. 2005; Morgan et al. 2006). Since deep sea corals are fragile, slow growing, and in some cases thousands of year’s old, physical human impacts have long-term deleterious effects (Freiwald et al.

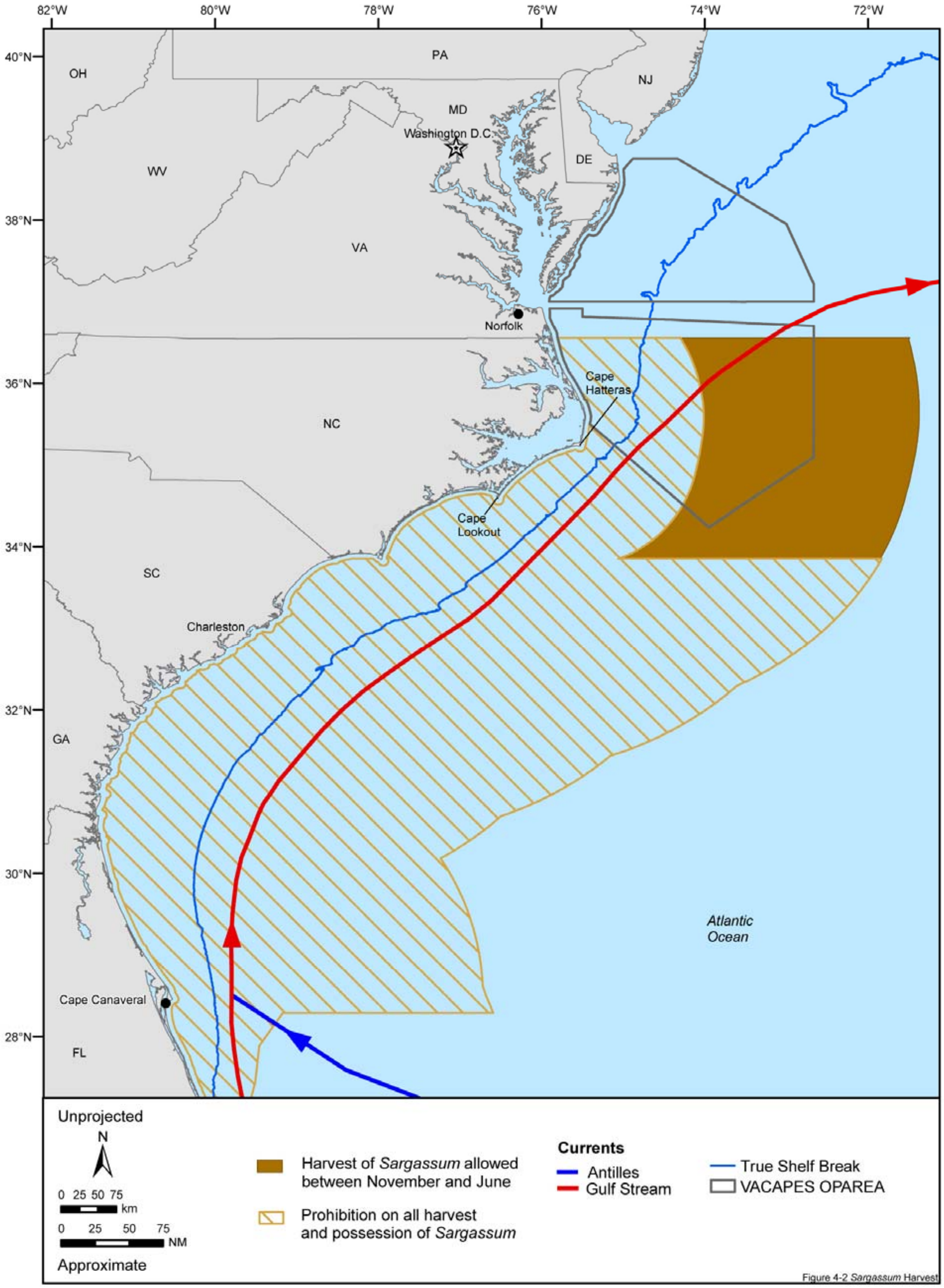

Figure 4-2. Area allowed for harvest of *Sargassum* between November and June. Source data: General Oceanics (1986), SAFMC (2005).

2004; Roberts and Hirshfield 2004). Besides world organizations such as the United Nations Environmental Programme, World Conservation Monitoring Center (UNEP-WCMC) addressing the vulnerability of deep sea coral communities, individual countries (including the U.S.) are also developing plans to protect these ecologically valuable habitats (Oceana 2004). The Mid-Atlantic Fishery Management Council currently has no fishery management plans protecting corals or sponges (MAFMC 2005), but the SAFMC has developed strategies and plans to protect deep sea coral and sponge habitat. Corals are currently protected under the SAFMC fishery management plan for coral. This plan states that: “The Coral, Coral Reef and Live/Hardbottom Habitat Plan prohibits the harvest of stony corals, sea fans, coral reefs, and live rock except as authorized for scientific and educational purposes” (SAFMC 2006b).

4.2.1 Live/Hardbottom Communities

Seafloor substrates of the VACAPES OPAREA are summarized in Chapter 2. Hardbottom is a type of benthic habitat that can support sessile fauna, flora, and demersal fish species (Jones et al. 1985; Cahoon et al. 1990). Hardbottom is made up of three-dimensional geologic structures (topographic features i.e., rock outcroppings and hard fossil substrate) and is usually covered with a thin layer of soft sediments (Emery and Uchupi 1972; LBG 1999). Communities of living organisms found on hardbottom substrates include bryozoans, hard and soft corals, hydroids, anemones, encrusting algae, sponges, sea turtles, and commercial/recreational fishes (Jones et al. 1985; Cahoon et al. 1990). From Delaware Bay to Virginia there is not abundant hardbottom on the continental shelf but there are artificial reefs and shipwrecks throughout (Steimle and Zetlin 2000). In general there have not been many comprehensive surveys of seafloor substrates conducted in the southern region of the Mid-Atlantic Bight except Wigley and Theroux (1981) conducted comprehensive macrobenthic surveys on the shelf and slopes within the Mid-Atlantic Bight (Figure 4-3). Off the coast of North Carolina there is considerable hardbottom as documented by the Southeast Area Monitoring Program (SEAMAP 2001). The Bureau of Land Management (BLM) in 1975 also performed comprehensive benthic and hardbottom surveys along the continental shelf from North Carolina to Florida. The hardbottom that was surveyed by the BLM consisted of sponges, hard and soft corals, and various algae species (BLM 1976).

Hardbottom of the VACAPES OPAREA consist of a variety of naturally-occurring and human-made substrates (Steimle and Zetlin 2000) colonized by sessile and motile benthic organisms, and used by demersal organisms. Benthic communities include hard and soft corals, hydroids, anemones, crustaceans, encrusting algae, sponges, sea turtles, and commercial/recreational fishes (Wigley and Theroux 1981; Jones et al. 1985; Steimle and Zetlin 2000). Throughout the U.S. Atlantic continental shelf, hard bottom substrates composed of lower Miocene marl are overgrown by encrusting algae and various calcareous organisms (Emery and Uchupi 1972). Benthic habitats in this area also include numerous sand and sand-shell shoals which do not support high biotic diversity. Yet, between shoals, “valleys” carved by currents do support considerable benthic diversity such as annelids and bivalves (Cutter et al. 2000).

<u>Shelf Fauna</u>—Between, Delaware Bay and Maryland there is very little hardbottom (Wigley and Theroux 1981). Virginia’s shelf sediments are comprised mostly of shell and sand-shell (very little hardbottom) with various shoals scattered throughout supporting macrobenthic organisms such as annelids, arthropods, and bivalves (Wigley and Theroux 1981). North Carolina’s shelf sediments are mostly comprised of a mixture of sand-shell and sand with various shoals supporting macrobenthic species including hard and soft corals, anemones, hydrozoans, zoanthids, annelids, arthropods, mollusks, isopods, and amphipods (Wigley and Theroux 1981). The continental shelf off the coast of North Carolina is narrow. The convergence of the cold water currents flowing down from the north and the warm currents (i.e., Gulf Stream Current) flowing up from the south combined with steep topography off the coast of Cape Hatteras, NC characterizes an area called “The Point”. The Point supports a high assemblage of commercial fish species (e.g., dolphinfish and wahoo [*Acanthocybium solandri*]) (SAFMC 2003; NOAA 2006).

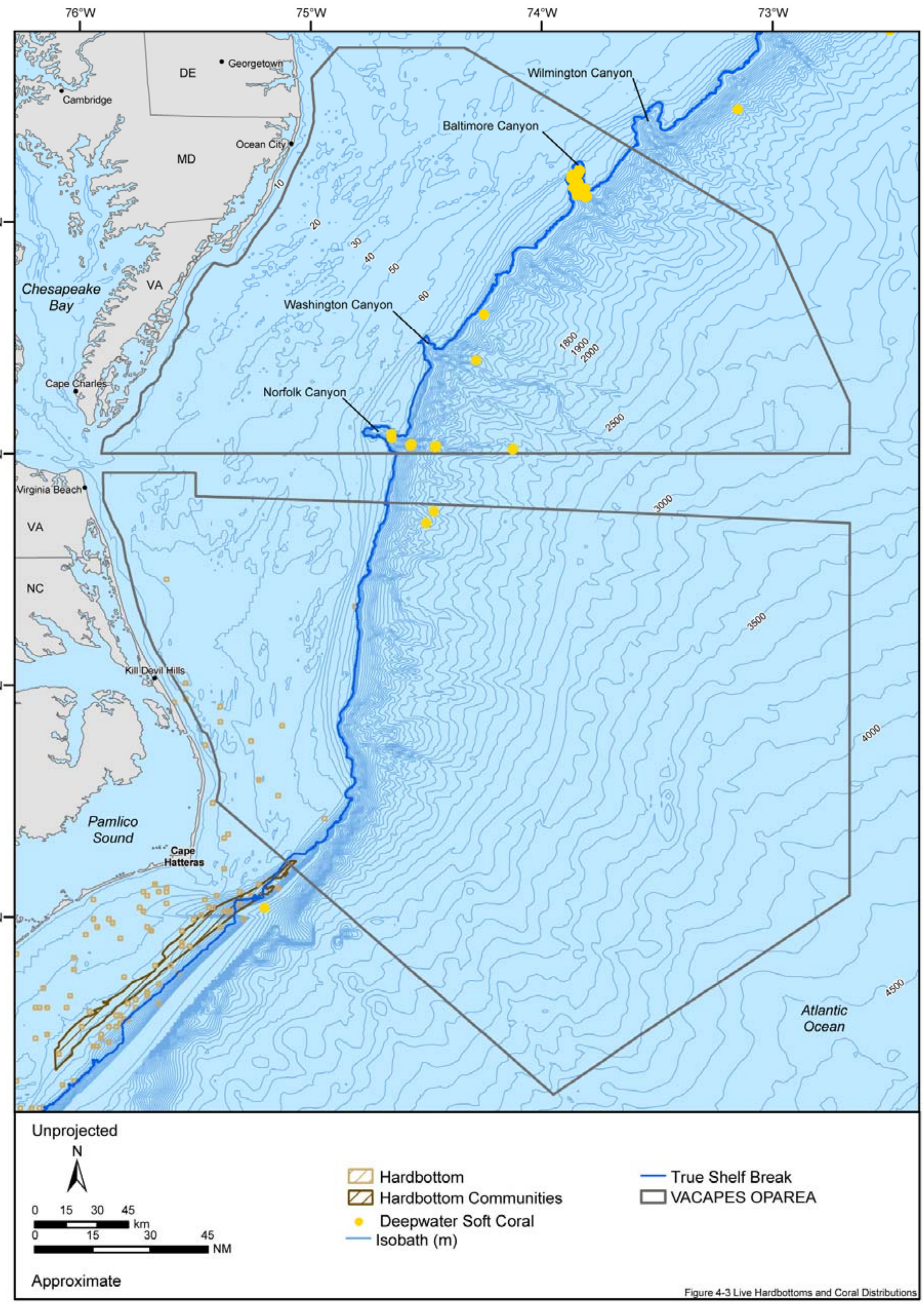

Figure 4-3. Hardbottom, live/hard bottom communities and coral/sponge distributions of the Virginia Capes OPAREA and vicinity. Source data: SEAMAP (2001), Watling et al. (2003). Source maps (scanned): BLM (1976), Wigley and Theroux (1981).

From Delaware to northern North Carolina, the benthic fauna (mostly annelids and ophiuroides) of the outer continental shelf and slope are not as dense as the inner and mid-shelf fauna (Wigley and Theroux 1981). Annelids are speciose whereas ophiuroides have high abundances but are represented by few species (Sanders 1977; Milliman and Wright 1987). The four submarine canyons within or near the VACAPES OPAREA (Wilmington, Baltimore, Washington, and Norfolk) support numerous benthic species (i.e., invertebrates, fish, and coral). In Baltimore Canyon Hecker (1980) found crabs (*Geryon quinquedens*) and fish (*Synaphobranchus kaupi*) to be the most abundant deep sea organisms. The coral and sponge species found in Baltimore canyon are discussed below.

4.2.2 Coral (Hard and Soft) and Sponge Distributions

Corals are invertebrates in the phylum Cnidaria and classes Hydrozoa (fire and lace corals) and Anthozoa (subclasses Octocoralia and Hexacoralia) (Veron 2000). Reef building corals are hexacorals and belong to the order Scleractinia. Octocorals include gorgonians, soft corals, and telastaceans. Corals exist throughout the worlds oceans at all depths (Veron 2000). The most widely known corals are the true stony corals or scleractinians (i.e., hermatypic hard corals) which are coral reef frame builders in the tropics. 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). There are no tropical coral reefs within the VACAPES OPAREA or vicinity but there are temperate corals found on the shelf that not only use photosynthesis as a mode of nutrition, but also consume zooplankton (Wigley and Theroux 1981; Steimle and Zetlin 2000). In addition deep sea corals are found along the continental slope between 200 and 1,000 m in the VACAPES OPAREA and vicinity and form large coral communities (see the section on deep sea corals for more information) (Reed et al. 2006).

Corals in the VACAPES OPAREA off North Carolina are protected from harvesting under the SAFMC, Fishery Management Plan (FMP) for coral. This FMP states that: “The Coral, Coral Reef, and Live/Hardbottom Habitat Plan prohibits the harvest of stony corals, sea fans, coral reefs, and live rock except as authorized for scientific and educational purposes (SAFMC 2006b)”. The Mid-Atlantic Fishery Management Council has no management plans for corals (MAFMC 2006).

Temperate corals appear to be limited in their distribution by biotic factors such as competition for substrate with macroalgae (Miller 1995). Temperate corals are capable of surviving at high latitudes where solar irradiance is much less compared to tropical areas because of the availability of greater concentrations of phytoplankton and nutrients. Indeed, hermatypic corals can grow in high latitudes because they can capture and digest zooplankton and possibly alter their photoadaptive responses by slowing their photosynthetic and respiration rates (Jaques et al. 1977). Corals reproduce through sexual (spawning) and asexual (fragmentation) reproduction. Spawning occurs seasonally (Szmant 1986). Physical-environmental factors influencing the growth of temperate corals, is not as clearly understood as it is for tropical corals (Miller 1995).

Sponges (phylum Porifera) are found throughout the VACAPES OPAREA (see below for species and distribution). Sponges are multicellular filter feeders (although some are carnivorous) that rely on the supply of food (microscopic organisms) transported by water currents (UCMP 2006). They live at all depths, temperatures, and latitudes, and come in many shapes (including vaselike, tubular, spherical, and fingerlike shapes) (Kaplan 1982). Sponges have a seasonal reproduction cycle and reproduce both sexually and asexually (UCMP 2006). Sponges are found in the VACAPES OPAREA (Wigley and Theroux 1981; Steimle and Zetlin 2000) and are not protected under the MAFMC (MAFMC 2006) (see their distributions in the following section).

<u>Nature and Distribution of Corals and Sponges on the Inner and Mid-shelf</u>—The VACAPES OPAREA has some isolated patches of soft and hard corals, hydroids, zoanthids, and sponges that colonize rock outcroppings, artificial reefs, and shipwrecks (Steimle and Zetlin 2000; Figure 4-3). The southern region (northern North Carolina) of the VACAPES OPAREA contains more sponge and coral coverage as natural hardbottom increases and warmer water temperatures prevail (Wigley and Theroux 1981; Figure 4-3). Seventeen species of hard corals are found from Cape Hatteras to Maine, only one species is shallow (northern star coral [*Astrangia poculata*]); the remaining species are found in water depths of 100

m and deeper (Cairns and Chapman 2001). The northern star coral is found in the shallow areas (1 to 35 m) of the VACAPES OPAREA and vicinity associated with hardbottom such as artificial reefs (Cairns and Chapman 2001; Figley 2003).

Whip coral (*Leptogorgia virgulata*) is a soft coral that grows in estuaries and coastal zones between 1 and 20 m deep. Whip coral is common in the Chesapeake Bay (Kaplan 1988). The most common anthozoans in the VACAPES OPAREA are sea anemones (*Metridium senile*) and hydroids (Wigley and Theroux 1981; Steimle and Zetlin 2000). Sponges of the VACAPES OPAREA include *Halichondria* sp., *Polmastia* sp. and the loggerhead sponge, *Spheciosponia vesparia* (Wigley and Theroux 1981; Steimle and Zetlin 2000).

4.2.3 Deep Sea Coral and Sponge Distributions

<u>Nature and Distribution of Corals and Sponges on the Outer Shelf and Slope</u>—While shallow reef building corals typically contain zooxanthellae which promote calcium carbonate accretion, deep sea corals do not. Nevertheless, localized accumulations of deep sea corals (scleractinians) can form extensive bioherms (mounds made of living organisms). Deep sea corals are found within a broad depth range (39 to 3,383 m), in cool water (4 to 13ºC), and on top of canyons, plateaus, edges of the continental shelf, and bases of slopes (Hecker et al. 1981; Freiwald et al. 2004). Deep sea corals occur as solitary colonies, thickets, coppices, and banks (Stetson et al. 1962; Avent et al. 1977; Cairns and Stanley 1981; Mullins et al. 1981). Deep sea corals are slow growing, can live thousands of years, and thrive in areas exposed to strong currents and upwelling. They reproduce sexually and asexually and grow as large as their skeleton can support (Freiwald et al. 2004). Deep sea coral bioherms support hundreds of species of invertebrates and act as spawning and feeding grounds for commercially important species of fish such as grouper (SAFMC 1998). Like deep sea corals, deep sea sponges can live thousands of years (8,000+ yr) (Freiwald et al. 2004).

Within the VACAPES OPAREA sponges exist in moderate densities between 1 and 24 m^2 along the outer shelf and rise region. Finger sponge (*Haliclona oculata*) is found in this region on the inner shelf from 1 to 124 m and can grow to a height of 46 cm (Wigley and Theroux 1981). In addition to sponges, soft corals (*Alcyonaria*) are found in abundance along the shelf, slope, and part of the rise (Watling and Auster 2005; Figure 4-3). *Alcyonaceans* (in water depths greater than 500 m) such as *Anthomastus* spp., *Acanthogorgia* spp. *Acanella* spp., and *Anthothela* spp. are found within the VACAPES OPAREA. *Paragorgia arborea* and *Primnoa resedaeformis* are also found in the VACAPES OPAREA on the outer Continental shelf and upper slope (150 m) (Watling and Auster 2005).

Besides sponges and soft coral species, several hard coral species also exist on the outer continental shelf within the VACAPES OPAREA such as: *Dasmosmilia lymani* (depth range: 48 to 366 m), and *Dellocyathus italicus* (403 to 2,634 m) (Cairns and Stanley 1981). Past the outer shelf on the slope more hard coral species exist such as: *Solenosmilia variabilis* (280 to 2,165 m), *Flabellum alabastrum* (357 to 1,977 m), *Flabellum macandrewi* (128 to 1,170 m), *Flabellum angulare* (2,266 to 3,186 m), and *Javania cailleli* (400 to 2,165 m) (Cairns and Stanley 1981).

Submarine canyons in the VACAPES OPAREA provide habitat for deep sea corals and sponges (primarily at depths between 100 and 2,000 m) along with commercially important fish species (Watling and Auster 2005). Corals and sponges are found in the canyons despite heavy sedimentation and limited suitable substrates for attachment. The upper slope fauna of Baltimore Canyon is similar to the fauna found on the nearby shallow water shelf (Hecker et al. 1980). The most abundant coral in the Baltimore Canyon is the small, white, sea pen (soft coral), *Pennatula aculeata*, which lives on soft sediment between 100 and 300 m (Hecker et al. 1980). The lower slope fauna of Baltimore Canyon (1,400 m+) has similar species to the upper slope fauna and is mainly composed of soft corals (Alcyonaceans) (Hecker et al. 1980, 1983).

4.3 ARTIFICIAL HABITATS

Artificial habitats made of human-made materials placed on the seafloor (reefballs, pipes, sunken vessels and ship wrecks) (DNREC 2005; VMRC 2006) can benefit benthic communities and onshore economies. The benefits, biotic communities experience increase with time. Artificial substrates are typically introduced to seafloor areas predominantly composed of soft sediments to provide habitats for the settlement and colonization of epibenthic organisms (algae, sponges, barnacles, soft corals, anemones, hydroids) (Fitzhardinge and Bailey-Brock 1989; Bohnsack et al. 1991). The succession of colonizing, benthic organisms on artificial substrates, ultimately attract large predatory game fish and even sea turtles (Bohnsack et al. 1991; Bjorndal 1997). Such artificial reefs are prime fishing spots for recreational and commercial fishermen. The preservation and management of artificial habitats can influence the biological productivity and economic value of offshore areas (Steimle and Zetlin 2000). Fishermen commonly target both smaller and larger fishes (black sea bass [*Centropristis striata*] and tautog [*Tautoga onitis*]) on artificial reefs in the VACAPES OPAREA (DNREC 2005).

4.3.1 Fish Aggregating Devices

Fish aggregating devices (FADs) are apparatuses suspended in the water column or floated at the surface to attract pelagic fishes (Beets 1989). FADs have had varying levels of success in attracting commercially important species such as dolphinfish (*Coryphaena hippurus*) and kingfish (*Menticirrhus saxatilis*), possibly due to location, size of structure, and biofouling (Nelson 2003). FADs are either dedicated FADs (e.g., netting wrapped around floats and set adrift in the currents) or unintentional devices that attract fish including trash, debris (washing machines and planks of wood), and oceanographic buoys. Dedicated FADs can in some cases be harmful to marine resources, such as sharks and marine mammals that can get entangled in FADs, a worldwide issue similar to the bycatch in purse seines used to harvest tuna in the western Indian Ocean (Romanov 2001). Under the UN Convention on the Law of the Sea 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). Neither, the SAFMC or the MAFMC, currently enforce regulations for the use of FADs.

4.3.2 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 (i.e., reefballs, ships, and subway cars) (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, sighting, 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.

The Mid-Atlantic Bight (MAB) nearshore topography is comprised of sand and mud with very little relief (DNREC 2005). The MAB can be viewed as a ‘highway’ for migratory fish species (i.e., black sea bass and summer flounder [*Paralichthys dentatus*]) which spend their winters on the outer continental shelf in the southern portion of the MAB and spawn in the spring and early summer in the northern portion of the MAB on the shelf mostly associated with structure and reef habitat (Musick and Mercer 1977). Because migratory fish and the relatively featureless topography of the MAB are such prominent features in the VACAPES OPAREA, artificial reefs deployed in this area attract commercially important fish species (Steimle and Zetlin 2000). The four states which make up the VACAPES OPAREA (Delaware, Maryland, Virginia, and Northern North Carolina) each have implemented their own artificial reef programs.

The Delaware Reef Program was established in 1995 as a fisheries management tool to promote recruitment of various reef fishes, and provide recreational fisherman and divers various locations to use (DNREC 2005). Originally, the Delaware artificial reef program was managed by Delaware's Department of Natural Resources. Within Delaware Bay there are eight artificial reef sites and offshore of Delaware (within the VACAPES OPAREA) there are three artificial reef sites, each associated with multiple reefs (Figure 4-4). The three artificial reef complexes within the VACAPES OPAREA are all located south of Delaware Bay and are mainly comprised of recycled ballasted tires, concrete, construction equipment, and military vehicles (DNREC 2005). The artificial reefs located nearshore, support mainly blue mussels, (*Mytilus edulis*), black sea bass, scup (*Stenotomus chrysops*), weakfish (*Cynoscion regalis*), bluefish (*Pomatomus saltatrix*), stripe bass (*Morone saxatilis*), and tautog (*Tautoga onitis*) and are fabricated by concrete, ballasted tires, barges, and marine cables (DNREC 2005).

Maryland's artificial reefs have been managed by the Ocean City Reef Foundation (OCRF) since 1997 (OCRF 2001). Maryland's artificial reef program is used as a tool to enhance fisheries, promote reef fish habitat, and provide recreational areas for fishing and diving. There are seven permitted artificial reef complexes, with multiple artificial reefs within each site managed by the OCRF: Russell's Reef, African Queen Reef, Jackspot Reef, Great Eastern Reef, Bass Grounds Reef, Kelly's Reef, and Purnell's Reef (OCRF 2001). The African Queen Artificial Reef contains the *U.S.S. Blenny*, which was a World War II submarine. It serves as an artificial reef and wreck dive site (AWEX 2006).

Virginia's artificial reefs have been managed by the Virginia Marine Resources Commission since the 1950's (VMRC 2006). Due to the lack of hard substrate, Virginia has supplemented its nearshore coastal environment for over fifty years with various artificial materials, such as tires, sunken vessels, and numerous U.S. Navy landing craft. In the past 10 to 15 years concrete igloos and tetrahedrons were deployed in five offshore artificial reef complexes (VMRC 2006).

Located offshore of Virginia Beach is an artificial reef called Triangle Reef and offshore of Watchapreague, Virginia is an artificial reef called Parramore Reef. Six World War II Liberty Ships sunk in the 1970's make up these two reefs. Parramore Reef is made up of two Liberty Ships, *The Page* and *Mona Isle* located about eight and a half miles from the Parramore Coast Guard Tower (VMRC 2006). Triangle Reef contains four Liberty Ships (*Webster*, *George P. Garrison*, *James Haviland*, and *Edgar Clark*) and a Coast Guard cutter (*Cuyahoga*). Currently ninety-nine igloos and thousands of tetrahedrons supplement Virginia's artificial reef program (VMRC 2006). Tower Reef located near the Chesapeake Light Tower is made up of over 100 pontoon parts and landing craft material, two barges, and four drydock sections. Watchapreague Reef located near the Parramore Coast Guard Tower was originally established as an artificial reef testing site and is made up of various tetrahedron and igloo structures. Blackfish Bank Reef is located southeast of Assateague Beach. The artificial reef is comprised of forty armored vehicles donated by the military in the late 1990's called 'Operation Reef-Ex 98' (VMRC 2006).

North Carolina's artificial reef program is managed by the North Carolina Division of Marine Fisheries (NCDMF 2006). North of Cape Hatteras, NC four artificial reef complexes make up numerous artificial reefs. The artificial reefs are comprised of various materials such as subway cars, tires, concrete structures (reefballs), pipe, barges, and ships. The largest of the artificial reef complexes is called the Oregon Inlet Reef. The Oregon Inlet Reef is comprised of two ships, one trawler, numerous pipe, over 60 reefballs, and parts of ships (NCDMF 2006).

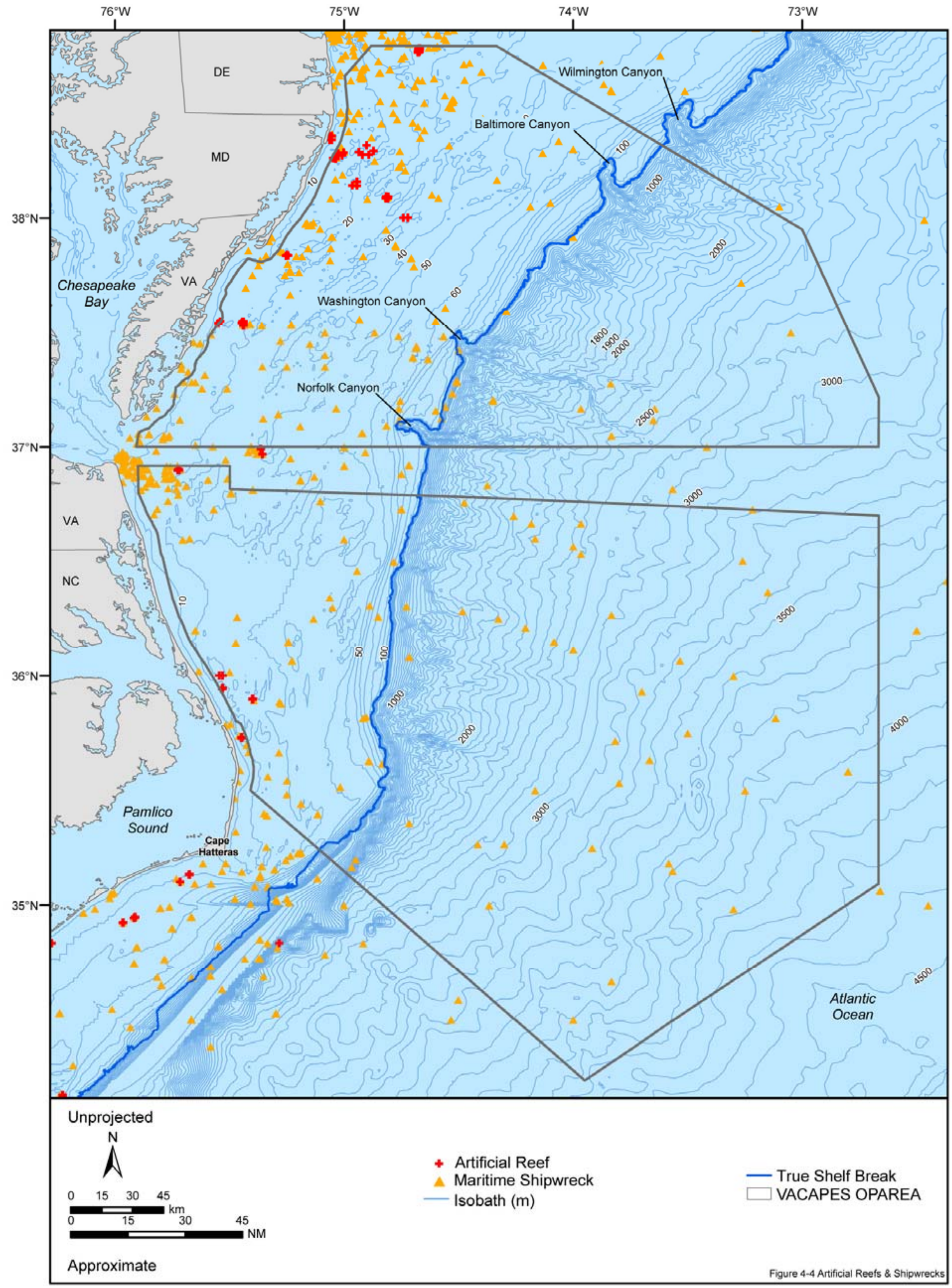

Figure 4-4. Artifcial reefs and shipwrecks in Virginia Capes OPAREA and vicinity. Source data: Veridian (2001), DNREC (2005), NCDMF (2005), OCRF (2005), VMRC (2005), DDFW (2008).

4.3.3 Shipwrecks

Along the Delaware and Maryland coastline there are at least 32 shipwrecks resulting from severe weather or warfare (AWEX 2006). Off the coast of Virginia there are over 40 shipwrecks ranging from ocean liners to ships of war. There are clusters of shipwrecks located around the mouth of the Chesapeake Bay and along the continental slope. The *U.S.S. Tulip* is an archaeologically significant shipwreck and is managed by the Maryland Maritime Archaeology Program (MMAP) (AWEX 2006). It was built in 1862 as a steamer and sunk in 1864 off Ragged Point, Virginia (Figure 4-4). Off the northern coast of North Carolina within the VACAPES OPAREA and vicinity there are at least 25 shipwrecks. One in particular, the *U.S.S. Huron* has been designated a Historic Shipwreck Preserve (HSP) and is located off of Nags Head, NC between 5 and 15 m (AWEX 2006).

4.4 MARINE MANAGED AREAS AND MARINE 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) have documented all current 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. While at one time the National MPA Center was compiling a comprehensive inventory of all federal, state, tribal, and local sites that met certain criteria for designation as a Marine Managed Area (MMA) and ultimately as a MPA, work has now been concluded on the MMAs and they have been placed in an archive. The current MPA inventory is based on the MMA inventory which was active from 2001 to 2007 (NMPAC 2008). MMAs and MPAs are similar in that they both have conservation or management purposes, defined boundaries, and some legal authority to protect resources. MMAs encompass a wider range of management intents than MPAs. MMAs may include areas of protection for geological, cultural, or recreational resources that might not meet the definition provided in EO 13158 for MPAs. MMAs 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).

MPAs are defined in EO 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Section 5 of the EO 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." EO 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.

EO 13158 provides a formal, albeit vague, definition of a MPA and calls for the development of a national system of MPAs. In order to clarify what specifically constitutes a MPA, the National MPA Center 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

(6) Restrictions on extraction

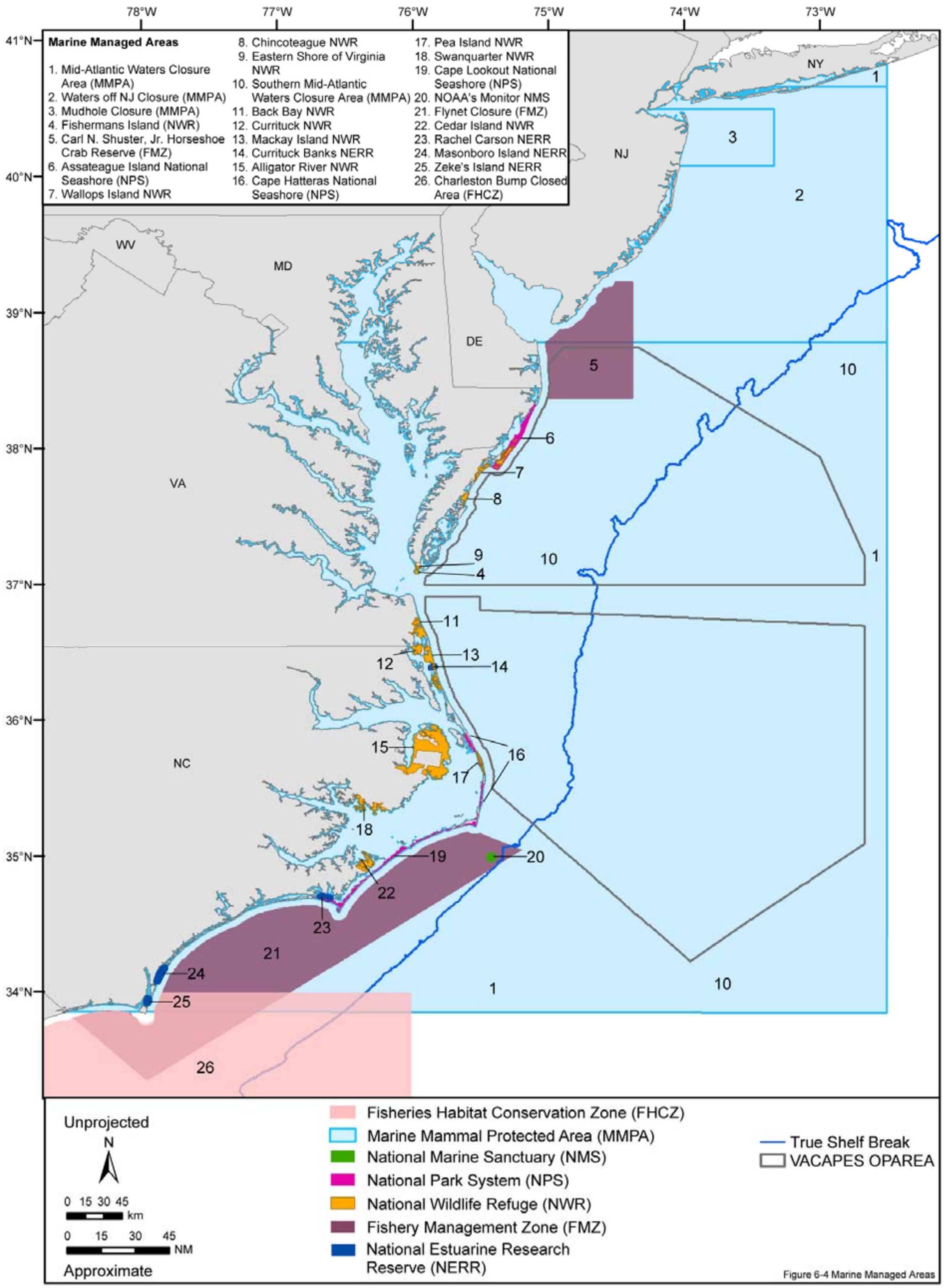

Figure 4-5. Federal Marine Protected Areas for the VACAPES OPAREA and vicinity. Source data: NMPAC (2008).

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 allows 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 are chosen. The goal of the MMA inventory 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: (1) Area; (2) marine; (3) reserved; (4) duration (lasting) (5) protections; and (6) cultural (NMPAC 2008). These six terms are based on the definition of an MPA as stated in EO 13158, and are intended to guide government agencies in identifying sites to include in the MMA inventory. Each selected site must possess qualities related to each criteria (excluding cultural, which is not a required attribute for a site) to be included in the inventory.

There are currently 1,688 sites listed in the MPA inventory encompassing over 7 million km^2 (NMPAC 2008). Of these, 330 are federally designated, 1,238 are state designated, 66 are designated through a federal/state partnership, and 53 are designated by a U.S. territory. There is one site that is designated as local in the MPA inventory (NMPAC 2008).

4.4.1 Federally Designated Marine Protected Areas

There are currently 28 U.S. federally designated MPAs located in the VACAPES OPAREA and vicinity (Figure 4-5; Table 4-1).

4.4.1.1 National Estuarine Research Reserves

The National Estuarine Research Reserve System (NERRS) is a partnership between the NOAA and the coastal states. The system is currently a network of 27 reserves, including one in Puerto Rico, consisting of relatively pristine estuarine areas that contain key habitat and are protected from significant ecological change or developmental impacts (NERRS 2008). The reserves provide reference sites for research, monitoring, and educational programs that focus on functional estuarine ecosystems. NERRs provide habitat and protection for a variety of rare, endangered, and threatened species.

The North Carolina NERR consists of four sites and is managed by the North Carolina Department of Environment and Natural Resources (NMPAC 2008). Currituck National Wildlife Refuge is the only one of the four sites located immediately adjacent to the VACAPES OPAREA. The other three sites border the Cherry Point OPAREA farther to the south. The Virginia NERR, which is adjacent to the VACAPES OPAREA, is called the Chesapeake Bay NERR of Virginia (CBNERRVA), and is composed of four sites within the York River, although only three are shown on the map. These four sites are Sweet Hall Marsh, Taskinas Creek, Catlett Island and Goodwin Islands (CBNERRVA 2008). The Delaware NERR is adjacent to the VACAPES OPAREA and consists of two sites; the Blackbird Creek and St. Jones Reserve (DNERR 2002). Both sites consist of estuaries that are both brackish and freshwater (DNERR 2002). The NERR in New Jersey that is adjacent to the OPAREA is the Jacques Cousteau Reserve (NERRS 2002; Figure 4-5; Table 4-1). It is part of the Mullica River-Great Bay ecosystem, and stretches to the Atlantic Ocean (NERRS 2002).

4.4.1.2 National Marine Sanctuaries

There are currently 13 National Marine Sanctuaries (NMSs) found in U.S. waters. Designated by the NOAA, these NMSs protect over 46,000 km^2 of ocean habitat. Each NMS has an established management plan that guides the sanctuary's activities and programs, sets priorities, and contains

Table 4-1. Summary of federally designated Marine Protected Areas in the Virginia Capes OPAREA and vicinity (NMPAC 2008).

MPA Type	*Federally Designated MPA*	*Area (km^2)*
National Estuarine Research Reserve	North Carolina NERR (NC) (consists of four independent sites)	42.9
	Chesapeake Bay NERR (VA) (consists of four sites)	14.0
	Delaware NERR (DE) (consists of two sites)	21.9
	Jacques Cousteau NERR (NJ)	450.5
National Marine Sanctuary	U.S.S. Monitor	2.2
Fishery Management Zone	Carl N. Shuster, Jr. Horseshoe Crab Reserve	4,132.2
	Flynet Closure	15,675.8
Fishery Habitat Conservation Zone	Charleston Bump Closed Area	125,494.3
National Park System	Assateague Island National Seashore (MD)	124.4
	Cape Hatteras National Seashore (NC)	126.1
	Cape Lookout National Seashore (NC)	57.1
National Wildlife Refuge	Chincoteague (MD)	59.4
	Wallops Island (VA)	26.0
	Fisherman Island (VA)	6.7
	Eastern Shore of Virginia (VA)	5.6
	Back Bay (VA)	64.8
	Currituck (NC)	1.2
	Mackay Island (NC)	29.9
	Alligator River (NC)	547.4
	Pea Island (NC)	18.5
	Swanquarter (NC)	67.1
	Cedar Island (NC)	68.0

Table 4-1. Summary of federally designated Marine Protected Area in the Virginia Capes OPAREA and vicinity (NMPAC 2008) (cont'd).

MPA Type	***Federally Designated MPA***	***Area (km2)***
Marine Mammal Protected Area	Mid-Atlantic Coastal Waters Area	111,767.5
	Waters off New Jersey Closure	34,197.4
	Southern Mid-Atlantic Waters Closure Area	113,534.1
	Mudhole Closure	2,742.5
	Southern Nearshore Lobster Waters	65,705.9
	Offshore Lobster Waters	336,041.9

relevant regulations. More information on NMSs can be found at the NMS Program website (NOAA 2008). There is one NMS in the vicinity of the VACAPES OPAREA: NOAA's *Monitor* National Marine Sanctuary located 14 NM off Cape Hatteras, North Carolina. The *U.S.S. Monitor* was a Civil War ship and the Navy's first ironclad warship (NMPAC 2008). Access to the *Monitor* NMS is restricted to scientific research and managing officials.

4.4.1.3 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. There are two FMZs located within the vicinity of the VACAPES OPAREA. The Carl N. Shuster, Jr. Horseshoe Crab Reserve is centered in the waters off of the mouth of Delaware Bay at the northern end of the OPAREA and is intended to protect the stock of horseshoe crabs found within the Bay and adjacent waters (NMPAC 2008). Horseshoe crabs are important bait fish used in several other east coast fisheries and their blood has been used for important research in the biomedical industry. The Flynet Closure FMZ is located between three and 40 NM off the coast of Cape Hatteras and extends southward off the coast of South Carolina (NMPAC 2008). The purpose of this FMZ is to provide some protection to weakfish populations which have been suffering from overfishing in recent years.

4.4.1.4 Fisheries Habitat Conservation Zones

The 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). There are no FHCZs located within the vicinity of the VACAPES OPAREA; however, there is one FHCZ adjacent to the VACAPES OPAREA. The Charleston Bump Closed Area FHCZ extends from southern North Carolina to southern Georgia covering both coastal and offshore waters of the U.S. EEZ (NMPAC 2008). The Charleston Bump is an area of high topographic relief, rising from 700 to 300 m over a span of 20 km. The change in bathymetry causes the Gulf Stream Current to deflect offshore and results in the formation of eddies, including the persistent Charleston Gyre found just downstream of the Charleston Bump. The eddies are associated with upwelling increased primary productivity in the regions which serve as highly productive habitat for various wreckfish species (e.g., snapper-groupers) as well as deep sea corals (e.g., *Lophelia pertusa*) and other invertebrates (NMPAC 2008).

4.4.1.5 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 (NP) 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).

There are three National Seashores located adjacent to the waters of the VACAPES OPAREA. Assateague Island National Seashore is located on the coast of Maryland and Virginia and is known for the wild horses that roam the dunes and marsh habitat found on the island (NMPAC 2008). Cape Hatteras NS extends for over 113 km along the barrier islands, or Outer Banks, of North Carolina. Habitat includes coastal sand dunes, marshes, and wooded areas which serve as a refuge for various shorebirds (e.g., migrating waterfowl). Offshore areas are frequented by numerous fish species including channel bass, pompano, sea trout, and bluefish which make the NS one of the most popular recreational fishing sites along the east coast (NPS 2000); NMPAC 2008). Cape Lookout NS is located in the southern portion of the Outer Banks, between Ocracoke and Beaufort inlets, and extends along the coast for over 90 km. Marine mammals and sea turtles frequent the nearshore area along with migrating birds in the fall and spring. Four undeveloped barrier islands complete Cape Lookout NS: North Core Banks, Middle Core Banks, South Core Banks, and Shackelford Banks (Cordes and Rikard 2005). Cape Lookout NS also attracts large numbers of tourists in the summer months as well as local residents who participate in activities such as fishing, swimming, hiking, and boating.

4.4.1.6 National Wildlife Refuges

The USFWS protects over 388,000 km^2 of habitat through the National Wildlife Refuge System, with 544 established National Wildlife Refuges (NWRs) and 37 Wetland Management Districts under its jurisdiction (USFWS 2003; USFWS 2004). The refuge system encompasses all types of habitat, including 162 refuges nation-wide that contain marine and estuarine habitat (NMPAC 2008). Within the VACAPES OPAREA and vicinity there are 11 NWRs; there are also a number of NWRs located in and around Chesapeake Bay and in other areas adjacent to the OPAREA which are not discussed in this section.

One of the largest NWRs in the vicinity of the OPAREA is Mackay Island NWR which is found along the Outer Banks of northern North Carolina and extends into Virginia. Nearly three quarters of this NWR is composed of brackish marsh habitat which is used primarily by migrating waterfowl, such as the greater snow goose which numbers over 12,000 in November; however, several other bird species as well as reptiles and mammals take advantage of the estuarine habitat (USFWS 2002).

Chincoteague NWR stretches over parts of several coastal islands in both Maryland and Virginia, including Assateague, Assawoman, Metompkin, Cedar and Chincoteague. Habitat in the refuge is composed primarily of fresh and brackish water marsh and is utilized mostly by migrating waterfowl including the black duck and shore birds including the threatened piping plover (NMPAC 2008). Back Bay NWR located in southern Virginia is comprised of marshes, dunes, forests, and farmlands and provides habitat for bald eagles, peregrine falcons, over 10,000 migrating snow geese, piping plovers, and sea turtles (NMPAC 2008).

Alligator River NWR located in Manteo, North Carolina is the largest NWR in the vicinity encompassing an area of approximately 540 km^2. It is an undisturbed region of swamps and estuaries providing habitat for the endangered Red cockaded woodpecker, threatened bald eagle, peregrine falcon, several species of waterfowl, and numerous shorebirds (NMPAC 2008).

4.4.1.7 Federal Marine Mammal Protected Areas

The Marine Mammal Protection Act was established in 1972 to ultimately protect marine mammals and is enforced by the U.S Fish and Wildlife Service (USFWS) and the NMFS (NOAA 2006). The Act "prohibits the take of marine mammals which is defined as to harass, hunt, capture or kill, or attempt to harass, hunt, capture or kill any marine mammal" (NOAA 2006). There are six federally designated Marine Mammal Protected Areas located within the VACAPES OPAREA and vicinity: (1) the Mid-Atlantic Coastal Waters Area; (2) the Waters off New Jersey Closure; (3) the Southern Mid-Atlantic Waters Closure Area; (4) the Mudhole Closure; (5) the Offshore Lobster Waters and (6) the Southern Nearshore Lobster Waters (Figure 4-5; Table 4-1).

The Mid-Atlantic Coastal Waters Area MMPA extends from New York south to North Carolina and was established in 1997 to reduce takes of humpback, finback, and right whales (NMPAC 2008). Specific types of gear are restricted in this region, which supports an active gillnet fishery, between 1 December and 31 March when whales are seen most frequently in the area.

The Waters off New Jersey Closure includes both state and federal waters along the coasts of New Jersey and southwestern Long Island, including all of Delaware Bay. This MPA was designated as part of the Harbor Porpoise Take Reduction Plan and is intended to reduce takes of harbor porpoises by the commercial gillnet fishing industry (NMPAC 2008). All gillnet fishing gear is restricted during the month of April, and limitations on specific types of gillnet fishing gear are enforced from 1 January through 1 April.

Similar to the Waters off New Jersey Closure, The Southern Mid-Atlantic Waters Closure Area was established to reduce incidental takes of harbor porpoises by the gillnet fishing industry (NMPAC 2008). This MPA includes offshore waters between Delaware and North Carolina and imposes a restriction on the use of large mesh gillnets from 15 February through 15 March. It furthermore requires limits on specific types of gillnets used from 1 February through 30 April.

The Mudhole Closure MMPA was established in 1999 also to reduce the number of incidental takes of harbor porpoises by the gillnet fishing industry (50 CFR 229.2). Both the Offshore Lobster Waters and the Southern Nearshore Lobster Waters were established in 1997. The Offshore Lobster Waters is the largest Marine Mammal Protected Area in the vicinity of the OPAREA (NMPAC 2008; Table 4-1).

4.4.2 State Designated Marine Protected Areas

There are currently 16 state designated MPAs located in the vicinity of the VACAPES OPAREA: 5 are found in the state waters and coastal areas of Virginia and 11 are located in North Carolina (Figure 4-6; Table 4-2). Some additional MPAs located farther inland are mapped (Figure 4-6) but are not labeled or identified with a number on the map. Specific information on these MPAs can be found in the GIS metadata accompanying this report or from the NMPAC website (NMPAC 2008). The following designations represent the categories of state MPAs located in the vicinity of the VACAPES OPAREA.

- State Natural Area
- Wildlife Management Area
- State Park
- Game Land
- Coastal Reserve
- Dedicated Nature Preserve
- Gear Restricted Area

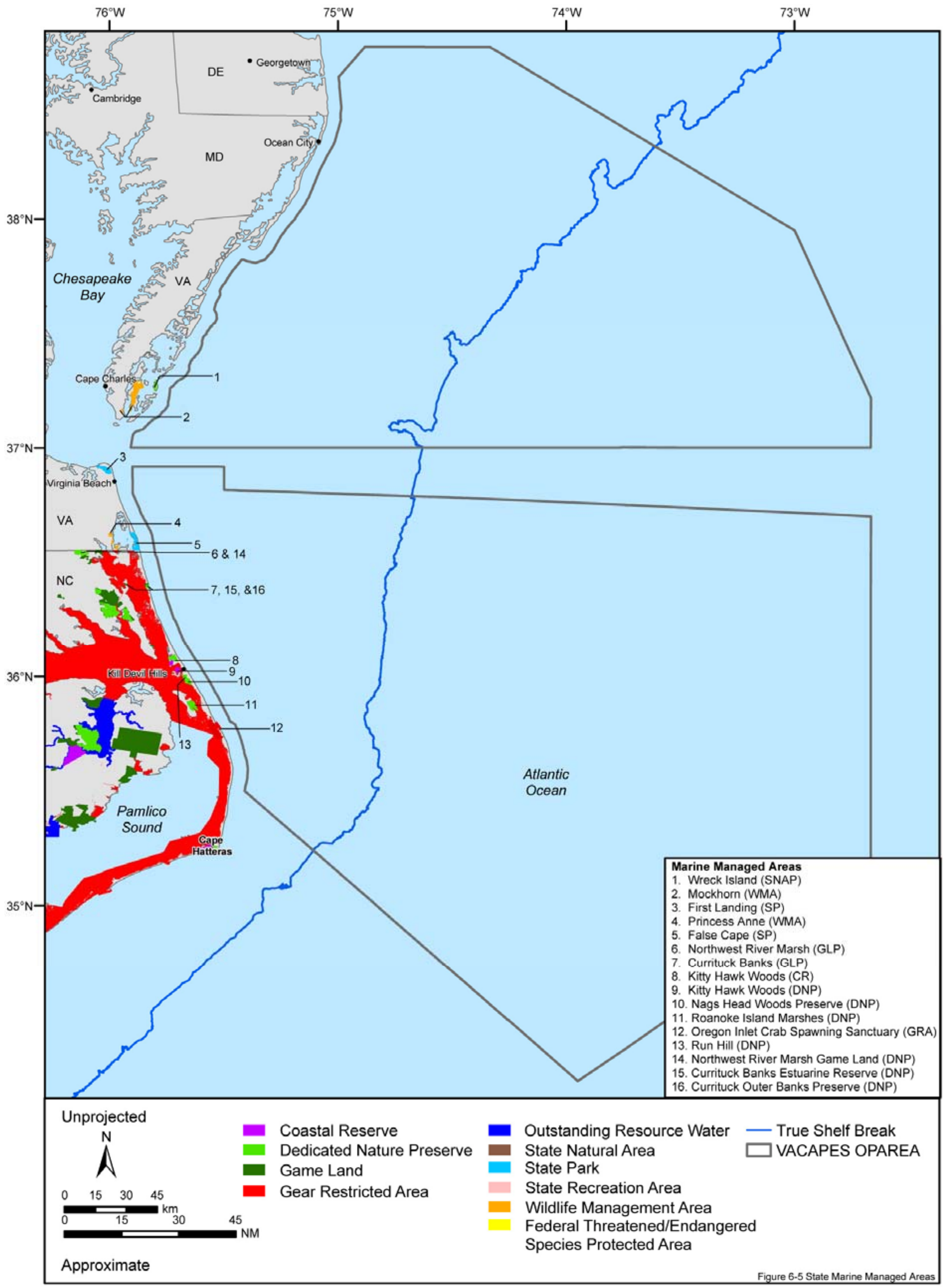

Figure 4-6. State Marine Protected Areas for the Virginia Capes OPAREA and vicinity. Source data: NMPAC (2008).

Table 4-2. Summary of state designated Marine Protected Areas in the Virginia Capes OPAREA and vicinity (NMPAC 2008).

MPA Type	*State Designated MPA*	*Area (km^2)*
State Natural Area	Wreck Island (VA)	0.5
Wildlife Management Area	Mockhorn (VA)	5.6
	Princess Anne (and Guard Shore) (VA)	0.5
State Park	First Landing (VA)	11.7
	False Cape (VA)	15.5
Game Land	Northwest River Marsh (NC)	11.7
	Currituck Banks (NC)	0.9
Coastal Reserve	Kitty Hawk Woods (NC)	1.7
Dedicated Nature Preserve	Kitty Hawk Woods Coastal Reserve (NC)*	0.1
	Nags Head Woods Preserve (NC)	0.1
	Run Hill State Natural Area (NC)	0.5
	Roanoke Island Marshes (NC)	9.5
	Northwest River Marsh Game Land (NC)	6.3
	Currituck Banks Estuarine Reserve (NC)	0.1
	Currituck Outer Banks Preserve (NC)	<0.1
Gear Restricted Area	Oregon Inlet Crab Spawning Sanctuary (NC)	24.8

*Kitty Hawk Woods Coastal Reserve DNP is a specially designated area located within Kitty Hawk Woods Coastal Reserve.

4.4.2.1 Dedicated Nature Preserves

The most prevalent designation for state MPAs in the vicinity of the VACAPES OPAREA is the Dedicated Nature Preserve (DNP). DNPs are usually a smaller part of an area already protected under the authority of another state of federal authority and set aside as a pristine natural area for preservation. There are seven DNPs in the vicinity of the OPAREA, and all are located in northern North Carolina. Roanoke Island Marshes is the largest DNP in the region with an area of 9.5 km^2 and exemplifies the habitat DNPs aim to preserve. It is comprised of brackish marsh habitat and patchy pine forest habitat between Croatan and Roanoke Sounds (NMPAC 2008).

4.4.2.2 Wildlife Management Areas

There are two Wildlife Management Areas (WMA) in the vicinity of the VACAPES OPAREA. One of the largest state MPAs in the vicinity of the OPAREA is Mockhorn WMA located along the Eastern Shore near Cape Charles, Virginia. There are three types of WMAs in Virginia: Mountain, Piedmont, and Coastal. Mockhorn is a Coastal WMA composed of two separate sites, Mockhorn Island and the GATR site located just southeast of Mockhorn Island. Habitat at both sites is primarily marshland dominated by saltmarsh cordgrass with upland areas supporting pines, cedars, and other littoral plant species. Mockhorn Island is primarily below sea level at high tide (NMPAC 2008; (VDGIF 2008)).

4.4.2.3 Gear Restricted Areas

Oregon Inlet Crab Spawning Sanctuary is a Gear Restricted Area (GRA) that encompasses the waters of Oregon Inlet, which is used heavily by ships transiting between Pamlico Sound and the Atlantic Ocean. The abundance of submerged aquatic vegetation at this site supports various lifestages of shellfish and serves as excellent spawning ground for local crab species (NMPAC 2008). It is the only GRA in the vicinity of the OPAREA.

4.4.2.4 State Parks

Two State Parks (SP), First Landing and False Cape, are located in the vicinity of the OPAREA along the southern Virginia coast. State Parks are intended to provide designated recreational areas and to protect wildlife.

4.4.2.5 Game Lands

Two Game Lands (GL), Northwest River Marsh and Currituck Banks, are located in northern North Carolina. They are set aside to promote fishing, hunting, and trapping (NCWRC 2006).

4.4.2.6 Coastal Reserves

There is one Coastal Reserve (CR) located along the Outer Banks of northern North Carolina and near the VACAPES OPAREA. Kitty Hawk Woods CR is at the center of the town of Kitty Hawk, and consists of upland forest and lowland swamp forest that comprise habitat for indigenous and migrating birds. The maritime swamp forests at this site are found in only four other locations worldwide (NMPAC 2008).

4.4.2.7 State Natural Areas

There is one State Natural Area in the vicinity of the VACAPES OPAREA. It is located on the Eastern Shore of Virginia and is 0.5 km^2 in area.

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5.0 FISH AND FISHERIES

5.1 FISH AND INVERTEBRATES

The zoogeography of marine fishes is closely tied to oceanographic processes and their position to continents (Moyle and Cech 1988). Fishes residing on continental shelves are affected by the topography of the continental shelf, water temperatures, and currents (Moyle and Cech 1988). Climates throughout the world, along with topographic features, divide the continental shelves into five categories: tropical regions, north temperate regions, south temperate regions, arctic regions, and Antarctic regions (Moyle and Cech 1988). In addition to continental shelf regions, there are also pelagic and deep sea regions that support various fish species. Fish distributions in these regions such as the mesopelagic zone (200 to 1,000 m) and the offshore area of the epipelagic zone (0 to 200 m) are not confined to specific geographic locations (Moyle and Cech 1988). In addition, the distributions of marine invertebrates, like those of marine fishes, are also subjected to currents, ocean temperatures, and topographic features but are also largely dependent upon the composition (firmness, texture, and stability) of the substrate they reside upon (Sumich 1988). Their larval stage allows extensive distributions by drifting along stretches of open water and miles of coastline (Sumich 1988).

The fishes and invertebrates of the VACAPES OPAREA are part of the Mid-Atlantic and northern South Atlantic Bights and can be classified primarily as temperate species but also include subtropical-tropical and highly migratory species. The oceanography of the VACAPES OPAREA is complex due to mixing currents and cooler water temperatures. In winter, the water temperatures on the continental shelf in the VACAPES OPAREA range between 4° and 15°C due to the encroaching cold water influxes from the north in the winter, while in the summer, the warmer water temperatures occurring on the shelf range between 20° and 28°C due to the influence of the Gulf Stream Current (Moyle and Cech 1988).

The topography in the VACAPES OPAREA is divided into four distinct habitats: coastal habitats (1 to 18 m), open-shelf habitat (18 to 55 m), shelf-edge habitat (55 to 110 m), and lower-shelf habitat (110 to 182 m) (Struhsaker 1969). Coastal habitats receive influxes of fresh water from river discharge whereas the open shelf is more affected by winds, tides, and the Gulf Stream Current. The cold water influxes flowing down from the north and the Gulf Stream Current flowing up from the south in the summer create a dynamic environment for fish in this area. Since the warm waters of the Gulf Stream are directed away from the coast off Cape Hatteras, North Carolina (just south of the VACAPES OPAREA), the region is known to divide the fishes of the north (i.e., temperate species) from the fishes of the south (i.e., subtropical-tropical species) (Moyle and Cech 1988).

The coastal pelagic fish in the vicinity of the VACAPES OPAREA include a diversity of species (e.g., bluefish [*Pomatomus saltatrix*], cobia [*Rachycentron canadum*], king mackerel [*Scomberomorus cavalla*], smooth puffer [*Lagocephalus laevigatus*], northern kingfish [*Menticirrhus saxatilis*], weakfish [*Cynoscion regalis*], clearnose skates [*Raja eglanteria*], spiny dogfish [*Squalus acanthias*], red drum [*Sciaenops ocellatus*], porgies [Sparidae], and Spanish mackerel [*Scomberomorus maculates*]) that move through the VACAPES OPAREA seasonally to offshore and southern regions as the coastal waters become too cold (Huntsman and Manooch 1978; Schwartz 1989; VMRC 2006). The offshore reef fish of the VACAPES OPAREA (e.g., jolthead porgy [*Calamus bajonado*], snappers [Lutjanidae], Warsaw grouper [*Epinephelus nigritus*], grunts [Haemulidae], and black sea bass [*Centropristis striata*]) inhabit deeper water associated with hardbottom habitat that does not fluctuate in temperature as much as the nearshore areas (Huntsman and Manooch 1978; VMRC 2006). The fishes residing in the offshore shelf waters of the VACAPES OPAREA (mainly southern portion of OPAREA) are temperate and subtropical-tropical (Huntsman and Manooch 1978; VMRC 2006).

Lastly, highly migratory fishes are distributed from coastal waters seaward into the open ocean such as billfishes (marlins and sailfish), swordfish, members of the mackerel (Scombridae) family (tuna), and many shark species. These species are capable of moving great distances seasonally (north to south or inshore to offshore), as well as vertically in the water column (NMFS 2003a). In contrast to 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 1999a, 1999b, 2003a).

Although the VACAPES OPAREA does not include any estuarine areas (boundary is ~3 NM from shore), their importance as nursery and maturation areas for various fish species should not be minimized (Schwartz 1989). The Chesapeake Bay is nearby and is the largest estuary in the U.S. It serves as nursery and habitat for various fishes and invertebrate species (WTU 2002). In addition, coastal plumes created by river flow, tides, and currents are also associated with the Chesapeake Bay and range between 10 to 100 km in width, 5 to 20 m in depth, and lasts from 1 to 10 days coinciding with phytoplankton blooms (Boicourt et al. 1987; Reiss and McConaughan 1999). Plumes generated from the Chesapeake Bay attract various adult and juvenile fish species (i.e., striped anchovy [*Anchoa hepsetus*], northern kingfish [*Menticirrhus saxatilis*], Spanish mackerel, Atlantic croaker [*Micropogonias undulates*], and jacks [*Caranx hippos*]) that forage on the rich diversity of marine life (i.e., zooplankton, phytoplankton, and fish eggs) that collect in the plumes (Reiss and McConaughan 1999).

Species within federal waters of the VACAPES OPAREA fall primarily under the jurisdiction of two fishery management councils (FMCs) and one federal agency: the South Atlantic Fishery Management Council (SAFMC; jurisdiction is federal waters from North Carolina to eastern Florida at Key West), the Mid-Atlantic Fishery Management Council (MAFMC; jurisdiction is federal waters from New York to North Carolina), and the NMFS (National Marine Fisheries Service; jurisdiction limited to HMS in federal waters off the U.S. Atlantic and the Gulf of Mexico). The SAFMC manages a total of 88 species of fishes and invertebrates (not including ~118 species of corals), the MAFMC manages 7 species, and the NMFS manages 68 HMS species under various Fishery Management Plans (FMPs). Additionally many species are co-managed by more than one FMC and/or commission. The SAFMC and the Gulf of Mexico Fishery Management council (GMFMC) co-manage two management units (MUs): the spiny lobster MU and the coastal migratory pelagic MU. The MAFMC jointly manages the bluefish MU and the summer flounder, scup, and black sea bass MU with the Atlantic States Marine Fisheries Commission (ASFMC). The MAFMC also co-manages the monkfish and the spiny dogfish with the New England Fishery Management Council (NEFMC). The NEFMC serves as the lead on the monkfish MU and the MAFMC the lead on the spiny dogfish MU. These FMCs and the NMFS manage the commercial and recreational fisheries for these species in federal waters, as well as designate essential fish habitat (EFH) and habitat areas of particular concern (HAPC). The remainder of this chapter will focus solely on those managed species found in federal waters.

5.2 FISHERIES RESOURCES

5.2.1 Commercial Fishing

Commercial fisheries in the Chesapeake region (Maryland through Virginia) are a ~$180 million annual industry (Figure 5-1; NMFS 2007). Within this region, Virginia ranks first in average volume of landings (greater than 200,000 metric tons) with North Carolina and Maryland ranking second (approximately 55,000 and 25,000 metric tons) (Figure 5-2; NMFS 2007). Delaware averages below 40, 000 metric tons per year (Figure 5-2; NMFS 2007). Summer flounder is the most commercially valuable fishery in the VACAPES OPAREA and vicinity (NMFS 2005b). Invertebrates such as shrimp, sea scallop, Atlantic surfclam, and ocean quahog averaged over $70 million a year from 1994 through 2004 with the sea scallop accounting for almost 50% of that value (NMFS 2005b).These landings are based on the amount of fish brought back to port, not necessarily the locations of where species were harvested.

Within the VACAPES OPAREA, there are numerous commercial fishery closures (geographic and seasonal) established to protect stocks by reducing fishing pressure (Table 5-1). These closures may be seasonal or year-round and some are associated with a specific gear type in order to minimize impacts on specific habitats. Additionally, many of these closure sites are also part of the Marine Managed Area (MMA) Inventory. Changes to fishery regulations involving area and seasonal closures are published

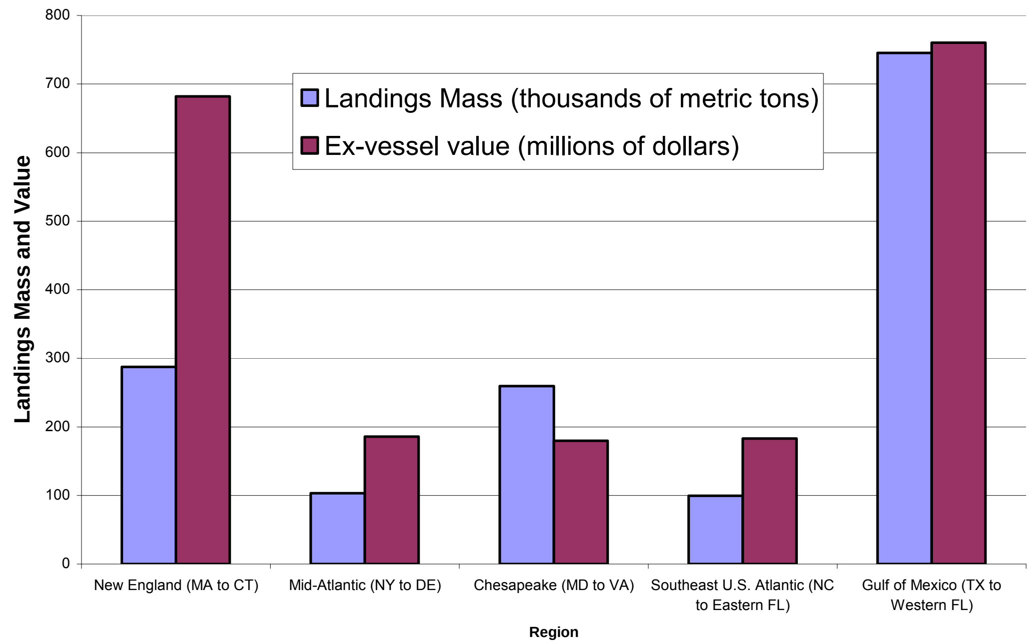

Figure 5-1. **Average landings (thousands of metric tons) and ex-vessel (price paid directly to fisherman) value (millions of dollars) for commercial fisheries by eastern U.S. regions from 1996 to 2005. Source data: NMFS (2007).**

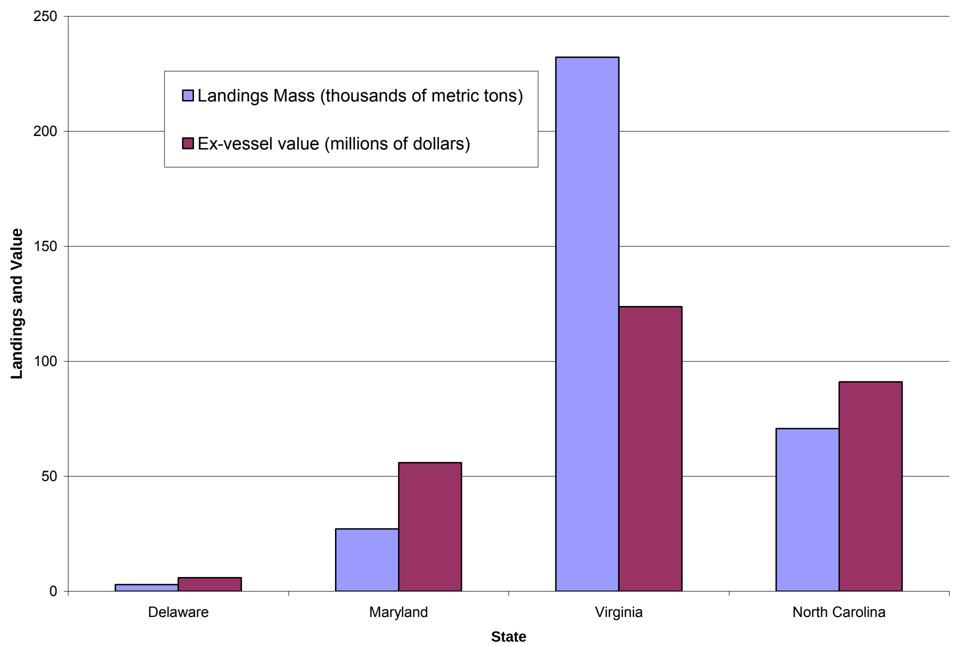

Figure 5-2. **Average commercial fishing landings (millions of dollars) and mass (thousands of metric tons) for each of the U.S. Mid-Atlantic Atlantic states from 1996 to 2005. Source data: NMFS (2007).**

Table 5-1. Average annual commercial landings and ex-vessel value for fisheries in Delaware, Maryland, Virginia, and North Carolina waters from 1996 to 2005 by management unit (MU) and major species targeted in each fishery NMFS (2007).

Management Unit & Species	Delaware		Maryland		Virginia		North Carolina	
	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value
Atlantic Herring MU								
Atlantic herring	<0.1	$4	23.7	$6,336	5.1	$1,882	53.0	$8,171
Atlantic mackerel, squid, and butterfish MU								
Atlantic mackerel	0.4	$190	19.9	$9,170				
Butterfish	0.5	$612	1.8	$2,046				
Longfin inshore squid			29.0	$43,502	93.7	$115,122		
Northern shortfin squid			2.1	$6,181	260.2	$115,302	294.9	$192,765
Unidentified squid			4.9	$8,832	231.1	$269	29.3	$38,088
Atlantic sea scallop MU								
Sea scallop	3.4	$56,512	38.9	$592,840	4,720.0	$143,383	76.9	$679,255
Bluefish MU								
Bluefish	13.7	$9,621	54.0	$39,505	263.8	$162,173	1,487	$888,940
Coastal migratory pelagics MU								
Cobia			0.1	$177	4.5	$15,473	11.2	$30,254
King mackerel			0.2	$573	0.9	$1,984	462.9	$1,613,650
Spanish mackeral	<0.1	$4	6.2	$13,004	67.4	$393,928	243.6	$430,425
Dolphin Wahoo MU								
Dolphinfish	0.1	$615	2.4	$9,750	0.3	$1,113	83.0	$293,104
Wahoo			0.2	$1,208	0.1	$65	9.7	$45,524

Table 5-1. Average annual commercial landings and ex-vessel value for fisheries in Delaware, Maryland, Virginia, and North Carolina waters from 1996 to 2005 by management unit (MU) and major species targeted in each fishery (NMFS 2007) (cont'd).

Management Unit & Species	Delaware		Maryland		Virginia		North Carolina	
	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value
Highly migratory species								
Sharks: Large Coastal Shark MU, Small Coastal Shark MU, Pelagic Shark MU, and Prohibited Species MU	2.0	$3,326	12.3	$23,346	166.4	$1,525	631.0	$616,048
Swordfish MU								
Swordfish			26.8	$169,145	6.9	$1,582	209.6	$1,079,639
Marlin MU								
Marlins			0.4	$300				
Tunas MU	2.4	$12,259	49.9	$237,611	9.9	$119,515	587.2	$2,257,367
Tunas								
Monkfish MU								
Goosefish/monkfish	2.3	$4,574	129.2	$223,618	752.7	$827,313	207.1	$420,667
Northeast multispecies MU								
Atlantic cod	<0.1	$1	<0.1	$21	0.1	$168	<0.1	$31
Offshore hake	0.4	$156	0.5	$289			1.0	$719
Red hake	<0.1	$22	3.3	$2,424	0.6	$96,253		
Silver hake			0.7	$467	2.1	$14,888		
Summer flounder	3.3	$14,894	150.3	$599,847	1,297.5	$49,161	1,588.9	$5,662,311
White hake			<0.1	$5	0.1	$18		
Windowpane flounder	0.2	$229			<0.1	$606		
Winter flounder	<0.1	$4	2.1	$7,475	0.3	$1,678		
Witch flounder			0.3	$469	1.1	$13	0.8	$1,119

Table 5-1. Average annual commercial landings and ex-vessel value for fisheries in Delaware, Maryland, Virginia, and North Carolina waters from 1996 to 2005 by management unit (MU) and major species targeted in each fishery (NMFS 2007) (cont'd).

Management Unit & Species	Maryland		Delaware		Virginia		North Carolina	
	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value
Northeast skates MU								
Skates			58.2	$24,198	65.5	$2	5.3	$2,755
Red drum MU								
Red drum			0.3	$428	2.4	$393	73.0	$175,315
Shrimp MU								
Brown shrimp			<0.1	$65	0.3	$3,171	1,763.0	$8,008,309
Pink shrimp							108.2	$456,802
Rock shrimp							1.7	$3,673
White shrimp							910.3	$4,587,298
Snapper-grouper MU								
Snappers					<0.1	$112,437	185.0	$991,471
Groupers					0.1	$413	298.7	$1,475,007
Porgies	<0.1	$29	1.4	$2,352	75.8	$4,791	122.2	$203,937
Jacks			0.1	$133	0.8	$916	60.8	$76,125
Tilefishes			0.3	$326	0.7	$46,024	10.7	$49,095
Grunts			0.3	$163	<0.1	$8	43.5	$70,190
Wrasses			0.4	$160	<0.1	$3,487	4.8	$20,287
Sea basses	34.9	$131,988	160.9	$526,956	291.0	$48,390,555	322.8	$1,130,741
Spiny dogfish MU								
Spiny dogfish	<0.1	$14	1,479.3	$617,908	1,061.6	$3,609,179	2,176.4	$702,303
Summer flounder, scup, and black sea bass MU								
Black sea bass	34.9	$131,988	160.9	$526,956	291.0	$1,242,519	322.8	$1,130,734
Scup	<0.1	$34	1.3	$2,318	72.7	$1,242,519	1.1	$1,252
Summer flounder	3.3	$14,894	150.3	$599,847	1,297.5	$49,161	1,558.9	$5,662,311

Table 5-1. Average annual commercial landings and ex-vessel value for fisheries in Delaware, Maryland, Virginia, and North Carolina waters from 1996 to 2005 by management unit (MU) and major species targeted in each fishery (NMFS 2007) (cont'd).

Management Unit & Species	Maryland		Delaware		Virginia		North Carolina	
	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value	Metric Tons	Value
Surfclam and ocean quahog MU								
Atlantic surfclam			3,203.4	$4,290,897	81.7	$105,372	3.2	$25,165
Ocean quahog	35.6	$247,167	40.3	$469,164	219.9	$2,694,649	280.3	$4,043,911
Tilefish MU								
Tilefish					0.5	$2,092	10.3	$48,691
Other species (non-federally managed)	2,864.4	$5,557,960	22,721.0	$49,319,525	223,464.5	$65,875,411	58,919.4	$53,559,774

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federally (Federal Register). Since closures are dynamic events for which the timing or area closed may change over time in response to the status of the fish stock, the information should be considered perishable. For the most current commercial fishery regulations, the FMC, and the NMFS Highly Migratory Species (HMS) Division, the Code of Federal Regulations, or the Federal Register should be consulted.

Harvest or possession of the red drum, several members of the snapper-grouper MU (goliath and Nassau groupers), and most coral species and live rock are prohibited in the federal waters of the VACAPES OPAREA; in North Carolina federal waters, the harvest or possession of pelagic *Sargassum* is prohibited from July through August and within 87 NM of shore but harvest of no more than 2,268 kg (wet weight) per year is ever permitted (SAFMC 2005a).

Although harvesting of pelagic *Sargassum* is permitted on a limited basis in North Carolina waters, no harvest is currently taking place and likely hasn't since 1997 (SAFMC 2002b; Cassazza 2006). Due to these prohibitions, effectively no red drum, coral/live rock, or *Sargassum* fisheries exist in the VACAPES OPAREA federal waters. Other members of the snapper-grouper complex are fished in the VACAPES OPAREA, however, and the snapper-grouper fishery accounts for a large percentage of the commercial landings in North Carolina waters (NMFS 2005b).

5.2.1.1 Atlantic Mackerel, Squid, and Butterfish Fishery

Target Species—Atlantic mackerel (*Scomber scombrus*), longfin inshore squid (*Loligo pealeii*), northern shortfin squid (*Illex illecebrosus*), and butterfish (*Peprilus triacanthus*).

Management—These species are managed via MAFMC through the Atlantic Mackerel, Squid, and Butterfish FMP (MAFMC 1998a; MAFMC 2006a).

Distribution—Longfin inshore squid and butterfish harvests primarily occur in the fall and winter, while northern shortfin squid harvest occurs from June to September (MAFMC 2006a). Atlantic mackerel harvest is concentrated on the shelf but mostly in shallower waters during the early part of the year, while northern shortfin, longfin inshore squid, and butterfish are primarily harvested along the shelf break (MAFMC 2006a).

Gear—Bottom otter trawls are predominantly used to harvest squid species (>95% of landings) and butterfish (~88% of harvest) (MAFMC 1998a, 2006a). Mid-water trawls are primarily (~99% of landings) used to harvest Atlantic mackerel but gillnets and pound nets are also used (MAFMC 1998a, 2006a) (Figures 5-3, 5-4, and 5-5).

Current Regulations—Numerous regulations apply to the use of gear or size limit for this fishery (MAFMC 2006a). Though, the MAFMC is considering future closures for trawl gear (MAFMC 2006a).

- <u>Southern Gear Restricted area</u>: From 1 January through 15 March, all trawl vessels in the Southern Gear Restricted Area that fish for or possess non-exempt species (i.e., longfin inshore squid, black sea bass and silver hake) must fish with nets that have a minimum mesh size of 11.43 centimeters (cm) diamond mesh, applied throughout the codend for at least 75 continuous meshes forward of the terminus of the net. For codends with fewer than 75 meshes, the minimum-mesh-size codend must be a minimum of one-third of the net, measured from the terminus of the codend to the headrope, excluding any turtle excluder device extension (50 CFR 648.122).
- <u>Mid-Atlantic coastal waters area</u>: This closure was established as part of the Atlantic large whale take reduction plan to reduce incidental take of humpback, fin, and right whales by gillnets. Specific gear requirements are mandated from 1 December through 31 March in this region (NOAA and DoI 2006). This area is also designated as a MMA.

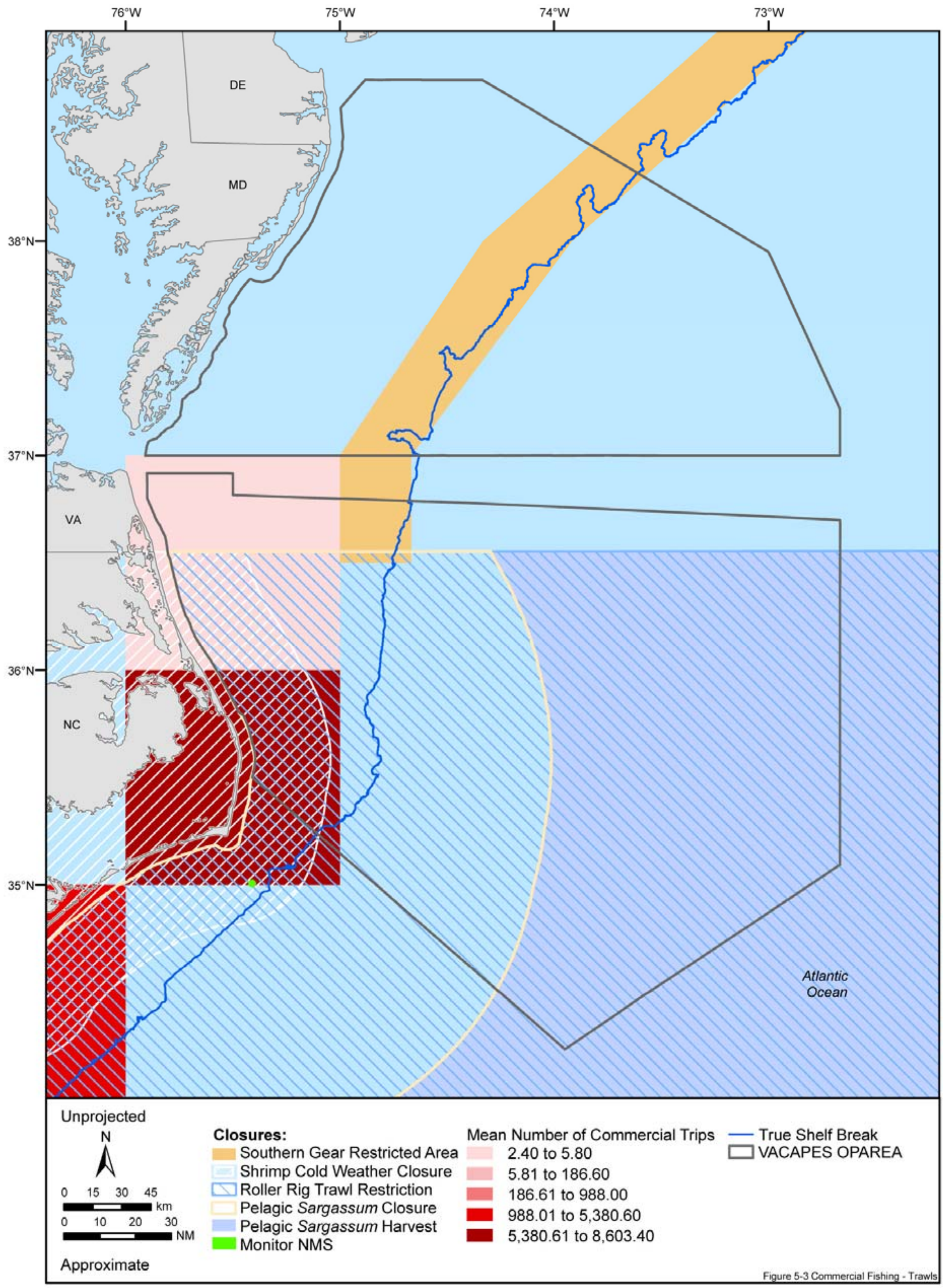

Figure 5-3. Distribution of fishing effort and closures relevant to the trawl gear commercial fisheries in Virginia Capes OPAREA and vicinity. Fishing effort is displayed as the average number of trips from 2000 to 2004. Source data: NMFS (2000), SAFMC (2005d). Source information: NOAA (1996) and ACCSP (2006a).

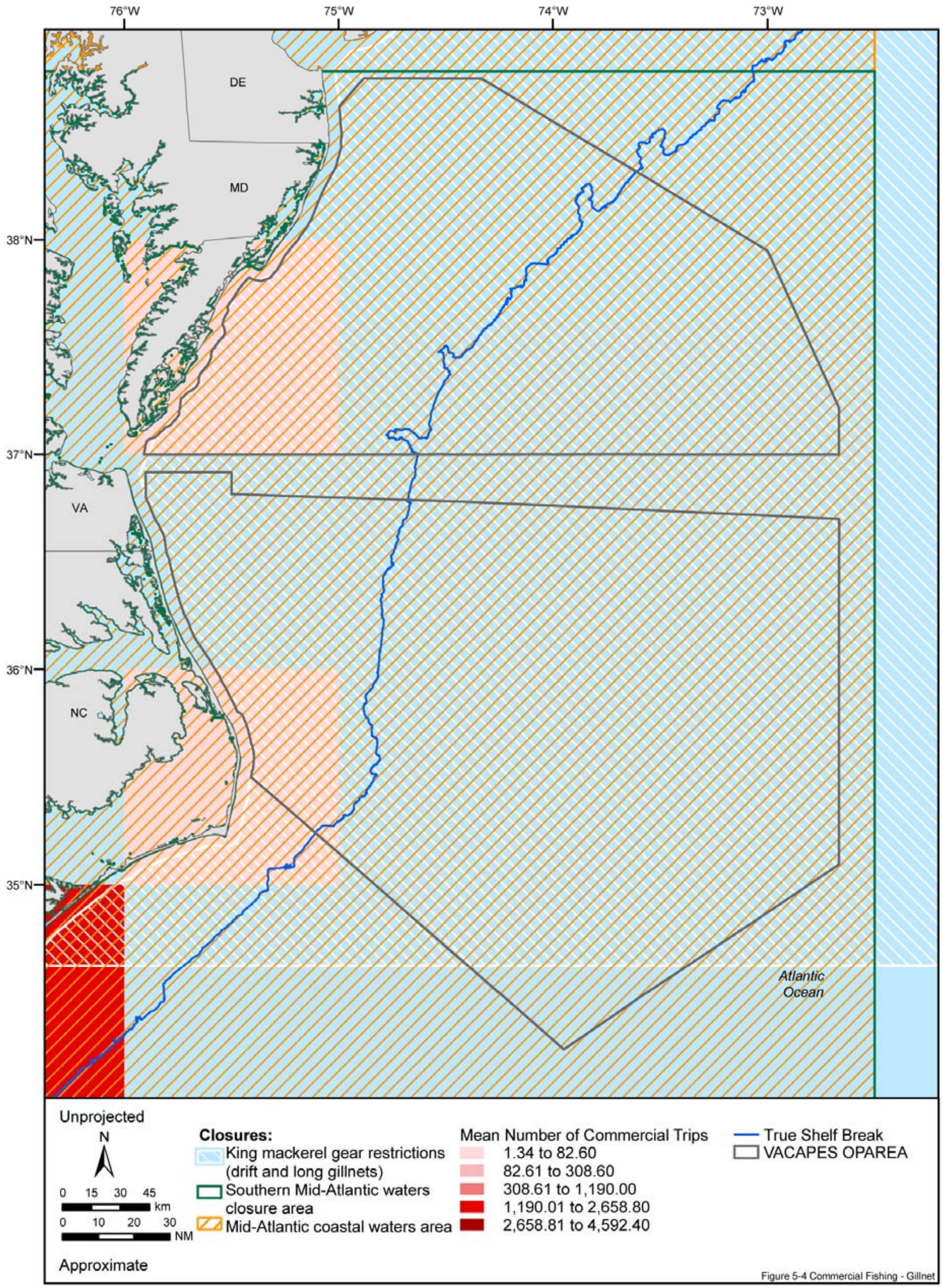

Figure 5-4. Distribution of fishing effort and closures relevant to the gillnet commercial fisheries in the Virginia Capes OPAREA and vicinity. Fishing effort is displayed as the average number of trips from 2000 to 2004. Source information: NMFS (2005e), SAFMC (2005a), and ACCSP (2006a).

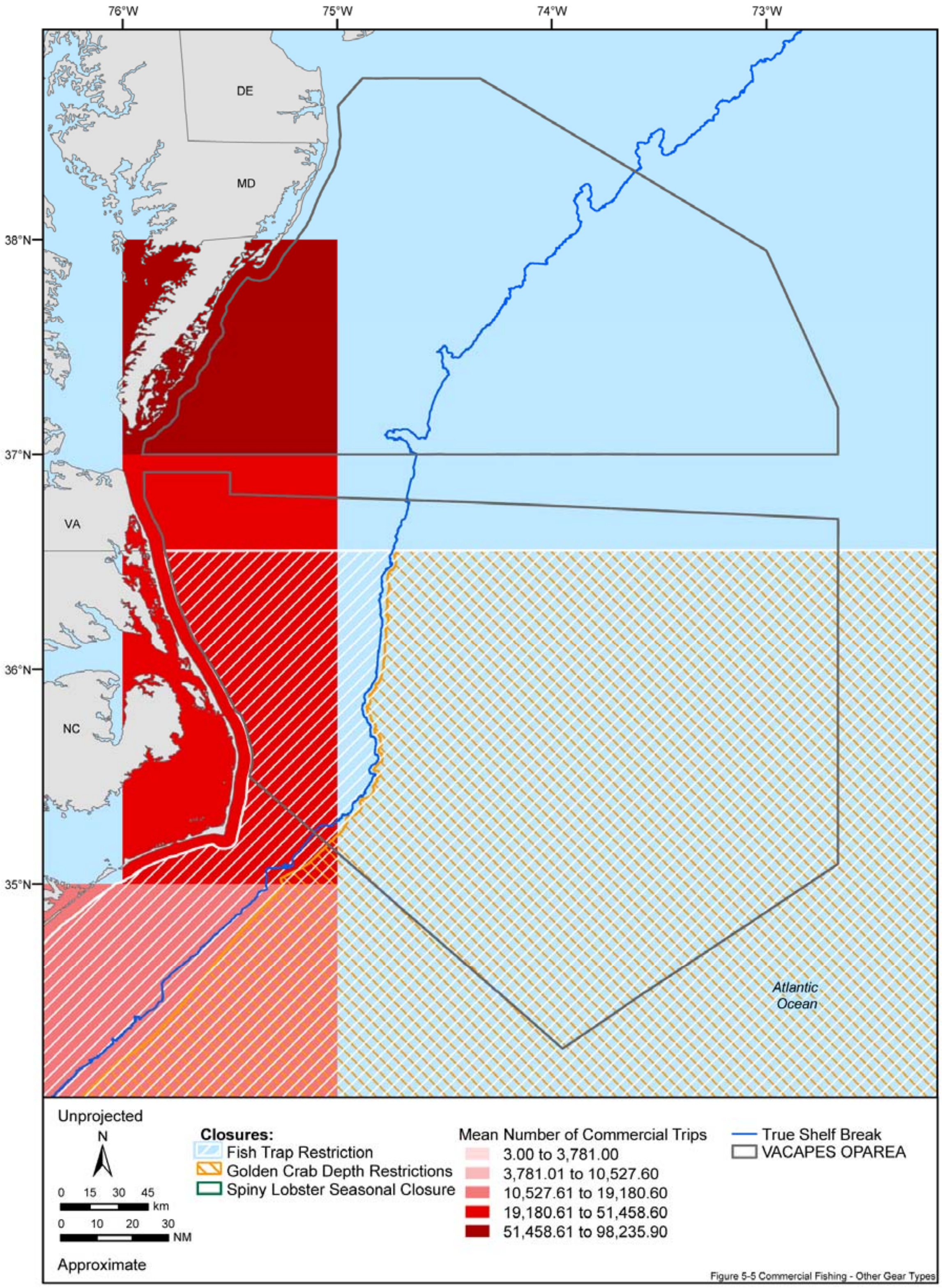

Figure 5-5. Distribution of fishing effort and closures relevant to the other gear type (e.g., pots, spearfishing, traps, cast nets; not trawls, lines, dredges, gillnets or seines) commercial fisheries in Virginia Capes OPAREA and vicinity. Fishing effort is displayed as the average number of trips from 2000 to 2004. Source data: NOAA-CSC (2002), SAFMC (2006b). Source information: SAFMC (2002a, 2005a) and ACCSP (2006a).

Status—These fisheries all have annual quotas. Quotas are set by tri-mesters for the longfin inshore squid (MAFMC 2007). In 2005, 2,987 commercial permits were issued in the Atlantic mackerel, squid, and butterfish fishery (NMFS 2006b). Commercial fishermen from the states within the VACAPES OPAREA and vicinity account for only a small percent of these vessel permit holders. Only the butterfish is considered overfished, but a moratorium is currently being considered by the MAFMC for entry into the northern shortfin squid fishery to protect against overexploitation (MAFMC 2006a).

5.2.1.2 Bluefish Fishery

Target Species—Bluefish (*Pomatomus saltatrix*)

Management—This species is jointly managed by the MAFMC and ASMFC through the Bluefish FMP (MAFMC 1998b; MAFMC 2005b).

Distribution—Bluefish are commercially harvested from Maine through Florida. Harvest primarily occurs from May to October, with greatest effort (>30% of total landings) occurring off Cape Hatteras, North Carolina (MAFMC and ASMFC 1998a; MAFMC 2005b).

Gear—Handlines (~5% of landings), trawls (~22% of landings), and gillnets (65% of landings) are used to harvest bluefish primarily in the spring and fall (MAFMC and ASMFC 1998a; MAFMC 2005b) (Figures 5-3, 5-4, and 5-6).

Current Regulations—The following closure exists for this fishery:

- Mid-Atlantic coastal waters area: This closure (which is also an MMA) was established as part of the Atlantic large whale take reduction plan to reduce incidental take of humpback, fin, and right whales by gillnets. Specific gear requirements are mandated from 1 December through 31 March in this region (NOAA and DoI 2006).

Status—The MAFMC annually sets commercial landing quotas for the bluefish. A current status review indicates that this species is no longer overfished (NMFS 2006). In 2005, 3,441 vessels had commercial bluefish permits (MAFMC 2005b).

5.2.1.3 Spiny Dogfish Fishery

Target Species—Spiny dogfish (*Squalus acanthias*)

Management—This species is jointly managed by the MAFMC (lead) and NEFMC through their Spiny Dogfish FMP (MAFMC and NEFMC 1999; ASMFC 2002a).

Distribution—Harvest occurs year-round but in the VACAPES OPAREA is concentrated in fall and winter, with peak catches in January through April (MAFMC and NEFMC 1999; ASMFC 2002a; MAFMC 2006c). In the VACAPES OPAREA and vicinity, north of Cape Hatteras, North Carolina, commercial effort for this species occurs from 1 to 17 NM offshore, while south of Cape Hatteras effort is primarily restricted to state waters (ASFMC 2002a). Approximately 83% of the landings of this species are of female spiny dogfish due to their larger size (i.e., fishery is selective for larger individuals) (ASMFC 2006).

Gear—Bottom longline (~57% of landings), gill nets (~31% of landings), and trawls (~11% landings) are the primary gear types used to harvest the spiny dogfish (ASMFC 2002a) (Figures 5-3, 5-4, and 5-6).

Current Regulations—The following closure exists for this fishery:

- Mid-Atlantic coastal waters area: This closure (which is also an MMA) was established as part of the Atlantic large whale take reduction plan to reduce incidental take of humpback, fin, and right whales by gillnets. Specific gear requirements are mandated from 1 December through 31 March in this region (NOAA and DoI 2006).

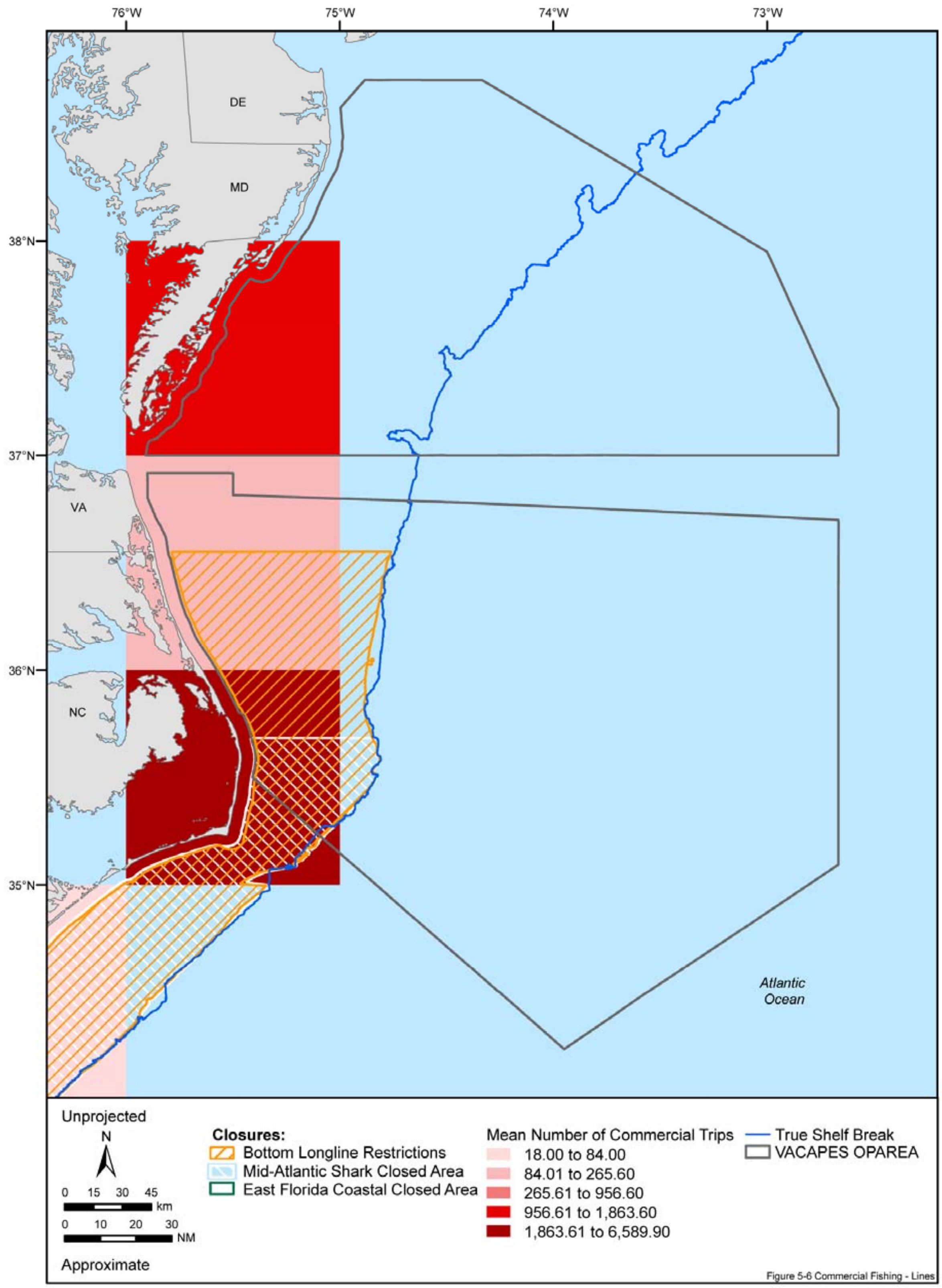

Figure 5-6. Distribution of fishing effort and closures relevant to the line gear (e.g., handlines, bottom longlines, pelagic longlines) commercial fisheries in the Virginia Capes OPAREA and vicinity. Fishing effort is displayed as the average number of trips from 2000 to 2004. Source data: NOAA-CSC (2002), SAFMC (2005b), and NOAA and DoI (2006). Source information: NMFS (2005e) and ACCSP (2006a).

Status—Quotas are set in periods for this fishery and a federal permit is required to commercially harvest this species in federal waters. In 2004, 3,283 permits were issued in this fishery. None of the states in the VACAPES OPAREA, contribute significantly to the total number of commercial permits issued for this fishery (MAFMC 2006c; Table 5-2). Currently, there is no definition in the Spiny Dogfish FMP to a make a determination of biomass target. However, biomass estimates indicate that this species is overfished (MAFMC 2006c).

Table 5-2. Spiny dogfish commercial vessel permit holders by state for 2004 in the Virginia Capes OPAREA (MAFMC 2006c).

Home port state	Number of commercial vessel permits (percent of total permits for fishery)
Delaware	18 (0.6)
Maryland	26 (0.9)
Virginia	141 (4.8)
North Carolina	152 (5.2)

5.2.1.4 Monkfish Fishery

Target Species—Monkfish (*Lophius americanus*)

Management—This species is jointly managed by the NEFMC (lead) and MAFMC under the Monkfish FMP (NEFMC and MAFMC 1998; NEFMC and MAFMC 2004a). Management is divided into two areas: a northern fishery management area and a southern fishery management area. Only the southern stock is within the VACAPES OPAREA. This species is sold whole or specifically for its tail or liver (NEFMC and MAFMC 2004a).

Distribution—The majority of the commercial effort for this fishery is north of the VACAPES OPAREA (i.e., Massachusetts) (NEFMC and MAFMC 2004a). Deepwater corals are often found in regions where this fishery occurs. As a result, FMCs are investigating means (i.e., closed areas) to protect these areas from potential damage associated with this fishery (NEFMC and MAFMC 2004b).

Gear—Otter trawls and sink gillnets are the primary gear types used for direct harvest of monkfish in this fishery (NEFMC and MAFMC 2004a) (Figures 5-3 and 5-4). Monkfish are also taken incidentally using dredges (NEFMC and MAFMC 2004a). Commercial effort typically peaks from September through April (NEFMC and MAFMC 2004a).

Current Regulations—Numerous gear regulations apply to this fishery and the following closure (MAFMC 2007):

- <u>Southern Mid-Atlantic waters closure area</u>: This closure was established as part of the harbor porpoise take reduction plan to prevent incidental take of this species in the commercial groundfish gillnet fishery. It is closed to large mesh gillnet gear from 1 February to 15 March annually (NOAA and DoI 2006). This area is also an MMA.

Status—The monkfish is subject to overfishing (NMFS 2006a). In 2004, 752 limited access permits were issued for the monkfish fishery (NEFMC and MAFMC 2006). Of 752 limited access permits issued, 343 were Category C permits for limited access permits in a Multispecies (61%) or Scallop (48%) fisheries.

The other 355 limited access vessel permits were Category D permits, of which 98% were Multispecies limited access vessel permits (NEFMC and MAFMC 2006). In general, 74% of monkfish limited access vessel permit holders also hold multispecies limited access permits (NEFMC and MAFMC 2006).

5.2.1.5 Summer Flounder, Scup, and Black Sea Bass Fishery

Target Species—Summer flounder (*Paralichthys dentatus*), scup (*Stenotomus chrysops*), and black sea bass (*Centropristis striata*)

Management—These three species are jointly managed by the MAFMC and ASMFC (MAFMC and ASFMC 2002). South of Cape Hatteras, North Carolina, the black sea bass and scup are managed by the SAFMC through the Snapper Grouper FMP (SAFMC 1983, 2003a).

Distribution—Most scup are caught in the months from November to May, peaking from February to May (MAFMC and NEFMC 2002). Summer flounder and scup are primarily harvested from Cape Cod, Massachusetts through Cape Hatteras, North Carolina (Terceiro 2001a, 2001b). For summer flounder, the winter fishery exists offshore, while in the summer the fishery concentrates in inshore and coastal waters (ASMFC 2005).

Gear—Otter trawls, pots, and traps, hook-and-line, and trawl roller gear (all subject to certain restrictions) are used to harvest black sea bass in this region, with trawls (54% of total landings) and pots (~37% of catch) being the primary gear types used (MAFMC and ASMFC 1998b; MAFMC 2006b; NMFS 2005b) (Figures 5-3, 5-5, and 5-6) . Black sea bass pots are often set near shipwrecks and the season runs from April to September (MAFMC and ASMFC 1998a). Otter and beam trawls (~97% of landings) are used primarily to target summer flounder in the VACAPES OPAREA and vicinity in depths less than 183 m (MAFMC and ASMFC 1998b; MAFMC 2006b). Trawls (beam and otter) are also the main gear used (~83% of landing) to harvest scup from winter to spring, but they are also landed using fish pots/traps and lines (MAFMC and ASMFC 1998b; NMFS 2005a, 2006b).

Current Regulations—Numerous regulations (i.e., gear restrictions and size limits) apply to this fishery in the VACAPES OPAREA (MAFMC 2007), including the following (Figure 5-5):

- Scup restriction (proposed): The proposed fishing season for scup is from 1 January to 28 February and from 18 September to 30 November (MAFMC 2007).
- Southern Gear Restricted area: From 1 January through 15 March, all trawl vessels in the Southern Gear Restricted Area that fish for or possess non-exempt species (i.e., longfin inshore squid, black sea bass and silver hake) must fish with nets that have a minimum mesh size of 11.43 cm diamond mesh, applied throughout the codend for at least 75 continuous meshes forward of the terminus of the net. For codends with fewer than 75 meshes, the minimum-mesh-size codend must be a minimum of one-third of the net, measured from the terminus of the codend to the headrope, excluding any turtle excluder device extension (NMFS 2003b).

Status—Permits are required to commercially harvest all three of these species in federal waters. For the scup fishery, quotas are set in trimesters (NMFS 2005a, 2007). In 2005, 1,013 commercial permits were issued for summer flounder, 871 for scup, and 927 for black sea bass (NEFMC and MAFMC 2006). Currently, both the summer flounder and scup are subject to overfishing, while the scup is also considered overfished (NMFS 2007). In the Southeast region only (i.e., SAFMC jurisdiction), the black sea bass is considered overfished and subject to overfishing (NMFS 2007).

5.2.1.6 Atlantic Surfclam and Ocean Quahog Fishery

Target Species—Atlantic surfclam (*Spisula solidissima*) and ocean quahog (*Arctica islandica*)

Management—These species are managed by the MAFMC's Atlantic Surfclam and Ocean Quahog FMP (MAFMC 1998b, 2005d).

Distribution—Commercial concentrations of ocean quahogs are found on the continental shelf to depths of 76 m (MAFMC 1998b). Commercial concentrations of surfclams are associated with sandy sediments up to depths of 55 m (MAFMC 2005d). Approximately, 70% of surfclam harvests and >90% of ocean quahog landings occur in federal waters (MAFMC 1998b). Historically, the Delmarva Peninsula was the focus of commercial fishery efforts, but effort for this fishery is currently concentrated further north of the VACAPES OPAREA (i.e., New Jersey and New York) (MAFMC 1998b, 2005d).

Gear—Dredges and trawls are the gear type used to harvest these species (MAFMC 1998b) (Figures 5-3 and 5-7).

Current Regulations—Currently, there are no closures for these fisheries in the VACAPES OPAREA (e-CFR 2007).

Status—In 2005, there were 1,975 commercial permits issued for Atlantic surf clam fishery and 1,928 commercial permits issued for ocean quahog fishery (MAFMC 2005d). Neither species is considered overfished (NMFS 2006a).

5.2.1.7 Tilefish Fishery

Target Species—Golden tilefish (*Lopholatilus chamaeleonticeps*); more commonly referred to as the tilefish

Management—This species is managed within the MAFMC's jurisdiction (north Virginia/North Carolina border) by the Tilefish FMP (MAFMC 2000). Additionally, in the SAFMC's jurisdiction (south of the Virginia/North Carolina border) this species is managed as part of the Snapper Grouper FMP (SAFMC 1998, 2003a).

Distribution—The bulk of the effort for this fishery occurs north of the VACAPES OPAREA (i.e., New York [68% of total landings] and New Jersey [22% of total landings]) in areas associated with underwater canyons (e.g., Atlantis, Alvin, Block, and Hudson canyons) (MAFMC 2000). States within the VACAPES OPAREA land <1% total landings (MAFMC 2000). Peak landings occur from January through June (MAFMC 2000).

Gear—The tilefish is primarily landed using longline gear (~93% of landing), but otter trawls (~7% of landings) are also used to a much lesser extent (Figures 5-3 and 5-6; MAFMC 2000).

Current Regulations—There are no closed areas in the VACAPES OPAREA for this fishery in the MAFMC's jurisdiction (MAFMC 2007).

Status—The tilefish is subject to overfishing only in the Southeast region (i.e., SAFMC jurisdiction), and is neither subject to overfishing nor overfished in the Northeast region (i.e., NEFMC and MAFMC jurisdictions) (NMFS 2006a).

5.2.1.8 Shrimp Fishery

Target Species—Brown (*Farfantepenaeus aztecus*), pink (*F. duorarum*), white (*Litopenaeus setiferus*), royal red (*Pleoticus robustus*), and brown rock (*Sicyonia brevirostris*)

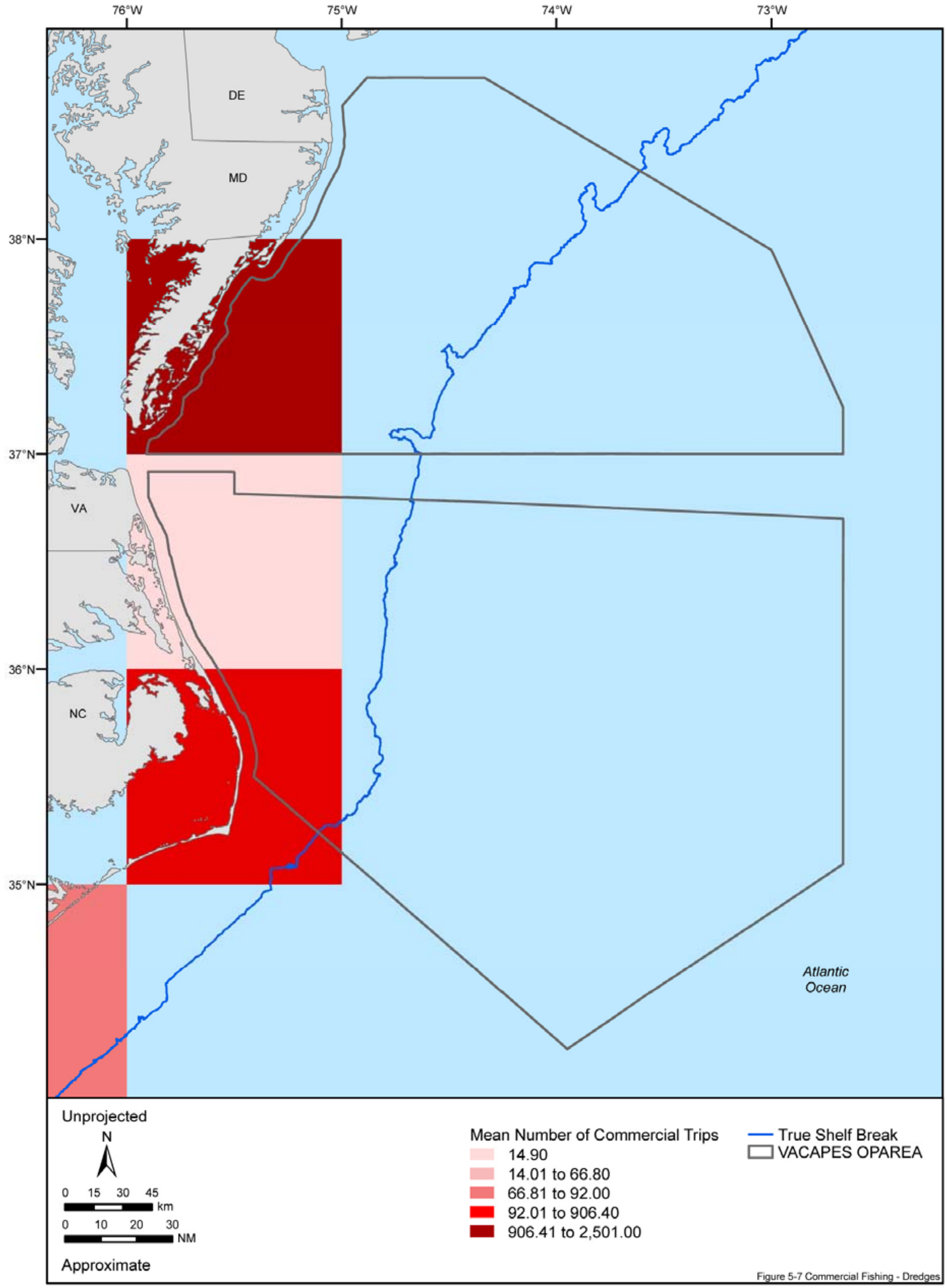

Figure 5-7. Distribution of fishing effort and closures relevant to the dredge gear commercial fisheries in the Virginia Capes OPAREA and vicinity. Fishing effort is displayed as the average number of trips from 2000 to 2004. Source data: NOAA and DoI (2006). Source information: ACCSP (2006a).

Management—These shrimp species are managed by the SAFMC through their Shrimp FMP (SAFMC 1998, 2002a).

Distribution—Brown, pink, and white shrimp, which are shallow water species, are primarily harvested compared to the deeper water brown rock and royal red shrimp (SAFMC 1993). Approximately 70% of the shrimp harvest in North Carolina occurs in inshore areas, with brown shrimp being the dominant species landed (SAFMC 1993; NRC 2002).

Gear—Shrimp fisheries utilize otter trawls to harvest various species (SAFMC 2005a) (Figure 5-3).

Current Regulations—Numerous regulations apply to this fishery in the VACAPES OPAREA :

- Shrimp cold weather closures: North Carolina, South Carolina, Georgia, and Florida (east coast) can request a closure in federal waters that are adjacent to closed state waters for brown, pink, or white shrimp following a severe winter that results in an 80% or greater reduction in shrimp populations. For this closure a buffer zone ranging from shore to 25 NM from shore is established where shrimping is prohibited (NOAA 1996; SAFMC 2005a).
- Bycatch reduction devices (BRDs): Shrimp trawlers utilizing a net with a mesh size of ≤6.35 cm must have a SAFMC certified BRD installed (i.e., extended funnel, expanded mesh, or fisheye) (SAFMC 2005a).
- Turtle excluder devices (TEDs): Brown, pink, white, and brown rock shrimp fisheries require TEDs, which are regulated by the NMFS, Southeast Regional Office (SAFMC 2005a).

Status—One of the shrimp species (pink shrimp) in this fishery is subject to overfishing and the others are not (NMFS 2006a). In 2005, there were 873 commercial permits issued (NEFMC 2006).

5.2.1.9 Snapper Grouper Fishery

Target Species—In the SAB, there are over 100 species of reef fishes (groupers, snappers, tilefishes, wrasses, jacks, triggerfishes, sea basses, spadefishes, and porgies) but only 73 are managed by the SAFMC (Table 5-3).

Management—These 73 species are managed by the SAFMC through their Snapper Grouper FMP. The black sea bass which is part of this fishery is managed by the MAFMC north of Cape Hatteras, North Carolina through their Summer Flounder, Scup, and Black Sea Bass FMP.

Distribution—Black sea bass, red porgy, and vermilion snapper constitute the majority of landings from this fishery (Harris and Machowski 2004). Shallow-water snappers (e.g., yellowtail snapper, gray snapper, mutton snapper, lane snapper, hogfish, cubera snapper, dog snapper, schoolmaster, and mahogany snapper) and groupers (e.g., gag grouper, red grouper, scamp, black grouper, rock hind, red hind, graysby, yellowfin grouper, coney, yellowmouth grouper, and tiger grouper) constitute the majority of species landed in this fishery and are landed primarily from March through July (SAFMC 2006a, 2006b). Deepwater species targeted include snowy grouper, red porgy, blueline tilefish, warsaw grouper, yellowedge grouper, and speckled hind (SAFMC 2006a). Overall, the snapper grouper fishery is often one of the largest offshore commercial fisheries for most states along the southeastern U.S. coast (NMFS 2006a).

Gear—Vertical lines (hook-and-line), spearfishing gear, powerheads, bottom longline, black sea bass pots, and sink nets (North Carolina only) are permissible gear types for these fisheries (SAFMC 2005a) (Figures 5-5 and 5-6). Most involved in this commercial fishery utilize boats less than 15 m in length (SAFMC 2006a). Those using vertical lines typically fish at depths ranging from 23 to 201 m during daylight and night hours (SAFMC 2006a). Except for the golden tilefish (longline) and black sea bass (pots), the majority of effort for this fishery results from the use of hook-and-line (SAFMC 2006a). Longline snapper grouper fisheries target primarily snowy grouper and golden tilefish. They can only operate

Table 5-3. Species managed by the SAFMC under the Snapper-Grouper MU (SAFMC 2005a).

Snappers				
Blackfin snapper (*Lutjanus buccanella*)	Black snapper (*Apsilus dentatus*)	Cubera snapper (*Lutjanus cyanopterus*)	Dog snapper (*Lutjanus jocu*)	Gray snapper (*Lutjanus griseus*)
Lane snapper (*Lutjanus synagris*)	Mahogany snapper (*Lutjanus mahogoni*)	Mutton snapper (*Lutjanus analis*)	Queen snapper (*Etelis oculatus*)	Red Snapper (*Lutjanus campechanus*)
Schoolmaster (*Lutjanus apodus*)	Silk snapper (*Lutjanus vivanus*)	Vermilion snapper (*Rhomboplites aurorubens*)	Yellowtail snapper (*Ocyurus chrysurus*)	
Groupers				
Black grouper (*Mycteroperca bonaci*)	Coney (*Cephalopholis fulva*)	Gag (*Mycteroperca microlepis*)	Goliath grouper (*Epinephelus itajara*)	Graysby (*Cephalopholis cruentata*)
Misty grouper (*Epinephelus mystacinus*)	Nassau grouper (*Epinephelus striatus*)	Red grouper (*Epinephelus morio*)	Red hind (*Epinephelus guttatus*)	Rock hind (*Epinephelus adscensionis*)
Scamp (*Mycteroperca phenax*)	Snowy grouper (*Epinephelus niveatus*)	Speckled hind (*Epinephelus drummondhayi*)	Tiger grouper (*Mycteroperca tigris*)	Warsaw grouper (*Epinephelus nigritus*)
Wreckfish (*Polyprion americanus*)	Yellowedge grouper (*Epinephelus flavolimbatus)*			
Porgies				
Grass porgy (*Calamus arctifrons*)	Jolthead porgy (*Calamus bajondo*)	Knobbed porgy (*Calamus nodosus*)	Longspine porgy (*Stenotomus caprinus*)	Red porgy (*Pagrus pagrus*)
Saucereye porgy (*Calamus calamus*)	Scup (*Stenotomus chrysops*)	Sheepshead (*Archosargus probatocephalus*)	Whitebone porgy (*Calamus leucosteus*)	
Jacks				
Almaco jack (*Seriola rivoliana*)	Banded rudderfish (*Serioloa zonata*)	Bar jack (*Caranx ruber*)	Blue runner (*Caranx crysos*)	Crevalle jack (*Caranx hippos*)
Greater amberjack (*Seriola dumerili*)	Lesser amberjack (*Seriola fasciata*)	Yellow jack (*Caranx bartholomaei*)		

Table 5-3. Species managed by the SAFMC under the Snapper-Grouper MU (SAFMC 2005a) (cont'd).

Grunts

Black margate (*Anisotremus surinamensis*)	Blue stripe grunt (*Haemulon sciurus*)	Cottonwick (*Haemulon melanurum*)	French grunt (*Haemulon flavolineatum*)	Margate (*Haemulon album*)
Porkfish (*Anisotremus virginicus*)	Sailors choice (*Haemulon parra*)	Smallmouth grunt (*Haemulon chrysargyreum*)	Spanish grunt (*Haemulon macrostomum)*	Tomtate (*Haemulon aurolineatum*)
White grunt (*Haemulon plumieri*)				

Tilefishes

Blueline tilefish (*Caulolatilus microps*)	Golden tilefish (*Lopholatilus chamaeleonticeps*)	Sand tilefish (*Malacanthus plumieri*)

Sea Basses

Bank sea bass (*Centropristis ocyurus*)	Black sea bass (*Centropristis striata*)	Rock sea bass (*Centropristis philadelphica*)

Triggerfishes

Gray triggerfish (*Baliste capriscus*)	Ocean triggerfish (*Canthidermis sufflamen*)	Queen triggerfish (*Balistes vetula*)

Wrasses

Hogfish (*Lachnolaimus maximus*)	Puddingwife (*Halichoeres radiatus*)

Spadefish

Atlantic spadefish (*Chaetodipterus faber*)

during daylight hours and can only fish in depths greater than 91 m (SAFMC 2006a). Longline fisheries operate farther from shore and stay out for longer periods of time compared to other snapper grouper fisheries (SAFMC 2006a). Most of the fisheries for this MU operate year-round with lower effort during winter or during highly active hurricane seasons (SAFMC 2006a). Pot effort for black sea bass typically occurs more heavily (i.e., set more pots) in the winter (November through March) than in the summer (SAFMC 2006a). In North Carolina and South Carolina, the black sea bass pot fishery is more of a winter fishery with most pots set at depths ranging from 9 to 37 m deep (SAFMC 2006a). In 2003, 2,267 pots were set from North Carolina through Florida, with North Carolina constituting 87% of these pots (SAFMC

2006a). In 2003, 906 vessels reported commercial landings of species within this fishery, with 81% of these vessels only operating part-time in these fisheries (SAFMC 2006a).

Current Regulations—Several closed areas/seasonal closures and various restrictions apply to this fishery in the VACAPES OPAREA (Figures 5-5 and 5-6):

- Bottom longline restrictions: North of St. Lucie Inlet, Florida (27°10'N), this gear type can only be used in waters of depths greater than 91 m. Furthermore, this gear type is prohibited for landing wreckfish (SAFMC 2005a).
- Black sea bass pot restrictions: The use of black sea bass pots is only permitted north of Cape Canaveral, Florida (28°35.1'N) (NOAA 1996; SAFMC 2005a).
- Longline gear species restriction: This gear type may only be used to land snowy grouper, warsaw grouper, yellowedge grouper, misty grouper, golden tilefish, blueline tilefish, and sand tilefish (SAFMC 2005a).
- Fish trap restriction: The use of fish traps to harvest species within the SAFMC's jurisdiction of this fishery is prohibited (SAFMC 2005a).
- Roller rig trawl restriction: The use of roller rig trawls to harvest species within the SAFMC's jurisdiction of this fishery is prohibited (SAFMC 2005a).
- Greater amberjack restriction: This fishery is closed during April. Additionally, no sales are allowed during this month (SAFMC 2005a).
- Red porgy restriction: From January to April, sale or purchase of this species is prohibited (SAFMC 2005a).
- Wreckfish restriction: From 15 January to 15 April, this fishery is closed to protect spawning wreckfish. Furthermore, this fishery is operating by an Individual Transferable Quota Program (i.e., no one other than shareholders may possess this species). Additionally, the use of bottom longline gear for this species is prohibited (NOAA 1996).
- Speckled hind and warsaw grouper restriction: Possession of only one of each is permitted per vessel trip within the U.S. Atlantic EEZ (NOAA 1996).
- Goliath grouper and Nassau grouper restriction: Harvest and possession is currently prohibited (SAFMC 2005a).

Status—Currently, ten species are overfished (red snapper, snowy grouper, red grouper, black sea bass speckled hind, warsaw grouper, black grouper, goliath grouper, Nassau grouper, and red porgy), while ten species are subject to overfishing (vermilion snapper, red snapper, snowy grouper, red grouper, black sea bass, gag, speckled hind, warsaw grouper, golden tilefish, and black grouper) (NMFS 2006a). The SAFMC is currently in the process of establishing Marine Protected Areas (MPAs) for overfished deepwater species in this fishery through their Snapper Grouper Amendment 14, it currently has been approved by the Council with the condition that a transit arrangement be instigated to allow fishermen to cross areas with fish onboard and gear stowed. The Council is expected to give final approval during the summer of 2007 (SAFMC 2007). The proposed deepwater MPAs will not be located within the VACAPES OPAREA.

5.2.1.10 Coastal Migratory Pelagic Fishery

Target Species—Cobia (*Rachycentron canadum*), king mackerel (*S. cavalla*), Spanish mackerel (*S. maculatus*), cero (*Scomberomorus regalis*), and little tunny (*Euthynnus alletteratus*).

Management—All species are co-managed by the GMFMC and the SAFMC under their Coastal Migratory Pelagic Resources FMP. These species are managed and catch is regulated for the Atlantic and Gulf separately by the appropriated FMC (i.e., the SAFMC manages species within the OPAREA) (GMFMC, SAFMC, MAFMC, and NMFS 2004). King mackerel, Spanish mackerel, and cobia are managed within the coastal migratory pelagics MU and commercial harvest is regulated, while the other species are not in the MU and commercial harvest is not regulated (SAFMC 2005a). Only the king mackerel, Spanish mackerel, and cobia are managed by the SAFMC in the Mid-Atlantic (i.e., Virginia through New York) (NOAA 1996).

Distribution—Off Florida and North Carolina, the king and Spanish mackerel are regarded as the two of the mostly highly targeted commercial species (GMFMC, SAFMC, MAFMC, and NMFS 2004).

Gear—For king mackerel, north of Cape Lookout, North Carolina, all gear types are permitted except for drift and long gillnets. South of Cape Lookout, North Carolina (34°37.3'N) automatic reel, bandit gear, handline, and rod and reel are used to harvest king mackerel (SAFMC 2005a). Automatic reel, bandit gear, handline, rod and reel, cast net, run around gillnet, and stab nets are authorized gear types for Spanish mackerel (Figures 5-4, 5-5, and 5-6; SAFMC 2005a). Off the coast of North Carolina, the use of gill nets is predominantly in state waters (GMFMC, SAFMC, MAFMC, and NMFS 2004). The Spanish mackerel commercial fishery harvest is divided into two groups to regulate quotas (i.e., from New York to Georgia is the northern group and the southern group is from the east coast of Florida south to the Miami-Dade/Monroe county border) (SAFMC 2005a). For cobia, automatic reel, bandit gear, handline, rod and reel, and pelagic longlines are allowed (SAFMC 2005a).

Current Regulations—The following regulations apply to this fishery in the VACAPES OPAREA (Figure 5-3):

- King mackerel gear restrictions: North of Cape Lookout, North Carolina (34°37.3'N) drift gillnets and long gillnets are prohibited (SAFMC 2005a).
- Mid-Atlantic coastal waters area: This closure was established as part of the Atlantic large whale take reduction plan to reduce incidental take of humpback, fin, and right whales by gillnets. Specific gear requirements are mandated from 1 December through 31 March in this region (NOAA and DoI 2006). This area is also designated as a MMA.
- Cobia restriction: Possession of more than two cobia per day is prohibited within the U.S. Atlantic EEZ (NOAA 1996).

Status—Commercial permits are required for king mackerel, Spanish mackerel, and bluefish. Currently, a moratorium exists for the issuing of new king mackerel permit (SAFMC 2005a). Currently, none of the three species are considered overfished or subject to overfishing (NMFS 2006a).

5.2.1.11 Dolphin Wahoo Fishery

Target Species—Common dolphfish (*Coryphaena hippurus*), pompano dolphinfish (*C. equiselis*), and wahoo (*Acanthocybium solandri*) (SAFMC 2003b).

Management—These species are managed by the SAFMC throughout the entire U.S. Atlantic coast (SAFMC 2003b; NMFS 2006a).

Distribution—This fishery primarily occurs along the U.S. Atlantic coast south of Virginia with harvests typically occurring from April through September (SAFMC 2003b). Those commercial harvesters that rely on longline gear also target highly migratory species (e.g., swordfish and sharks) in addition to dolphfishes and wahoo (SAFMC 2003b). The heaviest fishing effort occurs near the Gulf Stream (SAFMC 2003b). Landings are typically highest off Florida, followed by North Carolina, South Carolina, and then Georgia (SAFMC 2003b).

Gear—Pelagic longlines, hook-and-line gear, bandit gear, handline, and spearfishing gear (including powerheads) are permissible gear types for these fisheries (NMFS 2006a; SAFMC 2005a) (Figures 5-5 and 5-6). For dolphinfishes, longlines and hook-and-line are the two primary gear types utilized (SAFMC 2003b).

Current Regulations—The following is a list of major closed areas for this fishery in the VACAPES OPAREA (Figure 5-6):

- Charleston Bump Closed Area: This area is closed from 1 February to 30 April annually to pelagic longline gear for all highly migratory species and species in the dolphin wahoo fishery (NMFS 2006a; 2005b). This area is also designated as an MMA (NOAA and DoI 2006).

Status—Permits (i.e., dealer permit, commercial vessel permit, charter vessel/headboat permit, or operator permit) are required to harvest dolphinfishes and wahoo (SAFMC 2003b, NMFS 2006a). Approximately, 1,300 vessels are active in this fishery (NMFS 2006a). All species in this fishery are not overfished or subject to overfishing (NMFS 2006a).

5.2.1.12 Golden Crab Fishery

Target Species—Red deepsea crab (*Geryon quinquedens*), Jonah crab (*Cancer borealis*) and golden deepsea crab (*Chaceon fenneri*)

Management—Management of the golden deepsea crab is regulated by the SAFMC under their Golden Crab FMP. Only the golden deepsea crab is part of the MU and harvest is regulated (SAFMC 1999a).

Distribution—This fishery is divided into three zones: northern (EEZ north of 28°N within the SAFMC jurisdiction [North Carolina/Virginia border]), middle (EEZ from 25°N to 28°N), and southern (EEZ from 25°N south to SAFMC jurisdiction) (SAFMC 1999a). Only the northern zone occurs within the VACAPES OPAREA. The greatest number of landings for this species occurs primarily off southeastern Florida from December through May and not in the VACAPES OPAREA (SAFMC 1999a). Little is known about the biomass or amount of suitable habitat available for this species in the SAB (SAFMC 1999a). In the SAB, most effort occurs from depths of 350 to 550 m (SAFMC 1999a).

Gear—For this fishery, traps are the only permissible gear type (SAFMC 2005a) (Figure 5-5).

Current Regulations—Numerous regulations apply to this fishery in the VACAPES OPAREA (Figure 5-4):

- Golden crab depth restrictions: Harvest of this species in the northern zone must occur in depths greater than 275 m (SAFMC 2002).

Status—Permits are required for this fishery and permits are issued by zone (SAFMC 1999a; SAFMC 2005a). In 1998, out of the 35 permits issued by NMFS for this fishery, only two were issued for the northern zone (SAFMC 1999a). This species is not considered overfished (NMFS 2006a).

5.2.1.13 Spiny Lobster Fishery

Target Species—The Caribbean spiny lobster (*Panulirus argus*) is the only species in the MU, but other species are taken incidentally in this fishery (spotted spiny lobster [*P. guttatus*], smooth tail lobster [*P. laevicauda*], slipper lobster [*Scyllarides nodifer*] and Spanish lobster [*S. aequinoctialis*]) (GMFMC and SAFMC 1982).

Management—The spiny lobster fishery is co-managed by the SAFMC and GMFMC via the Spiny Lobster FMP.

Distribution—Over 60% commercial landings for this species occur in federal waters and in depths typically less than 60 m off Florida (GMFMC and SAFMC 1982). Most of the effort for this fishery occurs off the Florida Keys (90% of total landings) or Florida's west coast and not in the VACAPES OPAREA (SAFMC 1999b). In North Carolina, South Carolina, and Georgia year-round harvest is permitted, while in Florida, harvest is closed from 1 April to 5 August annually (SAFMC 2005a).

Gear—Traps, pots, dip nets, bully nets, or snares are permissible gear types for this fishery (Figure 5-5; SAFMC 2005a). This fishery is typically considered to be a small boat-based fishery with average vessel size ranging from 6 to 12 m (SAFMC 1999b). In 1996, 30 vessels were registered in this fishery (SAFMC 1999b).

Current Regulations—Gear regulations exist for the harvest of this species, and there are closed areas south of the VACAPES OPAREA (SAFMC 2005a). A permit is required to harvest this species (SAFMC 2005a).

Status—Currently, the status of this species is unknown (NMFS 2006a).

5.2.1.14 Highly Migratory Species Fishery

Target Species—The fishery for highly migratory species consists of tuna, marlin, oceanic sharks, sailfishes, spearfish, and swordfish species. Billfishes (marlin and sailfish) may only be harvested in recreational fisheries (NMFS 2006b). Recreational or commercial anglers may land Longbill spearfish (NMFS 2006b).

Management—Highly migratory species are managed by the NMFS through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Distribution—Effort for these fisheries occurs throughout the U.S. Atlantic coast (NMFS 2006e). Most shark species in the region are landed off North Carolina or off eastern Florida (NMFS 2003a).

Gear—Pelagic longlines, bottom longlines, rod and reel, and bandit gear are permitted to harvest most HMS species. Gillnets are only permitted for the harvest of sharks, traps and purse seines are only permitted to target tunas (NMFS 2006b, 2005e) (Figures 5-4, 5-6, and 5-8). Driftnets are prohibited for the harvesting of any Atlantic tuna species (NMFS 2006b).

The pelagic longline fishery primarily harvests swordfish, yellowfin tuna, and bigeye tuna and secondarily targets albacore tuna and several pelagic and large coastal shark species. Depth, hook type, and other parameters can be modified to target different species (e.g., lines are set deeper for tuna and shallower for swordfish). Pelagic longlines also incidentally catch other non-targeted species, including marine mammals and sea turtles. Purse seines most commonly land bluefin, yellowfin, and skipjack tuna species. Handgear (e.g., handlines, harpoons, rod and reel, and bandit gear) primarily target tuna and swordfish. Sharks are harvested via drift gill nets and bottom longlines. Sandbar and blacktip sharks are the two large coastal species that account for highest landings in this fishery, while the finetooth and Atlantic sharpnose shark are the two small coastal species most commonly taken. The shortfin mako is the most commonly landed pelagic shark species (NMFS 2006e).

Current Regulations—The following regulations apply to this fishery along the U.S. Atlantic Coast (Figure 5-6). Other closures are being considered by NMFS (2006e):

- Charleston Bump Closed Area: This area is closed from 1 February to 30 April annually to pelagic longline gear for all highly migratory species (NMFS 2006e). This area is also designated as an MMA (NOAA and DoI 2006).
- Mid-Atlantic Shark Closed Area: This area is closed from 1 January to the end of the second week in July annually to bottom longline gear for all highly migratory species. (NMFS 2006e).
- Mid-Atlantic coastal waters area: This closure was established as part of the Atlantic large whale take reduction plan to reduce incidental take of humpback, fin, and right whales by gillnets. Specific gear requirements are mandated from 1 December through 31 March in this region (NOAA and DoI 2006). This area is also designated as a MMA.
- Swordfish season: The swordfish season ranges from 1 June to 31 May each year (NMFS 2006e).

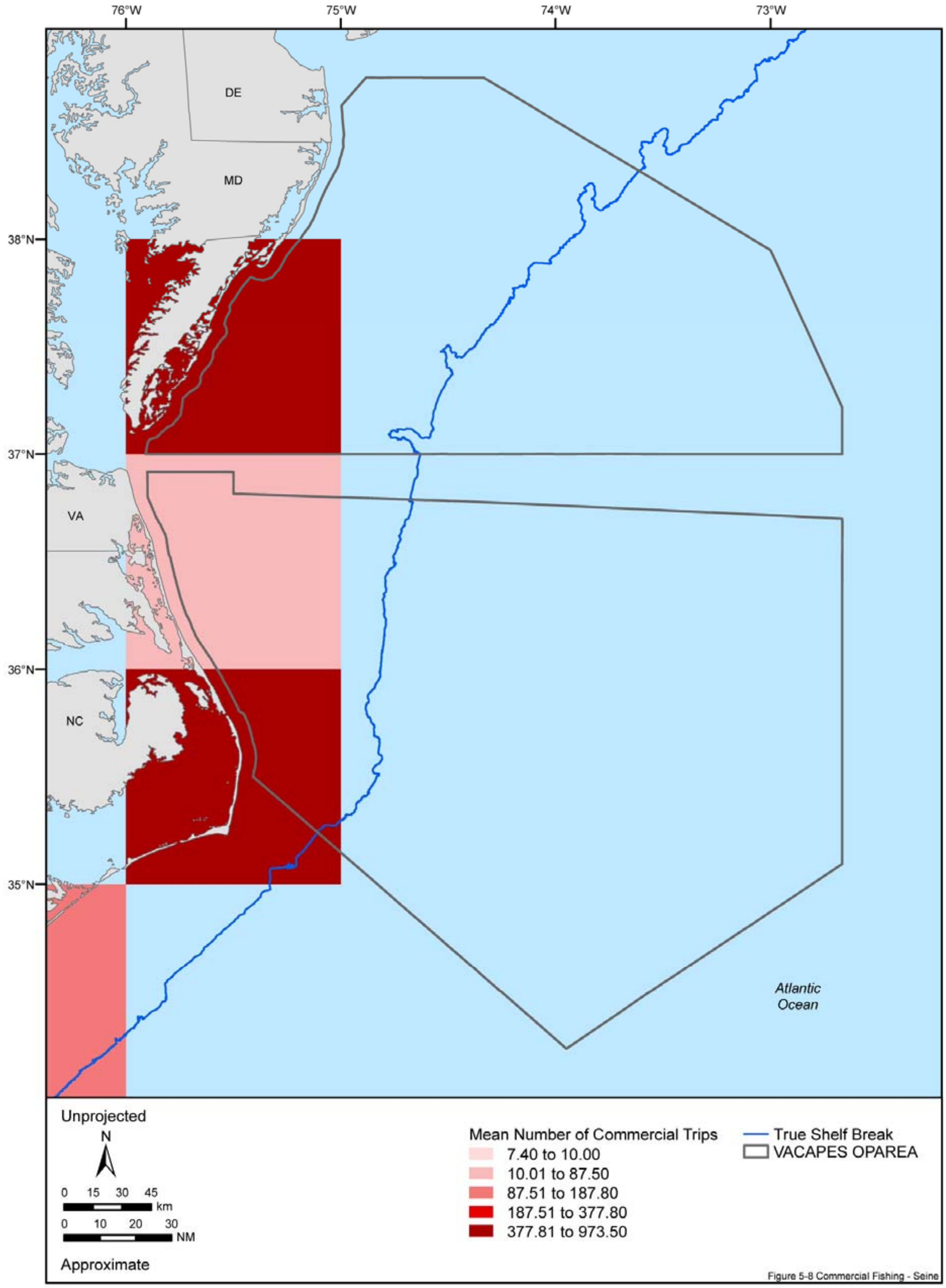

Figure 5-8. Distribution of fishing effort and closures relevant to the seine gear commercial fisheries in Virginia Capes OPAREA and vicinity. Fishing effort is displayed as the average number of trips from 2000 to 2004. Source information: ACCSP (2006a).

- Tuna season: For all species, except the bluefin tuna (see below), the fishing season ranges from 1 June to 31 May (NMFS 2006e).
- Bluefin tuna seasons (NMFS 2006e):
  - General—1 June to 31 January (or until quota is filled)
  - Harpoon—1 June to 15 November (or until quota is filled)
  - Purse seine—15 July to 31 December (or until quota is filled)
  - Longline—1 June to 31 May (or until quota is filled)
  - Trap—1 June until 31 May (or until quota is filled)

Status—Quotas for this fishery along the U.S. Atlantic coast are divided into two regions: North Atlantic (Maine to Virginia) and South Atlantic (North Carolina to east coast of Florida). For sharks, the fishing year is divided into three trimesters. The use of bottom and pelagic longline gear require federal permits. Additionally, commercial harvesting of Atlantic bluefin, bigeye, yellowfin, albacore, and skipjack tuna requires federal permits. The harvest of swordfish requires a federal permit, as well, but the NMFS is no longer issuing new permits for this species (NMFS 2006b). In 2005, 1,144 permits were issued for highly migratory species (i.e., 222 longline permits were issued for tuna, 189 permits for the direct harvest of swordfish, 90 incidental swordfish, 229 permits for the direct harvest of sharks, and 321 for the incidental harvest of sharks)(NMFS 2005e). Many of these permit holders have multiple permits (NMFS 2006e).

Twenty species of sharks may be landed and retained in the VACAPES OPAREA (Table 5-4). Twenty-eight species of commercially harvested HMS currently have an overfished status (NMFS 2006a) (Table 5-5). Additionally, the yellowfin tuna is approaching an overfished condition (i.e., estimated that the fishery will become overfished within 2 years) (NMFS 2006a).

Table 5-4. Retainable Shark Species (NMFS 2006b).

Large Coastal Sharks			
Blacktip shark (*Carcharhinus limbatus*)	Bull shark (*Carcharhinus leucas*)	Great hammerhead shark (*Sphyrna mokarran*)	Lemon shark (*Negaprion brevirostris*)
Nurse shark (*Ginglymostoma cirratum*)	Sandbar shark (*Carcharhinus plumbeus*)	Scalloped hammerhead shark (*Sphyrna lewini*)	Silky shark (*Carcharhinus falciformis*)
Smooth hammerhead shark (*Sphyrna zygaena*)	Spinner shark (*Carcharhinus brevipinna*)	Tiger shark (*Galeocerdo cuvier*)	
Small Coastal Sharks			
Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)	Blacknose shark (*Carcharhinus acronotus*)	Bonnethead shark (*Sphyrna tiburo*)	Finetooth shark (*Carcharhinus isodon*)
Pelagic Sharks			
Blue shark (*Prionace glauca*)	Oceanic whitetip shark (*Carcharhinus longimanus*)	Porbeagle shark (*Lamna nasus*)	Shortfin mako shark (*Isurus oxyrinchus*)
Thresher shark (*Alopias vulpinus*)			

Table 5-5. Overfished commercially harvested highly migratory species (NMFS 2006b; 2006a).

Pelagic Sharks (cont'd)			
Albacore tuna (*Thunnus alalunga*)	Caribbean reef shark (*Carcharhinus perezi*)	Nurse shark (*Ginglymostoma cirratum*)	Tiger shark (*Galeocerdo cuvier*)
Basking shark (*Cetorhinus maximus*)	Dusky shark (*Carcharhinus obscurus*)	Sailfish (*Istiophorus platypterus*)	Whale shark (*Rhincodon typus*)
Bigeye sand tiger shark (*Odontaspis noronhai*)	Finetooth shark (*Carcharhinus isodon*)	Sand tiger shark (*Carcharias taurus*)	White shark (*Carcharodon carcharias*)
Bigeye tuna (*Thunnus obesus*)	Galapagos shark (*Carcharhinus galapagensis*)	Sandbar shark (*Carcharhinus plumbeus*)	White marlin (*Tetrapturus albidus*)
Bignose shark (*Carcharhinus altimus*)	Great hammerhead shark (*Sphyrna mokarran*)	Scalloped hammerhead shark (*Sphyrna lewini*)	
Blue marlin (*Makaira nigricans*)	Lemon shark (*Negaprion brevirostris*)	Silky shark (*Carcharhinus falciformis*)	
Bluefin tuna (*Thunnus thynnus*)	Narrowtooth shark (*Carcharhinus brachyurus*)	Smooth hammerhead shark (*Sphyrna zygaena*)	
Bull shark (*Carcharhinus leucas*)	Night shark (*Carcharhinus signatus*)	Spinner shark (*Carcharhinus brevipinna*)	

5.2.1.15 Other species of importance

The Atlantic menhaden are considered one of the largest commercial fisheries along the U.S. Atlantic coast in terms of landing size (ranked 2nd in the nation) (NMFS 2007; SAI and Loftus 2006). This species is harvested to produce oils, meal, and other products, and is also a bait fishery (SAI and Loftus 2006). Oils from the menhaden contain omega-3 fatty acids which have been marketed as a health supplement, with the company Omega Protein, based out of Reedville, Virginia, harvesting an estimated 90% of the industrial catch (CBF 2004a). Menhaden is harvested using seines with Chesapeake Bay being the dominant region for this fishery (Smith 1999; SAI and Loftus 2006). North Carolina ranks second in this fishery. Effort is concentrated from June through September off Mid-Atlantic (primarily Virginia) states and from November through January off North Carolina (Smith 1999). In 2004, this fishery brought $24.1 million dollars (181,347 metric tons) to Virginia and $1.9 million dollars (24,020 metric tons) to North Carolina (NMFS 2005e). Though the majority of this fishery occurs in state waters, 10% occurs in federal waters (NMFS 2005a). Due to recent concerns about overharvesting of Atlantic menhaden, Viriginia's governor, Tim Kaine, implemented steps (i.e., cap on industrial harvest) in the summer of 2006 to control and sustain the harvest of this species in the Chesapeake Bay (CCA 2006).

5.2.1.16 Ports

There are eleven major ports/port areas (i.e., Hampton Roads area) that support the commercial fishing industry in the VACAPES OPAREA and vicinity. Reedville, Virginia ranks highest in terms of landings mass, primarily due to the harvest of menhaden, while the Hampton Roads area ranks highest in terms of monetary value (Table 5-6; Figure 5-9).

Table 5-6. Major commercial fishing ports in the Virginia Capes OPAREA and vicinity for 2004, unless otherwise indicated (Mcay and Cieri 2000; NMFS 2007).

Port Location	Landings weight (metric tons)	Landing value (millions)
Delaware		
Mispillion-Brower Beach (1998 data)	1,163	$1.8
New Castle County (1998 data)	862	$1.5
Port Mahon-Indian River (1998 data)	783	$1.1
Maryland		
Ocean City (2003 data)	4,127	$6.6
Virginia		
Cape Charles-Oyster (1998 data)	1,179	$1.4
Chincoteague (2005 data)	2,132	$14.7
Hampton Roads Area (Newport News, Hampton, Virginia Beach) (2005 data)	10,660	$85.2
Reedville (2005 data)	12,292	$27.1
North Carolina		
Elizabeth City (1996 data)	2,948	$5.4
Engelhard-Swanquarter (2005 data)	2,404	$5.3
Wanchese-Stumpy Point (2005 data)	8,900	$19.6

5.2.2 Recreational Fishing

Marine recreational fishing is both a popular and profitable activity along the eastern coast of the United States (Table 5-7). The continental shelf break, located near the VACAPES OPAREA and the close proximity to Cape Hatteras, stimulates the potential for marine recreational fishing. The Gulf Stream is another unique oceanographic feature that heightens the appeal for recreational fishing in this area. Warm waters of the Gulf Stream supply dispersed eggs and larvae of southern subtropical-tropical fish species to the North Carolina continental shelf and provide the warm temperatures needed for their existence at temperate latitudes (Govoni and Spach 1999). Additionally, extensive bays and estuaries support nursery grounds for juvenile fishes, while artificial reefs, shipwrecks and natural hard-bottom substrate on the continental shelf provide habitat for varied communities of reef fish and invertebrates (Steimle and Zetlin 2000; Street et al. 2005). Offshore recreational fishing has been aided by an increase in angler mobility. This sport supports a thriving onshore goods and services economy and has experienced a rise in popularity in recent years (Gillis and Millikin 1999).

5.2.2.1 Fishing Activity Statistics

Six million saltwater fishing trips were undertaken in the four states bordering the VACAPES OPAREA, of those, almost 5 million were out of North Carolina (ACCSP 2006b). Of these, approximately 11% (533,133) were in federal waters (3 to 200 nm offshore). Thus, most recreational effort is concentrated in state waters outside the boundaries of the VACAPES OPAREA.

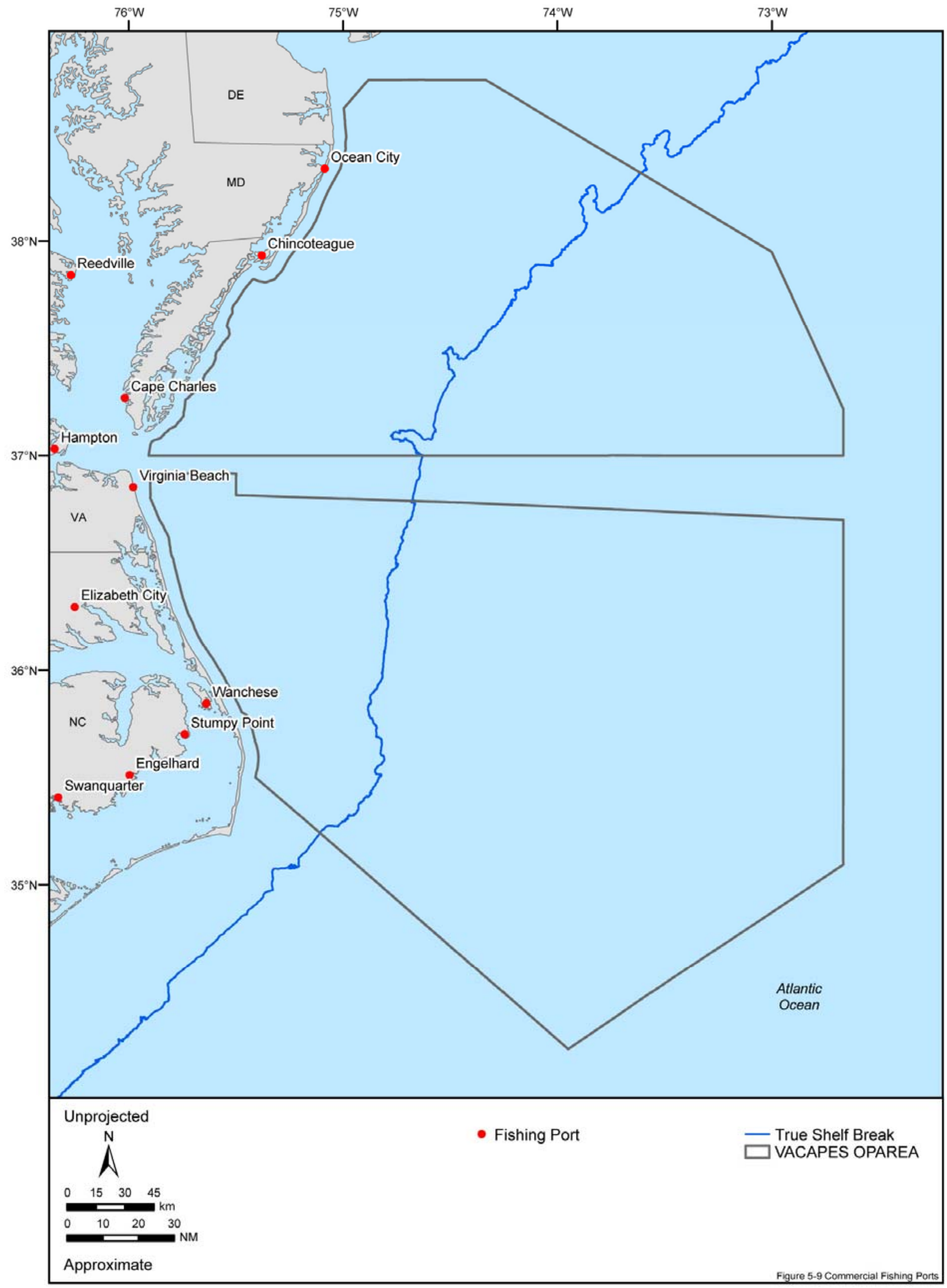

Figure 5-9. Major commercial fishing ports in the Virginia Capes OPAREA and vicinity. Source information: NMFS (2007).

Table 5-7. Number of marine recreational fishing trips from Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and eastern Florida from 2000 through 2004 (ACCSP 2006).

	Delaware	Maryland	Virginia	North Carolina	South Carolina	Georgia	Eastern Florida
Federal Waters (3 to 200 NM from shore)	93,475	112,455	150,408	533,133	105,701	34,604	1,620,083
Inshore & State Waters (<3 NM from shore)	119,373	152,044	413,530	4,257,821	814,406	178,798	4,348,774
Total	212,848	264,500	563,938	4,790,954	920,107	213,402	5,968,857

Recreational saltwater fishing is either an onshore or boat-based activity. Three modes of fishing exist in the VACAPES OPAREA and its vicinity: shore, private/rental, and charter. Shore-based fishing refers to fishing that takes place from the beach, jetty, bank, pier, or any shore-based structure that extends into or over the water, and accounts for a large percentage of overall fishing in North Carolina (Figure 5-9). Private and rental boat trips include any fishing that takes place from either a personal or rented boat. Charter companies offer fishing service to those who do not own their own boats or fishing gear. A single group of fishermen usually hire charter boats on a per-trip basis, while head boats are regularly scheduled, taking groups of anglers who pay a flat rate per fishermen. Several advantages exist for charter and head boats as compared to private rentals. Charter and head boats are generally capable of traveling further distances than private boats and professional captains are typically more experienced than private boat operators (Abbas 1978).

Charter and head boats usually perform full day trips, and some charter boats may occasionally spend nights at sea (Abbas 1978). However, despite the greater capabilities of charter boats and headboats, private or rental boats trips are more popular in North Carolina, Virginia, Maryland, and Delaware (Figure 5-10).

Methods of recreational fishing include rod and reel, trolling, and spearfishing. Depending upon sea conditions or on the target species, vessels rigged for trolling may occasionally remain stationary and fish with rod and reel (Abbas 1978). While fishing with rod and reel, a vessel may remain anchored or secured to a structure; alternatively, it may be allowed to drift. Spearfishing is not as common as other forms of recreational fishing, yet occurs in North Carolina mainly near artificial reefs and wrecks. Boats are used to reach fishing sites and scuba gear may be employed while spearfishing.

In addition to typical recreational fishing, North Carolina offers a recreational commercial gear license, which is an annual license that allows recreational anglers to use limited amounts of commercial gear to harvest species for their personal consumption. Such harvest cannot be sold (NCDMF 2006a). There are only certain gear authorized and various regulations associated with each (NCDMF 2005). In 2005, of the 46,935 recreational commercial gear license trips, 48% used small and large mesh gill nets, 43% used crab pots, 5% used shrimp trawls, 2% fish pots, and the other 2% used other commercial gear types (e.g., seines) (NCDMF 2006b).

Recreational fishing effort varies seasonally in the VACAPES OPAREA. The majority of boat-based fishing trips occur from July through August, while the least activity occurs during the winter months of January and February (Strand et al. 1991).

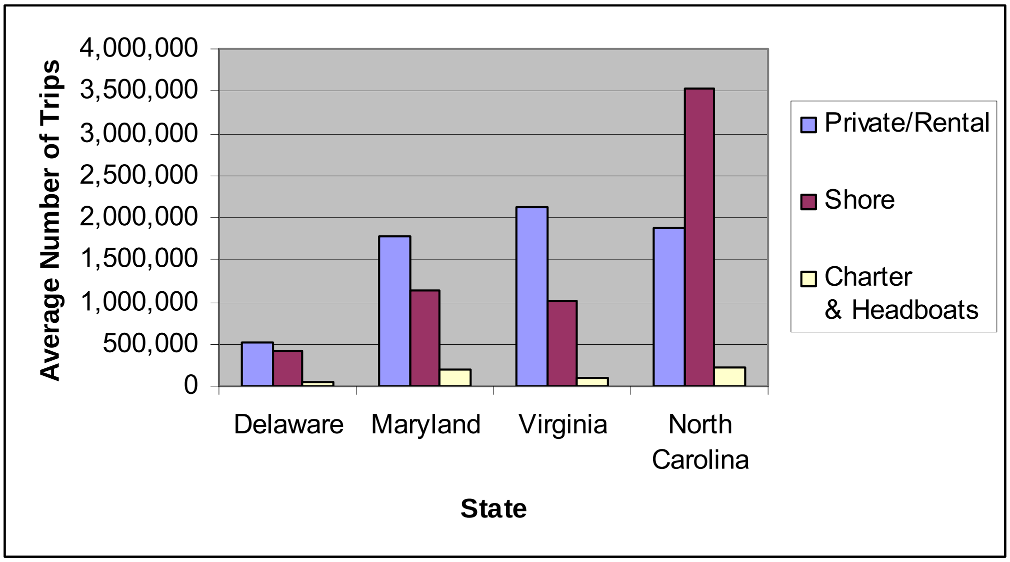

Figure 5-10. Average number of recreational fishing trips originating from Delaware, Maryland, Virginia, and North Carolina by fishing mode during 1995 through 2004. Source data: NMFS (2007).

5.2.2.2 Fish Species

The distribution and abundance of game fish varies seasonally as well as annually. Biotic and abiotic factors such as habitat, nutrients, prey availability, currents, spawning behavior, fishing pressure, and strength of fishery stocks play a role in determining the timing and locations of fish presences. Reef fishes and coastal pelagic fishes are targeted over the continental shelf, while big-game fishes are mainly targeted near the shelf break and beyond (Huntsman and Manooch 1978). Flat and open bottom expanses of the continental shelf are considered areas of low productivity and support few recreational fish species. Preferred fishing areas are associated with bottom relief, hard-bottom communities, and canyon heads near the shelf break. Although coastal pelagic fisheries range widely over the continental shelf, greater numbers of fish tend to be caught near artificial reefs and *Sargassum* weed lines (Huntsman and Manooch 1978).

A variety of game fish are targeted recreationally in the VACAPES OPAREA. Bottom fishermen target fishes near structures such as artificial reefs, rock outcrops, and canyons. Popular gamefish in the VACAPES OPAREA include bigeye tuna, bluefin tuna, yellowfin tuna, bluefish, cobia, cod, dolphinfish, king mackerel, Spanish mackerel, sharks, blue marlin, white marlin, sailfish, sea trout, and wahoo (Ross 1998). Recreationally targeted bottom fishes include summer flounder, black sea bass, snappers, groupers, and porgies. Surface and mid-water fishing for coastal pelagic fishes are also popular, targeting game species such as mackerels, bluefish, dolphinfish, wahoo, and cobia. Trolling and chumming (the release of blood and fish parts into the water) target big game tunas, billfish, and sharks (Huntsman and Manooch 1978). Fishermen commonly fish at *Sargassum* weed lines for dolphinfish and wahoo. From 1996-2005, the most popular fish species landed by recreational fishermen in VACAPES OPAREA were bluefish, dolphinfish (off North Carolina), drum, flounder, porgies (off North Carolina) grouper/sea basses, temperate basses, and tuna/mackerels (Table 5-8) (NMFS 2007).

5.2.2.3 Recreational Fishing Hotspots

Recreational anglers focus their efforts in specific locations generally associated with subtle habitat features that concentrate fishes. Most hotspots are located between shore and the shelf break (Figure 5-11), given the limited range of most recreational fishing boats and the difficulty of fishing for demersal fishes in deep waters beyond the shelf break. The majority of the productive fishing areas in the

Table 5-8. Average annual recreational landings (metric tons) of each major species group from 1996 through 2005 (NMFS 2007).

Species Group	Delaware	Maryland	Virginia	North Carolina
Barracudas	0.0	0.0	2.4	14.1
Bluefish	85.1	254.1	194.0	411.3
Cartilaginous Fishes	14.4	8.5	8.7	7.3
Catfishes	7.9	124.7	40.4	0.2
Cods and Hakes	0.2	1.2	0.2	0.1
Dolphinfishes	6.7	38.0	51.9	2,071.8
Drums	52.8	156.1	391.5	137.5
Eels	0.1	0.1	0.1	0.2
Flounders	73.7	90.2	303.6	67.4
Grunts	0.1	0.1	10.5	34.7
Herrings	1.7	3.8	2.8	2.0
Jacks	0.0	0.0	3.4	17.6
Mullets	0.0	0.0	0.4	103.8
Other Fishes	1.1	42.0	261.2	112.4
Porgies	0.6	3.8	2.5	33.2
Puffers	1.4	0.4	2.3	30.7
Groupers & Sea Basses	67.7	87.1	115.5	34.2
Searobins	0.4	0.2	0.6	0.0
Snappers	0.0	0.0	0.0	4.8
Temperate Basses	67.9	586.8	475.5	270.7
Toadfishes	0.1	0.1	0.1	0.0
Triggerfishes/Filefishes	3.3	8.3	8.5	22.6
Tunas & Mackerels	41.9	143.5	84.4	844.1
Wrasses	69.6	20.3	111.3	6.4
All Species	**496.6**	**1,569.5**	**2,0111.7**	**4,227.0**

VACAPES OPAREA and vicinity are located along the continental shelf (Ross 1998). Favored fishinghotspots may change over time in response to changes in fish populations or communities, changes in preferred target species, or changes in fishing modes and styles.

5.2.2.4 Tournaments

Organized fishing tournaments are popular in North Carolina (Figure 5-12; Table 5-9). Some tournaments have weigh-in categories for a number of species. Seasonally, the greatest number of tournaments occurs in the summer months (July through September). Organizations and companies usually sponsor the various tournaments. Each tournament has its own set of rules, which include time limits and geographical boundaries. The maximum distance typically traveled by offshore tournament participants in 75 NM from the tournament host site. The sites fished by anglers within the tournament zones are still dependent on several factors including the species targeted, tournament rules, or weather. Among the different tournaments, the level of participation varies between individual events, seasons, and years. Although most tournaments are annual events, the scheduled list of tournaments is not static. Existing tournaments may be cancelled due to a lack of participation or support. New tournaments may be organized as well. The exact dates of annual tournaments will vary slightly from year to year.

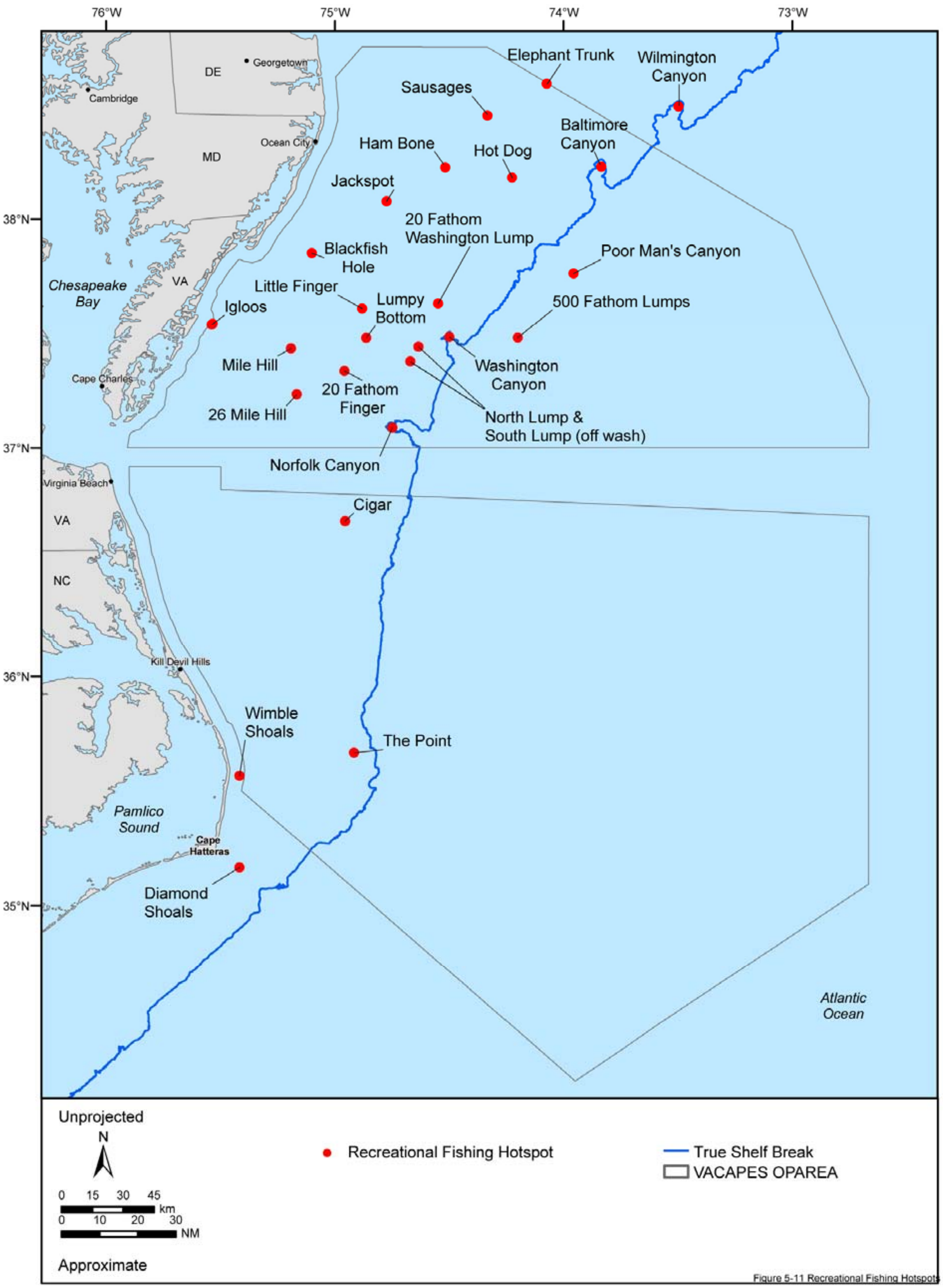

Figure 5-11. Recreational fishing hotspots in the Virginia Capes OPAREA and vicinity. Source information: Coastal Guide (2007), Fishermans Post (2005), Freeman et al. (1976).

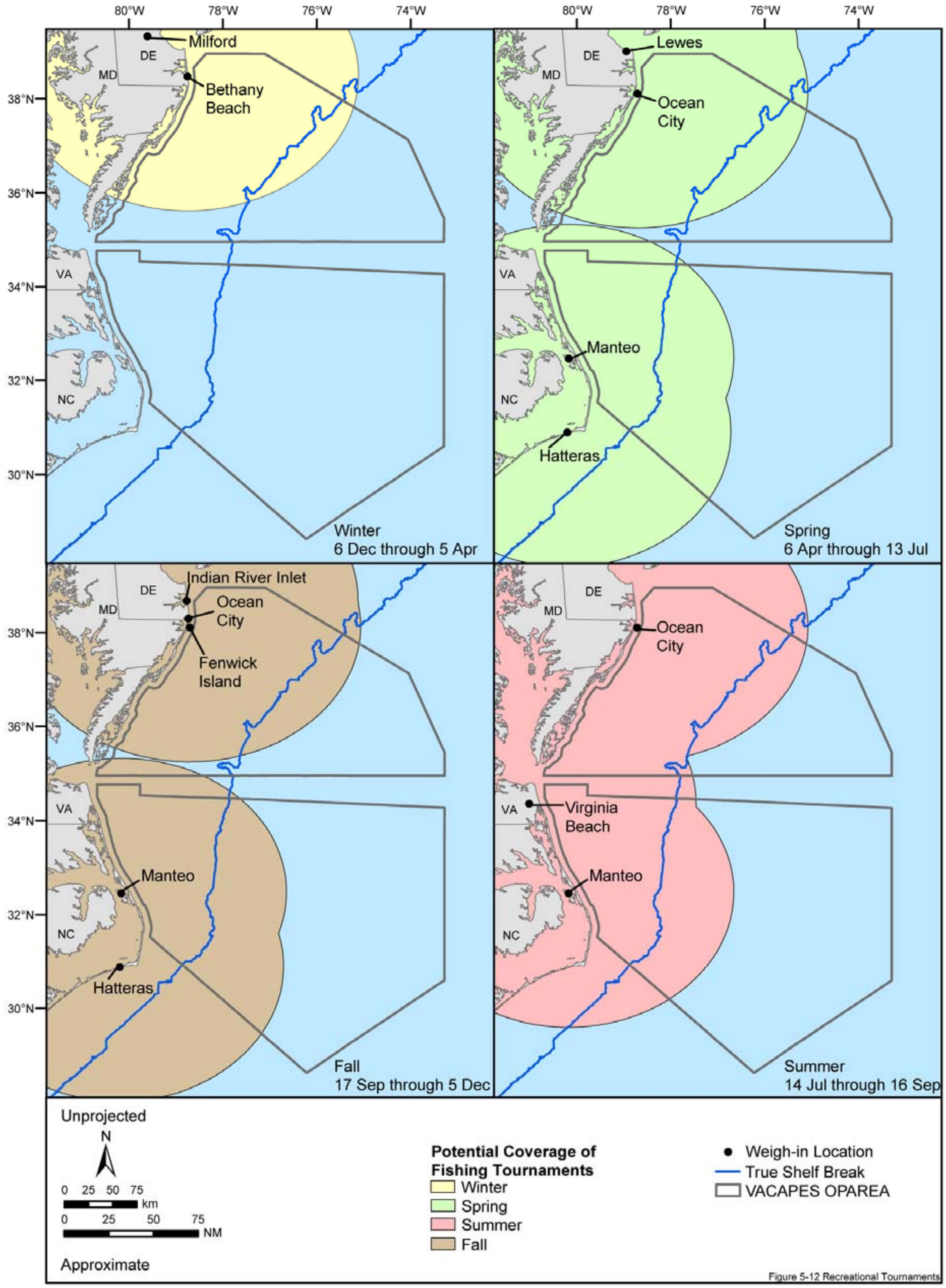

Figure 5-12. Potential area covered by recreational fishing tournaments in the Virginia Capes OPAREA and vicinity by season. Source data: Coastal Fisherman (2007), CWC (2007), Sinclair Communications (2007), and VBBT (2007).

Table 5-9. Major recreational fishing tournaments in the Virginia Capes OPAREA and vicinity in 2007 (Coastal Fisherman 2007; CWC 2007; Sinclair Communications 2007; and VBBT 2007).

Date	Weigh-In City	Tournament	Species
Delaware			
12 May	Bethany-Fenwick	Bethany-Fenwick Spring Surf Fishing Tournament	Flounder
Maryland			
All summer	Ocean City	Ocean City Inshore & Offshore Challenge 2005	Multispecies
14 Jun-16 Jun	Ocean City	28th Annual Ocean City Shark Tournament	Shark, Bluefish, Tuna
22 Jun-24 Jun	Ocean City	27th Annual Small Boat Tournament	Multispecies
5 Jul-8 Jul	Ocean City	24rd Annual Canyon Kick-Off	Dolphin, Wahoo, Tuna, Billfish
12 Jul-15 Jul	Ocean City	19th Annual Ocean City Tuna Tournament	Tuna
12 Jul-15 Jul	Ocean City	20th Annual Tuna Mania Roundup Tournament	Tuna, Dolphinfishfish
20 Jul-22 Jul	Ocean City	12th Annual Marina Shootout	Dolphin, Wahoo, Tuna, Billfish
27 Jul-29 Jul	Ocean City	2ndst Annual Marlin Kids' Classic	Marlin
6 Aug-10 Aug	Ocean City	34rth Annual White Marlin Open	White Marlin
16 Aug-18th Aug	Ocean City	14th Annual Capt. Steve Harman Poor Girls Open	Tuna, Dolphinfish, Billfish
30 Aug-2 Sept	Ocean City	49th Annual Labor Day White Marlin Tournament	Dolphin, Wahoo, Tuna, Billfish
13 Sept-15 Sept	Ocean City	29th Annual Challenge Cup	Marlin
To be determined	Ocean City	8th Annual Rocktoberfest Tournament	Rockfish, Sea Trout, Tautog, Flounder
27-Oct	Ocean City	13th Annual Halloween Rockfish Tournament	Rockfish

Table 5-9. Major recreational fishing tournaments occurring in the VACAPES OPAREA and vicinity in 2007 (Coastal Fisherman 2007; CWC 2007; Sinclair Communications 2007; VBBT 2007) (cont'd).

Virginia			
11 Jul-14 Jul	Virginia Beach	Virginia Beach Tuna Tournament	Tuna
22 Aug-25 Aug	Virginia Beach	Virginia Beach Billfish Tournament	Billfish
North Carolina			
16 May-19 May	Hatteras	Hatteras Village Offshore Open	Billfish
10 May-15 May	Wilmington	Annual Cape Fear Blue Water Open	Tuna, Dolphinfish, Wahoo
25 May-27 May	Manteo	Pirate's Cove Memorial Weekend Tournament	Billfish, Tuna, Dolphinfish, Wahoo
25 May-27 may	Manteo	Annual Cobia Tournament	Cobia
31 May -02 Jun	Bald Head Island	14th Annual Bald Head Island Fishing Rodeo	Wahoo, Dolphinfish, Billfish
25 May-27 May	Manteo	Pirate's Cove Memorial Weekend Tournament	Billfish, Tuna, Dolphinfish, Wahoo
25 May-27 may	Manteo	Annual Cobia Tournament	Cobia
31 May -02 Jun	Bald Head Island	14th Annual Bald Head Island Fishing Rodeo	Wahoo, Dolphinfish, Billfish
09-Jun	Morehead City	Lady Angler Tournament, Big Rock Blue Marlin Tournament	Blue Marlin
09 Jun-16 Jun	Morehead City	Big Rock Blue Marlin Tournament	Blue Marlin
22 Jun-23 Jun	Manteo	Pirates Cove Annual Small Fry Tournament	Bluefish, Spot, Flounder
2 Jul-3 Jul	Manteo	Pirates Cove Annual Cobia Tournament Weekend	Cobia
05 Jul-08 Jul	Wrightsville Beach	Cape Fear Blue Marlin Tournament	Blue Marlin
19 Jul-21 Jul	Beaufort	Barta Boys and Girls Club Billfish Tournament	Billfish
20 Jul-22 Jul	Manteo	Annual North Carolina Boat Builders Challenge	Blue marlin, White Marlin, Sailfish, Spearfish, Wahoo, Tuna, Dolphinfish

Table 5-9. Major recreational fishing tournaments occurring in the VACAPES OPAREA and vicinity in 2007 (Coastal Fisherman 2007; CWC 2007; Sinclair Communications 2007; VBBT 2007) (cont'd).

27 Jul-29 Jul	Oriental	13th Annual Oriental Rotary Tarpon Tournament	Tarpon
3-Aug-5 Aug	Oak Island	Long Bay Lady Anglers King Mackerel Tournament	King Mackerel
11-Aug	Sneads Ferry	Annual Sneads Ferry Rotary King Mackerel Tournament	King Mackerel
13 Aug- 18 Aug	Manteo	Pirate's Cove Annual Billfish Tournament	Billfish
31-Aug-02 Sept.	Manteo	Annual Allison White Marlin Release Tournament	White Marlin
9 Sept.-10 Sept.	Atlantic Beach	Atlantic Beach King Mackerel Tournament	King Mackerel
18-Oct-20 Oct.	Wrightsville Beach	Wrightsville Beach King Mackerel Tournament	King Mackerel
21 Sep.-23 Oct.	Swansboro	Onslow Bay Open King Mackerel Tournament	King Mackerel
5 Oct.-6 Oct.	Southport	U.S. Open King Mackerel Tournament	King Mackerel
6 Oct.	Southport	Captain Charlies Kids Fishing Tournament	King Mackerel
31 Aug-1Sept.	Beaufort	Drum Inlet King Mackerel Tournament	King Mackerel
17 Oct.-20 Oct.	Morehead City	Calcutta Wahoo Challenge	Wahoo
8 Nov.-10 Nov.	Hatteras	Cape Hatteras Anglers Club Team and Open Individual Invitational Tournaments	Red drum, Bluefish
12-Nov.	Belhaven	Annual Fishing Tournament	Rockfish
10-Nov.	Swansboro	Friendly City Speckled Trout Tournament	Speckled Trout
30 Nov.-01 Dec.	Manteo	Manteo Rotary Rockfish Rodeo	Rockfish

5.3 ESSENTIAL FISH HABITAT DISTRIBUTION AND SPECIES

As mentioned in 1.3.1, the MSFCMA contains an Essential Fish Habitat (EFH) provision which was put forth to conserve fish habitat. Within the VACAPES OPAREA, fishes, invertebrate, and macroalgae species are managed or co-managed by fishery management councils, a fisheries commission, and a federal agency: NEFMC (jurisdiction is federal waters from Maine to Connecticut), MAFMC (jurisdiction is federal waters from New York to North Carolina), SAFMC (jurisdiction is federal waters from North Carolina to eastern Florida at Key West), GMFMC (jurisdiction is federal waters from western Florida to Texas), ASFMC (jurisdiction is state waters from Maine through eastern Florida), and the NMFS (jurisdiction over highly migratory species is in federal waters off the U.S. Atlantic coast and the Gulf of Mexico). The councils, commission, or agency may designate EFH outside their region of jurisdiction.

EFH has been designated for 91 fish and invertebrate species, not including the numerous species of corals, within the VACAPES OPAREA; hereinafter these designated species will be referred to as managed species (Tables 5-10 and 5-11). In this report, these managed species are categorized as temperate, subtropical-tropical, and highly migratory species. Of the 91 managed species with EFH designation, 31 are classified as temperate, 33 are considered subtropical-tropical (not including the coral species), and 28 are defined as highly migratory species. Several species or MU are managed by more than one FMC; the tilefish is not only managed by two FMCs due to its extensive range but is also categorized as both a temperate and subtropical-tropical species.

The FMCs classify EFH for temperate and subtropical-tropical managed species in terms of five basic lifestages: (1) Eggs; (2) Larvae; (3) Juveniles; (4) Adult; and (5) Spawning Adult (MAFMC 1998a; MAFMC and ASFMC 1998a, 1998b; NEFMC 1998, 1999, 2003). Eggs are those individuals that have been spawned but not hatched and are completely dependent on the egg's yolk for nutrition while larvae are individuals that have hatched and can capture prey; juveniles are those individuals that are not sexually mature but possess fully formed organ systems that are morphologically similar to adults whereas adults are sexually mature individuals that are not necessarily in spawning condition, while spawning adults are those individuals capable of spawning (Moyle and Cech 1988; MAFMC 1998a; MAFMC and ASFMC 1998a, 1998b; NEFMC 1998, 1999, 2003; 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 that are based on common habitat usage by all lifestages in each group: (1) Spawning Adults, Eggs, and Larvae; (2) Juveniles (3) Adult (NMFS 1999a, 1999b, 2006e). Subadults are those individuals just reaching sexual maturity. The category of spawning adult, eggs, and larvae is associated with spawning location and the circulation patterns that control the distribution of the eggs and larvae.

For the sharks, the NMFS uses a different lifestage classification system that bases the lifestage combinations on the general habitat shifts that accompany each developmental stage (NMFS 2006e). The three resulting categories are: (1) Neonate (including newborns and pups less than one year old); (2) Juvenile (age one to adult); and (3) Adult (sexually mature sharks) (NMFS 2006e).

The EFH that occurs within the VACAPES OPAREA can be broadly typified as:

- *Benthic Habitat:* Seafloor habitats including the continental shelf and slope that consist of substrate such as rocks, gravel, cobble, pebbles, sand, clay, mud, silt, shell fragments, and hard bottom as well as the water-sediment interface used by many invertebrates (i.e., members of surfclam and ocean quahog MU, shrimp MU). These benthic habitats are utilized by a variety of species for spawning/nesting, development, dispersal, and feeding (NMFS 1999a, 1999b; SAFMC 1998).
- *Structured Habitats:* Areas providing shelter for a variety of species, which may include:
    - Artificial reefs—Human-made structures derived of various types of materials and used primarily by adults, especially spawning adults of the snapper grouper MU (Clark and Livingstone 1982; Steimle and Figley 1996; SAFMC 1998).
    - Biogenic habitat—Habitat created by living organisms including sponges, mussels, hydroids, amphipod tubes, red algae, bryozoans, and coral reefs that is used by many members of the snapper grouper MU (NEFMC 1998; 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). 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).

Table 5-10. Fish and invertebrates for which EFH has been designated in the Virginia Capes OPAREA for the VACAPES OPAREAs. Taxonomy follows Nelson et al. (2004) for fishes, Turgeon et al. (1998) for mollusks, and Williams et al. (1984) for decapod crustaceans.

I. TEMPERATE SPECIES

Atlantic cod
Atlantic herring
Atlantic mackerel
Atlantic surfclam
Black sea bass
Bluefish
Butterfish
Clearnose skate
Goosefish/Monkfish
Haddock
Little skate
Longfin inshore squid
Northern shortfin squid
Ocean pout
Ocean quahog
Offshore hake
Red deepsea crab
Red hake
Rosette skate
Scup
Sea scallop
Silver hake/Whiting
Spiny dogfish
Summer flounder
Tilefish
White hake
Windowpane flounder
Winter flounder
Winter skate
Witch flounder
Yellowtail flounder

II. SUBTROPICAL-TROPICAL SPECIES

Atlantic calico scallop
Blackfin snapper
Blueline tilefish
Brown rock shrimp
Brown shrimp
Caribbean Spiny lobster
Cobia
Corals (stony corals, octocorals)
Dolphinfish
- Dolphinfish
- Pompano dolphinfish

Golden deepsea crab
Goliath grouper
Gray snapper
Greater amberjack
King mackerel
Mutton snapper
Pink shrimp
Red drum
Red porgy
Red snapper
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

III. HIGHLY MIGRATORY SPECIES

Albacore tuna
Atlantic angel shark
Atlantic sharpnose shark
Basking shark
Bigeye thresher shark
Bigeye tuna
Bignose shark
Blacktip shark
Blue marlin
Blue shark
Bluefin tuna
Dusky shark
Finetooth shark
Longbill spearfish
Longfin mako shark
Night shark
Oceanic whitetip shark
Sailfish
Sand tiger shark
Sandbar shark
Scalloped hammerhead shark
Shortfin mako shark
Silky shark
Skipjack tuna
Swordfish
Tiger shark
White marlin
Yellowfin tuna

Table 5-11. Management units (MU) and managed species with EFH designated within the Virginia Capes OPAREA by management agency. Taxonomy follows Nelson et al. (2004) for fishes, Turgeon et al. (1998) for mollusks, and Williams et al. (1984) for decapod crustaceans.

NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Atlantic Herring MU
Atlantic herring (*Clupea harengus*)

Atlantic Sea Scallop MU
Sea scallop (*Placopecten magellanicus*)

Deep-Sea Red Crab MU
Red deepsea crab (*Geryon quinquedens*)

Northeast Multispecies MU
Atlantic cod (*Gadus morhua*)
Haddock (*Melanogrammus aeglefinus*)
Ocean pout (*Zoarces americanus*)
Offshore hake (*Merluccius albidus*)
Red hake (*Urophycis chuss*)
Silver hake / whiting (*Merluccius bilinearis*)
Summer flounder (*Parlichthys dentatus*)
White hake (*Urophycis tenuis*)
Windowpane flounder (*Scophthalmus aquosus*)
Winter flounder (*Pseudopleuronectes americanus)*
Witch flounder (*Glyptocephalus cynoglossus*)
Yellowtail flounder (*Limanda ferruginea*)

Northeast Skate Complex MU
Clearnose skate (*Raja eglanteria*)
Little skate (*Leucoraja erinacea*)
Rosette skate (*Leucoraja garmani virginica*)
Winter skate (*Leucoraja ocellata*)

Monkfish MU[2]
Goosefish / monkfish (*Lophius americanus*)

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Atlantic Mackerel, Squid, and Butterfish MU
Atlantic mackerel (*Scomber scombrus*)
Butterfish (*Peprilus triacanthus*)
Longfin inshore squid (*Loligo pealeii*)
Northern shortfin squid (*Illex illecebrosus*)

Bluefish MU[3]
Bluefish (*Pomatomus saltatrix*)

Spiny Dogfish MU[4]
Spiny dogfish (*Squalus acanthias*)

Summer Flounder, Scup, & Black Sea Bass MU[3]
Black sea bass (*Centropristis striata*)
Scup (*Stenotomus chrysops*)
Summer flounder (*Paralichthys dentatus*)

Surfclam and Ocean Quahog MU
Atlantic surfclam (*Spisula solidissima*)
Ocean quahog (*Arctica islandica*)

SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

Tilefish MU
Tilefish (*Lopholatilus chamaeleonticeps)*

Calico Scallop MU
Atlantic calico scallop (*Agopecten gibbus)*

Coastal Migratory Pelagics MU[5]
Cobia (*Rachycentron canadum*)
King mackerel (*Scomberomorus cavalla*)
Spanish mackerel (*Scomberomorus maculatus*)

Coral, Coral Reefs, & Live Bottom Habitats MU
Corals (stony corals, 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[6]
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[5]
Caribbean spiny lobster (*Panulirus argus)*
Ridged slipper lobster *(Scyllarides notifer)*

Table 5-11. Management units (MU) and managed species with EFH designated within the VACAPES OPAREA by management agency. Taxonomy follows Nelson et al. (2004) for fishes, Turgeon et al. (1998) for mollusks, and Williams et al. (1984) for decapod crustaceans (cont'd).

NATIONAL MARINE FISHERIES SERVICE
(Highly Migratory Species Management Division)

Billfish MU
Blue marlin (*Makaira nigricans*)
Longbill spearfish (*Tetrapturus pfluegeri*)
Sailfish (*Istiophorus platypterus*)
White marlin (*Tetrapturus albidus*)

Tuna MU
Bluefin tuna (*Thunnus thynnus*)
Bigeye tuna (*Thunnus obesus*)
Yellowfin tuna (*Thunnus albacares*)
Skipjack tuna (*Katsuwonus pelamis*)

Swordfish MU
Swordfish (*Xiphias gladius*)

Large Coastal Shark MU
Blacktip shark (*Carcharhinus limbatus*)
Sandbar shark (*Carcharhinus plumbeus*)
Scalloped hammerhead shark (*Sphyrna lewini*)
Silky shark (*Carcharhinus falciformis*)
Spinner shark (*Carcharhinus brevipinna*)
Tiger shark (*Galeocerdo cuvier*)

Small Coastal Shark MU
Atlantic sharpnose shark (*Rhizopriondon terraenovae*)
Finetooth shark (*Carcharhinus isodon*)

Pelagic Shark MU
Blue shark (*Prionace glauca*)
Oceanic whitetip shark (*Carcharhinus longimanus*)
Shortfin mako shark (*Isurus oxyrinchus*)

Prohibited Species MU
Atlantic angel shark (*Squatina dumeril*)
Basking shark (*Cetorhinus maximus*)
Bigeye thresher shark (*Alopias superciliosus*)
Bignose shark (*Carcharhinus altimus*)
Dusky shark (*Carcharhinus obscurus*)
Longfin mako shark (*Isurus paucus*)
Night shark (*Carcharhinus signatus*)
Sand tiger shark (*Carcharius taurus*)

[1]Jointly managed by the NEFMC and the ASMFC
[2]Jointly managed by the NEFMC (lead) and the MAFMC
[3]Jointly managed by the MAFMC and the ASMFC
[4]Jointly managed by the MAFMC (lead) and the NEFMC
[5]Jointly managed by the SAFMC (lead) and the GMFMC
[6]Jointly managed by the SAFMC and the ASMFC

- *Gulf Stream Current:* 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, where it is deflected and begins flowing northeastward (Bumpus 1973). The Gulf Stream provides a dispersal mechanism for the larvae of many species (e.g., snapper grouper MU, coastal migratory pelagic MU, dolphin wahoo MU, and golden deepsea crab MU) (SAFMC 1998).
- *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 (NEFMC 1998; SAFMC 1998; NMFS 1999a, 2003a).
- *Habitat Areas of Particular Concern:* Twenty-five species have designated HAPC for some or all lifestages in the VACAPES OPAREA and include the following habitat types:
  - All lifestages for the snapper grouper MU (18 species)—Medium to high profile, offshore, hard bottom habitat where spawning normally occurs (areas of known spawning aggregation); pelagic and benthic *Sargassum;* all hermatypic coral habitats and reefs; and the Point (North Carolina) are designated HAPC within the VACAPES OPAREA. Additional HAPC designated for this MU but not within the OPAREA include: manganese outcroppings on the Blake Plateau; FMC-designated artificial reef special management zones (SMZs); seagrass habitat, mangrove habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats, nearshore hard

bottom habitat (<4 m), Charleston Bump (South Carolina), Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina), and the *Oculina* Bank HAPC.

- All lifestages of the coastal migratory pelagic MU (cobia, king mackerel, and Spanish mackerel)—sandy shoals associated with Cape Lookout, North Carolina, Cape Fear, North Carolina, and Cape Hatteras, North Carolina from shore to the ends of the respective shoals but shoreward of the Gulf Stream; the Point (North Carolina); and pelagic *Sargassum* have been designated as HAPC in the VACAPES OPAREA. Additional areas designated as HAPC, but not located within the VACAPES OPAREA include: Ten Fathom Ledge (North Carolina); Big Rock (North Carolina); Charleston Bump (South Carolina); Hurl Rocks (South Carolina), the Point off Jupiter Inlet (Florida); *Phragmatopoma* (worm) reefs (central east-coast of Florida); nearshore hard bottom (<4 m) south of Cape Canaveral, Florida; the Hump off Islamorada, Florida; the Marathon Hump (Florida); and the “Wall” off the Florida Keys.
- All lifestages of the common and pompano dolphinfish and wahoo—The Point (North Carolina) is designated HAPC in the VACAPES OPAREA. Additional designated HAPC include Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); Charleston Bump (South Carolina); Georgetown Hole (South Carolina); Amberjack Lump (Florida); the Hump off Islamorada (Florida); Marathon Hump (Florida); and the “Wall” off the Florida Keys.
- 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, and near the Outer Banks, North Carolina 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. Only those within Delaware and New Jersey are not located in the VACAPES OPAREA.
- All lifestages of the red drum—all coastal inlets; all state-designated nursery habitats of particular importance to red drum; documented sites of spawning aggregation; barrier islands and their inlets; submerged aquatic vegetation beds in Virginia, North Carolina, and Florida; the entire estuarine systems in South Carolina and Georgia; and the inlets, adjoining channels, sounds, and outer bars of ocean inlets are designated HAPC. None of these are within the boundaries of the VACAPES OPAREA.
- All lifestages for members of the penaeid shrimp MU (brown, pink, and white shrimp)—all coastal inlets, state-designated nursery areas, and state-identified overwintering areas are designated as HAPC. These are not located within the boundaries of the VACAPES OPAREA.
- All lifestages of the Caribbean spiny lobster—Florida Bay, Biscayne Bay, Card Sound, and coral/hard bottom habitat from Jupiter Inlet, Florida through the Dry Tortugas, Florida are designated as HAPC. These are located south of the VACAPES OPAREA.
- Juvenile and adult lifestages of the cobia—the portions of Broad River, South Carolina with salinities exceeding 25 practical salinity units (psu) from May through July have been designated as HAPC. These are located south of the VACAPES OPAREA.
- Juvenile and adult lifestages of the Spanish mackerel—HAPC have been designated as the portions of Bogue Sound, North Carolina with salinities >30 psu from May through September and the portions of New River, North Carolina with salinities >30 psu from May through October. These areas are not located within the boundaries of the VACAPES OPAREA.
- Juvenile and adult lifestages of the summer flounder—all native marine and freshwater species of submerged aquatic vegetation in any size bed, as well as loose aggregations, within adult and juvenile summer flounder EFH, ranging from the Gulf of Maine to Cape Hatteras, North Carolina, are designated as HAPC (MAFMC and ASFMC 1998a). Despite being classified as macroalgae, pelagic *Sargassum* is not designated as HAPC for the summer flounder (Hoff 2005). Thus, none of these habitats are located within the VACAPES OPAREA.

5.3.1 Temperate Water Species

- Atlantic Cod *(Gadus morhua)*

  Management—EFH for the Atlantic cod is designated under Final Amendment #11 to the Northeast Multispecies FMP (NEFMC 1998). The Atlantic cod is managed as two separate stocks (Georges Bank and Gulf of Maine stocks) in U.S. waters (NEFMC 1998). The Georges Bank stock, whose southern distributional extent ranges into the MAB, is the only stock that occurs within the VACAPES OPAREA (Mayo and O'Brien 2000).

  Status—The Georges Bank stock is subject to overfishing, as well as having an overfished status (NMFS 2006a). The International Union designates this species as vulnerable on the Conservation of Nature and Natural Resources (IUCN) Red List (Sobel 1996).

  Distribution—The Atlantic cod's range extends to both sides of the northern Atlantic Ocean, but in the northwest Atlantic, this species is distributed from Greenland to Cape Hatteras, North Carolina (Fahay et al. 1999).

  Habitat Associations—Cod are a demersal (live usually within 2 m of the bottom), temperate species. This species associates with cobble or gravel shoals as well as waters with depths of 10 to 150 m and temperatures between 0º and 10ºC (NEFMC 1998; Klein-MacPhee 2002a). Larger cod commonly utilize deeper waters (up to 600 m) than smaller and younger individuals (Cohen et al. 1990). Eggs are pelagic and larvae utilize surface waters, moving deeper with maturity (Fahay et al. 1999; Klein-MacPhee 2002a).

  Life History—In the VACAPES OPAREA, cod are nonmigratory and only undertake minor seasonal movements in reaction to changing temperatures (moving to the northern parts of their range as water temperatures warm in the summer and early fall) (Cohen et al. 1990). Older fishes display vertical movements while searching for prey (Klein-MacPhee 2002a). Spawning occurs on Georges Bank, in the Gulf of Maine, and over the inner half of the continental shelf off southern New England at night. Spawning events normally occur from November to April in waters with temperatures ranging from 0º to 12ºC and depths of less than 50 m (Cohen et al. 1990; Fahay et al. 1999).

  Common Prey Species—Atlantic cod feed primarily on fishes but also consume crustaceans and mollusks. Prey include: herring, sand lance, Atlantic mackerel, rock crab, longfin inshore squid, and northern shortfin squid (Klein-MacPhee 2002a).

  EFH Designations (NEFMC 1998; Figure D-1)

  - Egg—EFH for this lifestage is designated in the Gulf of Maine, Georges Bank, MAB south to Long Island, NY, and southern New England estuaries and embayments. This is not located within the VACAPES OPAREA.
  - Larva—EFH designated for this lifestage includes the Gulf of Maine, Georges Bank, southern New England as well as the estuaries and embayments of southern New England. These regions are not located within the VACAPES OPAREA.
  - Juvenile—EFH designated for this lifestage is the Gulf of Maine and Georges Bank, which is located north of the VACAPES OPAREA.
  - Adult—Bottom habitats with a substrate of rocks, pebbles, or gravel from the Gulf of Maine south to Delaware Bay are designated as EFH.
  - Spawning Adult—Bottom habitats with a substrate of smooth sand, rocks, pebbles, or gravel from the Gulf of Maine south to the Delaware Bay are designated as EFH.

  HAPC Designations—Juvenile cod designated HAPC is located on the northern edge of the Georges Bank.

- Atlantic Herring *(Clupea harengus)*

Management—EFH for the Atlantic herring is designated by the NEFMC under the Atlantic Herring FMP (NEFMC 1998).

Status—Clupeids are among the most abundant and commercially important of the world's fishes. The Atlantic herring supports one of the oldest and most important fisheries in the northwestern Atlantic (Overholtz 2000a). The Atlantic herring is neither subject to overfishing nor does it have an overfished status (NMFS 2006a).

Distribution—The Atlantic herring inhabits both sides of the north Atlantic Ocean in temperate and boreal waters (Munroe 2002). In the northwestern Atlantic, this species ranges from the Labrador Province, Canada to Cape Hatteras, North Carolina (Overholtz 2000a).

Habitat Associations—Atlantic herring are a pelagic schooling species found at various depths depending on lifestage, season, and geographic location. Eggs are demersal, adhesive, and deposited on a variety of benthic habitats including boulders, rocks, gravel, shell fragments, and macrophytes in water depths ranging from 20 to 80 m. Larvae are pelagic and can remain at spawning sites for months or can be dispersed by local currents. Larvae are found in waters with temperatures ranging from 6º to 16ºC, salinity of 32 psu, and depths of 50 to 90 m (Reid et al. 1999). Juveniles prefer water temperatures below 10°C, salinities ranging from 26 to 32 psu, and water depths from 15 to 135 m; adults utilize waters with temperatures below 10°C, water depths from the surface to 200 m, and salinities above 28 psu (NEFMC 1998; Munroe 2002).

Life History—Atlantic herring spawn over rocks, shells, pebbles, gravel, and clay substrates in well-mixed waters with 1.5 to 3 knot tidal currents, temperatures below 15°C, depths of 20 to 90 m, and a salinity range from 32 to 33 psu (Reid et al. 1999; Munroe 2002). Spawning events most often occur between the months of July and November in known spawning locations with shallow waters from southwest Nova Scotia, Georges Bank/Nantucket Shoals, and the Gulf of Maine (Reid et al. 1999). Adult and juvenile herring undergo complex and extensive north-south and inshore-offshore migrations for the purpose of spawning, feeding, overwintering; they also undertake diel vertical migrations in response to light intensity (Reid et al. 1999; Munroe 2002).

Common Prey Species—Atlantic herring are opportunistic filter feeders, preying primarily on zooplankton (copepods and euphasiids) with larger fish also preying on shrimp. This species feeds in the upper layers of the water with peak feeding activity occurring at dusk and dawn (Munroe 2002).

EFH Designations (NEFMC 1998; Figure D-2)

- Egg—EFH designated for this lifestage of Atlantic herring is the Gulf of Maine, Georges Bank, and southern New England estuaries and embayments. These areas are not located within the VACAPES OPAREA.
- Larva—EFH designated for this lifestage includes the Gulf of Maine, Georges Bank, MAB south to New Jersey [~40ºN], and estuaries and embayments of southern New England and the MAB. These regions are located north of the VACAPES OPAREA.
- Juvenile—Pelagic waters and bottom habitats from the Gulf of Maine, Georges Bank, and MAB south to Cape Hatteras, North Carolina are designated as EFH. Additionally, Chesapeake and Delaware Bays as well as southern New England and mid-Atlantic estuaries and embayments are designated as EFH for this lifestage of Atlantic herring.
- Adult—Pelagic waters and bottom habitats from the Gulf of Maine, Georges Bank, and MAB south to Cape Hatteras, North Carolina are designated as EFH. EFH is also designated in Chesapeake and Delaware Bays as well as southern New England and mid-Atlantic estuaries and embayments.
- Spawning Adult—Bottom habitats, with a substrate of gravel, sand, cobble, and shell fragments and aquatic macrophytes from the Gulf of Maine, Georges Bank, and MAB south to Cape Hatteras, North Carolina are designated as EFH. Additional designated EFH for this lifestage includes southern New England estuaries.

HAPC Designations—No HAPC are identified for this species.

- Atlantic Mackerel *(Scomber scombrus)*

Management—The MAFMC designates EFH for the Atlantic mackerel through Amendment 8 to the Atlantic Mackerel, Squid, and Butterfish FMP (MAFMC 1998a).

Status—Currently the Atlantic mackerel is not considered overfished and is not subject to overfishing (NMFS 2006a).

Distribution—The Atlantic mackerel inhabits the north Atlantic Ocean, including the Baltic, Black, and Mediterranean Seas. In the northwest Atlantic Ocean, the distribution of the Atlantic mackerel ranges from Black Island, Labrador, Canada to Cape Lookout, North Carolina (Collette 2002a).

Habitat Associations—The Atlantic mackerel is found primarily in the open sea but rarely occurs beyond the continental shelf. It does not depend directly on the coastline or bottom waters during any of its lifestages (Collette 2002a). Water depths at which the Atlantic mackerel occurs varies according to lifestage: eggs are pelagic and have been collected from shore to a depth of 15 m in water temperatures between 5° and 23°C, larvae occur at depths between 10 and 130 m in water temperatures between 6° and 22°C, juveniles are found from shore to a depth of 320 m in water temperatures between 4° and 22°C, and adults occur from shore to 381 m in water temperatures between 4° and 16°C (Studholme et al. 1999).

Life History—The Atlantic mackerel is a fast-swimming, pelagic schooling fish, which undergoes seasonal inshore and offshore migrations. This species overwinters in waters between 70 and 200 m over the continental shelf and utilizes inshore areas to spawn (Collette 2002a). Atlantic mackerel are serial spawners (spawning in bursts or pulses more than once in a spawning season). From the Delaware Bay to the Chesapeake Bay, spawning occurs from April to July, peaking in mid-April off the Chesapeake Bay and May off New Jersey and Long Island, when water temperatures begin to warm to 9° to 14°C (Overholtz 2000b; Studholme et al. 1999; Collette 2002a). The majority of spawning events occur shoreward of the continental shelf (Collette 2002a).

Common Prey Species—Atlantic mackerel are opportunistic feeders that prey upon small fauna such as copepods, amphipods, mysid shrimp, decapod larvae, pelagic mollusks, euphausiids, and larvae of various other marine species. Larger mackerel are also capable of eating squid and fishes (silver hake, sand lance, herring, hake, and sculpin) (Collette 2002a).

EFH Designations (MAFMC 1998a; Figure D-3)

- Egg—EFH is designated as the pelagic waters over the continental shelf in areas that comprise the highest 75% of the catch where Atlantic mackerel eggs were collected during the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) ichthyoplankton surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. Additionally, southern New England and mid-Atlantic estuaries and embayments are designated as EFH for this lifestage. None of these regions are located within the VACAPES OPAREA.
- Larva—EFH includes the pelagic waters overlying the continental shelf in areas that comprise the highest 75% of the catch where Atlantic mackerel larvae were collected in the MARMAP ichthyoplankton surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. Additionally, southern New England and mid-Atlantic estuaries and embayments are designated as EFH for this lifestage.
- Juvenile—EFH for the Atlantic mackerel includes the pelagic waters found over the continental shelf in areas that comprise the highest 75% of the catch where juvenile Atlantic mackerel were collected in the NEFSC trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. Additionally, southern New England and mid-Atlantic estuaries and embayments are designated as EFH for this lifestage.
- Adult—EFH includes the pelagic waters occurring over the continental shelf in areas that comprise the highest 75% of the catch where adult Atlantic mackerel were collected in NEFSC

trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. Southern New England and mid-Atlantic estuaries and embayments are also designated as EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Atlantic Surfclam (*Spisula solidissima*)

Management—EFH for the Atlantic surfclam is designated by the MAFMC under Amendment 12 to the Atlantic Surfclam and Ocean Quahog FMP of the MAFMC (1998b).

Status—Currently, the Atlantic surfclam does not have an overfished status nor is subject to overfishing (NMFS 2006a).

Distribution—This mollusk is distributed throughout the northwestern Atlantic Ocean in continental shelf waters from southern Gulf of St. Lawrence to Cape Hatteras, North Carolina (Cargnelli et al. 1999a). Concentrations of this species occur on Georges Bank, south of Cape Cod, MA; off Long Island, NY; off southern New Jersey; and off the Delmarva Peninsula (Cargnelli et al. 1999a).

Habitat Associations—Larvae are dispersed by currents and settlement corresponds with the relaxation of upwelling events (Cargnelli et al. 1999a). Juvenile and adult lifestages concentrate in areas of sandy substrate at depths from 8 to 66 m (Cargnelli et al. 1999a).

Life History—Atlantic surfclams spawn from summer through early fall in waters with temperatures greater than 15°C (Cargnelli et al. 1999a). In Virginia, spawning occurs from May to the end of July (Cargnelli et al. 1999a). Atlantic surfclams do not migrate or exhibit seasonal movements (Ropes et al. 1982).

Common Prey Species—Atlantic surfclams are opportunistic filter feeders that feed upon plankton as small as 4 micrometers (μm) in diameter (Cargnelli et al. 1999a).

EFH Designations (MAFMC 1998b; Figure D-4)

- Juvenile and Adult—Substrate to a depth of 1 m below the water-sediment interface is designated as EFH for those areas that encompass the highest 90% of catch during the NEFSC surfclam dredge surveys, from the eastern edge of Georges Bank and the Gulf of Maine through Cape Hatteras, North Carolina.

HAPC Designations—No HAPC are identified for this species.

- Black Sea Bass *(Centropristis striata)*

Management—The Atlantic black sea bass are managed as two separate stocks divided north and south of Cape Hatteras, North Carolina. The northern stock has EFH designated by the MAFMC under Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP (MAFMC and ASMFC 1998a). The southern black sea bass stock, which occurs between Cape Hatteras, North Carolina and Cape Kennedy, Florida, is managed by the SAFMC and does not have EFH designated in the VACAPES OPAREA (SAFMC 1998).

Status—The NMFS (2006a) states in the in Southeast region black sea bass stocks are overfished and that overfishing is currently occurring.

Distribution—Black sea bass occur from southern Nova Scotia and Bay of Fundy to Cape Canaveral, Florida and into the Gulf of Mexico (Steimle et al. 1999a; Klein-MacPhee 2002b).

Habitat Associations—This species is usually associated with structured and artificial habitats such as artificial reefs and shipwrecks located on the continental shelf (Steimle et al. 1999a; Klein-MacPhee 2002b). The black sea bass utilizes a wide range of water depths from 1 to 165 m (Musick and Mercer 1977). When inshore, black sea bass associate with hard bottom habitats around shipwrecks; while offshore, they tend to be associated with ledge, bank, rock, and coral habitats. Adults and juveniles are also found in estuaries but are not common in areas with salinities below 12 psu (Klein-MacPhee 2002b). Eggs are buoyant and found over the continental shelf from May through October, while larvae move to estuarine habitat, between New York and Virginia, to transform into juveniles. Larvae are initially benthic but become demersal and utilize structured inshore habitats such as sponge beds (MAMFC and ASFMC 1998a). Juveniles and adults prefer waters warmer than 6°C (MAMFC and ASFMC 1998a).

Life History—Schools of black sea bass from the northern stock demonstrate inshore-offshore movements, which is dependent on water temperature (Klein-MacPhee 2002b). As coastal waters cool below 14°C in the fall, the MAB population begins to migrate south and offshore to wintering areas in deeper waters between central New Jersey and North Carolina (Musick and Mercer 1977). As bottom waters warm above 7°C in the spring, the population migrates inshore into coastal areas and bays in the MAB. The southern stock of black sea bass is not known to make an extensive migration but may move away from shallow coastal areas during cold winters, especially in the Carolinas (Steimle et al. 1999a; Klein-MacPhee 2002b). The northern stock spawns on the continental shelf from May through October, peaking in June, at depths from 18 to 45 m, while the southern stock spawns in April and May (Musick and Mercer 1977; Klein-MacPhee 2002b).

Common Prey Species—Black sea bass prey upon crustaceans (lobster and crabs), mollusks (clams), worms, and fishes (anchovy, herring, seahorse, pipefish, cusk-eel, scup, sand lance, and windowpane flounder) (Klein-MacPhee 2002b). Feeding activities increase after periods of spawning (Steimle et al. 1999a).

EFH Designations (MAMFC and ASFMC 1998a; Figure D-5)

- Egg—EFH for this lifestage of the black sea bass has been designated in mid-Atlantic embayments. These regions are not within the VACAPES OPAREA.
- Larva—EFH for this lifestage includes the pelagic waters found over the continental shelf in areas that encompass the highest 90% of all the area where black sea bass larvae were collected in MARMAP (Marine Resources Monitoring Assessment and Prediction Program) surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. Additionally, northern mid-Atlantic estuaries and embayments are designated as EFH for this lifestage of the black sea bass.
- Juvenile—EFH includes the demersal waters over the continental shelf in areas that encompass the highest 90% of all the area where black sea bass juveniles were collected in the Northeast Fisheries Science Center (NEFSC) surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. Mid-Atlantic estuaries and embayments such as Delaware Bay, Delaware Inland Bays, Chincoteague Bay, Chesapeake Bay Mainstem, Tangier/Pocomoke Sound, and James River are designated as EFH for this lifestage as well.
- Adult—The demersal waters over the continental shelf is designated as EFH for those areas that encompass the highest 90% of all the area where black sea bass adults were collected in NEFSC surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. In addition, mid-Atlantic estuaries and embayments including New Jersey Inland Bays, Delaware Bay, Chincoteague Bay, Chesapeake Bay Mainstem, Tangier/Pocomoke Sound, and James River are designated as EFH for this lifestage of the black sea bass.

HAPC Designations—No HAPC are identified for this species.

- Bluefish (*Pomatomus saltatrix*)

Management—The population along the east coast is thought to be comprised of a single stock, with EFH designated under Amendment 1 to the Bluefish FMP developed by the MAFMC and the ASMFC (MAFMC and ASMFC 1998b).

Status—The current status review indicates that the bluefish is no longer considered overfished (NMFS 2006a).

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 is considered rare between southern Florida and northern South America (Fahay et al. 1999).

Habitat Associations—Bluefish is a warm-water pelagic species that rarely occurs in temperatures below 14°C and utilizes both offshore and inshore habitats (Klein-MacPhee 2002c). Bluefish eggs typically are pelagic and inhabit waters with temperatures above 18°C and salinities greater than 31 psu between the months of April and August. Bluefish larvae are pelagic and are found from April through September in waters with a temperature 18°C and salinity greater than 30 psu (MAFMC and ASMFC 1998b). Larvae are transported from spawning grounds in the SAB to northeast estuaries via the Gulf Stream (Hare and Cowen 1996). Juveniles utilize estuarine habitat in coastal southern New England from June to October, in the MAB from May through October, and in the SAB from March to December (MAFMC and ASMFC 1998b). Adult bluefish utilize offshore and estuarine habitats with water temperatures above 16°C (Fahay et al. 1999). Adults typically are found in estuaries of coastal southern New England from June through October, in the MAB from April through October, and in the SAB from May through January (MAFMC and ASMFC 1998b).

Life History—Bluefish adults are highly migratory and perform both north-south and inshore-offshore movements. Bluefish move north in the spring to summer seasons, when their highest abundance is found off the coast of New York and coastal southern New England (Klein-MacPhee 2002c). 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 2002c). There are two discrete spawning events for the western Atlantic bluefish: (1) a spring spawning event occurs near the edge of the continental shelf in the SAB during March through May, and (2) a summer spawning event occurs over the mid-continental shelf in the MAB between June and August in waters with temperatures between 18° and 25°C and salinities from 25 to 31 psu (Fahay et al. 1999; Klein-MacPhee 2002c).

Common Prey Species—Bluefish are piscivorous and feed on a variety of species including menhaden, herring, alewife, anchovy, eel, sculpin, killifish, silverside, croaker, scup, goby, sand lance, butterfish, and mackerel. This species also feeds on invertebrates (shrimp, squid, crabs, and worms) and is known for cutting and tearing prey in pieces (Klein-MacPhee 2002c).

EFH Designations (MAFMC and ASMFC 1998b; Figure D-6)

- Egg—EFH includes mid-shelf pelagic waters over the continental shelf (from the coast to the limits of the U.S. EEZ) in areas that encompass the highest 90% of all the area where bluefish eggs were collected in MARMAP surveys, from Montauk Point, NY south to Cape Hatteras, North Carolina. South of Cape Hatteras, EFH includes 100% of the mid-shelf pelagic waters over the continental shelf (from the coast out to the eastern wall of the Gulf Stream) south to Key West, Florida.
- Larva—EFH includes pelagic waters found over the continental shelf (from the coast to the limits of the U.S. EEZ), most commonly less than 15 m, in areas that encompass the highest 90% of all the area where bluefish larvae were collected in MARMAP surveys, from Montauk Point south to Cape Hatteras, North Carolina. South of Cape Hatteras, EFH includes 100% of the pelagic waters deeper than 15 m over the continental shelf (from the coast out to the eastern wall of the Gulf Stream) through Key West, Florida. The EFH also includes the “Slope Sea” (between the continental shelf and north wall of the Gulf Stream) and Gulf Stream Current between latitudes 29° and 40°N to the limits of the U.S. EEZ.
- Juvenile—EFH includes pelagic waters found over the continental shelf (from the coast to the limits of the U.S. EEZ) in areas that encompass the highest 90% of all the area where bluefish juveniles were collected in NEFSC trawl surveys, from Nantucket Island, MA, south to Cape Hatteras, North Carolina. South of Cape Hatteras, EFH includes 100% of the pelagic waters over the continental shelf (from the coast out to the eastern wall of the Gulf Stream) south to Key West, Florida. EFH also includes the “Slope Sea” (between the continental shelf and north wall of the Gulf Stream) and Gulf Stream between latitudes 29° and 40°N to the limits of the U.S. EEZ. The following embayments and estuaries are designated as EFH, based on salinity, for this

lifestage of bluefish: Delaware Bay and inland waters, eastern shore of MD and VA, Chesapeake Bay Mainstem, Chester River, Choptank River, Patuxent River, Potomac River, Tangier/Pocomoke Sound, Rappahannock River, York River, James River, Albemarle Sound, Pamlico Sound, Pungo River, Neuse River, Bogue Sound, New River, Cape Fear River, Winyah Bay, Santeee Rivers (north and south), Charleston River, St. Helena Sound, Broad River, Savannah River, Ossabow Sound, Sapelo Sound/St. Catherine, Altamaha River, St. Andrew/St. Simon Sound, and St. John's River.

- Adult—EFH includes pelagic waters found over the continental shelf (from the coast to the limits of the U.S. EEZ) in areas that encompass the highest 90% of all the area where bluefish adults were collected in NEFSC trawl surveys, from Cape Cod Bay, MA south to Cape Hatteras, North Carolina. South of Cape Hatteras, EFH includes 100% of the pelagic waters over the continental shelf (from the coast out to the eastern wall of the Gulf Stream) through Key West, Florida. Additionally, estuaries and embayments from southern New England through the SAB including Delaware Bay, Delaware Inland Bay, Chesapeake Bay Mainstem, Chester River, Choptank River, Patuxent River, Potomac River, Tangier/Pocomoke Sound, Rappahannock River, York River, James River, Albemarle Sound, Pamlico Sound, Pungo River, Bogue Sound, Cape Fear River, St. Helena Sound, Broad River, St. Johns River, and Indian River are designated as EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Butterfish (*Peprilus triacanthus*)

Management—Butterfish have EFH designated under Amendment 8 to the Atlantic Mackerel, Squid, and Butterfish FMP by the MAFMC (MAFMC 1998a).

Status—The butterfish stock in the northwestern Atlantic is overfished (NMFS 2006a).

Distribution—Butterfish range from the Gulf of St. Lawrence and the southern coast of Newfoundland to the deeper waters off Florida in the northwestern Atlantic Ocean but are most common between Nova Scotia and Cape Hatteras, North Carolina (Colton 1972; Klein-MacPhee 2002d).

Habitat Associations—All lifestages of the butterfish are common from the outer continental shelf to the lower, high salinity portions of bays and estuaries. Butterfish eggs are buoyant and pelagic and occur between June and August (Waring and Murawski 1982; Klein-MacPhee 2002d). They are found in surface waters ranging in temperature from 6° to 26°C, salinities of 25 to 33 psu, and depths of 10 to 1,250 m (most common in water of less than 200 m). As larval butterfish develop, they become more nektonic than planktonic (Cross et al. 1999). They often live in the shelter of large jellyfish and are also associated with *Sargassum* mats and other flotsam (Waring and Murawski 1982; Cross et al. 1999; Klein-MacPhee 2002d). Larvae are found from April through December in waters with temperatures of 4.4° to 27.9°C, salinities of 6.4 to 37.4 psu, and depths of 10 to 1,750 m (most found in water less 120 m) (Waring and Murawski 1982; Cross et al. 1999). As juveniles, butterfish leave their sheltered habitat and begin schooling; they occur anywhere in the water column over sandy and muddy substrates at temperatures of 4.4° to 29.7°C, salinities of 3 to 37.4 psu, and depths ranging from 10 to 330 m (most often found in less than 120 m) (Cross et al. 1999; Klein-MacPhee 2002d). Schools of adults occur throughout the water column from the surface to depths of 420 m over areas with sandy, sandy-silt, and muddy substrates. They are eurythermal and euryhaline, tolerating temperatures from 4.4° to 29.7°C and salinities from 3.8 to 33 psu (Cross et al. 1999; Klein-MacPhee 2002d).

Life History—Butterfish are broadcast spawners (Klein-MacPhee 2002d). Spawning occurs in nearshore waters of the MAB and SAB annually from late January through July in waters with temperatures greater than 15°C (Colton 1972; Rotunno and Cowen 1997). Butterfish north of Cape Hatteras, North Carolina undergo seasonal migrations in response to changes in the water temperature. They move northward and inshore in the summer (Klein-MacPhee 2002d).

Common Prey Species—Butterfish feed on a variety of invertebrates but primarily on tunicates, sea squirts, salps, and sea angels (Klein-MacPhee 2002d).

EFH Designations MAFMC 1998a; Figure D-7)

- Egg—EFH includes the pelagic waters found over the continental shelf in areas that encompass the highest 75% of all the area where butterfish eggs were collected in MARMAP surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. The Chesapeake Bay Mainstem is also designated as EFH for this lifestage as well as estuaries and bays in New England and the northern mid-Atlantic.
- Larva—EFH includes the pelagic waters found over the continental shelf in areas that encompass the highest 75% of all the area where butterfish larvae were collected in NEFSC trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. Additionally, Delaware Bay, Chesapeake Bay Mainstem, and estuaries and embayments in southern New England and the northern mid-Atlantic are designated as EFH for this lifestage.
- Juvenile—EFH includes the pelagic waters found over the continental shelf in areas that encompass the highest 75% of all the area where butterfish juveniles were collected in NEFSC trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. The following embayments and estuaries are designated as EFH, based on salinity, for this lifestage: New Jersey Inland Bays, Delaware Bay, Delaware Inland Bays, Chesapeake Bay Mainstem, York River, and James River as well as southern New England and northern mid-Atlantic estuaries and embayments.
- Adult—EFH includes the pelagic waters found over the continental shelf in areas that encompass the highest 75% of all the area where butterfish adults were collected in NEFSC trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina. Delaware Bay, Delaware Inland Bays, Chesapeake Bay Mainstem, York River, and James River in addition to estuaries and embayments in New York and southern New England are designated as EFH for this lifestage of the butterfish.

HAPC Designations—No HAPC are identified for this species.

- Clearnose Skate (*Raja eglanteria*)

Management—Clearnose skates have EFH designated under the NEFMC Final FMP for the Northeast (NE) Skate Complex (NEFMC 2003a).

Status—Currently, this skate species is neither overfished nor subject to overfishing (NMFS 2006a).

Distribution—The clearnose skate occurs along the eastern U.S. coast from the Nova Scotia shelf to northeastern Florida, as well as in the northern Gulf of Mexico from northwestern Florida to Texas (McEachran and Musick 1975). It is a southern species that is most abundant from Cape Hatteras, North Carolina north to Delaware Bay although rare north of Cape Hatteras (except during warmer months) (McEachran and Musick 1975; McEachran 2002).

Habitat Associations—This species primarily is associated with mud and sand substrates along the continental shelf but can also occur on rocky or gravelly bottoms (Packer et al. 2003a). It has been captured from shore out to depths of 330 m but is most abundant at depths less than 111 m (McEachran and Musick 1975). Juveniles and adults inhabit waters with temperatures ranging from 9° to 30°C (Packer et al. 2003a).

Life History—Very little information is known about this species' spawning habitat. Eggs are encapsulated in egg capsules known as "mermaid's purses" (McEachran 2002). In Delaware Bay, incubation time has been reported to be approximately three months, with spawning occurring in the spring. Off the central west coast of Florida, egg deposition occurs from December through mid-May (Packer et al. 2003a). As water temperatures begin to cool, individuals north of Cape Hatteras, North Carolina move offshore and southward, while those skates south of Cape Hatteras do not move to deeper waters during the winter (McEachran and Musick 1975).

Common Prey Species—Clearnose skates feed on a variety of invertebrate (shrimp, amphipods, mollusks, and squid) and fish species (anchovy, croaker, spot, tonguefish, weakfish, and butterfish), with crabs being the primary component of their diet (McEachran 2002; Packer et al. 2003a).

EFH Designations (NEFMC 2003; Figure D-8)

- Egg—There is no information available on the offshore habitat association or distributions of the egg stage for this species. The Chesapeake Bay Mainstem and one additional northern mid-Atlantic bay are designated as EFH for this lifestage of the clearnose skate, but these regions are not located within the VACAPES OPAREA.
- Larva—No larval stage exists for this species. Upon hatching, they are fully developed juveniles.
- Juvenile—Bottom habitats with a substrate of soft bottom along the continental shelf and rocky or gravelly bottom from the Gulf of Maine south along the continental shelf to Cape Hatteras, North Carolina that encompass the highest 90% where this species was collected during NMFS trawl surveys are designated as EFH. The Chesapeake Bay Mainstem and one additional northern mid-Atlantic bay are designated as EFH for this lifestage of the clearnose skate.
- Adult—Bottom habitats with soft substrate or rocky or gravelly bottom from the Gulf of Maine south on the continental shelf to Cape Hatteras, North Carolina that encompass the highest 90% where this species was collected during NMFS trawl surveys are designated as EFH. Additionally, New Jersey Inland Bays, Delaware Bay, Delaware Inland Bays, and Chesapeake Bay Mainstem, as well as northern mid-Atlantic estuaries and embayments are designated as EFH for this lifestage of the clearnose skate.
- Spawning Adult—Northern mid-Atlantic estuaries and bays outside the OPAREA and vicinity are designated as EFH.

HAPC Designations—No HAPC are identified for this species.

- Goosefish/Monkfish (*Lophius americanus*)

Management—Goosefish currently have EFH designated under Amendment #1 to the Monkfish FMP and are separated into two stocks for management purposes (NEFMC 1998). The northern stock inhabits the Gulf of Maine and the northern Georges Bank. The southern stock ranges from southern Georges Bank to Cape Hatteras, North Carolina (Almeida et al. 1995; Richards 2000).

Status—Both stocks are currently subject to overfishing but neither stock is considered overfished (NMFS 2006a).

Distribution—The range of the goosefish extends from the Gulf of St. Lawrence and the Grand Banks of Newfoundland to the east coast of Florida; however, they are considered uncommon south of Cape Hatteras, North Carolina (Wood 1982; Caruso 2002).

Habitat Associations—Goosefish release their eggs in long mucous egg veils that float at the surface and are subject to the actions of the currents, wind, and waves (Wood 1982; Steimle et al. 1999b; Caruso 2002). Eggs occur both inshore and offshore on the continental shelf from March through September in waters ranging from 4° to 18°C (Wood 1982; Steimle et al. 1999b). Larval goosefish are pelagic and occur across the continental shelf in waters with temperatures ranging from 10° to 16°C and depths of 30 to 90 m (Steimle et al. 1999b). Upon transition into juveniles, goosefish begin a benthic existence. Juveniles are found in bottom habitats with temperatures of 3° to 19°C, salinities of 32.6 to 33.9 psu, and depths of 25 to 182 m (Steimle et al. 1999b). Adult goosefish associate with habitats of hard sand, gravel and broken shells, pebbly bottoms, and soft mud at depths just below the tide line to 840 m, although large adults rarely occur below 400 m (Almeida et al. 1995; Caruso 2002). They also prefer water temperatures ranging from 0° to 24°C with salinities of 30 to 36 psu (Almeida et al. 1995; Steimle et al. 1999b).

Life History—Goosefish spawn between spring and early fall, depending on the latitude (Wood 1982). Spawning occurs from March to May off North Carolina, between May and June in the Gulf of

Maine, and as late as September off Maine and in Canadian waters (Steimle et al. 1999b; Caruso 2002). Breeding occurs across the continental shelf throughout the species' range (Caruso 2002). Goosefish migrate onshore and offshore seasonally in response to thermal conditions. Larger goosefish (>20 cm) in the Gulf of Maine move offshore in the winter and spring to avoid cold coastal conditions and return inshore as the coastal waters warm in the summer and fall (Steimle et al. 1999b). Conversely, smaller goosefish (<20 cm) in the Gulf of Maine and along the MAB remain inshore during the winter and spring and then move offshore during the summer and fall, presumably to avoid overly warm summer conditions (Wood 1982; Almeida et al. 1995; Steimle et al. 1999b).

Common Prey Species—Goosefish feed on benthic prey, such as bony fishes (silver hake, squirrel hake, American plaice, little skate, red hake, sand lance, and herring species), cephalopods (squid), and elasmobranches. They have also been recorded to feed on various seabird species. This species uses its angling apparatus (modified first dorsal spine) to lure small fishes (Caruso 2002).

EFH Designations (NEFMC 1998; Figure D-9)

- Egg—Surface waters from the Gulf of Maine, Georges Bank, and MAB south to Cape Hatteras, North Carolina are designated as EFH for this lifestage of the goosefish.
- Larva—EFH is designated as the pelagic waters from the Gulf of Maine, Georges Bank, and MAB south to Cape Hatteras, North Carolina.
- Juvenile—Bottom habitats with substrates of a sand-shell mix, algae-covered rocks, hard sand, pebbly gravel, or mud from the outer continental shelf of the MAB south to Cape Hatteras, North Carolina and all areas of the Gulf of Maine are designated as EFH.
- Adult—Bottom habitats with substrates of a sand-shell mix, algae-covered rocks, hard sand, pebbly gravel, or mud from the outer continental shelf of the MAB south to Cape Hatteras, North Carolina, the outer perimeter of Georges Bank, and all areas of the Gulf of Maine are designated as EFH.
- Spawning Adult—Bottom habitats with substrates of a sand-shell mix, algae-covered rocks, hard sand, pebbly gravel, or mud from the outer continental shelf of the MAB, the outer perimeter of Georges Bank, and all areas of the Gulf of Maine are designated as EFH.

HAPC Designations—No HAPC are identified for this species.

- Haddock *(Melanogrammus aeglefinus)*

Management—Haddock EFH is designated by the NEFMC under the Final Amendment #11 to the Northeast Multispecies FMP (NEFMC 1998). Five haddock stocks have been identified in the northwest Atlantic from Newfoundland to Georges Bank. Haddock are managed in the U.S. as two principal stocks, the Georges Bank and Gulf of Maine stocks (NEFMC 1993). One of these stocks exists in the VACAPES OPAREA and occurs from Georges Bank south into the MAB.

Status—The Georges Bank haddock stock has an overfished status (NMFS 2006a). This species also is considered vulnerable or facing a high risk of extinction in the wild in the medium-term future according to the IUCN Red List (Sobel 1996b).

Distribution—The haddock is a demersal species found throughout the North Atlantic Ocean. In the northwestern Atlantic Ocean, haddock are distributed from Greenland to Cape Hatteras, North Carolina (Cargnelli et al. 1999a). Areas of highest abundance include the Georges Bank, Scotian Shelf (including Browns Bank), and the southern Grand Bank (Cargnelli et al. 1999a).

Habitat Associations—Haddock associate with bottom habitats consisting of broken ground, gravel pebbles, smooth hard sand, shell, and smooth areas between rocky patches at depths generally below 10 m; they can be found from depths of 40 to 135 m (Cohen et al. 1990; Klein-MacPhee 2002e). This species specifically avoids muddy substrates except while spawning (Colton 1972;

Klein-MacPhee 2002e). Eggs are spawned at the bottom but become pelagic after fertilization, while larvae remain pelagic for the first three months (Cohen et al. 1990; Cargnelli et al. 1999a).

Life History—No long distance migrations are noted for this groundfish in the northwest Atlantic Ocean, only short inshore/offshore movements (Cohen et al. 1990). Juveniles are more abundant inshore in autumn than spring in shallower water with lower temperatures, while adults are more abundant offshore in autumn than spring. This most likely reflects the offshore movements to pre-spawning and spawning aggregations. Distribution is influenced more by restrictive spawning area and bottom type conditions than by temperature variation (Cargnelli et al. 1999a). Depths from 40 to 100 m on Browns Bank and Georges Bank are principal spawning areas for haddock, which typically spawn over substrates of rock, gravel, smooth sand, or mud (Colton 1972; Klein-MacPhee 2002e). Spawning occurs from January to July with a delay occurring in peak spawning time as one moves north (Cohen et al. 1990). For example, on Georges Bank, spawning peaks during March and April and in April and May on Browns Bank (Colton 1972).

Common Prey Species—Haddock are opportunistic feeders that prey upon a variety of benthic invertebrate (crabs, shrimp, brittlestars, and worms) and fish species (Cargnelli et al. 1999a). They specifically feed on silverside, sand lance, herring, mackerel, hake, and eel, as well as cannibalizing their young (Klein-MacPhee 2002e).

EFH Designations (NEFMC 1998; Figure D-10)

- Egg—EFH designated for this lifestage includes the Gulf of Maine, Georges Bank, coastal southern New England, and southern New England Atlantic and mid-Atlantic estuaries and embayments. These regions are all north of the VACAPES OPAREA.
- Larva—Surface waters with water temperatures below 14°C, depths from 30 to 90 m, and salinity ranging from 34 to 36 psu, from Georges Bank southwest to the Delaware Bay are designated as EFH. Additionally, southern New England and mid-Atlantic estuaries and bays are designated as EFH for this lifestage.
- Juvenile—Bottom habitats with a substrate of pebble gravel and waters with temperatures below 11°C, depths from 35 to 100 m, and salinity ranging from 31 to 34 psu, from the perimeter of Georges Bank, the Gulf of Maine, and the MAB south to Delaware Bay are designated as EFH.
- Adult—EFH designated for this lifestage of the haddock includes the Gulf of Maine, Georges Bank, and coastal southern New England, which are all located north of the VACAPES OPAREA.
- Spawning Adult—EFH designated for this lifestage includes the Gulf of Maine, Georges Bank, and coastal southern New England. These regions are not located within the VACAPES OPAREA.

HAPC Designations—No HAPC are identified for this species.

- Little Skate *(Leucoraja erinacea)*

Management—EFH for little skates are designated under the NEFMC Final FMP for the NE Skate Complex (NEFMC 2003a).

Status—The little skate is not overfished and is not subject to overfishing (NMFS 2006a).

Distribution—The little skate ranges from Nova Scotia to Cape Hatteras, North Carolina with its center of abundance occurring on Georges Bank and in coastal waters south to the mouth of Chesapeake Bay (McEachran 2002; Packer et al. 2003b).

Habitat Associations—Little skate juveniles and adults typically utilize sand, gravel, or mud substrates (McEachran and Musick 1975; Packer et al. 2003b). They have been associated with microhabitat features including biogenic depressions and flat sand during the day with their abundances increasing in the spring and fall (Packer et al. 2003b). This species occurs at depths up to 384 m but is most common at depths less than 111 m, especially in the northern section of the

MAB (McEachran and Musick 1975). Little skate eggs are found in waters with temperatures greater than 7°C and depths less than 27 m, while larvae inhabit regions with temperatures from 4° to 15°C and depths from shore to 137 m deep (NEFMC 2003a).

Life History—Egg cases, known as a "mermaid's purse," are found partially to fully developed year-round but are most frequently recorded from late October to January and from June to July (McEachran 2002; Packer et al. 2003b). The little skate does not undertake extensive migrations but instead moves inshore and offshore, along with north-south movements along the southern end of its range, in response to seasonal temperature changes (McEachran and Musick 1975). This species typically moves to deeper waters in December and January, while migrating to shallower waters beginning in April and May (McEachran 2002).

Common Prey Species—Little skate prey upon benthic invertebrates (shrimp, crabs, and worms) and fishes (herring, alewife, tomcod, silver hake, sculpin, silverside, wolfish, sand lance, cunner, winter flounder, and yellowtail flounder) (McEachran 2002; Packer et al. 2003b).

EFH Designations (NEFMC 2003a; Figure D-11)

- Egg—Bottom habitats with a sandy substrate from Georges Bank and MAB south to Cape Hatteras, North Carolina are designated as EFH. Chesapeake Bay and estuaries and bays in southern New England and the northern MAB are also designated as EFH for this lifestage of the little skate.
- Larva—No larval stage exists for this species. Upon hatching, they are fully developed juveniles.
- Juvenile—Bottom habitats with a sandy or gravelly substrate from Georges Bank through the MAB to Cape Hatteras, North Carolina that encompass the highest 90% where this species was collected during NMFS trawl surveys are designated as EFH. Additionally, the Chesapeake Bay Mainstem and southern New England and northern MAB estuaries and embayments are designated as EFH for this lifestage. These regions are not located with in the VACAPES OPAREA.
- Adult—Bottom habitats with a sandy or gravelly substrate or mud ranging from Georges Bank through the MAB to Cape Hatteras, North Carolina that encompass the highest 90% where this species was collected during NMFS trawl surveys are designated as EFH. Delaware Bay, Delaware Inland Bays, and Chesapeake Bay Mainstem as well as bays and estuaries in southern New England through the northern MAB are designated as EFH for this lifestage. These regions are not located within the VACAPES OPAREA.
- Spawning Adult—EFH designated for this lifestage includes northern mid-Atlantic estuaries and embayments.

HAPC Designations—No HAPC are identified for this species.

- Longfin Inshore Squid (*Loligo pealeii*)

Management—The population of the longfin inshore squid from southern Georges Bank to Cape Hatteras, North Carolina has EFH designated by MAFMC under Amendment 8 to the Atlantic Mackerel, Squid and Butterfish FMP (MAFMC 1998a).

Status—This species currently is not overfished or subject to overfishing (NMFS 2006a).

Distribution—This pelagic, schooling species is located across the continental shelf and slope from Newfoundland to the Gulf of Venezuela; however, the principal concentrations occur from Georges Bank to Cape Hatteras, North Carolina (Lange 1982; Cargnelli et al. 1999b).

Habitat Associations—Longfin inshore squid are found on mud or sand/mud substrate in water with temperatures greater than 8°C (Lange and Sissenwine 1980). Demersal egg masses are commonly found attached to rocks and small boulders on sandy-muddy bottom and on aquatic vegetation in waters with temperatures of less than 8°C. Their larvae are pelagic and are found near the surface in waters with temperatures between 10° and 26°C (Vecchione 1981). Juveniles inhabit the upper 10 m of the water column over water 50 to 100 m deep and prefer water temperatures ranging from 10° to 26°C. Adult longfin inshore squid inhabit waters over the continental shelf and upper continental slope to depths of 400 m (Cargnelli et al. 1999a). This species is typically demersal during the day and utilizes the water column at night (Vecchione 1981).

Life History—This species seasonally migrates inshore and offshore in relation to bottom water temperatures, moving offshore during late fall to overwinter along the edge of the continental shelf and moving inshore during the spring and early summer to spawn (Lange 1982; MAFMC 1998a). During winter and early spring when inshore waters are coldest, the population concentrates along the outer edge of the continental shelf where waters are 9° to 13°C. The inshore and northerly movement to the shelf regions occurs when water temperatures start rising (MAFMC 1998a; Cargnelli et al. 1999b). Spawning occurs in May with eggs hatching in July (Lange and Sissenwine 1980).

Common Prey Species—This species feeds on crustaceans (crabs, worms, and shrimp) and small fishes (silver hake, sand lance, anchovy, weakfish, silversides, mackerel, herring, and menhaden). Longfin inshore squid have also been recorded engaged in cannibalism. While inshore, they prey primarily on fish, and when offshore, they feed upon fishes, squid, and crustaceans (Cargnelli et al. 1999b).

EFH Designations (MAFMC 1998a; Figure D-12)

- Juvenile (±8 cm)—EFH is designated as pelagic waters found over the continental shelf in areas that comprise the highest 75% of the catch where juvenile longfin inshore squids were collected in the NEFSC trawl surveys from the Gulf of Maine through Cape Hatteras, North Carolina.
- Adult (>8 cm)—EFH for this lifestage is designated as pelagic waters found over the continental shelf in areas that comprise the highest 75% of the catch where recruited adult longfin inshore squids were collected in the NEFSC trawl surveys from the Gulf of Maine through Cape Hatteras, North Carolina.

HAPC Designations—No HAPC are identified for this species.

- Northern Shortfin Squid *(Illex illecebrosus)*

Management—The northern shortfin squid, which is considered a single stock throughout its range, has EFH designated under Amendment 8 to the Atlantic Mackerel, Squid, and Butterfish FMP by the MAFMC (MAFMC 1998a).

Status—Currently, the northern shortfin squid does not have an overfished status, and it is unknown if overfishing is occurring (NMFS 2006a).

Distribution—This pelagic, schooling species is located across the continental shelf and slope. In the western Atlantic Ocean, the northern shortfin squid distribution is from the Labrador Sea south to Florida (Wigley 1982). This species is most abundant in the Newfoundland region, is moderately abundant between Newfoundland and New Jersey (Wigley 1982), and is commercially exploited from Newfoundland south to Cape Hatteras, North Carolina (Cargnelli et al. 1999c).

Habitat Associations—Both juveniles and adults of this species are commonly collected in waters with depths of less than 183 m and temperatures ranging from 4° to 19°C (MAFMC 1998a). When utilizing habitat over the continental shelf, this species can be found throughout the entire water column, but in deeper waters, they inhabit only the upper levels of the water column (Wigley 1982). Larvae occur along the continental shelf from surface waters to depths of 360 m and prefer water temperatures ranging from 5° to 20°C (Cargnelli et al. 1999c). Northern shortfin squid eggs have never been collected but are believed to be free-floating (Wigley 1982).

Life History—Northern shortfin squids are highly migratory and are capable of long-distance migrations of more than 869 NM between boreal, temperate, and subtropical waters (Cargnelli et al. 1999d). They also undergo inshore-offshore migrations, which may be related to temperature, food, or both (MAFMC 1998a). The northern shortfin squid forms dense aggregations in waters ranging from 8° to 14°C in the winter, from January to March, along the outer continental shelf and upper slope, and in the spring, from April to May, they migrate shoreward (Wigley 1982). Spawning of the northern shortfin squid is believed to occur in the deep waters of the continental shelf primarily from August through March, depending on location. Between Cape Canaveral, Florida and Charleston, South Carolina spawning likely occurs during December to January (Cargnelli et al. 1999c). The principal spawning habitat is hypothesized to occur south of Cape Hatteras, North Carolina over Blake Plateau (Cargnelli et al. 1999c; Hendrickson and Holmes 2004). The only confirmed spawning area was between 39°10'N and 35°50'N (southern New Jersey to Cape Hatteras, North Carolina) along the shelf break in the MAB during May (Hendrickson 2004).

Common Prey Species—Northern shortfin squid prey upon fishes (smelt, capelin, mummichog, haddock, sculpin, cod, redfish), crustaceans, and squid (longfin inshore squid, cannibalism is common) (Cargnelli et al. 1999d).

EFH Designations (MAFMC 1998a; Figure D-13)

- Juvenile (±10 cm)—EFH is designated as pelagic waters found over the continental shelf in areas that comprise the highest 75% of the catch where juvenile northern shortfin squid were collected during NEFSC trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina.
- Adult (>10 cm)—EFH is designated as pelagic waters found over the continental shelf in areas that comprise the highest 75% of the catch where recruited adult northern shortfin squid were collected during NEFSC trawl surveys, from the Gulf of Maine through Cape Hatteras, North Carolina.

HAPC Designations—No HAPC are identified for this species.

- Ocean Pout *(Zoarces americanus)*

Management—EFH for the ocean pout is designated by the NEFMC under Final Amendment #11 to the Northeast Multispecies FMP (NEFMC 1998). Two separate stocks have been suggested based on stock identification studies. The first stock is found within the region of the Bay of Fundy and the northern Gulf of Maine, while the second stock ranges from Cape Cod Bay south to Delaware (Wigley 2000).

Status—The ocean pout in the northwestern Atlantic is overfished but overfishing is not currently occurring (NMFS 2006a).

Distribution—Ocean pout commonly occur from Labrador, Canada and the southern Grand Banks to Maryland (Dunaway 2001) but can also occur in the deeper, cooler waters south of Cape Hatteras, North Carolina (Steimle et al. 1999c).

Habitat Associations—Ocean pout lay demersal eggs in gelatinous clumps within sheltered areas where either one or both of the parents guard them (Steimle et al. 1999c; Wigley 2000). Upon hatching, larvae remain near the sheltered area throughout the duration of the transition stage into juveniles, when the fish disperse along the shallow, coastal waters. Juveniles are typically found in association with rocks and attached algae (Klein-MacPhee 2002f), while adults commonly occur in the deeper, cooler waters (3º to 14ºC) of the continental shelf and the upper continental slope (Clark and Livingstone 1982; Steimle et al. 1999c).

Life History—Spawning occurs in late summer through early winter (peak in September through October) with earlier peaks (August through October) in the southern part of their range. This species spawns on hard bottom, sheltered areas (Klein-MacPhee and Collette 2002), including rock crevices, artificial reefs, and shipwrecks, at depths of less than 50 m and temperatures of 10°C or less (Clark and Livingstone 1982; Steimle et al. 1999c). Although ocean pout move seasonally within a region to remain at preferred temperatures, this species is considered nonmigratory (Klein-MacPhee 2002f), and seasonal inshore/offshore movements are not extensive (Wigley 2000).

Common Prey Species—Ocean pout prey primarily on mollusks, crustaceans (crabs), echinoderms (sand dollars, brittle stars, and sea urchins), and other invertebrates, and less commonly, on fishes and fish eggs. This species feeds primarily near the bottom and during the daytime (Klein-MacPhee and Collette 2002).

EFH Designations (NEFMC 1998; Figure D-14)

- Egg—EFH is designated as bottom habitats, primarily hard bottom, on the continental shelf from the Gulf of Maine, Georges Bank, and MAB south to Delaware Bay. Additionally, southern New England estuaries and embayments are designated as EFH for this lifestage.
- Larva—EFH is designated as bottom habitats, primarily hard bottom, on the continental shelf from the Gulf of Maine, Georges Bank, and MAB south to Delaware Bay. Southern New England estuaries and bays are also designated as EFH for this lifestage.
- Juvenile—EFH is designated as bottom habitats of smooth bottom near rocks or algae from the Gulf of Maine, Georges Bank, and MAB south to Delaware Bay; also designated as EFH for this lifestage are southern New England estuaries and embayments.
- Adult—EFH is designated as bottom habitats, primarily hard bottom, on the continental shelf from the Gulf of Maine, Georges Bank, and MAB south to Delaware Bay with additional EFH designated in some southern New England bays.

HAPC Designations—No HAPC are identified for this species.

- Ocean Quahog *(Arctica islandica)*

Management—EFH for the ocean quahog is designated under Amendment 12 to the Atlantic Surfclam and Ocean Quahog FMP of the MAFMC (1998b).

Status—This species is not subject to overfishing and does not have an overfished status (NMFS 2006a).

Distribution—The ocean quahog inhabits temperate and boreal waters occurring on both sides of the north Atlantic (Serchuk et al. 1982). In the northwestern Atlantic, the ocean quahog occurs on the continental shelf from Newfoundland to Cape Hatteras, North Carolina (Mann 1982; Weinberg 2001).

Habitat Associations—The egg and larval stages of the ocean quahog are planktonic and subject to dispersal by ocean currents (Cargnelli et al. 1999e). Following metamorphosis, juveniles settle to the bottom, displaying a preference for sandy substrates in offshore waters but also inhabit muddy intertidal environments (Cargnelli et al. 1999e). Ocean quahog are generally found in waters with salinities ranging from 32 to 34 psu and between 45 and 75 m in depth. Adults typically congregate in dense beds, right below the sediment surface. Silty or fine to medium grade sand are the preferred habitat (Serchuk et al. 1982; Cargnelli et al. 1999e).

Life History—The spawning period for ocean quahog is protracted, lasting from spring until fall with multiple spawning events occurring at both the individual and population levels (Mann 1982; Cargnelli et al. 1999e). The spawning season begins in late spring or early summer as water temperatures reach 13.5ºC. Peak spawning occurs starting in August and ending by early October (Serchuk et al. 1982). Adult quahogs do not exhibit seasonal movements (Serchuk et al. 1982).

Common Prey Species—Ocean quahogs are filter feeders that primarily consume phytoplankton (Cargnelli et al. 1999e).

EFH Designations (MAFMC 1998b; Figure D-15)

- Juvenile and Adult—EFH is designated throughout the bottom substrate to a depth of 1 m below the water-sediment interface in areas that encompass the top 90% of NEFSC surfclam and ocean quahog dredge surveys, from the eastern edge of Georges Bank and the Gulf of Maine throughout the U.S. Atlantic EEZ.

HAPC Designations—No HAPC are identified for this species.

- Offshore Hake *(Merluccius albidus)*

Management—Offshore hake have EFH designated by the NEFMC under the Final Amendment #12 to the NE Multispecies FMP (Whiting, Red Hake, and Offshore Hake) (NEFMC 1999).

Status—Currently, offshore hake are not overfished or subject to overfishing (NMFS 2006a).

Distribution—Offshore hake inhabit the outer part of the continental shelf and upper part of the slope along the Atlantic coast of the U.S. from Georges Bank through the Caribbean, including the Gulf of Mexico south to French Guiana (Cohen et al. 1990; Chang et al. 1999a).

Habitat Associations—Offshore hake eggs are pelagic and found in waters ranging between 8º and 20ºC and depths of 110 to 270 m on the outer continental shelf (Chang et al. 1999a). Similar to the eggs, the larvae also are pelagic and found on the outer continental shelf. They frequent waters between 5º and 19ºC and display a preference for depths between 70 and 130 m (Chang et al. 1999a). Juveniles are typically found along the continental slope waters between 1º and 12ºC and depths of 70 to 440 m (Chang et al. 1999a). The adult offshore hake also occur on the continental slope but prefer a temperature range of 3º to 14ºC and depths of 60 to 460 m (Chang et al. 1999a).

Life History—Spawning occurs at depths from 330 to 550 m, from April through July, in coastal southern New England (Cohen et al. 1990). There is no available information on large-scale migrations of offshore hake (Chang et al. 1999a), though diel vertical migrations do occur (Klein-MacPhee 2002e).

Common Prey Species—Offshore hake prey primarily on fishes (herring, anchovy, lanternfish) and secondarily on crustaceans (shrimp) and squid (Klein-MacPhee 2002g).

EFH Designations (NEFMC 1999; Figure D-16)

- Egg—Pelagic waters from the outer continental shelf of Georges Bank and the MAB south to Cape Hatteras, North Carolina are designated as EFH.
- Larva—EFH is designated as pelagic waters from the outer continental shelf of Georges Bank and the MAB south to Chesapeake Bay.
- Juvenile—Bottom habitats from the outer continental shelf of Georges Bank and the MAB south to Cape Hatteras, North Carolina are designated as EFH.
- Adult—Bottom habitats and waters with temperatures below 12°C and depths 150 to 380 m, from the outer continental shelf of Georges Bank and the MAB south to Cape Hatteras, North Carolina, are designated as EFH.
- Spawning Adult—Bottom habitats from the outer continental shelf of Georges Bank and the MAB south to Cape Hatteras, North Carolina are designated as EFH.

HAPC Designations—No HAPC are identified for this species.

- Red Deepsea Crab (*Geryon quinquedens*)

Management—Red deepsea crabs have EFH designated under the FMP for Deepsea Red Crab by the NEFMC (2002)

Status—It is unknown if they are overfished or subject to overfishing (NMFS 2006a).

Distribution—Red deepsea crabs are ubiquitously distributed along the outer continental shelf and mid- to upper continental slope of the northwestern Atlantic from Nova Scotia into the Gulf of Maine southward to the continental shelf edge and slope of the Gulf of Mexico (Wigley et al. 1975; Steimle et al. 2001). This species has been reported to occur in the deepwater canyons along the U.S. east coast, such as Norfolk, Hudson, Hydrographer, and Oceanographer (Steimle et al. 2001).

Habitat Associations—Red deepsea crab eggs are brooded attached to the underside of the female crab, which are most commonly found on the continental slope, until they hatch and are released into the water column. Once in the water column, eggs are typically found in waters with temperatures ranging from 4° to 10°C, while pelagic larvae are found in waters with temperatures between 4° and 25°C, salinities of 29 to 36 psu, and depths between 200 and 1,800 m (NEFMC 2002). Juveniles occur at depths from 700 to 1,800 m in waters with temperatures ranging from 4° to 10°C and salinities of approximately 35 psu, while adults inhabit waters 200 to 1,300 m deep with temperatures between 5° and 14°C and salinities of approximately 35 psu (NEFMC 2002). Both juveniles and adults associate with a range of hard and soft substrates including silt and clay (Steimle et al. 2001).

Life History—This species demonstrates movements (up to 54 nautical miles [NM] in distance) up and down the continental slope that are believed to be associated with spawning (Steimle et al. 2001). Additionally, as deepsea red crabs age and grow larger, they have been reported to migrate up the continental slope into areas of shallower water (Wigley et al. 1975). There is very little information on spawning location or season for this species. There is no evidence of any restricted seasonality in spawning activity in any geographic region of the population, although a mid-winter peak is suggested as larval releases are reported to extend from January to June (Erdman et al. 1991; Steimle et al. 2001).

Common Prey Species—No data exist on the feeding habits or prey consumed by the red deepsea crab in the wild, but they are suspected to feed on zooplankton and scavenge on dead fishes or squid. In laboratory studies, they have been reported to prey upon rotifers, brine shrimp, worms, and small mollusks (Steimle et al. 2001).

EFH Designations (NEFMC 2002; Figure D-17)

- Egg—EFH designated for red deepsea crab eggs is the same as the known distribution of egg-bearing females: depths between 200 and 400 m from the southern flank of Georges Bank south to Cape Hatteras, North Carolina.
- Larva—The entire water column, from surface to seafloor, across the entire depth range identified for the species (200 to 1,800 m) from the southern flank of Georges Bank south to Cape Hatteras, North Carolina is designated as EFH.
- Juvenile—Bottom habitats of the continental shelf with a substrate of silts, clays, and silt-clay-sand composites within water depths of 700 to 1,800 m from the southern flank of Georges Bank south to Cape Hatteras, North Carolina are designated as EFH.
- Adult—EFH is designated as bottom habitats of the continental shelf with a substrate of silts, clays, and silt-clay-sand composites within the depths of 200 to 1,300 m from the southern flank of Georges Bank south to Cape Hatteras, North Carolina.
- Spawning Adult—Bottom habitats of the continental shelf with a substrate of silts, clays, and silt-clay-sand composites within the depths of 200 to 1,300 m from the southern flank of Georges Bank south to Cape Hatteras, North Carolina are designated as EFH.

HAPC Designations—No HAPC are identified for this species.

- Red Hake *(Urophycis chuss)*

Management—EFH for red hake is designated by the NEFMC under Final Amendment #11 to the Northeast Multispecies FMP (NEFMC 1998). The red hake is divided into two separate stocks (northern and southern separated by the central axis of Georges Bank) in U.S. waters (NEFMC 1999).

Status—The red hake is not currently overfished and it is unknown if it is subject to overfishing (NMFS 2006a).

Distribution—Red hake are found in the coastal waters off southern Newfoundland to North Carolina, with their center of abundance concentrated along Georges Bank, in the Gulf of Maine off Cape Cod, and in the northern MAB off Long Island, NY. All lifestages of the red hake are also found in estuaries from southern Maine to Chesapeake Bay (Steimle et al. 1999d).

Habitat Associations—The eggs of the red hake are pelagic, buoyant, and most prevalent off Georges Bank and coastal southern New England during May and June (Klein-MacPhee 2002h). The larvae are present from May to December on Georges Bank and coastal southern New England but are most numerous during September and October (Klein-MacPhee 2002h). In the MAB, larvae occur in water ranging from 8º to 23ºC and at depths between 10 and 200 m (Steimle et al. 1999d). Both the eggs and larvae are known to drift with the prevailing currents to the southwest (Clark and Livingstone 1982). Upon recruitment from the plankton to the benthos, juvenile red hake are commonly found in close association with benthic debris (e.g., shells, sponges, rocks, etc.), which they use for shelter (Klein-MacPhee 2002h). Juveniles display a preference for waters between 4.2º and 7.5ºC, depths from 40 to 50 m, and salinities of 31 to 32.8 psu. Adults prefer waters ranging from 5º to 12ºC in temperature with a salinity range of 33 to 34 psu. They inhabit soft sediments at depths of 35 to 980 m, being found less frequently over gravel, shell, or rocky bottoms (Steimle et al. 1999d; Klein-MacPhee 2002h).

Life History—The main spawning grounds for red hake include the southwest portion of Georges Bank, the continental shelf off coastal southern New England, and eastern Long Island, NY. Spawning adults are commonly found in the marine areas of most of the coastal bays between Narragansett Bay and Massachusetts Bay but rarely north or south of this range (Steimle et al. 1999d). Spawning occurs from April through November at temperatures of 5º and 10ºC (Steimle et al. 1999d). Red hake undergo extensive seasonal migrations and are found in the coastal waters (less than 100 m) during the warmer months and migrate further offshore (greater than 100 m) during colder months (Steimle et al. 1999d).

Common Prey Species—Red hake feed primarily on crustaceans (crab and shrimp) and other invertebrates (bivalves, squid, and worms) and secondarily on fishes (haddock, silver hake, sand lance, sea robin, and mackerel) (Klein-MacPhee 2002h).

EFH Designations (NEFMC 1998; Figure D-18)

- Egg—EFH is designated as the surface waters from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina.
- Larva—Surface waters from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina are designated as EFH for this lifestage of the red hake. Additionally, southern New England and mid-Atlantic estuaries and embayments are also designated as EFH for this lifestage.
- Juvenile—EFH is designated as the bottom habitats with a substrate of shell fragments, including areas with an abundance of live scallops, from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina. Chesapeake Bay, northern MAB, and southern New England estuaries and bays are designated as EFH for this lifestage.
- Adult—Bottom habitats in depressions with a substrate of sand and mud from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina are designated as EFH for this lifestage of the red hake. Based on salinity, Delaware and Chesapeake Bays as well as estuaries and bays in southern New England have also been designated as EFH.
- Spawning Adult—EFH is designated as the bottom habitats in depressions with a substrate of sand and mud from the Gulf of Maine, the southern edge of Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina. In addition, southern New England and mid-Atlantic estuaries and embayments are designated as EFH for this lifestage of the red hake.

HAPC Designations—No HAPC are identified for this species.

- Rosette Skate *(Leucoraja garmani virginica)*

  Management—The northern subspecies of the rosette skate has EFH designated under the Final FMP for the NE Skate Complex by the NEFMC (2003a).

  Status—This skate species is not overfished nor subject to overfishing (NMFS 2006a).

  Distribution—The northern subspecies of rosette skate occurs along the outer continental shelf and upper slopes from Nantucket Shoals to Cape Hatteras, North Carolina (McEachran 2002).

  Habitat Associations—Single fertilized eggs are laid in egg capsules (McEachran 2002; Packer et al. 2003c). During spring, juveniles are found in waters with depths of 31 to 400 m, temperatures ranging from 5º to 21ºC, and salinities from 32 to 36 psu. In the fall, juveniles are observed at depths of 11 to 500 m, water temperatures of 6º to 24ºC, and salinities ranging from 31 to 36 psu (Packer et al. 2003c). Adult rosette skate inhabit areas of soft bottom, including mud and sand bottoms, mud with echinoid and ophiuroid fragments, as well as shell and pteropod ooze (Packer et al. 2003c). They are found at depths of 33 to 530 m (most common between 74 and 274 m) and in water temperatures ranging from 6º to 19ºC north of Cape Hatteras, North Carolina (greatest abundance at temperatures ranging between 9º and 13ºC) (McEachran and Musick 1975; McEachran 2002; Packer et al. 2003c).

  Life History—Little is known about the reproductive behavior of this species. Egg capsules are found throughout the year north of Cape Hatteras, North Carolina but are most common in the summer months (McEachran 2002; Packer et al. 2003c).

  Common Prey Species—Sand shrimp and rock crab are considered the main prey of the rosette skate, but they also feed on other invertebrates and small fishes (McEachran 2002).

  EFH Designations (NEFMC 2003a; Figure D-19)

  - Larva—No larval stage exists for this species. Upon hatching, rosette skates are fully developed juveniles.
  - Juvenile—Bottom habitats along the shelf break region with soft substrate, including sand/mud bottoms, mud with echinoid and ophiuroid fragments, and shells and pteropod ooze from Nantucket Shoals and the southern edge of Georges Bank to Cape Hatteras, North Carolina that encompass the highest 90% where this species was collected during NMFS trawl surveys are designated as EFH.
  - Adult—Bottom habitats along the shelf break region with soft substrate, including sand/mud bottoms, mud with echinoid and ophiuroid fragments, and shells and pteropod ooze from Nantucket Shoals and the southern edge of Georges Bank to Cape Hatteras, North Carolina that encompass the highest 90% where this species was collected during NMFS trawl surveys are designated as EFH. These regions are located north of the VACAPES OPAREA.

  HAPC Designations—No HAPC are identified for this species.

- Scup *(Stenotomus chrysops)*

  Management—The scup fishery has EFH designated jointly by the MAFMC and the ASMFC under Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP (MAFMC and ASMFC 1998a).

  Status—The scup stock in the northwestern Atlantic is overfished and overfishing is currently occurring (NMFS 2006a).

  Distribution—Scup are a continental shelf species found in the western North Atlantic Ocean, occur primarily from Cape Cod, MA to Cape Hatteras, North Carolina (Morse 1982), although scup have been observed as far north as the Bay of Fundy and Sable Island Bank, Nova Scotia (Steimle et al. 1999e; Klein-MacPhee 2002i) and as far south as Florida (Manooch 1988).

Habitat Associations—During May through August, the buoyant, pelagic eggs of scup are primarily observed in larger bodies of coastal waters, including bays and sounds, in and around coastal southern New England (Morse 1982; Steimle et al. 1999e). Larval scup are also pelagic and occur from May through September in coastal waters at temperatures ranging from 14º to 22ºC. Both the eggs and the larvae are typically found in waters less than 50 m in depth (Steimle et al. 1999e). During the transition of larvae into juveniles, the scup abandons its pelagic lifestyle in favor of bottom habitats (Morse 1982). Juvenile scup tend to be associated with intertidal and subtidal habitats. During summer and fall, these areas include sand bottoms, mud bottoms, mussel beds, and eelgrass beds, while during winter and spring, juvenile scup are found on the continental shelf over habitats ranging from flat, open, sandy-silty bottoms to the heads of submarine canyons. Adult scup are commonly associated euryhaline waters with soft, sandy bottoms on or near structures including rock ledges, mussel beds, artificial reefs, and shipwrecks. Both juveniles and adults prefer waters with temperatures ranging between 5º and 27ºC (Steimle et al. 1999e).

Life History—In the MAB, scup spawn once a year during the daytime and typically close to shore from May through August, with peaks occurring in June and July (Morse 1982; Steimle et al. 1999e; Klein-MacPhee 2002i). Migration times and overwintering localities vary from year to year depending on water temperatures. Scup migrate out of the inshore waters to the warmer, deeper waters of the outer continental shelf ranging in depth from 70 to 180 m south of Hudson Canyon off New Jersey and along the coast from south of Long Island, NY to North Carolina (Tercerio 2001a; Klein-MacPhee 2002i). Scup return to the inshore waters once the temperatures begin to rise again in the spring (Steimle et al. 1999d). During the summer, scup are most common in most large estuaries and coastal areas (Klein-MacPhee 2002i).

Common Prey Species—Scup feed on benthic invertebrates (mollusks, crab, shrimp, squid, crustaceans, and worms) and fishes but rarely feed any higher in the water column (Klein-MacPhee 2002i).

EFH Designations (MAFMC and ASMFC 1998a; Figure D-20)

- <u>Egg</u>—EFH designated for this lifestage includes southern New England and mid-Atlantic estuaries and embayments. None of these areas are within the VACAPES OPAREA.
- <u>Larva</u>—Southern New England and mid-Atlantic estuaries and bays are designated as EFH for this lifestage of scup and are not located within the VACAPES OPAREA.
- <u>Juvenile</u>—EFH is designated as the bottom waters from the coast to the limits of the U.S. EEZ in areas that encompass the highest 90% of the region where juvenile scup were collected in NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras, North Carolina. Additionally, southern New England and mid-Atlantic estuaries and embayments are designated as EFH for this lifestage.
- <u>Adult</u>—EFH is designated as the bottom waters from the coast out to the limits of the U.S. EEZ in areas that encompass the highest 90% of all the area where juvenile scup were collected in the NEFSC trawl surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. Addition estuaries and bays, such as Delaware Bay, Delaware Inland Bays, and Chesapeake Bay Mainstem as well as some southern New England and northern mid-Atlantic estuaries and embayments are designated as EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- <u>Sea Scallop</u> *(Placopecten magellanicus)*

Management—Sea scallops have EFH designated under the NEFMC Final Amendment #9 to the Atlantic Sea Scallop FMP (NEFMC 1998).

Status—Sea scallops are neither overfished nor subject to overfishing (NMFS 2006a).

Distribution—The sea scallop range in the northwestern Atlantic Ocean extends along the continental shelf from the north shore of the Gulf of St. Lawrence south to Cape Hatteras, North

Carolina (Packer et al. 1999a). Large concentrations exist on Georges Bank and the mid-Atlantic shelf (NEFMC 2003b).

Habitat Associations—Sea scallops typically occur in dense aggregations called beds at depths ranging from 18 to 110 m (Packer et al. 1999a). The highest concentration of many sea scallop beds corresponds to regions where suitable temperatures, food availability, substrate, and physical oceanographic features (e.g., fronts, currents, and gyres) are found (Packer et al. 1999a). Eggs are demersal and remain on the seafloor until they develop into free-swimming larvae. Eggs are typically found in waters with temperatures below 17°C and larvae in water temperatures below 18°C and salinities between 17 and 30 psu (NEFMC 1998; Packer et al. 1999a). Juvenile and adult sea scallops typically utilize waters with temperatures below 21°C and are found in depths of 18 to 110 m (NEFMC 1998; Packer et al. 1999a). Larvae are planktonic for a month after hatching and then typically settle on bottom substrates covered with biofilm (Parsons et al. 1993; Hart and Chute 2004). Juveniles and adults attach themselves to shells, gravel, and other bottom debris, with gravel substrates hosting the greatest numbers of scallops (Hart and Chute 2004).

Life History—Spawning occurs from May through October, peaking in May and June in the MAB portion of the VACAPES OPAREA in waters with temperatures below 16°C, depths from 18 to 110 m, and salinities above 17 psu (NEFMC 1998). Males and females release their gametes synchronously during spawning events with timing varying with latitude. Spawning occurs off Virginia and North Carolina beginning in July; off Long Island, NY in August; and off Georges Bank and Cape Cod Bay in late September through early October (MacKenzie et al. 1978; Hart and Chute 2004). A biannual spawning cycle has been reported on the U.S. middle Atlantic shelf south of the Hudson Canyon (Packer et al. 1999a; Hart and Chute 2004). Sea scallop spawning events are related to lunar and tidal cycles (Parsons et al. 1993). This species does not migrate and any movements, typically by juveniles, are highly localized, random, and a result of currents (Packer et al. 1999a; Hart and Chute 2004).

Common Prey Species—Sea scallops are filter feeders that eat plankton, bacteria, and detritus (Packer et al. 1999a; Hart and Chute 2004).

EFH Designations (NEFMC 1998; Figure D-21)

- Egg—Bottom habitats from the Gulf of Maine, Georges Bank, and the MAB south to the Virginia-North Carolina border are designated as EFH. Additionally, southern New England estuaries and embayments are designated as EFH for this lifestage.
- Larva—Pelagic waters and bottom habitats with a substrate of gravelly sand, shell fragments, and pebbles or with communities of red algae, hydroids, amphipod tubes, and bryozoans from the Gulf of Maine, Georges Bank, and the MAB south to the Virginia-North Carolina border are designated as EFH. In addition, some southern New England estuaries and bays are also designated as EFH for this lifestage of the sea scallop.
- Juvenile—Bottom habitats with substrates of cobble, shells, and silt from the Gulf of Maine, Georges Bank, and the MAB south to the Virginia-North Carolina border are designated as EFH. Southern New England estuaries and embayments are also designated as EFH for this lifestage.
- Adult—Bottom habitats with substrates of cobble, shells, coarse/gravelly sand, and sand as well as salinities above 17 psu from the Gulf of Maine, Georges Bank, and the MAB south to the Virginia-North Carolina border as well some southern New England estuaries and bays are designated as EFH for this lifestage of sea scallops.
- Spawning Adult—Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand from the Gulf of Maine, Georges Bank, and the MAB south to the Virginia-North Carolina border are designated as EFH. Additionally, southern New England estuaries and embayments are designated as EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Silver Hake/Whiting *(Merluccius bilinearis)*

Management—Two main stocks are recognized in U.S. coastal waters: a northern stock within waters of the Gulf of Maine and the northern portion of Georges Bank and a southern stock inhabiting the southern portion of Georges Bank to the MAB (Helser 1996; Brodziak 2001). Both stocks have EFH designated by the NEFMC under Final Amendment #11 to the Northeast Multispecies FMP (NEFMC 1998).

Status—The southern stock of silver hake (the only stock in the VACAPES OPAREA) is not overfished, and it is unknown if the fishery is subject to overfishing (NMFS 2006a).

Distribution—Silver hake are found in the northwestern Atlantic Ocean from the southern edge of the Grand Banks off Newfoundland, Canada and the Gulf of St. Lawrence south to Cape Fear, North Carolina along the continental shelf (Klein-MacPhee 2002j). They are most common in the Gulf of Maine and on the Scotian Shelf, Georges Bank, the MAB off Long Island, NY, and the southern flank of Grand Banks (Morse et al. 1999).

Habitat Associations—Silver hake eggs are pelagic and drift with the prevailing currents. Eggs are typically observed in waters with temperatures between 5º and 21ºC and bottom depths of 10 to 1,250 m but are most abundant at depths of 50 to 150 m (Lock and Packer 2004). The pelagic larval stage inhabits waters with temperatures ranging from 5º to 16ºC and at depths of 10 to 1,250 m, although they are most common in depths of 50 to 130 m (Lock and Packer 2004). During the transition between larvae and juveniles, silver hake drop out of the plankton and settle into benthic habitats (Lock and Packer 2004). While juvenile silver hake are found over a wide range of temperatures and depths (Lock and Packer 2004), they display a preference for bottom temperatures between 8º and 10ºC and depths of 60 to 100 m (Lock and Packer 2004). Adults have been observed in waters ranging from 3º to 18ºC in temperature, although they are most common between 7º and 17ºC. Silver hake are nocturnal hunters, and during the day they are believed to rest on the sea bottom, on sand or pebbly substrate or mud but seldom over rocks. During the night, silver hake can be found throughout the water column in pursuit of prey with no limits to their vertical movements (Klein-MacPhee 2002j).

Life History—During periods of feeding and spawning, the silver hake is often found in dense schools. Spawning extends throughout the year and peaks between May and August (Brodziak 2001; Klein-MacPhee 2002j). The majority of the spawning activity on the continental shelf occurs along the southeastern and southern slopes of Georges Bank, around Nantucket Shoals, and south of Martha's Vineyard to Cape Hatteras, North Carolina (Klein-MacPhee 2002j). Silver hake migrate in response to seasonal changes in water temperatures. During the spring, silver hake migrate into shallow water where spawning occurs throughout late spring and early summer. When autumn arrives, they move back into the deeper waters of the Gulf of Maine and the outer continental shelf and slope waters (Brodziak 2001).

Common Prey Species—Silver hake prey upon crustaceans, fishes (anchovy, herring, lanternfish, mackerel, sand lance, and butterfish), and squid (Klein-MacPhee 2002j).

EFH Designations (NEFMC 1998; Figure D-22)

- Egg—EFH is designated as the surface waters from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina. Additionally, southern New England estuaries and embayments are designated as EFH for this lifestage.
- Larva—EFH is designated as the surface waters from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina. Additional southern New England estuaries and bays have also been designated as EFH for this lifestage of the silver hake.
- Juvenile and Adult—EFH is designated as bottom habitats of all substrate types from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina. Southern New England bays and estuaries are additionally designated as EFH for this lifestage.

- Spawning Adult—EFH is designated as bottom habitats of all substrate types from the Gulf of Maine, Georges Bank, and the continental shelf of the MAB south to Cape Hatteras, North Carolina. EFH is also designated for southern New England estuaries and bays for this silver hake lifestage.

HAPC Designations—No HAPC are identified for this species.

- Spiny Dogfish (*Squalus acanthias*)

Management—Spiny dogfish have EFH designated under the joint management of the MAFMC and the NEFMC through the Spiny Dogfish FMP (MAFMC and NEFMC 1999).

Status—The spiny dogfish stock is not subject to overfishing; however, there is no definition in the FMP for determining a biomass target. Based on the NMFS' recommended biomass threshold, the current biomass level indicates that the stock is overfished (NMFS 2006a). According to the International Union for Conservation of Nature and Natural Resources (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 Associations—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 2002a).

Life History—Spiny dogfish spawn in the winter in offshore waters (Cohen 1982; Burgess 2002a). 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 2002a). 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-23)

- Juvenile—EFH is designated as the waters off the continental shelf in areas that encompass the highest 90% of all the area where juvenile dogfish were collected in NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras, North Carolina. South of Cape Hatteras and extending through Cape Canaveral, Florida, EFH is designated in waters with depths to 390 m. In addition, southern New England estuaries and bays are designated as EFH for this lifestage.
- Adult—EFH is designated as the waters over the continental shelf in areas that encompass the highest 90% of all the area where adult dogfish were collected in NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras, North Carolina. South of Cape Hatteras and extending through Cape Canaveral, Florida, EFH is designated in waters to depths reaching 450 m. 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 has EFH jointly designated by the MAFMC and the ASMFC under Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP (MAFMC and ASMFC 1998a).

Status—As of 2003, the summer flounder stock is no longer overfished nor is it subject to overfishing (NMFS 2006a).

Distribution—The range of summer flounder includes the continental shelf and estuaries from Nova Scotia to Florida, but their occurrence north of Cape Cod, MA and south of Cape Hatteras, North Carolina is rare (Byrne and Azarovitz 1982; Klein-MacPhee 2002k).

Habitat Associations—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, North Carolina within 25 NM of shore. 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. Following their metamorphosis into juveniles, the summer flounder seeks inshore demersal habitats (Byrne and Azarovitz 1982). They are associated with 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 2002k). 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 2002k).

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 2002k). Summer flounder feed on benthos as well as throughout the water column to the surface (Klein-MacPhee 2002k).

EFH Designations (MAFMC and ASFMC 1998a; Figure D-24)

- Egg—EFH is designated as the pelagic waters found over the continental shelf in the highest 90% of all the area where summer flounder eggs were collected during the MARMAP surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. South of Cape Hatteras and extending to Cape Canaveral, Florida, EFH is designated as waters over the continental shelf (from the coast to the U.S. EEZ) to depths of 110 m.
- Larva—EFH is designated as pelagic waters found over the continental shelf in the highest 90% of all the area where summer flounder larvae were collected during the MARMAP surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. South of Cape Hatteras and extending to Cape Canaveral, Florida, EFH is designated as nearshore waters (to 44 NM from shore) of the continental shelf (from the coast to the limits of the U.S. EEZ). Additional estuaries and bays such as Delaware Inland Bays, Chesapeake Bay Mainstem, Rappahannock River, York River, James River, Albemarle Sound, Pamlico Sound, Neuse River, Bogue Sound, New River, Cape Fear River, Winyah Bay, North and South Santee rivers, Charleston Harbor, St. Helena Sound, Broad River, Savannah River, Ossabaw Sound, St. Cathe/Sapelo Sound, Altamaha River, St. Andrew/St. Simon Sound, St. Johns River, and Indian River have been designated as EFH for this lifestage of the summer flounder.

- Juvenile—EFH is designated as demersal waters over the continental shelf in the highest 90% of all the area where juvenile and adult summer flounder were collected in the NEFSC trawl surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. South of Cape Hatteras and extending to Cape Canaveral, Florida, EFH is designated as waters over the continental shelf (from the coast out to the limits of the U.S. EEZ) to depths of 152 m. Delaware Bay, Delaware Inland Bays, Chicoteague Bay, Chesapeake Bay Mainstem, Chester River, Choptank River, Patuxent River, Potomac River, Tangier/Pocomoke Sound, Rappahannock River, York River, James River, Albemarle Sound, Pamlico Sound, Pamilico/Pungo rivers, Neuse River, Bogue Sound, New River, Cape Fear River, Winyah Bay, North and South Santee rivers, Charleston Harbor, St. Helena Sound, Broad River, Savannah River, Ossabaw Sound, St. Cathe/Sapelo Sound, Altamaha River, St. Andrew/St. Simon Sound, St. Johns River, and Indian River have been designated as EFH for this lifestage as well.
- Adult—EFH is designated as bottom waters over the continental shelf in the highest 90% of all the area where juvenile and adult summer flounder were collected in NEFSC trawl surveys, from the Gulf of Maine to Cape Hatteras, North Carolina. South of Cape Hatteras and extending to Cape Canaveral, Florida, EFH is designated as waters over the continental shelf (from the coast out to the limits of the U.S. EEZ) to depths of 152 m. Estuaries and bays including Delaware Bay, Delaware Inland Bays, Chicoteague Bay, Chesapeake Bay Mainstem, Chester River, Choptank River, Patuxent River, Potomac River, Tangier/Pocomoke Sound, Rappahannock River, York River, James River, Albemarle Sound, Pamlico Sound, Pamilico/Pungo rivers, Neuse River, Bogue Sound, New River, Cape Fear River, Winyah Bay, North and South Santee rivers, Charleston Harbor, St. Helena Sound, Broad River, St. Johns River, and Indian River have been designated as EFH.

HAPC Designations—(MAFMC and ASFMC 1998a; Figure D-24)

- Juvenile and Adult—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 EFH are considered as HAPC but are not within the boundaries of the VACAPES OPAREA (MAFMC and ASFMC 1998a).

- Tilefish (*Lopholatilus chamaeleonticeps*)

  This species has EFH designated by both the MAFMC and SAFMC. See Section 5.3.2 for a complete write-up on this species.

- White Hake *(Urophycis tenuis)*

  Management—White hake have EFH designated by the NEFMC under the Final Amendment #11 to the NE Multispecies FMP (NEFMC 1998).

  Status—The white hake is subject to overfishing and has an overfished status (NMFS 2006a).

  Distribution—The primary range of white hake in the northwest Atlantic Ocean is from Labrador and the Grand Banks of Newfoundland to Cape Hatteras, North Carolina, although they have been reported as far south as Florida and as far east as Iceland (Klein-MacPhee 2002l). They occur in the deep, muddy basins of the Gulf of Maine, in estuaries, and across the continental shelf to the submarine canyons along the continental slope (Chang et al. 1999b).

  Habitat Associations—White hake eggs are buoyant and most often observed in waters with temperatures between 7º and 20ºC and depths of 10 to 250 m during the months of August and September (Chang et al. 1999b). Larval white hake are typically found in waters with temperatures of 10º to 18ºC and depths ranging from 10 to 150 m. Most larvae have been collected off the MAB in slope waters, although some have been noted in warm core rings from the Gulf Stream (Chang et al. 1999b). The majority of smaller, pelagic juvenile white hake that are spawned offshore cross the continental shelf and enter estuarine nursery areas. These fish display a preference for waters with temperatures between 4º and 19ºC and depths of less than 75 m. The larger, demersal juveniles prefer offshore habitats with water temperatures of 4º to 16ºC and depths of less than 225 m. Although eelgrass beds are an important habitat for demersal juveniles, they are not dependent on this or any other type of vegetation or structure (Chang et al. 1999b). Adult white hake are demersal and are often associated with fine-grained, muddy substrates in waters with temperatures ranging from 5º to 14ºC and depths of 15 to 325 m, depending on the location (Chang et al 1999b).

Life History—Spawning occurs between August and September in the southern Gulf of St. Lawrence and on the Scotian Shelf for fish in the northern part of their range. White hake found further south are believed to spawn in the deep waters along the continental slope, primarily off the MAB and southern Georges Bank during April and May (Chang et al 1999b). Both juvenile and adult white hake utilize deeper waters during the colder months and migrate inshore during the warmer months (Klein-MacPhee 2002l).

Common Prey Species—White hake feed primarily on bony fishes (herring, argentine, hake, cod, haddock, redfish, mackerel, sand lance, and winter flounder), krill, and squid (Klein-MacPhee 2002l).

EFH Designations (NEFMC 1998; Figure D-25)

- Egg—EFH is designated as surface waters in the Gulf of Maine, Georges Bank, and MAB. Additionally, southern New England estuaries and bays are designated as EFH for this lifestage.
- Larva—EFH is designated as pelagic waters of the Gulf of Maine, the southern edge of Georges Bank, and the MAB. In addition, southern New England bays and estuaries are designated as EFH for this lifestage of the white hake.
- Juvenile—EFH is designated as pelagic waters and the bottom habitats with seagrass beds or a substrate of mud or fine-grained sand of the Gulf of Maine, the southern edge of Georges Bank, and the MAB. Southern New England estuaries and bays are also designated as EFH for this lifestage.
- Adult—EFH is designated as bottom habitats with a substrate of mud or fine-grained sand in the Gulf of Maine, the southern edge of Georges Bank, and the MAB. EFH for this lifestage is also designated as southern New England estuaries and embayments.
- Spawning Adult—EFH is designated as bottom habitats with a deepwater substrate of mud or fine-grained sand in the Gulf of Maine, the southern edge of Georges Bank, and the MAB.

HAPC Designations—No HAPC are identified for this species.

- Windowpane Flounder (*Scophthalmus aquosus*)

Management—Windowpane flounder currently have EFH designated by the NEFMC through the Final Amendment #11 to the NE Multispecies FMP (NEFMC 1998). This species is managed as two stocks: a northern stock, located in the Gulf of Maine and Georges Bank region, and a southern stock, located in the MAB region (NEFMC 1998; 2004).

Status—Both the northern and southern stocks are overfished although overfishing is no longer occurring (NMFS 2006a).

Distribution—The windowpane flounder is distributed throughout the northwest Atlantic Ocean from the Gulf of St. Lawrence to Florida but occurs with highest frequency between Georges Bank and the Chesapeake Bay (Morse and Able 1995).

Habitat Associations—Windowpane flounder eggs are primarily found throughout the high salinity areas of estuaries and the inner continental shelf in waters between 5º and 20ºC in temperature and less than 70 m in depth (Chang et al. 1999c). Larval windowpane flounder start off as pelagic but settle to the bottom at approximately a size of 10 millimeters (mm). They are found primarily in estuaries and on the nearshore continental shelf in waters with temperatures ranging from 3º to 19ºC and at depths of less than 70 m (Morse and Able 1995; Chang et al. 1999c). Juveniles and adults are found in estuaries and throughout much of the continental shelf between depths of 5 and 207 m (most common in waters less than 50 m) and temperatures of 0º to 27ºC (Morse and Able 1995; Chang et al. 1999c; Klein–MacPhee 2002m). Adults are euryhaline and can tolerate salinity ranges of 5.5 to 36 psu (Chang et al. 1999c; Klein–MacPhee 2002m). Adult windowpane flounder are associated with sandy substrates off coastal southern New England and the MAB but are also frequently observed on mud grounds in the Gulf of Maine (Chang et al. 1999).

Life History—Spawning occurs in the inner shelf waters between New Jersey and Cape Hatteras, North Carolina in February or March. By April, spawning has expanded into the deeper waters and on to Georges Bank. The peak spawning period is between May and October (Klein–MacPhee 2002m) with spawning completed by January (Morse and Able 1995). Spawning typically occurs in waters with temperatures of 6º to 17ºC (Klein–MacPhee 2002m). Windowpane flounder display limited seasonal movement (Morse and Able 1995). Based on trawl survey data, windowpane flounder are concentrated in shoal waters during the summer and early fall and migrate offshore during winter and early spring as water temperatures decline (Dery and Livingstone 1982).

Common Prey Species—The three main prey of the windowpane flounder's diet are opossum shrimp, sand shrimp, bony fishes (anchovy, snake eel, silver hake, tomcod, cusk, killifish, silverside, pipefish, blackbelly rosefish, sculpin, striped bass, sand lance, and flatfish species) and fish larvae (Klein–MacPhee 2002m). They have also been reported to feed on various other invertebrates, including squids, mollusks, worms, isopods, krill, and salps (Klein–MacPhee 2002m).

EFH Designations (NEFMC 1998; Figure D-26)

- Egg—EFH is designated as surface waters around the perimeter of the Gulf of Maine, Georges Bank, and the MAB south to Cape Hatteras, North Carolina. Delaware Bay and Delaware Inland Bays plus southern New England estuaries are designated as EFH for this lifestage of the windowpane flounder.
- Larva—EFH is designated as pelagic waters around the perimeter of the Gulf of Maine, Georges Bank, and the MAB south to Cape Hatteras, North Carolina. Additionally, Delaware Bay and Delaware Inland Bays as well as southern New England estuaries and bay are designated as EFH for this lifestage.
- Juvenile—EFH is designated as bottom habitats with a substrate of mud or fine-grained sand around the perimeter of the Gulf of Maine, Georges Bank, and the MAB south to Cape Hatteras, North Carolina. EFH has also been designated as Delaware Bay, Delaware Inland Bays, Chincoteague Bay, and Chesapeake Bay as well as southern New England bays and estuaries for this lifestage of the windowpane flounder.
- Adult—EFH is designated as bottom habitats with a substrate of mud or fine-grained sand around the perimeter of the Gulf of Maine, Georges Bank, and the MAB south to the Virginia/North Carolina border. Based on salinity, bays and estuaries including Chincoteague Bay, Chesapeake Bay, as well as some in southern New England are designated as EFH for this lifestage.
- Spawning Adult—EFH is designated as bottom habitats with a substrate of mud or fine-grained sand in the Gulf of Maine, Georges Bank, and the MAB south to the Virginia/North Carolina border. Also designated as EFH for this lifestage are Delaware Bay, Delaware Inland Bays, and southern New England estuaries and bays.

HAPC Designations—No HAPC are identified for this species.

- Winter Flounder *(Pseudopleuronectes americanus)*

Management—EFH for the winter flounder is designated by the NEFMC under the Final Amendment #11 to the NE Multispecies FMP (NEFMC 1998).

Status—This species is considered overfished and overfishing is currently occurring (NMFS 2006a).

Distribution—Winter flounder are distributed in the northwestern Atlantic Ocean from Labrador to Georgia (McCracken 1963), with the highest concentrations found between the Gulf of St. Lawrence and the Chesapeake Bay (Klein-MacPhee 2002n).

Habitat Associations—Winter flounder eggs are demersal and stick together in clusters. They are laid in estuaries, coves, and inlets in less than 5 m of water, at temperatures of 10ºC or less, and salinities of 10 to 30 psu. Eggs occur on a variety of substrates including sand, muddy sand, mud, and gravel (Pereira et al. 1999). Larval winter flounder are negatively buoyant and sink when not swimming (Klein-MacPhee 2002n). They occur inshore, except on Georges Bank and Nantucket Shoals, in waters ranging from 2º to 19.5ºC in temperature, 6 to 26 psu in salinity, and 2 to 70 m in water depth, depending upon the location (Pereira et al. 1999). Newly settled juvenile winter flounder are found in waters with temperatures ranging from 4º to 15ºC and are the most densely congregated over muddy substrates or fine-grained substrates. Older juveniles are found to a lesser extent in a variety of habitats, including mud-shell litter, marsh creeks, macroalgae beds, and eelgrass beds (Pereira et al. 1999; Klein-MacPhee 2002n). Adult winter flounder prefer waters with temperatures from 2º to 19.5ºC and salinities of 15 psu or greater (McCracken 1963; Pereira et al. 1999). They are found in a variety of habitats ranging from muddy sand, sand, clay, pebbles, and gravel inshore to hard bottom on the offshore banks (Klein-MacPhee 2002n).

Life History—Winter flounder are batch spawners, spawning on sandy bottoms in shallow waters, estuaries, and coastal ponds (Pereira et al. 1999; Klein-MacPhee 2002n). Spawning occurs between January and May off coastal southern New England and during November to April in the southern part of their range, from Delaware south (Klein-MacPhee 2002n). Winter flounder migrate out of bays and the nearshore zone during the summer months south of Cape Cod, MA. North of Cape Cod, this movement pattern is not uniform in all areas. This migration has been correlated with an increase in temperature (>15ºC) in the inshore waters (McCracken 1963). In early fall, winter flounder reappear within the bays and estuaries once temperatures return to the preferred range (McCracken 1963).

Common Prey Species—Winter flounder are opportunistic feeders that prey primarily on benthic invertebrates (shrimp, mollusks, and worms) during the daytime. They have also been recorded to eat sand lances and fish eggs (Pereira et al. 1999; Klein-MacPhee 2002n).

EFH Designations (NEFMC 1998; Figure D-27)

- Egg—EFH is designated as bottom habitats with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, inshore areas of the Gulf of Maine, and the MAB south to the Delaware Bay. Delaware Bay and Delaware Inland Bays as well as southern New England estuaries and bays are designated as EFH for this lifestage of winter flounder.
- Larva—EFH is designated as pelagic and bottom waters of Georges Bank, the inshore areas of the Gulf of Maine, and the MAB south to the Delaware Bay. Delaware Bay and Delaware Inland Bays as well as southern New England estuaries and bays are designated as EFH for this lifestage.
- Juvenile—EFH is designated as bottom habitats with a substrate of mud or fine-grained sand on Georges Bank, the inshore areas of the Gulf of Maine, and the MAB south to the Delaware Bay. Additionally, Delaware Bay, Delaware Inland Bays, Chincoteague Bay, and southern New England estuaries and embayments are designated as EFH for this lifestage of the winter flounder.
- Adult—EFH is designated as bottom habitats including estuaries with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, inshore areas of the Gulf of Maine, and the MAB south to the Delaware Bay. In addition, Delaware Bay, Delaware Inland Bays, and Chincoteague Bay plus southern New England estuaries and bays are designated as EFH for this lifestage.
- Spawning Adult—EFH is designated as bottom habitats including estuaries with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, inshore areas of the Gulf of Maine, and the MAB south to the Delaware Bay. Delaware Bay and Delaware Inland Bays as well as southern New England estuaries are designated as EFH.

HAPC Designations—No HAPC are identified for this species.

- Winter Skate *(Leucoraja ocellata)*

  Management—Winter skates have EFH designated by the NEFMC through the Final FMP for the NE Skate Complex (NEFMC 2003a).

  Status—They are not overfished but whether they are subject to overfishing is unknown (NMFS 2006a).

  Distribution—Winter skates are found from coastal southern Newfoundland and the southern Gulf of St. Lawrence to Cape Hatteras, North Carolina (McEachran and Musick 1975; McEachran 2002; Packer et al. 2003d).

  Habitat Associations—The eggs of winter skates are laid on the bottom in capsules (McEachran 2002; Packer et al. 2003d). Upon hatching, the skates are already fully developed juveniles (NEFMC 2003a). During the spring, juvenile winter skates are most common in waters with temperatures of 4º to 5ºC, salinities of 32 to 33 psu, and depths of 11 to 70 m. In the fall, juveniles are typically observed in waters with temperatures of 7º to 16ºC (peaks between 13º and 15ºC), salinities between 32 and 33 psu, and depths ranging from 21 to 80 m (Packer et al. 2003d). In spring, adult winter skates are most abundant in waters ranging from 4 to 6ºC in temperature, salinities of 33 psu, and depths of 31 to 60 m, while during the fall, adults are most commonly distributed in waters with temperatures ranging from 11º to 15ºC, salinities of 32 psu, and depths of 31 to 50 m (Packer et al. 2003d). Winter skates are most frequently found in habitats containing sandy to gravelly bottoms (McEachran 2002).

  Life History—Female winter skates carrying fully formed egg capsules are present throughout the year but are most commonly recorded during the summer and fall (McEachran 2002). Winter skates undergo seasonal movements in the southern portion of their range (McEachran and Musick 1975). Only during the winter months are winter skates abundant south of Delaware. In addition, they are more abundant during the winter than the rest of the year in inshore waters near Woods Hole, MA and in Massachusetts Bay (McEachran 2002).

  Common Prey Species—Winter skate prey primarily on benthic invertebrates, including squid, worms, crabs, krill, shrimp, bivalves, amphipods, echinoderms, and fishes (skates, eels, herring, alewife, menhaden, silver hake, red hake, tomcod, cod, smelt, sculpins, redfish, sand lance, cunner, butterfish, mackerel, summer flounder, and yellowtail flounder) (McEachran 2002).

  EFH Designations (NEFMC 2003a; Figure D-28)

  - Egg—Chesapeake Bay Mainstem and northern MAB estuaries and embayments are designated as EFH for this lifestage of winter skate and are not located in the VACAPES OPAREA.
  - Larva—No larval stage exists for this species. Upon hatching, they are fully developed juveniles.
  - Juvenile—EFH is designated as bottom habitats with a substrate of sand and gravel or mud that encompass the highest 90% where this species was collected during NMFS trawl surveys in Cape Cod Bay, on Georges Bank, and through the MAB to North Carolina. Chesapeake Bay Mainstem and addition northern MAB estuaries and bay are designated as EFH for this lifestage.
  - Adult—EFH is designated as bottom habitats with a substrate of sand and gravel or mud that encompass the highest 90% where this species was collected during NMFS trawl surveys in Cape Cod Bay, on Georges Bank, and through the MAB to North Carolina. Delaware Bay, Delaware Inland Bays, and Chesapeake Bay Mainstem as well as MAB estuaries and embayments are designated as EFH for this lifestage.
  - Spawning Adult—EFH designated for this lifestage includes mid-Atlantic estuaries and embayments, which are located outside the VACAPES OPAREA.

  HAPC Designations—No HAPC are identified for this species.

- Witch Flounder (*Glyptocephalus cynoglossus*)

  Management—EFH for witch flounder is designated by the NEFMC through the Final Amendment #11 to the NE Multispecies FMP (NEFMC 1998).

  Status—The current NMFS stock assessment of witch flounder indicates that it is no longer subject to overfishing (NMFS 2006a).

  Distribution—Witch flounder are found in the western and eastern Atlantic Ocean. In U.S. waters, this species occurs on or adjacent to Georges Bank and along the continental shelf edge and upper slope south to Cape Hatteras, North Carolina (Cargnelli et al. 1999d).

  Habitat Associations—Witch flounder are benthic species exhibiting a preference for deepwater (Cargnelli et al. 1999d). Juveniles and adults are found at depths of 20 to 1,565 m, although the highest concentrations occur between 90 and 300 m (Klein-MacPhee 2002n). Juvenile witch flounder tend to inhabit deeper waters than their adult counterparts. Both juveniles and adults prefer waters with temperatures ranging from 0º to 15ºC (Klein-MacPhee 2002n) and salinities of 31 to 36 psu (Cargnelli et al. 1999d). Substrate associations for the species include mud, silt, clay, and muddy sand (Cargnelli et al. 1999d).

  Life History—Spawning for witch flounder occurs from March to November and generally begins earlier in the southern portion of the range. The peak spawning period occurs between May and August (Brander and Hurley 1992). During spawning, witch flounder form dense aggregations that are concentrated around areas of cold water, typically in the range of 0º to 10ºC (Cargnelli et al. 1999d).

  Common Prey Species—Witch flounder feed primarily on polychaete worms but also consume echinoderms, squid, mollusks, amphipods, and isopods (Klein-MacPhee 2002n).

  EFH Designations (NEFMC 1998; Figure D-29)

  - Egg—Surface waters of the Gulf of Maine, Georges Bank, and the MAB south to Cape Hatteras, North Carolina are designated as EFH.
  - Larva—Surface waters to 250 m from the Gulf of Maine, Georges Bank, and the MAB south to Cape Hatteras, North Carolina are designated as EFH.
  - Juvenile—Fine-grained substrates in the Gulf of Maine and along the shelf break region from Georges Bank south to Cape Hatteras, North Carolina are designated as EFH.
  - Adult—Fine-grained substrates in the Gulf of Maine and along the shelf break region from Georges Bank south to the Chesapeake Bay are designated as EFH.
  - Spawning Adult—Fine-grained substrate in the Gulf of Maine and along the shelf break region from Georges Bank south to the Chesapeake Bay are designated as EFH.

  HAPC Designations—No HAPC are identified for this species.

- Yellowtail Flounder (*Limanda ferruginea*)

  Management—Yellowtail flounder are managed by the NEFMC as five separate stocks (Nova Scotia, Georges Bank, southern New England, Cape Cod, and the MAB) and have EFH designated under the Final Amendment #11 to the NE Multispecies FMP (NEFMC 1998).

  Status—The yellowtail flounder stocks in the northwestern Atlantic are overfished and overfishing is currently occurring (NMFS 2006a). In addition, the yellowtail flounder is considered vulnerable or facing a risk of extinction in the wild according to the IUCN Red List (Sobel 1996).

  Distribution—Yellowtail flounder are found between the south coast of Labrador and the Chesapeake Bay but occur with greatest frequency from coastal southern New England and Georges Bank to the Grand Bank and Sable Island off southeastern Canada (Lux and Livingstone 1982).

Habitat Associations—Yellowtail flounder eggs are buoyant and remain suspended near the surface until hatching (Lux and Livingstone 1982; Johnson et al. 1999). They are typically found in waters with temperatures of 2º to 15ºC and depths of 10 to 750 m (most common from 30 to 90 m) between February and September (Johnson et al. 1999). Eggs are found on the continental shelf off New Jersey and Long Island, NY; on Browns Bank; on Georges Bank; northwest of Cape Cod, MA; and in some years as far south as the Chesapeake Bay (Lux and Livingstone 1982; Johnson et al. 1999). Larval yellowtail flounder are pelagic and found during April through August in 5º to 17ºC water temperatures and depths between 10 and 1,250 m (most abundant between 10 and 90 m) (Lux and Livingstone 1982; Johnson et al. 1999). Juvenile yellowtail flounder prefer benthic habitats and are most commonly found in water temperatures of 2º to 17ºC and between 5 and 125 m in depth (Johnson et al. 1999). Adult yellowtail flounder prefer sand and gravel substrates in waters ranging from 2º to 15ºC in temperature and depths of 10 to 100 m (Johnson et al. 1999; Klein-MacPhee 2002n).

Life History—Yellowtail flounder are batch spawners, spawning once a year primarily between March and July, with a peak around mid-May (Lux and Livingstone 1982; Klein-MacPhee 2002n). Little migration occurs between the five relatively distinct stocks of yellowtail flounder, and each stock remains primarily within its fishing grounds (Johnson et al. 1999). However, there is evidence to suggest that some yellowtail flounder move considerable distances (Klein-MacPhee 2002n).

Common Prey Species—Amphipods, particularly *Erichthonius rubricornis*, are the primary component of the yellowtail flounder's diet. They also consume other invertebrates and small fishes (Klein-MacPhee 2002n).

EFH Designations (NEFMC 1998; Figure D-30)

- Egg—EFH is designated as the surface waters of Georges Bank, Massachusetts Bay, Cape Cod Bay, and the MAB south to Delaware Bay. Additional EFH is designated for this lifestage in New England estuaries and embayments.
- Larva—EFH is designated as the surface waters of Georges Bank, Massachusetts Bay, Cape Cod Bay, and the MAB south to Chesapeake Bay. New England estuaries and embayments are designated as additional EFH for this lifestage.
- Juvenile and Adult—EFH is designated as bottom habitats with a substrate of sand or a combination of sand and mud on Georges Bank, the Gulf of Maine, and the MAB south to Delaware Bay. Additional EFH is designated for this lifestage as New England estuaries and embayments.
- Spawning Adult—EFH is designated as bottom habitats with a substrate of sand or a combination of sand and mud on Georges Bank, the Gulf of Maine, and the MAB south to Delaware Bay. EFH is also designated for this lifestage in some New England estuaries and embayments.

HAPC Designations—No HAPC are identified for this species.

5.3.2 Subtropical-Tropical Water Species

- Atlantic Calico Scallop (*Argopecten gibbus*)

Management—Atlantic calico scallops have EFH designated by the SAFMC through the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The status of this species' fishery is unknown (NMFS 2006a).

Distribution—Atlantic calico scallops have a patch 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 Associations—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 objects such as navigation buoys and other floating objects (SAFMC 1998). Upon reaching 2.5 cm, Atlantic calico scallops detach and are capable of swimming (SAFMC 1998). Larger, unattached Atlantic calico scallops are often associated with 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 (FMRI 2003a).

EFH Designations (SAFMC 1998; Figure D-31)

- Larva—The Gulf Stream has been designated as EFH due to its role as a dispersal mechanism for this lifestage.
- All Lifestages—EFH for Atlantic calico scallops has been designated as the unconsolidated sediments including hard-sand bottoms, sand and shell hash, quartz sand, smooth sand-shell-gravel, and dead shells in depths of 13 to 94 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

HAPC Designations—No HAPC are identified for this species.

- Blackfin Snapper (*Lutjanus buccanella*)

Management—EFH for the blackfin snapper is designated by the SAFMC under Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Currently this species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—Blackfin snapper range from Massachusetts to Brazil, including the Gulf of Mexico and Caribbean, but are rare north of Cape Hatteras, North Carolina (SAFMC 1998; Murray and Bester 1999a).

Habitat Associations—This demersal species is associated with sandy or rocky habitats near ledges or drop-offs and occurs from bottom depths of 40 to 300 m (typically 60 to 90 m) (Murray and Bester 1999a; SAFMC 2003a). Adults are found further offshore 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). Suitable substrate is considered a more important factor contributing to the distribution of this species than depth (SAFMC 2003a). Eggs and larvae are pelagic (SAFMC 1983).

Life History—This species is capable of spawning year-round but peaks occur 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 upon benthic invertebrates and fishes (Murray and Bester 1999a). In the Charleston Bump region, swimming crab are the main component of the blackfin snapper's diet (Weaver and Sedberry 2001).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-32)

- Larva—The Gulf Stream, which provides a mechanism of dispersion, and pelagic *Sargassum* are designated as EFH.

- Juvenile—EFH for this lifestage is interpreted as live/hard bottom habitat in depths of 12 to 40 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Adult—EFH is interpreted as hard bottom habitat in the vicinity of the continental shelf break from depths of 40 to 300 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-32)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Blueline Tilefish (*Caulolatilus microps*)

Management—Blueline tilefish have EFH designated within the SAFMC Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Currently this species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—Blueline tilefish are distributed from Cape Charles, VA to Campeche Banks, Mexico but are primarily found south of Cape Hatteras, North Carolina (Manooch 1988; SAFMC 1998).

Habitat Associations—This benthic species is typically found in waters with depths of 68 to 236 m and temperatures between 15° and 23°C and prefers 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 spawning occurs from February to October, peaking in the summer and correlating with photoperiod (SAFMC 1983; Manooch 1988; Sedberry et al. 2004). 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 from MARMAP surveys in waters with bottom temperatures ranging from 8.8° to 16.2°C (SAFMC 2004a).

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 2002; Figure D-33)

- Egg—EFH for this lifestage is interpreted as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) and seaward to the EEZ.
- Larva—The Gulf Stream, which provides a mechanism of dispersion, and pelagic *Sargassum* are designated as EFH.
- Adult—EFH is interpreted for this lifestage as irregular bottoms consisting of troughs and terraces that are intermingled with sand, mud, or shell hash along the continental shelf edge from depths of 68 to 236 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-33)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Brown Rock Shrimp (*Sicyonia brevirostris*)

Management—EFH for the brown rock shrimp is designated under the Final Habitat Plan for the South Atlantic Region by the SAFMC (SAFMC 1998).

Status—Currently brown rock shrimp stocks in the SAB are not considered overfished or subject to overfishing (NMFS 2006a).

Distribution—Brown rock shrimp are found in the Gulf of Mexico, around Cuba, in the Bahamas, and along the U.S. Atlantic coast as far north as Virginia. Their center of abundance in the SAB occurs off northeast Florida south to Jupiter Inlet (SAFMC 1998).

Habitat Associations—Brown rock shrimp live mainly on sand or silt bottoms in water depths from a few meters to 183 m but occasionally occupy deeper waters if suitable bottom habitat exists. The largest concentrations of brown rock shrimp are found between the 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. Development from egg to postlarvae takes approximately one month, while development into larvae from postlarvae takes an additional two to three months. Currents transport larvae into inshore areas during the spring (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. The major transport mechanisms affecting planktonic larval brown rock shrimp are the shelf current systems near Cape Canaveral, Florida. These currents keep larvae on the Florida Shelf and may transport them inshore in spring. Recruitment to the area offshore of Cape Canaveral, Florida 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 2002; Figure D-34)

- Larva—The Gulf Stream as well as surface current systems near Cape Canaveral, Florida are interpreted as EFH for this lifestage of the brown rock shrimp, as they provide a mechanism to disperse rock shrimp larvae.
- Adult—EFH interpreted for this lifestage of the brown rock shrimp includes terrigenous and biogenic sand bottom habitats located in waters from 18 to 182 m in depth extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

HAPC Designations—No HAPC are identified for this species.

- Brown Shrimp (*Farfantepenaeus aztecus*)

  Management—Brown shrimp EFH is designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

  Status—The brown shrimp is neither overfished nor subject to overfishing (NMFS 2006a).

  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, Florida to the Yucatan Peninsula, Mexico. In the SAB, brown shrimp are considered the most abundant along the North Carolina coast and moderately abundant from South Carolina to Florida (Larson et al. 1989).

  Habitat Associations—Depending upon lifestage, brown shrimp can be either pelagic or benthic, oceanic or estuarine. Both eggs and larvae are found in ocean waters, although eggs occur near the seafloor while larvae most often occur in the upper part of the water column (Larson et al. 1989). Post-larvae, juveniles, and subadults inhabit estuarine habitats with soft, muddy bottoms (e.g., salt marshes and tidal creeks) and often associate with submerged aquatic vegetation (SAV; e.g., seagrass beds). Adult brown shrimp, conversely, are found in offshore waters of the upper to mid-continental shelf, where they are associated with silt, muddy sand, 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 2002).

  Life History—Brown shrimp spawn in ocean waters at depths usually exceeding 18 m (Larson et al. 1989). 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. Migration to offshore spawning grounds occurs from May through August in waters ranging from depths of 14 to 110 m 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 migrate to nursery areas in North Carolina, Georgia, and Florida from March through June and migrate to South Carolina's estuaries between March and April (Larson et al. 1989).

  Common Prey Species—Brown shrimp are omnivorous, consuming benthic invertebrates, detritus, algae, diatoms, and small fishes (Larson et al. 1989).

  EFH Designations (SAFMC 1998; NMFS 2002; Figure D-35)

  - Egg—Bottoms located between 13.7 and 110 m, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W), are interpreted as EFH for this lifestage.
  - Larva—EFH for this lifestage is designated as the water column at depths less than 110 m, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
  - Juvenile—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 Florida Keys (SAFMC jurisdictional boundary 83°W), are interpreted as EFH for this lifestage. None of these regions are located within the VACAPES OPAREA.
  - Adult—EFH for this lifestage is interpreted as silty-sand and muddy sand bottoms located on continental shelf in waters less than 110 m deep, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

  HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-35)

- 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 VACAPES OPAREA.

- Caribbean Spiny Lobster (*Panulirus argus*)

  Management—Caribbean spiny lobsters are managed jointly by the GMFMC and the SAFMC, but EFH in the VACAPES OPAREA is designated only by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

  Status—The current status of the Caribbean spiny lobster stock on the southeastern U.S. Atlantic coast is unknown (NMFS 2006a).

  Distribution—Caribbean spiny lobster are found in the waters off the southeastern coast of the U.S. from Cape Hatteras, North Carolina to southeast Florida, the Gulf of Mexico, Bermuda, the Bahamas, the Caribbean Sea, and off the coast of central Brazil (Appeldoorn et al. 1987).

  Habitat Associations—The eggs of the Caribbean spiny lobster remain attached to the adult until they hatch after three weeks of embryonic development. 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 12 months as plankton while developing into pueruli (post-larvae) (Appeldoorn et al. 1987). The pueruli move across the continental 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 macroalgae beds along rocky shorelines and seagrass beds. Late juveniles seek 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. Upon reaching maturity, adult lobsters move offshore and disperse among the rocks or coral reefs (Marx and Herrnkind 1986).

  Life History—Adult Caribbean spiny lobster 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). As temperatures decline and storms increase during the autumn, males and females move offshore (Marx and Herrnkind 1986). In Florida, the mating season for spiny lobster occurs from February to April at the continental shelf edge (GMFMC and SAFMC 1982; Appeldoorn et al. 1987).

  Common Prey Species—Caribbean spiny lobster have a diverse diet including algae, foraminifera, sponge spicules, polychaetes, bivalves, conchs, hermit crabs, and other crustaceans (GMFMC 1998).

  EFH Designations (SAFMC 1998; Figure D-36)

  - Larva—The Gulf Stream, due to its role as a dispersal mechanism, is designated as EFH.
  - All Lifestages—Nearshore shelf/oceanic waters; shallow subtidal bottom; unconsolidated bottom, coral and live/hard bottom communities; sponges; seagrass and mangrove habitats; and algal (*Laurencia*) communities are designated as EFH for these lifestages ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

  HAPC Designations (SAFMC 1998; Figure D-36)

  - All Lifestages—Florida Bay, Biscayne Bay, Card Sound, and coral/hard bottom habitat from Jupiter Inlet, Florida through the Dry Tortugas, Florida are designated as HAPC for all lifestages. These are all located south of the VACAPES OPAREA.

- Cobia (*Rachycentron canadum*)

  Management—Cobia off the southeast coast of the U.S. are managed jointly by the SAFMC and GMFMC, but EFH in the VACAPES OPAREA is only designated by the SAFMC through the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

  Status—It is unknown if this species is overfished or if overfishing is currently occurring (NMFS 2006a).

  Distribution—Cobia are distributed worldwide throughout tropical, subtropical, and warm-temperate waters, with the exception of the eastern Pacific Ocean (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).

  Habitat Associations—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 found in surface water exceeding 20°C in temperature and between 19 and 35 psu in salinity. 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 (GMFMC 1998). They are closely associated with any type of structure, including artificial reefs, pilings, platforms, anchored boats, *Sargassum*, and flotsam (Bester 1999a; Williams 2001).

  Life History—Spawning occurs in the daylight hours between April and September in estuarine or shelf waters (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 and 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, and squid 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). Cobia 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; Figure D-37)

  - Larva—The Gulf Stream is designated as EFH for this lifestage because it provides a mechanism for dispersal of the larvae.
  - 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 the ocean side of barrier island waters from the surf zone to the shelf break but only from the Gulf Stream shoreward, including pelagic *Sargassum*. 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.

  HAPC Designations (SAFMC 1998; Figure D-37)

  - Juvenile and Adult—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. These areas are not within the VACAPES OPAREA.
  - All Lifestages—Sandy shoals of Cape Lookout, North Carolina, Cape Fear, North Carolina, and Cape Hatteras, North Carolina ranging from shore to the ends of the respective shoals but

shoreward of the Gulf stream; the Point (North Carolina); and pelagic *Sargassum* are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC are the Charleston Bump (South Carolina), the Ten-Fathom Ledge (North Carolina); Big Rock (North Carolina); Hurl Rocks (South Carolina), The Point off Jupiter Inlet (Florida); *Phragmatopoma* reefs (worm reefs) off the central east coast of Florida; nearshore hard bottom (<4 m) south of Cape Canaveral, Florida; the Hump off Islamorada (Florida); the Marathon Hump off Marathon (Florida); and the "Wall" off the Florida Keys.

- Corals (Stony Corals and Octocorals)

Management—EFH for corals is designated through the Final Habitat Plan for the South Atlantic Region by the SAFMC (SAFMC 1998). Coral, coral reefs, and live/hard bottom habitat are managed as one unit by the SAFMC, accounting for more than 300 species (stony corals, octocorals, gorgonians, and black corals) (SAFMC 1998).

Status—Currently, there are no species within the MU that are subject to overfishing or are overfished in the SAB (NMFS 2006a). Two species of corals are designated either as a species of concern (ivory bush corals [*Oculina varicosa*]) or a candidate species (fused-staghorn [*Acropora prolifera*]) (NMFS 2004b). The elkhorn coral (*A. palmata*) and the staghorn coral (*A. cervicornis*) have been recently designated by the NMFS as threatened (NMFS 2006c). All but the ivory bush corals are distributed south of the VACAPES OPAREA. Since no true coral reefs occur within the VACAPES OPAREA, the Coral Reef Protection Executive Order 13089 does not 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 ranges from Miami, Florida to the Dry Tortugas and 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 stony corals and gorgonians (represented as solitary corals or deepwater banks/mounds) can be found as far north as Cape Lookout, North Carolina (Jaap 1984). Octocorals are found commonly throughout southern Florida and the Gulf of Mexico. Although the FMP mentions that the area from southeastern Florida to North Carolina contains no distinctive octocorals elements (SAFMC 1998), octocoral species are present in these waters (Wheaton 2005). Consult Chapter 4 for more information on these species.

Habitat Associations—Corals exist in oceanic habitats ranging from the nearshore to the continental slopes and canyons, including intermediate shelf zones. Various coral species inhabit these oceanic habitats including stony corals, black corals, and octocorals (SAFMC 1998). Corals may be the primary component of a habitat (e.g., coral reefs), contribute to a habitat (e.g., live/hard bottom communities), or exist as individuals within a community characterized by other fauna (e.g., solitary corals) (SAFMC 1998).

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, 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 zooxanthellae to be expelled from the coral polyps, leading to coral bleaching. 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).

Life History—Octocorals reproduce by releasing sperm into the 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—Hermatypic coral and octocoral derive nutrition by photosynthesis via symbiotic algae (zooxanthellae) (SAFMC 1998). Ahermatypic corals feed on plankton and detritus.

EFH Designations (SAFMC 1998; Figure D-38)

- Hermatypic and Ahermatypic Stony Corals—Rough, hard, exposed, and stable substrate located from Palm Beach County south to the Florida Reef Tract 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 an adequate amount of light for photosynthesis are designated as EFH for hermatypic coral species. Ahermatypic stony corals are not light restricted and their EFH is defined as hard substrates ranging from subtidal to outer continental shelf depths.
- Octocorals (excluding sea pens and sea pansies)—EFH 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 depth and is located within the VACAPES OPAREA.
- 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.
- Black Corals (*Antipatharia*)—EFH is designated as rough, hard, exposed, and stable substrate in offshore (<18 m depths), high salinity (30 to 35 psu) waters that are not light restricted.

HAPC Designations—(SAFMC 1998; Figure D-38)

- All Coral Species (stony corals, black corals, gorgonians, and octocorals)—The Point (North Carolina) is designated as HAPC in the VACAPE OPAREA.. Additional designated HAPC, which are not located in the VACAPES OPAREA, are the Ten Fathom Ledge (North Carolina), Big Rock (North Carolina), Hurl Rock (South Carolina), Charleston Bump (South Carolina), Gray's National Marine Sanctuary (Georgia), *Oculina* Bank, *Phragmatopoma* (worm) reefs (central east coast of Florida); nearshore hard bottom (<4 m) from Cape Canaveral, Florida to Broward County, Florida; offshore (5 to 30 m) hard bottom from Palm Beach County, Florida to Fowey Rocks, Florida; Biscayne Bay, Florida; Biscayne National Park Florida; and the Florida Keys National Marine Sanctuary.

- Dolphinfish (*Coryphaena* spp.)

Management—There are two species of dolphinfish that have EFH designated 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*). This FMP was only partially approved by NMFS; specifically, the designation of *Sargassum* as EFH or HAPC was disapproved (NOAA 2004).

Status—It is unknown if either of the dolphinfish species are overfished or if overfishing is occurring in the northwestern Atlantic Ocean (NMFS 2006a).

Distribution—Dolphinfish have a worldwide distribution throughout tropical and subtropical waters (Rivera and Appeldoorn 2000). 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 are located in areas of warmer water (greater than 20°C) influenced by the Gulf Stream (Manooch 1988; Schultz 2004).

Habitat Associations—Dolphinfish eggs are found in oceanic waters over or beyond the continental shelf (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 *Sargassum* abundance (Ditty et al. 1994). Juvenile dolphinfish are found throughout the Atlantic but also tend to congregate around *Sargassum* and floating debris (Beardsley 1967). Adult dolphinfish are epipelagic with the 20°C isotherm considered to be the limit of their distribution (SAFMC 2003b). Adult dolphinfish 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 *Sargassum* and floating debris, while larger males more often frequent the open ocean (SAFMC 2003b).

Life History—Spawning in dolphinfish takes place throughout the year in the Atlantic Ocean in waters warmer than 24°C, with peak spawning periods occurring in the spring and early fall (Beardsley 1967). Two stocks of the common dolphinfish with separate migration patterns have been proposed for the western Atlantic. 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 Puerto Rico between December and February, between Florida and Georgia during May and June, off South Carolina and southeastern North Carolina between June and July, and around Bermuda during July through August (Rivera and Appeldoorn 2000).

Common Prey Species—Dolphinfish are nonselective, opportunistic foragers that feed during daylight hours in surface waters (SAFMC 2003b). Their diet consists of both fishes and invertebrates including small oceanic pelagic fishes (e.g., flying fish, halfbeaks, and rough triggerfish), the young of large oceanic pelagic species (e.g., jacks, dolphinfish, 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 dolphinfish prey upon (FMRI 2003c; SAFMC 2003b).

EFH Designations (SAFMC 2003b, 2004b; Figure D-39)

- All Lifestages—Oceanographic features such as the Gulf Stream and associated eddies occurring within the EEZ, the Florida Current and associated gyres and eddies, and the Charleston Gyre have been designated as EFH for dolphinfish.

HAPC Designations—(SAFMC 2003b, 2004b; Figure D-39)

- All Lifestages—The Point (North Carolina) is designated as HAPC for this species in the VACAPES OPAREA. HAPC have also been designated as the Ten Fathom Ledge (North Carolina), Big Rock (North Carolina), the Charleston Bump (South Carolina), the Georgetown Hole (South Carolina), the Amberjack Lump (Florida), the Hump off Islamorada (Florida), the Marathon Hump (Florida), and the "Wall" off the Florida Keys.

- Golden Deepsea Crab (*Chaceon fenneri*)

Management—Golden deepsea crabs have EFH designated by the SAFMC through the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—It is unknown whether or not this species is overfished or if overfishing is currently occurring (NMFS 2006a).

Distribution—Golden deepsea crabs are distributed on the continental slope from the Chesapeake Bay south through the Florida Straits and into the Gulf of Mexico (Wenner et al. 1987; Wenner and Barans 1990; SAFMC 1995).

Habitat Associations—Female golden deepsea crabs are typically found in shallower areas than males but they occur in highest abundance in the SAB at depths of 367 to 549 m. Their relative abundance in an area 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 a flat ooze covered bottom characterized by foraminifera and 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 release larvae from February through March, usually into prevailing currents, such as the Loop Current in the Gulf of Mexico or the Gulf Stream in the SAB (SAFMC 1998).

Common Prey Species—The feeding habits of the golden deepsea crab are not well known but they are often described as opportunistic scavengers that feed upon the dead carcasses that settle to the bottom from the overlying waters (SAFMC 1999a).

EFH Designations (SAFMC 1998; Figure D-40)

- Larva—The Gulf Stream has been designated as EFH due to its role as a dispersal mechanism.
- All Lifestages—The continental slope from the Chesapeake Bay to the Florida Straits has been designated as EFH for golden deepsea crabs. Seven distinct habitat types on the continental slope of the SAB have specifically been designated as EFH for the golden deepsea crab: 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—EFH for the goliath grouper is designated under the Final Habitat Plan for the South Atlantic Region the SAFMC (SAFMC 1998).

Status—The goliath grouper is overfished in the SAB (NMFS 2006a). From North Carolina south to the Gulf of Mexico, goliath grouper were designated as a species of concern (former candidate species 1999) by NMFS (2004b), but a recent status report indicates that this species no longer meets the criteria to be designated as a species of concern (NMFS 2006d). They are 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 Ocean, goliath grouper are distributed from Florida to Brazil, including Bermuda, Caribbean Sea, and Gulf of Mexico (Robins 1999). They 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, Africa and in the eastern Pacific from the Gulf of California to Peru (Robins 1999).

Habitat Associations—Rocks, corals, caves, shipwrecks, ledges, and muddy substrates, in waters with depths less than 46 m, are the primary habitat of territorial adults, while juveniles are found in estuarine areas associated with mangroves and oyster bars (Sadovy and Eklund 1999; Robins 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 15ºN and 26ºN latitudes (Sadovy and Eklund 1999; Robins 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 groupers 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—This species does not have EFH designated in the VACAPES OPAREA. All EFH designation are south of the OPAREA in Florida. Despite not having EFH designations in the VACAPES OPAREA, the goliath grouper does have HAPC designated in the OPAREA.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-41)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Gray Snapper (*Lutjanus griseus*)

Management—Gray snapper have EFH designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—This species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—Gray snapper range from North Carolina to Brazil, including Bermuda, the Caribbean, and northern Gulf of Mexico (SAFMC 1998; Burton 2001). Juveniles can occasionally be found as far north as Massachusetts (Manooch 1988).

Habitat Associations—Gray snapper are capable of inhabiting a wide variety of habitats. Offshore benthic habitats include shipwrecks, ledges, hard bottom, coral reefs, and rocky outcroppings to depths of 180 m, while inshore habitats consist of seagrasses, mangroves, and rock piles (Bortone and Williams 1986; Manooch 1988; 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 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 and larvae are pelagic until larvae settle at inshore nurseries consisting of either seagrass beds, mangroves, jetties, or pilings approximately three weeks after hatching, typically from July through September (Bortone and Williams 1986; Domeier et al. 1996; 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 daily movements associated with feeding and schooling. Gray snapper migrate from inshore waters to offshore waters to spawn between April and November, with spawning correlated with lunar cycles (Manooch 1988; Domeier et al. 1996; Bester 1999b). Spawning locations have not been identified but are believed to be associated with reefs and shipwrecks (Domeier et al. 1996). Individuals are capable of spawning multiple times during a season (Bester 1999b).

Common Prey Species—This species is an opportunistic predator. Adult gray snapper prey nocturnally on fishes, shrimp, and crabs (Manooch 1988; Bester 1999b). Crustaceans are a primary component of the adult gray snapper's diet (Starck and Schroeder 1971).

EFH Designations (SAFMC 1998; NFMS 2002; Figure D-42)

- Egg—EFH is interpreted for this lifestage as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

- Larva—Pelagic waters, pelagic *Sargassum*, and the Gulf Stream, which provides a mechanism of dispersion, from North Carolina to Florida are designated as EFH for this lifestage of the gray snapper.

- Juvenile—EFH interpreted for this lifestage includes aquatic vegetation, mangroves, and muddy substrates in nearshore areas (<5 m) as well as hard bottom habitats from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Adult—Bottom types such as coral reefs, hard bottom, artificial reefs, ledges of channels, mangroves, seagrass beds, and sponges in depths less than 77 m from the Virginia-North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) is interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NFMS 2002; Figure D-42)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Greater Amberjack (*Seriola dumerili*)

Management—EFH for the greater amberjack are designated within the SAFMC Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Currently, this species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—Greater amberjack inhabit the Pacific, Atlantic, and Indian Oceans, as well as the Mediterranean Sea (Manooch 1988). In the northwest Atlantic Ocean, their distribution ranges from Nova Scotia, Canada to Brazil, including the Gulf of Mexico and Caribbean Sea (Manooch 1988).

Habitat Associations—Greater amberjack are pelagic, as well as epibenthic, preferring habitats consisting of shipwrecks, reefs, and rocky outcrops around the continental shelf (Manooch 1988; SAFMC 2003a). Juveniles and adults also associate with floating debris and plants (*Sargassum*) in offshore waters (SAFMC 2003a; Wells and Rooker 2004). This species is commonly found inhabiting waters with depths as great as 360 m. 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; SAFMC 2003a).

Life History—Spawning occurs from January to July but peaks from April to June (Manooch 1988). 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; Manooch 1988). The majority of spawning females have been collected south of 30°N (Manooch 1988). 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, 2003a; NMFS 2002; Figure D-43)

- Larva—The Gulf Stream, which provides a mechanism of dispersion, and pelagic *Sargassum* are designated as EFH.
- Juvenile—EFH interpreted for this lifestage includes pelagic *Sargassum* or other pelagic macroalgae and floating debris from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

- Adult—Pelagic waters over reefs, from depths of 18 to 360 m, extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) are interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the same pelagic waters as the adult lifestage.

HAPC Designations (SAFMC 1998, 2003a; NMFS 2002; Figure D-43)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC..

- King Mackerel (*Scomberomorous cavalla*)

Management—This species is managed by the GMFMC and SAFMC, but EFH for this species in the VACAPES OPAREA is only designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The king mackerel stock on the Atlantic coast of the U.S. is not overfished nor is overfishing occurring (NMFS 2006a).

Distribution—King mackerel are commonly distributed along the continental shelf in the warmer waters of the western Atlantic Ocean 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 continental shelf break (GMFMC and SAFMC 1985).

Habitat Associations—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 over 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 (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; Figure D-37)

- Larva—The Gulf Stream is designated as EFH for this lifestage of the king mackerel because it provides a mechanism for dispersal.
- All Lifestages—EFH in the MAB and the SAB is designated as sandy shoals of capes and offshore bars, high profile rock bottoms and barrier island ocean side waters from surf zone to

shelf break but only from the Gulf Stream shoreward, including pelagic *Sargassum*. Additionally, all coastal inlets and state-designated nursery areas are designated as EFH.

HAPC Designations—(SAFMC 1998; Figure D-37)

- All Lifestages—Areas designated as HAPC in the VACAPES OPAREA for this species include the sandy shoals of Cape Lookout, North Carolina, Cape Fear, North Carolina, and Cape Hatteras, North Carolina ranging from shore to the ends of the respective shoals but shoreward of the Gulf Stream; the Point (North Carolina); and pelagic *Sargassum*. Additional HAPC designated for this species are Ten-Fathom Ledge (North Carolina), Big Rock (North Carolina), Charleston Bump (South Carolina), Hurl Rocks (South Carolina), the Point off Jupiter Inlet (Florida); *Phragmatopoma* reefs (worm reefs) off the central east coast of Florida; nearshore (< 4 m) hard bottom south of Cape Canaveral, Florida; the Hump off Islamorada (Florida); Marathon Hump (Florida); and the "Wall" off the Florida Keys.

- Mutton Snapper (*Lutjanus analis*)

Management—Mutton snapper have EFH designated under the SAFMC Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—This species is neither overfished nor is overfishing occurring (NMFS 2006a), but it is designated by the IUCN Red List (Huntsman 1996a) as vulnerable or facing a high risk of extinction in the wild in the medium-term future.

Distribution—Mutton snapper are distributed from throughout the western Atlantic Ocean from Massachusetts to Brazil, including the Gulf of Mexico but are most commonly observed in the tropical waters of Florida, the Bahamas, and the Caribbean Sea (Murray and Bester 1999b).

Habitat Associations—Adults have diverse benthic habitat associations ranging from shallow seagrass beds to deepwater reefs (Domeier et al. 1996). 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 in length) are planktonic (Murray and Bester 1999b). Larvae settle to inshore habitats after reaching a size of 10 to 20 mm (SAFMC 1998).

Life History—Over a period of several weeks, mutton snapper form an aggregation when spawning (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 in May and June, while spawning in the northern Caribbean occurs during February (Domeier et al. 1996; Murray and Bester 1999b). 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 (Murray and Bester 1999b). Mutton snappers feed on fishes and crustaceans, with crabs forming a substantial portion of their diet (Bortone and Williams 1986).

EFH Designations—This species does not have EFH designated in the VACAPES OPAREA. All EFH designation are south of the OPAREA in Florida. Despite not having EFH designations in the VACAPES OPAREA, the mutton snapper does have HAPC designated in the OPAREA.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-44)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake

Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Pink Shrimp (*Farfantepenaeus duorarum*)

Management—EFH for the pink shrimp is designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—This species of shrimp are not currently categorized as being overfished nor subject to overfishing (NMFS 2006a).

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. Maximum abundances of pink shrimp occur off southwestern Florida and in the southeastern Gulf of Campeche, Mexico (Pattillo et al. 1997).

Habitat Associations—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 tend to associate with sand/shell bottoms around SAV, while adults tend to associate with calcareous sediments but can also be found on hard shell-sand bottoms in non-turbid waters (Williams 1958; NMFS 2002). 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 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, Florida and Cape Lookout, North Carolina 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 (Bielsa et al. 1983; Patillo et al. 1997).

Spawning occurs when water temperatures rise, as water temperature is apparently critical to reproductive development (Bielsa et al. 1983). 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 bury 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 2002; Figure D-45)

- Egg—EFH for this lifestage of the pink shrimp is interpreted as nearshore demersal marine habitats located between 3.7 and 16 m ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—Pelagic ocean waters <16 m in depth ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) are interpreted as EFH for this lifestage.

- Juvenile—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 Florida Keys (SAFMC jurisdictional boundary 83°W) are interpreted as EFH for this lifestage.
- Adult—EFH for this lifestage of the pink shrimp is interpreted as marine habitats with hard sand/shell bottoms located in continental shelf waters <100 m deep ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-45)

- 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 within the boundaries of the VACAPES OPAREA.

- Red Drum (*Sciaenops ocellatus*)

Management—Red drum EFH is designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The red drum stock on the Atlantic coast of the U.S. is overfished and overfishing is currently occurring (NMFS 2006a).

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).

Habitat Associations—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 (SAFMC 1998). Subadult red drum exit the shallow nursery habitats and begin utilizing a variety habitats within the estuaries. Changes in temperature and food availability have been linked to the movement of subadults within the estuaries (ASMFC 2002b). Little is known about the habitat associations 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 2002b). Adults can primarily be found in high salinity surf zones and around live/hard bottom and artificial reefs (SAFMC 1998).

Life History—Spawning occurs 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 2002b). 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 2002b).

Common Prey Species—Decapod crustaceans, primarily mud crabs and fiddler crabs, and fishes, mostly juvenile spot and mummichog, are the primary food items of adult red drum along the southeastern coast of the U.S. (ASMFC 2002b).

EFH Designations (SAFMC 1998; Figure D-46)

- Adult—Unconsolidated bottom (soft sediments) and artificial reefs, from shore to the 50 m isobath, extending from Virginia to the Florida Keys to a depth of 50 m have been designated as EFH in the VACAPES OPAREA. EFH has also been designated in coastal or nearshore areas including: 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—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 are designated as EFH. None of these regions are within the VACAPES OPAREA.

HAPC Designations (SAFMC 1998; Figure D-46)

- All Lifestages—HAPC is 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. These regions are not located within the boundaries of the VACAPES OPAREA.

- Red Porgy (*Pagrus pagrus*)

Management—EFH for the red porgy is designated by the SAFMC within Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Red porgy are overfished (NMFS 2006a) and designated by the IUCN Red List (Huntsman 1996b) as endangered or facing a very high risk of extinction in the wild in the near future.

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, North Carolina to Cape Canaveral, Florida (SAFMC 1983). Red porgy have not been reported in the Caribbean Sea (SAFMC 1998).

Habitat Associations—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 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). MARMAP surveys collected spawning females at specific shelf-edge reef sites from depths of 26 to 57 m (Grimes et al.1982). 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—Red porgy are opportunistic feeders that prey primarily upon benthic invertebrates (crabs, shrimp, squid, octopus, snails, worms, and 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 2002; Figure D-47)

- Egg—This lifestage of the red porgy has EFH interpreted as the pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

- Larva—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) and pelagic *Sargassum*, and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH for this lifestage.

- Adult—EFH for this lifestage is interpreted as rough bottoms at depths of 18 to 280 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-47)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Red Snapper (*Lutjanus campechanus*)

Management—The red snapper has EFH designated by the SAFMC under Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The stock of red snapper in the south Atlantic is overfished and is currently still subject to overfishing (NMFS 2006a).

Distribution—Red snapper occur in the western Atlantic from Massachusetts south to Brazil, including the Gulf of Mexico (Bester 1999c). They are found most frequently between Cape Hatteras, North Carolina and the Campeche banks off Mexico (Nelson and Manooch 1982).

Habitat Associations—The eggs of the red snapper are planktonic and occur in offshore waters, usually in depths of 18 to 37 m. 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 associating with 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 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). 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 snapper have a diverse diet consisting of fishes, crabs, shrimps, worms, cephalopods, gastropods, tunicates, and some planktonic species (Moran 1988; SAFMC 2003a).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-48)

- Egg—EFH for this lifestage of the red snapper is interpreted as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—Pelagic waters from the Virginia-North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) and pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.
- Adult—EFH for this lifestage of the red snapper is interpreted as rocky bottoms located in 10 to 190 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).

- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002; Figure D-48)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- 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 2006a).

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 Associations—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 2004). 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 2004).

Life History—The eggs of the ridged spiny lobster remain attached to the adult for at least 30 days (GMFMC 2004). 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 2004).

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, 2004).

EFH Designations—(SAFMC 1998; NMFS 2002; Figure D-36)

- 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 VACAPES OPAREA, includes mangrove habitats, shallow subtidal bottom, and red algal (*Laurencia*) communities.

HAPC Designations—(SAFMC 1998; Figure D-36)

- 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. These areas are not within the boundaries of the VACAPES OPAREA.

- Royal Red Shrimp (*Pleoticus robustus*)

  Management—Royal red shrimp have EFH designated under the SAFMC Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

  Status—Although not considered overfished nor subject to overfishing, little information is available on the status of the royal red shrimp in the SAB (NMFS 2006a).

  Distribution—Royal red shrimp are found throughout the U.S. Atlantic (from Cape Cod, MA) and Gulf of Mexico waters. In U.S. waters, royal red shrimp are found in large concentrations primarily around St Augustine, Florida; the Dry Tortugas, Florida; and the Mississippi River Delta (Anderson and Linder 1971).

  Habitat Associations—Little is known about the habitat associations of this deepwater shrimp species. Unlike the penaeid shrimp species (brown, pink, white), royal red shrimp are not estuarine dependent (SAFMC 1993, 1998). They are typically found at depths ranging from 180 to 730 m but are most abundant between 250 and 550 m depths over soft substrates consisting primarily of mud (Anderson and Linder 1971; GMFMC 1998).

  Life History—Spawning is believed to occur year-round but peaks in January through May. Spawning sites have been recorded off St. Augustine, Florida (Anderson and Linder 1971).

  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 2002; Figure D-49)

  - Larva—The Gulf Stream, which provides a mechanism to disperse royal red shrimp larvae, is designated as EFH.
  - 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 83°W).

  HAPC Designations—No HAPC are identified for this species.

- Scamp (*Mycteroperca phenax*)

  Management—EFH for scamp are designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

  Status—This species is neither overfished nor is overfishing occurring (NMFS 2006a).

  Distribution—The distribution of scamp ranges from North Carolina to Florida, the Gulf of Mexico, and southern Caribbean Sea. Juveniles have been captured as far north as Massachusetts but are considered rare in these higher latitudes (Manooch 1988; SAFMC 2003a).

  Habitat Associations—This species prefers low relief live/hard bottom habitats, though they can also be found associating with shipwrecks and rock outcroppings (Manooch 1988). Adult scamp are typically found in waters with depths of 30 to 100 m, while juveniles are found closer to shore (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 with females comprising the majority of fishes less than 70 cm (SAFMC 2003a). Numerous spawning locations at shelf-edge reef sites, 33 to 93 m in depth, from North Carolina to Florida, have been identified from MARMAP survey data (SAFMC 2004b). 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). These 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). Scamp have been recorded moving to deeper waters during the winter, and tagging studies indicate that this species migrates to specific areas to spawn (SAFMC 1983).

Common Prey Species—Scamp feed opportunistically on crab, shrimp, and benthic fishes (scad, tomtate, and vermilion snapper) (Matheson et al. 1986; Manooch 1988).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-50)

- Larva—EFH for this lifestage of scamp is designated as pelagic waters, including the Gulf Stream, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) and pelagic *Sargassum*, and the Gulf Stream, which provides a mechanism of dispersion.
- Adult—Benthic communities consisting of low and high profile rock outcroppings encrusted with soft corals, sponges, hydroids, and bryozoa in water depths of 20 to 100 m, ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 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 2002; Figure D-50)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Silk Snapper (*Lutjanus vivanus*)

Management—Silk snapper have EFH designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Currently, this species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—Silk snapper are distributed in the western Atlantic Ocean from Cape Hatteras, North Carolina and Bermuda south to the Caribbean Sea and Brazil (Manooch 1988).

Habitat Associations—Off the Carolinas, adult silk snapper typically inhabit waters with depths ranging from 64 to 242 m and associate with limestone cliffs and rocky ledge habitats along the continental shelf edge (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 (SAFMC 1998).

Life History—Silk snapper are capable of spawning year-round but generally form aggregations either 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—This species feeds opportunistically on invertebrates (e.g., shrimp, crabs, and 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 2002; Figure D-51)

- Larva—Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.
- Juvenile—EFH is interpreted for this lifestage of the silk snapper as areas with 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 83°W).
- Adult—The continental shelf vicinity (limestone cliffs and ledges) at depths of 64 to 242 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) is interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-51)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Snowy Grouper (*Epinephelus niveatus*)

Management—EFH for the snowy grouper are designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The snowy grouper stock is overfished and is subject to overfishing (NMFS 2006a). 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 Ocean, this species is found from Massachusetts to Brazil, including the Gulf of Mexico, the Lesser Antilles, and Cuba (Manooch 1988). Only juvenile snowy grouper utilize 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 Associations—This benthic species is found in water depths from 30 to 525 m (SAFMC 2003a). Eggs and larvae are pelagic (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). Adults 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).

Life History—This species is a protogynous hermaphrodite with spawning occurring from April through September north of Cape Canaveral, Florida 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 2004a). Adults are typically sedentary but do undergo migrations to form spawning aggregations (Moore and Labisky 1984).

Common Prey Species—This species is an ambush predator that feeds opportunistically on fishes (snappers and porgies), cephalopods, and crustaceans (Manooch 1988; SAFMC 1998). On the Charleston Bump, swimming crabs and other benthic crustaceans are the major components of this species' diet (Weaver and Sedberry 2001).

EFH Designations—(SAFMC 1998; NMFS 2002; Figure D-52)

- Egg—EFH for this lifestage of the snowy grouper is interpreted as pelagic waters from the Virginia-North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—The Gulf Stream, which provides a mechanism of dispersion, and pelagic *Sargassum*, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) are designated as EFH.
- Adult—This lifestage of the snowy grouper has EFH interpreted as bottoms 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 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-52)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Spanish Mackerel (*Scomberomorous maculatus*)

Management—Spanish mackerel are managed jointly by the SAFMC and the GMFMC, but EFH in the VACAPES OPAREA is only designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The stock is not currently being overexploited nor is it considered to be overfished (NMFS 2006a).

Distribution—Spanish mackerel are abundant from Chesapeake Bay south through the Gulf of Mexico; however, they occasionally occur as far north as coastal southern New England (Collette 2002a).

Habitat Associations—The eggs of 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 depths of 9 to 84 m (most abundant in waters of <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). They 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 September (GMFMC and SAFMC 1985; Godcharles and Murphy 1986). The onset of spawning progresses from south to north and occurs over the inner continental shelf in waters 12 to 34 m deep. Spawning starts in April off the Carolinas, in mid-June in the Chesapeake Bay, and from late August into September off the coasts of New Jersey and New York (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 arrive 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).

Common Prey Species—Spanish mackerel feed primarily on small fishes, including round herring, menhaden, alewives, anchovies, pilchards, and mullets. This species also preys upon shrimp, crabs, and squid (GMFMC and SAFMC 1985; Collette 2002a).

EFH Designations (SAFMC 1998; Figure D-37)

- Larva—The Gulf Stream is designated as EFH for this lifestage because it provides a mechanism for dispersal.
- All Lifestages—EFH in the MAB and the SAB includes sandy shoals off capes and offshore bars, high profile rock bottoms, and the seaward regions off barrier islands from the surf zone to the shelf break, shoreward of the Gulf Stream, including pelagic *Sargassum*. Additionally, all coastal inlets and state-designated nursery areas are designated as EFH.

HAPC Designations (SAFMC 1998; Figure D-37)

- Juvenile and Adult—The portions of Bogue Sound, North Carolina with salinities exceeding 30 psu during May through September and the portions of New River, North Carolina with salinities exceeding 30 psu during May through October have been designated as HAPC but are not located within the VACAPES OPAREA.
- All Lifestages—Areas that are designated as HAPC include the sandy shoals of Cape Lookout, North Carolina, Cape Fear, North Carolina, and Cape Hatteras, North Carolina from shore to the ends of the respective shoals, but shoreward of the Gulf Stream; the Point (North Carolina); and pelagic *Sargassum*. Additional HAPC have also been designated, including the Ten Fathom Ledge (North Carolina); Big Rock (North Carolina); Charleston Bump (South Carolina); Hurl Rocks (South Carolina), The Point off Jupiter Inlet (Florida); *Phragmatopoma* reefs (worm reefs) off the central east coast of Florida; nearshore hard bottom (<4m) south of Cape Canaveral, Florida; the Hump off Islamorada, Florida; the Marathon Hump off Marathon, Florida; and the "Wall" off the Florida Keys.

- Speckled Hind (*Epinephelus drummondhayi*)

Management—Speckled hind have EFH designated under the Final Habitat Plan for the South Atlantic Region by the SAFMC (SAFMC 1998).

Status— Speckled hind are overfished and subject to overfishing in the SAB (NMFS 2006a). 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 2004b) 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—The speckled hind's range in the northwestern Atlantic Ocean is North Carolina and Bermuda south to the Bahamas, Cuba, and the Gulf of Mexico (Manooch 1988).

Habitat Associations—This species typically inhabits warm waters with depths 25 to 400 m (most common from 60 to 120 m) and temperatures of 15.5° to 29.4°C (Manooch 1988; SAFMC 2003a). Smaller individuals are found utilizing more inshore waters than 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, 2003a).

Life History—Speckled hind are protogynous hermaphrodites; males comprise the majority of older, larger fish (Manooch 1988). Spawning aggregations are formed from July to September offshore with specific locations recorded off South Carolina (Manooch 1988; SAFMC 2003a).

Common Prey Species—This species feeds on benthic prey, including crab, shrimp, mollusk, squid, octopus, and fish (Manooch 1988; SAFMC 1998).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-53)

- Larva—Pelagic waters, including the Gulf Stream, which provides a mechanism for dispersion, and pelagic *Sargassum*, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) are designated as EFH.
- Adult—EFH for this lifestage is interpreted as bottoms consisting of high and low relief hard bottom in waters depths of 27 to 122 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-53)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Tilefish (*Lopholatilus chamaeleonticeps*)

Management—There are two tilefish stocks recognized in the northwestern Atlantic Ocean. The northern stock is found primarily in the MAB while the southern stock ranges from south of Cape Hatteras, North Carolina to the Gulf of Mexico (Steimle et al. 1999e). The northern tilefish stock has EFH designated by the MAFMC through the Tilefish FMP (MAFMC 2000), while the southern stock has EFH designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Tilefish, in the Southeast region (i.e., SAFMC jurisdiction) are overfished and overfishing is currently occurring (NMFS 2006a).

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 Associations—Tilefish eggs have been most commonly collected in waters ranging from 8º to 19ºC and at depths of 80 to 800 m. It has been suggested, that larval tilefish are planktonic and prefer a relatively narrow temperature range from 13º to 18ºC in shallow waters with depths ranging between 50 and 150 m (Steimle et al. 1999e). Both juvenile and adult tilefish are shelter seekers and typically inhabit burrows, the size and shape of which varied 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 9º to 11ºC (24% of tilefish were observed in waters of 8ºC or less) and depths between 90 and 170 m (some were collected in water as deep as 264 m) (Steimle et al. 1999e). 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) but more commonly inhabit simple vertical shaft burrows in semi-lithified clay (Able et al. 1982). Adults prefer waters ranging from 8º to 18ºC and depths of 105 to 274 m. 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; Steimle et al. 1999e).

Life History—Spawning in tilefish generally occurs from March to November, with a peak during 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; MAFMC 2000; NMFS 2002; Figure D-54)—Since tilefish stocks are managed by two different FMPs, the tilefish have EFH and HAPC designated by two FMCs (MAFMC and SAFMC).

- Egg—EFH is designated by the MAFMC as the water column in the area between the 76 and 366 m isobaths from the U.S./Canada boundary to the Virginia/North Carolina boundary. EFH has not been designated for this lifestage by the SAFMC.
- Larva—EFH is designated by the MAFMC as the water column in the area between the 76 and 366 m isobaths from the U.S./Canada boundary to the Virginia/North Carolina boundary. Pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH by the SAFMC as extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) and seaward to the extent of the EEZ.
- Juvenile—EFH is designated by the MAFMC as the water column in the area between the 76 and 366 m isobaths from the U.S./Canada boundary to the Virginia/North Carolina boundary. EFH has not been designated for this lifestage by the SAFMC.
- Adult—EFH is designated by the MAFMC as the water column in the area between the 76 and 366 m isobaths from the U.S./Canada boundary to the Virginia/North Carolina boundary. From the SAFMC EFH for this lifestage is interpreted as clay substrate found in water depths of 76 to 457 m from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat designated by the SAFMC.

HAPC Designations (SAFMC 1998; MAFMC 2000; NMFS 2002; Figure D-54)—Additionally, tilefish have EFH and HAPC designated by two FMCs (MAFMC and SAFMC).

- Juvenile and Adult—HAPC have been designated for this lifestage by the MAFMC as the rocky, exposed ledges and stiff clay substrate between 76 and 366 m in the northeastern region of statistical areas 616 and 537. These areas are not located within the VACAPES OPAREA.
- All Lifestages—The SAFMC designates HAPC for all lifestages of 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Vermilion Snapper (*Rhomboplites aurorubens*)

Management—EFH for the vermilion snapper is designated under the Final Habitat Plan for the South Atlantic Region by the SAFMC (SAFMC 1998).

Status—The vermilion snapper are not overfished but are subject to overfishing (NMFS 2006a).

Distribution—Vermilion snapper range from Cape Hatteras, North Carolina and Bermuda, the Caribbean Sea, the Gulf of Mexico, to Brazil (Manooch 1988). This species is most abundant in the Gulf of Mexico and off the southeastern U.S. (SAFMC 2003a).

Habitat Associations—Vermilion snapper associate with benthic habitats near the continental shelf consisting of sand, gravel, or rock from depths of 180 to 300 m and typically utilize the part of the water column that is 2 to 6 m above the bottom (Dixon 1975; SAFMC 2003a). Habitat preference is influenced more by substrate type rather than depth (SAFMC 2003a). 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). Recently, numerous spawning locations, identified from MARMAP surveys, range from the coast of North Carolina to Florida at depths from 18 to 97 m (SAFMC 2004a). 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 (Manooch 1988). This species does not demonstrate seasonal movements (Grimes et al. 1982; Manooch et al. 1998b).

Common Prey Species—This species feeds opportunistically throughout the water column, primarily during the late afternoon and early evening (Dixon 1975; Grimes et al. 1982). Vermilion snapper examined from North Carolina were found to have fed primarily on small invertebrates, specifically amphipods, and partially on fishes and fish eggs (Dixon 1975; Manooch 1988).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-55)

- Egg—This lifestage has interpreted as EFH in pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) including pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.
- Juvenile and Adult—Reefs and hard bottom at depths from 20 to 200 m extending from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) is interpreted as EFH for this lifestage.
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-55)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Wahoo (*Acanthocybium solandri*)

Management—Wahoo have EFH designated by the SAFMC (2003b) through the FMP for the Dolphin and Wahoo Fishery of the Atlantic. This FMP was only partially approved by NMFS; specifically, the designation of *Sargassum* as EFH or HAPC was disapproved (NOAA 2004).

Status—The wahoo stock in the northwestern Atlantic Ocean is not overfished nor is it subject to overfishing (NMFS 2006a).

Distribution—Wahoo are found throughout the tropical and subtropical waters of the Atlantic, Pacific, and Indian Oceans (Manooch 1988). In the western Atlantic Ocean, wahoo have been reported from New York to Columbia, as well as in the Gulf of Mexico, the Caribbean Sea, Bermuda, and the Bahamas (SAFMC 2003b).

Habitat Associations—There are currently no data available for the Atlantic Ocean on the habitat use of wahoo eggs (SAFMC 2003b). The only reported wahoo larvae in the Atlantic were obtained in the Straits of Florida and Yucatan 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). No data exist on the habitat associations of juvenile wahoo, although it is believed that they are associated with pelagic *Sargassum* and prefer water temperatures ranging from 22° to 30°C (SAFMC 2003b). Adult wahoo are pelagic and commonly found near *Sargassum* mats. They prefer waters with temperatures ranging from 22° to 28°C (SAFMC 2003b).

Life History—Wahoo have a long spawning season that runs from May to October. The peak spawning period occurs in June and occurs near Cuba in the Straits of Florida and Yucatan (Wollam 1969). Wahoo are believed to undergo migrations through the Florida Straits and 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 also infrequently includes invertebrates such as squid and the paper nautilus (SAFMC 2003b).

EFH Designations (SAFMC 2003b, 2004b; Figure D-39)

- All Lifestages—The Gulf Stream and associated eddies occurring in the Atlantic EEZ, the Florida Current and associated eddies, and the Charleston Gyre have been designated as EFH for wahoo in the western North Atlantic Ocean.

HAPC Designations—(SAFMC 2003b, 2004b; Figure D-39)

- All Lifestages—The Point (North Carolina) is designated as HAPC in the VACAPES OPAREA. Also designated as HAPC are the Ten Fathom Ledge (North Carolina), and Big Rock (North Carolina), Charleston Bump (South Carolina), Georgetown Hole (South Carolina), the Amberjack Lump (Florida), the Hump off Islamorada (Florida), the Marathon Hump (Florida), and the “Wall” off the Florida Keys.

- Warsaw Grouper (*Epinephelus nigritus*)

Management—Warsaw grouper have EFH designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status— Warsaw grouper are overfished and subject to overfishing in the SAB (NMFS 2006a). 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 2004b) 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—Warsaw grouper distribution typically ranges from North Carolina south to the Florida Keys, Caribbean Sea, Gulf of Mexico, and northern coast of South America, though it has been reported as far north as Massachusetts (Manooch 1988; SAFMC 2003a).

Habitat Associations—Adults 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—Few data exist on the reproductive habits and spawning locations of this species. Spawning has been reported off Cuba from April to May (SAFMC 2003a). Not enough 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 2002; Figure D-56)

- Egg—EFH is interpreted for this lifestage as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) including pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.
- Adult—This lifestage of the Warsaw grouper has EFH interpreted as bottoms consisting of cliffs, notches, and rocky ledges from depths of 76 to 219 m, ranging from the Virginia-North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-56)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- White Grunt (*Haemulon plumieri*)

Management—EFH for the white grunt is designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Currently, this species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—White grunt are distributed from Virginia and Bermuda south to Brazil, including the Gulf of Mexico and the Caribbean Sea (Manooch 1988). White grunt are most numerous and regarded as two separate stocks off the Carolinas and from Palm Beach south through the Florida Keys but are considered rare off Georgia and northeast Florida (Potts and Manooch 2001).

Habitat Associations—Juvenile and adult white grunt inhabit waters from the shore to depths of at least 35 m and utilize substrates consisting of reefs, hard bottom, seagrasses, and mangroves (SAFMC 1998). Eggs and larvae are pelagic (SAFMC 1983).

Life History—White grunt do not exhibit long-range migrations, but they 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 (Manooch 1988).

Common Prey Species—White grunt are opportunistic feeders that prey upon benthic invertebrates (worms, crabs, shrimp, and mollusks) and fishes (Manooch 1988).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-57)

- Egg—EFH for this lifestage is interpreted as the pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—Pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) including pelagic *Sargassum* and the Gulf Stream, which provides a mechanism of dispersion, are designated as EFH.

- Juvenile and Adult—EFH for this lifestage is interpreted as 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 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations—(SAFMC 1998; NMFS 2002; Figure D-57)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- White Shrimp (*Litopenaeus setiferus*)

Management—White shrimp have EFH designated under the Final Habitat Plan for the South Atlantic Region by the SAFMC (SAFMC 1998).

Status—This group of shrimp are neither classified as overfished nor subject to overfishing (NMFS 2006a).

Distribution—In the U.S. Atlantic Ocean, white shrimp range from Fire Island, NY to the St. Lucie Inlet, Florida. In the Gulf of Mexico, this species is found from Ochlockonee River of Apalachee Bay, Florida to Ciudad Campeche, Mexico. Along the U.S. Atlantic coast, the white shrimp has centers of abundance in each of the southeast states: North Carolina, South Carolina, Georgia, and northeast Florida (Whitaker 1981).

Habitat Associations—White shrimp are generally concentrated in waters less than 27 m deep, although they are occasionally found in deeper waters of the mid-continental shelf (up to 82 m) (Muncy 1984). White shrimp can be either, pelagic or benthic, oceanic or estuarine, depending upon the lifestage. Eggs and larvae are oceanic, although the former are demersal and the latter are mainly pelagic. Post-larvae, juveniles, and subadults are benthic and estuarine, inhabiting mostly mud or peat bottoms with large quantities of decaying organic matter or vegetative cover (Pattillo et al. 1997). 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). 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. Off the southeast U.S. coast, the major southerly migration occurs from North Carolina to Cape Canaveral, Florida in the fall and the northerly migration from Cape Canaveral begins in the spring (Pattillo et al. 1997). Fall and winter migration 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).

Common Prey Species—White shrimp are omnivorous, feeding on detritus, gastropods, annelids, sponges, corals, algae, vascular plants, and small fishes (Muncy 1984).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-58)

- Egg—Nearshore, demersal marine habitats from 6.1 to 24.4 m in depth ranging from the Virginia/North Carolina border to the St. Lucie Inlet, Florida are interpreted as EFH for this lifestage.
- Larva—Pelagic ocean waters <24.4 m deep, ranging from the Virginia/North Carolina border to the St. Lucie Inlet, Florida, are interpreted as EFH for this lifestage of the white shrimp.
- Juvenile—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, Florida, are interpreted as EFH for this lifestage but are not located within the VACAPES OPAREA.
- Adult—Soft mud bottoms located shoreward of the 27 m ranging from the Virginia/North Carolina border to the St. Lucie Inlet, Florida are interpreted as EFH for this lifestage.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-58)

- 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 are within the boundaries of the VACAPES OPAREA.

- Wreckfish (*Polyprion americanus*)

Management—EFH for wreckfish are designated within the Final Habitat Plan for the South Atlantic Region by the SAFMC (SAFMC 1998).

Status—Currently, this species is neither overfished nor is overfishing occurring (NMFS 2006a). 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 Mediterranean Sea, as well as the Indian, Pacific, and Atlantic Oceans (McClane 1978). In the western Atlantic Ocean, wreckfish are distributed from Newfoundland to Argentina (SAFMC 1998). Juveniles are more abundant in the eastern than in the western Atlantic Ocean (Vaughan et al. 2001).

Habitat Associations—Wreckfish are a deepwater species typically found to depths of 610 m (with minimum and maximum reported depths of 42 and 1,000 m, respectively) and are associated with rocky ledges, seamounts, pinnacles, and shipwrecks (SAFMC 1998; Schultz 2004). In the northwest Atlantic, adult wreckfish have only been reported occurring on the Blake Plateau and in the Florida Straits from depths of 400 to 650 m (Sedberry et al. 2001). The Charleston Bump has been identified as an important habitat (shelter, feeding, spawning) for this species (Popenoe and Manheim 2001). This species is predominantly pelagic, associating with floating debris during its early lifestages (≤60 cm TL) (Sedberry et al. 1996; SAFMC 1998). Juveniles inhabit surface waters for a period lasting from several months to two years (Sedberry et al. 1996; Sedberry et al. 1999). As the species matures, it begins to utilize bottom habitats (Klein-MacPhee 2002o). Eggs and larvae are pelagic, with the Gulf Stream playing an essential role in dispersal (Klein-MacPhee 2002o).

Life History—There are few 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 Ocean. Specifically, spawning females have been collected at depths of 433 to 595 m. Insufficient data exist to determine if this species forms aggregations to spawn (Coleman et al. 2000).

Common Prey Species—This species feeds on crustaceans, mollusks, and fishes located near 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 2002o). Squid are the predominant prey species eaten by wreckfish in the vicinity of the Charleston Bump (Sedberry et al. 2001).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-59)

- Larva—The Gulf Stream, which provides a mechanism of dispersion, and pelagic *Sargassum* are designated as EFH.
- Juvenile—EFH for this lifestage is interpreted as all pelagic waters and floating debris within the jurisdiction of the SAFMC.
- Adult—EFH for this lifestage 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). These areas are not located within the VACAPES OPAREA.
- Spawning Adult—EFH is designated as the water column above the adult habitat and thus, is not located within the VACAPES OPAREA.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-59)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); Hoyt Hills (South Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

- Yellowedge Grouper (*Epinephelus flavolimbatus*)

Management—Yellowedge grouper have EFH designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—Currently this species is neither overfished nor is overfishing occurring (NMFS 2006a).

Distribution—This grouper species ranges from North Carolina to Brazil, including the Caribbean Sea and Gulf of Mexico (Manooch 1988). The yellowedge grouper is considered more abundant in the western Gulf of Mexico than in the Atlantic Ocean (SAFMC 1998).

Habitat Associations—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 or soft bottom habitats (sand or mud) (SAFMC 2003a). Eggs and larvae are pelagic (Manooch 1988). Larval yellowedge grouper cannot be distinguished from the snowy grouper so little is known about the early lifestages of this species (Cass-Calay and Bahnick 2002).

Life History—The yellowedge grouper is a protogynous hermaphrodite and males are typically larger individuals (>76 cm) (Manooch 1988). In the Atlantic Ocean, spawning occurs offshore from April to October, peaking in September (Manooch 1988). Spawning females have been collected at depths from 160 to 194 m with bottom water temperatures of 14.5°C (Sedberry et al. 2006). Insufficient data exist to determine if this species forms aggregations to spawn (Coleman et al. 2000).

Common Prey Species—The yellowedge grouper feeds opportunistically on squid, octopus, eel, crab, and fish (seahorses, scorpionfish, searobin, and lizardfish) (Manooch 1988).

EFH Designations (SAFMC 1998; NMFS 2002; Figure D-60)

- Egg—This lifestage has EFH interpreted as pelagic waters from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Larva—Pelagic waters, including the Gulf Stream, which provides a mechanism of dispersion, and pelagic *Sargassum*, from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W) are designated as EFH.

- Adult—This lifestage has EFH interpreted as habitats consisting of hard bottom and rocky outcropping from depths of 190 to 220 m ranging from the Virginia/North Carolina border to the Florida Keys (SAFMC jurisdictional boundary 83°W).
- Spawning Adult—EFH is designated as the water column above the adult habitat.

HAPC Designations (SAFMC 1998; NMFS 2002; Figure D-60)

- 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; and the Point (North Carolina) are designated as HAPC in the VACAPES OPAREA. Additional designated HAPC include the Ten Fathom Ledge (North Carolina); and Big Rock (North Carolina); the Charleston Bump (South Carolina); manganese outcroppings on the Blake Plateau; council-designated Artificial Reef SMZs; mangrove habitat, seagrass habitat, oyster/shell habitat; all coastal inlets; all state-designated nursery habitats; nearshore hard bottom habitat (<4 m); and *Oculina* Bank HAPC.

5.3.3 Highly Migratory Species

Each taxon group of HMS is managed as discrete MUs (NOAA 2006a), but recently the FMPs for all HMS taxa were consolidated into one FMP, the Final Consolidated Atlantic Highly Migratory Species FMP (NMFS 2006e). The HMS are presented below in alphabetical order as a group.

- Albacore Tuna *(Thunnus alalunga)*

Management—The albacore tuna is managed under the Tuna MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—This species consists of two separate stocks, the north and south Atlantic stocks (NMFS 2003a). These stocks are separated at 5°N with no evidence of mixing occurring between the two stocks (NMFS 1999b). According to the current NMFS stock assessment and fishery evaluation reports (NMFS 2006a, 2004c), the north Atlantic albacore tuna is overfished and overfishing is occurring. The albacore tuna 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.

Habitat Associations—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 (NMFS 2006e). 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 *Sargassum* mats (Collette and Nauen 1983; NMFS 1999a, 2006e).

Life History—Albacore tuna undergo extensive seasonal horizontal 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 1999a, 2006e). This species spawns in the spring and summer in the western tropical Atlantic (NMFS 1999a, 2006e).

Common Prey Species—Albacore tuna, as other tuna, are considered opportunistic feeders that prey on a diversity of fishes and invertebrates (NMFS 1999a, 2006e).

EFH Designations (NMFS 1999a, 2006e; Figure D-61)

- Juvenile (<90 cm fork length)—EFH is designated as surface waters with temperatures between 15.6° and 19.4°C from 50 to 2,000 m in the MAB from approximately the Massachusetts/Rhode Island border (71°W) south to the Maryland/Virginia Border (38°N).
- Adult (>90 cm fork length)—EFH is designated as surface waters with temperatures between 13.5° and 25.2°C between 100 and 2,000 m from southeastern Georges Bank (41.25°N) to the Virginia/North Carolina border (36. 5°N) and 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.

HAPC Designations—No HAPC are identified for this species.

- Atlantic Angel Shark (*Squatina dumeril*)

Management—The Atlantic angel shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The NMFS (1999a, 2006e) prohibits possession of this species as a precautionary measure since so little is known about its reproductive biology or life history.

Distribution—Atlantic angel sharks inhabit temperate and subtropical waters in the western Atlantic Ocean from Massachusetts to Florida, the Gulf of Mexico, and the Caribbean Sea (Castro 1983). It is common in the MAB south to Maryland.

Habitat Associations—This demersal shark species buries itself in the sand or mud in shallow waters of the northern part of its range but in the southern part of its range, it inhabits deeper waters (up to 1,390 m) off the continental shelf (Castro 1983; Compagno 1984a).

Life History—This shark appears seasonally in shallow water, moving inshore in the spring and summer. Its wintering grounds are presumably deeper water (Castro 1983). It gives birth to live young in the spring or early summer (Castro 1983).

Common Prey Species—This species feeds upon bottom fishes, crustaceans, and bivalves (Compagno 1984a).

EFH Designations (NMFS 1999a, 2006e; Figure D-62)

- Neonate (≤31 cm TL)—EFH is designated along the shallow coastal waters of southern New Jersey, Delaware, and Maryland, including the mouth of Delaware Bay (39°N to 38°N) out to the 25 m isobath.
- Juvenile (32 to 113 cm TL)—Identical to neonate EFH.
- Adult (≥113 cm TL)—Identical to neonate EFH.

HAPC Designations—No HAPC are identified for this species.

- Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*)

Management—The Atlantic sharpnose shark is managed under the Small Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—This species is not overfished or subject to overfishing (NMFS 2006a, 2006e).

Distribution—This shark is a subtropical-tropical species found throughout the Atlantic Ocean. The Atlantic sharpnose shark inhabits the waters of the northeastern coast of North America from New Brunswick to Florida, extending to the Yucatan area 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 1999a, 2006e).

Habitat Associations—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 mostly remains in waters less than 10 m deep (Delius and Morgan 1999). This demersal shark has a broad salinity tolerance and has been found up rivers, such as the Pascagoula River in Mississippi (Allen 1999). This species and its nursery areas can also be found in estuarine habitats (Castro 1993).

Life History—The Atlantic sharpnose shark performs inshore-offshore movements seasonally, moving into deeper offshore waters during winter as water temperatures fall (Compagno 1984a; 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 back inshore to give birth to live young in shallow, protected areas during the late spring to early summer of the following year, from North Carolina to central Florida (Castro 1983, 1993). Off North Carolina, Atlantic sharpnose sharks typically give birth starting in May (Castro 1993).

Common Prey Species—This species feeds on fishes (menhaden, eel, silverside, wrasse, jack, toadfish, filefish, smallmouth flounder, herring, anchovy, pipefish, sea robin stargazer, puffer), worms, shrimp, crabs, and mollusks (Delius and Morgan 1999; Branstetter 2002a).

EFH Designations (NMFS 1999a, 2006e; Figure D-63)

- Neonate (≤40 cm TL)—EFH for this early lifestage is designated as shallow coastal areas of bays and estuaries to the 25 m off the coast from Cape Hatteras, North Carolina to Daytona Beach, Florida. Additional EFH designated for this lifestage of the Atlantic sharpnose shark includes Apalachee Bay and St. Andrews Bay, Florida.
- Juvenile (41 to 78 cm TL)—EFH is designated from shallow coastal areas seaward to 25 m from Cumberland Island, Georgia to Daytona Beach, Florida and from Hilton Head Island, South Carolina north to Cape Hatteras, North Carolina (EFH is designated up to 50 m off North Carolina). The Gulf of Mexico is also designated as EFH for this lifestage of the Atlantic sharpnose shark. None of these regions are within the VACAPES OPAREA.
- Adult (≥79 cm TL)—EFH is designated as coastal waters to the 25 m isobath from Cape May, NJ south to Cape Hatteras, North Carolina, from the 25 to 100 m isobath south of Cape Hatteras, and inshore to the 100 m isobath from St. Augustine, Florida to Cape Canaveral, Florida. EFH is also designated in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Basking Shark *(Cetorhinus maximus)*

Management—The basking shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—In U.S. waters, fishing for the basking shark is prohibited by the NMFS (1999a, 2006e). This species is considered vulnerable or facing a high risk of extinction in the wild according to the IUCN Red List (Fowler 2000).

Distribution—The basking shark is found throughout the world in boreal to temperate waters (Compagno 1984a; Branstetter 2002b). In the western Atlantic Ocean, this species' distribution extends from Newfoundland to Florida and from Brazil to Argentina (Ferrari and Ferrari 2002). This shark is considered a rare inhabitant of the Gulf of Mexico (Castro 1983).

Habitat Associations—This coastal-pelagic shark can be found in nearshore waters, as well as over the continental shelf in subpolar to temperate waters, and regularly associates with thermal fronts where prey are more abundant (NMFS 1999a). The basking shark is often observed at the waters surface feeding on plankton (Branstetter 2002b).

Life History—The basking shark is a migratory species, appearing in the southern part of its range in the winter and shifting northward to Nova Scotia and the Gulf of Maine in the summer (Castro 1983;

Compagno 1984a; NMFS 1999a, 2006e). Female basking sharks may give birth to live young in high latitudes, but no data are available on their reproductive cycle, and pregnant females of this species have rarely been recorded (Compagno 1984a; NMFS 1999a, 2006e).

Common Prey Species—Zooplankton are primary prey of the basking shark, including small copepods, crustacean larvae, as well as fish eggs and larvae (Compagno 1984a). Sims and Quayle (1998) demonstrated that the distribution of basking sharks is directly linked to zooplankton abundance.

EFH Designations (NMFS 1999a, 2006e; Figure D-64)

- Neonate (≥182 cm TL)—At this time, there is no sufficient EFH information available for the identication of this lifestage.
- Juvenile (183 to 809 cm TL)—EFH is designated as offshore waters, from 50 to 200 m, extending from south of Nantucket Shoals (70°W) to the north edge of Cape Hatteras, North Carolina (35.5°N); the habitat for this stage is associated with frontal conditions created by the western edge (or west wall) of the Gulf Stream.
- Adult (≥810 cm TL)—EFH designated for this lifestage is off of southern New England and not within the VACAPES OPAREA.

HAPC Designations—No HAPC are identified for this species.

- Bigeye Thresher Shark (*Alopias superciliosus*)

Management—The bigeye thresher shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The status of the bigeye thresher stock is currently unknown (NMFS 2006a), but harvest and possession of the species are prohibited by the NMFS (1999a, 2006e).

Distribution—The bigeye thresher has a cosmopolitan distribution in warm-temperate to tropical oceanic and coastal waters (Jensen 1999). In the western Atlantic Ocean, this shark ranges from New York to Florida, throughout the Gulf of Mexico, and as far south as southern Brazil (Compagno 2001).

Habitat Associations—The bigeye thresher can be found in coastal and oceanic environments, from the surface to bottom waters on the continental slope (Compagno 2001). Although it has been recorded in intertidal waters, this species most commonly occurs in depths greater than 100 m (Jensen 1999; Compagno 2001). The bigeye thresher prefers waters with surface temperatures ranging between 16° and 25°C (Jensen 1999).

Life History—The bigeye thresher is ovoviviparous. Birth can occur year-round; however, more females give birth in the autumn and winter than during other times of the year in the eastern Atlantic Ocean (Compagno 2001). Only limited data are available on the movements of these sharks. At least some are known to undergo extensive movements, with one tagged individual moving 1,494 NM from waters off New York to the eastern Gulf of Mexico (Weng and Block 2004).

Common Prey Species—The bigeye thresher feeds on pelagic fishes and cephalopods. Prey includes mackerel, herring, lancetfishes, small billfishes, bottom fishes such as hake, and squid (Castro 1983; Compagno 2001).

EFH Designations (NMFS 1999a, 2006e; Figure D-65)

- Neonate (≤116 cm TL)—At this time there is no available information to sufficiently identify EFH for this lifestage.
- Juvenile (117 to 340 cm TL)—EFH for this lifestage is designated as offshore North Carolina (36.5°N to 34°N) between 200 and 2,000 m.

- Adult (≥341 cm TL)—EFH for this lifestage is designated as offshore North Carolina (35.5° to 35°N) between 200 and 2,000 m.

HAPC Designations—No HAPC are identified for this species.

- Bigeye Tuna (*Thunnus obesus*)

Management—The bigeye tuna is managed under the Tuna MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—According to current stock assessment and fishery evaluation reports by the NMFS (2004b, 2006a), the bigeye tuna is overfished and overfishing is occurring. This species is listed by IUCN Red List (Uozumi 1996b) as vulnerable or facing a high risk of extinction in the wild.

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 1999a, 2006e).

Habitat Associations—Bigeye tuna can inhabit water depths up to 500 m, deeper than most species of tuna occur. The bigeye commonly occurs in regions where water temperatures range from 13° to 29°C, with an optimal temperature range between 17° and 22°C (NMFS 1999a, 2006e). Variation in occurrence is closely related to seasonal and climatic changes in surface temperature and the thermocline depth (Collette and Nauen 1983; NMFS 1999a, 2006e). 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 1999a, 2006e).

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; NMFS 1999a, 2006e). Additionally, the Gulf of Guinea, off the coast of central Africa, is identified as important habitat for spawning adults, eggs, and larvae (NMFS 1999a, 2006e). Larger bigeye tuna migrate to temperate waters, while smaller individuals are restricted to the tropical range of their distribution (NMFS 1999a, 2006e).

Common Prey Species—Bigeye tuna feed during the day and night on fishes, cephalopods, and crustaceans (Collette and Nauen 1983).

EFH Designations (NMFS 1999a, 2006e; Figure D-66)

- Juvenile (<100 cm fork length)—EFH is designated as surface waters from southeastern Georges Bank south to Cape Hatteras, North Carolina, from 200 m to the U.S. EEZ boundary. Off the eastern coast of Florida, the EFH ranges from the Blake Plateau off Cape Canaveral, Florida (29°N), extending south to the U.S. EEZ boundary (28.25°N) and from 79°W east to the U.S. EEZ boundary (76.75°W).
- Adult[1] (≥100 cm fork length)—EFH is designated as pelagic waters from the surface to a depth of 250 m: from southeastern Georges Bank at the EEZ boundary south to Delaware Bay (38°N) from the 100 m isobath to the EEZ boundary, from Delaware Bay south to Cape Lookout, North Carolina, from Cape Canaveral, Florida (29°N) south to the U.S. EEZ boundary (28.25°N), and from 79°W east to the U.S. EEZ boundary (76.75°W).

HAPC Designations—No HAPC are identified for this species.

[1] EFH text description does not match the GIS shapefile provided the by NMFS (2003b) in a region south of the VACAPES OPAREA. 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 2006e). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2007).

- Bignose Shark *(Carcharhinus altimus)*

Management—The bignose shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Possession of this shark is prohibited in the U.S. by NMFS (1999a, 2006e) as a precautionary measure so that directed fisheries do not develop. Its stock is overfished and currently subject to overfishing (NMFS 2006a).

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 1999a, 2006e).

Habitat Associations—The bignose shark is a bottom-dwelling species that inhabits the deeper waters of the continental shelf and insular slope (Bester 1999d; NMFS 1999a). 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 1999a, 2006e; Figure D-67)

- Neonate (≤67 cm TL)—EFH is designated as the area offshore of the Delmarva Peninsula (38°N) southward to offshore of Bull's Bay, South Carolina (32°N), between the 100 and 200 m isobaths.
- Juvenile (68 to 225 cm TL)—Between the 100 and 500 m isobaths, EFH is designated from offshore of the Delmarva Peninsula (38°N) south to offshore Bull's Bay, South Carolina (32°N), as well as offshore St. Augustine, Florida (30°N), southward to offshore West Palm Beach, Florida (27°N).
- Adult (≥226 cm TL)—At this time there is insufficient information for the EFH designation of this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Blacktip Shark *(Carcharhinus limbatus)*

Management—The blacktip shark is managed under the Large Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The IUCN Red List currently designates the northwest Atlantic subpopulation 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 and overfishing is not occurring (NMFS 2006a).

Distribution—This shark is found worldwide in predominantly tropical seas but occurs 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).

Habitat Associations—The blacktip shark ranges from inshore estuarine waters, including bays and mangrove swamps, to offshore habitats (coral reefs) but rarely is found at depths greater than 30 m. This species often stays near the surface. Although often recorded offshore, it is not considered a true oceanic shark species. It has a wide salinity tolerance but generally does not move far into riverine systems (Compagno 1984a). 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 1999a; McCandless et al. 2002). Recent analysis has determined that sharks in Gulf of Mexico and Atlantic nurseries are genetically distinct and separate from one another (Keeney et al. 2003).

Life History—Large schools of blacktip sharks, off the coast of Florida, seasonally migrate north to south along the coast up to 1,159 NM (NMFS 1999a; Keeney et al. 2003). This 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 1984a).

Common Prey Species—Blacktip sharks are active mid-water hunters, feeding on benthic and pelagic fishes (menhaden, rays, herring, butterfish, sardines, and other shark species), cephalopods (squids), and other invertebrates (Compagno 1984a; Manooch 1988).

EFH Designations (NMFS 2003a, 2006e; Figure D-68)

- Neonate (≤69 cm TL)—EFH is designated for this lifestage of the blacktip shark as shallow and nearshore coastal waters to the 25 m isobath from Bull's Bay, South Carolina (33.5°N) south to Cape Canaveral, Florida (28.5°N) off the western Florida, and in the Gulf of Mexico. This designation is not within the VACAPES OPAREA.
- Juvenile (69 to 155 cm TL)—From Cape Hatteras, North Carolina (35.25°N) to Ponce de Leon Inlet, Florida (29°N), EFH is designated from the shoreline to the 25 m isobath. Additional EFH is designated for this lifestage off western Florida and in the Gulf of Mexico. These regions are located south of the VACAPES OPAREA.
- Adult (≥155 cm TL)—coastal waters of the Outer Banks, North Carolina (between 36°N and 34.5°N), is designated as EFH from the coastline to the 200 m isobath; additional EFH is designated in shallow coastal waters offshore to the 50 m isobath from Cumberland Island, Georgia (30.9°N) to Cape Canaveral, Florida (28.5°N), excluding areas south from Apalachicola Bay to Tarpon Springs (28.2°N). EFH is also designated for this lifestage off western Florida.

HAPC Designations—No HAPC are identified for this species.

- Blue Marlin *(Makaira nigricans)*

Management—The blue marlin is managed under the Billfish MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Currently, blue marlin are overfished and overfishing is occurring (NMFS 2004c, 2006a).

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 1999b; Schultz 2004).

Habitat Associations—This epipelagic (surface to a depth of 91 m) and oceanic species typically inhabits deep waters that have a temperature range from 22° to 31°C (NMFS 1999b; Collette 2002b). Blue marlin can also be found utilizing coastal habitats, such as those found near the Mississippi River Delta (Gardieff 1999a). In the northern Gulf of Mexico, they are associated with the Loop Current and are found in blue waters of low productivity. Eggs are planktonic (NMFS 1999b, 2006e).

Life History—Blue marlin are generally solitary and do not occur in schools. They undergo extensive migrations including trans-equatorial and trans-Atlantic migrations in response to changing sea surface temperatures (Gusey 1981; Nakamura 1985; Gardieff 1999a; NMFS 1999b, 2006e). Two seasonal concentrations occur in the Atlantic: in the southwest Atlantic (5°S to 30°S) from January to April and in the northwest Atlantic (10° to 35°N) from June to October (NMFS 1999b; 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 north Atlantic Ocean is believed to occur between the period of May to 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 1999b, 2006e).

Common Prey Species—Blue marlin feed primarily on near-surface pelagic fishes (tuna, dolphin fishes, and mackerel) as well as deep-sea fish species and cephalopods (Gardieff 1999a; NMFS 1999b, 2006e).

EFH Designations (NMFS 1999b, 2006e; Figure D-69)

- Spawning Adult, Egg, and Larva—EFH is designated from 100 m to 43 NM seaward (79.25°W) from Ponce de Leon Inlet, Florida (29.5°N) south to Melbourne, Florida. Additional EFH designated for this lifestage, but not found within the VACAPES OPAREA, is off southeast Florida, in the Florida Keys, and off Puerto Rico. This designation is not located within the VACAPES OPAREA.
- Juvenile and Subadult (20 to 189 cm lower jaw fork length [LJFL])—Pelagic waters from 100 to 2,000 m with temperatures not less than 24°C are designated as EFH from offshore of Delaware Bay to Cape Lookout, North Carolina but extending further offshore from 200 to 2,000 m at 73.25°W, 35°N from Cape Lookout, North Carolina south to Cumberland Island, Georgia (30.75°N) as well as from St. Augustine, Florida (30°N) south to Fort Lauderdale, Florida (26°N) from 100 m seaward, and south to the U.S. EEZ boundary at 29°N south. Additional EFH designated for this lifestage is off southwest Florida and in the Gulf of Mexico.
- Adult (>190 cm LJFL)—EFH is designated as pelagic waters with temperatures not less than 24°C from offshore Delaware Bay (38.5°N) south to offshore Wilmington, North Carolina (33.5°N) between 100 and 2,000 m; from Charleston, South Carolina (32°N) to the Georgia/Florida border from 100 m to 78°W; and from Ponce de Leon Inlet, Florida (29.5°N) south to offshore Melbourne, Florida from 100 m to 79.25°W. Additionally, EFH is designated for this lifestage off southwest Florida, in the Gulf of Mexico, and off Puerto Rico.

HAPC Designations—No HAPC are identified for this species.

- Blue Shark *(Prionace glauca)*

Management—The blue shark is managed under the Pelagic Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Blue sharks are neither subject to overfishing nor does overfishing occur (NMFS 2004c, 2006a). The IUCN Red List designates the blue shark as a lower risk but near threatened or likely to qualify for a threatened category in the near future (Stevens 2000a).

Distribution—The blue shark has a worldwide distribution and is considered one of the widest ranging shark species (Compagno 1984a). Even though its range extends into the tropics, it is commonly found in deeper, more temperate waters (Ferrari and Ferrari 2002). In the western Atlantic, this shark is found from Newfoundland south to Argentina (Compagno 1984a). There are no records of this shark in the Gulf of Mexico (Castro 1983).

Habitat Associations—This species can inhabit waters with depths up to 350 m, and although this species is oceanic, it can be found close to shore at night or in areas where the continental shelf is narrow (Castro 1983; Compagno 1984a; Cooper 1999). This shark is often found in large aggregations close to the surface in temperate waters. It prefers relatively cool water from 7° to 16°C but can tolerate water as warm as 21°C (Cooper 1999; NMFS 1999a, 2006e).

Life History—Very little is known about the reproductive locations of this species in the Atlantic, but mating is believed to occur in May and June (Branstetter 2002a). Blue shark nurseries are believed to occur in the open oceanic waters of the higher latitudes of their range (NMFS 1999a). The exact migration routes of this species are also poorly understood, but a population of blue sharks from the northwest Atlantic Ocean was reported to migrate to northeastern South America (Castro 1983).

Common Prey Species—Blue shark feed opportunistically on small fishes (herring, sardine, skate, lacetfish, cod, bluefish, scup, butterfish, mackerel, and yellowtail flounder) and invertebrates (squid, cuttlefish, and octopus), as well as scavenge on dead marine mammals (Cooper 1999). In the mid-Atlantic, squid are the primary component of the blue shark's diet (Branstetter 2002a).

EFH Designations (NMFS 1999a; Figure D-70)

- Neonate (≤60 cm TL)—EFH is designated for this lifestage in coastal southern New England but is not located within the VACAPES OPAREA.
- Juvenile (61 to 183 cm TL)—EFH is designated from offshore Cape Hatteras, North Carolina (35°N) in waters from the 25 m isobath to the U.S. EEZ boundary.
- Adult (≥184 cm TL)—EFH is designated from offshore Cape Hatteras, North Carolina (35°N) in waters from 25 m to the U.S. EEZ boundary and extending around Cape Cod, MA, including the southern part of the Gulf of Maine.

HAPC Designations—No HAPC are identified for this species.

- Bluefin Tuna (*Thunnus thynnus*)

Management—The bluefin tuna is managed under the Tuna MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The current stock assessment and fishery evaluation reports by the NMFS (2004b, 2006a) indicate that bluefin tuna in the western Atlantic are overfished and overfishing occurs, and this stock is listed as critically endangered or facing an extremely high risk of extinction in the wild according to the IUCN Red List (Safina 1996a).

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 1999a, 2006e).

Habitat Associations—This species can tolerate a considerable range of temperatures 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). 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 along the continental shelf 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 believed to associate with the Gulf Stream along the continental shelf that produces regions of upwelling (NMFS 1999a, 2006e).

Life History—The western Atlantic bluefin tuna spawns from mid-April to mid-June in the Gulf of Mexico, the Florida Straits, western edge of the Bahamas Banks, and along the eastern portion of the Florida current at temperatures of 24.9° to 29.5°C (Gusey 1981; Collette and Nauen 1983; NMFS 1999a). The Gulf of Mexico spawning site is considered the primary spawning area of 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 and finally to North Carolina, Blake Plateau, or the Bahamas for the winter (Gusey 1981; Schuck 1982; 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 upon squid, pelagic crustaceans, and school fishes (anchovies, sauries, and hakes) (Schuck 1982; NMFS 1999a, 2006e).

EFH Designations (NMFS 1999a, 2006e; Figure D-71)

- Spawning Adult, Egg, and Larva—EFH is designated as pelagic and near coastal surface waters from the North Carolina/South Carolina border (33.5°N) south to Cape Canaveral, Florida from 13 NM offshore to 200 m and all waters off the coast of Cape Canaveral, Florida (28.25°N) south around peninsular Florida to the U.S./Mexico border ranging from 13 NM offshore to the U.S. EEZ boundary. These regions are all south of the VACAPES OPAREA.
- Juvenile (<145 cm TL)—All inshore and pelagic surface waters warmer than 12°C from the Gulf of Maine to Cape Cod Bay (from Cape Ann [~42.75°N] east to 69.75°W, including water of the Great South Channel west of 69.75°W) and Nantucket Shoals (70.5°W) south to Cape Hatteras, North Carolina (~35.5°N) are designated as EFH. Additional EFH designated for this lifestage, but not found within the VACAPES OPAREA, is in the Florida Straits.
- Adult (≥145 cm TL)—EFH is designated as pelagic waters from 39°N to Cape Lookout, North Carolina (34.5°N) from the 50 m isobath to the 2,000 m isobath and pelagic waters from Daytona Beach, Florida (29.5°N) south of Key West, Florida (82°W) from the 100 m isobath to the U.S. EEZ boundary. Additional EFH designated outside the VACAPES OPAREA is in the Gulf of Maine, Georges Bank, and Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Dusky Shark *(Carcharhinus obscurus)*

Management—The dusky shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—To rebuild the stock of dusky sharks, they are listed as a prohibited species (i.e., harvest or possession is illegal). The dusky shark is currently identified as a species of concern (formerly a candidate species) by the NMFS (2004a) and is considered overfished, as well as subject to overfishing (NMFS 2006a). The IUCN Red List designated the northwest Atlantic 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—This species has a 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 1984a; Castro 1993).

Habitat Associations—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 1984a; Branstetter 2002a). Major nursery areas have been identified in coastal waters from Massachusetts to the South Carolina coast (Castro 1993; McCandless et al. 2002).

Life History—Mating for this species in the western Atlantic occurs in the spring, and birth to live young can occur over several months from late winter to summer (Compagno 1984a). In Bull's Bay, North Carolina, dusky sharks typically give birth from April to May, while in the Chesapeake Bay, this occurs in June and July (NMFS 2003a). Females mate in alternate years as a result of their long gestation period (9 to 16 months). 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 1984a; NMFS 2003a, 2006e).

Common Prey Species—Bony fishes (eels, menhaden, herring, anchovies, hakes, goosefish, black sea bass, scups, croakers, bluefish, sand lance, mackerels, tunas, and flatfish) are the most important component of the dusky shark's diet, but they also prey upon sharks, crustaceans, and squid (Branstetter 2002a).

EFH Designations (NMFS 2003a, 2006e; Figure D-72)

- Neonate[2] (≤110 cm TL)—EFH is designated as shallow coastal waters, inlets, and estuaries to the 25 m isobath from Delaware Bay and off Delaware; coastal waters to the 200 m isobath off Maryland south to North Carolina; and from Cape Lookout, North Carolina (34.5°N) south to West Palm Beach, Florida (27.5°N) in shallow waters, inlets, and estuaries and offshore areas to the 90 m isobath.
- Juvenile (110 to 299 cm TL)—EFH is designated as coastal and pelagic water between 25 and 200 m from the coast of southern New England (70°W); shallow coastal waters, inlets, and estuaries to the 200 m isobath from Assateague Island at the Virginia/Maryland border (38°N) to Jacksonville, Florida (30°N); and shallow coastal waters, inlets, and estuaries to the 500 m isobath and continuing south to Dry Tortugas, Florida (83°W).
- Adult (≥299 cm TL)—EFH is designated as pelagic waters offshore of the Virginia/North Carolina border (36.5°N) south to Cape Romain, South Carolina out to the 25 m isobath; from Cape Romain south to the Georgia/Florida border (30.8°N), the EFH consists of waters between the 25 and 200 m isobaths; and coastal waters out to the 200 m isobath from the Georgia/Florida border south to Cape Canaveral, Florida (28.5°).

HAPC Designations—No HAPC are identified for this species.

- Finetooth Shark (*Carcharhinus isodon*)

Management—The finetooth shark is managed under the Small Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Currently, this species is subject to overfishing but is not overfished (NMFS 2006a).

Distribution—In the western Atlantic Ocean, the finetooth shark is distributed from North Carolina south to Cuba and southern Brazil, including the Gulf of Mexico (Compagno 1984a).

Habitat Associations—Not a lot is known about habitat associations of this species. Finetooth sharks form large schools and are located in waters close to shore to depths of 10 m (Compagno 1984a). Finetooth shark estuarine nursery areas have been documented from South Carolina to the Gulf of Mexico (McCandless et al. 2002).

Life History—In the shallow coastal waters off the coast of South Carolina, adults and juveniles are common during the warm summer months, migrating south when surface water temperatures drop below 20°C and spend the winter months in the waters off the coast of Florida. Finetooth sharks give birth to live young from May to June (Bester 1999e).

[2] EFH text description does not match the GIS shapefile provided the by NMFS (2003b) for regions outside the OPAREA. 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 2006e). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2007).

Common Prey Species—This species feeds on bony fishes (mullet, Spanish mackerel, spot, and menhaden), crustaceans, and cephalopods (Compagno 1984a; Bester 1999e).

EFH Designation (NMFS 2003a, 2006e; Figure D-73)

- Neonate (≤65 cm TL)—EFH is designated as the shallow coastal waters of South Carolina, Georgia, and Florida out to the 25 m isobath from 30°N to 33°N but is not in the VACAPES OPAREA. Additional EFH designated for this lifestage is located in the Gulf of Mexico.
- Juvenile (65 to 135 cm TL)—EFH is designated as the shallow coastal waters of North Carolina, South Carolina, Georgia, and Florida out to the 25 m isobath from 30°N to 35.5°N. Additional EFH is also designated for this lifestage in the Gulf of Mexico.
- Adult (≥135 cm TL)—EFH is designated as the shallow coastal waters of North Carolina, South Carolina, Georgia, and Florida out to the 25 m isobath from 30°N to 35.5°N. EFH for this lifestage is designated in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Longbill Spearfish (*Tetrapturus pfluegeri*)

Management—The longbill spearfish is managed under the Billfish MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—This species is neither overfished nor subject to overfishing (NMFS 2006a).

Distribution—The longbill spearfish ranges from 40°N to 35°S in the Atlantic and occurs in the western Atlantic Ocean from Georges Bank south through the Gulf of Mexico to Brazil (Manooch 1988; NMFS 1999b).

Habitat Associations—Little is known about the habitat associations of this species (Nakamura 1985; de Sylva and Breder 1997). Longbill spearfish are an epipelagic, oceanic species usually inhabiting waters above the thermocline and are found further offshore than other billfish species (Nakamura 1985). Larvae have been collected near the mid-Atlantic Ridge and in the Caribbean from December to February (NMFS 1999b).

Life History—Few data exist on reproductive behavior or locations for this species, but spawning is thought to occur in widespread areas in the tropical and subtropical Atlantic Ocean, well offshore, from November through May (Manooch 1988; de Sylva and Breder 1997).

Common Prey Species—Longbill spearfish, which are surface feeders, prey primarily on pelagic fishes (anchovy and dolphin-fish) and squid (NMFS 1999b). Feeding occurs during both daylight and night hours, and it is not known if this species uses its bill to aid in capturing prey (Manooch 1988).

EFH Designations (NMFS 1999b, 2006e; Figure D-74)

- Juvenile and Subadult (~20 to 182 cm LJFL)—EFH is designated in offshore North Carolina (36.5°N to 35°N) from the 200 m isobath to the U.S. EEZ boundary.
- Adult (≥183 cm LJFL)—EFH is designated at the Charleston Bump area from 78°W to 79°W and from 32.5°N to 31°N but is not located in the VACAPES OPAREA. Additional EFH designated for this lifestage, but not found within the OPAREA, is off of the U.S. Virgin Islands.

HAPC Designations—No HAPC are identified for this species.

- Longfin Mako Shark (*Isurus paucus*)

Management—The longfin mako shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The NMFS prohibits possession of this species as a precautionary measure (NMFS 1999a). 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, this species can be found from Georges Bank to the Gulf of Mexico, is common in the southern sections of the Gulf Stream, and probably has a wider distribution than is currently known (Castro 1983).

Habitat Associations—Longfin mako sharks prefer deep tropical to warm-temperate oceanic waters and have been recorded at depths from 18 m to at least 219 m deep (Castro 1983). There is very little information available on habitat associations of this species.

Life History—Specifics of the location and reproductive behavior for this ovoviviparous species is unknown, but they are believed to come close to shore to give birth. Specific information on migrational patterns of the longfin mako shark does not exist (Castro 1983; Compagno 2001).

Common Prey Species—Longfin mako sharks primarily prey upon schooling fish species and pelagic cephalopods (Compagno 2001).

EFH Designations (NMFS 1999a, 2006e; Figure D-75)

- Neonate (≤149 cm TL)—EFH is designated from 100 m to the U.S. EEZ, extending from south of Georges Bank to Cape Hatteras, North Carolina (35°N); from Cape Hatteras southward to Cape Canaveral, Florida (28.25°N) between 100 and 500 m; and from Cape Canaveral extending around peninsular Florida to 92.5°W in the Gulf of Mexico between the 200 m isobath and the U.S. EEZ.
- Juvenile (150 to 244 cm TL)—EFH designation is same as neonate lifestage.
- Adult (≥245 cm TL)—EFH designation is same as neonate lifestage.

HAPC Designations—No HAPC are identified for this species.

- Night Shark *(Carcharhinus signatus)*

Management—The night shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Night sharks are overfished and subject to overfishing (NMFS 2006a). 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, it 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).

Habitat Associations—This benthopelagic, coastal, and semi-oceanic species is found on or along the outer continental and insular shelves and off the upper slopes (Compagno 1984a). Night sharks prefer depths from 50 to 100 m but have been recorded in waters up to 600 m deep (Compagno 1984a). No information exists on nursery locations for this species (NMFS 1999a, 2006e).

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 1999a, 2006e). Off Cuba, this species has been recorded making seasonal migrations (Compagno 1984a). 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 1999a).

Common Prey Species—Night sharks feed primarily on bony fishes, including butterfish, flyingfish, tuna, mackerel, and sea bass, as well as squid (Compagno 1984a).

EFH Designations (NMFS 1999a, 2006e; Figure D-76)

- Neonate (≤70 cm TL)—At this time there is no available EFH information to identify this lifestage.
- Juvenile (71 to 177 cm TL)—EFH is designated from Assateague Island, VA (38°N) south to offshore Cape Fear, North Carolina (33.5°N) from 100 to 2,000 m.
- Adult (≥178 cm TL)—EFH is designated from Oregon Inlet, North Carolina (36°N) to off the coast of Miami, Florida (25.5°N) from 100 m to either 2,000 m, 87 NM from shore, or the U.S. EEZ boundary, whichever is closest.

HAPC Designations—No HAPC are identified for this species.

- Oceanic Whitetip Shark (*Carcharhinus longimanus*)

Management—The oceanic whitetip shark is managed under the Pelagic Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Currently, they are not overfished or subject to overfishing (NMFS 2006a). 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 warm oceanic waters and is circumtropical (20°N to 20°S). In the western Atlantic, this species ranges from Georges Banks to Argentina, including the Gulf of Mexico and Caribbean (Compagno 1984a).

Habitat Associations—This species is most abundant in the tropics but can occur far beyond its normal range, when it moves in conjunction with warm-water masses The oceanic whitetip shark seldom swims into shallow waters less than 37 m deep and is most often found offshore in the open ocean. This shark typically inhabits waters deeper than 180 m with temperatures above 21°C (Compagno 1984a). Nurseries are believed to be located in offshore waters over the continental shelf (NMFS 1999a).

Life History—Oceanic whitetip sharks give birth to live young during the early summer in the north Atlantic. Few data exist on the migratory patterns of this species (Compagno 1984a).

Common Prey Species—This 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 1984a; Bester 1999f).

EFH Designations (NMFS 1999a, 2006e; Figure D-77)

- Neonate (≤83 cm TL)—EFH is designated from 200 to 2,000 m off the Charleston Bump, South Carolina (32.5°N and 31°N).This area is not within the VACAPES OPAREA.
- Juvenile (84 to 136 cm TL)—EFH is designated from 32°N to 26°N ranging from 200 m to either the U.S. EEZ boundary or 75°W, whichever is closer to shore. This region is south of the VACAPES OPAREA.
- Adult (≥137 cm TL)—EFH is designated from 200 m seaward to the U.S. EEZ boundary between 36°N and 30°N. Additional EFH designated for this lifestage is in the Caribbean Sea.

HAPC Designations—No HAPC are identified for this species.

- Sailfish *(Istiophorus platypterus)*

Management—The sailfish is managed under the Billfish MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—Sailfish are subject to overfishing and are considered overfished (NMFS 2006a).

Distribution—Sailfish have a circumtropical distribution ranging from Massachusetts south to Brazil, including the Caribbean 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 Associations—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 land masses, 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 1999b, 2006e).

Life History—During the summer, sailfish move north along the western wall of the Gulf Stream, and during winter, sailfish regroup off the east coast of Florida, Florida Keys, Caribbean, and offshore waters in the Gulf of Mexico (NMFS 1999b). 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, Florida to the Florida Keys in shallow waters with depths from 9 to 12 m (de Sylva and Breder 1997; NMFS 1999b, 2006e).

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 (sea robin, cephalopods, and gastropods). Feeding occurs during daylight hours (Manooch 1988; NMFS 1999b, 2006e).

EFH Designations (NMFS 1999b, 2006e; Figure D-78)

- <u>Spawning Adult, Egg, and Larva</u>—EFH is designated from 28.25°N south to Key West, Florida in waters associated with the Gulf Stream and the Florida Straits from 4 NM off shore to the U.S. EEZ boundary. These areas are not located within the VACAPES OPAREA.
- <u>Juvenile and Subadult</u> (20 to 142 cm LJFL)—EFH is designated as pelagic and coastal surface waters between 21° and 28°C and from 32°N south to Key West, Florida between 4 and 109 NM offshore or to the U.S. EEZ boundary, whichever is closer to shore. These regions are not in the VACAPES OPAREA. Additional EFH designated for this lifestage, outside the OPAREA, is located in the Gulf of Mexico.
- <u>Adult</u> (≥143 cm LJFL)—EFH is designated as pelagic and coastal surface waters between 21° and 28°C from 4 NM offshore to 2,000 m between 36°N and 34°N; south of 34°N to Key West, Florida, EFH extends from 4 to 109 NM offshore or to the U.S. EEZ boundary, whichever is nearer to shore. Additional EFH for this lifestage is also designated in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- <u>Sand Tiger Shark</u> (*Carcharias taurus*)

Management—The sand tiger shark is managed under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

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). This species 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 2002b). In the western Atlantic, the sand tiger shark occurs from the Gulf of Maine to Florida, the northern Gulf of Mexico, the Bahamas, and Bermuda and southward to Argentina (Castro 1983; Compagno 1984b). In warmer months, this species is common from Cape Cod, MA to the Delaware Bay (Castro 1983).

Habitat Associations—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 1984b; NMFS 1999a; Branstetter 2002b). Neonate and juvenile sand tiger sharks utilize estuarine waters as nurseries from Massachusetts to South Carolina (McCandless et al. 2002).

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 1999a; Branstetter 2002b). 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 1984b).

Common Prey Species—Sand tiger sharks feed primarily on fishes (skates, goosefish, sea robin, scup, spot, bluefish, and butterfish), specifically summer flounder, as well as invertebrates (lobster, crab, and squid) (Branstetter 2002b).

EFH Designations (NMFS 1999a, 2006e; Figure D-79)

- Neonate (≤117 cm TL)—EFH is designated as the shallow coastal waters to 25 m from Barnegat Inlet, NJ to Cape Canaveral, Florida.
- Juvenile (118 to 236 cm TL)—At this time there is no available EFH information designated for this lifestage.
- Adult (≥237 cm TL)—EFH is designated as the shallow coastal waters to 25 m from Barnegat Inlet, NJ to Cape Lookout, North Carolina and from St. Augustine, Florida to Cape Canaveral, Florida.

HAPC Designations—No HAPC are identified for this species.

- Sandbar Shark *(Carcharhinus plumbeus)*

Management—The sandbar shark is managed under the Large Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—This species does not have an overfished status but is considered subject to overfishing (NMFS 2006a). 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, found in shallow coastal waters from Cape Cod, MA, southward to Brazil, including the Gulf of Mexico and Caribbean Sea but are most common from South Carolina to Florida and in the eastern Gulf of Mexico (Castro 1983; Branstetter 2002a).

Habitat Associations—This bottom-dwelling species is found in temperate to tropical waters over the continental shelf and in deepwater adjacent to the shelf break. Sandbar sharks are found in water depths ranging from the intertidal zone to 280 m during migration but are common in 20 to 65 m depths (Compagno 1984a; Knickle 1999a). Sandbar sharks avoid surf zones, coral reefs, or rough benthic substrates, preferring smooth substrates (Castro 1983; Compagno 1984a). It is common in inshore areas with mud or sand substrates such as estuaries, river mouths, and harbors but does not enter freshwater (Compagno 1984a).

Life History—The sandbar shark makes an extensive seasonal migration, where it moves 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 this behavior (Compagno 1984a). 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 young being born from March to August after a gestation period of approximately one year (Castro 1983; Knickle 1999a; NMFS 1999a, 2006e). This species segregates by sex with large females dominating shallow, nursery areas from Delaware Bay to Cape Canaveral, Florida, as well as the Gulf of Mexico (Castro 1983, 1993; McCandless et al. 2002). The Chesapeake Bay is regarded as one of the primary nursery grounds in the mid-Atlantic (Branstetter 2002a).

Common Prey Species—Sandbar sharks feed opportunistically on benthic prey, such as fishes (eels, skates, rays, and dogfish) and invertebrates (squid, octopus, bivalves, shrimp, and crabs). They feed all day but are most active at night (Knickle 1999a).

EFH Designations—(NMFS 2003a, 2006e; Figure D-80)

- Neonate (≤71 cm TL)—EFH is designated as shallow coastal areas seaward to 25 m from Montauk, Long Island, NY (72°W) south to Cape Canaveral, Florida (80.5°W), except from the Virginia/Maryland border (37.8°N) south to Pamlico Sound, North Carolina, 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, Florida, 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 (71 to 147 cm TL)—EFH is designated as all coastal and pelagic waters offshore from Cape Poge Bay and the south shore of Cape Cod, MA to Long Island, NY (north of 40°N and west of 70°W); shallow coastal areas out to the 25 m isobath from Barnegat Inlet, NJ (40°N) to Cape Canaveral, Florida (27.5°N); and in the MAB (39° to 36°N) during the winter, the benthic areas underlying the shelf break between the 90 and 200 m isobaths. EFH excludes areas from 39.2°N off the coast of New Jersey south to 35.2°N off Cape Hatteras, North Carolina (finger-like projection roughly following the 200 m isobath). Additional EFH designated for this lifestage is in the Florida Keys and off western Florida.
- Adult (≥147 cm TL)—EFH is designated from Nantucket, MA south to Miami, Florida 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, North Carolina (finger-like projection roughly following the 200 m isobath). Additional EFH designated for this lifestage is in the Florida Keys and off western Florida.

HAPC Designations (NMFS 1999a, 2003a, 2006e; Figure D-80)

- All Lifestages—HAPC are designated 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, North Carolina, 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—The scalloped hammerhead shark is managed under the Large Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—They are listed as lower risk but near threatened according to the IUCN Red List (Kotas 2000). This species is subject to overfishing and has an overfished status (NMFS 2006a).

Distribution—Scalloped hammerhead sharks are found in warm-temperate to tropical waters worldwide over the continental shelf and slope (Castro 1983; Compagno 1984a). 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 1999g).

Habitat Associations—This species inhabits waters from the surface to depths of 275 m and is found close to shore, in bays and estuaries, preferring water temperatures of at least 22°C (Castro 1983; Compagno 1984a). Typically, scalloped hammerhead sharks spend the day close to shore and move to deeper waters at night to feed (Bester 1999g).

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 1999a, 2006e, 2006e).

Common Prey Species—Scalloped hammerhead sharks consume a wide variety fishes, as well as invertebrates, and have been reported feeding only at night (Compagno 1984a).

EFH Designations (NMFS 1999a, 2006e; Figure D-81)

- Neonate (≤62 cm TL)—EFH is designated as shallow coastal waters from the shoreline to the 22 NM offshore from South Carolina to Florida (west of 79.5°W and north of 30°N), but this region is not located within the VACAPES OPAREA. Additional EFH for this lifestage of the scalloped hammerhead is designated in the Gulf of Mexico.
- Juvenile (63 to 227 cm TL)—EFH is designated as all shallow coastal waters, from shoreline to the 200 m isobath, extending from 39°N southward to the vicinity of the Dry Tortugas and the Florida Keys (82°W). The Gulf of Mexico is also designated as EFH for this lifestage.
- Adult (≥228 cm TL)—EFH is designated from 25 to 200 m from 36.5°N to 33°N; from 33°N south to 30°N from the 50 to 200 m isobath; and from 25 to 200 m from 30°N south to 28°N. Additional EFH designated for this lifestage is in the Florida Keys.

HAPC Designations—No HAPC are identified for this species.

- Shortfin Mako Shark (*Isurus oxyrinchus*)

Management—The shortfin mako shark is managed under the Pelagic Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The IUCN Red List designates the shortfin mako as lower risk but near threatened (Stevens 2000b). The shortfin mako shark is not currently overfished or subject to overfishing (NMFS 2006a).

Distribution—The shortfin mako shark has a worldwide distribution. It ranges from the Grand Banks and Gulf of Maine in the western Atlantic southward to the tropics, including the Gulf of Mexico (Schultz 2004). It is typically common offshore from Cape Cod, MA to Cape Hatteras, North Carolina (Castro 1983).

Habitat Associations—This shark is found in warm-temperate to tropical waters around the world but is rarely found in water temperatures lower than 16°C (Compagno 1984b). This shark is an epipelagic species typically found from the surface to depths of 152 m but has been recorded as deep as 740 m (Compagno 1984b; Passarelli et al. 1999).

Life History—Few data exist on the migratory patterns of the shortfin mako shark. Within the northern extent of its range, this species is believed to follow the movement of warm-water masses towards the poles in the summer (Compagno 1984b). The shortfin mako shark has a two- or three-year reproductive cycle, a gestation period of approximately 18 months, and a late winter to mid-spring parturition (Mollet et al. 2000). Locations of nursery areas have not been identified but are hypothesized to be located within deep tropical waters (NMFS 1999a, 2006e).

Common Prey Species—Shortfin mako sharks prey upon pelagic fishes, such as swordfish, tuna, eel, menhaden, ocean pout, saury, redfish, butterfish, mackerel, and other sharks, as well as squid (Passarelli et al. 1999; Branstetter 2002c). In the northwestern Atlantic, bluefish are the primary component of this species' diet (Passarelli et al. 1999).

EFH Designations (NMFS 1999a, 2006e; Figure D-82)

- Neonate (≤85 cm TL)—EFH is designated between 50 and 2,000 m from southeast of Georges Bank (~42°N and 66°W) to Cape Lookout, North Carolina (~35°N) and from 25 and 50 m offshore from the Chesapeake Bay to a line running west of Long Island, NY to just southwest of Georges Bank (~67°W and 41°N).
- Juvenile (108 to 262 cm TL)—EFH is designated as the area between 25 and 2,000 m from offshore Onslow Bay, North Carolina north to Cape Cod, MA and extending west between 38°N and 41.5°N to the U.S. EEZ boundary.
- Adult (≥263 cm TL)—EFH is designated as the area between 25 and 2,000 m from offshore Cape Lookout, North Carolina north to Long Island, NY and extending west between 38.5°N and 41°N to the U.S. EEZ boundary.

HAPC Designations—No HAPC are identified for this species.

- Silky Shark *(Carcharhinus falciformis)*

Management—The silky shark is managed under the Large Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—This species is considered subject to overfishing, as well as being overfished (NMFS 2006a).

Distribution—Silky sharks are found in the Pacific, Indian, and Atlantic oceans. In the western Atlantic, this species ranges from Massachusetts to southern Brazil, including the Gulf of Mexico and Caribbean Sea (Manooch 1988).

Habitat Associations—The silky shark inhabits tropical to warm-temperate waters (23° to 24°C) from depths of 18 to 500 m and associates with deepwater reefs and shelf edges (Compagno 1984a). Nurseries have been recorded in offshore waters of Florida and Texas, as well as in the Caribbean (Compagno 1984a; McCandless et al. 2002). Campeche Bank is considered the primary nursery area in the region (NMFS 1999a). Adults are typically found further offshore than younger sharks. Neonates utilize reef habitats (Knickle 1999b).

Life History—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 1999a, 2006e).

Common Prey Species—Silky sharks feed on fishes (mullet, mackerel, and tuna), crab, and squid (Compagno 1984a; Manooch 1988).

EFH Designations (NMFS 1999a, 2006e; Figure D-83)

- Neonate (≤85 cm TL)—EFH is designated as waters off Cape Hatteras, North Carolina between depths of 100 and 2,000 m; in shallow coastal waters just north and immediately east of Cape Hatteras; and between depths of 25 and 1,000 m from St. Augustine, Florida south to Miami, Florida (likely along the west edge of the Gulf Stream). Additional EFH designated for this lifestage of the silky shark is in the Gulf of Mexico.
- Juvenile (86 to 231 cm TL)—EFH is designated from the mouth of the Chesapeake Bay south to the North Carolina/South Carolina border in waters from 50 to 2,000 m and from the North Carolina/South Carolina border south to Key West, Florida paralleling the 200 m isobath. The Gulf of Mexico is also designated as EFH for this lifestage of the silky shark.
- Adult (≥232 cm TL)—At this time there is no designated EFH information for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Skipjack Tuna *(Katsuwonus pelamis)*

  Management—The skipjack tuna is managed under the Tuna MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

  Status—According to current stock assessment and fishery evaluation reports by the NMFS (2004a), the stock assessment of the west Atlantic skipjack tuna is unknown due to a lack of knowledge about this 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 1999a; Schultz 2004).

  Habitat Associations—This species is 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 1999a). 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 1999a, 2006e).

  Common Prey Species—Skipjack tuna are opportunistic feeders that prey upon fishes (herring, anchovies, and sardines), cephalopods, and crustaceans with peak feeding occurring at dawn or dusk (visual feeders) (Gardieff 1999c; NMFS 1999a). Additionally, *Sargassum* and species associated with *Sargassum* have been recorded in their stomachs (NMFS 1999a, 2006e). Cannibalism is also considered common (Gardieff 1999c).

  EFH Designations (NMFS 1999a, 2006e; Figure D-84)

  - Spawning Adult, Egg, and Larva—EFH is designated as offshore waters from the 200 m isobath outward to the U.S. EEZ boundary, from 28.25°N south around peninsular Florida and the Gulf coast to the U.S./Mexico border. This area is south of the VACAPES OPAREA.
  - Juvenile and Subadult (<45 cm fork length)—EFH designated for this lifestage is off southeastern Florida and is not located within the VACAPES OPAREA..
  - Adult[3] (≥45 cm fork length)—EFH is designated as pelagic surface waters with a temperature range of 20° to 31°C from 25 to 200 m in the MAB off the coast of Martha's Vineyard, MA (71°W) south and west to offshore of Oregon Inlet, North Carolina (35.5°N).

  HAPC Designations—No HAPC are identified for this species.

- Swordfish *(Xiphias gladius)*

  Management—The swordfish is managed under the Swordfish MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

[3] EFH text description does not match the GIS shapefile provided the by NMFS (2003b) for regions outside the VACAPES OPAREA. 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 2006e). Until the NMFS addresses the discrepancy, neither the GIS data depictions nor the text designations are to be altered (Rilling 2007).

Status—According to current stock assessment and fishery evaluation reports by the NMFS (2006a), 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 according to the IUCN Red List (Safina 1996b).

Distribution—Swordfish inhabit the tropical, temperate, and sometimes cold water regions of all the 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. It is also common in the Gulf of St. Lawrence and on the Grand Banks. Its presence in the waters of the western Atlantic is generally restricted to the warmer seasons (Gusey 1981).

Habitat Associations—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, North Carolina (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 and 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 upon pelagic fishes but also feed on squid and demersal fishes. They use their sword to slash and obtain larger prey, while consuming smaller prey whole (Gardieff 1999d).

EFH Designations (NMFS 1999a, 2006e; Figure D-85)

- Spawning Adult, Egg, and Larva—EFH is designated from offshore Cape Hatteras, North Carolina (~35°N) south around peninsular Florida and through the Gulf of Mexico to the U.S./Mexico border from 200 m to the U.S. EEZ boundary. EFH is associated with the Loop Current boundaries in the Gulf and the western edge of the Gulf Stream in the Atlantic. Additional EFH designated for this lifestage is in the Caribbean Sea.
- Juvenile and Subadult (<180 cm LJFL)—EFH is designated in pelagic waters warmer than 18°C from the surface to a depth of 500 m: from offshore Manasquan Inlet, NJ (40°N) east to 73°N and south to off Georgia (31.5°N) between the 25 and 2,000 m isobaths, and from 100 m to the U.S. EEZ boundary (south and east) extending from Cape Canaveral, Florida (~29°N) around peninsular Florida. Additional EFH designated for this lifestage is in the Gulf of Mexico.
- Adult (≥180 cm LJFL)—EFH is designated as pelagic waters warmer than 13°C from the surface to 500 m extending from the southeast of Cape Cod, MA to Biscayne Bay, Florida (25.5°N), from the 100 to 2,000 m isobath or the U.S. EEZ boundary (whichever is closer to shore). Additional EFH designated for this lifestage is in the Gulf of Mexico.

HAPC Designations—No HAPC are identified for this species.

- Tiger Shark *(Galeocerdo cuvier)*

Management—The tiger shark is managed under the Large Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—This species is considered overfished in the northwest Atlantic, as well as subject to overfishing (NMFS 2006a). 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, they 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).

Habitat Associations—Tiger sharks are present over a wide variety of marine habitats but display a preference for cloudy or turbid coastal waters (Compagno 1984a; 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 1984a; 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 1984a; Tricas et al. 1997; Ferrari and Ferrari 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 1984a; Knickle 1999c). This species undergoes extensive seasonal migrations throughout the north Atlantic, traveling distances of 1,242 NM to as far as 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 and bluefish), squid, horseshoe crab, crab, conch, birds, marine mammals, and sea turtles (Branstetter 2002a).

EFH Designations (NMFS 1999a, 2006e; Figure D-86)

- Neonate (≤90 cm TL)—EFH is designated as shallow coastal areas out to 200 m, from offshore Montauk, Long Island, NY south to Cape Canaveral, Florida. EFH is also designated for this lifestage of the tiger shark in the Gulf of Mexico.
- Juvenile (91 to 296 cm TL)—EFH is designated as shallow coastal areas, 25 to 100 m isobath, from offshore Montauk, Long Island, NY to north of the mouth of the Chesapeake Bay; from south of the Chesapeake Bay to south of Cape Lookout, North Carolina from shore to the 100 m isobath; from Cape Lookout south to the Florida/Georgia border from the 25 to 100 m isobath; and from the Florida/Georgia border south around peninsular Florida from shore to the 100 m isobath. Additional EFH is also designated for this lifestage in the Gulf of Mexico and off Puerto Rico.
- Adult (≥297 cm TL)—EFH is designated offshore from the Chesapeake Bay south to Ft. Lauderdale, Florida, along the western edge of the Gulf Stream. Additional EFH designated for this lifestage is in the Gulf of Mexico and off Puerto Rico.

HAPC Designations—No HAPC are identified for this species.

- White Marlin *(Tetrapturus albidus)*

Management—The white marlin is managed under the Billfish MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—The stock in the northwest Atlantic Ocean is overfished and overfishing is occurring NMFS (2004b, 2006a). Additionally, the 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 occurs only in the Atlantic (NMFS 1999b). They are commonly distributed from Cuba, the Bahamas, and southern Florida to the Delaware Bay in the northwest Atlantic but extend as far as southern New England in lesser abundance during warmer months (Collette 2002b).

Habitat Associations—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 1999d; Collette 2002b). They often occur in the upper 20 to 30 m of the water column but are found down to depths of 200 to 250 m when the thermocline is deep (NMFS 1999b). 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 1999b, 2006e).

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 1999a, 2006e). White marlin migrate extensively over large distances, some recorded making trans-Atlantic movements (NMFS 1999b, 2006e).

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 1999a). As with other billfishes, white marlin are suspected to use their spear to stun prey species (Manooch 1988).

EFH Designations (NMFS 1999b, 2006e; Figure D-87)

- Juvenile (20 to 158 cm LJFL)—EFH is designated as pelagic waters with temperatures warmer than 22°C, from 50 to 2,000 m, extending from the U.S. EEZ at Georges Bank (41°N) south to offshore Miami, Florida (25.25°N). Additional EFH designated for this lifestage is in the Gulf of Mexico.
- Adult (≥159 cm LJFL)—EFH is designated as pelagic waters with temperatures warmer than 22°C that occurs offshore of the northeast U.S coast (33.75°N to 39.25°N) from the 50 to 2,000 m isobaths and extending along 39.25°N out to the EEZ boundary; off the coast of South Carolina in the Charleston Bump area starting from the 200 m isobath (32.25°N) east to 78.25°W, south to 31°N, west to 79.5°W, and north to the 200 m isobath; and offshore Cape Canaveral, Florida from the 200 m isobath, east at 29°N to the U.S. EEZ boundary, south along the 200 m isobath, and out to the U.S. EEZ boundary to 82°W, in the vicinity of Key West, Florida. The Gulf of Mexico is also designated as EFH for this lifestage.

HAPC Designations—No HAPC are identified for this species.

- Yellowfin Tuna (*Thunnus albacares*)

Management—The yellowfin tuna is managed under the Tuna MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006e).

Status—According to current stock assessment and fishery evaluation reports by the NMFS (2004b, 2005), the Atlantic yellowfin tuna is approaching an overfished condition (i.e., estimated that the fishery will become overfished within 2 years) (NMFS 2006a). According to Punt (1996), this species is listed as lower risk/least concern on the IUCN Red List.

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 1999a, 2006e).

Habitat Associations—Yellowfin tuna are an epipelagic, oceanic species found in waters with temperatures between 18° and 31°C. 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, and marine mammals) (Collette and Nauen 1983; Gardieff 1999f). 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 1999a). Larval distribution is restricted to waters above the thermocline with temperatures above 24°C and salinities greater than 33 psu (Collette and Nauen 1983; NMFS 1999a, 2006e).

Life History—Spawning 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 and also in the Gulf of Mexico and the Caribbean Sea (Gardieff 1999f; NMFS 1999a, 2006e). Larvae have been previously collected in the northern Gulf of Mexico, along the Mississippi Delta, in September (NMFS 1999b, 2006e). Movement patterns for this HMS are not well documented, but tuna spawned in the Gulf of Guinea, off central Africa, are believed to migrate toward the U.S. coast (Collette and Nauen 1983; NMFS 1999a, 2006e).

Common Prey Species—Yellowfin tuna feed opportunistically on fishes (dolphin, pilchard, anchovy, flying fish, mackerel, lanternfish, squirrelfish, and other tuna species) and invertebrates (cuttlefish, squid, octopus, shrimp, lobster, and crabs) from the surface to depths of 100 m (Gardieff 1999f; NMFS 1999a). *Sargassum* and *Sargassum*-associated species have been recorded in yellowfin tuna stomach contents (NMFS 1999a). They are considered sight-oriented predators that feed during daylight hours (Gardieff 1999f).

EFH Designations (NMFS 1999a, 2006e; Figure D-88)

- Spawning Adult, Egg, and Larva—EFH is designated in offshore waters from 200 m seaward to the U.S. EEZ boundary, from 28.25°N south around peninsular Florida into the Gulf of Mexico to the U.S./Mexico border, and this region is not located within the VACAPES OPAREA. The Caribbean Sea is also designated as EFH for this lifestage of the yellowfin tuna but is not located within the OPAREA.
- Juvenile and Subadult (<110 cm fork length)—EFH is designated as pelagic waters from the surface to 100 m, with a temperature between 18° and 31°C from offshore Cape Cod, MA (70°W) southward to Jekyll Island, Georgia (31°N) between the 500 and 2,000 m isobaths and off Cape Canaveral, Florida (29°N) south to the U.S. EEZ (approximately 28.25°N) and from 79°W east to the U.S EEZ (approximately 76.75°N). Additional EFH is designated for this lifestage in the Gulf of Mexico.
- Adult (≥110 cm fork length)—EFH is designated as pelagic waters from the surface to 100 m, with temperatures between 18° and 31°C, from offshore Cape Cod, MA (70°W) southward to Jekyll Island, Georgia (31°N) between the 500 and 2,000 m isobaths and off Cape Canaveral, Florida (29°N) south to the U.S. EEZ (approximately 28.25°N) and from 79°W east to the U.S EEZ (approximately 76.75°N). The Gulf of Mexico is designated as EFH for this lifestage as well.

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 delimit the extent of a nation's sovereignty, exclusive rights, jurisdiction, and control over the ocean areas off its coast. They are critical elements that affect the planning of activities in the marine environment (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 2006a).

Historically the U.S., as well as other nations, have used 3 NM as their seaward territorial limit; although, two American states, Texas and Florida (along its Gulf coast), and U.S. territories, such as Puerto Rico, established seaward boundaries of three marine leagues or 9 NM. Maritime boundaries, including 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 across the coastal feature (Figure 6-1). Rather than use the normal baseline, an increasing number of countries use either the straight baseline or an archipelagic baseline 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, differs from the geologic definition of the continental shelf. The continental shelf, as it is used in the OCS Lands Act, is not limited to that portion of the continental margin located shoreward of the shelf break (the geologically defined boundary of the continental shelf), but actually includes the entire continental margin as defined in chapter two of this MRA. In fact, the U.S. claims a portion of the seabed and seafloor located well beyond the shelf break as a part of its "continental shelf." 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 2006).

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 baseline 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. Once the FCMA went into effect in 1977, the U.S. formally claimed a 200 NM fishery conservation zone (except where countries were closer than 400 NM) in which it exercised exclusive fishery management authority.

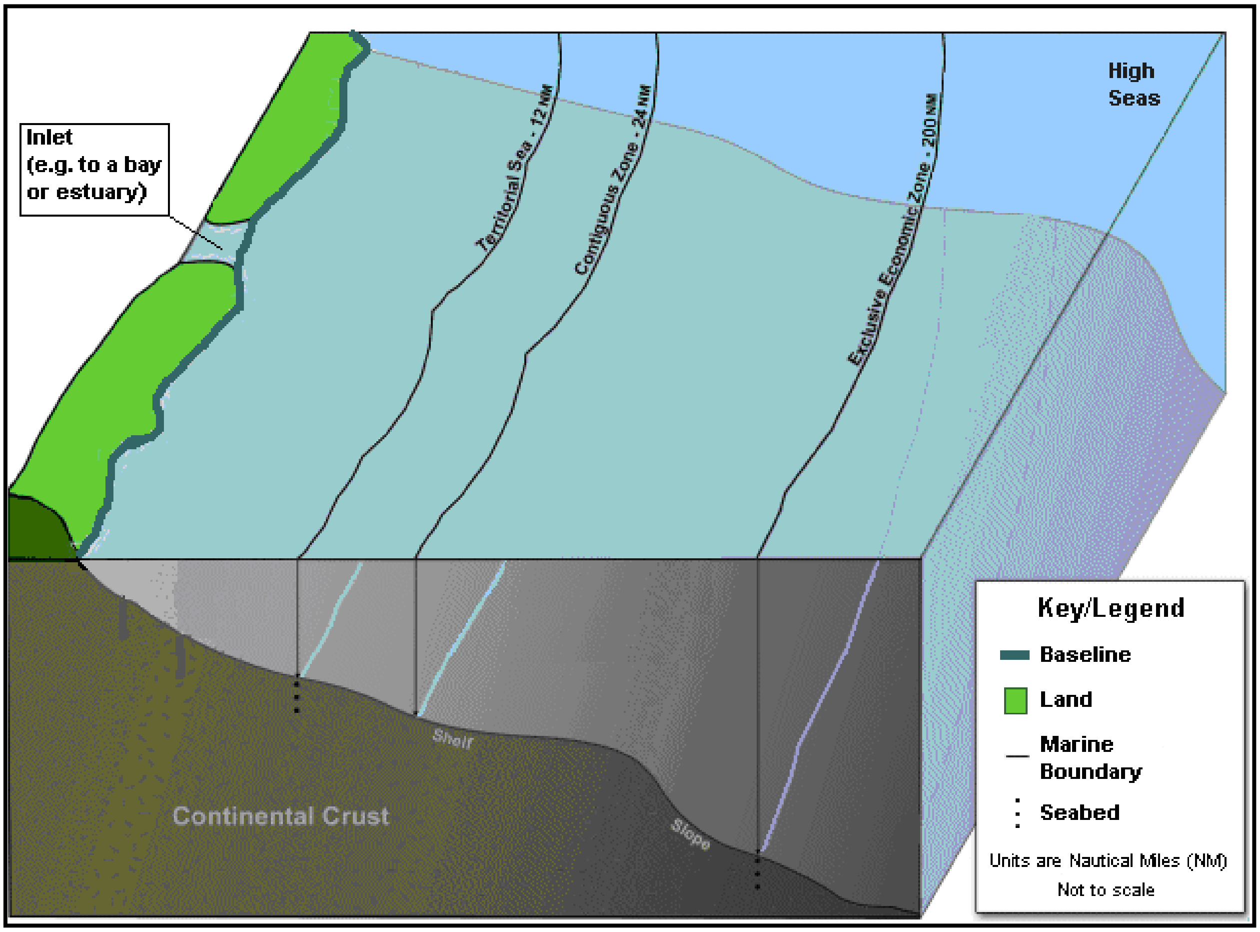

Figure 6-1. Generic three-dimensional representation of maritime boundaries with the baseline defined as the mean low water/tide line along the coast or a straight line drawn across coastal bays or other inlets. Adapted from NOAA (2006a).

Pending the establishment of permanent maritime boundaries by treaty or agreement between nations located within 400 NM, the FCMA set forth fishery limits based on a median line drawn equidistantly between each nation (DoS 1977).

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. Such a case occurs off the southeast U.S. coast where The Bahamas is approximately 50 NM from the east coast of Florida.

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 located within the U.S. EEZ, but sovereignty does not affect the lawful use of an EEZ by other nations for navigation or overflight (Table 6-2).

All of the VACAPES OPAREA is included within the limits of the U.S. EEZ (Figure 6-2). The shoreward boundary of the OPAREA is contiguous with that part of the U.S. Territorial Waters falling under the

Table 6-1. Timeline detailing the establishment of U.S. jurisdiction and maritime boundaries in the Virginia Capes OPAREA and vicinity as determined by treaty, legislation, and presidential proclamation (DoS 1977; DOALOS 2005, 2006a; Rosenberg 2006).

- **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 the U.S. baseline, except in several areas such as the Caribbean Sea, where to the west, south, and east of Puerto Rico and the 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, lines equidistant from each nation’s baseline delineated the EEZ boundary. The EEZ boundaries coincided with those established by the 1976 Fishery Conservation and Management Act. 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 U.S 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 VACAPES OPAREA and vicinity as determined by treaty, legislation, and presidential proclamation (DoS 1977; DOALOS 2005, 2006a; Rosenberg 2006) (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 U.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.

Table 6-2. Maritime boundaries and jurisdictional extent associated with the Virginia Capes OPAREA (DOALOS 2006b).

Maritime Boundary	Seaward Extent of Boundary	Jurisdictional Extent
State Waters	3 or 9 NM from U.S. baseline (depending on state's historical maritime boundary)	State jurisdiction of the air, sea, and seabed
U.S. Territorial Waters	12 NM from the U.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	Power to prevent and punish infringement of fiscal, customs, immigration, and sanitary laws or regulations
Exclusive Economic Zone (EEZ)	200 NM from the U.S. baseline (unless a neighboring nation is less than 400 NM away)	Sovereign rights over all natural resources and jurisdiction to protect the marine environment

jurisdiction of the coastal states of Delaware, Maryland, Virginia, and North Carolina. The remaining 9 NM of the U.S. Territorial Waters and 21 NM of the U.S. Contiguous Zone overlap with the VACAPES OPAREA.

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 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

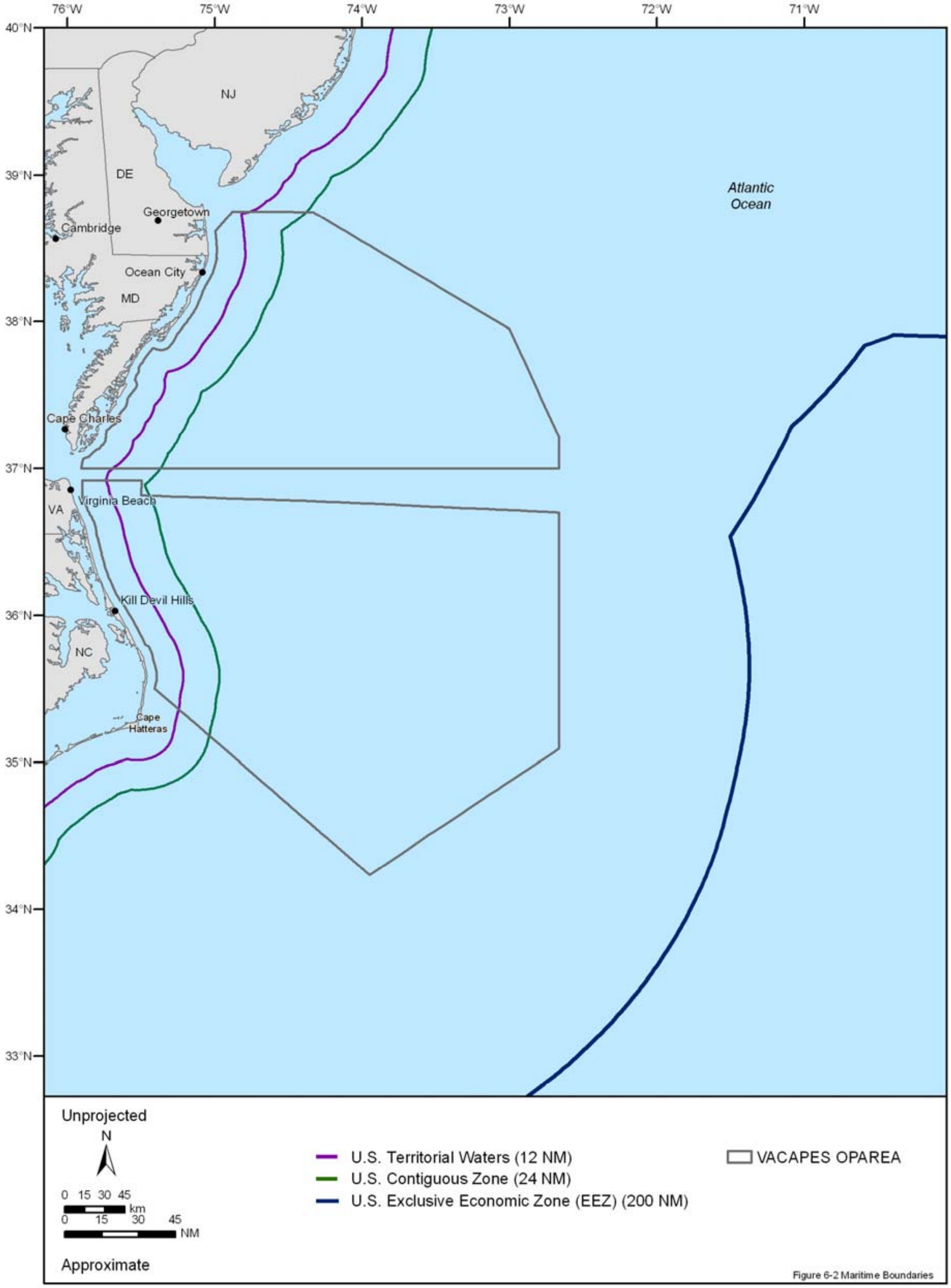

Figure 6-2. Proximity of the Virginia Capes OPAREA to U.S. maritime boundaries. The U.S. territorial waters (12 NM), contiguous zone (24 NM), and exclusive economic zone (EEZ) (200 NM) are measured seaward from a baseline (usually the mean low-tide line along the shore). Source data: GDAIS (2005).

and supreme power over this area. 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 the U.S. contiguous zone by an additional 12 NM to the 24 NM maximum allowed by international law. The contiguous zone is measured from the U.S. baseline and, as its name implies, is an area adjacent 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. The broadening of the U.S. contiguous zone advances both the law enforcement and public health interests of the nation.

6.1.1 U.S. Maritime Boundary Effects on Federal Legislation and Executive Orders

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 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.

- Executive Order 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 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.

- 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/SHIPPING LANES

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). Navigable waterways aid all vessels, commercial, recreational, and military, in avoiding conflicts and collisions while entering and leaving major ports. More than 40,000 km (21,000 NM) of commercially navigable waterways exist within the U.S. transportation system (BTS 2004a). Offshore, waterways or shipping lanes are not designated; instead vessels follow routes determined by their destination, depth requirements, and weather conditions.

The western North Atlantic supports a large volume of both domestic and international maritime traffic. Waterways and shipping lanes connect major ports along the U.S. Atlantic coast with five major commodities exchange regions: (1) the Caribbean; (2) Northern Europe; (3) the Mediterranean; (4) West Africa; and (5) the Persian Gulf (Gaines et al. 1987). Ships transiting within or in the vicinity of the VACAPES OPAREA may use any one of over 15 shipping lanes that intersect the OPAREA. One shipping lane runs roughly parallel to the coast and serves as a connecting route between domestic ports to the north and south of the OPAREA. Offshore shipping lanes extend to the southeast towards the Caribbean or to the northeast towards Europe and the Mediterranean (Figure 6-3).

Chesapeake Bay and Delaware Bay, which are immediately adjacent to the VACAPES OPAREA, provide access to several major U.S. east coast ports, including Baltimore, Maryland; Philadelphia, Pennsylvania; and the Hampton Roads area of Virginia. Access to these and other ports located along the two bays and their tributaries is gained through the mouth of each bay, both of which open into the OPAREA. To facilitate organized and safe transit into and out of each bay, a traffic separation scheme has been defined at the mouth of each bay. Traffic separation schemes are designed to ensure that ships entering and exiting a passage where navigation is restricted either by topography or traffic density (or both) can do so safely. The traffic separation scheme at the mouth of Chesapeake Bay consists of two approaches (southern and eastern) and a two-mile radius precautionary area located shoreward of the approaches. The eastern approach has an inbound and an outbound lane, the exact coordinates of which can be found in 33 CFR 167.200-203, with a no-transit area between each lane designed to keep traffic separated. The southern approach also consists of an inbound and outbound lane; however, between the two lanes is a deep-water route to be used by ships with drafts that exceed 13.5 m (45 ft) in freshwater, and for Navy aircraft carriers (33 CFR 167.200). Ships using the deep-water route, which services both inbound and outbound traffic, should announce their intention to do so as they approach the route using VHF FM Channel 16 (33 CFR 167.203). The Delaware Bay traffic separation scheme consists of two approaches (southeastern and northeastern), a two-way traffic route, and a precautionary area. Each approach consists of an inbound and outbound lane, the exact coordinates of which are defined in 33 CFR 167.170-172. The two-way traffic route is located along the northern side of the traffic separation scheme and is recommend for use by tug and tow traffic entering or leaving the bay (33 CFR 167.173). The precautionary area, which is larger than the one at the mouth of Chesapeake Bay, is located on the shoreward side of the traffic separation scheme (33 CFR 167.174).

The major commercial shipping ports of Baltimore, Philadelphia, and port of Virginia (which consists of several port cities) all access the Atlantic by transiting the VACAPES OPAREA (Figure 6-3). In 2003, the port of Baltimore was the eighth busiest U.S. seaport and the eighteenth busiest port overall (including all modes of transport) for international trade, handling $26 billion of international freight (BTS 2004b). The primary commodities passing through the port of Baltimore include automobiles and other “roll-on-roll-off” equipment (e.g., farm vehicles), steel, and forest products (e.g., lumber). Canada leads all other nations in both imports and exports through Baltimore (BTS 2004b). In 2004, the port of Philadelphia, in combination with other Delaware River ports, ranked as the sixth most frequented port in the U.S. with over 2,900 vessel calls, equal to 5% of all U.S. vessel calls (DoT 2005). Several piers specialize in handling the shipment, storage, and distribution of goods, such as fruits and vegetables, cocoa products, and forest products (e.g., newsprint, wood pulp, and lumber), and the Tioga Marine Terminal serves as the homeport for two Navy supply vessels (PRPA 2006a and 2006b). These two Large, Medium Speed Roll-on/Roll-off (LMSR) vessels can be docked at the port to handle military supplies, because the port of Philadelphia was designated by the DOD in 2002 as one of 14 U.S. strategic military ports permitted to exchange military supplies (PRPA 2006b). The port of Virginia is made up of four cargo terminals

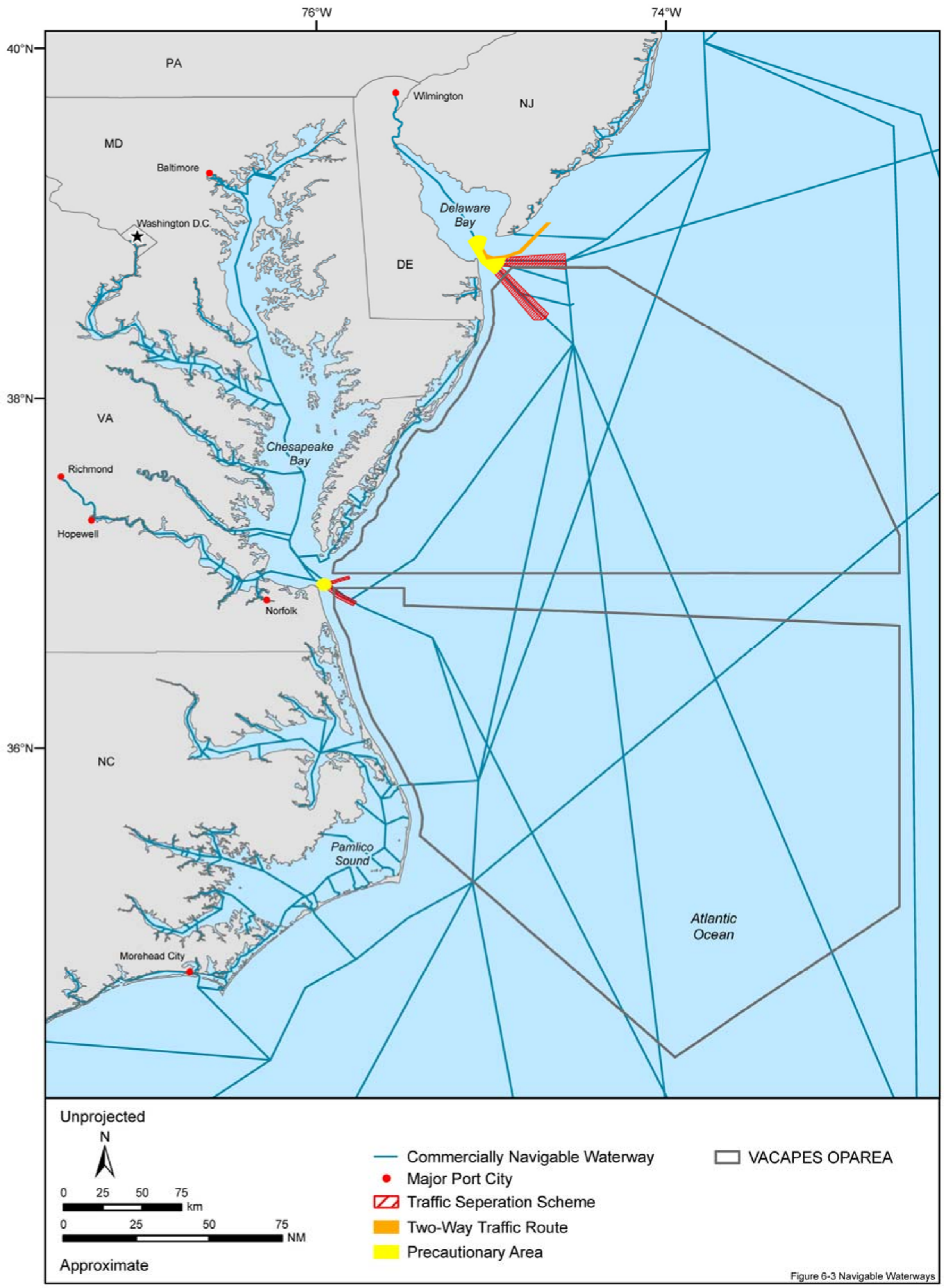

Figure 6-3. Commercially navigable waterways found in the Virginia Capes OPAREA and vicinity. Source data: PHMSA (2008), 33 CFR 167.200-203, and 33 CFR 167.170-174.

including: the Norfolk International Terminals, the marine ports of Portsmouth and Newport News, and the Virginia Inland Port at Front Royal (Port of Virginia 2005a). The top three exports in terms of tons of cargo shipped are coal, wood, and wood pulp, and the top three imports are oil, geologic-based products (i.e., salt, sulfur, earth, and stone), and machinery (Port of Virginia 2005b). The top three destinations for goods (in tons) exported from the port of Virginia are Japan, Brazil, and Italy, and the top three import countries are Canada, Norway, and Brazil (Port of Virginia 2005b).

Major ports connected by navigable waterways and shipping lanes to the north and south of the OPAREA include New York and Boston to the north and Savannah, Charleston, and Miami as well as access into the Gulf of Mexico to the south. It is highly likely that military vessels could encounter commercial shipping traffic transiting the VACAPES OPAREA, particularly near the entrance to Chesapeake Bay.

6.3 SCUBA DIVING SITES

The VACAPES OPAREA contains a number of dive sites frequented by both recreational scuba divers and snorkelers. The most popular sites include shipwrecks (especially off of the Delaware and North Carolina coasts) and artificial reefs, several of which are located within or immediately adjacent to the OPAREA (Figure 6-4). The dive season off of Delaware, Maryland, and Virginia starts in May and runs through October (Weeden 2003). During that time visibility can be up to 15 m and temperatures generally range between 20°C to 28°C in summer on the inner and middle shelf with cooler temperatures in fall and spring. Winter temperatures between 4°C and 12°C are much too cold for the average diver (Weeden 2003). In addition to shipwrecks, oyster reefs and mussel beds also attract divers to the waters surrounding the OPAREA; although most of these sites are located closer to shore or are found in the bays adjacent to the OPAREA (i.e., Chesapeake Bay) (Brady 2005).

The majority of diving in or near the VACAPES OPAREA takes place on the inner and mid-shelf off of North Carolina, where one of the largest concentrations of shipwrecks on the east coast is found. Diving occurs throughout the year off of North Carolina where warm Gulf Stream waters maintain temperatures between about 21°C and 26°C for the majority of the year, but the most popular recreational season is still from May to October. Most divers remain between depths of about 25 and 38 m (Seldon 2004; Rodriquez 2006). Shipwrecks along the Outer Banks in North Carolina, and in particular Nags Head, include sunken WWII-era U-Boats, freighters, and liberty ships (OBDC 2006). See chapter 4 for more information on specific shipwrecks located in the waters off North Carolina.

6.4 OCEANOGRAPHIC BUOYS AND LIGHT TOWERS

There are two oceanographic weather buoys moored and maintained by NOAA's National Data Buoy Center (NDBC) in the VACAPES OPAREA. In addition, there is also a light tower platform fitted with a Coastal-Marine Automated Network (C-MAN) instrument package located in the OPAREA that is also maintained by the NDBC (Figure 6-5). Most of the weather buoys and C-MAN sites, which are strategically placed on lighthouses, offshore platforms, capes, nearshore islands, and beaches, were established by the NDBC for the National Weather Service. C-MAN sites are capable of monitoring wind direction, wind speed and gust, air temperature, and barometric pressure; however, some sites also measure relative humidity, precipitation, sea surface temperature, and visibility (NOAA 2006b). The moored oceanographic buoys maintained by the NDBC monitor most of the same parameters as the C-MAN sites as well as wave energy spectra which allow the calculation of wave height, dominant and average wave period, and in some cases, the direction of wave propagation (NOAA 2006c).

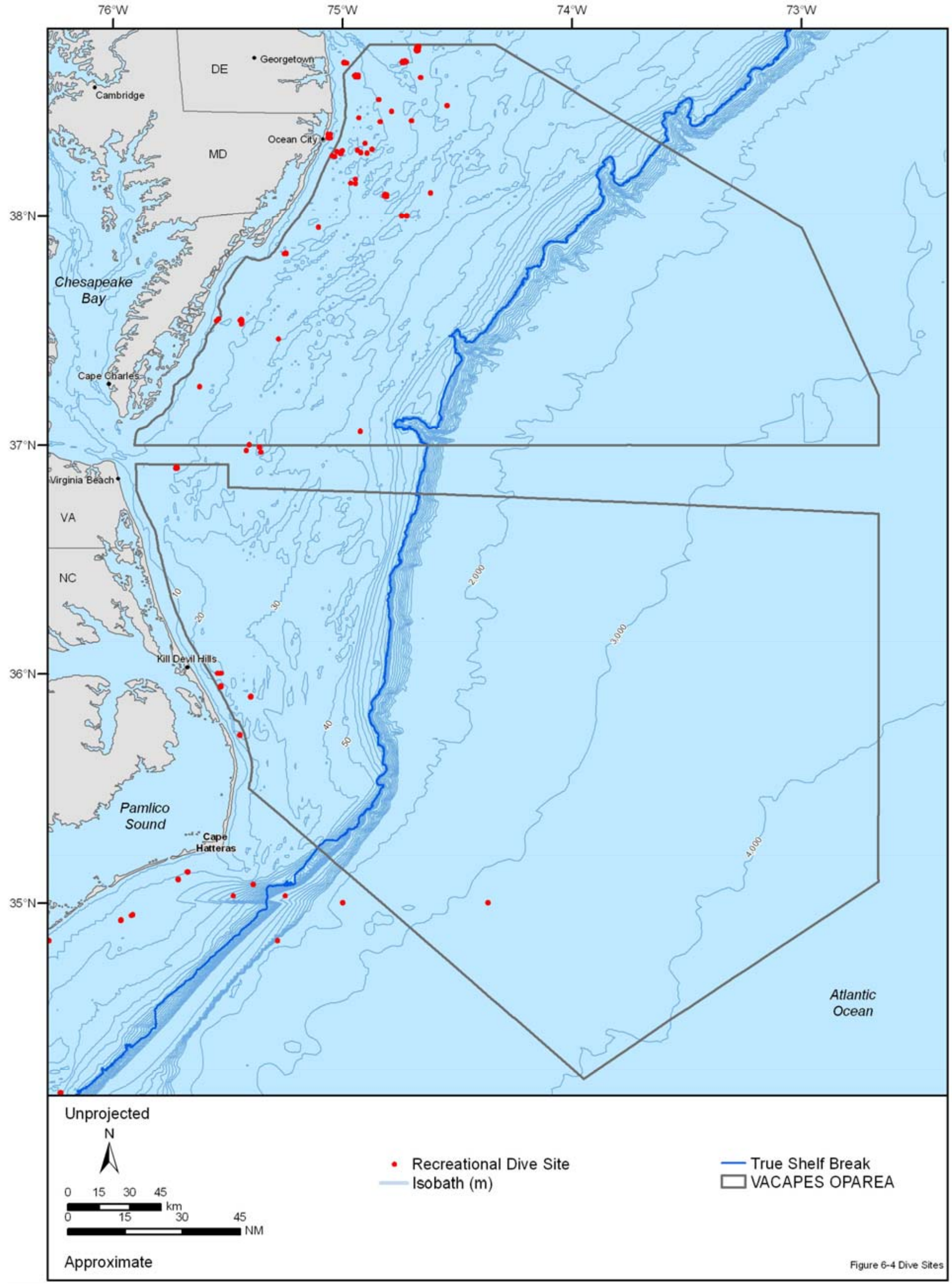

Figure 6-4. Popular recreational dive sites in the Virginia Capes OPAREA and vicinity. Source data: DDFW (2008), NCDMF (2005), NOAA (2008), OCRF (2005), and VMRC (2005).

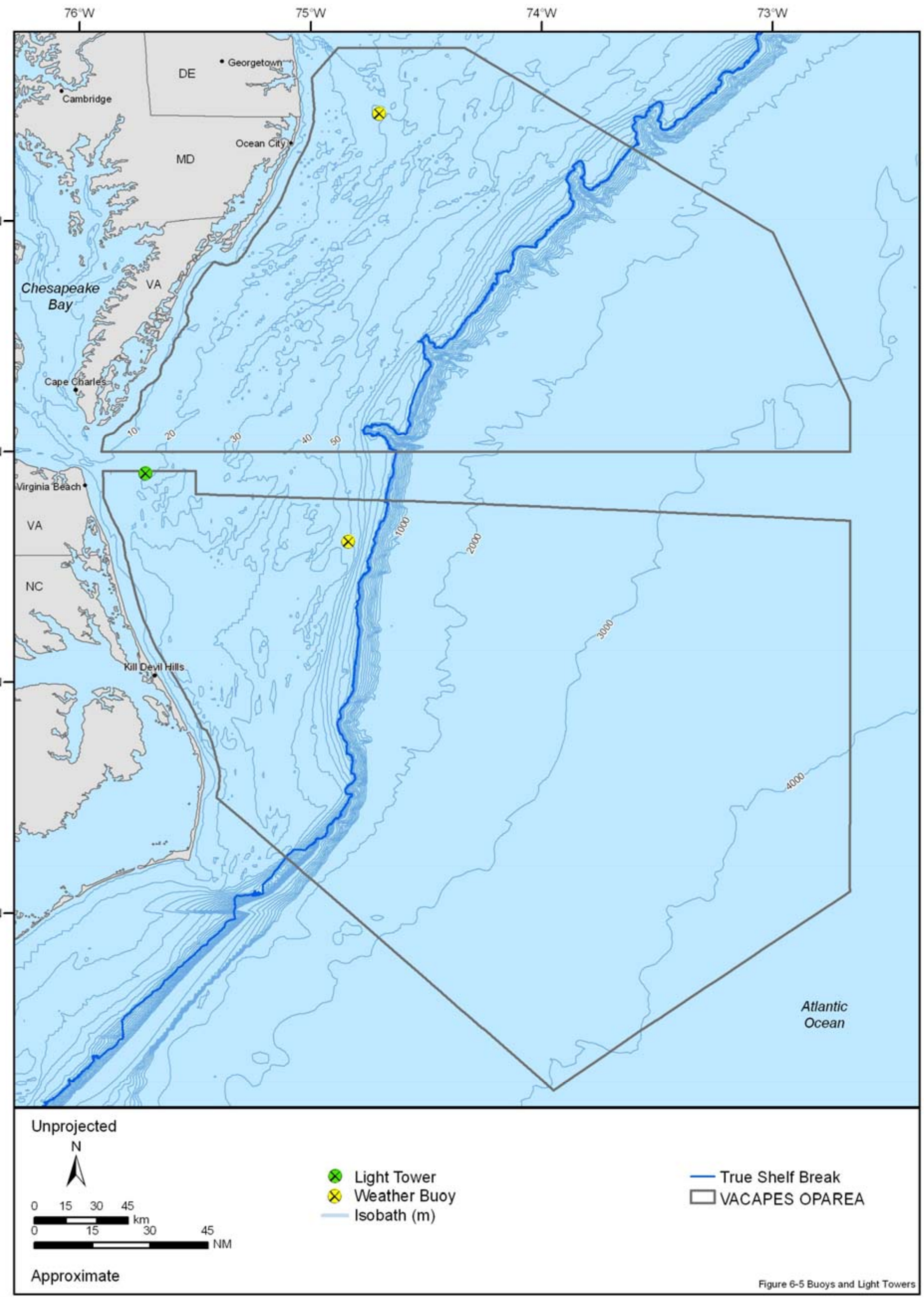

Figure 6-5. Oceanographic Buoys and Light Towers in the Virginia Capes OPAREA and vicinity. Source data: NDBC (2008).

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7.0 RECOMMENDATIONS

The VACAPES OPAREA is located within the Mid-Atlantic Bight (MAB) and northern South Atlantic Bight (SAB). It is a dynamic region that has been studied and surveyed heavily by various universities (i.e., University of North Carolina Wilmington and Virginia Institute of Marine Science), government agencies (i.e., NOAA, MMS, BLM, DoN, and USGS), and academic institutions (i.e., Woods Hole Oceanographic Institute and Harbor Branch Oceanographic Institute). Despite the wealth of scientific knowledge for the VACAPES OPAREA and vicinity, much remains to be learned to support Navy environmental planning. The following recommendations are designed to improve our understanding of the marine resources of the Mid-Atlantic Bight waters, especially those resources that may be potentially affected by Navy operations.

Each recommendation presented in this chapter is assigned a priority ranking of 1, 2, or 3 with 1 being the highest and 3 the lowest priorities. The priority designations are relative to one another and in no way reflect a project's overall value. The relative cost of each recommendation is characterized as low, moderate, or high. Low-cost recommendations may be completed at a cost of several hundred to a few thousand dollars. Moderate-cost projects could range from thousands to tens of thousands of dollars, while high-cost research initiatives range from tens to hundreds of thousands of dollars. The recommendations are ordered by priority ranking (i.e., Priority 1 projects are listed first) and are grouped into those related to the production and evaluation of this MRA and those needed to adequately complete environmental documentation for the VACAPES OPAREA MRA.

7.1 MARINE RESOURCE ASSESSMENTS

- Develop an improved approach to updating and maintaining data and information within the context of the MRA Program. Due to the rapidly developing nature of marine resources information, the Navy should work towards implementing a more dynamic MRA program with the ability to continuously update text and incorporate data as it becomes available. This will help ensure the best and most current information and data that are available for use in planning and compliance analyses on an ongoing basis rather than relying on a 5-year update schedule that can become time consuming and cumbersome. This new system should be based primarily on online access to text, data, and maps, as well as establish a process for evaluating new information as it becomes available. **Cost**: High. **Priority**: 1.

- Subject this MRA to peer review. Peer review by regulatory agencies (e.g., NMFS), the scientific community, and potential government users will only increase the quality and effectiveness of this document. Scientists and specialists in fields relevant to this MRA can provide critical comments and reviews that can only improve the usability, content, and quality of the MRAs (Table 7-1). **Cost**: Low to Moderate. **Priority**: 1.

- Obtain marine mammal and sea turtle datasets for the study area that were not available for inclusion in this assessment. While all 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 occurrence data for two sea turtle species (loggerheads and leatherbacks) from these surveys, data for the remaining turtle species would be most useful in delineating the seasonal distributions of those species.

    - Mid-Atlantic *Tursiops* surveys (MATS) for 1994 to complete our MATS inventory from NMFS-SEFSC; although sea turtle records were provided for the 1994 survey, a complete dataset would also provide the marine mammal records.

    - Acquisition and analysis of existing data will be less expensive than generating new data. The potential contribution of these datasets to our understanding of the distribution of these protected species is high, and the acquisition should be a very low cost. **Cost**: Low. **Priority**: 2.

Table 7-1. Suggested expert reviewers for the Virginia Capes OPAREA MRA.

Name	Affiliation	Area of Expertise
Dr. Bill Boicourt	University of Maryland, Horn Point Lab	Oceanography
Dr. John Music	Virginia Institute of Marine Science	Sharks, ray, and sea turtle conservation
Dr. Steve Ross	University of North Carolina, Wilmington	Deep sea corals
Mr. Joseph Uravitch	National Oceanic and Atmospheric Association	Marine protected areas
Dr. Aleta Hohn	NMFS Southeast Fishery Science Center	Marine mammal population dynamics
Dr. Ric Ruebsamen	NMFS Panama City Habitat	Essential fish habitat
Dr. Dawn Wright	Oregon State University	Oceanography and marine geospatial resources
Dr. Andy Read	Duke University, Nicholas School of the Environment and Earth Sciences	Marine mammal ecology
Dr. Lance Garrison	NMFS Southeast Fishery Science Center	Spatial ecology of marine mammals
Mr. Matthew Godfrey	North Carolina Wildlife Resources Commission	Sea turtle reproduction and conservation
Dr. Scott Eckert	Duke University, Nicholas School of the Environment and Earth Sciences – Marine Sciences & Conservation	Sea turtle ecology
Mr. David Taylor	NCDMF Morehead City Office	Fisheries management
Dr. Michael Coyne	Duke University, Nicholas School of the Environment and Earth Sciences – Environmental Sciences & Policy	Sea turtle biology and Spatial ecology of marine protected species

7.2 ENVIRONMENTAL DOCUMENTATION

- Support dedicated marine mammal and sea turtle aerial and/or shipboard surveys in the sections of the VACAPES OPAREA 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

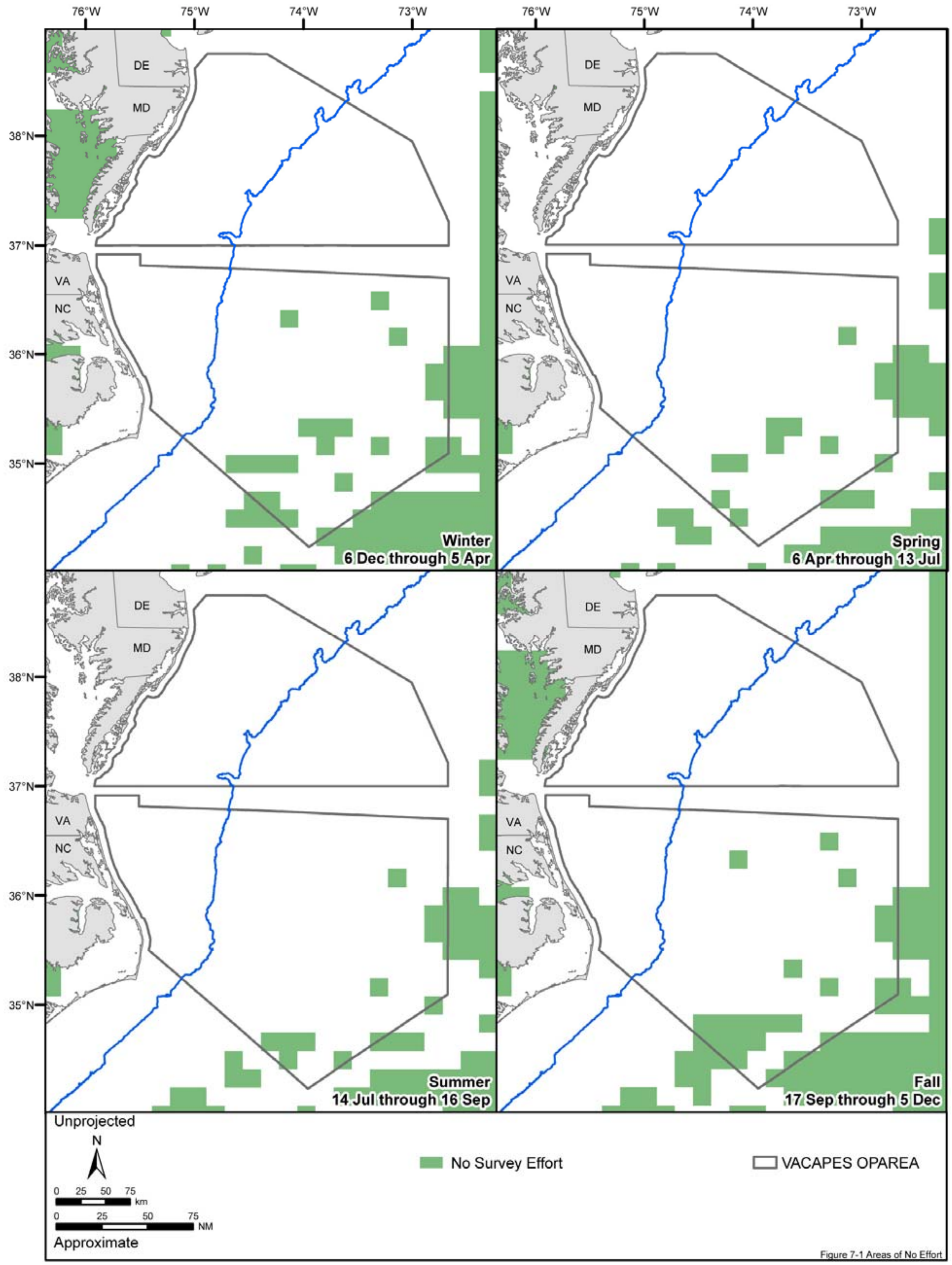

Figure 7-1. Spatial coverage of shipboard and aerial survey effort for protected species in the Virginia Capes OPAREA and vacinity.

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 adjacent to the southeastern section of the OPAREA during all seasons as very little data beyond fisheries bycatch exist for this region. **Cost**: High. **Priority**: 2.

- Support efforts that allow experienced observers to collect marine mammal and sea turtle sighting data during NMFS ichthyoplankton, fish, or other dedicated surveys. Providing experienced observers can be done at relatively low cost (primarily the salaries of the observers) since the monitoring would occur simultaneously during ongoing ships surveys. Existing research cruises provide a valuable chance to collect data opportunistically that would overwise only be collected during dedicated cruises, which are very expensive. **Cost**: Low. **Priority**: 3.

- Support marine mammal and sea turtle stranding networks and their analysis of their collected data, efforts to rehabilitate and release stranded marine mammals and sea turtles, and the tagging andtracking of released animals with satellite or radio telemetry tags. Stranding data is a vital adjunct to sighting and fisheries bycatch data in discerning occurrence patterns of protected species, particularly of sea turtles. Stranding networks are generally understaffed and under-funded, resulting in less than desirable data management and quality assurance. Tracking of released animals provides information on habitat associations and movement patterns of individual animals that would otherwise be unknown. **Cost**: Low. **Priority**: 3.

- Sponsor habitat mapping and classification research of deepsea corals in the U.S. Atlantic waters. The importance of deep water corals has been recognized and steps to federally protect these corals are underway (Deep Sea Coral Protection Act). If enacted, occurrence information on deep water corals will be vital for compliance with the statute and to ensure that Naval operations are conducted to reduce detrimental impacts to these deep water habitats. **Cost**: Moderate to High. **Priority**: 2.

  One effort to acquire this much needed data and information on deep water corals is the NOAA sponsored Southeastern Deep Sea Coral (SEADESC) Initiative, which involved dives of submersibles and remotely operated vehicles off North Carolina and other areas. During the dives, video and occurrence data on deepsea corals, especially of *Lophelia,* were collected. One of the project's investigators, Dr. Steve Ross (University of North Carolina), is searching for funding to initiate the second phase of the project to analyze the video footage and produce an atlas of the deep sea corals in the region of North Carolina already surveyed. The atlas will include all published and unpublished data in a searchable electronic format.

- Promote efforts of the SAFMC to update and provide clear and concise EFH/HAPC designations, including maps, for the waters of the southeastern U.S. 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) and no maps of the designated EFH are provided in the SAFMC FMPs. Thus, life history information must be interpreted to provide EFH designations for individual species. Since interpretations are subjective, concerns exist should EFH consultations be required. Supporting and encouraging EFH revision efforts by the SAFMC would ensure that the most accurate EFH/HAPC designations and maps would be available so the extent of protected fish habitat areas is apparent and no interpretations are necessary. **Cost**: Low. **Priority**: 1.

- Declassify Navy deep water (>200 m) bathymetry data. High-resolution deep water bathymetry data are not publicly available except for selected areas of the U.S. Atlantic. The Navy, however, has collected oceanographic, including bathymetry, data for decades and possesses data that is nonexistent elsewhere. The U.S. Commission on Ocean Policy, under the Oceans Act of 2000, has recommended that the U.S. Navy periodically declassify relevant oceanographic data. Not only would civilian scientists benefit from access to these data, but Navy environmental planners would as well. The declassification would also fulfill the Navy's responsibility regarding aspects of national ocean policy. **Cost**: Low. **Priority**: 3.

- Support and/or fund the augmentation of marine mammal shipboard surveys with passive acoustic surveys or with the deployment and monitoring of sonobuoys. Acoustic surveys have been conducted in conjunction with some sighting surveys and are particularly useful for identifying and tracking vocal, deep-diving species such as sperm whales, which spend less time at the surface and are often missed during visual sighting surveys. **Cost**: Moderate to High. **Priority**: 2.

- Utilize satellite-tracking technology to monitor the movements of species of special interest. Several species of endangered cetaceans and sea turtles occur in the VACAPES OPAREA, yet little is known about their seasonal movements in or through the OPAREA. Satellite-tracking programs are expensive, precluding the study of more than a few individuals. While insights on an individual's behaviors or movements may be gained, questions at the population level may go unanswered. **Cost**: Moderate. **Priority**: 3.

- Sponsor sea turtle telemetry studies along coastal Virginia. Such research is necessary to further understand turtle migrations along the U.S. coast as well as in the northwestern Atlantic Ocean. Tagging studies should focus on post-nesting females as well as adults and juveniles stranded and rehabilitated along the U.S. Atlantic coast. Tracking rehabilitated animals may also provide insight into successful rehabilitation techniques and optimal rehabilitation durations. **Cost**: Moderate. **Priority**: 3.

- Fund research efforts utilizing land-based radar to acquire data on surface and subsurface ocean currents, which contribute to the overall circulation on the continental shelf; the ultimate goal of this research is the identification of circulation patterns in this highly dynamic environment. Recent studies measuring the speed and direction of surface currents using land-based radar systems have provided near real-time data on wind-driven circulation at the shelf edge (Shen et al. 2000; Gangopadhyay et al. 2005). An advantage of having real-time information to detect transient circulation, such as regional upwelling events, is the increased predictive capability to identify areas of marine mammal occurrence. **Cost**: Low. **Priority**: 3.

- Collect limited temperature and depth (oceanographic) data with Navy ships. The deployment of expendable bathythermographs (XBTs) from Navy ships transiting the VACAPES OPAREA and vicinity would provide a means to collect low-cost information from areas not routinely surveyed by oceanographic cruises and would help to ground-truth data acquired from satellite remotely sensed ocean temperature data. 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.

- Support efforts of the Atlantic Coastal Cooperative Statistics Program (ACCSP). The ACCSP is a cooperative state-federal program whose goal is to design, implement, and conduct marine fisheries statistics data collection programs (both commercial and recreational fisheries) and to integrate those data into a single data management system that will meet the needs of fishery managers, scientists, and fishermen. Access to the fisheries data compiled by this program would provide Navy environmental planners with the location of recreational and commercial fisheries, data that is often difficult to acquire. **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

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

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

Anomaly—something irregular or abnormal

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

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

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

Auditory brainstem response (ABR)—a technique for measuring hearing sensitivity by which electrodes measure the brain's electrical output that results from sound stimuli

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

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 increasing 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, and 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; living and feeding near the bottom, mid-water, or near the surface

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

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

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

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

Candidate species—refers to species that are subject of petition to list and for which NMFS has determined that listing may be warranted in pursuant to ESA section 4(b)(3)(A), and species for which NMS has determined, following a status review, that listing is warranted

Cape[1]—a darker region on the back of many species of dolphins and small whales, generally with a distinct margin

Cape[2]—a point or head of land (e.g., a peninsula) projecting into a body of water (e.g., Cape Hatteras or Cape Lookout)

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

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

Carbonate—type of rock or sediment formed of carbonate (CO3-2) and another elements such as calcium or magnesium; limestone and dolomite are common carbonate rocks

Carnivore—an animal that feeds exclusively on another animal's tissue

Cell size—the length and width of a raster cell in map units

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

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

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—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 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 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

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

Coral reef—a massive, wave-resistant structure built largely by colonial, stony coral via deposition of calcium carbonate

Coriolis effect (or force)—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 (see also centripetal acceleration or 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

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 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

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

Decompression sickness—disease occurring as a result of release of nitrogen bubbles in tissue upon too rapid ascent after time spent in high pressure environments, such as encountered by deep-diving marine mammals

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

Deepsea 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

Delimitation—fixing a boundary

Delta—fan-shaped deposit of sediments such as sand and clay that is formed at the mouth of a river

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

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

Distinct Population Segment—distinct population segment, as defined by NMFS, is a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species

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 interannual 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 the low-tide line outwards to 200 NM (except for those that are close together, i.e., Mediterranean countries) in which the inner boundary of that zone is a line coterminous with the seaward boundary of each of the coastal states; the country has the power to manage all natural resources

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

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

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

Gas embolism—the sudden obstruction of a blood vessel by an obstruction, such as a gas bubble

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

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

Gulf of Mexico—a semi-enclosed body of water that opens into the Atlantic Ocean and Caribbean Sea; is bordered by the southern United States, eastern Mexico, and Cuba

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—the living place of an organism or community of organisms that is characterized by its physical or living properties

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

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—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

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

Hatchling—a newly hatched bird, amphibian, fish, or reptile; in reference to sea turtles, recently hatched individuals still dependent upon the internalized yolk sac for nutrients

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

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

Ichthyofauna—all fish that live in a particular area

Ichthyoplankton—fish eggs and larvae drifting in the water column

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

Infrasonic—sound at frequencies too low to be audible to humans, generally below 20 Hz

Inshore—lying close to the shore or coast

In situ—in the natural or original position

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

Irregular bottom features—the GMFMC defines these features as live bottom, coral reefs, geologic features, and artificial reefs (i.e., shipwrecks, artificial reefs, and oil and gas platforms)

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*)

Kriging—geostatistical interpolation method derived from statistical models that weight the measured values in relation to unknown values to derive a prediction for an unmeasured location

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

Littoral—the zone or division of the ocean bottom that lies between the high and low tide lines; intertidal

Live bottom community—a concentration of benthic invertebrates and demersal fishes that is associated with a region of vertical relief and structural complexity that can be organic (e.g., coral skeletons) and inorganic (e.g., rocks) in origin; such oasis-like communities are often surrounded by expanses of bottom with little relief or structure

Longline—a type of fishing gear using a buoyed line onto which are attached numerous branch lines each terminating in a baited hook; longlines may extend for tens of kilometers and are usually left to drift in surface waters or near the seafloor

Lost year—the early juvenile stage (first years of life) of most sea turtle species that is spent far offshore; few turtles are observed during this time

Lower jaw fork length—longest distance from tip of lower jaw to midline of the tail fin; used to measure billfish

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)

Macro algae—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 (MMA)—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 (MPA)—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

Mesoplodont—any member of the beaked whale genus *Mesoplodon*

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

Mid Atlantic Bight (MAB)—that part of the ocean coastal region extending from Cape Cod, Massachusetts to Cape Hatteras, North Carolina

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

Morphology—the form and structure of an organism considered as a whole; appearance

Morphometric—the study of comparative morphological measurements

Mysticeti—suborder of cetaceans comprised of the baleen whales

Natal beach—original beach of birth for a sea turtle, to which many adult species return to for nesting

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—the part of the Atlantic Ocean found north of the Equator

North Atlantic Oscillation (NAO)—the climatic phenomenon, one phase of which leads 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 can lead to mild, rainy weather in Europe while causing cold, dry weather in the northeastern U.S. and Canada

North Atlantic Oscillation (NAO) Index—the difference of sea-level atmospheric pressure between two stations situated over Iceland and the Azores

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. A single occurrence record may represent multiple individuals

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 or air 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

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

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

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

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

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—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

Pelagic longline—a longline suspended by floats in the water column (i.e., not fixed or in contact with the ocean bottom)

Pelecypod—marine or freshwater mollusks having a soft body with platelike gills enclosed within two hinged shells

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)

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

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"

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

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

Rostrum—the snout or beak of a cetacean; in fish, a forward projection of the snout

Saddle—a light-colored patch behind the dorsal fin of some cetaceans

Salinity—the concentration of 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

Sexual maturity—age when animals first produce eggs or viable sperm

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

South Atlantic Bight (SAB)—that part of the ocean coastal region extending from Cape Hatteras, North Carolina south to Cape Canaveral, Floirda

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—a population or series of populations of organisms that can interbreed freely with each other but not with members of the other species

Species diversity—the number of different species in a given area

Species of concern—identifies species about which NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA

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 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 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 fishes—species that tolerate a minimum water temperature between 10º to 20ºC

Subtropical—the regions lying between the tropical and temperate latitudes

Surface-active—behaviors of whale groups performed at the surface

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

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

Thickets—dense growth of *Oculina* colonies

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

Tombolo—a sandbar that connects an island to the mainland or to another island

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 or marine mammal's snout lengthwise to the outermost portion of the tail fin, or the notch between the flukes for cetaceans

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 chain

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

Tropical fishes—species that prefer a water temperature of 20ºC or above

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 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

Weaning—age at which offspring first ingest a food source other than mother's milk

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

Zoogeography—the geographic distribution of animal species

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

APPENDIX A: DATA SOURCES

List of Tables

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Appendix A-1. Data confidence and geographic information systems (GIS).

The level of data confidence is dependent upon three factors: precision, accuracy, and currency. Each of these three factors is affected by all the variables involved in obtaining the data and putting them into a GIS to display the data on a map. The following is a brief description of the three main factors and some of the variables that affect the 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 geographic locations.
- ***Accuracy***—Refers to how well the data reflect reality. There may be 10 sightings of harbor porpoises in an area, but the sightings may actually have been of 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. Recent developments in equipment and methods have improved precision and accuracy in data collection, resulting in higher confidence for data that have been recorded more recently.

Appendix A-2. Map projections.

Understanding the role map projections play in the creation of valid and usable maps is critical. 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 coordinates (in 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 upon at 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 this MRA are in geographic coordinates, the map figures should not be used for measurement as 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 all known research efforts that provide occurrence information for marine mammals and sea turtles in the Virginia Capes OPAREA.

The following is a review of the federal, state, non-profit, and academic research efforts from which marine mammal and sea turtle data were pulled to describe occurrence patterns in the VACAPES OPAREA. For a variety of reasons, it was not possible to obtain data from every known source; all sighting, stranding, incidental fisheries bycatch, and tagging data available were included in this MRA report (Table A-1). The aerial coverage of the shipboard and aerial surveys included in this report are shown in Figures A-1 through A-4. Data that were used to generate the SPUE surfaces are denoted by a double asterisk (**).

For a brief description of how aerial and shipboard surveys are conducted, see Henwood and Epperly (1999) or Forney (2002). 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(s) sighted while the observation platform (e.g., ship or plane) is traveling along the transect line (and observers are actively searching for animals) is "on-effort" and is included in the abundance estimation. Any animal or group sighted while the observation platform is diverted from the transect line is recorded as "off-effort." Sightings made while the plane or ship is in transit to and from the actual survey transect line(s) are also considered off-effort. While off-effort sightings may not be used for abundance estimates, these sightings are useful in providing more information on the occurrence patterns of a species.

<u>**National Marine Fisheries Service (NMFS) Shipboard Surveys**</u>

- The **R/V *Chapman*** was used to conduct marine mammal sighting surveys from **5 August to 18 August 1990 (Cruise CH 90-05) and 8 June to 16 July 1991 (Cruise 91-03)** in the shelf-break waters from Cape Hatteras to Georges Bank (NMFS-NEFSC 1990; Waring 1998; Waring et al. 1992; Waring et al. 2002). The objectives of these cruises were: (1) to investigate the fine scale distribution and habitat use of marine mammals in such physiographic or oceanographic features such as warm-core rings, submarine canyons, and the continental shelf edge; (2) to determine if the distribution of marine mammals is continuous between major canyons and the north wall of the Gulf Stream; (3) to conduct line transect population surveys along the shelf edge and out to the Gulf Stream; and (4) to determine how the variation in species composition is correlated with oceanographic features. The second *Chapman* cruise represents the first NMFS systematic survey of marine mammals in shelf edge (break) waters off the northeastern U.S. (Waring 1998).

- **The *R/V* ***Pelican*** **Cruise PE-95-01** was a marine mammal sighting survey in slope waters from Chesapeake Bay, Virginia to Cape Cod, Massachusetts between 10 NM inshore of the 50 fathom contour (92 m) and 10 NM offshore of the 1,000 fathom contour (1,830 m), conducted from **9 July to 3 August 1995** (NMFS-NEFSC 1995b). The objectives of this leg of the survey were to: (1) determine the spatial distribution and estimate the abundance of marine mammals in the study area; and (2) determine if spatial distribution patterns of marine mammals are correlated with hydrographic features, such as, water depth, temperature or salinity, or with biological features, such as zooplankton distribution.

  The *R/V* ***Abel-J* **Cruise AJ 95-01** was a marine mammal sighting survey in the Gulf Stream and slope waters between Chesapeake Bay and southern New England conducted from **9 July to 2 August 1995** (NMFS-NEFSC 1995a). The objectives of the survey were to: (1) conduct line-transect population surveys within the study area; (2) investigate cetacean distribution along the Gulf Stream; (3) determine if the distribution of cetaceans, principally species designed as "strategic" (i.e., beaked whales, pilot whales) in stock assessment reports, is continuous in Gulf Stream and slope water habitats; (4) collect information on the relationship between cetaceans and oceanographic features; and (5) collect biopsy samples for stock identification and contaminant studies.

Table A-1. Data sources for marine mammal and sea turtle occurrence records that are included in the Virginia Capes OPAREA MRA. Data used to generate the SPUE surfaces are denoted by a double asterisk (**).

Data	Year(s)
Shipboard Sighting Surveys	
NMFS-NEFSC R/V *Chapman* Cruise CH 90-05	1990
NMFS-NEFSC R/V *Chapman* Cruise CH 91-03	1991
**NMFS-NEFSC R/V *Pelican* Cruise PE-95-01	1995
**NMFS-NEFSC R/V *Abel-J* Cruise AJ-95-01	1995
**NMFS-NEFSC R/V *Delaware* II Cruise DE 97-05	1997
**NMFS-NEFSC R/V *Delaware* II Cruise DE 98-04	1998
NMFS-NEFSC R/V *Abel-J* Cruise AJ 98-01	1998
NMFS-NEFSC R/V *Endeavor* Cruise EN 04-395	2004
**NMFS-SEFSC R/V *Relentless* Cruise 98-01 (3)	1998
**NMFS-SEFSC R/V *Oregon* II Cruise 99-05 (236)	1999
**NMFS-SEFSC R/V *Gordon Gunter* Cruise GU-02-01 (Mid-Atlantic Cetacean Survey)	2002
**NMFS-SEFSC R/V *Gordon Gunter* Cruise GU-04-03 (028)	2004
**NMFS-SEFSC R/V *Gordon Gunter* Cruise GU-05-03	2005
Virginia Aquarium MONAH Surveys	2004; 2007
North Atlantic Right Whale Consortium (NARWC) Database	1762-2001
**CETAP Shipboard Survey	1978-1982
Aerial Sighting Surveys	
**NMFS-SEFSC Southeast Cetacean Aerial Surveys (SECAS)	1992
DoN SEAWOLF Shock Trial	1995
University of North Carolina at Wilmington (UNCW) – Wallops Island Aerial Survey	1998-1999
**NMFS-SEFSC Mid-Atlantic *Tursiops* Surveys (MATS)	1995; 2002; 2004-2005
**NMFS-NEFSC SAS Right Whale Aerial Survey	2002
North Atlantic Right Whale Consortium (NARWC) Database	1762-2001
**NMFS-NEFSC Twin Otter Aerial Survey	1995-1998;2004
**UNCW—Onslow Bay	1998-1999
**CETAP Aerial Survey	1978-1981
**NMFS-NEFSC Experimental Aerial Survey	1991
**UNCW Aerial Surveys	2001-2002; 2005-2008
Miscellaneous Opportunistic Sightings	n/a

Table A-1. Data sources for marine mammal and sea turtle occurrence records that are included in the Virginia Capes OPAREA MRA. Data used to generate the SPUE surfaces are denoted by a double asterisk (**) (cont'd).

Incidental Fisheries Bycatch	
NMFS-NEFSC Fishery Bycatch (all fisheries)	1989-2004
NMFS-SEFSC Fishery Bycatch (only longline fishery)	1992-2004
Strandings	
NMFS-NER Marine Mammal Stranding Data	2004
Sea Turtle Stranding and Salvage Network	1980-1994
Mixed/Miscellaneous	
NMFS-NEFSC SAS Sightings (opportunistic)	1996-2004
NMFS-NEFSC Sea Turtle Mapping and Information System	1963-1998
NMFS-SEFSC Sea Turtle Sighting Program	1988-2001
Patteson Opportunistic Beaked Whale Sightings	2007
Published Literature and Reports	
Fertl et al.	2003
Katona et al.	1988
Parker	1995
Read et al.	1996
Read et al.	2003
Reeves and Mitchell	1988
Schwartz	1995
Wilson et al.	1987

- **The *R/V* ***Delaware*** **Cruise DE-97-05** was a mid-Atlantic marine mammal distribution survey, from Long Island Sound to just south of Cape Hatteras, North Carolina conducted from **5 March to 19 March 1997** (NMFS-NEFSC 1997a). The objectives of this survey were to: (1) determine the spatial distribution and relative abundance of harbor porpoises and bottlenose dolphins in the mid-Atlantic region; (2) obtain biopsy samples of bottlenose dolphins and other strategic stocks to determine stock boundaries of the stocks; (3) determine the spatial distribution of other cetacean species; and (4) compare the distribution of cetaceans with their age composition, depth contours, water temperature, observed fishing vessels, and acoustic imagery.
- **The **R/V *Delaware* Cruise DE-98-04** was a mid-Atlantic marine mammal distribution survey, from Long Island Sound to just south of Cape Lookout, North Carolina, conducted from **9 March to 27 March 1998** (NMFS-NEFSC 1998b). The objectives of this survey were to: (1) determine the spatial distribution and relative abundance of harbor porpoises and bottlenose dolphins in the mid-Atlantic region; (2) obtain biopsy samples of bottlenose dolphins and other strategic stocks to determine stock boundaries of the stocks; (3) determine the spatial distribution of other cetacean species; and (4) compare the distribution of cetaceans with their age composition, depth contours, water temperature, and observed fishing vessels.
- The ***Abel-J* Cruises AJ 98-01** was a cetacean abundance survey conducted from **6 July to 4 August 1998** (NMFS-NEFSC 1998a). Leg I was from 6 July to 4 August 1998 and conducted from Cape Cod to Virginia. Leg II was from 8 August to 6 September 1998 and conducted from Cape Cod

to Halifax, Nova Scotia. Both study areas extended from the 100 m depth contour to the Gulf Stream. Only Leg I took place in the VACAPES OPAREA. The objectives of the surveys were to: (1) estimate the abundance of strategic species of pelagic dolphins and whales, such as, common, spotted and bottlenose dolphins, and sperm, pilot, and beaked whales, and (2) estimate the abundance of all other dolphins and whales detected in these waters.

- The NMFS-NEFSC conducted a survey aboard the **R/V *Endeavor*** of marine mammals and sea turtles in mid-Atlantic waters from Virginia to Cape Cod, Massachusetts during the summer of **2004** (NMFS-NEFSC 2004a). The survey area included waters seaward of the 100 m isobath to the Gulf Stream. The cruise took place in two legs; the first leg ran from **23 June to 12 July** and the second from **16 July to 04 August**. The objectives of the survey were to: (1) determine the distribution and abundance of marine mammals, sea turtles, and seabirds in mid-Atlantic waters; (2) use acoustic monitoring to assist in determining the abundance of cetaceans in the study area; and (3) identify the oceanographic and biological parameters associated with the distribution of these species.
- **From **8 July to 17 August 1998**, the ***Relentless* (Cruise 98-01)** was a survey to gain abundance, distribution, and stock structure information on cetaceans in the North Atlantic between Maryland and central Florida from the 10 m isobath to the boundary of the EEZ (Mullin 1999). The objective of the survey was to estimate the abundance of cetaceans in U.S. Atlantic waters south of Maryland.
- **From **4 August to 30 September 1999**, the ***Oregon II* (Cruise 236; 99-05)** surveyed for abundance, distribution, and stock structure of cetaceans in southeastern U.S. Atlantic waters (NMFS-SEFSC 1999a). The cruise consisted of three legs of effort conducted between 10 m of water depth to 185 km offshore from Cape Canaveral, Florida, north to the Delaware Bay. The objectives of this surveys were to: (1) obtain minimum abundance estimate for calculating Potential Biological Removal for each species; (2) collect biopsy tissue samples to evaluate stock structure; (3) establish and build time-series databases for monitoring trends in abundance; (4) examine distribution in relation to physiographic and oceanographic features; and (5) obtain photographs and video images of selected species for photo-identification studies.
- **The ***Gordon Gunter* Cruise GU-02-01** took place from **10 February to 8 April 2002**. This survey covered the continental shelf and inner continental slope of the U.S. Atlantic from Cape Canaveral, FL to Delaware Bay (NMFS-SEFSC 2002c). The cruise, requested by the Navy, had the following objectives: (1) conduct a visual line-transect survey of the mid-Atlantic to determine distribution and abundance of marine mammals; (2) conduct a passive acoustic survey using sonobuoys and two- and five-element towed hydrophone arrays; (3) obtain biopsy samples of skin and blubber from selected cetacean species; (4) obtain photographs of selected cetacean species for photo-identification studies; (5) collect data on distribution and abundance of sea turtles, seabirds, and other marine life; and (6) collect associated environmental data.
- **The ***Gordon Gunter* Cruise GU-04-03 (028)** took place from **22 June to 19 August 2004** (NMFS-SEFSC 2004a). Line-transect surveys occurred in the waters from the 50 m isobath seaward to the EEZ from the Maryland/Delaware border south to southern Florida (NMFS-SEFSC 2004a). 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 2004a). The specific objectives of this survey were to: (1) conduct visual line-transect surveys for cetacean abundance and distribution estimations; (2) conduct passive hydro-acoustic surveys concurrent with visual detection efforts; (3) collect biopsy samples; (4) conduct photo-identification on cetaceans; (5) collect data on sea turtle and sea bird distribution and abundances, and (5) collect oceanographic and environmental information to aid in quantifying the degree to which fishes and zooplankton contribute to acoustic backscatter (NMFS-SEFSC 2004a).
- **The ***Gordon Gunter* Cruise GU-05-03 (062)** took place from **14 June to 16 August 2005**. The primary objective of this cruise was to collect tissue samples of bottlenose dolphins and pilot whales to assess their population structure in the mid-Atlantic Ocean (NMFS-SEFSC 2005a). Study area and specific objectives for line-transect surveys varied by cruise leg. The first leg of the cruise focused survey effort on the continental shelf between Florida and South Carolina and collected biopsy samples from nearshore and offshore bottlenose dolphins. The second leg covered the mid-Atlantic

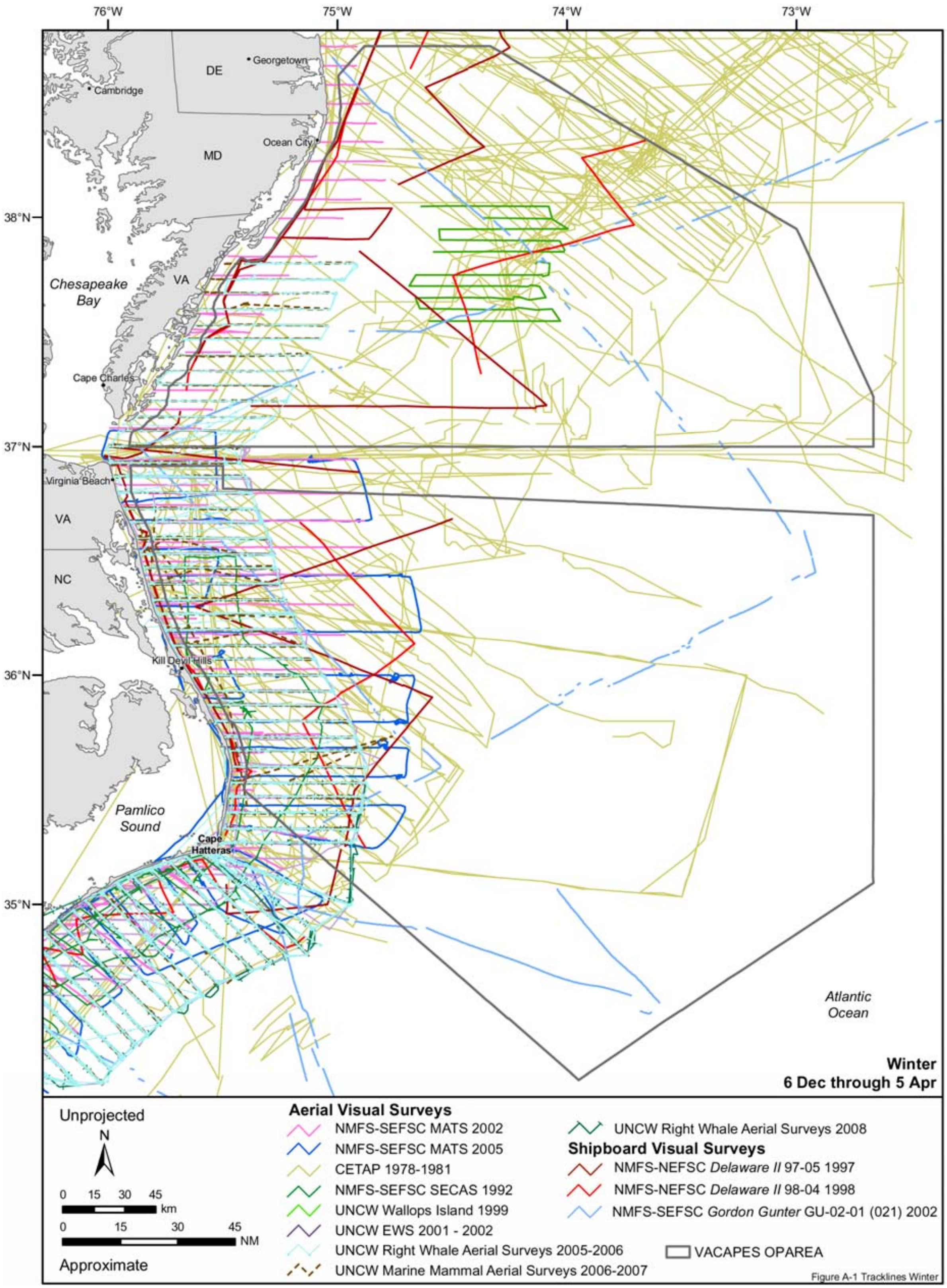

Figure A-1. Tracklines and transect coordinates for aerial and shipboard visual surveys in the Virginia Capes OPAREA during the winter season. Source data: NMFS-NEFSC (1992, 1997b, 1998c); NMFS-SEFSC (1992b, 2002a, 2002b, 2005b); URI (1981, 1992). Source map (scanned): UNCW (1999).

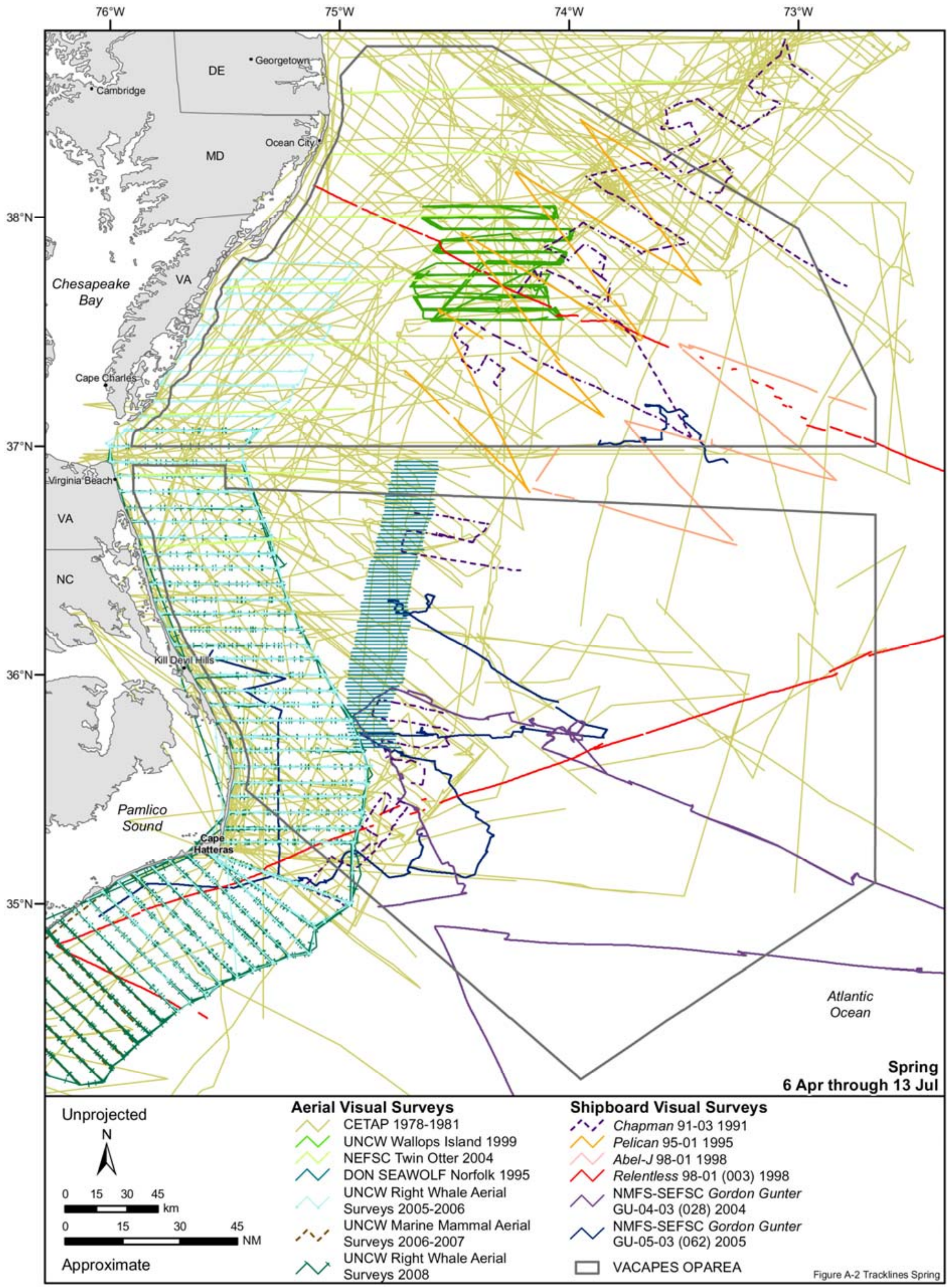

Figure A- 2. Tracklines and transect coordinates for aerial and shipboard visual surveys in the Virginia Capes OPAREA during the spring season. Source data: NMFS-NEFSC (1995c, 1995d, 1998d, 2004b, 2004c); NMFS-SEFSC (1995, 1998, 2002b, 2004b, 2005c); URI (1981). Source map (scanned): UNCW (1999).

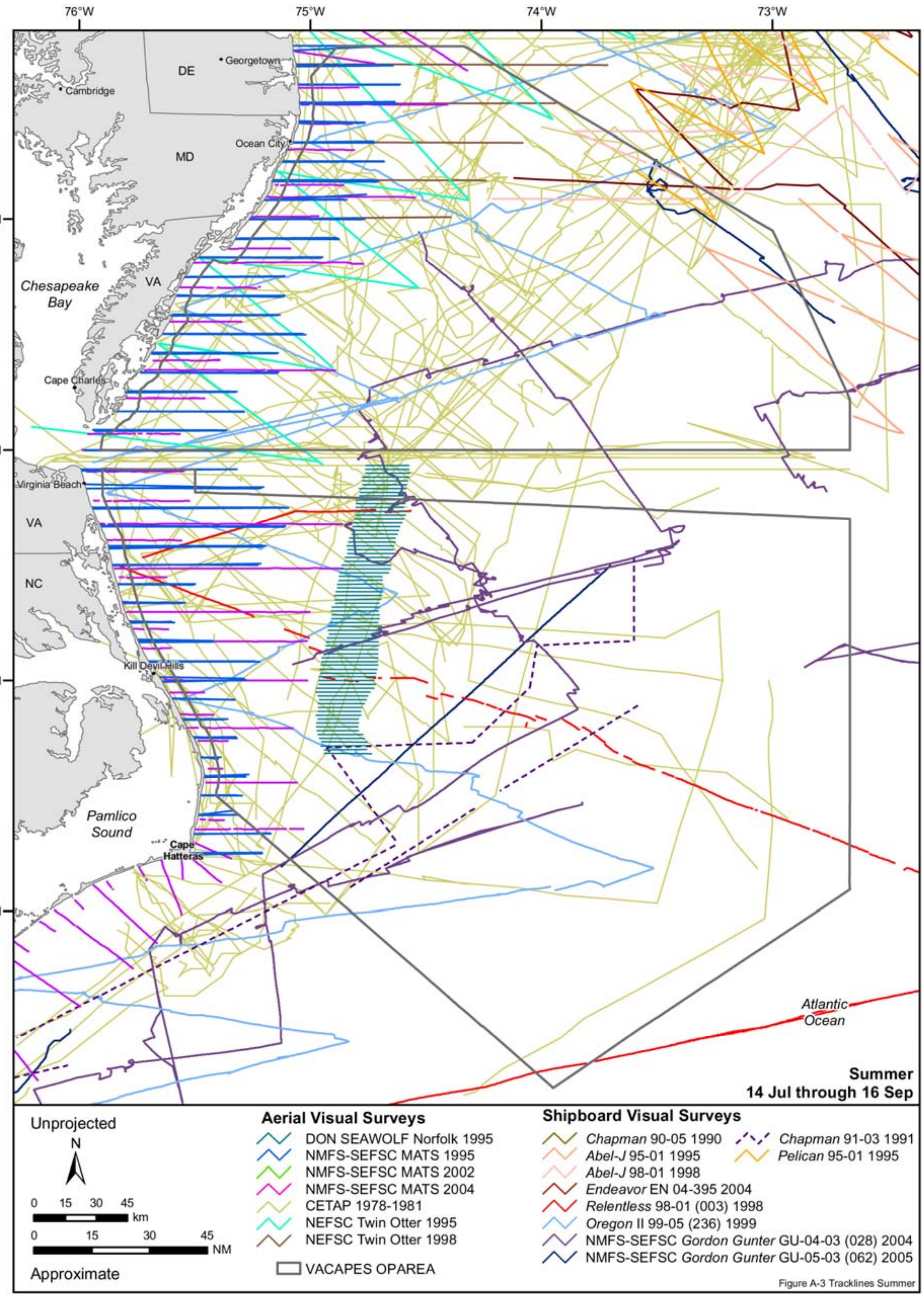

Figure A- 3. Tracklines and transect coordinates for aerial and shipboard visual surveys in the Virginia Capes OPAREA during the summer season. Source data: NMFS-NEFSC (1995c, 1995d, 1995e, 1998d, 1998e, 2004c); NMFS-SEFSC (1995, 1998, 1999b, 2002a, 2004b, 2005c), URI (1981).

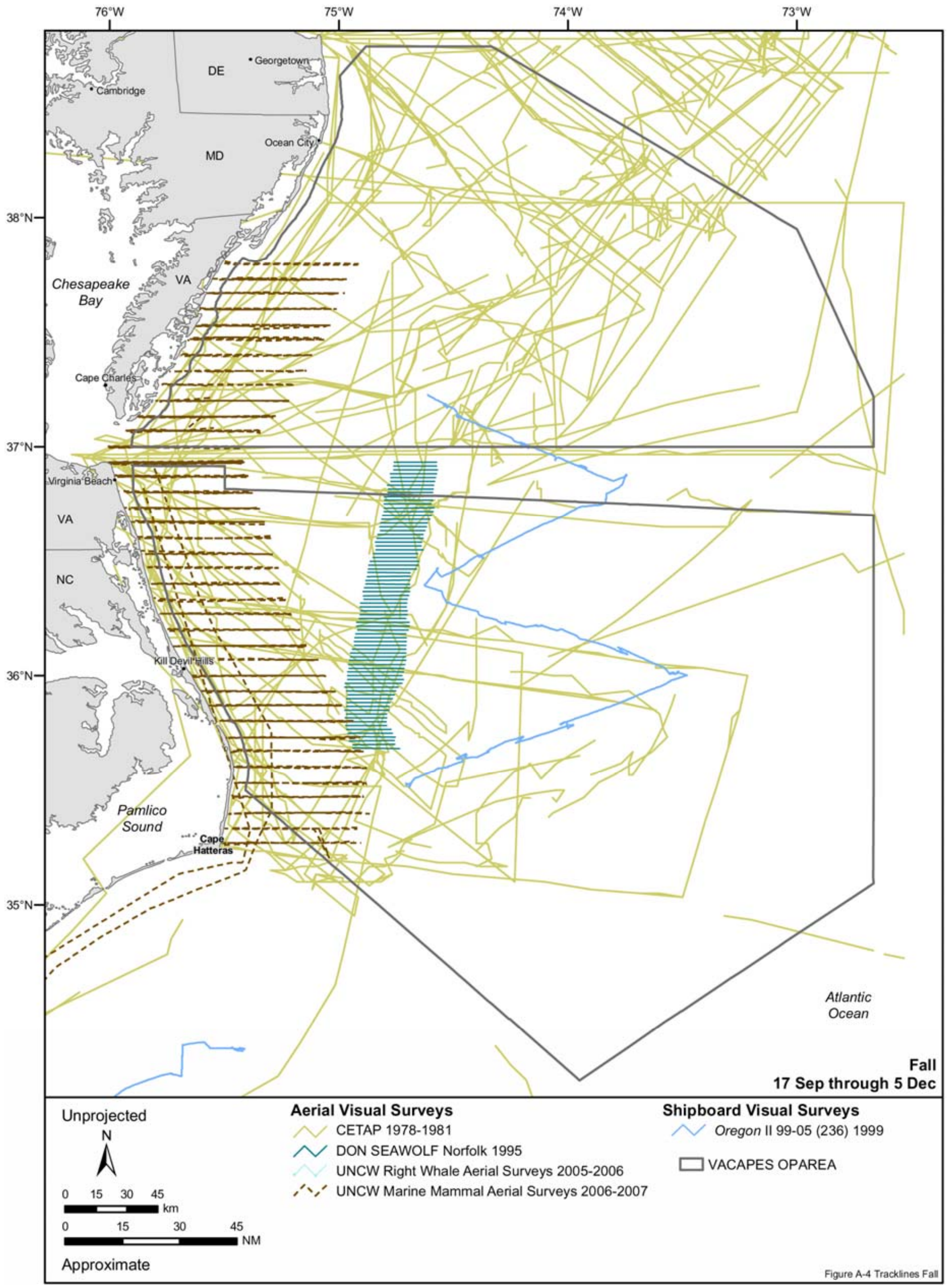

Figure A- 4. Tracklines and transect coordinates for aerial and shipboard visual surveys in the Virginia Capes OPAREA during the fall season. Source data: NMFS-SEFSC (1999b); URI (1981). Source map (scanned): UNCW (1999).

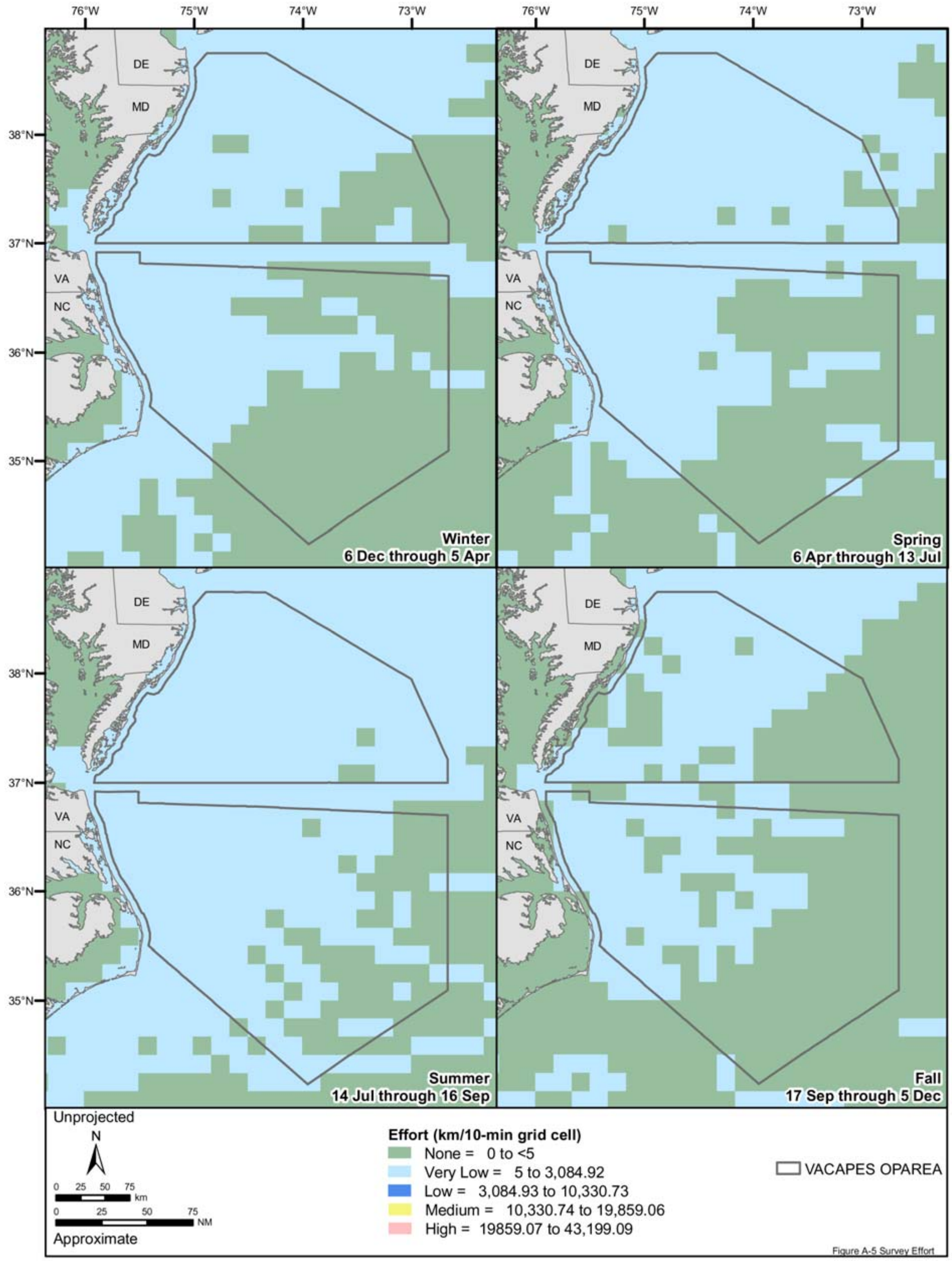

Figure A- 5. Grid cells (10-minute^2) in which there were more than 5-km of dedicated survey effort in the Virginia Capes OPAREA. Survey effort was summed for all years of dedicated survey data in each grid cell; the summed effort was used in the derivation of sightings-per-unit-effort values for each grid cell. Source data: refer to Table A-1.

Bight along the shelf break and collected biopsy samples from pilot whales. The third leg concentrated on areas along and inshore of the shelf break, from approximately Cape Fear, NC to Fort Pierce, FL with the purpose of observing and tagging nearshore and offshore bottlenose dolphins (NMFS-SEFSC 2005a).

NMFS Aerial Surveys

- ******The **Southeast Cetacean Aerial Surveys (SECAS)** were conducted during **1992 and 1995** by the NMFS-SEFSC. The purpose of these surveys was to estimate cetacean abundance in the region. Sightings of sea turtles and fishes were also recorded. Survey results provided an index of the abundance for the coastal bottlenose dolphin population, which had a significant die-off in 1987. SECAS '92 was a survey of the U.S. Atlantic coast from Cape Hatteras, NC to Key West, FL conducted during **January to March 1992** (NMFS-SEFSC 1992a). Transects extended from shore to approximately 9.25 km past the western wall of the Gulf Stream into waters as deep as 140 m (Blaylock & Hoggard 1994). Data from SECAS '95 were not used in this report.
- ******The NMFS-SEFSC initiated the **Mid-Atlantic *Tursiops* Surveys (MATS)** in 1994. MATS were conducted during the 1994 and 1995 seasons. They resumed again in 2002 and were conducted during the winter **(15 January to 28 February 2002)** and summer **(15 July to 31 August 2002)**. The MATS Winter 2002 survey spanned the region from the Georgia/Florida state line to southern Delaware Bay (Waring et al. 2006). MATS Summer 2002 extended the study area north and south to cover waters between Sandy Hook, NJ and Vero Beach, FL (Hoggard 2002; Waring et al. 2006). Surveys were flown perpendicular to shore, covering coastal waters out to the 40 m isobath (Waring et al. 2006). The primary objective was to compare bottlenose dolphin seasonal distribution and abundance estimates (Garrison et al. 2003; Hoggard 2002). Another purpose was to update the MATS 1995 abundance estimates based upon the stock structure of seasonal management units (Garrison et al. 2003). Data from 1994 and 1995 are not included in this report.
- ****MATS** for the **2004/2005** season took place in the summer **(16 July and 31 August 2004)** (Fertl & Fulling 2007) and winter **(30 January to 09 March 2005)** (Mullin 2004). The survey area during the summer included waters from Sandy Hook, NJ south to Cape Canaveral, FL. The MATS Winter 2005 surveys were conducted in waters from the southern eastern shore of Virginia south to Cape Canaveral, FL and out to the 40 m isobath. The specific objectives of the 2004/2005 MATS were to delineate bottlenose dolphin seasonal distribution and abundance.
- ******Since 1996, the **NMFS Northeast Fishery Science Center (NMFS-NEFSC)** has operated a sighting advisory system (SAS) to inform commercial and recreational vessel traffic of the presence of North Atlantic right whales from **January to July** in the waters off the northeastern U.S. (NMFS-NEFSC 2008). Aerial and shipboard surveys take place within the critical habitat areas in Cape Cod Bay and the Great South Channel. Opportunistic sighting information is also provided to the SAS by other organizations, including state, federal, and non-profit organizations (NMFS-NEFSC 2008). The information from the SAS is processed and managed, and disseminated to mariners by the NMFS. Sightings information is also incorporated into the NARWC database. SAS aerial survey and opportunistic sightings from **2001 to 2005** are included in this report. Opportunistic sightings were not used to generate the SPUE surfaces.

North Atlantic Right Whale Consortium Database

In 1986, a cooperative research program, the **North Atlantic Right Whale Consortium (NARWC)**, was initiated to focus on North Atlantic right whales (Kenney 2001). Every organization and agency conducting right whale surveys submits their data for inclusion in this database, which is supported by NMFS. The database contains over 20,000 sightings of right whales, as well as more than 70 other species including other whales, dolphins, seals, manatees, sea turtles, sharks, rays, and other fishes–214,000 sightings in total (Kenney 2001). Most of the sightings are between FL and Nova Scotia. The NARWC also attempts to include any other marine mammal survey data for the Atlantic U.S., which means there are sighting data within, as well as outside, of the boundaries of the VACAPES OPAREA. Effort sources are either dedicated or opportunistic (IWC 2001). Opportunistic sightings are those coming from observers on aircraft and vessels of opportunity (such as the U.S. Coast Guard [USCG] and NMFS shipboard and aerial surveys). Listed below are the majority of data sources within the NARWC database that provide data for the VACAPES OPAREA. Descriptions of data provided by the NARWC database but resulting from studies sponsored by NMFS or the Department of the Navy (DoN) are included in other sections. Dedicated or directed aerial surveys for right whales have only been conducted since the early 1980s (DoN 1996).

- **During the summers of **1995, 1998**, and **2004** the NMFS-NEFSC conducted aerial (DeHavilland Twin Otter) line-transect surveys to estimate cetacean abundance off the mid-Atlantic coast. These surveys were flown **05 August to 17 September 1995**; **18 July through 21 August 1998;** and **13 June to 12 July 2004** (Palka et al. 2001). The surveys were flown from the Gulf of St. Lawrence south to Virgina.
- During **September 1998 through October 1999**, the **University of North Carolina – Wilmington (UNCW)**, in cooperation with **TAMS Consultants**, conducted aerial surveys at two offshore sites located off Wallops Island, VA and off Onslow Bay, NC (McLellan et al. 1999). The purpose of the surveys was to determine the best location to install a Naval underwater range. The objectives of the UNCW survey were to: 1) determine spatial distribution of marine mammals and sea turtles at the survey sites; 2) to provide data to compare species distribution and relative abundance between the survey sites: and 3) to collect age and behavior data as well as photographic records of animals.
- **The **Cetacean and Turtle Assessment Program (CETAP)** was initiated by the University of Rhode Island, with support from the Bureau of Land Management (Scott & Gilbert 1982). The study took place from **October 1978 to January 1982**. CETAP used both aerial surveys and shipboard observers to collect data on cetaceans and sea turtles in outer continental shelf waters between Cape Hatteras, NC, and Nova Scotia. The study area ran from the shore out to 5NM seaward of the 2,000 m isobath. The objectives of CETAP were: (1) to determine the species composition of cetaceans and sea turtles in the mid and North Atlantic region; (2) to identify and describe geographic areas important to the life history of cetaceans and turtles in the region; (3) to determine the distribution in space and time of cetaceans and sea turtles in the region; (4) to make behavioral observations of cetaceans and sea turtles in the region; (5) to determine population size and extent in this region; and (6) to focus on describing these characteristics for threatened and endangered species in the region (Scott & Gilbert 1982). Data from CETAP included in this report come from both aerial and shipboard platforms. CETAP opportunistic sightings were not used to generate the SPUE surfaces.
- **The **UNCW** conducted seven aerial surveys from **27 January through 08 February 2000** to investigate right whale occurrence north of the Florida and Georgia calving grounds. Surveys were conducted off the coast of North Carolina and South Carolina (Martin et al. 2001), spanning from Savannah, GA to Cape Lookout, NC. Transects were spaced 4 nm apart and ranged 30 nm from shore (Martin et al. 2001). In 2001 and 2002, these tracklines were extended north to Chesapeake Bay (McLellan et al. 2001; Neuhauser 2002). Aerial surveys took place from **06 February to 02 March 2001** and **22 January to 19 March 2002** (McLellan et al. 2001; McLellan et al. 2002). These surveys were sponsored by the NMFS-SEFSC, but the data were provided for this report through the NARWC database. Data from 2001 and 2002 are included in this report. From **October 2005 to April 2006** and **December 2006 to May 2007**, UNCW conducted right whale aerial surveys from the South Carolina/North Carolina border to the southern end of Assateague Island, Virginia. Additional surveys were flown from South Carolina/North Carolina border, across the Chesapeake Bay mouth, and to the southern tip of Cape Charles, Virginia during **February to June 2008**. Data from these 2005-2008 surveys are included in this report.
- **Opportunistic sightings** from commercial vessels, private pleasure craft, fishing vessels, Navy vessels and aircraft, harbor pilots, volunteer networks, and the general public are reported to various Georgia and Florida state agencies and are all forwarded to the New England Aquarium (NEA) for incorporation into the NARWC (Kraus et al. 1993). Since 1994, the Marine Resources Council of East Florida has coordinated a network of volunteer spotters, living in high-rise condos beachside, which report right whale sightings (DoN 1996). Sighting logs are also maintained by the Navy (DoN 1996). The following organizations/programs provided to the NARWC database the opportunistic sightings included in this report: CETAP, DoN CSA aerial survey, FACSFACJAX, FMRI, NEA, NMFS-NEFSC, URI, Wildlife Trust, and PIROP.

NMFS Fisheries Bycatch

- NMFS-NEFSC directs the observer program for fisheries operating in the north Atlantic off the northeastern seaboard of the U.S. Effort in these fisheries has been primarily directed towards Atlantic mackerel and squid fisheries. Observers routinely record the number of marine mammals and sea turtles taken incidentally by fishing activities. Observers are required to complete sighting forms, document the circumstances of capture and obtain biological data (e.g., measurements) on incidentally captured marine mammals and sea turtles. Bycatch data from **1989 to 2004** were provided by the **NMFS-NEFSC** and are included in this report.
- The **Pelagic Longline Observer Program** began in **1992**, when systematic sampling by scientific observers on board U.S. pelagic longline vessels (permitted to land and sell swordfish) was mandated by the 1991 amendments to the U.S. Fishery Management Plan for Swordfish (Yeung 1999). Since October 1995, the NMFS-SEFSC has had sole responsibility for implementation and data management of the observer program for the entire Atlantic longline fishery (previously, responsibility was vested in the NMFS-NEFSC as well) (Yeung 1999). The focus of the Observer Program is 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 and sailfish), sea turtles, marine mammals, and other nontarget species by pelagic longline gear has been a major concern for several years. The program's mission is collect data on effort, directed catch and bycatch quantity, morphometrics, biological characteristics, and the interaction of the fishery with marine mammals, sea turtles, and birds. Data on bycaught species from **1992 through 2004** are included in this report.

NMFS Stranding Data

- **Marine mammal stranding networks** are under the jurisdiction of the NMFS and are nominally based on the administrative regions of NMFS; stranding oversight for the study area is vested in the NMFS-Northeast Region (Geraci & Lounsbury 1993). Wilkinson and Worthy (1999) discuss the genesis of marine mammal stranding networks in the U.S. Legal authority for the U.S. stranding response network is contained in the MMPA. Through the Marine Mammal Health and Stranding Response Act (14 U.S.C. §1421), Congress made it 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. Volunteer stranding networks were established in all coastal states, which are part of the Northeast Region Marine Mammal Stranding Network. The NMFS is responsible for cetaceans and all pinnipeds in the vicinity of the VACAPES OPAREA. Stranding data for **2004** were received from the NMFS-NER marine mammal stranding network.
- The **Sea Turtle Stranding and Salvage Network** is a network of private citizens, 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. It too is under the jurisdiction of NMFS. Sea turtle strandings along the Atlantic coast have been recorded since 1980 (Shaver & Teas 1999). The Department of Natural Resources from each state collects the data, which are then reported to the NMFS. Species, size, location, condition, and final disposition of stressed or dead turtles are recorded. Data from **1980-1994** for North Carolina were provided by NMFS-SER. Stranding data for NC were also provided by the **NMFS-NEFSC Sea Turtle Mapping and Information System**.

NMFS Multiple-Source Data

- **The Northeast Regional Office of the NMFS (NMFS-NER) undertook the development of a comprehensive geographic database for sea turtles within its jurisdiction called the **Sea Turtle Mapping and Information System (STMIS)** (NMFS 1999). The project goals included centralizing sea turtle data in the northeast region to allow for the evaluation of real-time information on commercial fisheries and sea turtle interactions for use in management decisions under Section 7 of the ESA. Three categories of information are included in this database: incidental capture in fishing gear; observations from scientific cruises and aerial surveys; and stranding databases. The geographic coverage of this database extends from the Gulf of Maine south to approximately Onslow Bay, NC. Data from 1963 to 1998 were included.

- **NMFS-SEFSC** (Joanne McNeil) provided sea turtle data from offshore North Carolina aerial surveys, tagging information collected from fishery-captured sea turtles, and data from a public sighting program. The data cover the area just north of Cape Hatteras, NC south to near Cape Canaveral, FL. NMFS-SEFSC employs two techniques to obtain public sighting data: utilization of the Marine Recreational Fishery Statistics Survey (sponsored since 1979) and voluntary reporting by the public (since 1989) (Epperly et al. 1995b). Sightings of live turtles in the Atlantic Ocean are reported during statistical survey interviews; recreational fishermen and boaters typically report inshore sightings. A limited number of fishermen from Core Sound and eastern Pamlico Sound in NC were trained to identify and tag sea turtles. Most of the cooperating fishermen used pound nets. Some fishermen were also involved in other fishing operations throughout the year and report incidental captures from those activities as well. The tagging data were collected from **June 1988 through December 1992**. Aerial surveys covered Raleigh, Onslow, and Long bays, NC during **November 1991 through March 1992** (Epperly et al. 1995a).

Navy-supported Surveys

- **Monthly aerial surveys of marine mammals and sea turtles were conducted by Continental Shelf Associates, Inc. to assist in the selection of a site for the SEAWOLF Shock Test. CSA, Inc. conducted surveys to determine the temporal and spatial distribution of marine mammals and sea turtles at the Norfolk, VA test site from **April through September 1995** (DoN 1995). The surveys occurred along the 500 foot depth contour within 100 nm of Naval Air Station Norfolk, Virginia.

Additional Projects

- In **2004** and **2007**, the **Virginia Aquarium Foundation** conducted nearshore surveys for humpback whales along the North Carolina coast. These surveys were done as a part of the NMFS More North Atlantic Humpbacks (**MONAH**) program, an assessment of populations in the North Atlantic Ocean. The 2004 survey, conducted from **1 February to 6 March**, was focused on an area off the Outer Banks, primarily in the vicinity of Oregon Inlet and Hatteras Inlet (Barco et al. 2004). The objectives of the survey were to sight humpback whales, obtain biopsy samples, and take photographs for photo-identification of individuals (Barco et al. 2004). The survey was conducted opportunistically based upon reports from other vessels in the area, the presence of birds associated with the surface, and sightings of whales by personnel onboard the survey vessel (Barco et al. 2004). In addition to humpback whales, fin whales and one North Atlantic right whale were also sighted (Barco et al. 2004). Surveys were also conducted from **10 to 14 March** in 2007. Data from the 2004 and 2007 surveys are included in this report.
- Opportunistic beaked whale sightings were made during pelagic bird-watching trips offshore of Hatteras, North Carolina between **12 May and 13 October 2007** in the waters at and seaward of the continental shelf break. These data include sightings of Cuvier's beaked whales, Gervais beaked whales, *Mesoplodon* spp., and unidentified beaked whales. Thirteen sightings of a total of 34 to 41 individuals were recorded (Patteson 2007).

Published Literature

- There are several published papers that contain data on strandings or opportunistic sightings within the VACAPES OPAREA. Papers from which data were taken for this report are summarized below.
  - Wilson et al. (1987) summarized records of the striped dolphin (*Stenella coeruleoalba*) from around the world. This summation pulled from both published and unpublished records and includes information up to 1986.
  - Katona et al. (1988) examined published and unpublished records of killer whales (*Orcinus orca*) in the North Atlantic Ocean from 1817 to 1987. These records were summarized based upon latitude and month of occurrence; Katona et al. (1988) suggest a seasonally migrating population along the east coast of the U.S. as well as a year-round population south of 35 degrees North latitude.

- Reeves and Mitchell (1988) describe the history of the shore-based whale fishery in North Carolina. A permanent shore fishery was established in the middle of the eighteenth century and lasted through until the early twentieth century. The primary target of this fishery was North Atlantic right whales migrating along the coast of North Carolina from December to May. Catches peaked between February and May. The presence of a shore-based fishery for North Atlantic right whales is indicative of the near-shore occurrence of this species. Whaling records also reflect the whales' seasonal migration.
- Parker (1995) is a record of a juvenile hawksbill turtle (*Eretmochelys imbricata*) sighted off of the southeastern U.S. 37 nautical miles from the coast of Georgia. The juvenile hawksbill was associated with floating *Sargassum*.
- Schwartz (1995) summarized occurrences of West Indian manatees (*Trichechus manatus*) in North Carolina from 1919 to 1994. Records of manatees in the OPAREA and just inshore of the OPAREA boundary are included in this report.
- Fertl et al. (2003) summarized published and unpublished records of Clymene dolphins (*Stenella clymene*) to determine range-wide distribution. The distribution of Clymene dolphins is throughout the North Atlantic Ocean, including the eastern seaboard of the U.S. north to New Jersey, including the entire study area.
- Read et al. (1996) summarized information on a harbor porpoise which was caught in a pelagic drift net off Nag's Head, North Carolina in February 1993. The authors suggest that harbor porpoises in the western North Atlantic may primarily occur in offshore waters during winter.
- Read et al. (2003) used photo-identification techniques to document and identify bottlenose dolphins (*Tursiops truncatus*) in the inshore waters of North Carolina. Most of the occurrences took place in the inshore waters north of Cape Lookout; this mark-recapture study was used to estimate the abundance of bottlenose dolphins in the bays, sounds and estuaries of North Carolina. Records from this study are included in this report.

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APPENDIX B: MARINE MAMMALS

List of Figures

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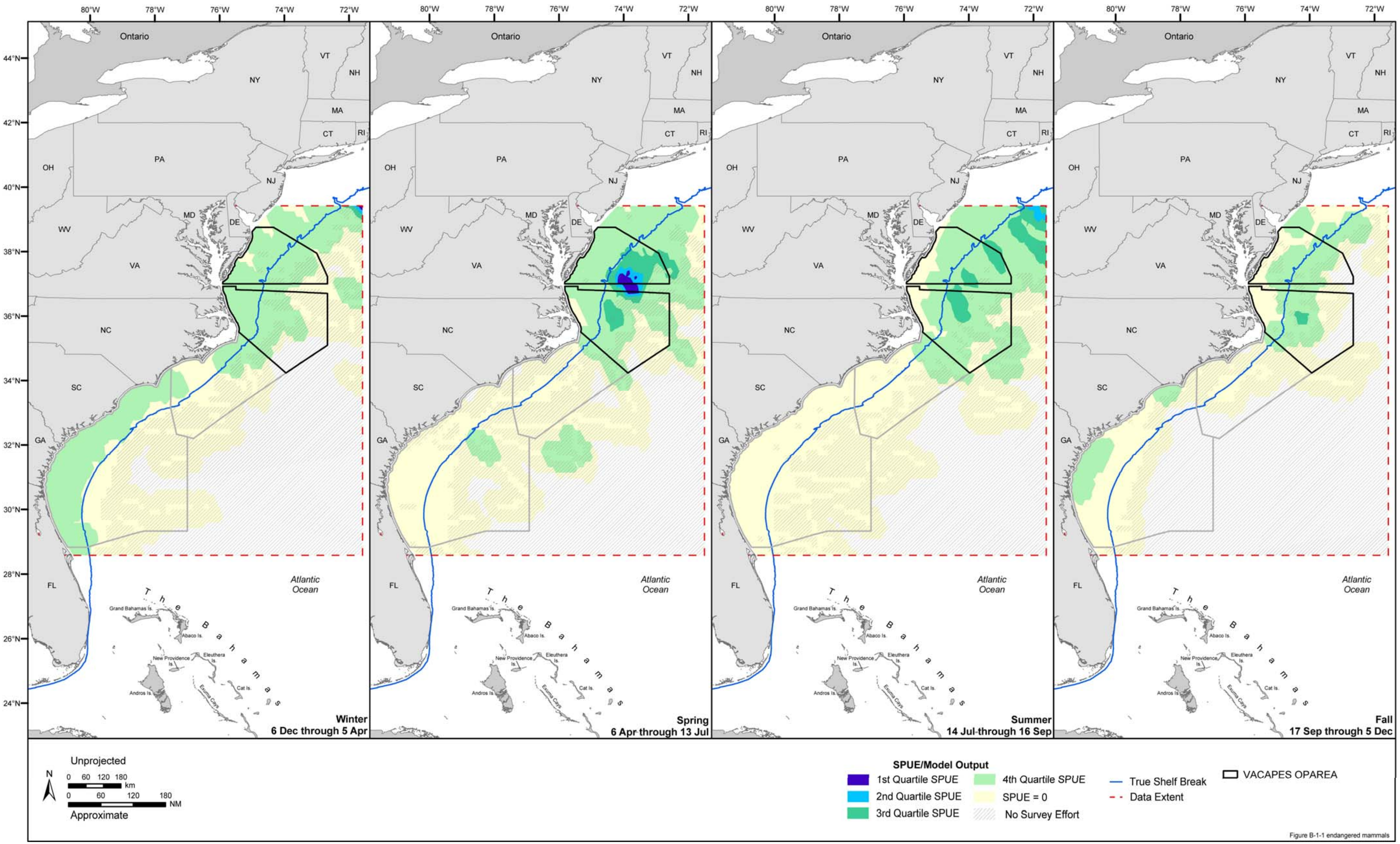

Figure B-1-1. Seasonal SPUE/model output of endangered marine mammals in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

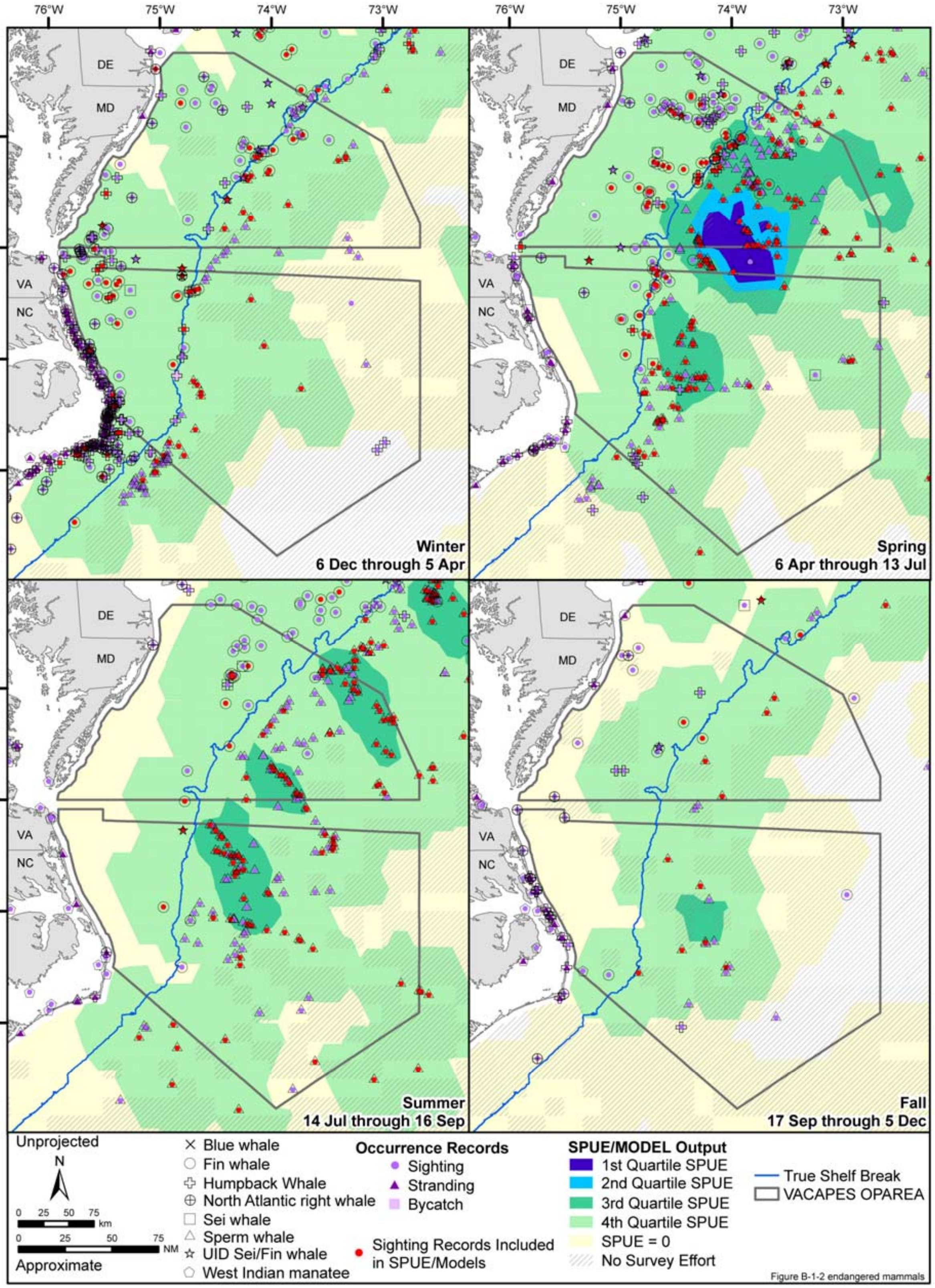

Figure B-1-2. Seasonal occurrence of endangered marine mammals in the Virginia Capes OPAREAs, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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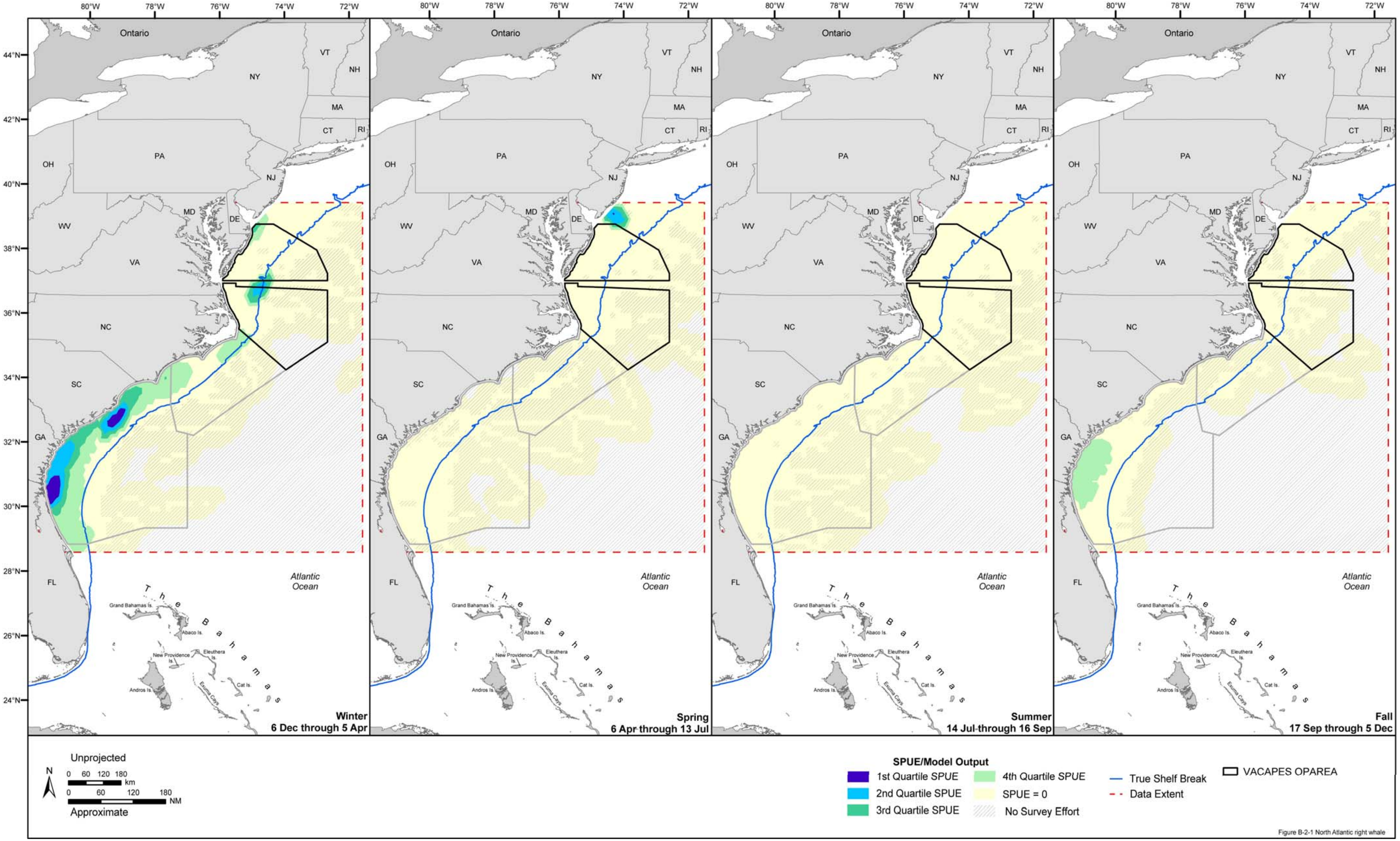

Figure B-2-1. Seasonal SPUE/model output of the North Atlantic right whale in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

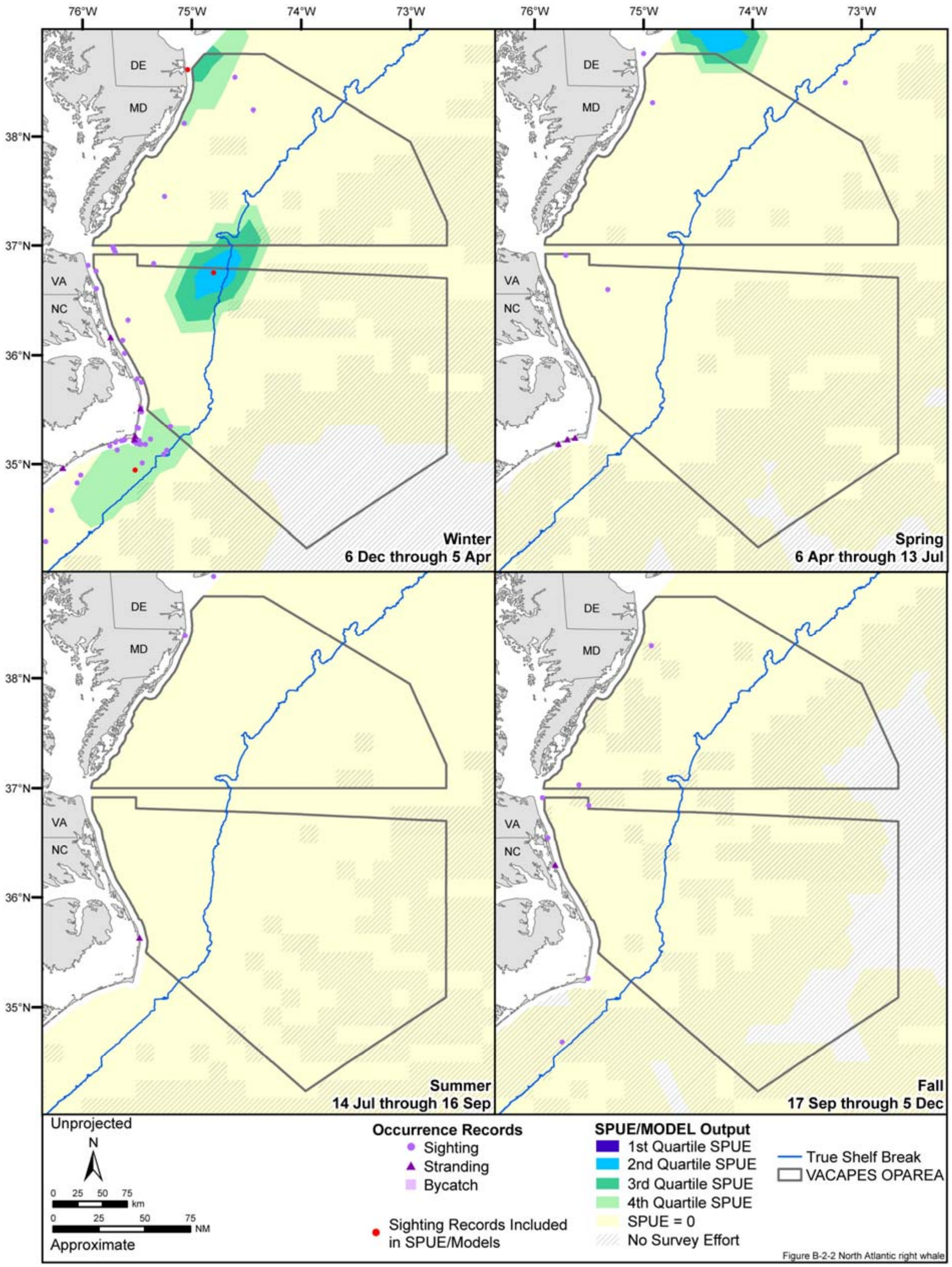

Figure B-2-2. Seasonal occurrence of the North Atlantic right whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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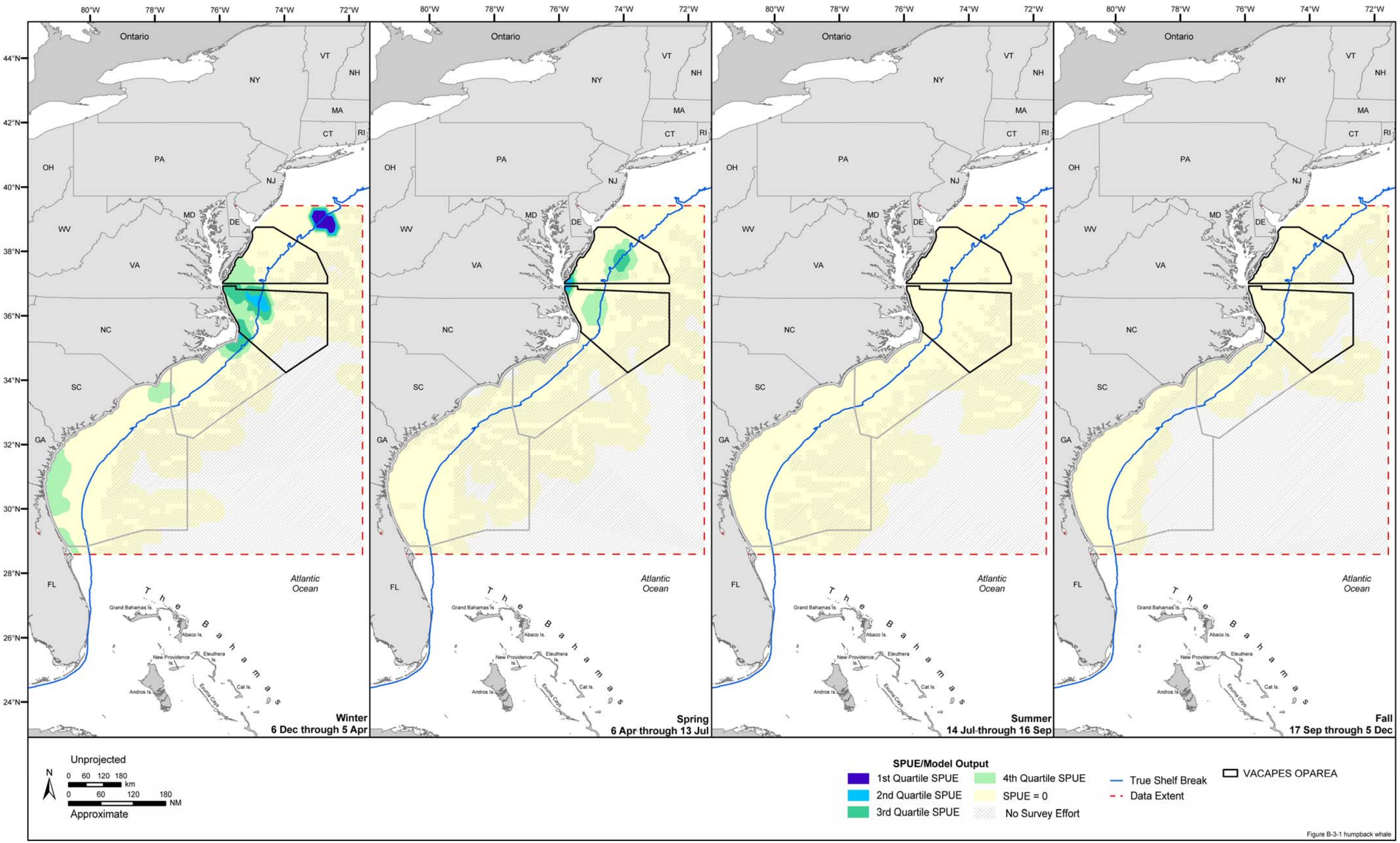

Figure B-3-1. Seasonal SPUE/model output of the humpback whale in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

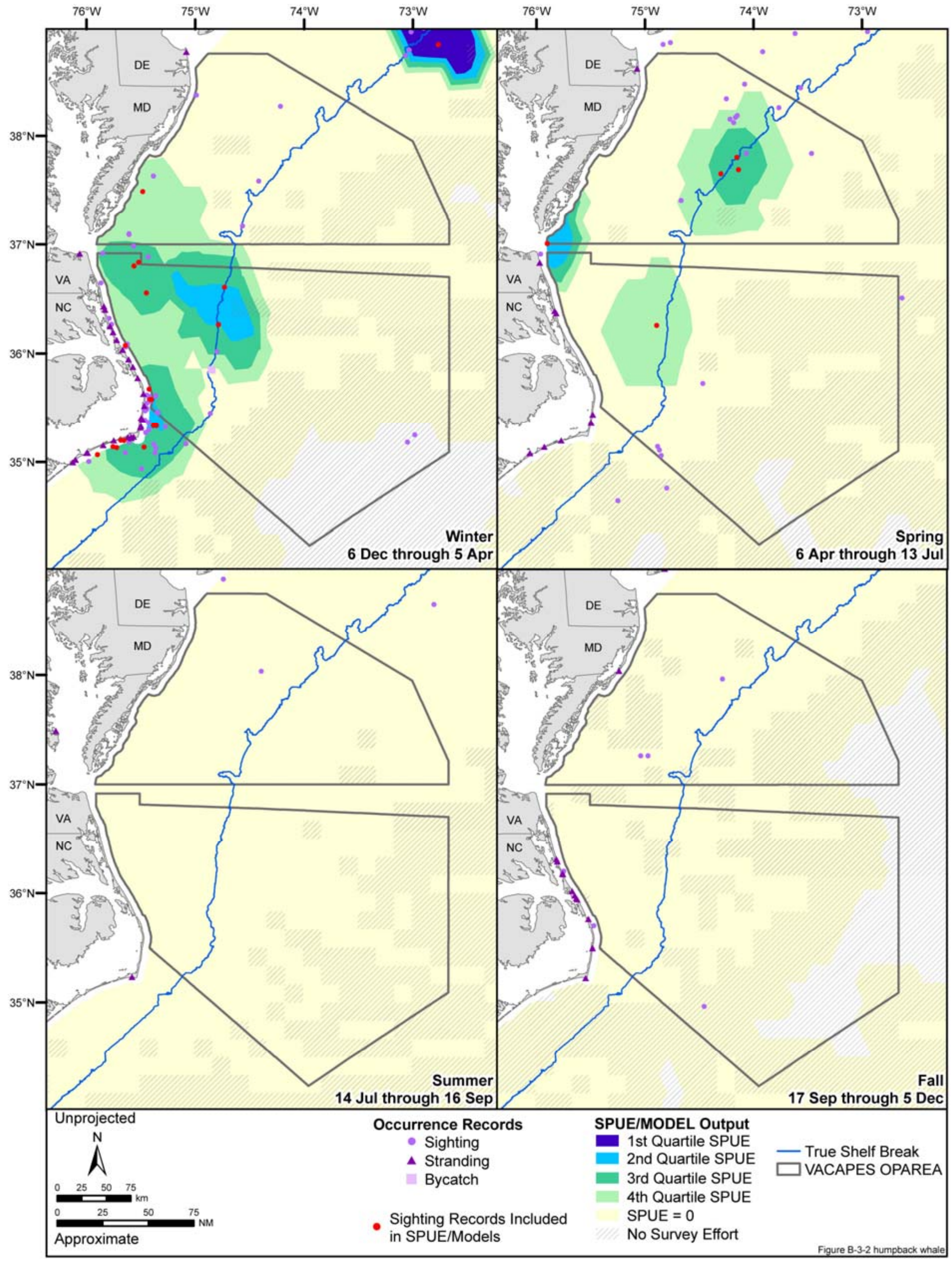

Figure B-3-2. Seasonal occurrence of the humpback whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

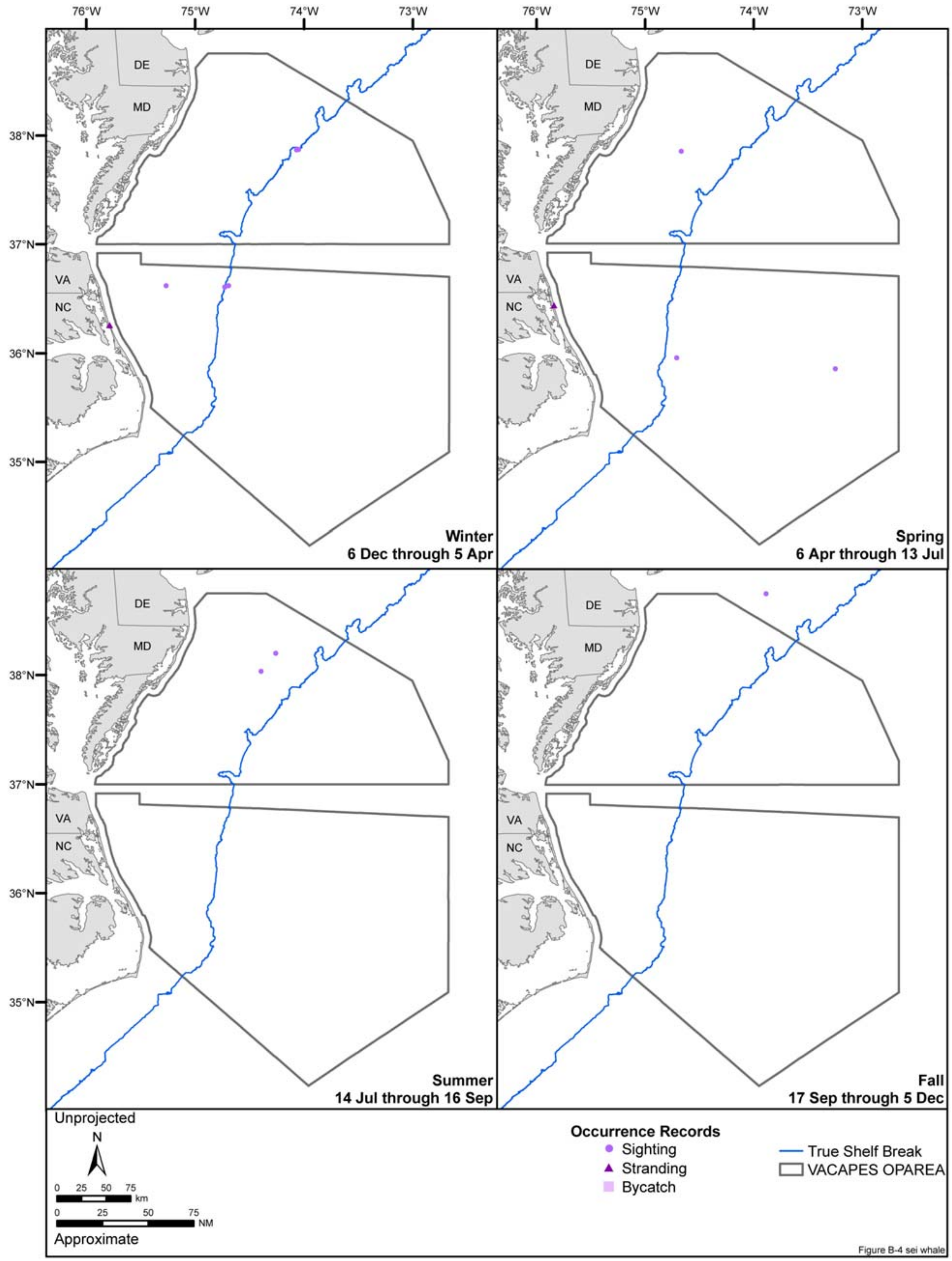

Figure B-4. Seasonal occurrence records of the sei whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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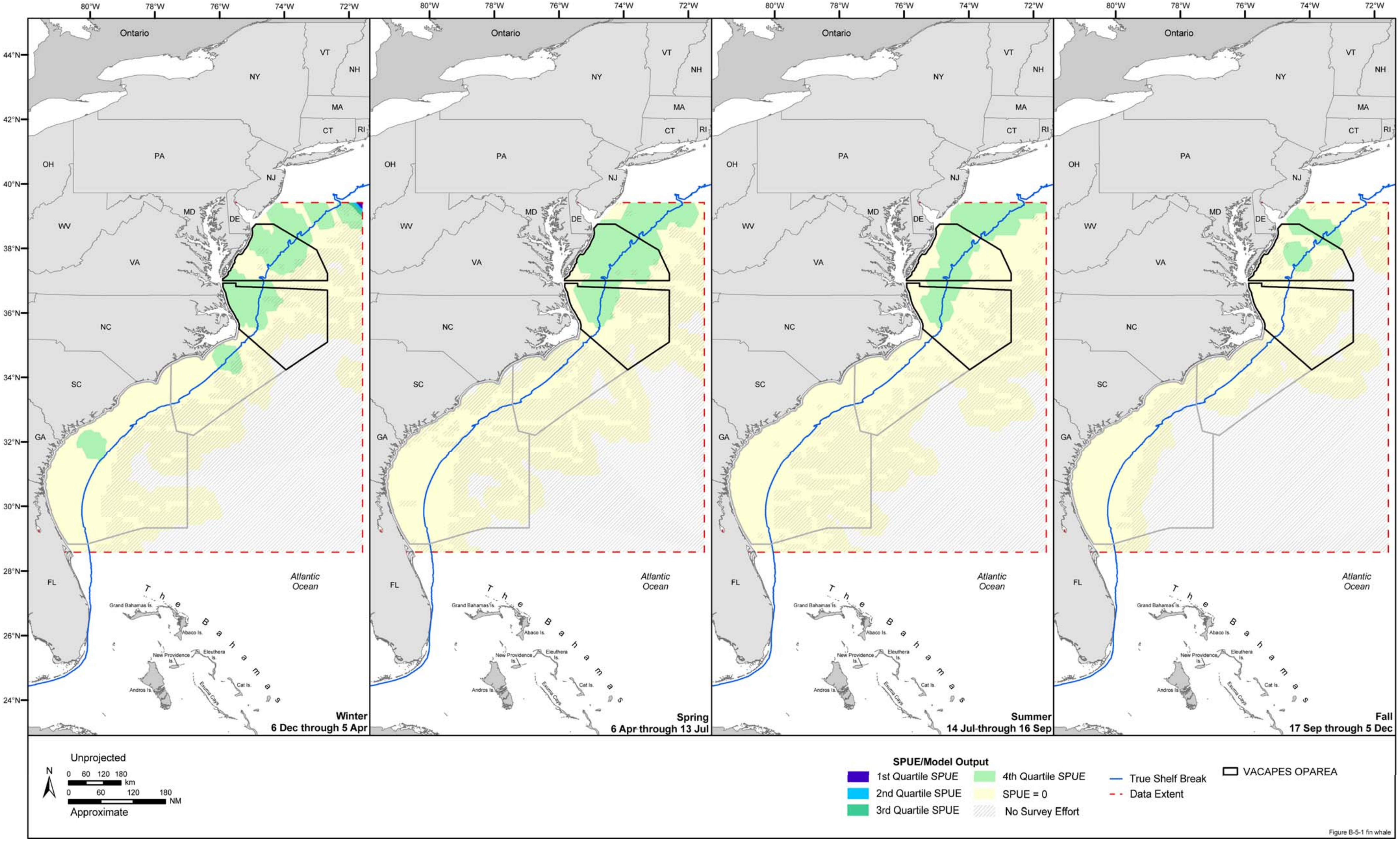

Figure B-5-1. Seasonal SPUE/model output of the fin whale in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

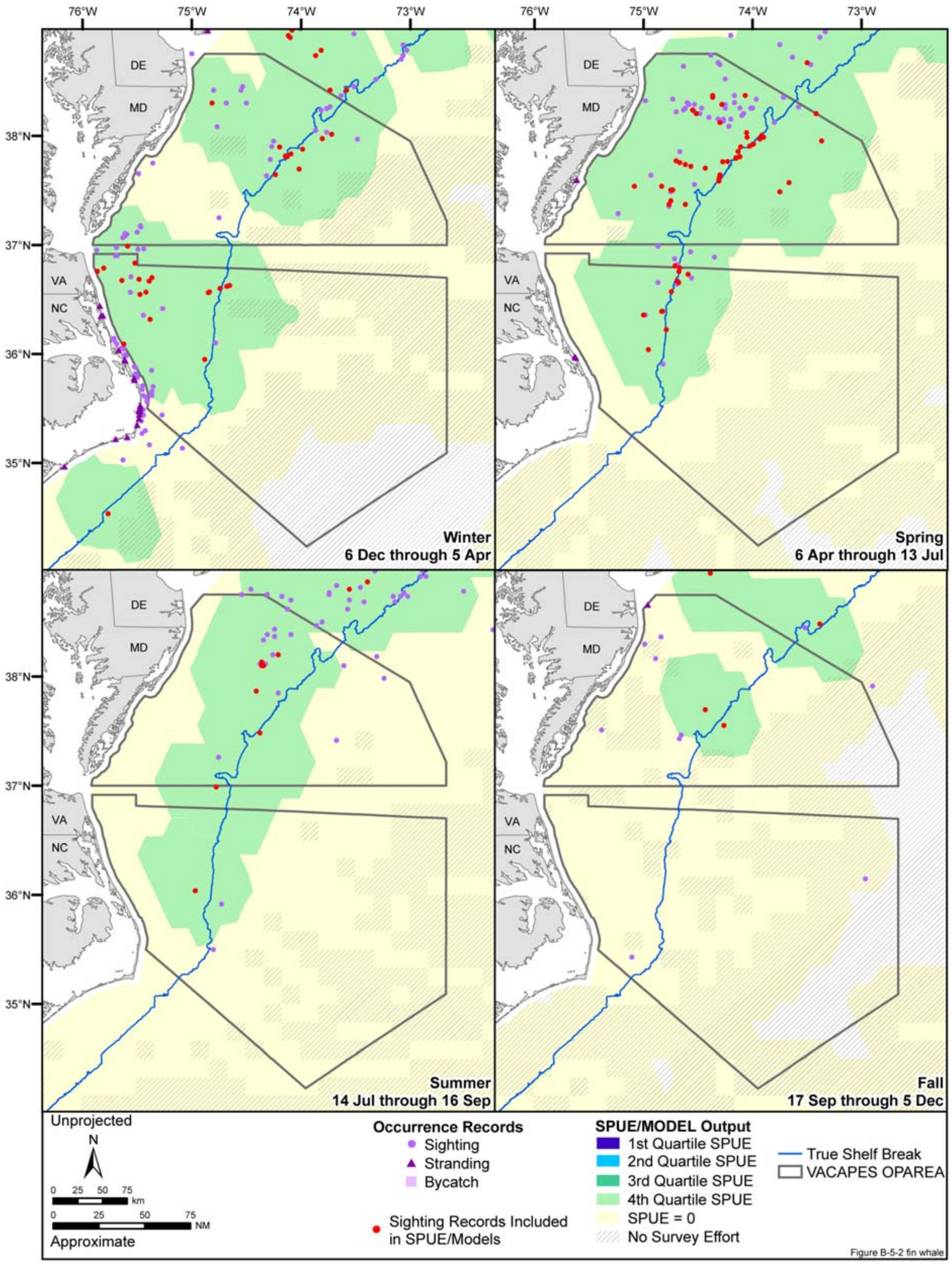

Figure B-5-2. Seasonal occurrence of the fin whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

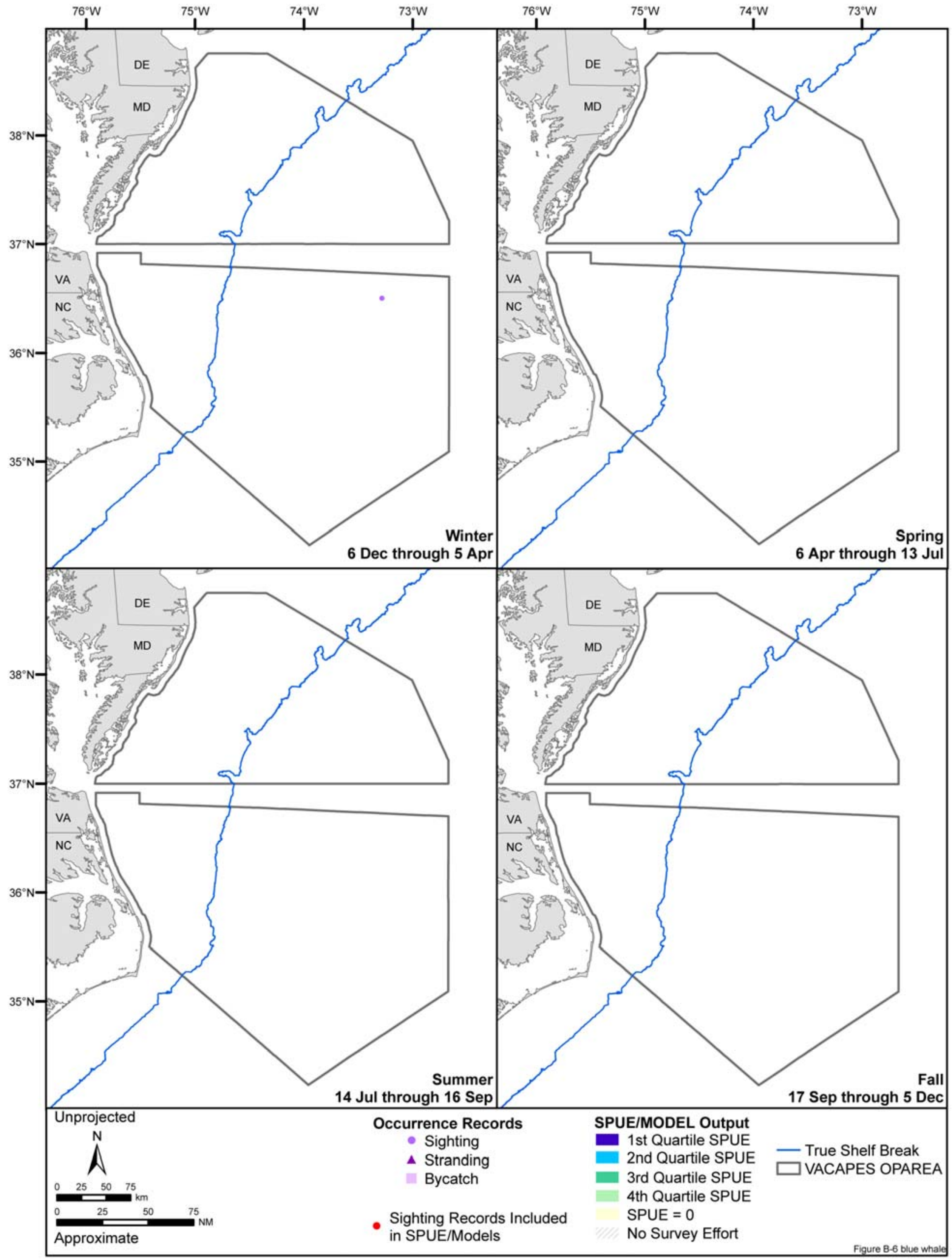

Figure B-6. Seasonal occurrence records of the blue whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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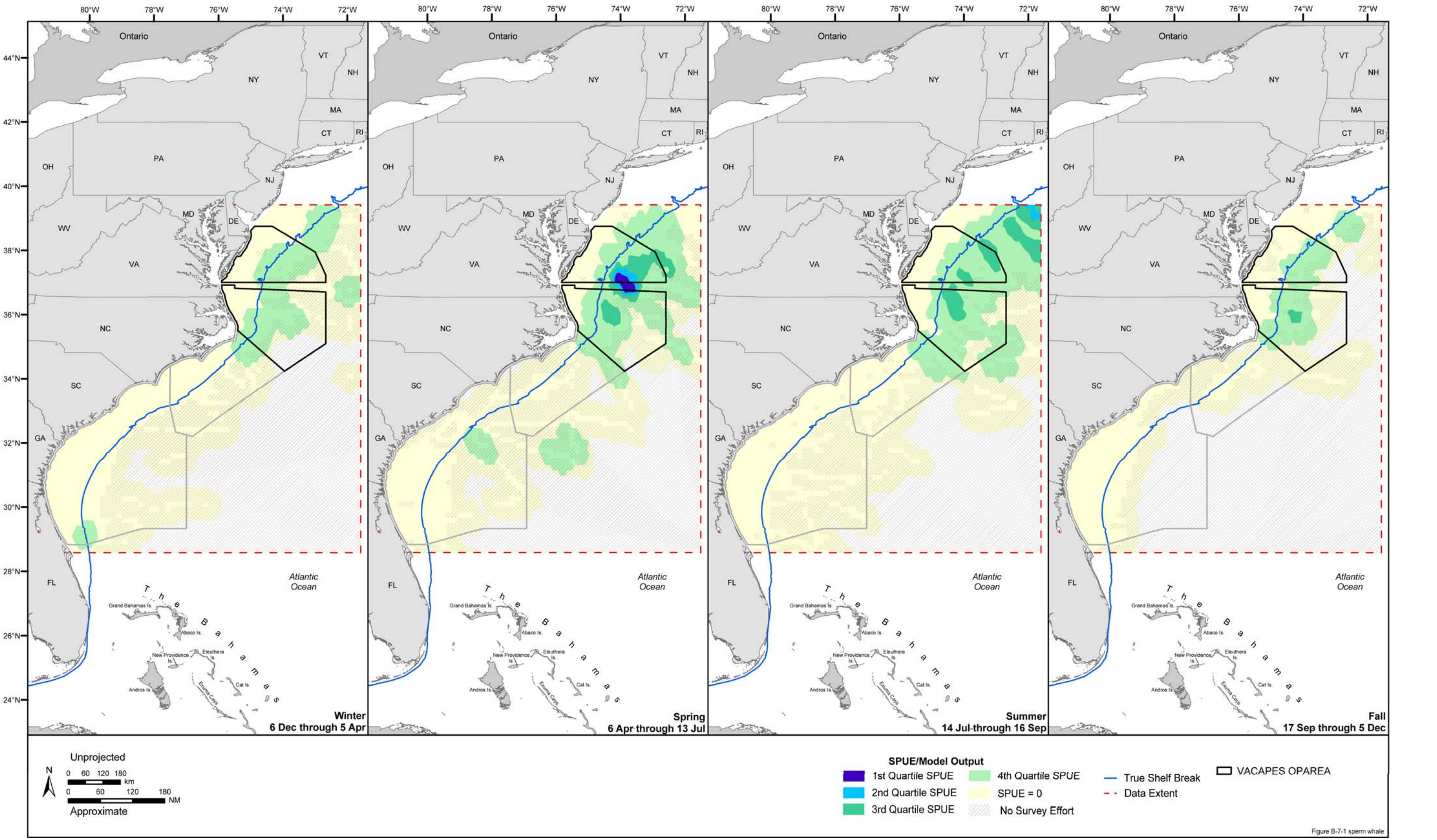

Figure B-7-1. Seasonal SPUE/model output of the sperm whale in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

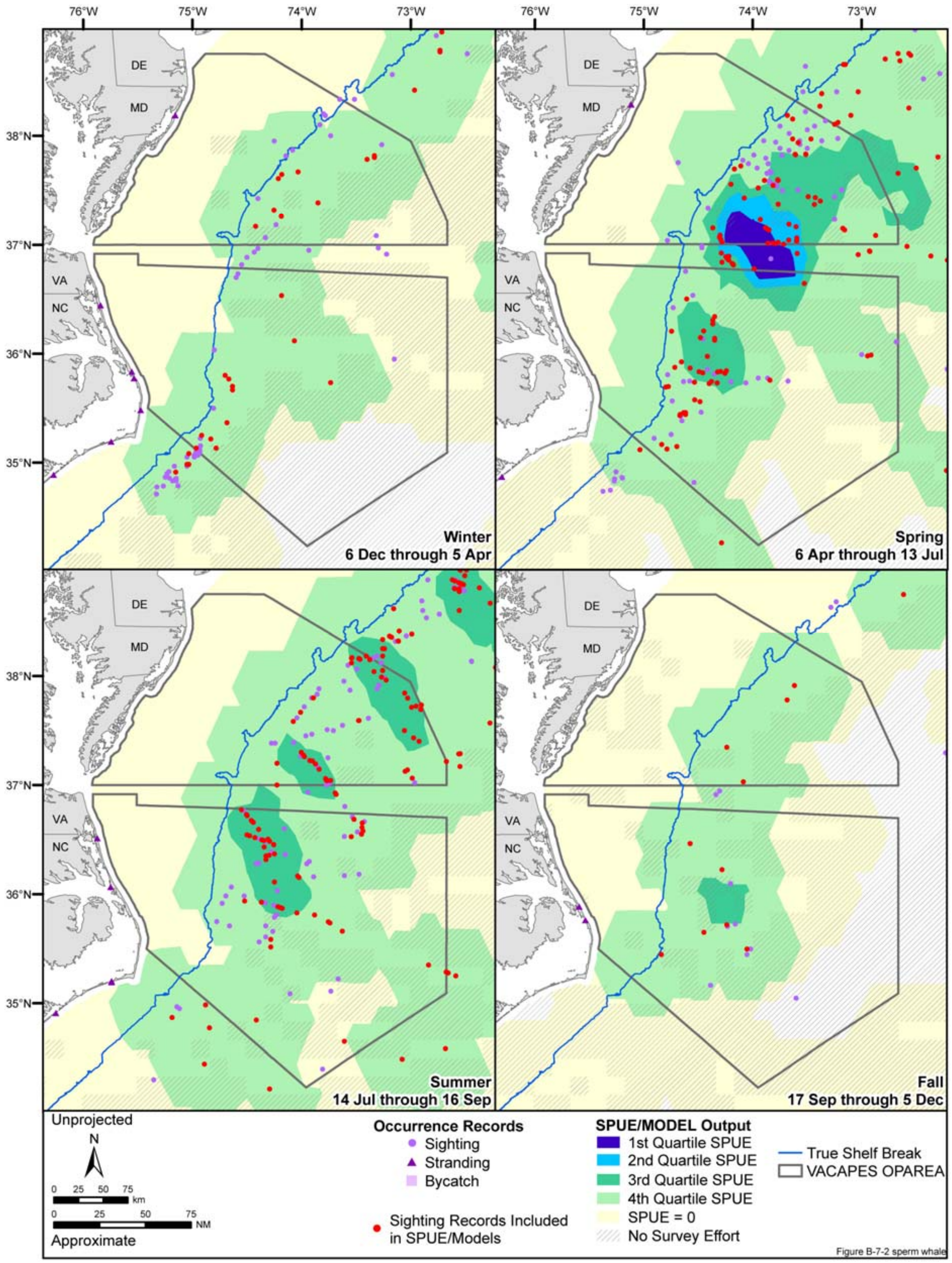

Figure B-7-2. Seasonal occurrence of the sperm whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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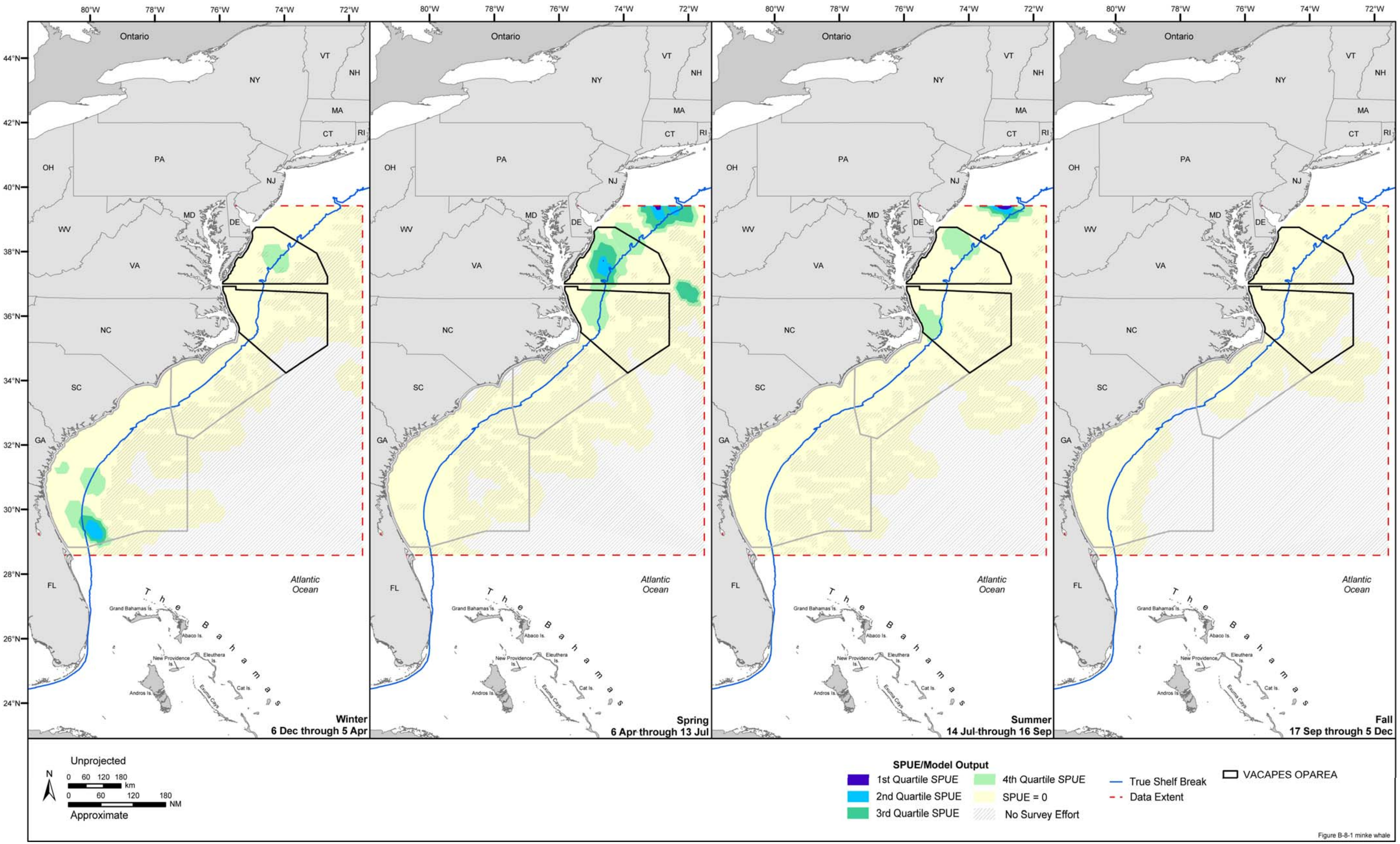

Figure B-8-1. Seasonal SPUE/model output of the minke whale in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

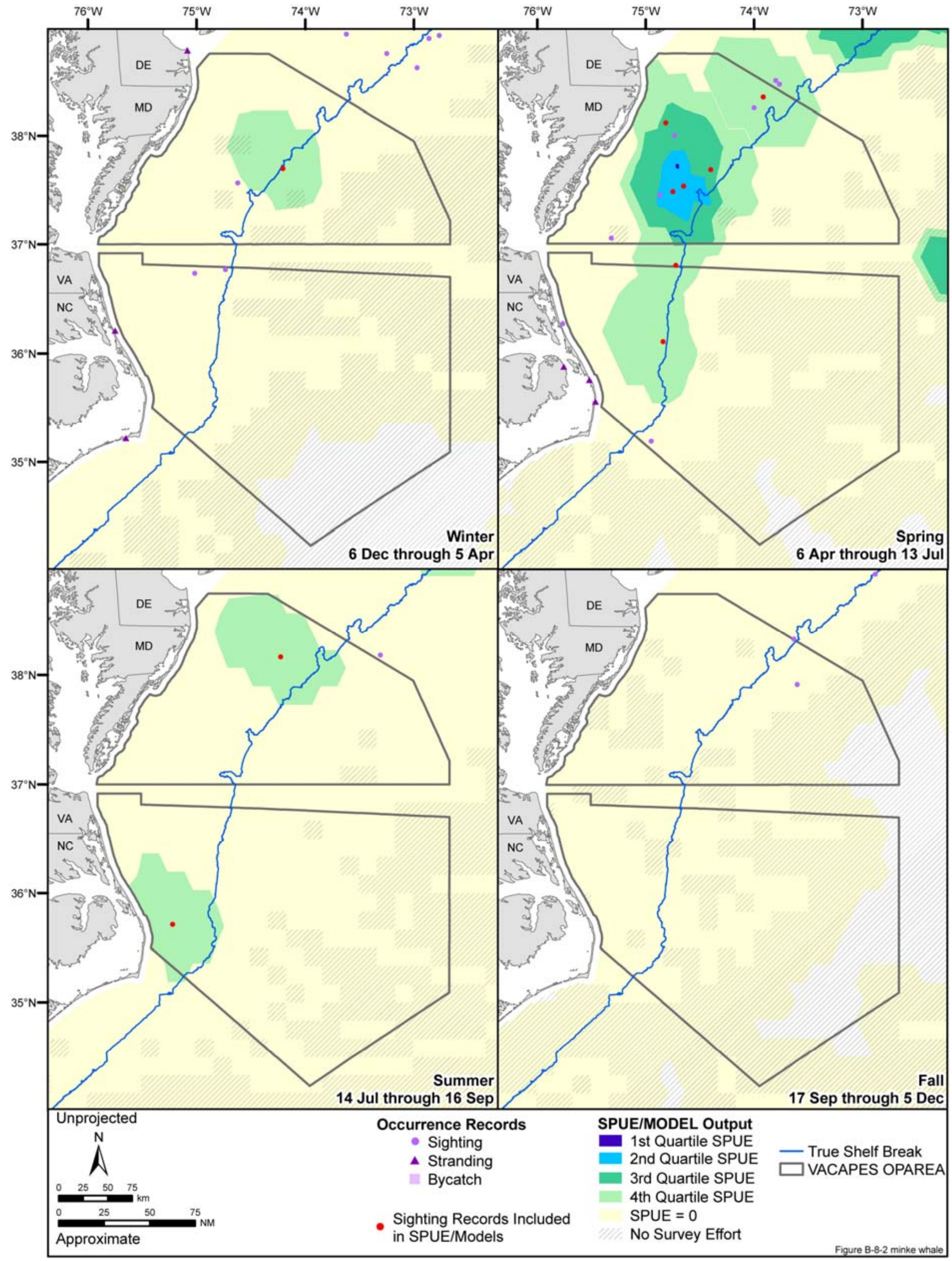

Figure B-8-2. Seasonal occurrence of the minke whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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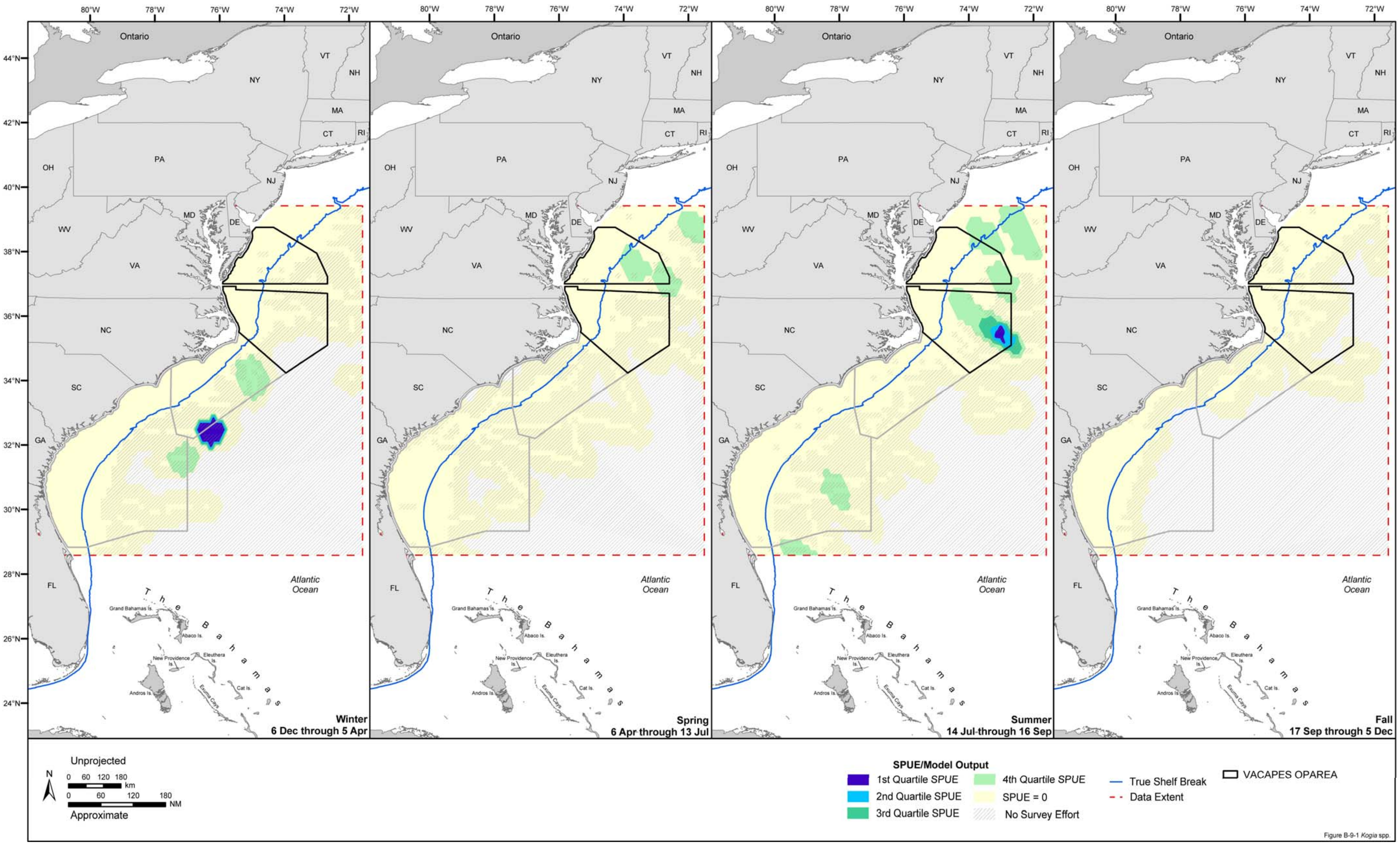

Figure B-9-1. Seasonal SPUE/model output of *Kogia* spp. in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

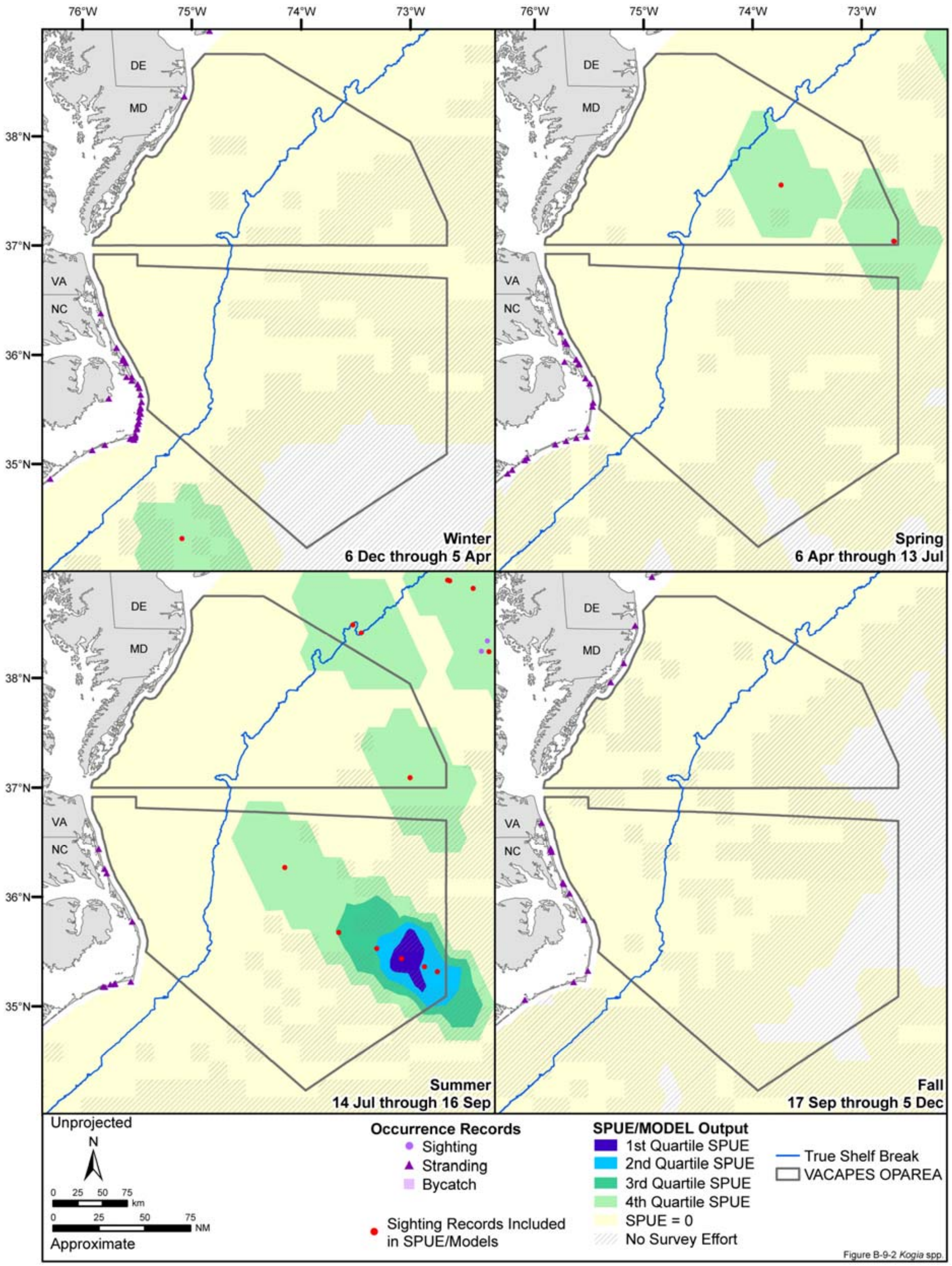

Figure B-9-2. Seasonal occurrence of *Kogia* spp. in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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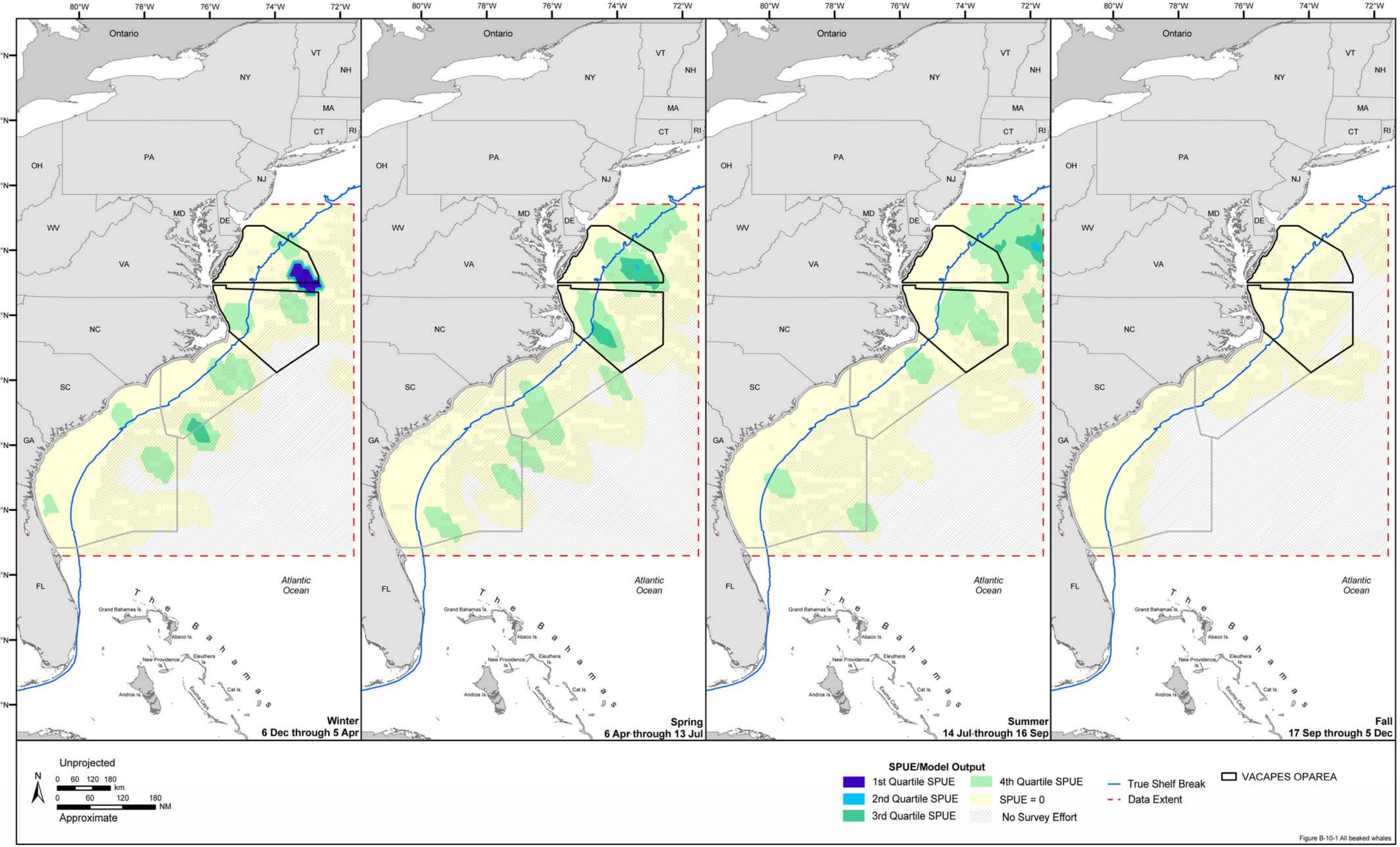

Figure B-10-1. Seasonal SPUE/model output of beaked whales in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

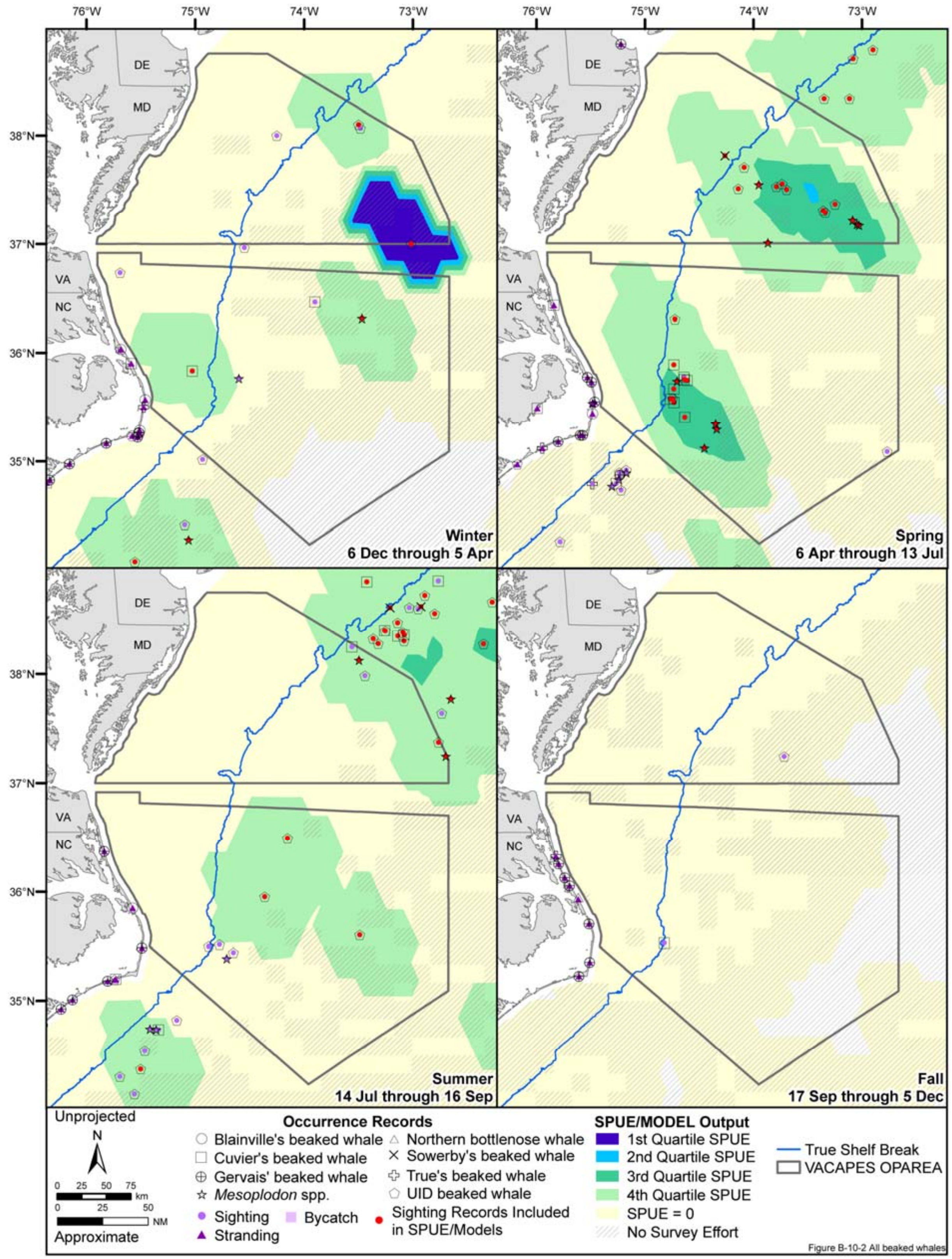

Figure B-10-2. Seasonal occurrence of beaked whales in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

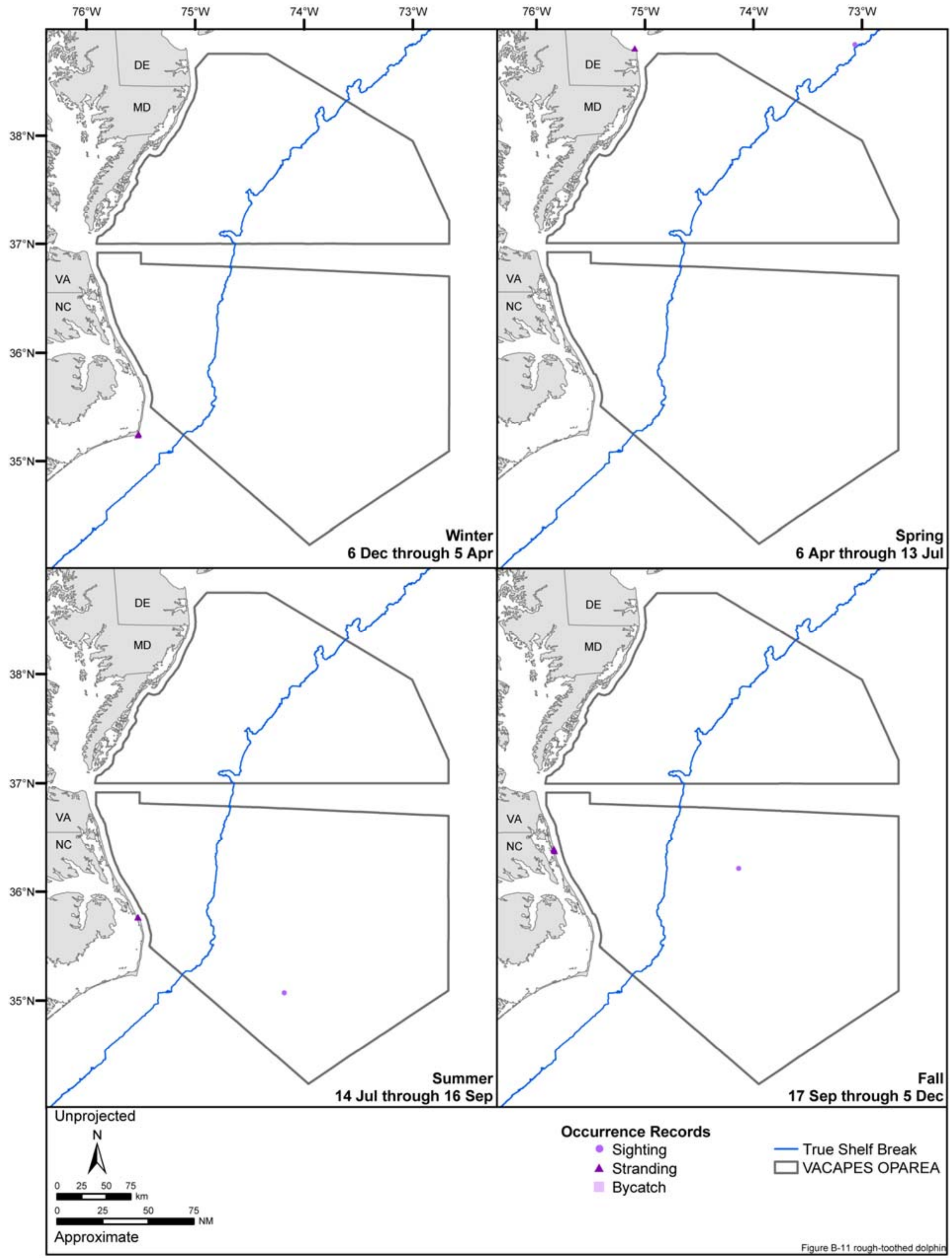

Figure B-11. Seasonal occurrence records of the rough-toothed dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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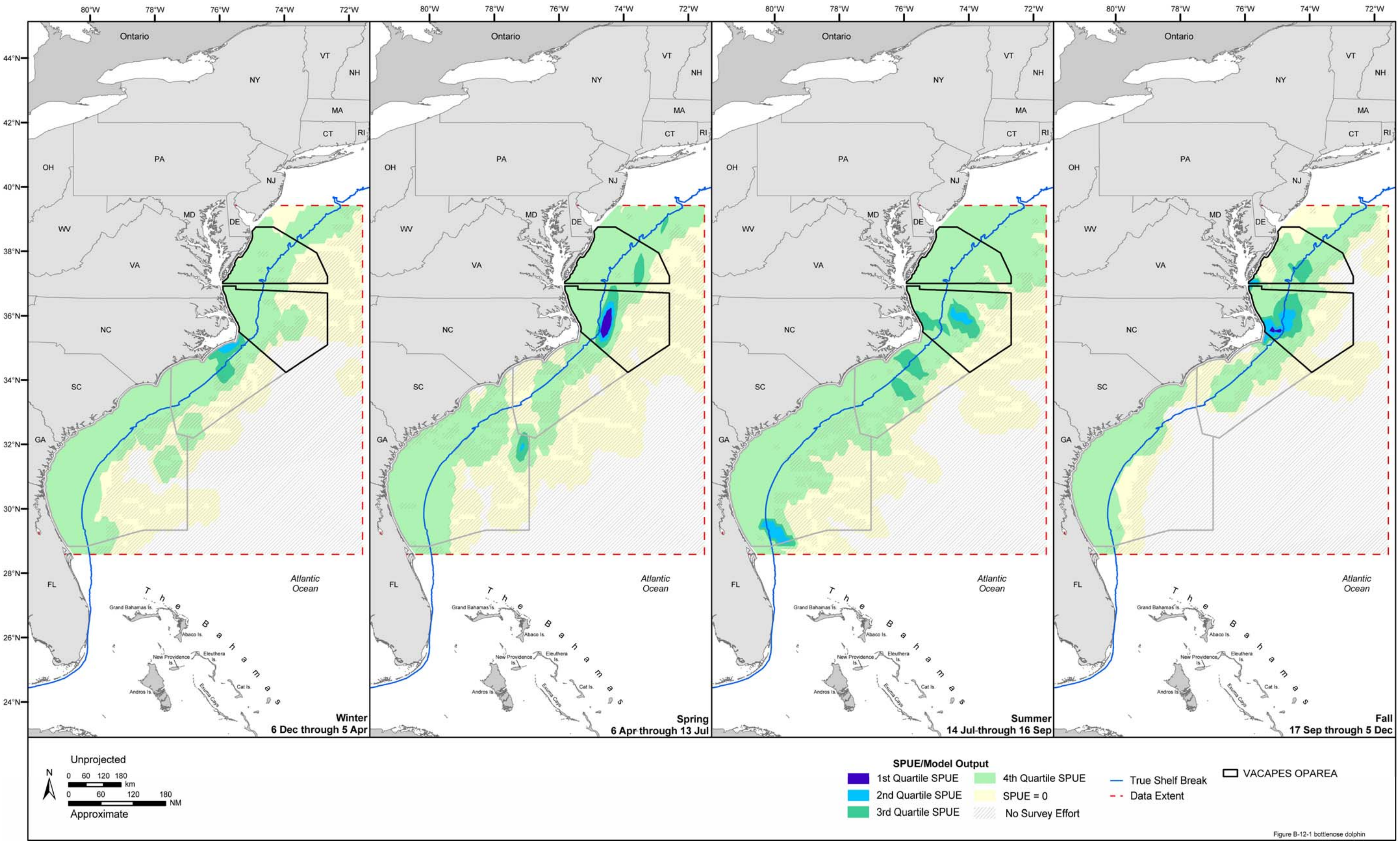

Figure B-12-1. Seasonal SPUE/model output of the bottlenose dolphin in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

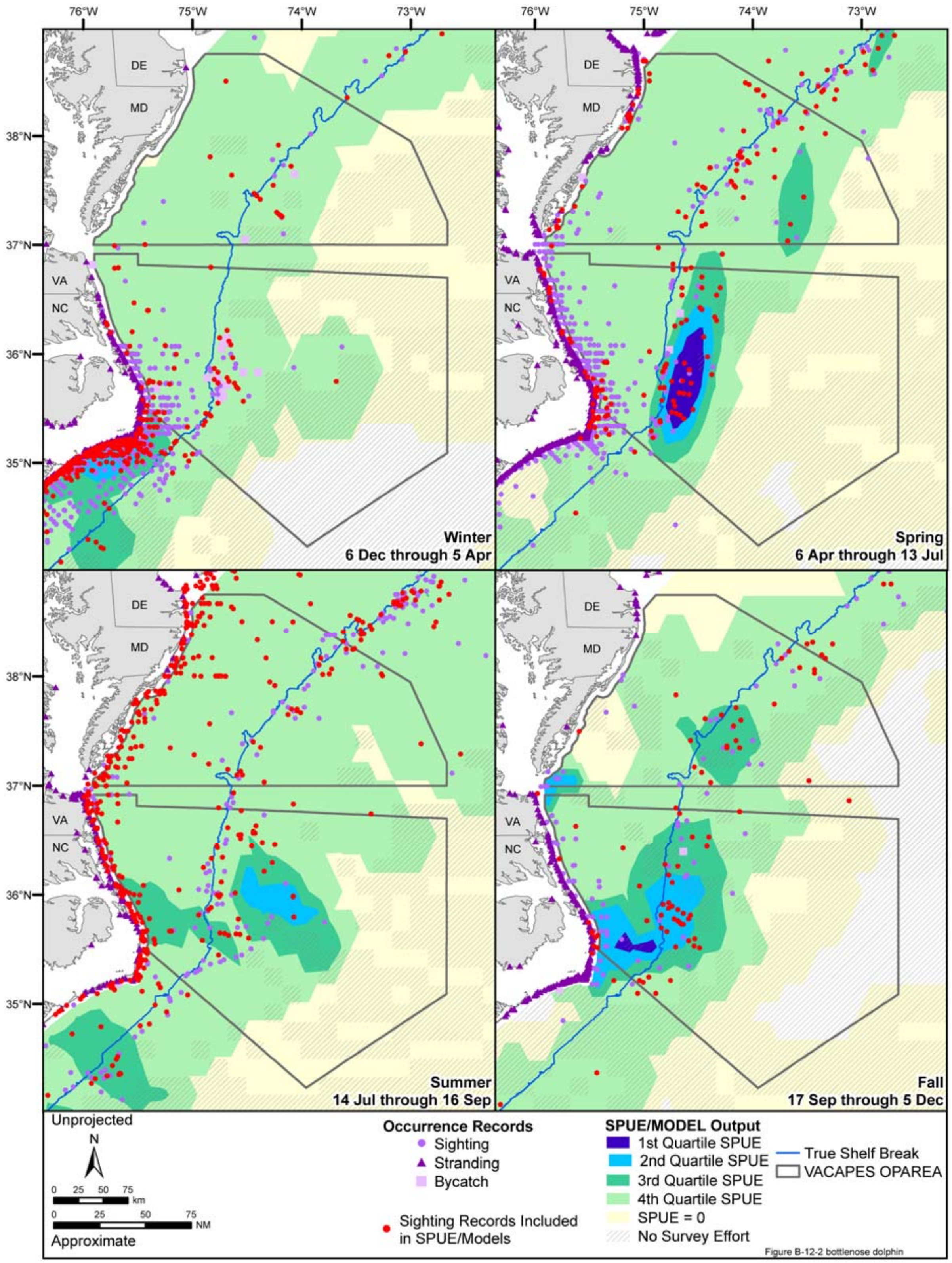

Figure B-12-2. Seasonal occurrence of the bottlenose dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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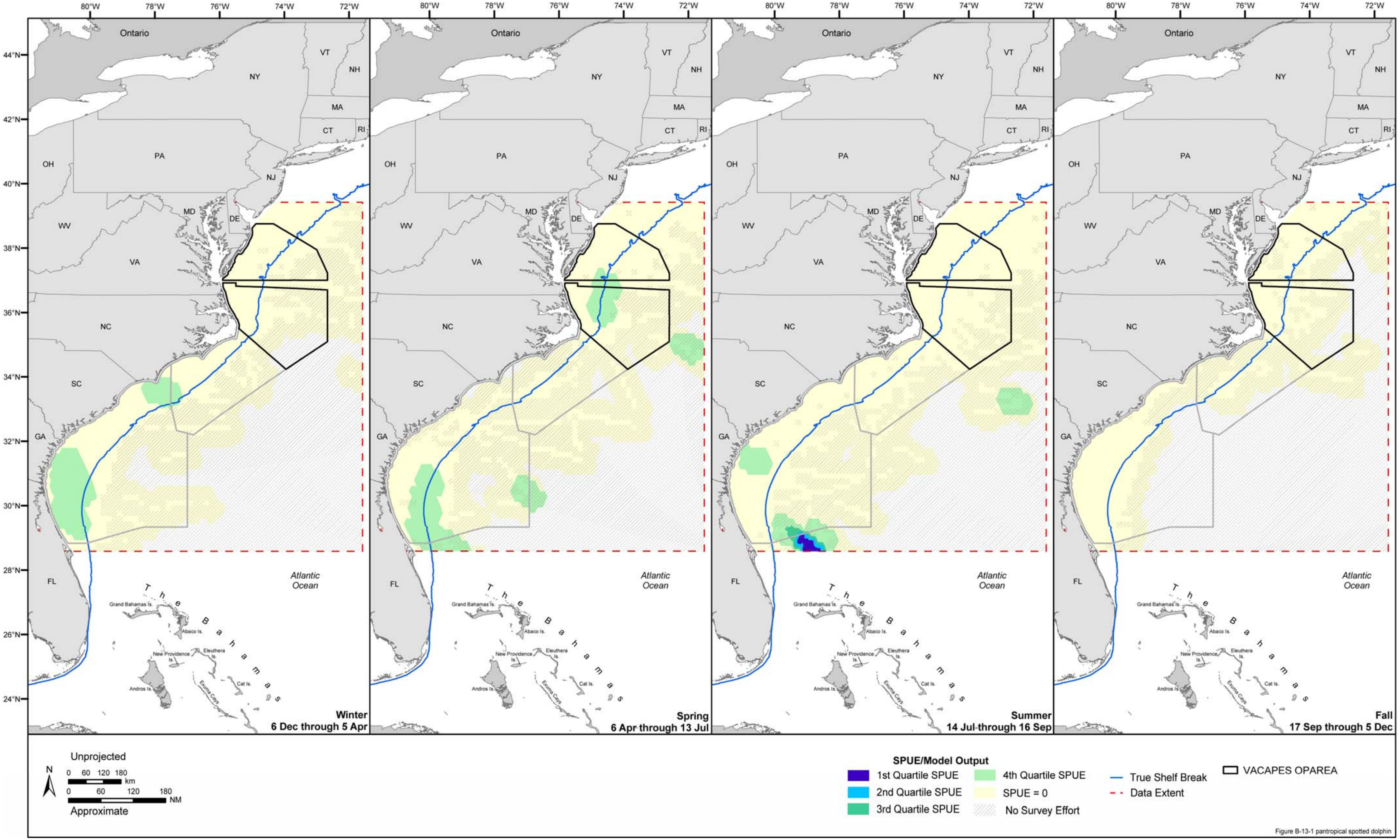

Figure B-13-1. Seasonal SPUE/model output of the pantropical spotted dolphin in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

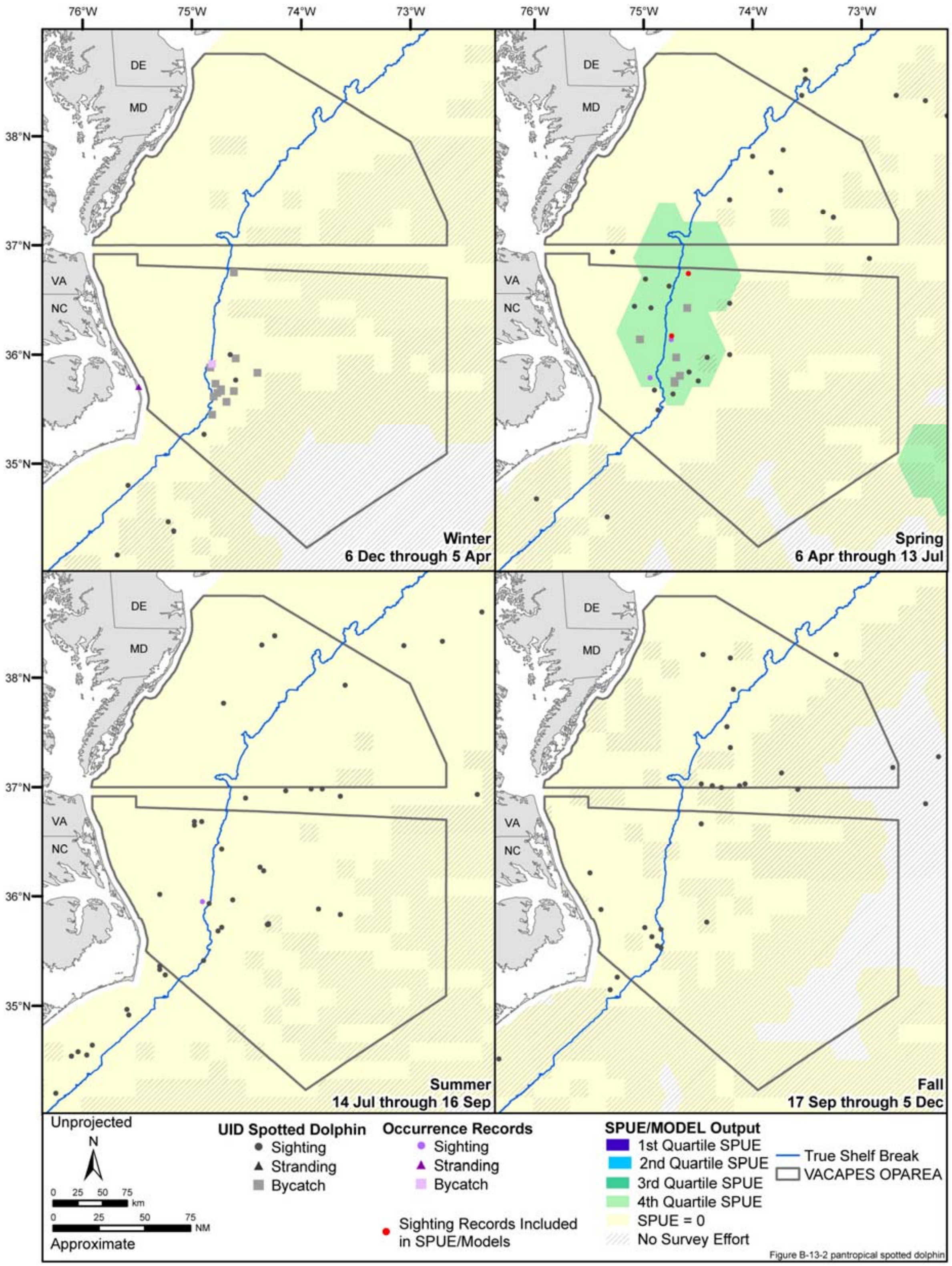

Figure B-13-2. Seasonal occurrence of the pantropical spotted dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platfom-of-opportunity sighting data. Seasonal occurrence records of unidentified spotted dolphins are also depicted in the figure. Source data: refer to Table A-1.

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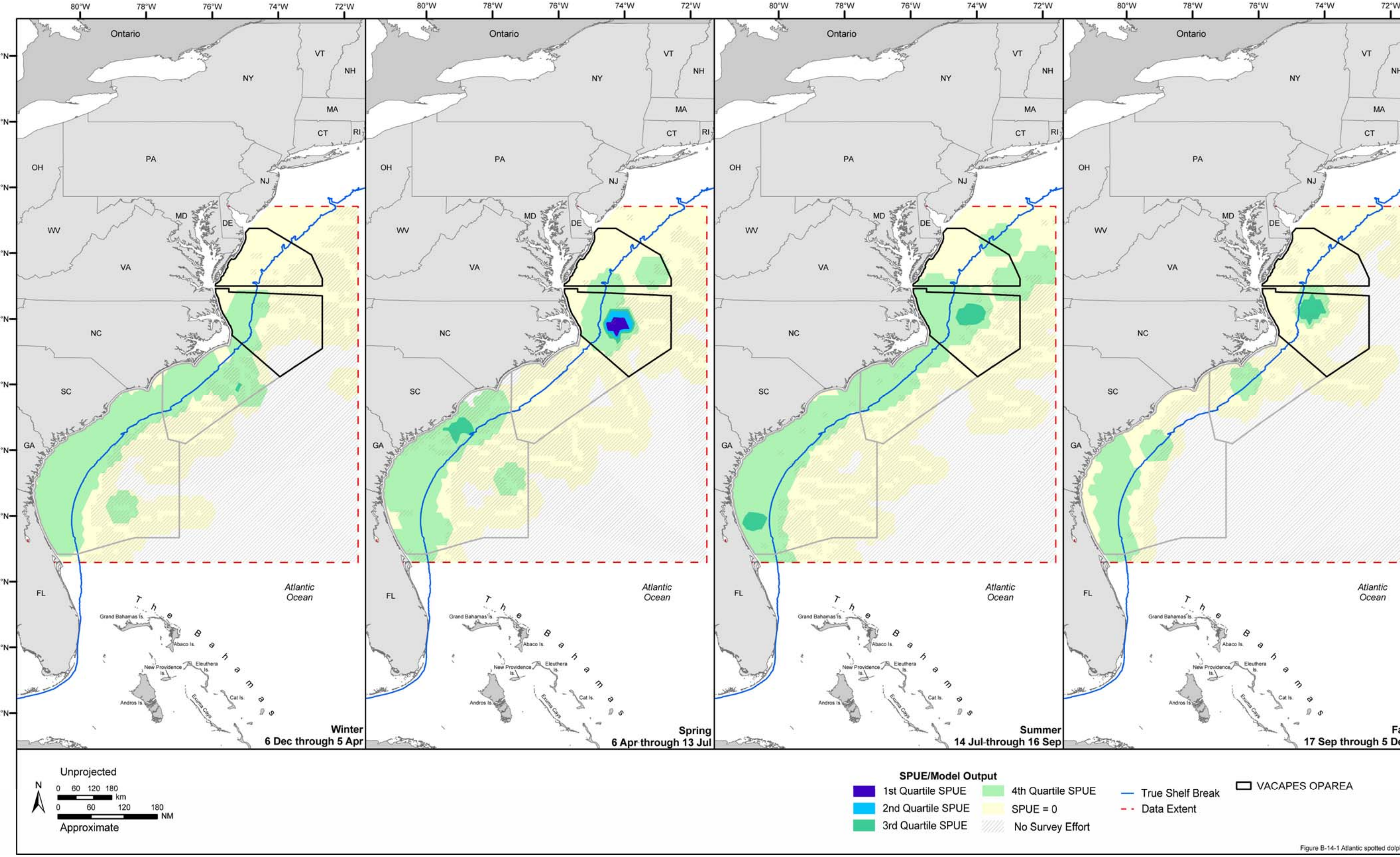

Figure B-14-1. Seasonal SPUE/model output of the Atlantic spotted dolphin in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

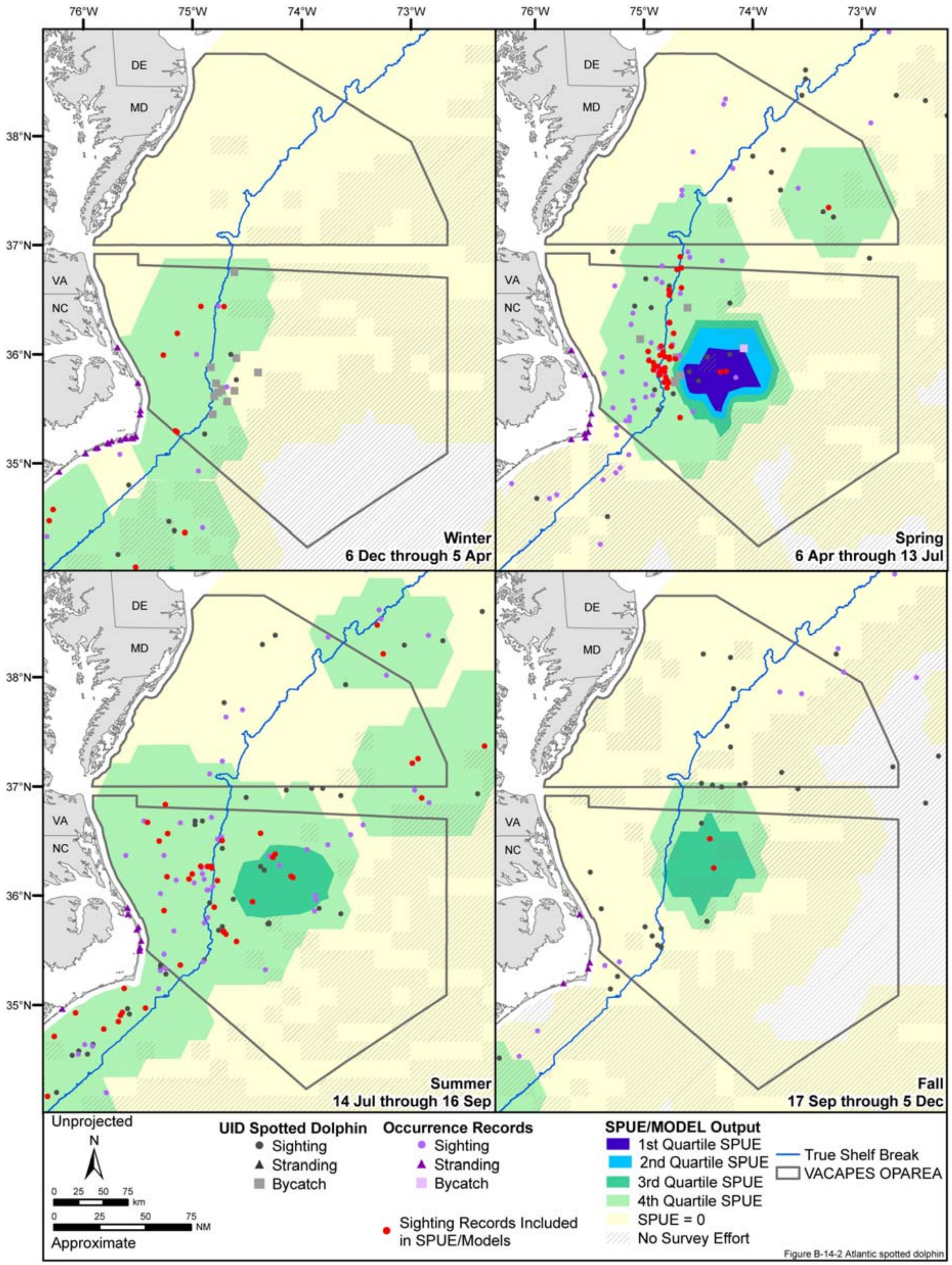

Figure B-14-2. Seasonal occurrence of the Atlantic spotted dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Seasonal occurrence records of unidentified spotted dolphins are also depicted in the figure. Source data: refer to Table A-1.

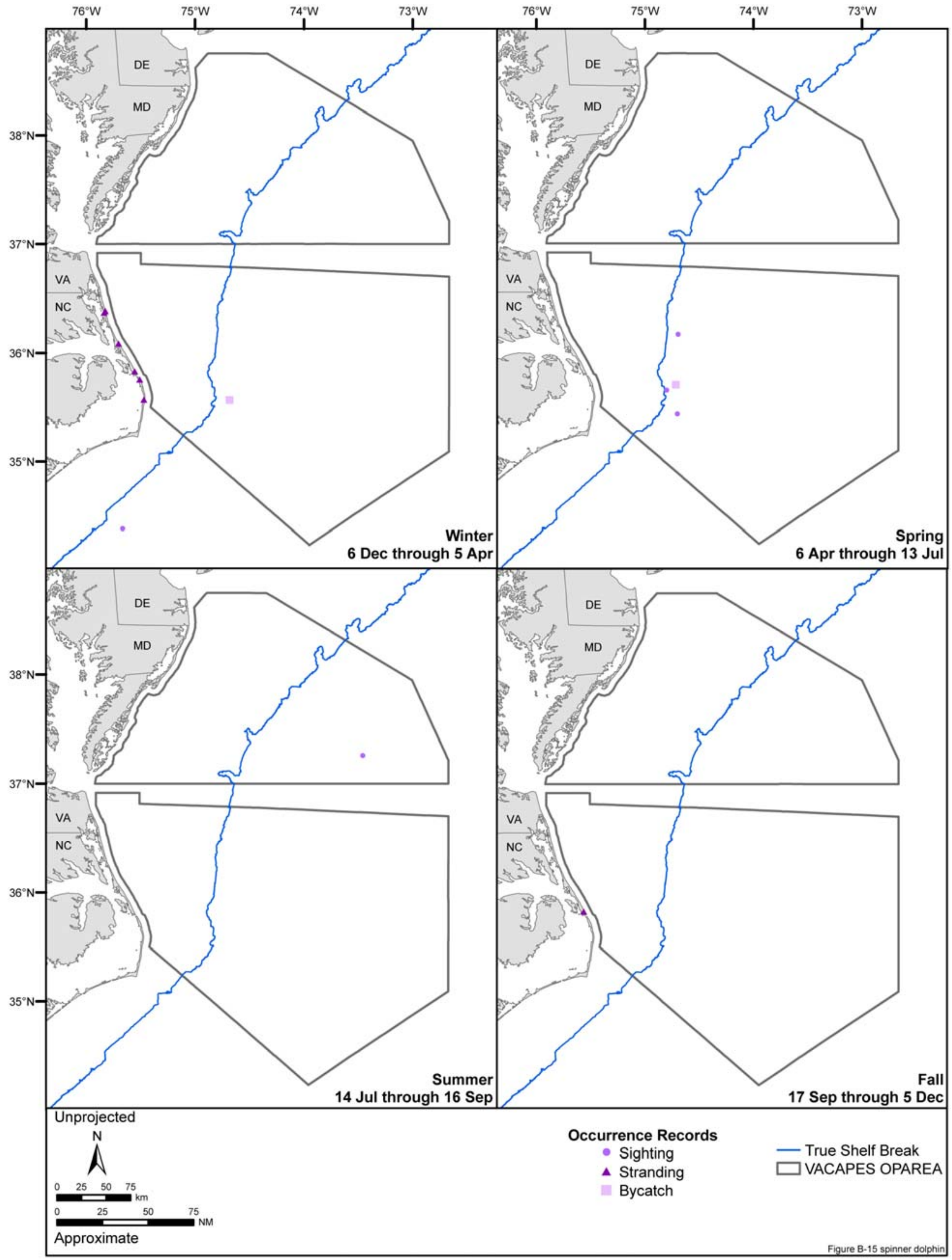

Figure B-15. Seasonal occurrence records of the spinner dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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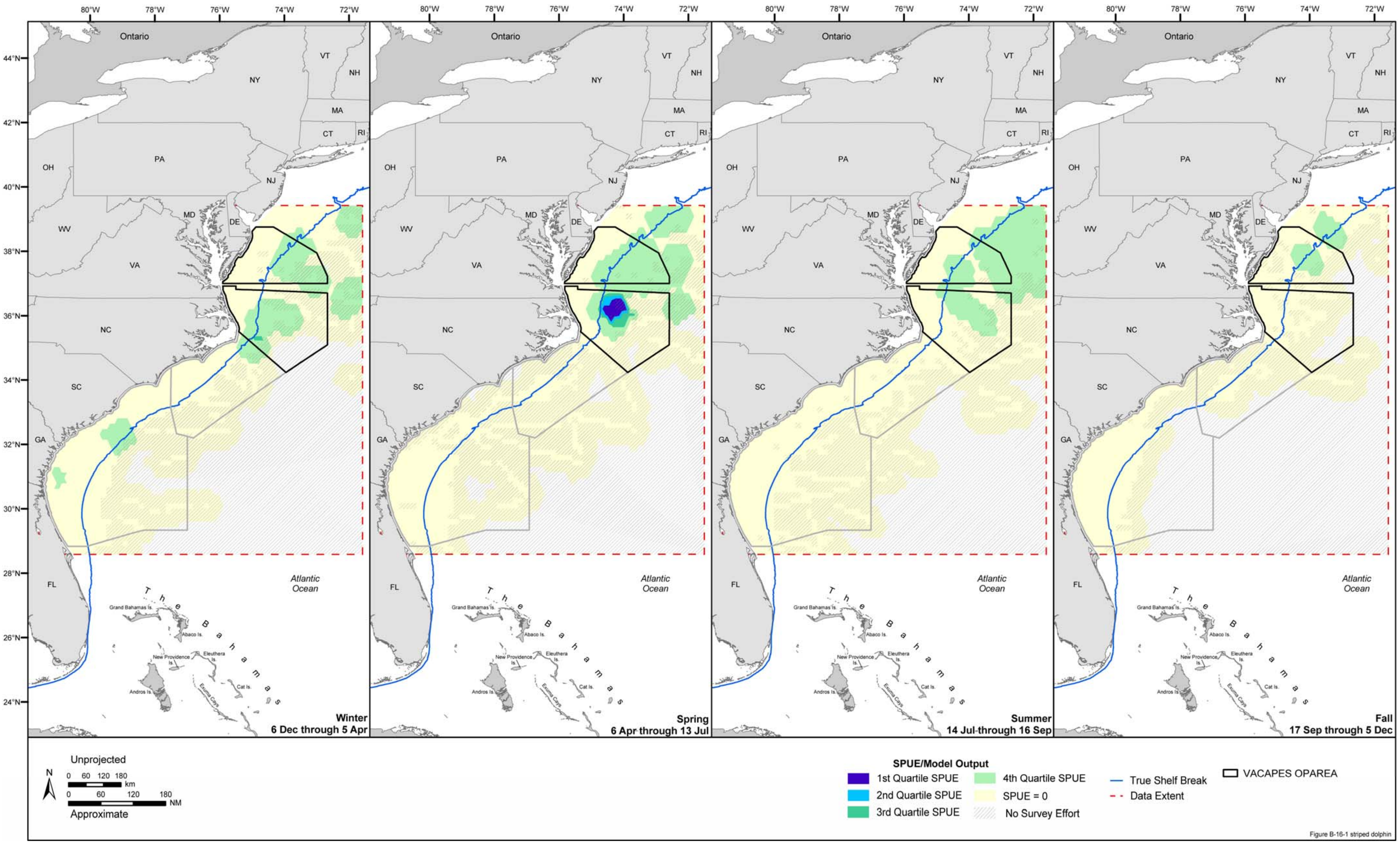

Figure B-16-1. Seasonal SPUE/model output of the striped dolphin in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

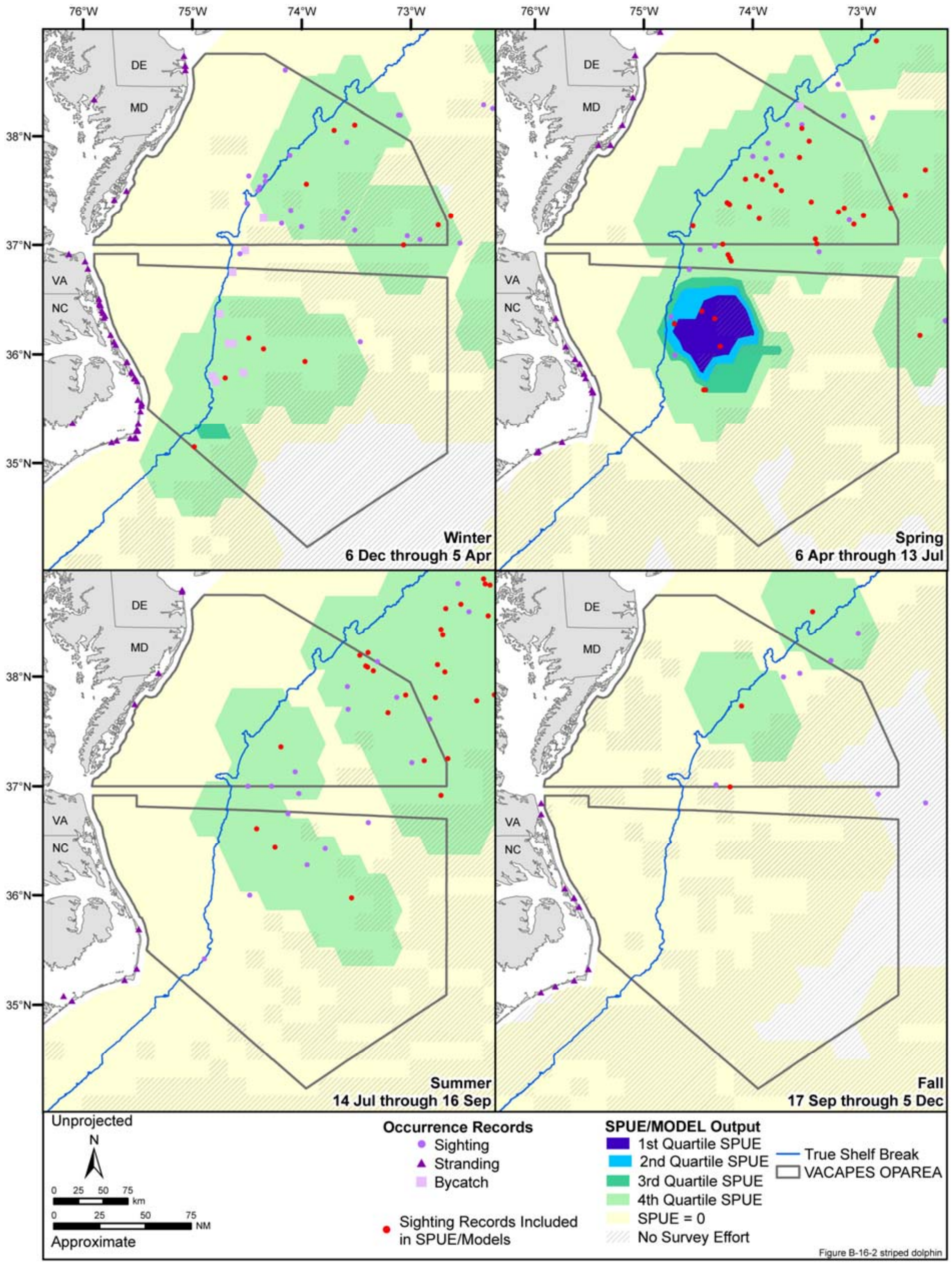

Figure B-16-2. Seasonal occurrence of the striped dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

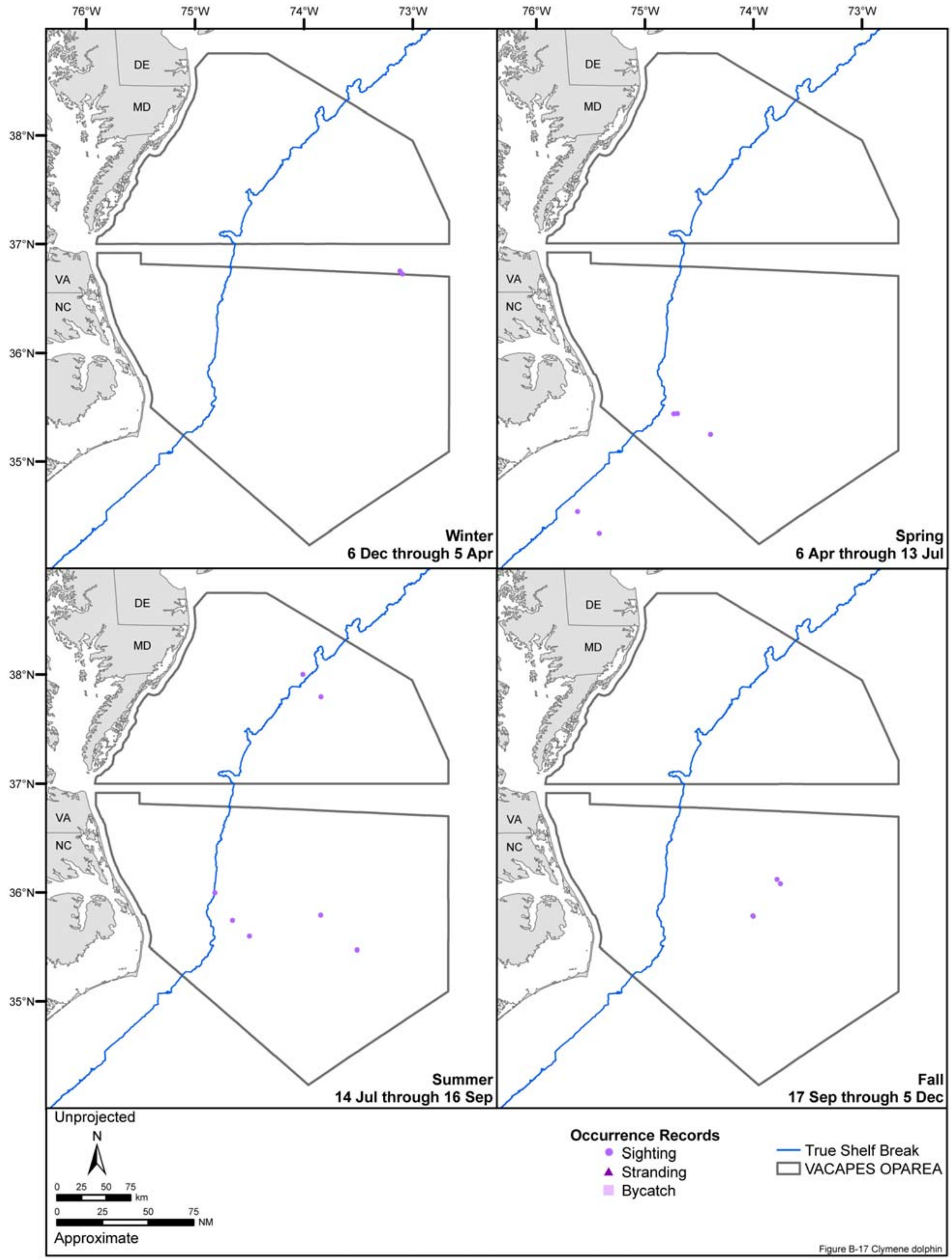

Figure B-17. Seasonal occurrence records of the Clymene dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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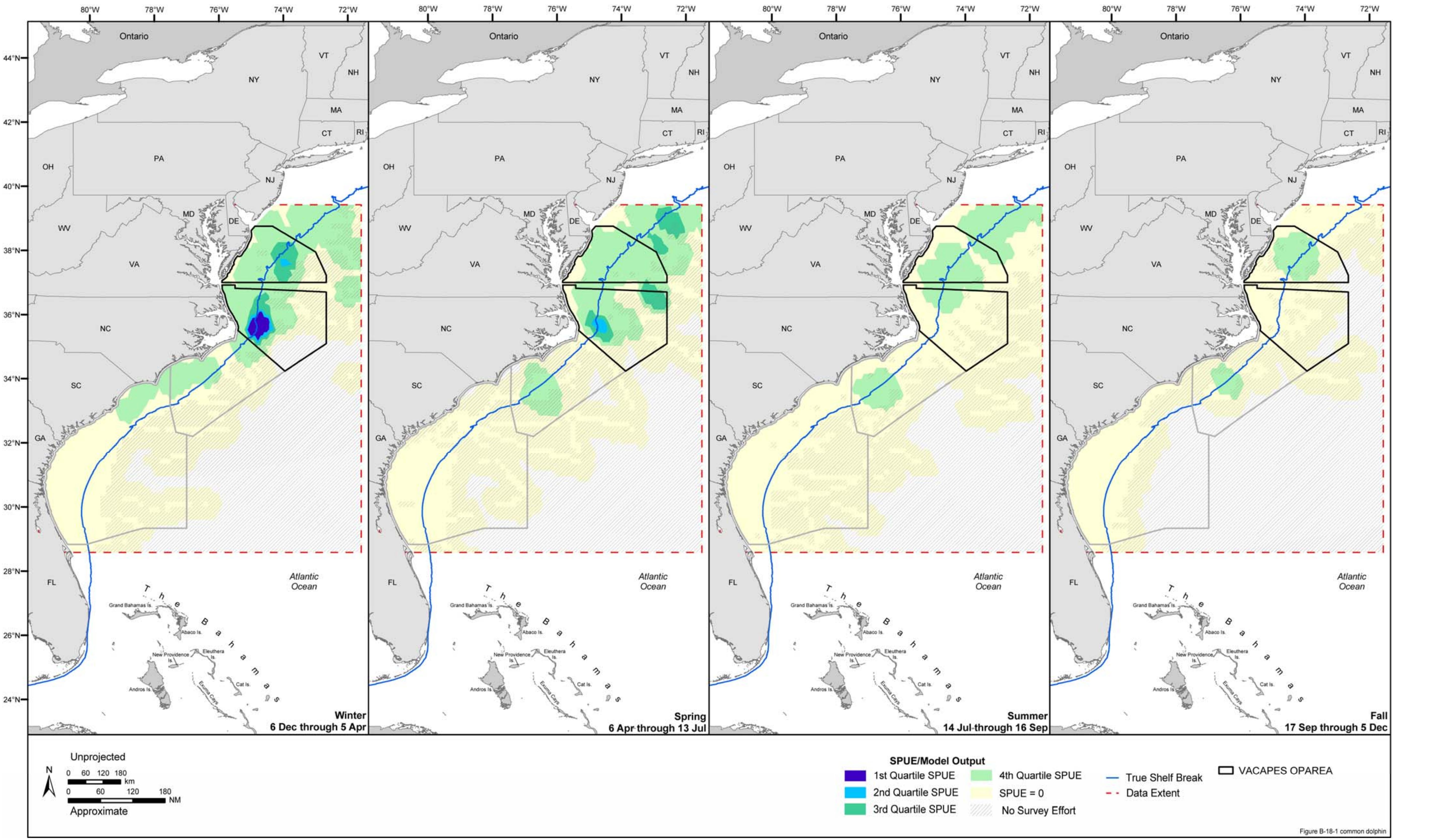

Figure B-18-1. Seasonal SPUE/model output of the common dolphin in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

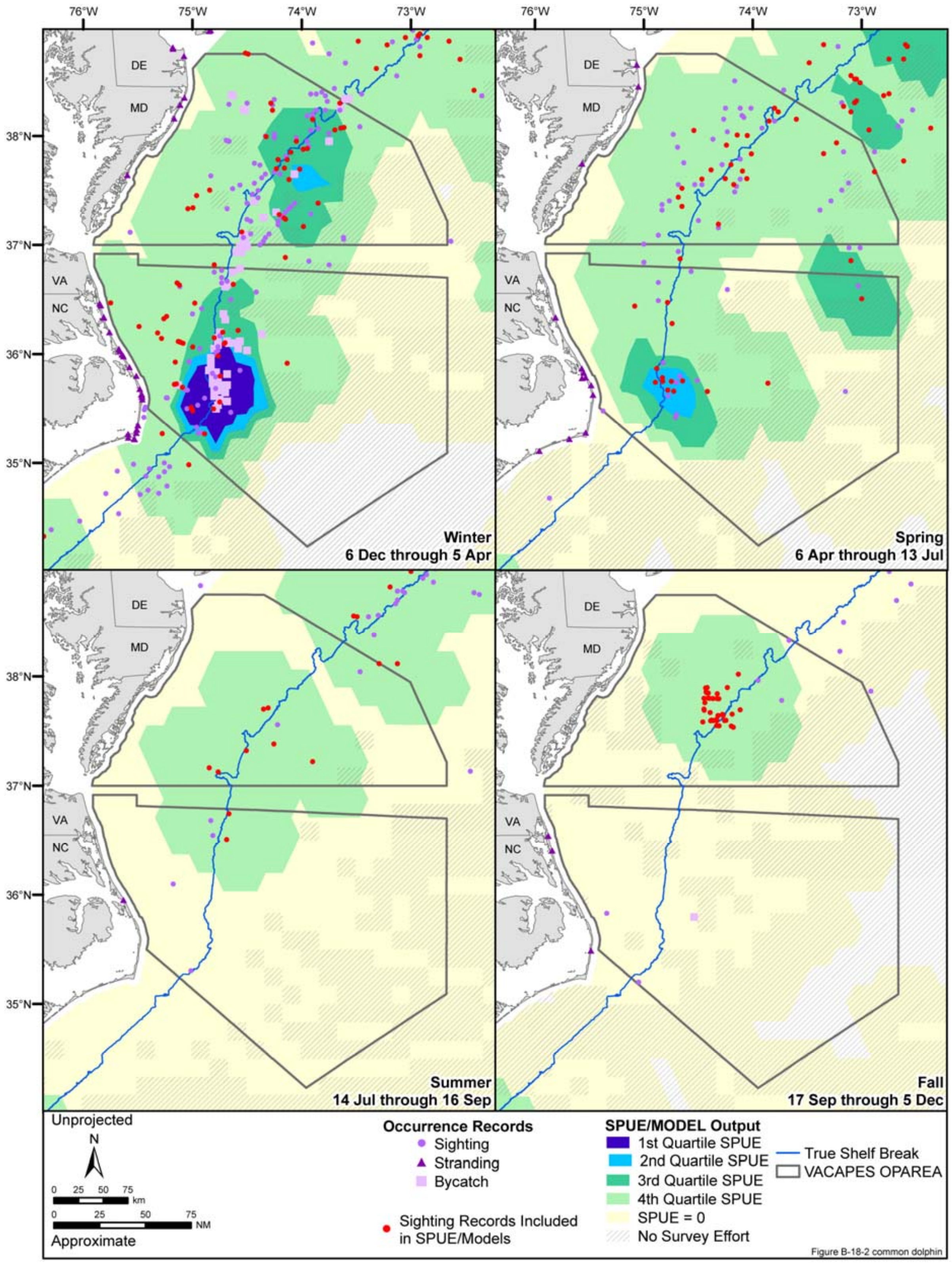

Figure B-18-2. Seasonal occurrence of the common dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

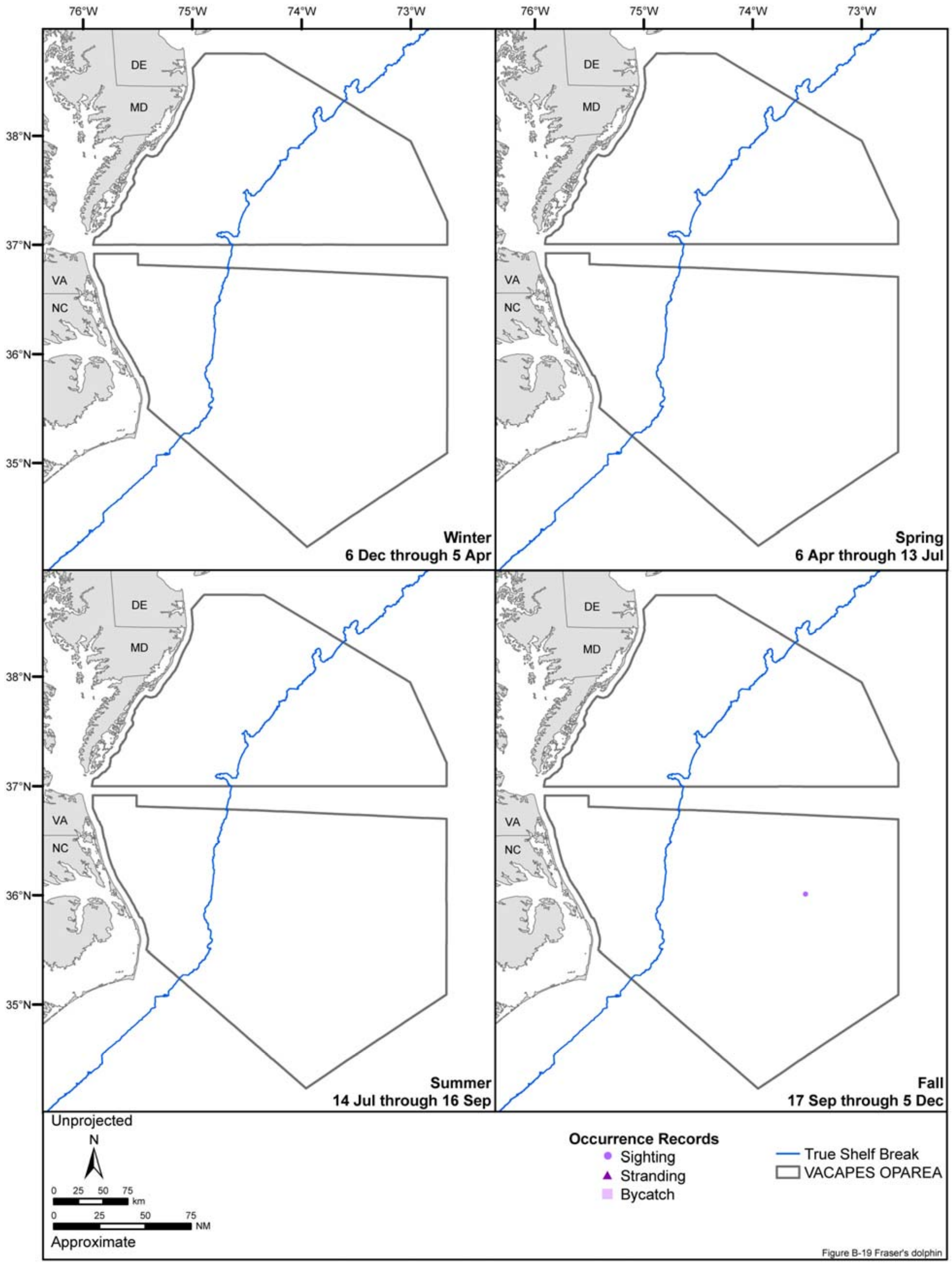

Figure B-19. Seasonal occurrence records of the Fraser's dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

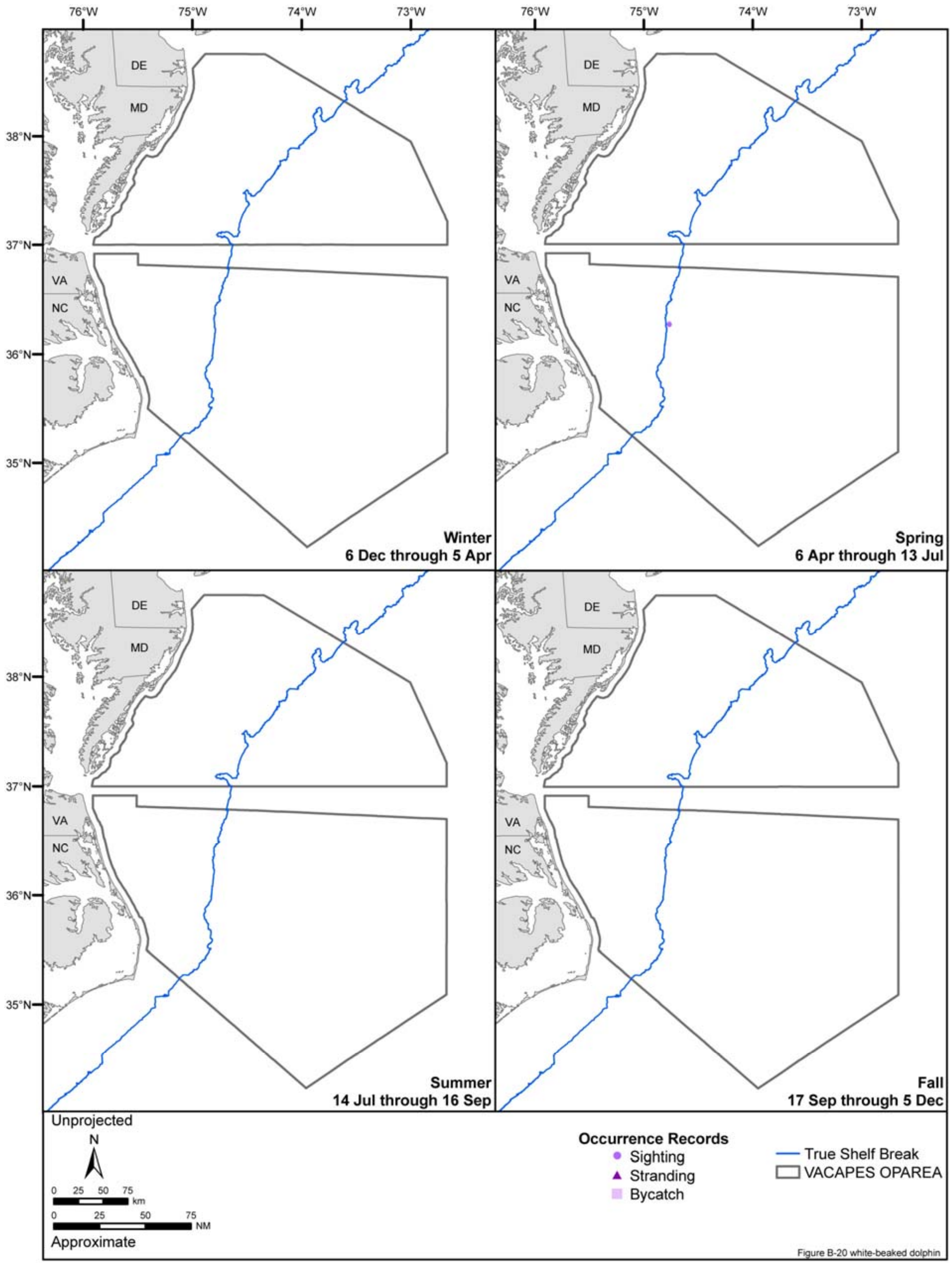

Figure B-20. Seasonal occurrence records of the white-beaked dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

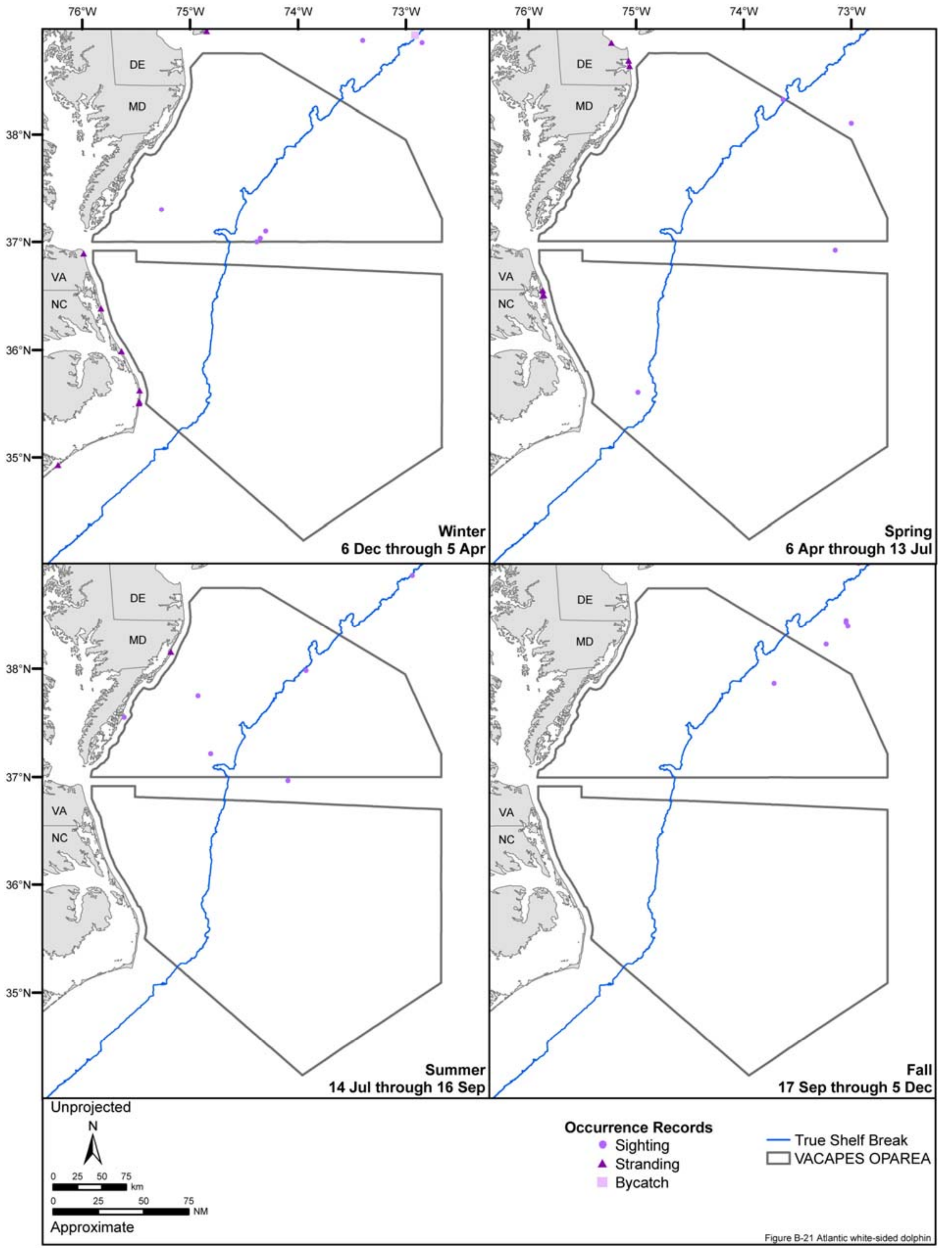

Figure B-21. Seasonal occurrence records of the Atlantic white-sided dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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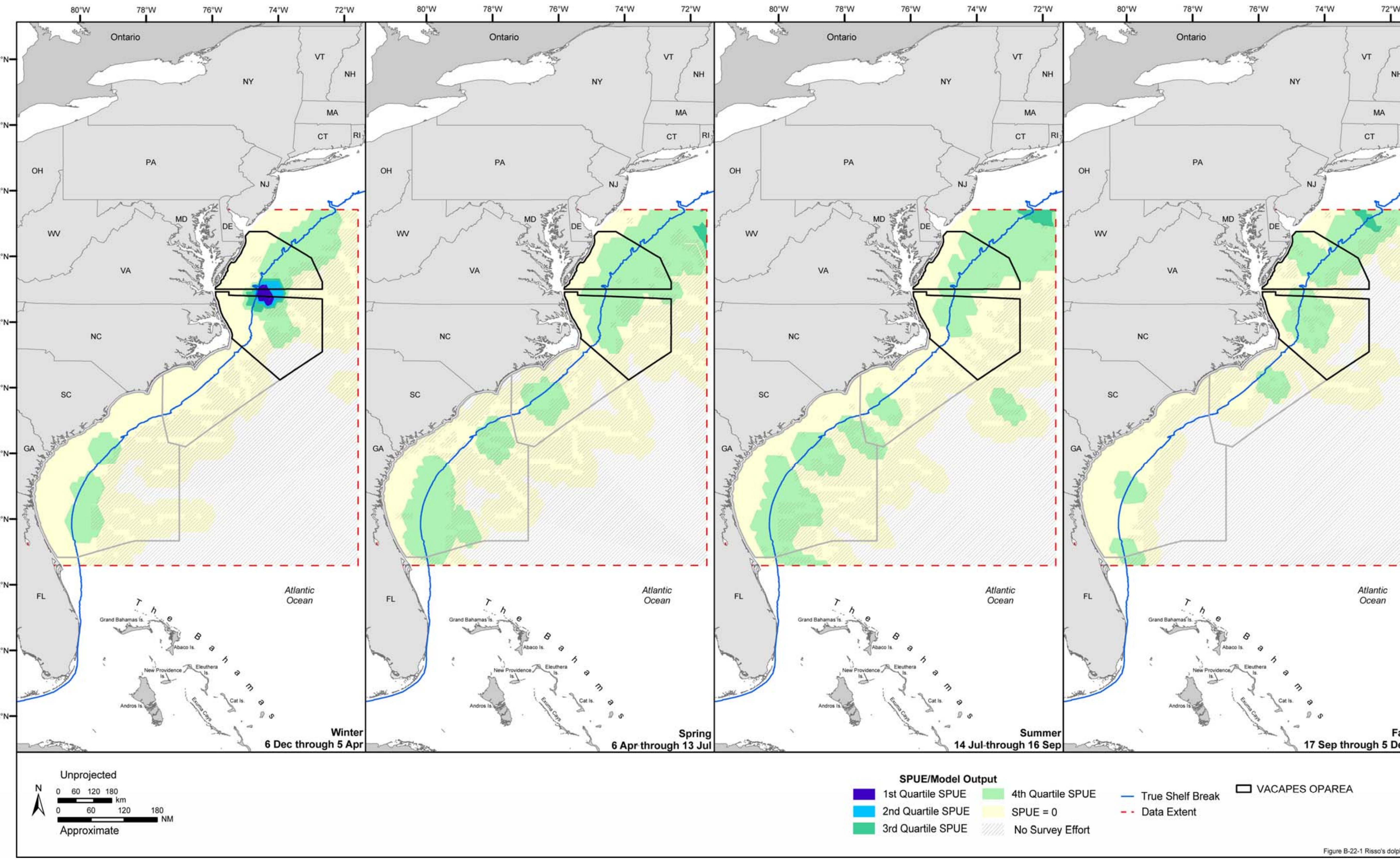

Figure B-22-1. Seasonal SPUE/model output of the Risso's dolphin in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

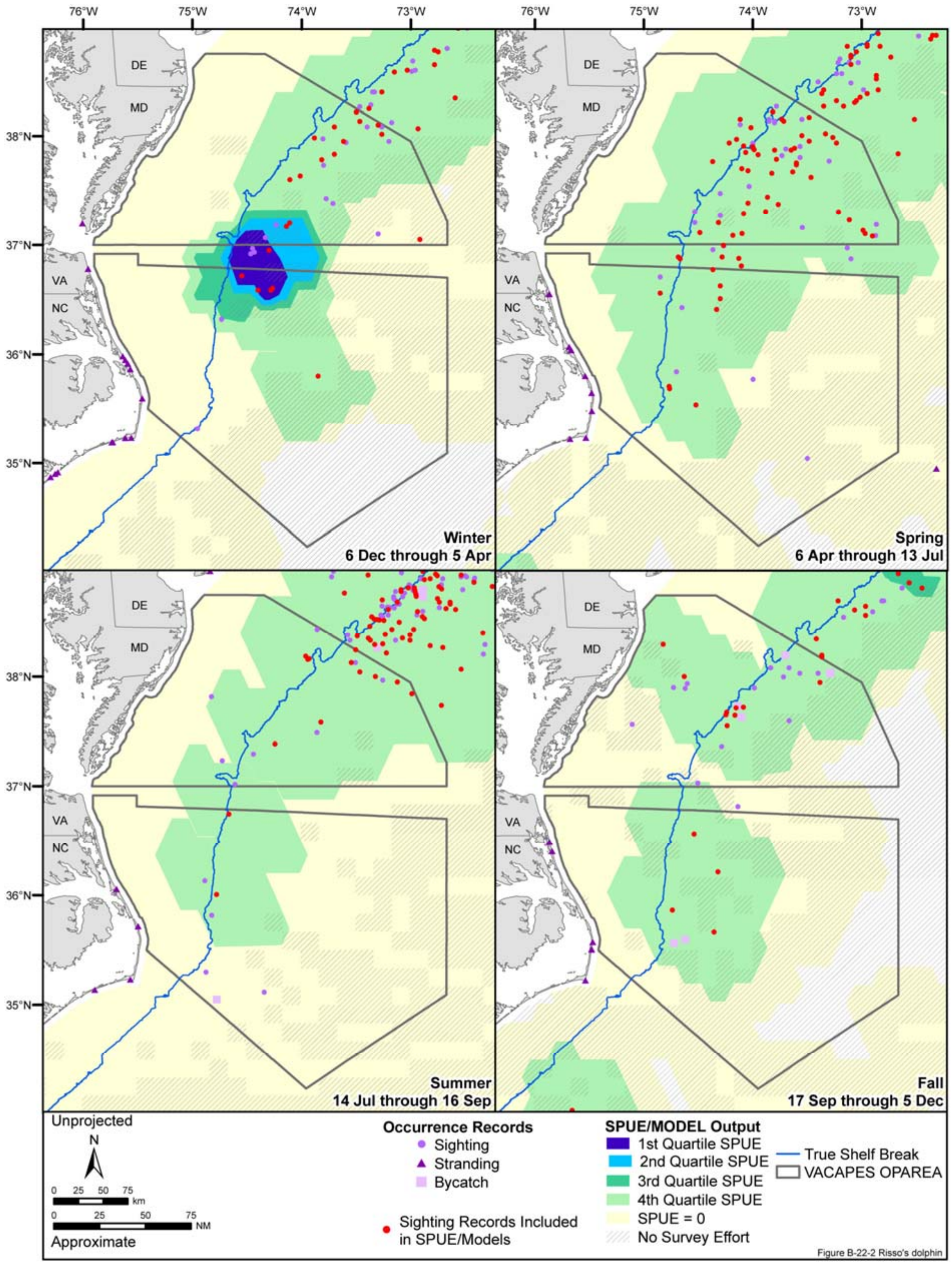

Figure B-22-2. Seasonal occurrence of the Risso's dolphin in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

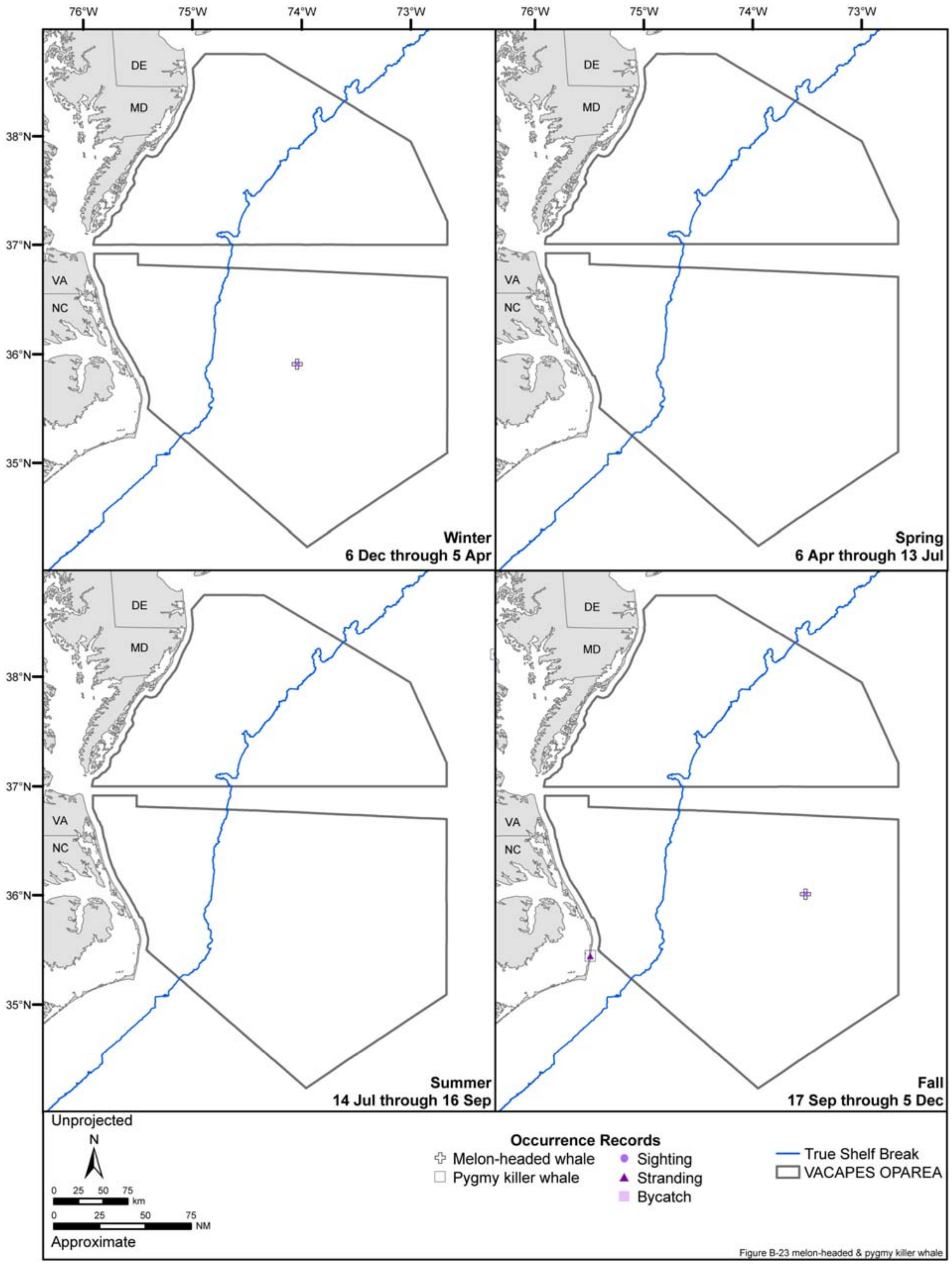

Figure B-23. Seasonal occurrence records of melon-headed and pygmy killer whales in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

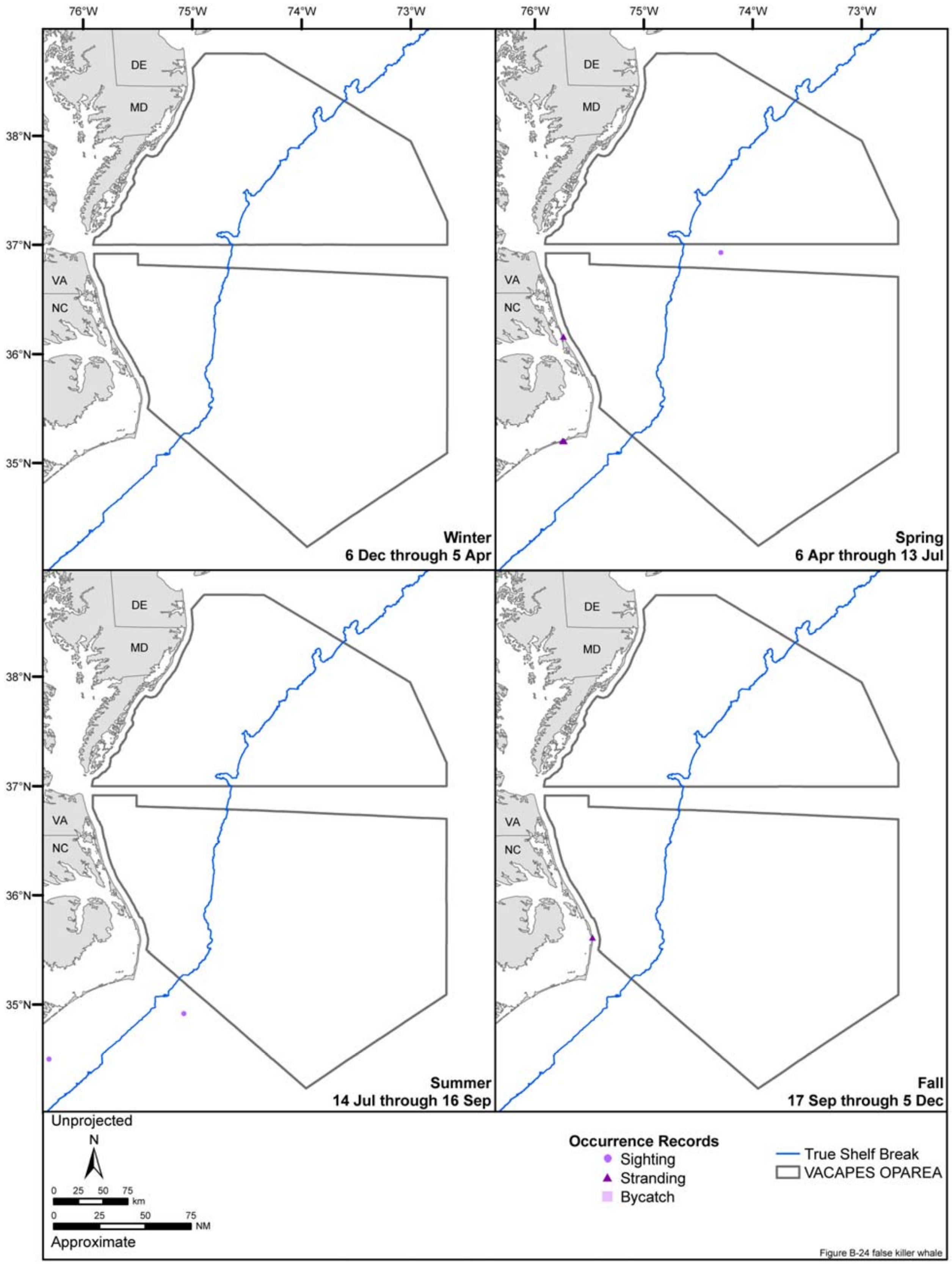

Figure B-24. Seasonal occurrence records of the false killer whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Source data: refer to Table A-1.

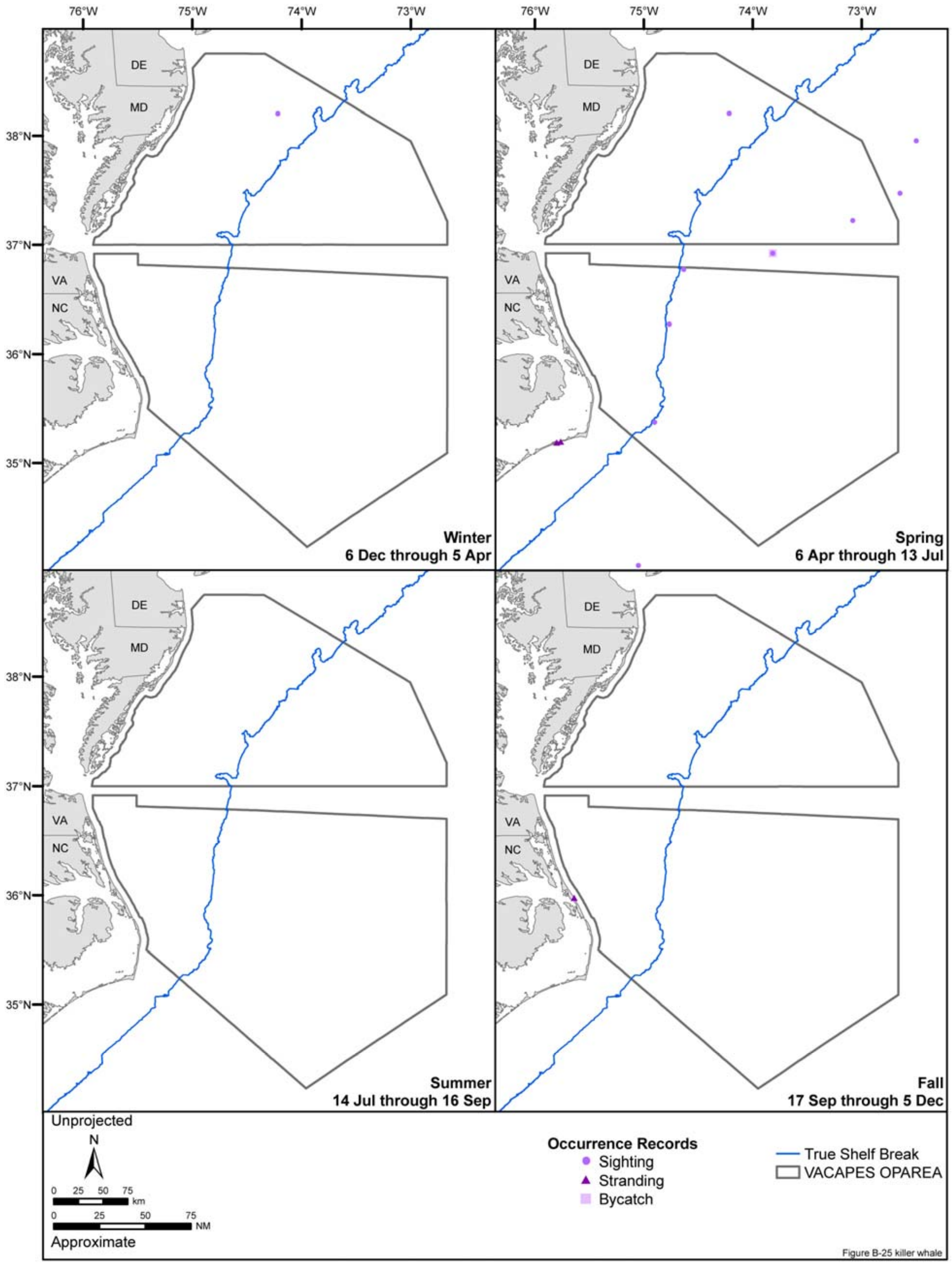

Figure B-25. Seasonal occurrence records of the killer whale in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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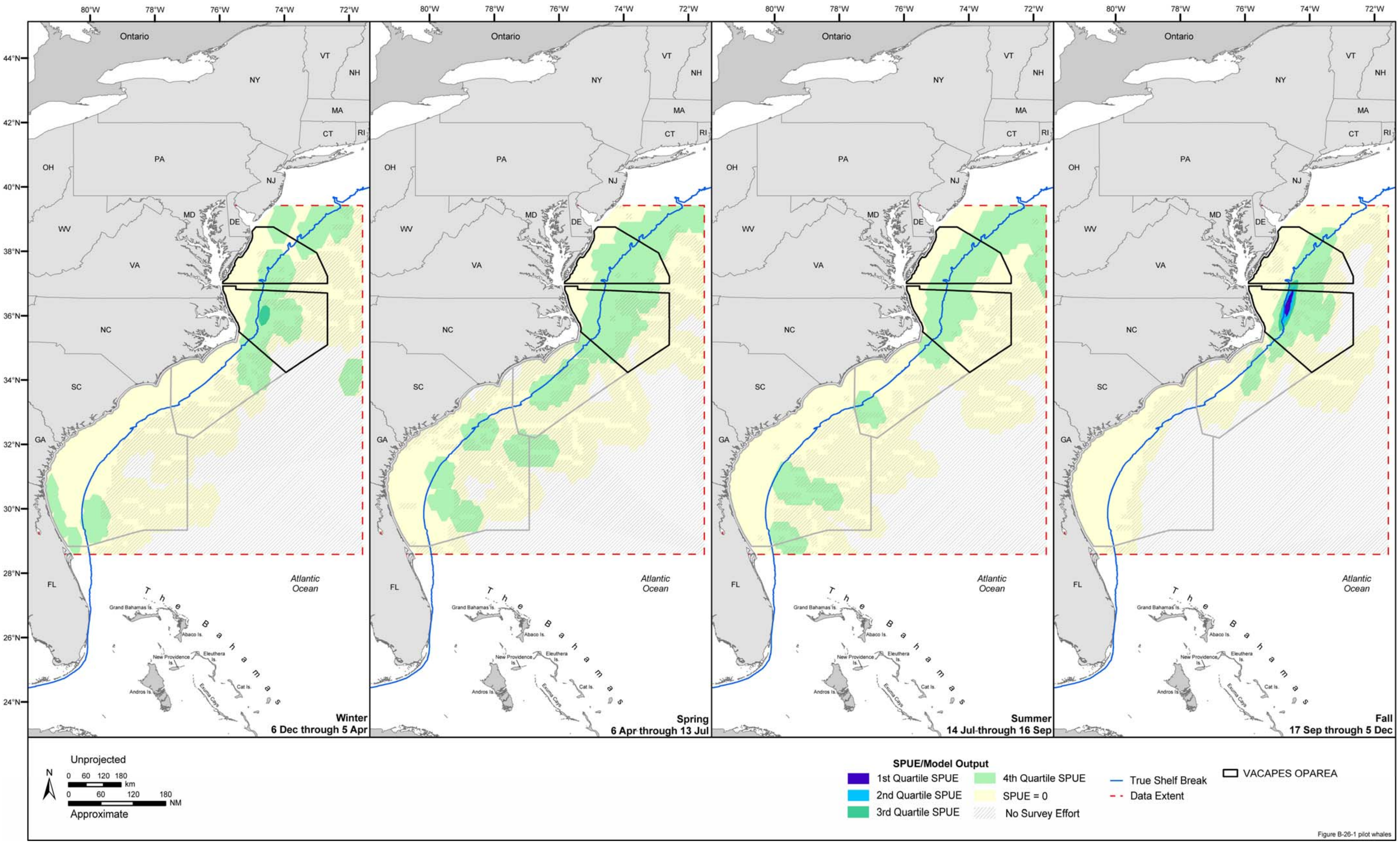

Figure B-26-1. Seasonal SPUE/model output of pilot whales in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

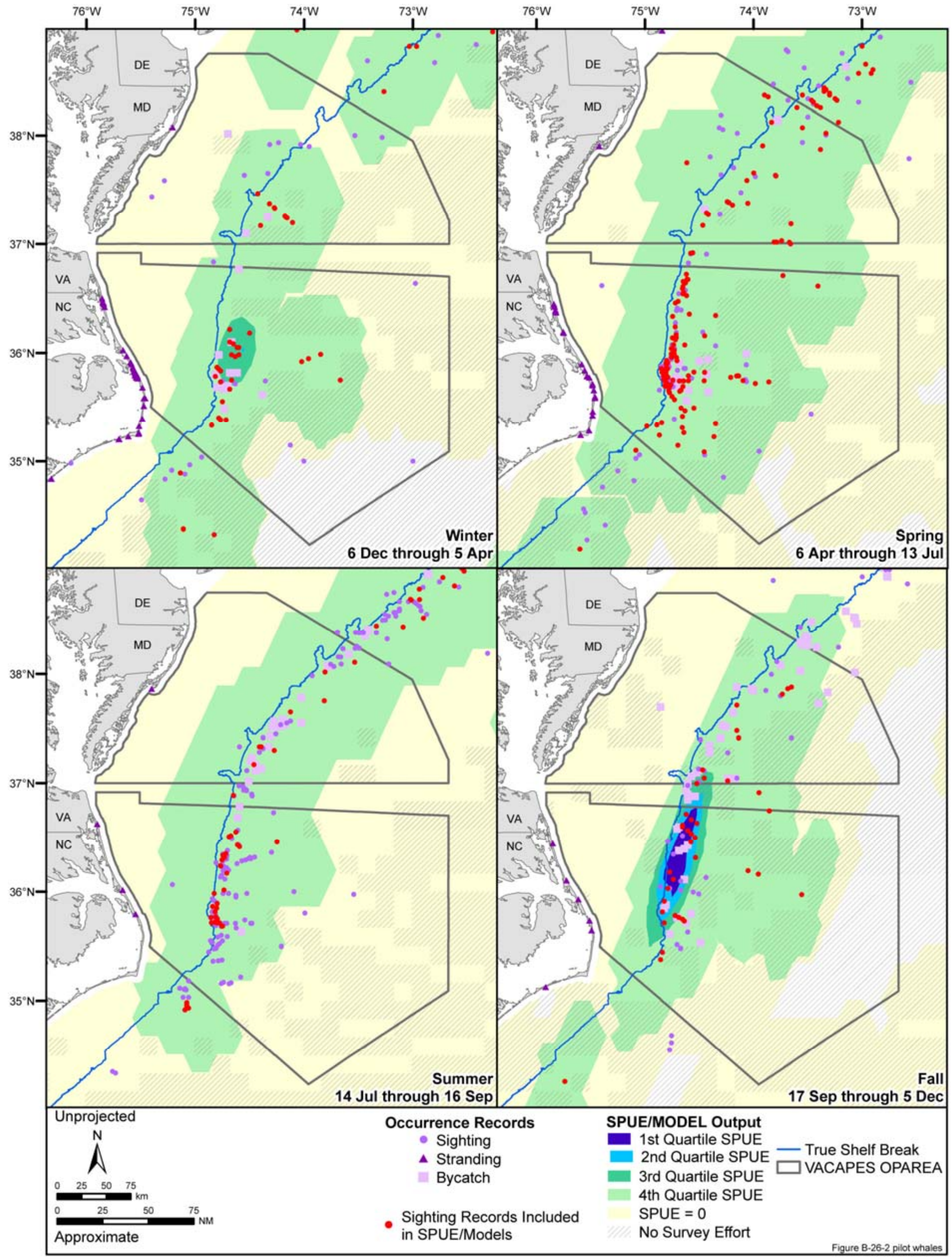

Figure B-26-2. Seasonal occurrence of pilot whales in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

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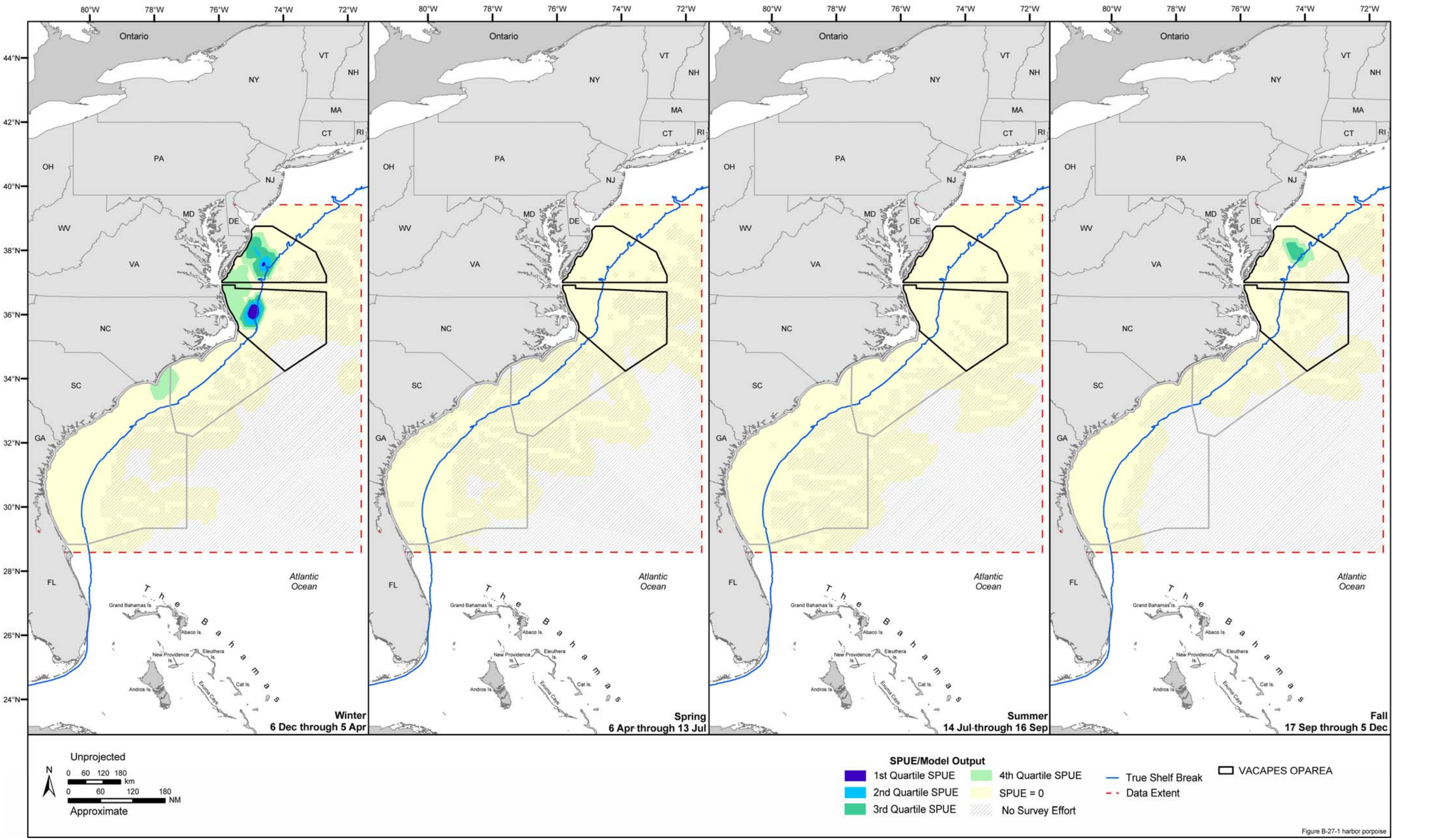

Figure B-27-1. Seasonal SPUE/model output of the harbor porpoise in the Virginia Capes, Cherry Point, and Charleston/Jacksonville OPAREAs. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

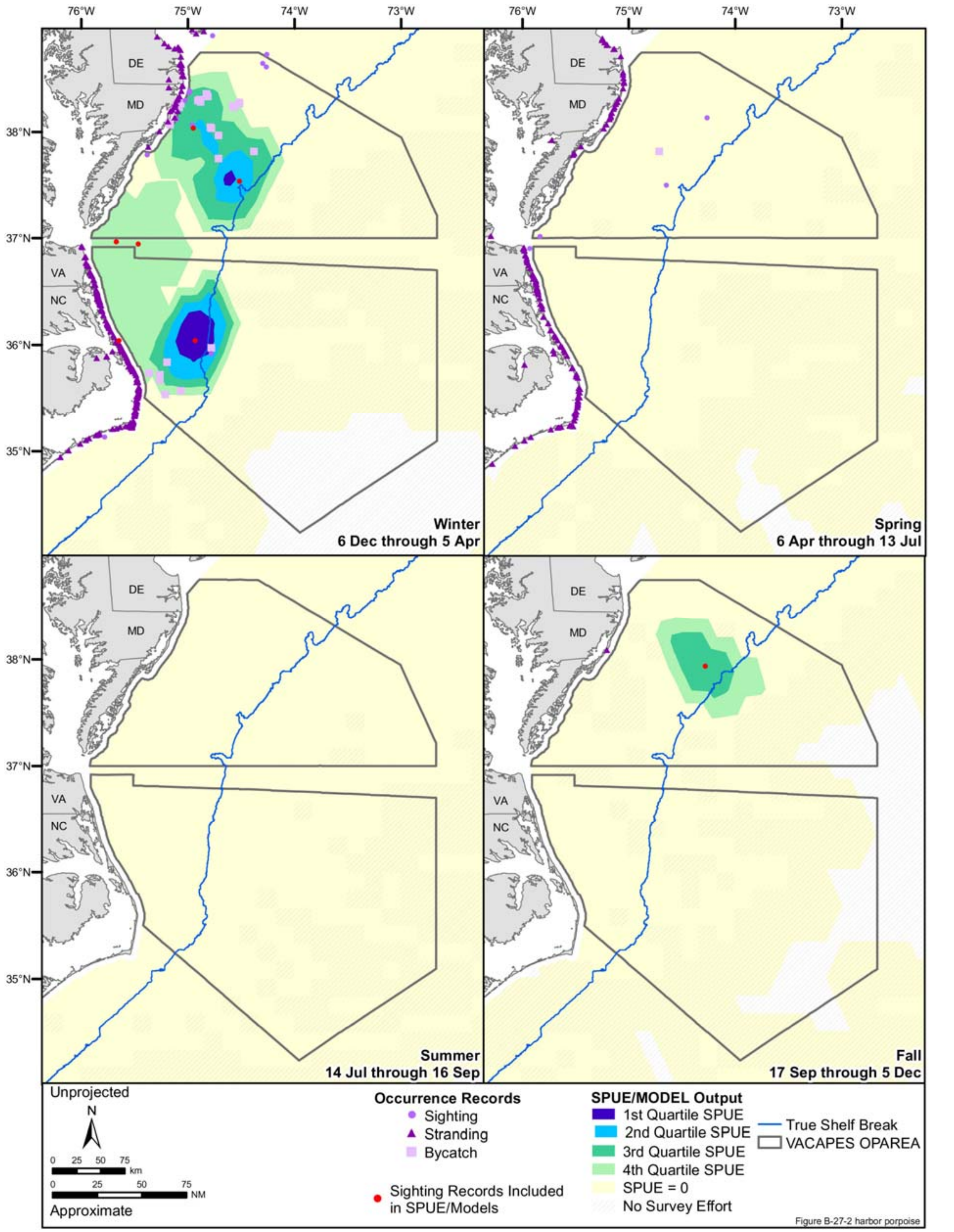

Figure B-27-2. Seasonal occurrence of the harbor porpoise in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch records. Model output was derived using sighting-per-unit-effort (SPUE) data, which were calculated only from line-transect and platform-of-opportunity sighting data. Source data: refer to Table A-1.

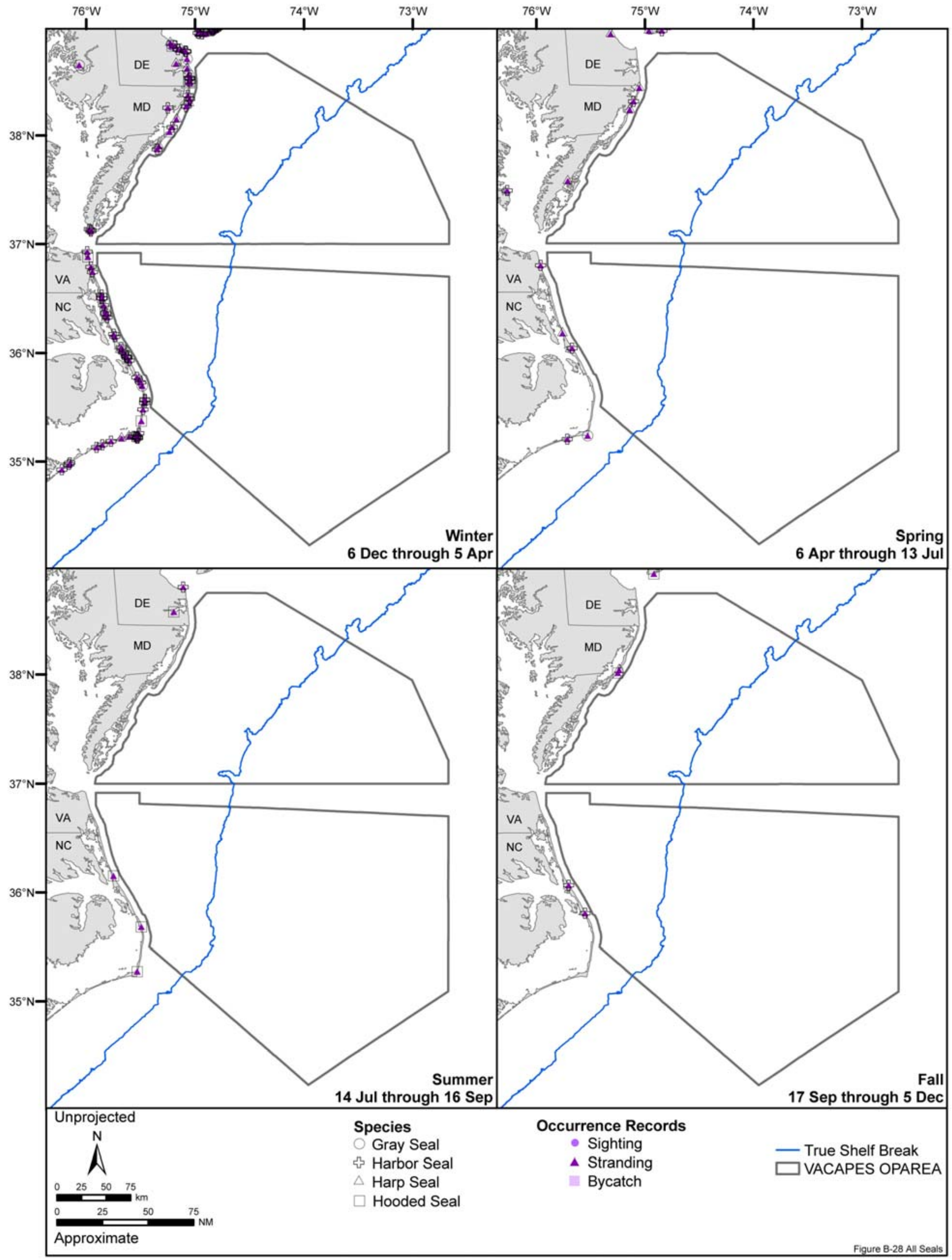

Figure B-28. Seasonal occurrence records of seals in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

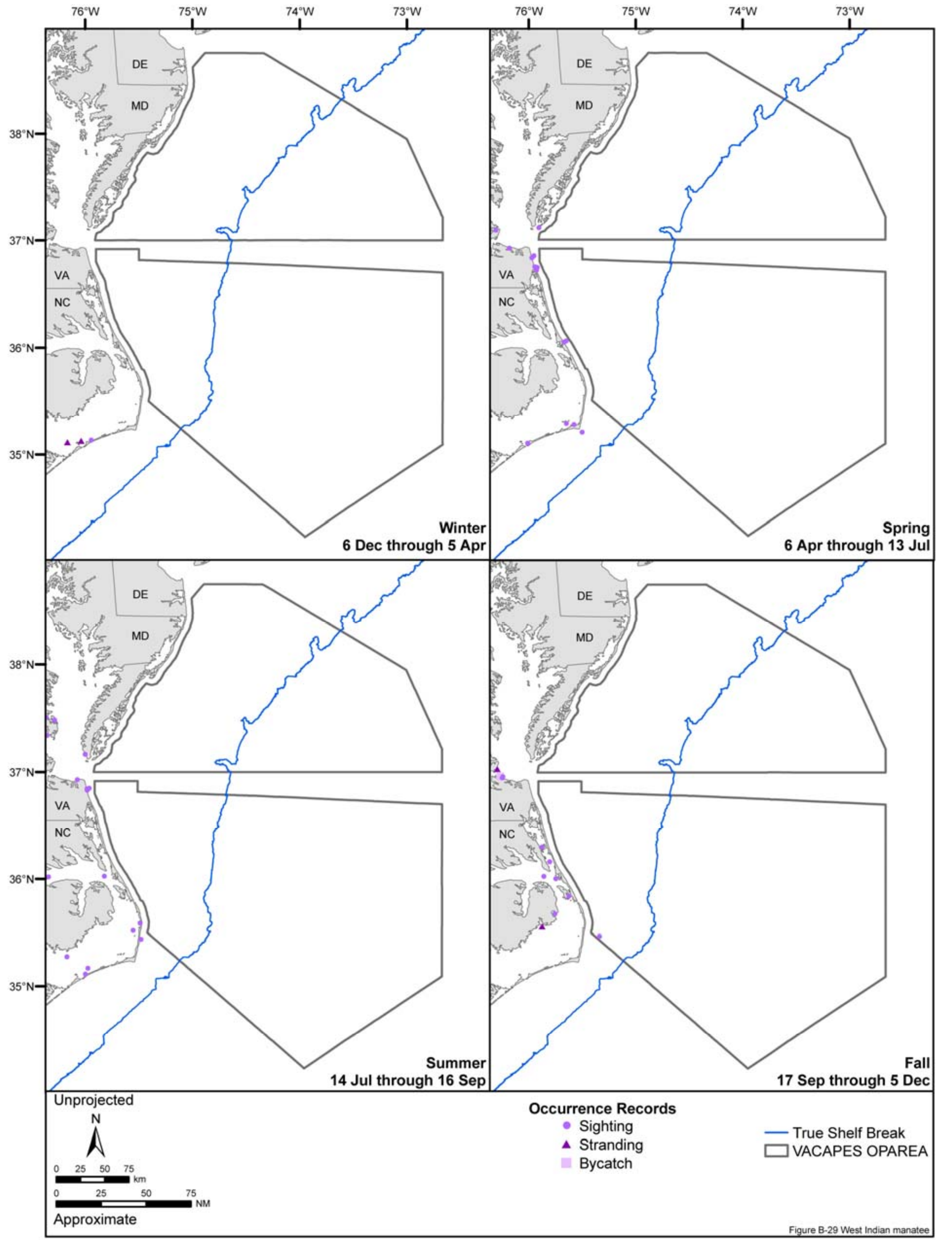

Figure B-29. Seasonal occurrence records of the West Indian manatee in the Virginia Capes OPAREA, including all available sighting, stranding, and incidental fisheries bycatch data. Source data: refer to Table A-1.

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APPENDIX C: SEA TURTLES

List of Figures

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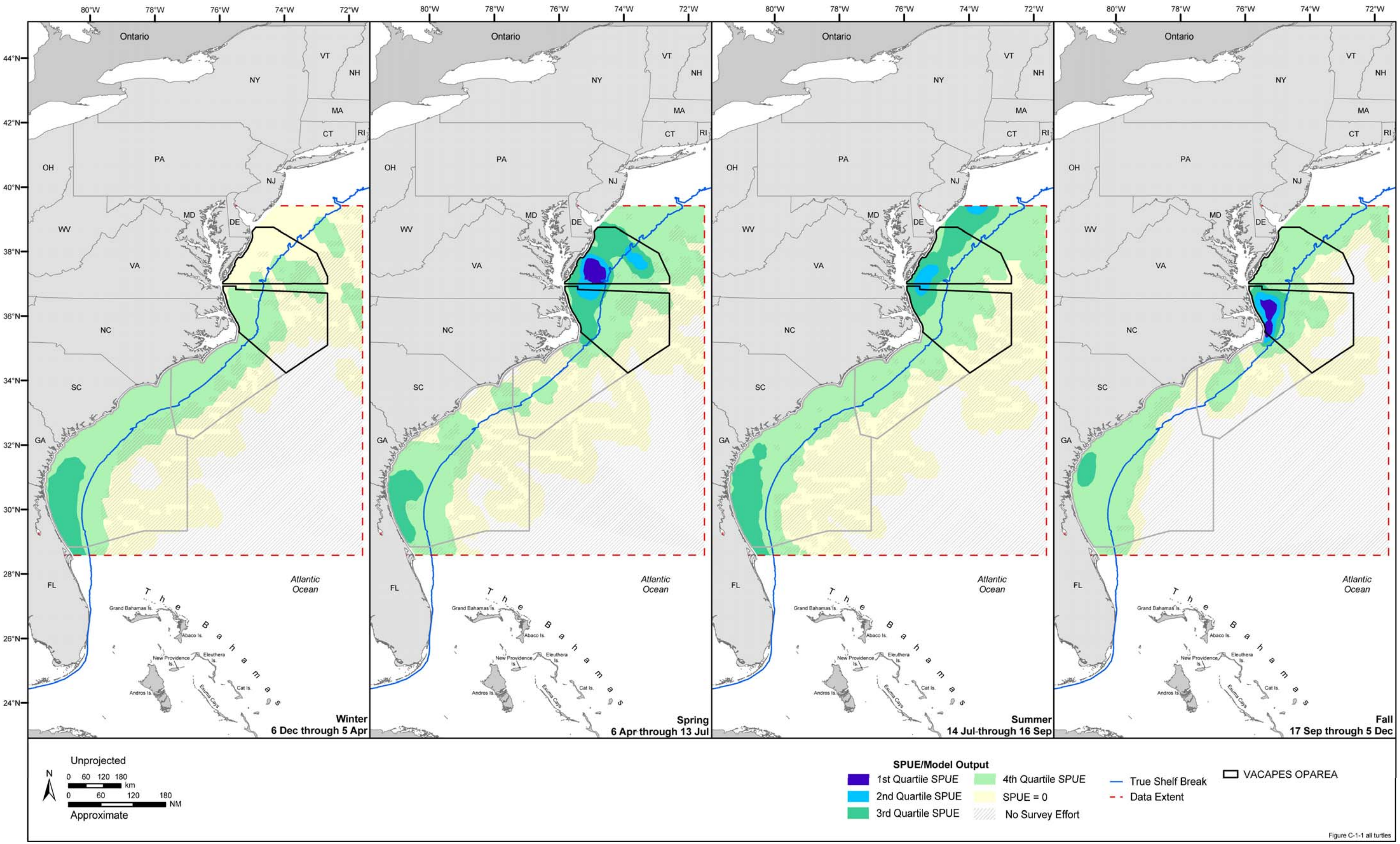

Figure C-1-1. Occurrence model output of all sea turtles in the Virginia Capes, Cherry Point, and Charleston/Jackson OPAREAs.

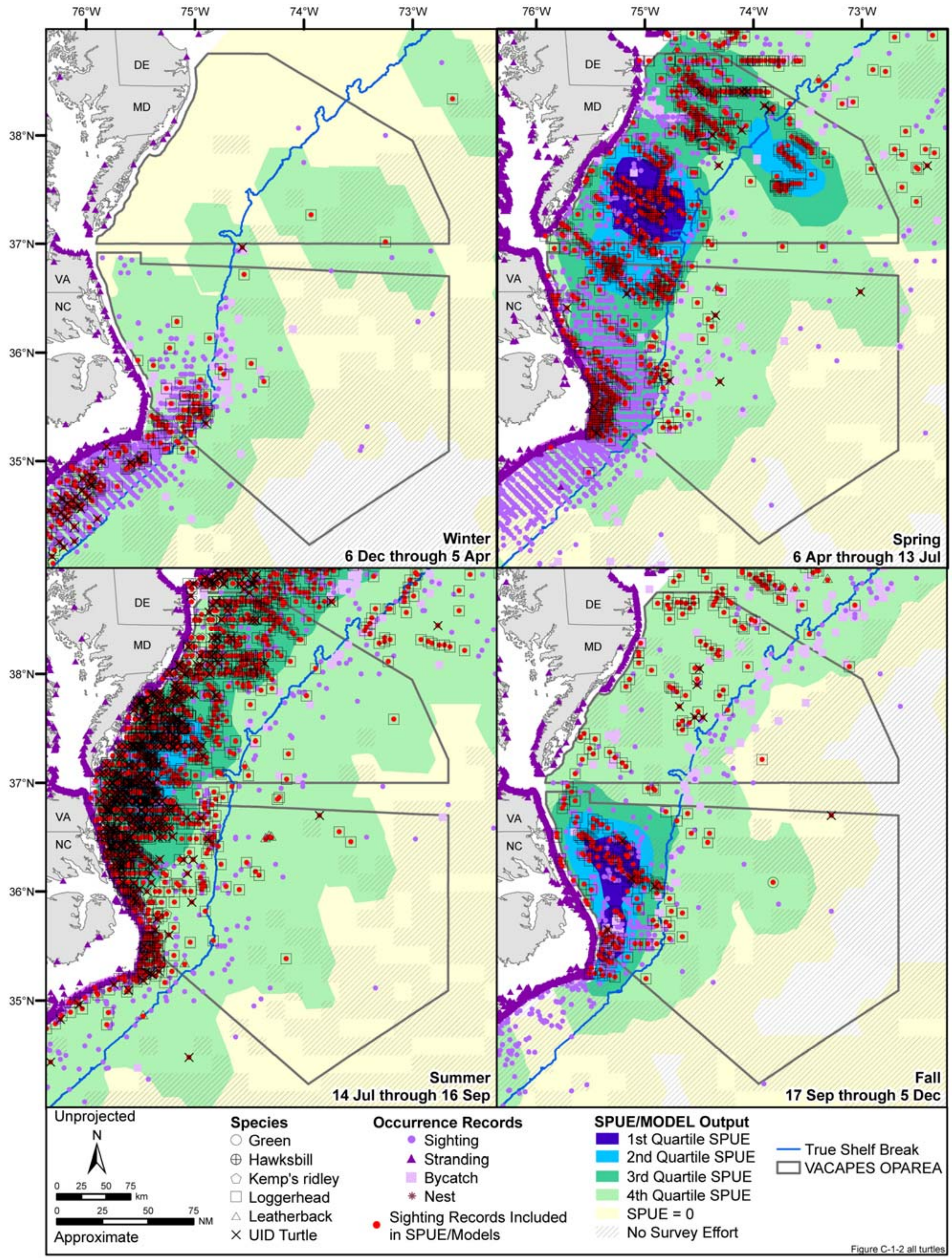

Figure C-1-2. Occurrence records of all sea turtles in the Virginia Capes OPAREA and vicinity.

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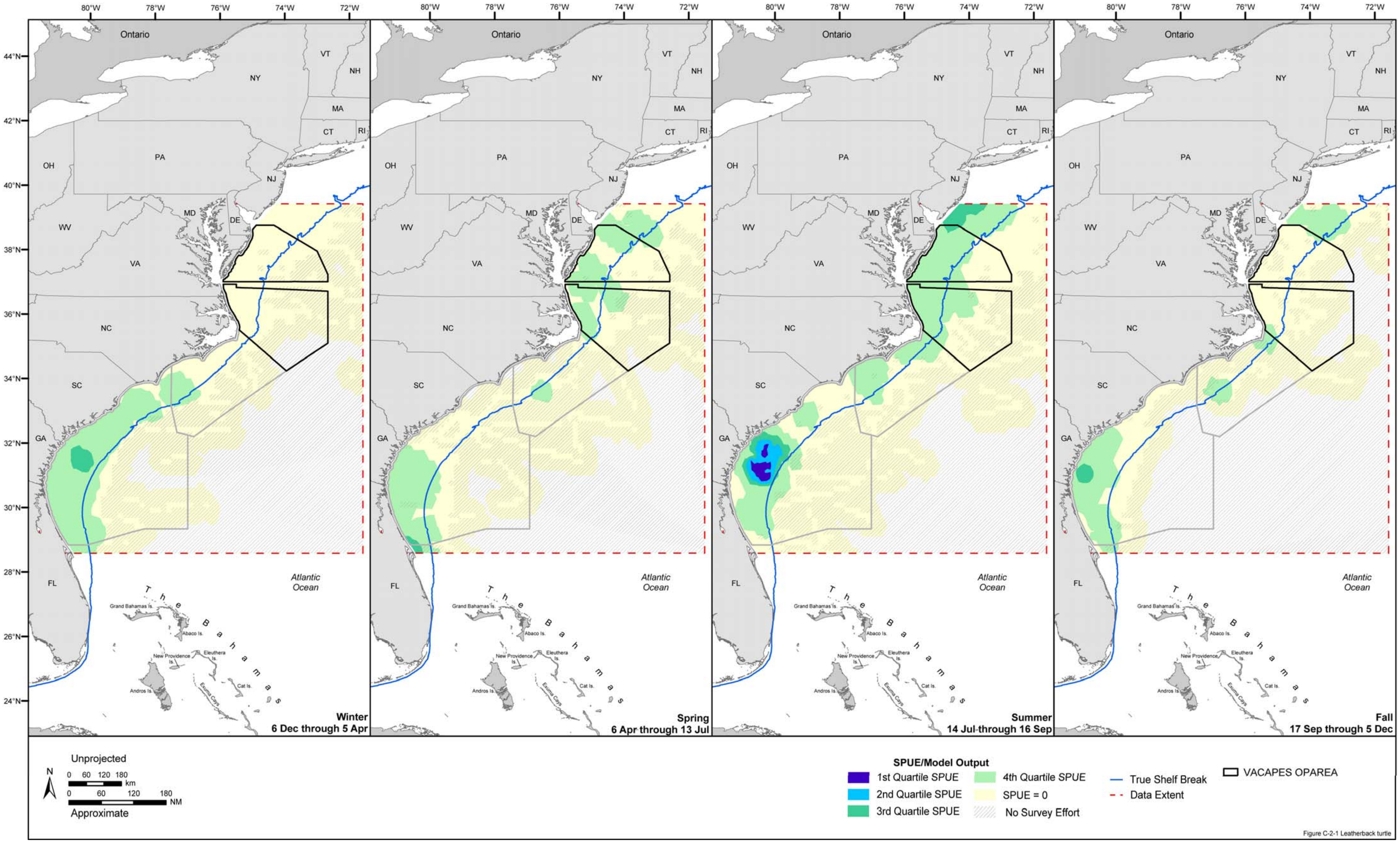

Figure C-2-1. Occurrence model output of the leatherback sea turtle in the Virginia Capes, Cherry Point, and Charleston/Jackson OPAREAs.

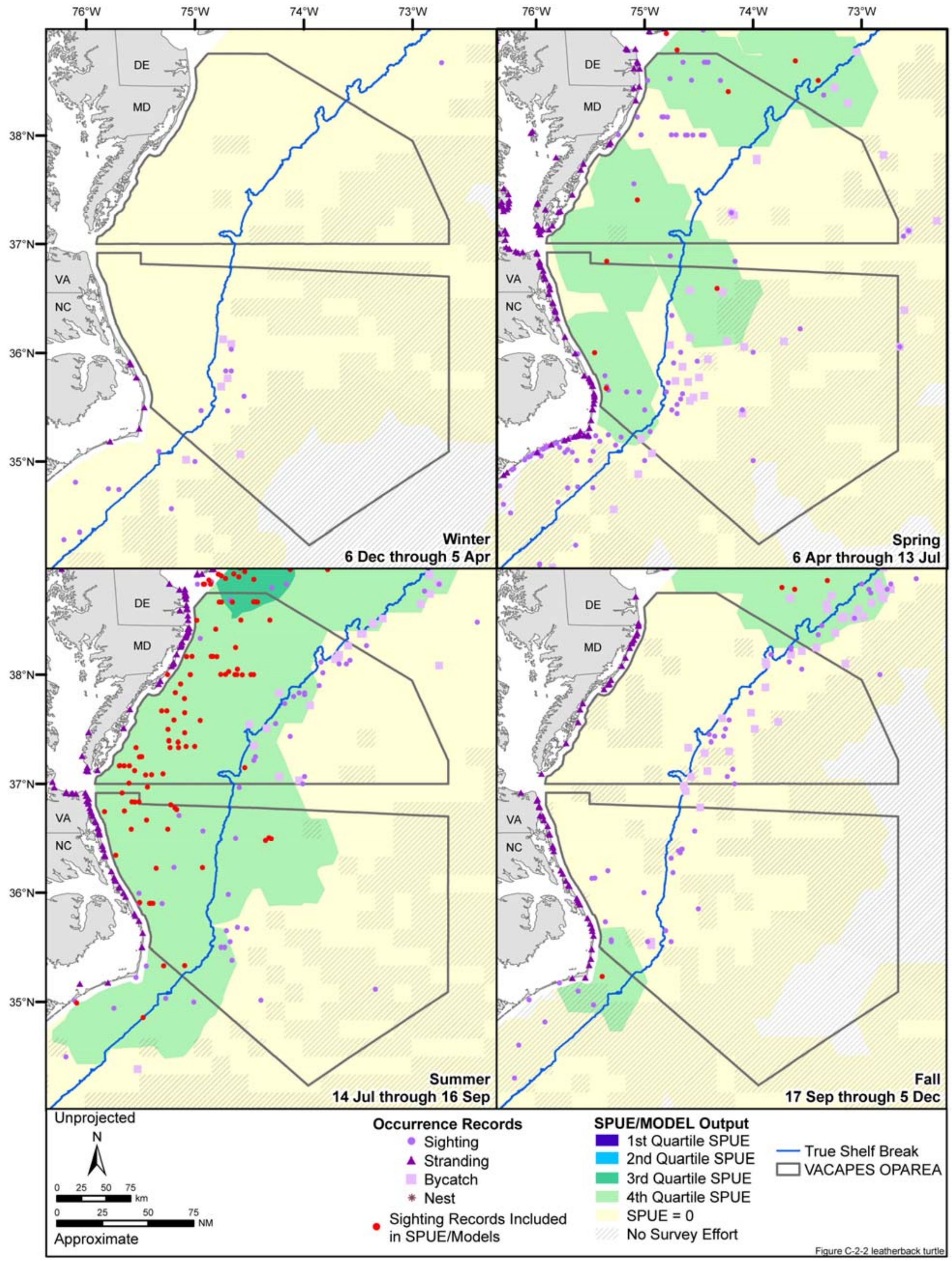

Figure C-2-2. Occurrence records of the leatherback sea turtle in the Virginia Capes OPAREA and vicinity.

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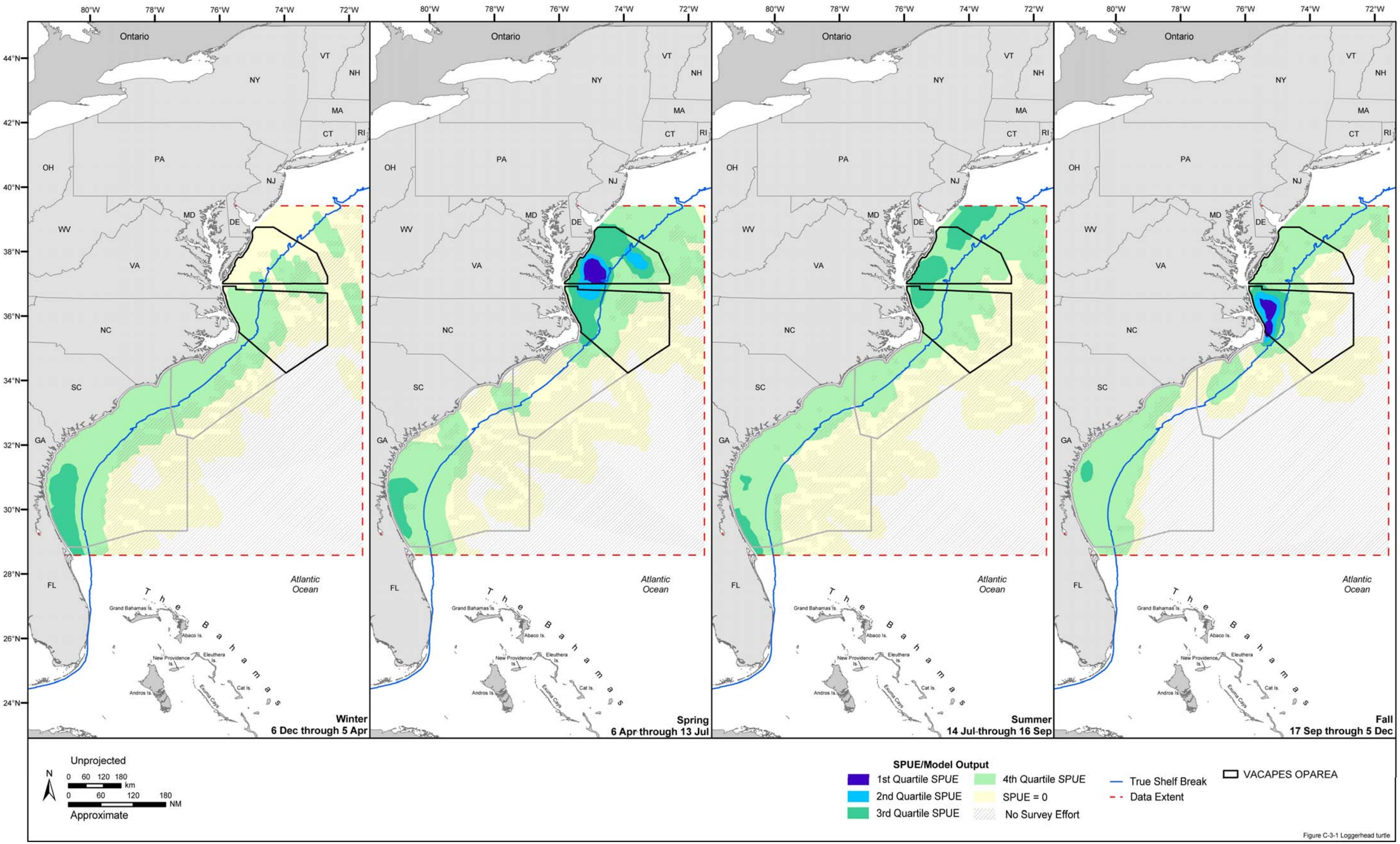

Figure C-3-1. Occurrence model output of the loggerhead sea turtle in the Virginia Capes, Cherry Point, and Charleston/Jackson OPAREAs.

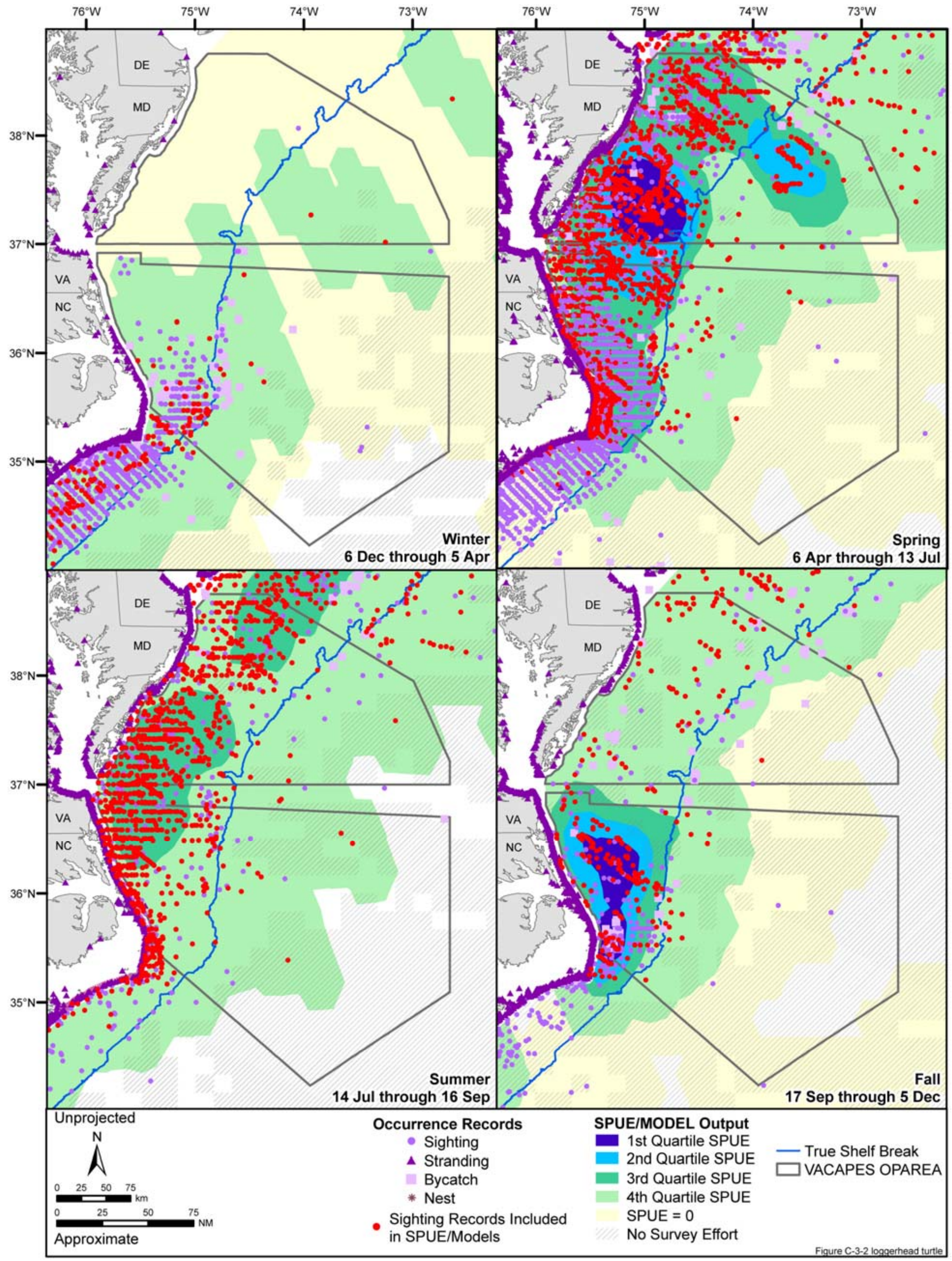

Figure C-3-2. Occurrence records of the loggerhead sea turtle in the Virginia Capes OPAREA and vicinity.

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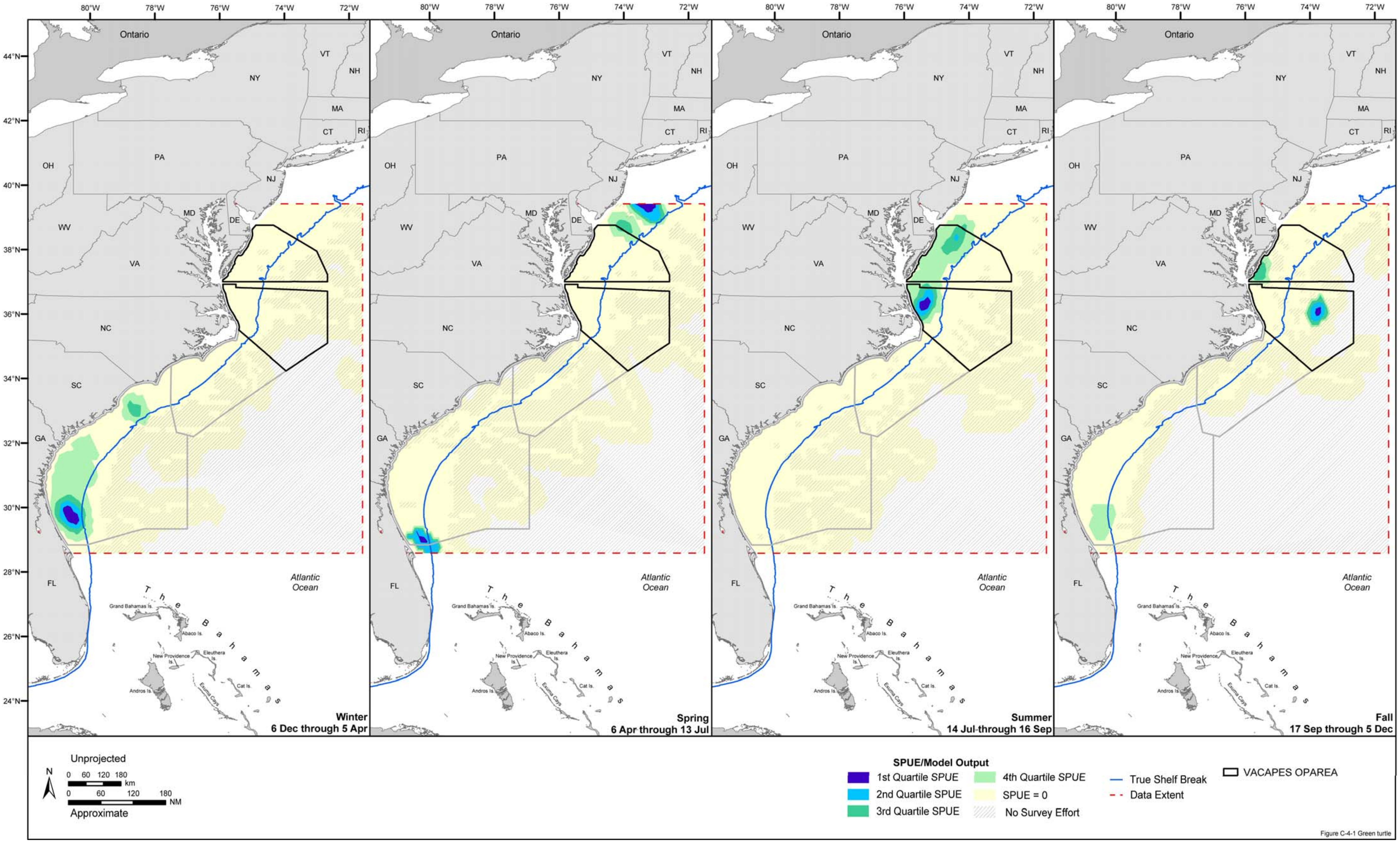

Figure C-4-1. Occurrence model output of the green sea turtle in the Virginia Capes, Cherry Point, and Charleston/Jackson OPAREAs.

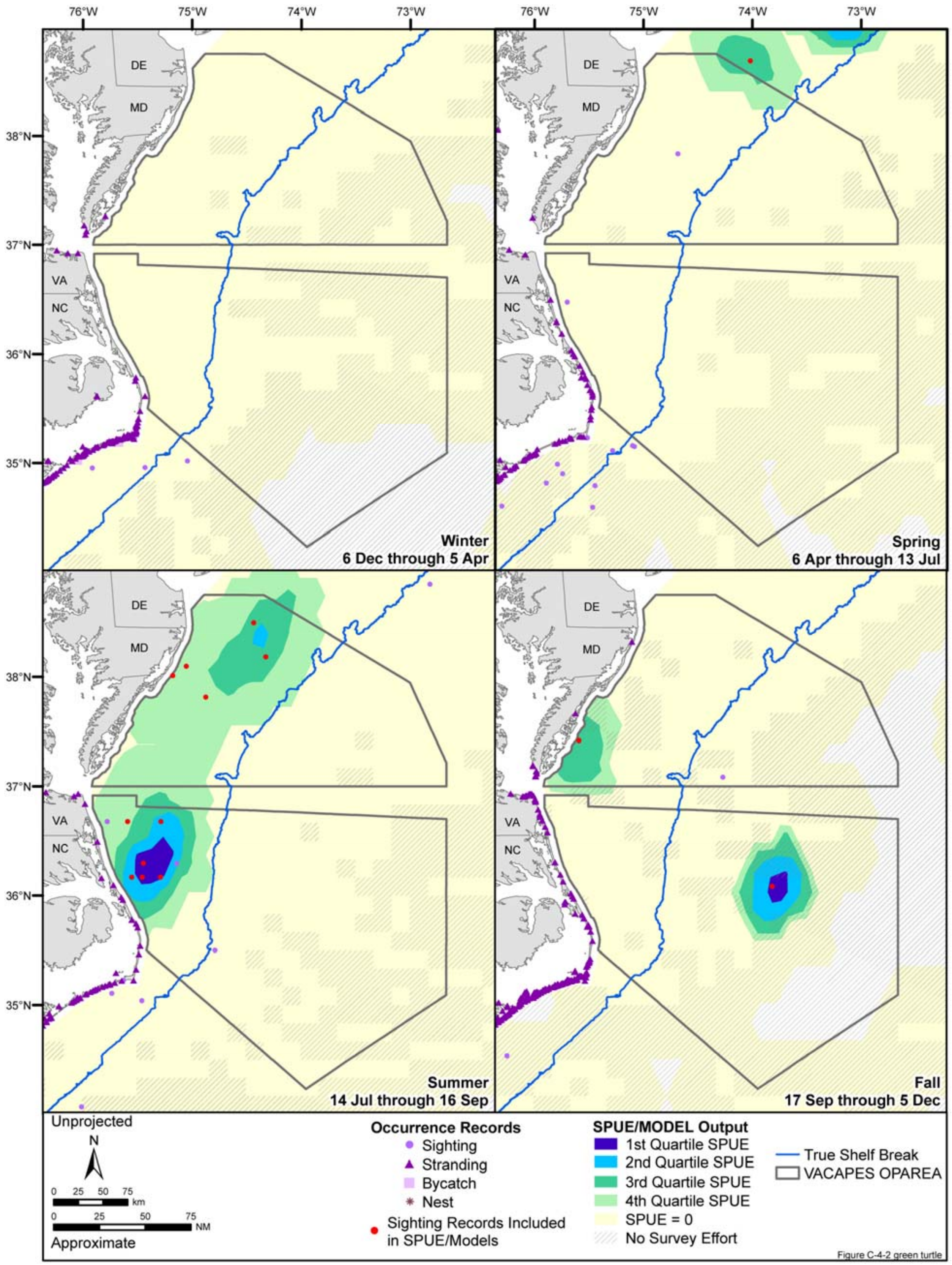

Figure C-4-2. Occurrence records of the green sea turtle in the Virginia Capes OPAREA and vicinity.

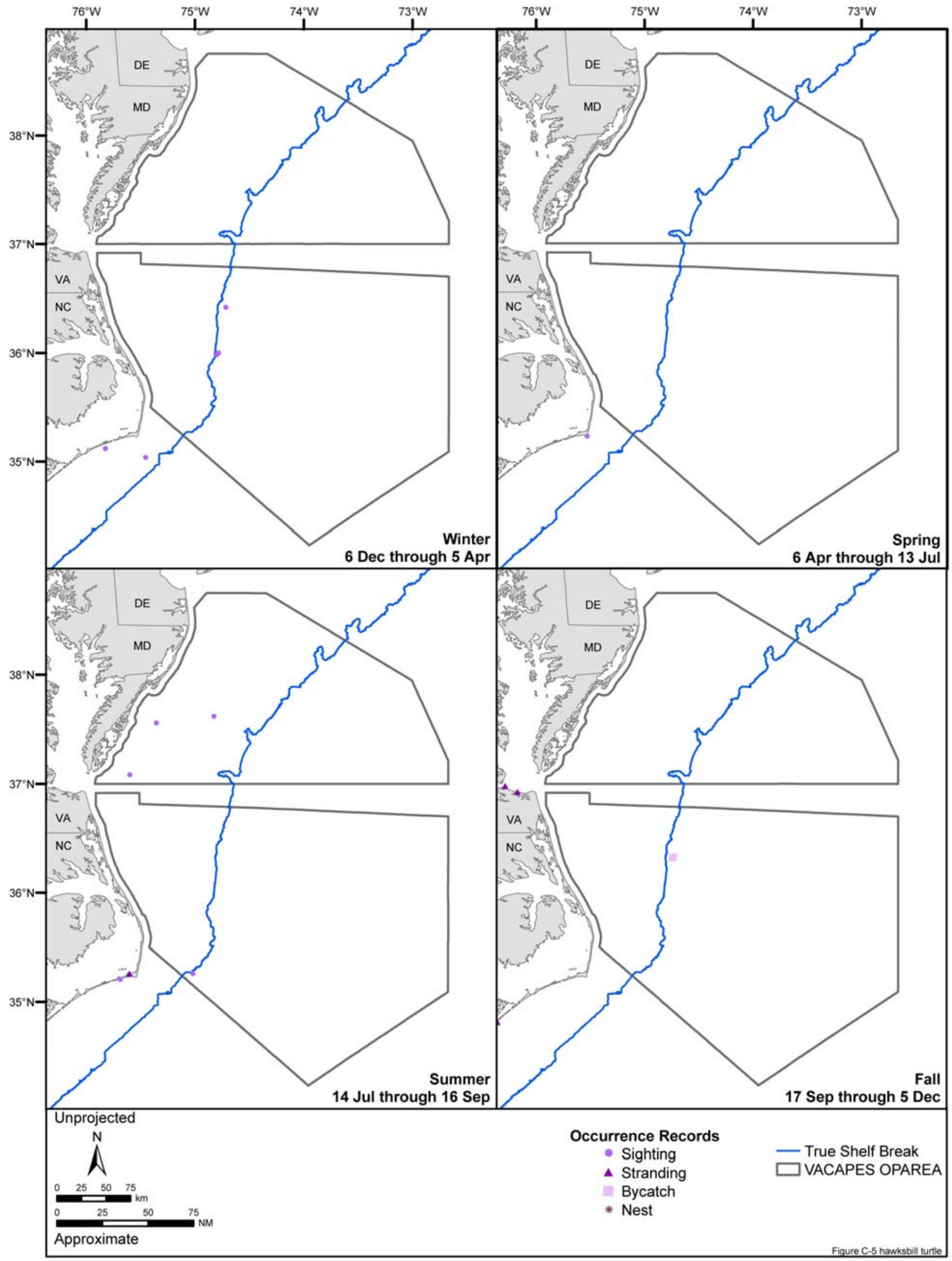

Figure C-5. Occurrence records of the hawksbill sea turtle in the Virginia Capes OPAREA and vicinity.

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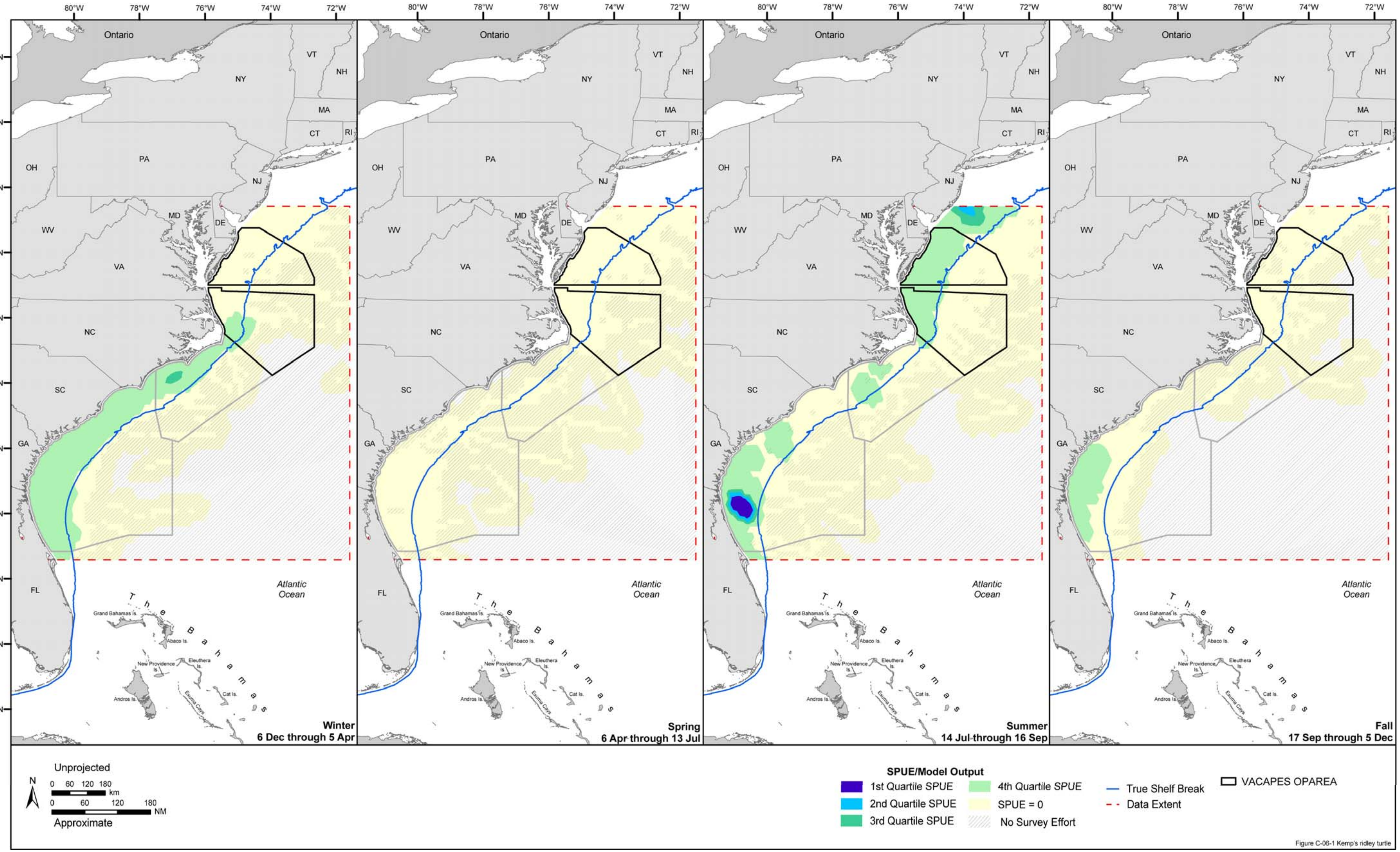

Figure C-6-1. Occurrence model output of the Kemp's ridley sea turtle in the Virginia Capes, Cherry Point, and Charleston/Jackson OPAREAs.

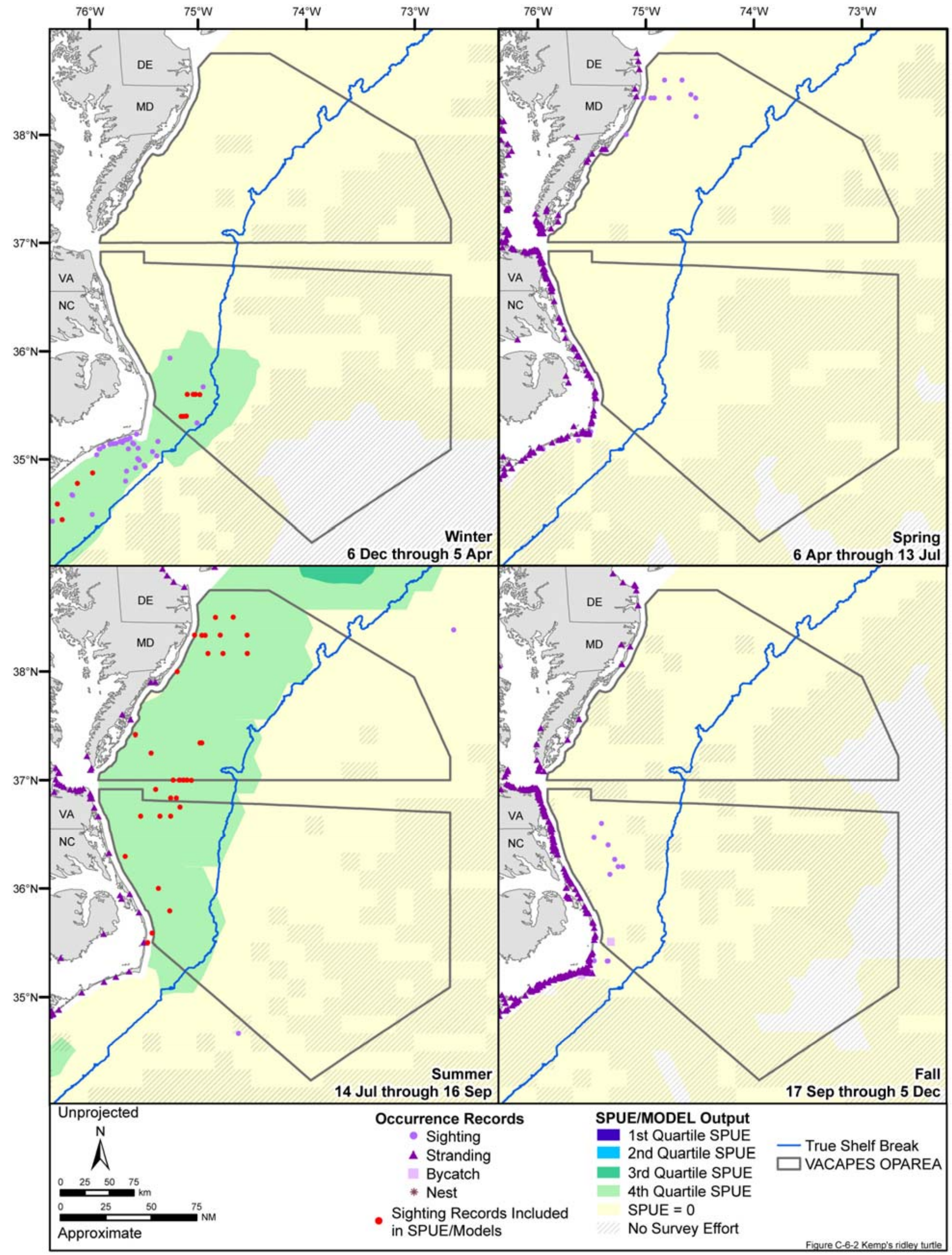

Figure C-6-2. Occurrence records of the Kemp's ridley sea turtle in the Virginia Capes OPAREA and vicinity.

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APPENDIX D: ESSENTIAL FISH HABITAT

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Table D-1. Source data, source maps, and source information used to map EFH and HAPC for subtropical-tropical managed species in the Virginia Capes OPAREA and vicinity.

Figure Number	Species	Source Type
D-32	Blackfin snapper	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAMFC (2003b), NOAA (2002), and GDAIS (2005). Source map (scanned): Huntsman and Mcintyre (1971), BLM (1976), Wenner et al. (1984), and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-33	Blueline tilefish	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source map (scanned): Huntsman and Mcintyre (1971), General Oceanics, Inc. (1986), and Amato (1994). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-37	Cobia, king mackerel, and Spanish mackerel	Source data: SAFMC (2003b) and GDAIS (2005). Source map (scanned): General Oceanics, Inc. (1986). Source information: SAFMC (1998; 2003b) and NMFS (2002).
D-40	Golden deepsea crab	Source maps (scanned): General Oceanics, Inc. (1986). Source information: SAFMC (1998), NMFS (2002), Brouwer (2005).
D-41	Goliath grouper	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), and NCDMF (2005b). Source map (scanned): Huntsman and Macintyre (1971). (1986). Source information: SAFMC (1998, 2003b), NMFS (2002), and Francesconi (2005).
D-42	Gray snapper	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), GDAIS (2005), and NCDMF (2005b). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998, 2003b), NMFS (2002), and Francesconi (2005).
D-43	Greater amberjack	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), NCDMF (2005b), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971), and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003a, 2003b), NMFS (2002), and Francesconi (2005).
D-44	Mutton snapper	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005). Source maps (scanned): Huntsman and Macintyre (1971) and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-46	Red drum	Source data: NOAA (1998), GDNR (2001), FFWCC (2005), GDNR (2005), NCDMF (2005), and SCMRD (2005). Source Information: SAFMC (1998), VMRC (2002), Francesconi (2005), Horn (2005), and VMRC (2005).
D-47	Red porgy	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), and GDAIS (2005). Source maps (scanned): Huntsman and Macintyre (1971), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998) and NMFS (2002).

Table D-1. Source data, source maps, and source information used to map EFH and HAPC for subtropical-tropical managed species in the Virginia Capes OPAREA and vicinity (cont'd).

Figure Number	Species	Source Type
D-48	Red snapper	Source data: Reed (1980), USGS (1993), SEAMAP (2001), and SAFMC (2003b). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998) and NMFS (2002).
D-50	Scamp	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-51	Silk snapper	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), GDAIS (2005), and NCDMF (2005b). Source map (scanned): Huntsman and Macintyre (1971), BLM (1976), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998, 2003b), NMFS (2002), and Francesconi (2005).
D-52	Snowy grouper	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971) and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-53	Speckled hind	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-54	Tilefish	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971) and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-55	Vermillion snapper	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source map (scanned): Huntsman and Macintyre (1971), BLM (1976), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-56	Warsaw grouper	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), GDAIS (2005). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-57	White grunt	Source data: Reed (1980), USGS (1993), SEAMAP (2001), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), General Oceanics, Inc. (1986), and Riggs et al. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).

Table D-1. Source data, source maps, and source information used to map EFH and HAPC for subtropical-tropical managed species in the Virginia Capes OPAREA and vicinity (cont'd).

Figure Number	Species	Source Type
D-59	Wreckfish	Source data: Reed (1980), USGS (1993), SAFMC (2003b), and GDAIS (2005). Source maps (scanned): Huntsman and Macintyre (1971) and General Oceanics, Inc. (1986).Source information: SAFMC (1998, 2003b) and NMFS (2002).
D-60	Yellowedge grouper	Source data: Reed (1980), USGS (1993), SAFMC (2003b), GDAIS (2005), and Sedberry (2005). Source maps (scanned): Huntsman and Macintyre (1971), BLM (1976), and General Oceanics, Inc. (1986). Source information: SAFMC (1998, 2003b) and NMFS (2002).

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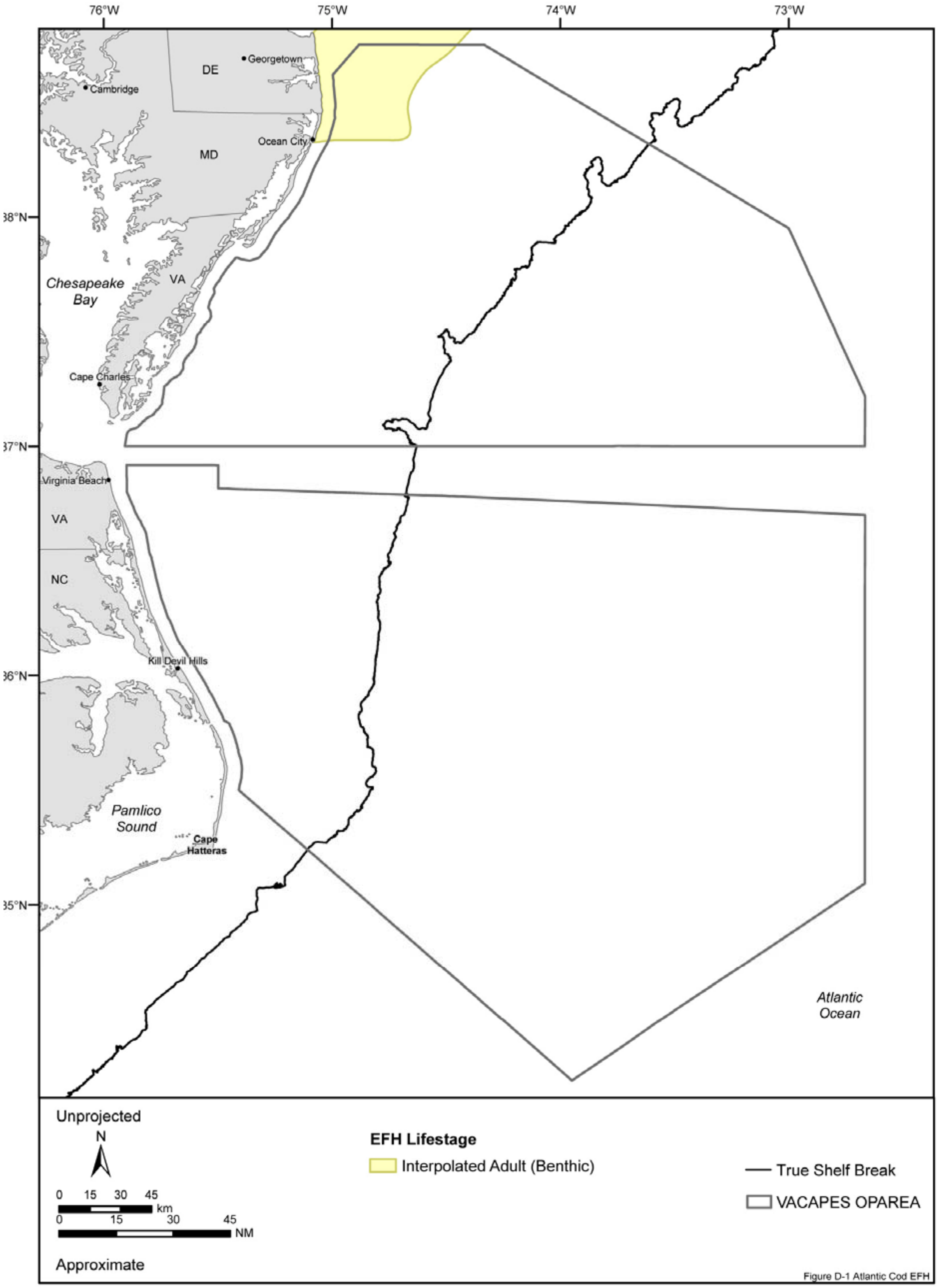

Figure D-1. Essential fish habitat for all lifestages of the Atlantic cod designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

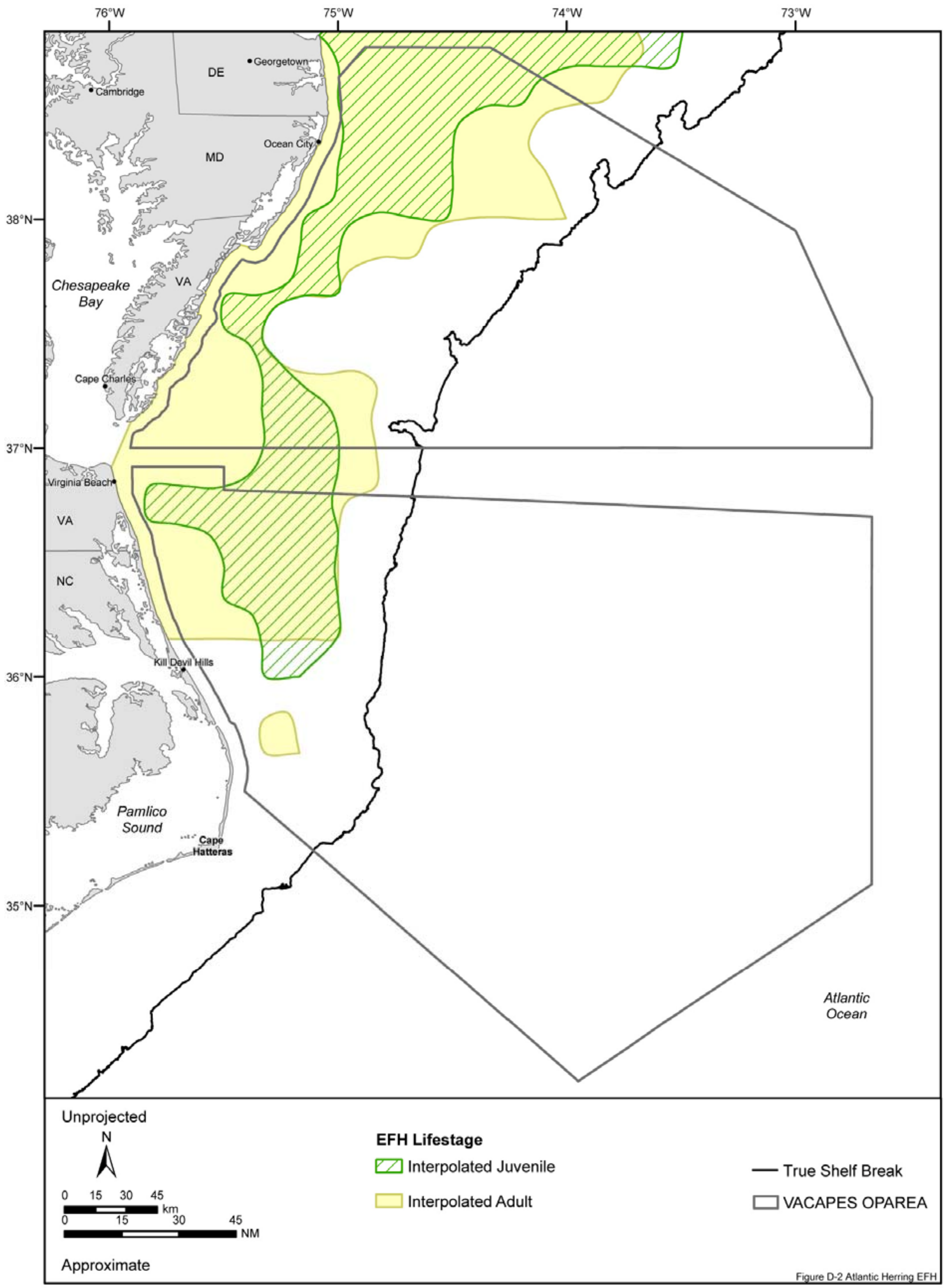

Figure D-2. Essential fish habitat for all lifestages of the Atlantic herring designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

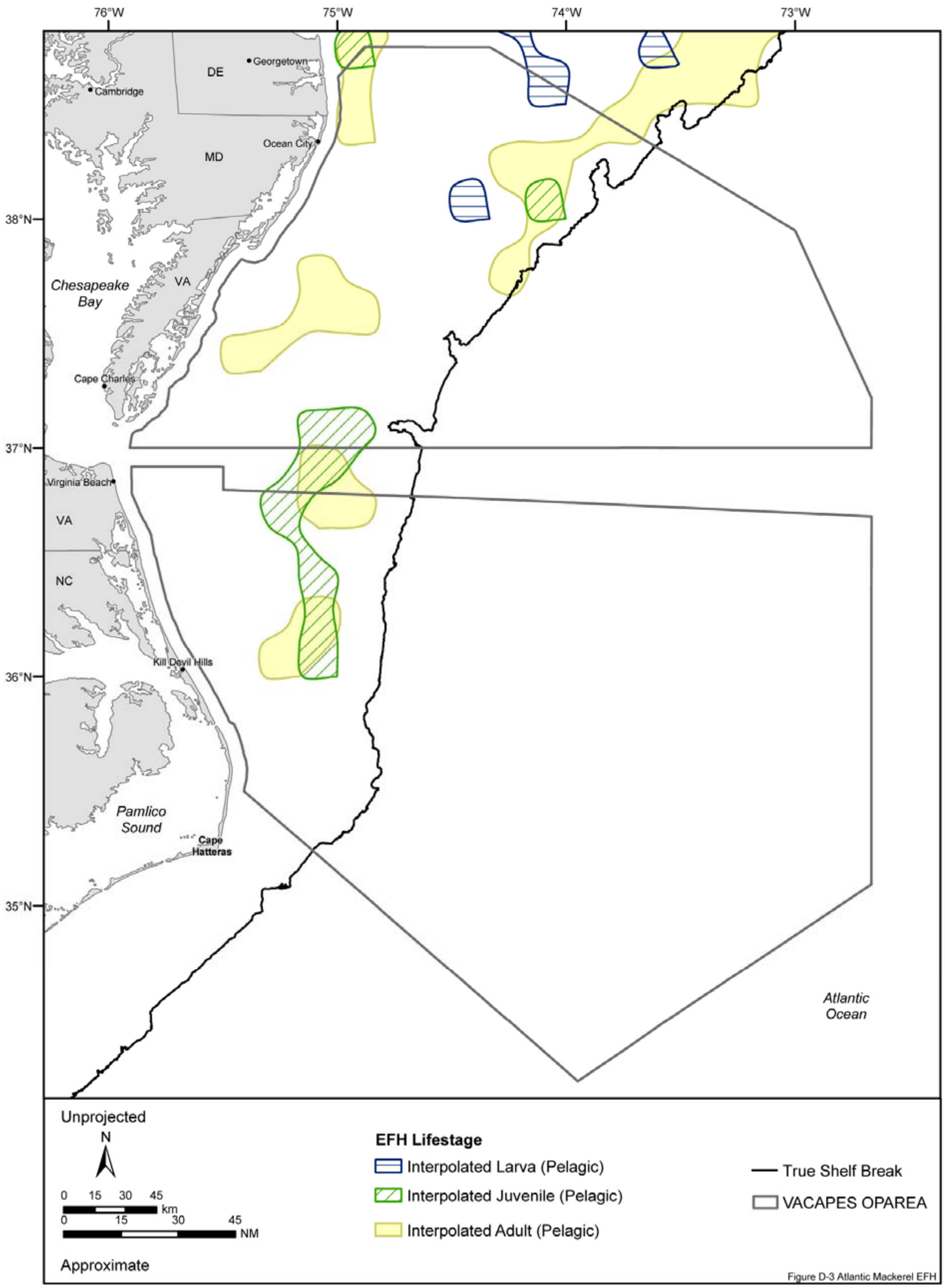

Figure D-3. Essential fish habitat for all lifestages of the Atlantic mackerel designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC (1998a).

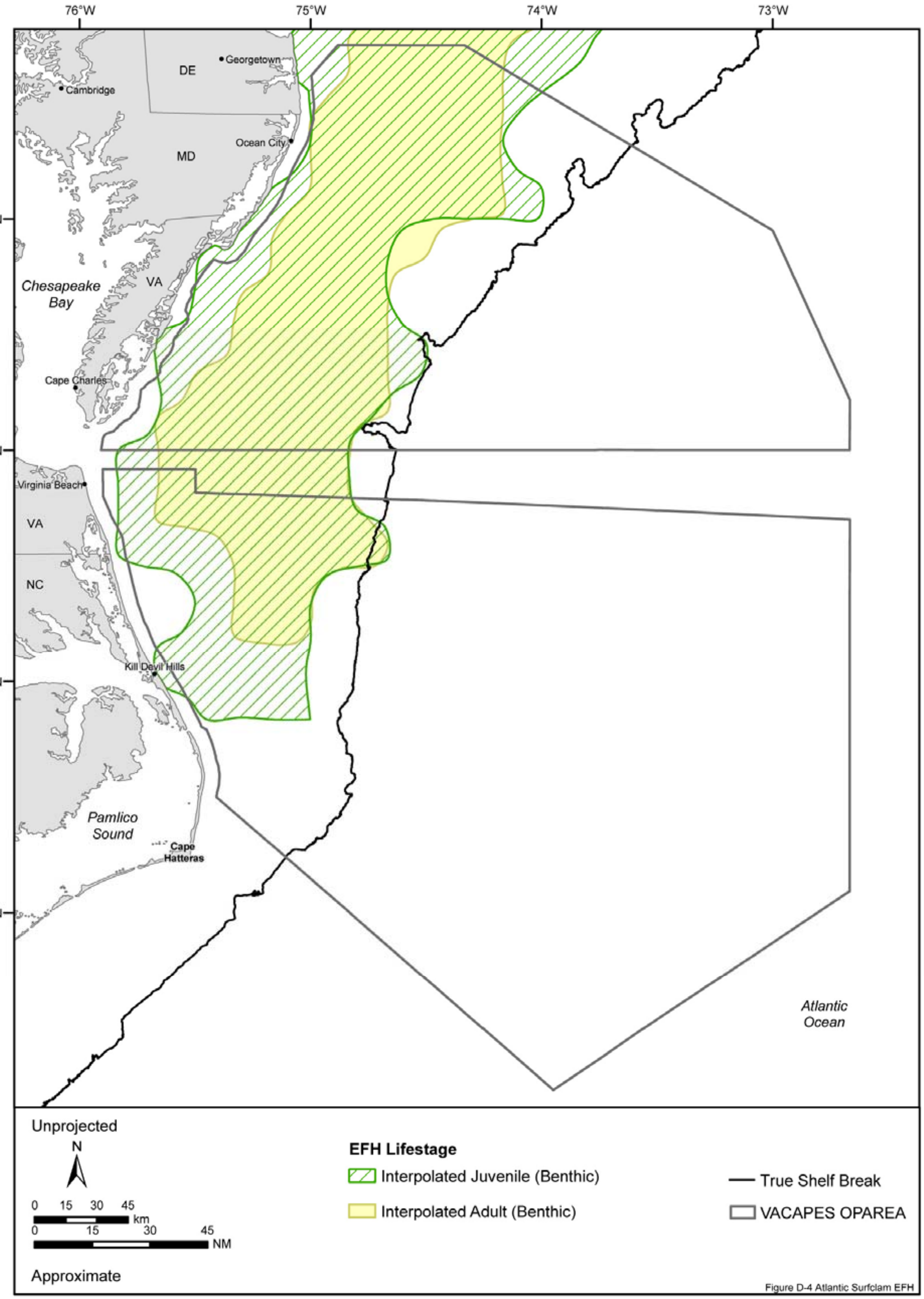

Figure D-4. Essential fish habitat for all lifestages of the Atlantic surfclam designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC (1998b).

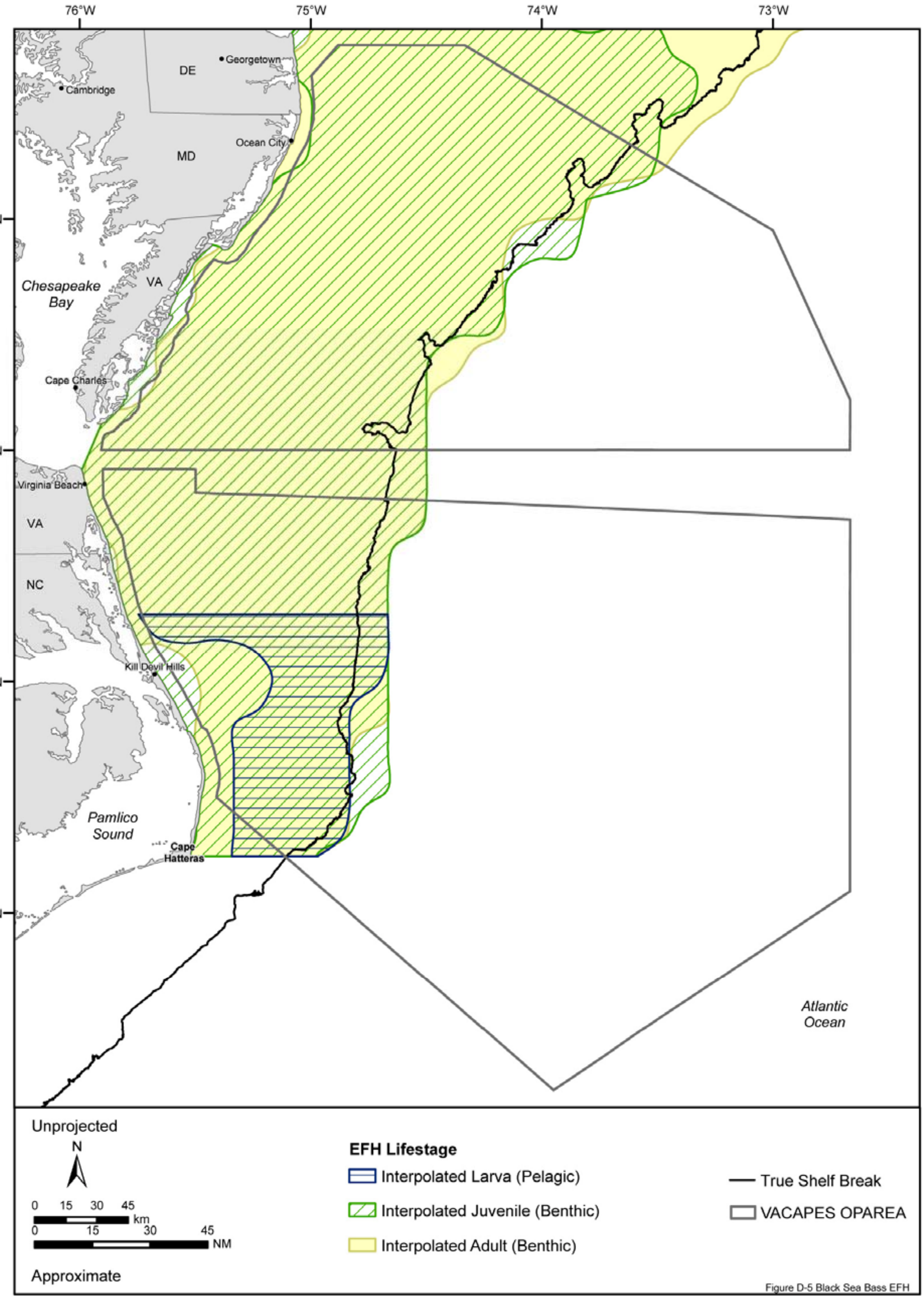

Figure D-5. Essential fish habitat for all lifestages of the black sea bass designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC and ASMFC (1998a).

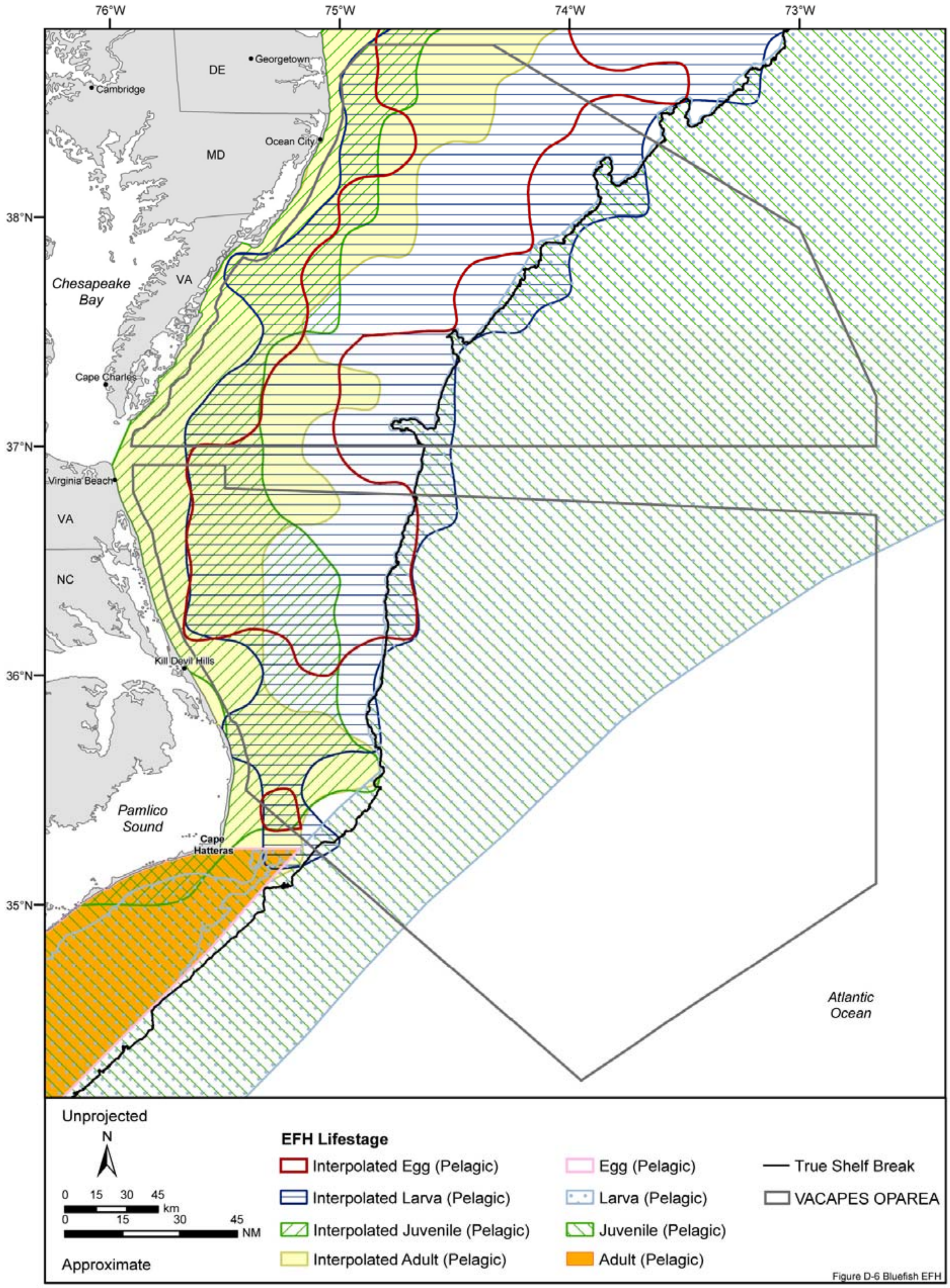

Figure D-6. Essential fish habitat for all lifestages of the bluefish designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC and ASMFC (1998b). Source information: MAFMC and ASMFC (1998b).

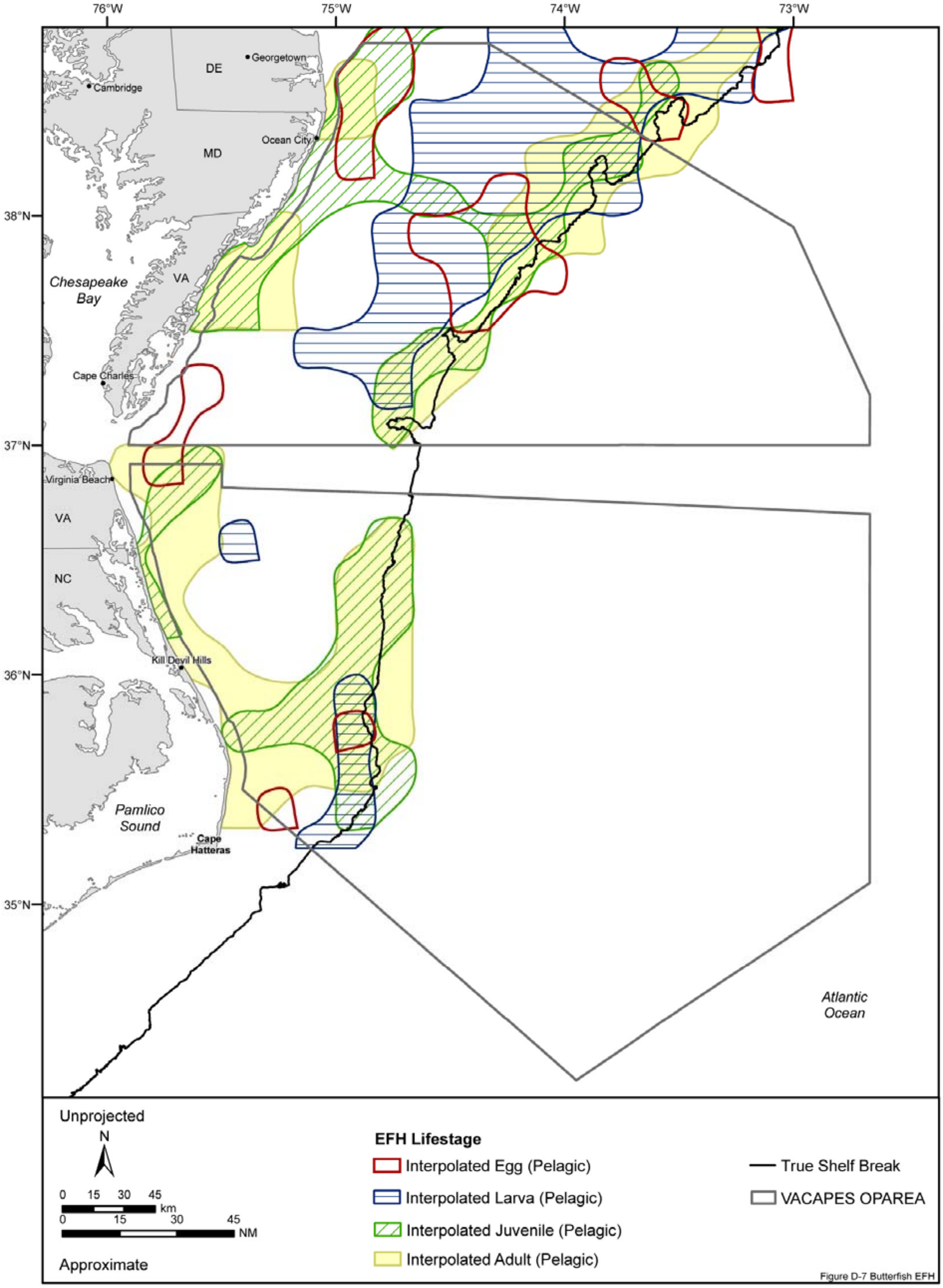

Figure D-7. Essential fish habitat for all lifestages of the butterfish designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC (1998a).

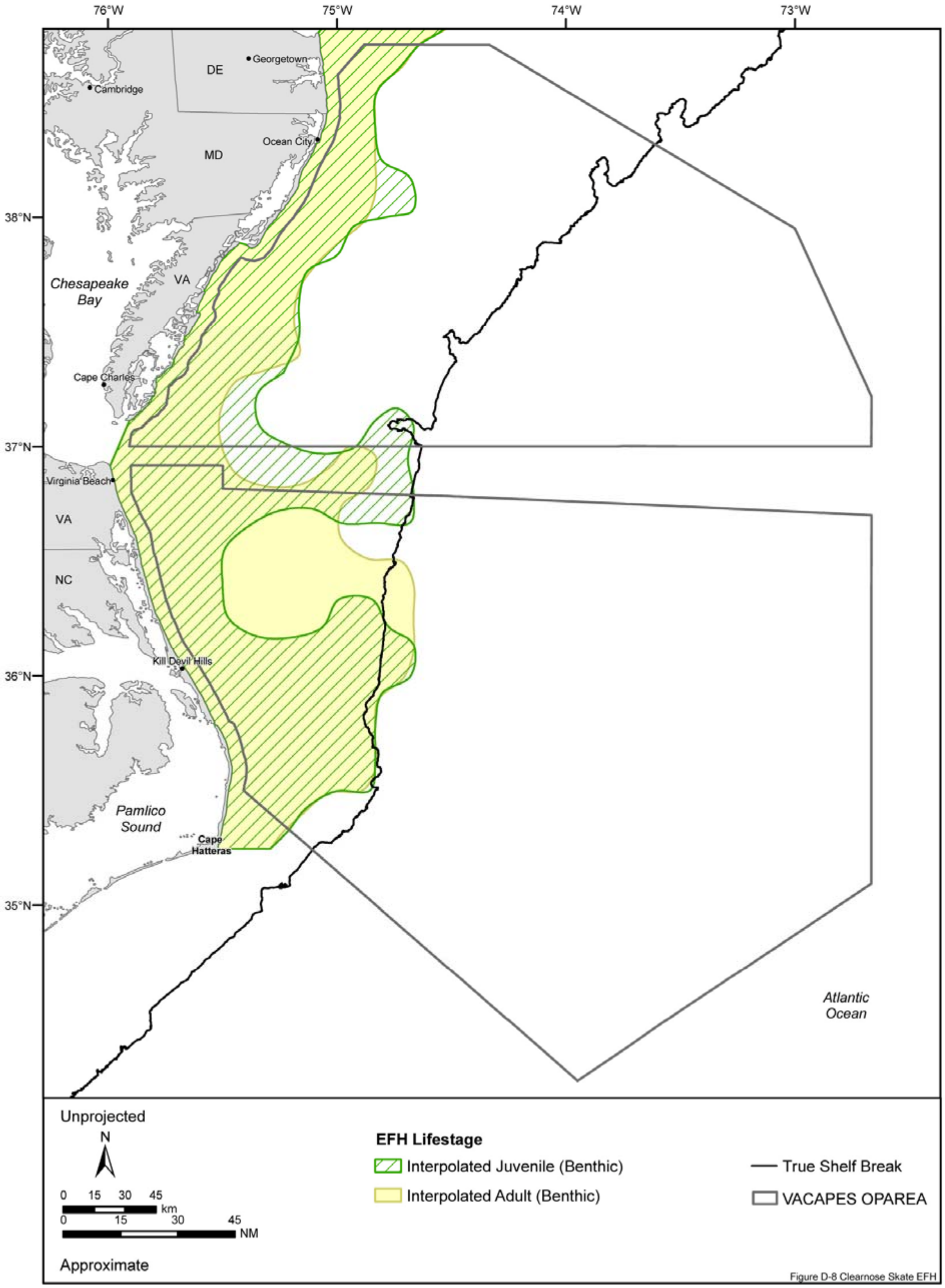

Figure D-8. Essential fish habitat for all lifestages of the clearnose skate designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (2003a).

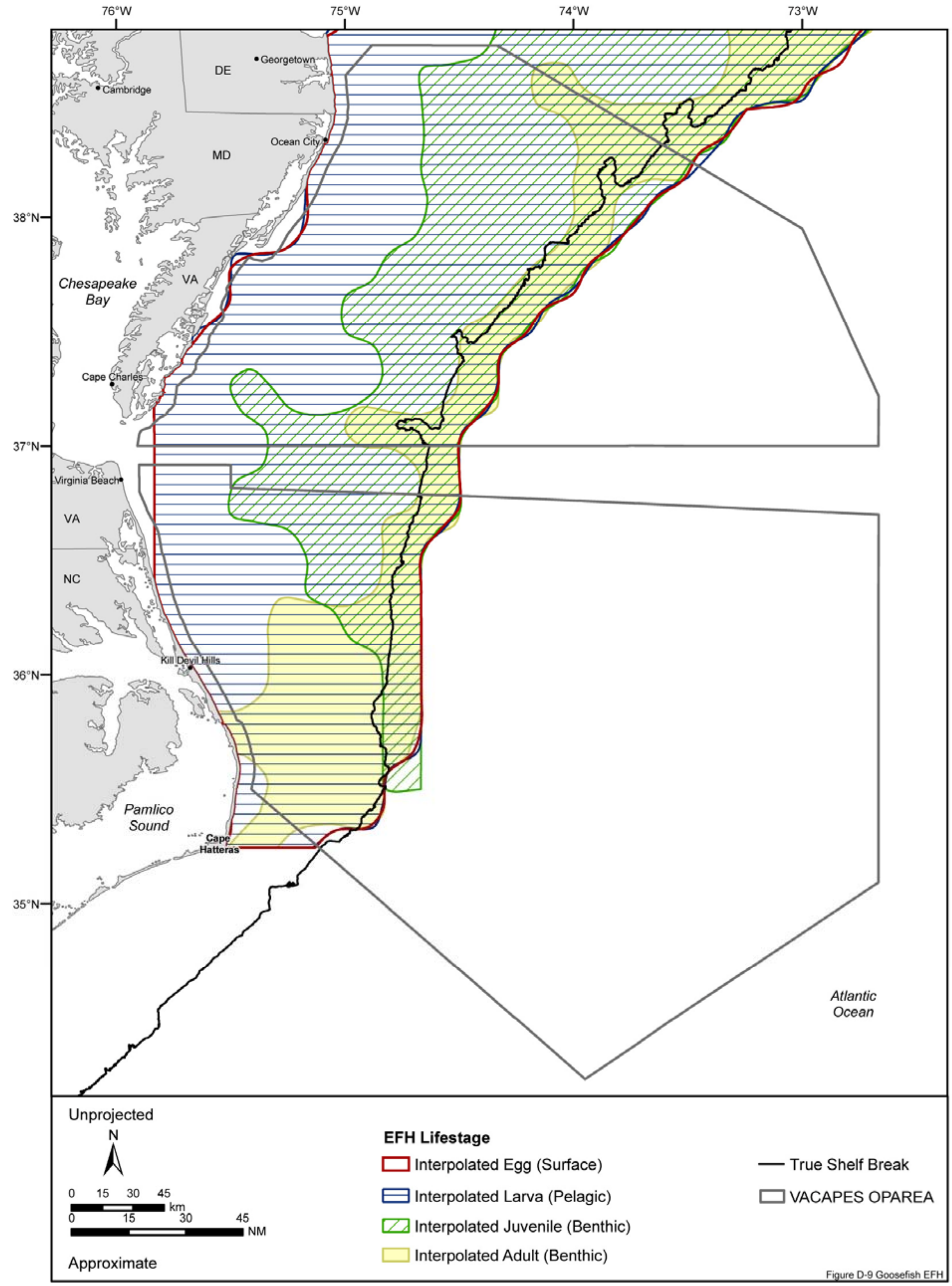

Figure D-9. Essential fish habitat for all lifestages of the goosefish designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

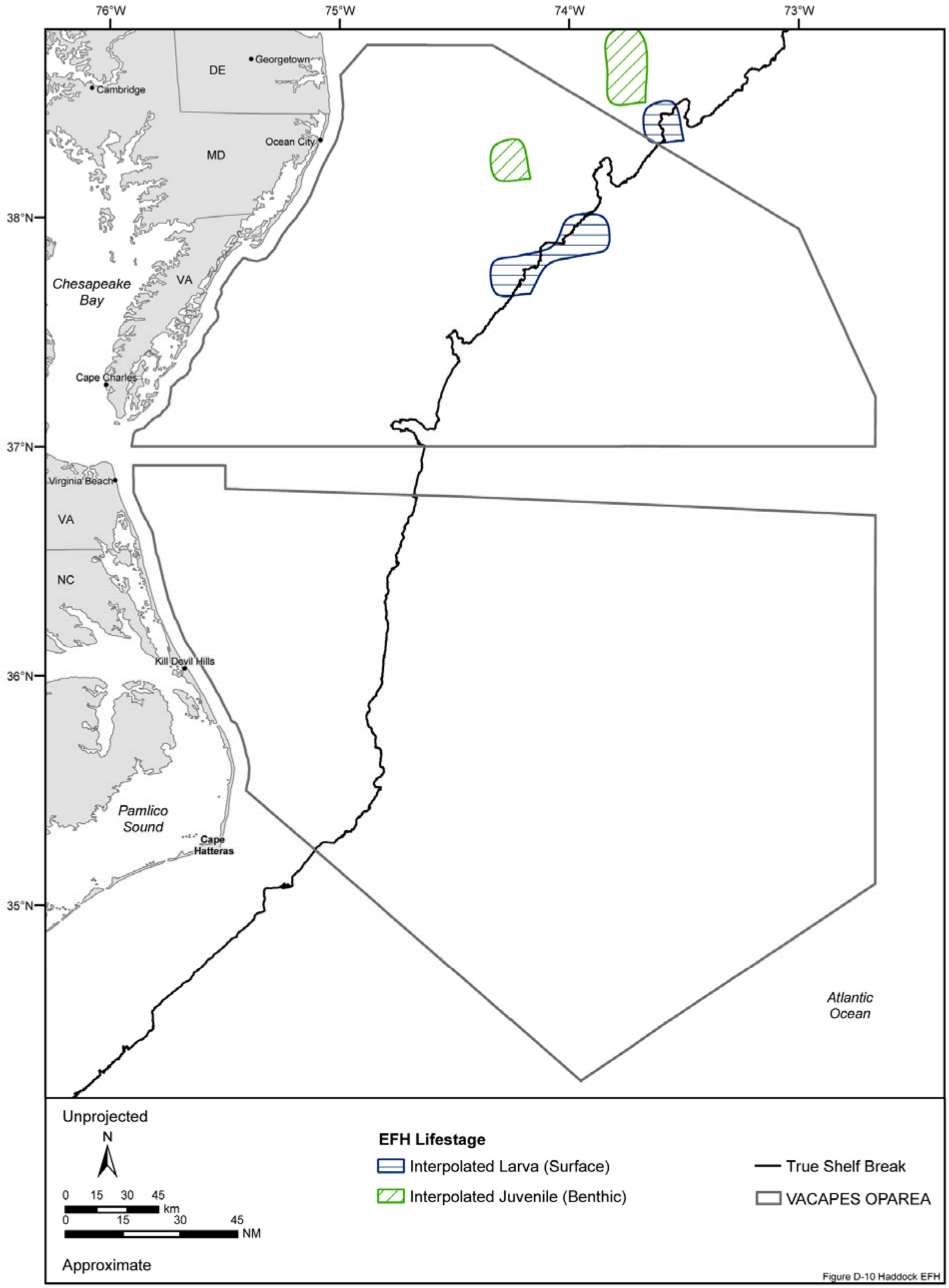

Figure D-10. Essential fish habitat for all lifestages of the haddock designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

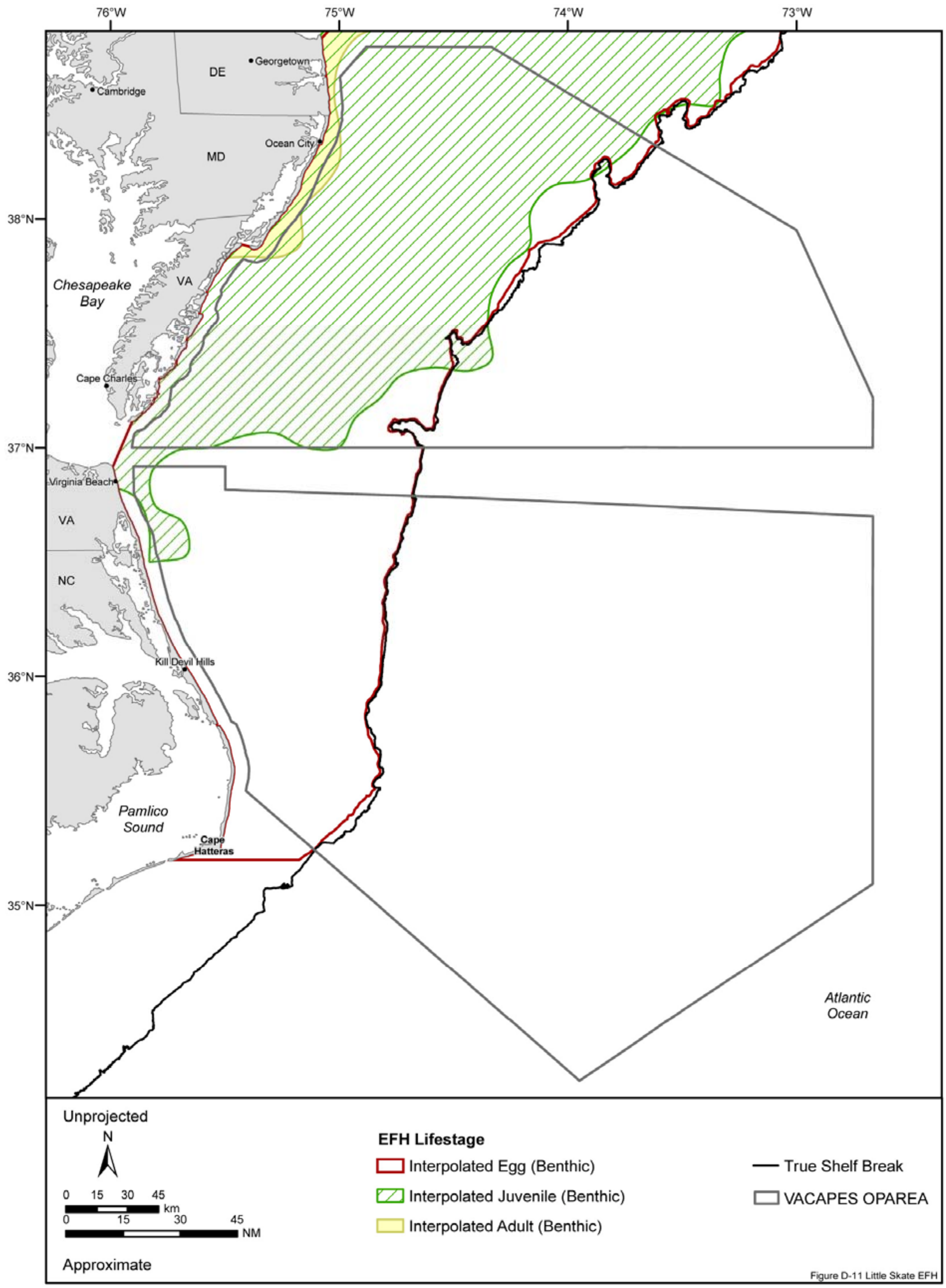

Figure D-11. Essential fish habitat for all lifestages of the little skate designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (2003a). Source information: NEFMC (2003a).

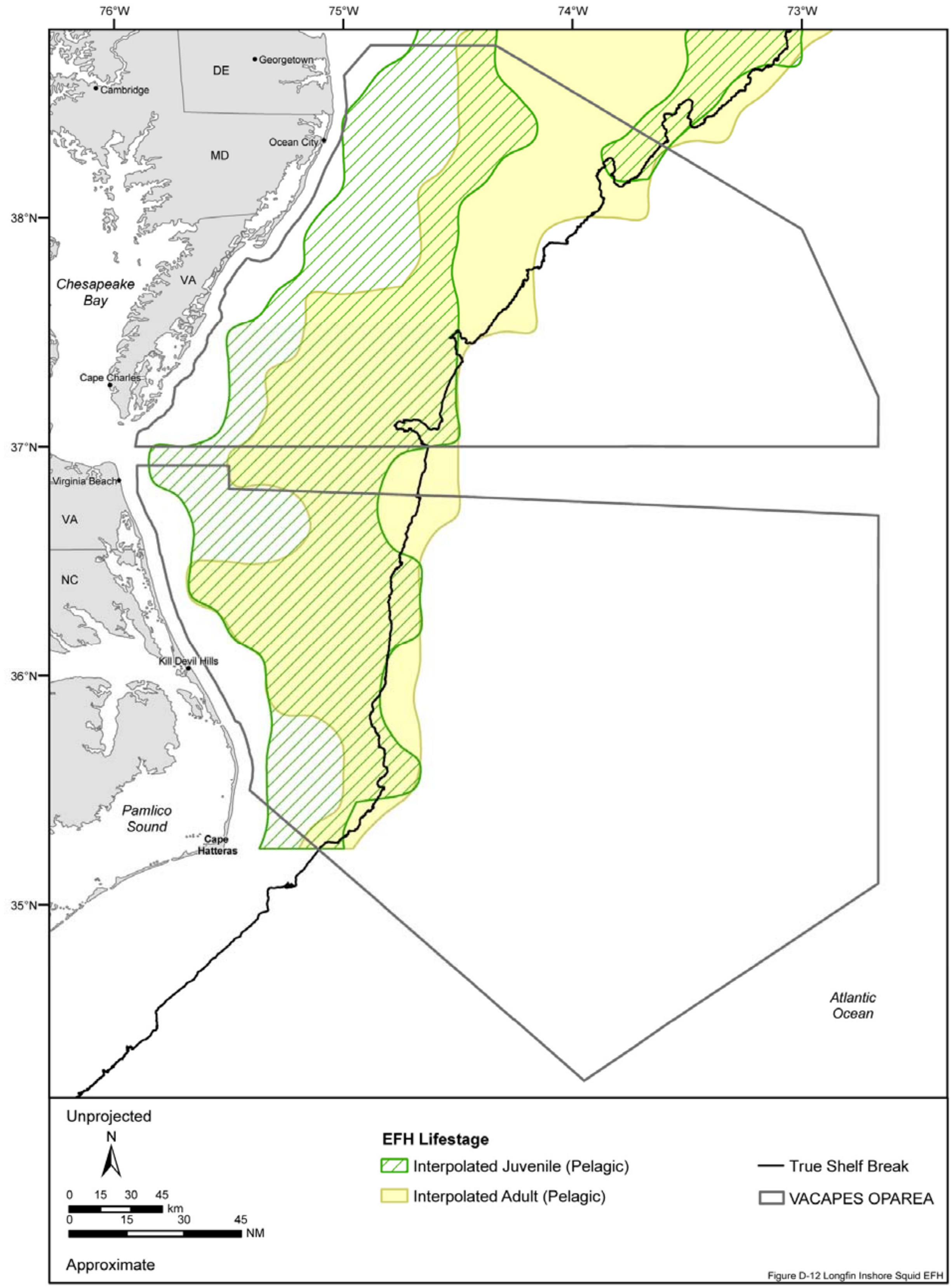

Figure D-12. Essential fish habitat for all lifestages of the longfin inshore squid designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC (1998a).

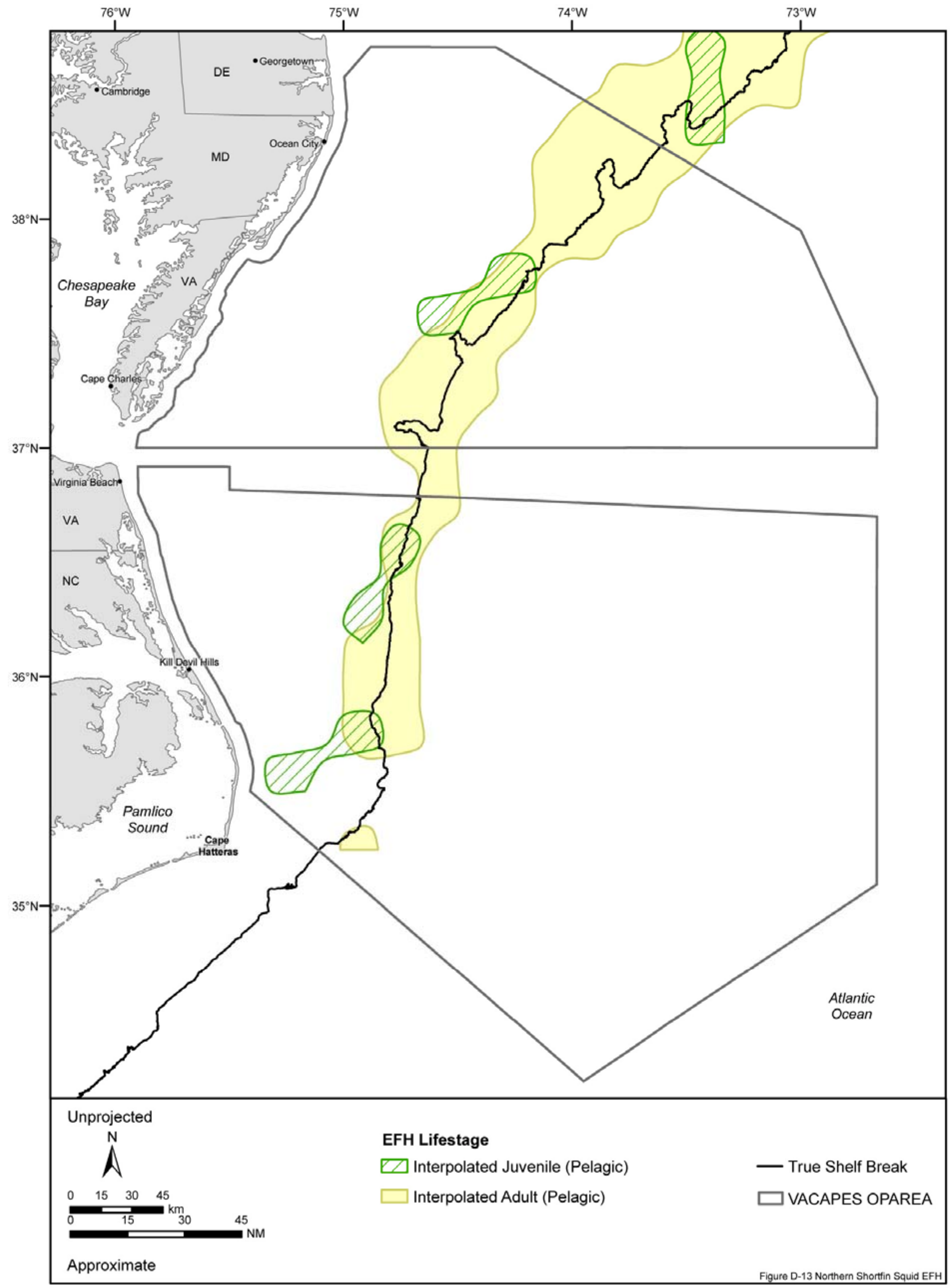

Figure D-13. Essential fish habitat for all lifestages of the northern shortfin squid designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC (1998a).

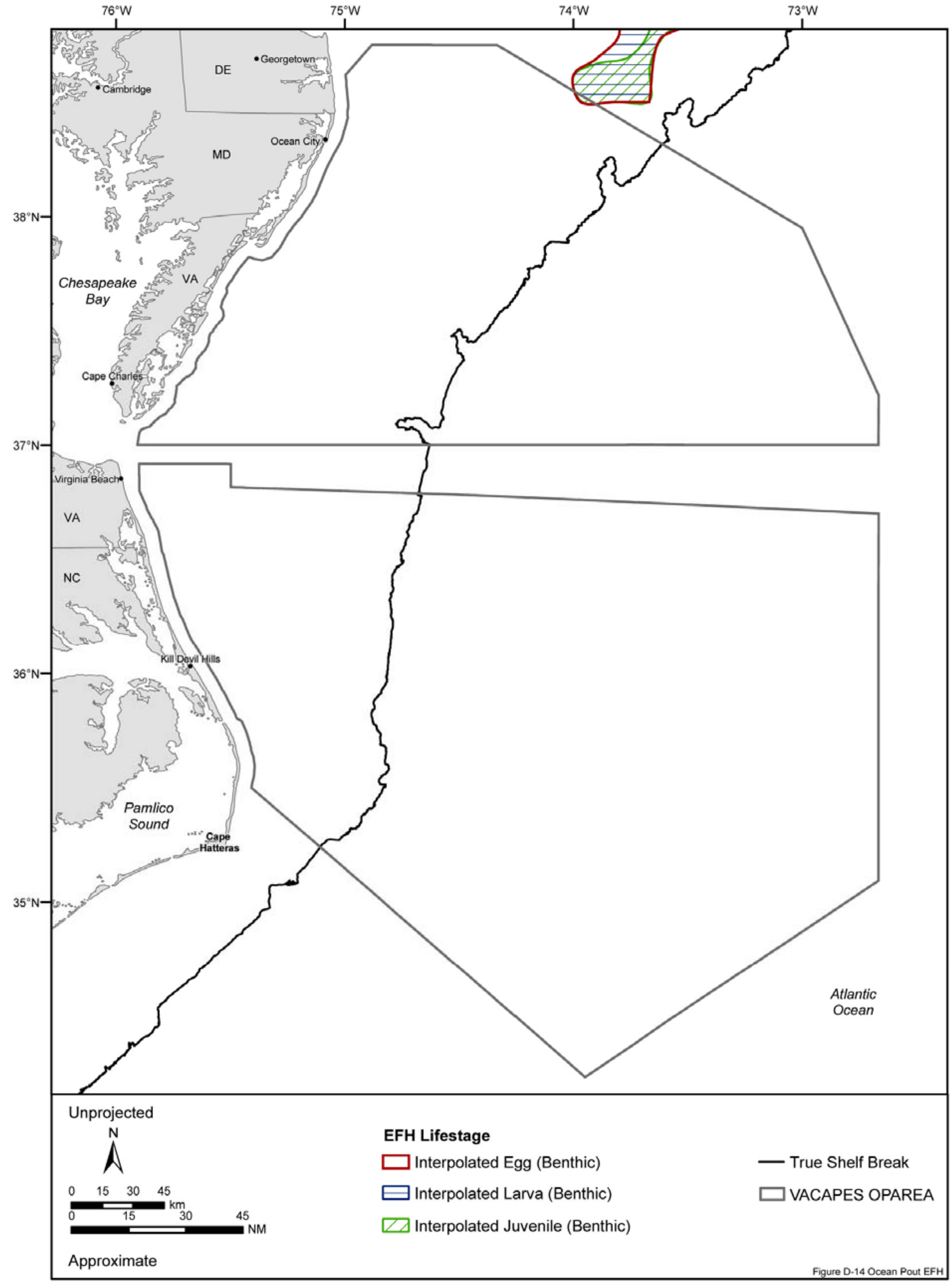

Figure D-14. Essential fish habitat for all lifestages of the ocean pout designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

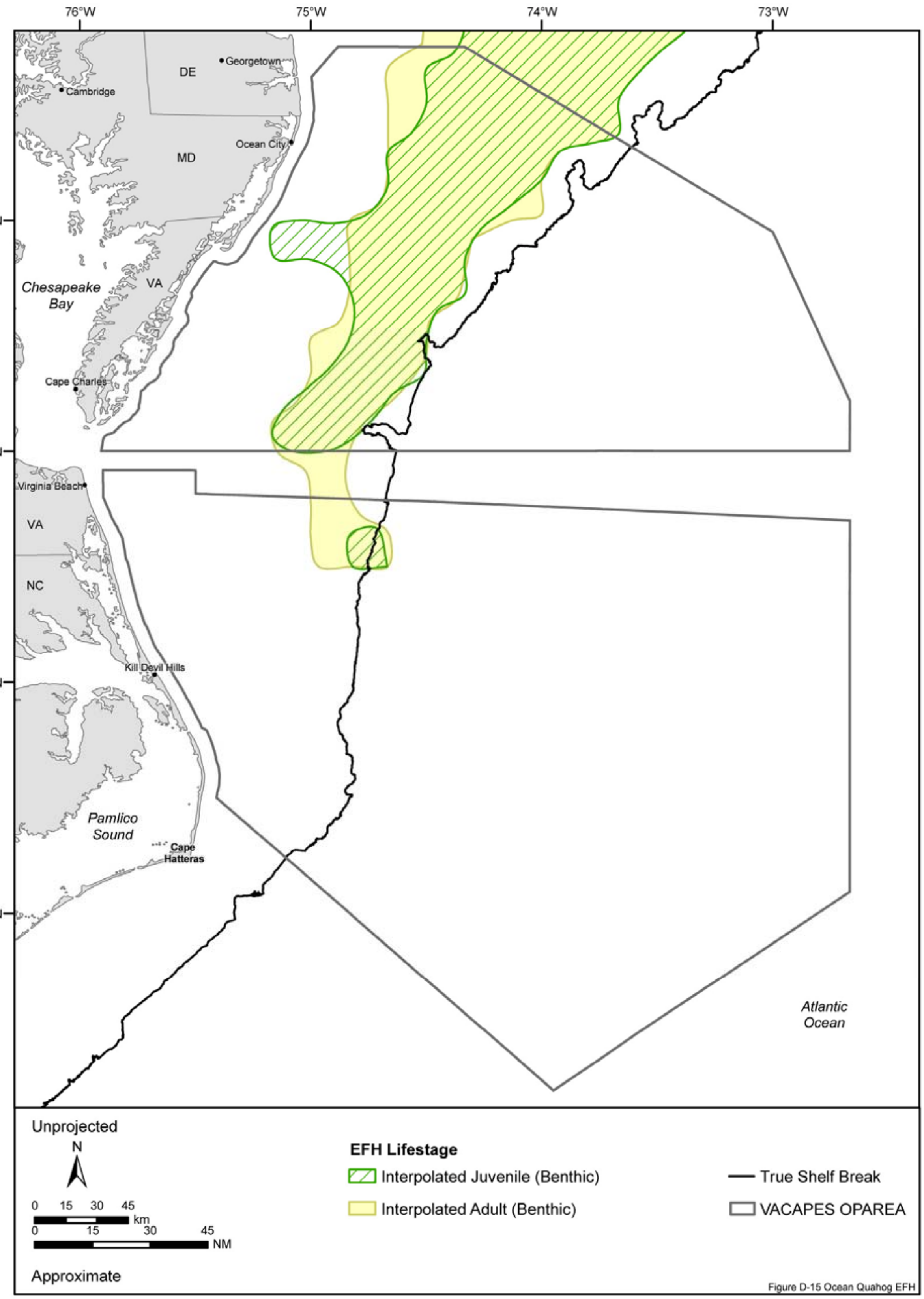

Figure D-15. Essential fish habitat and habitat for all lifestages of the ocean quahog designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC (1998b).

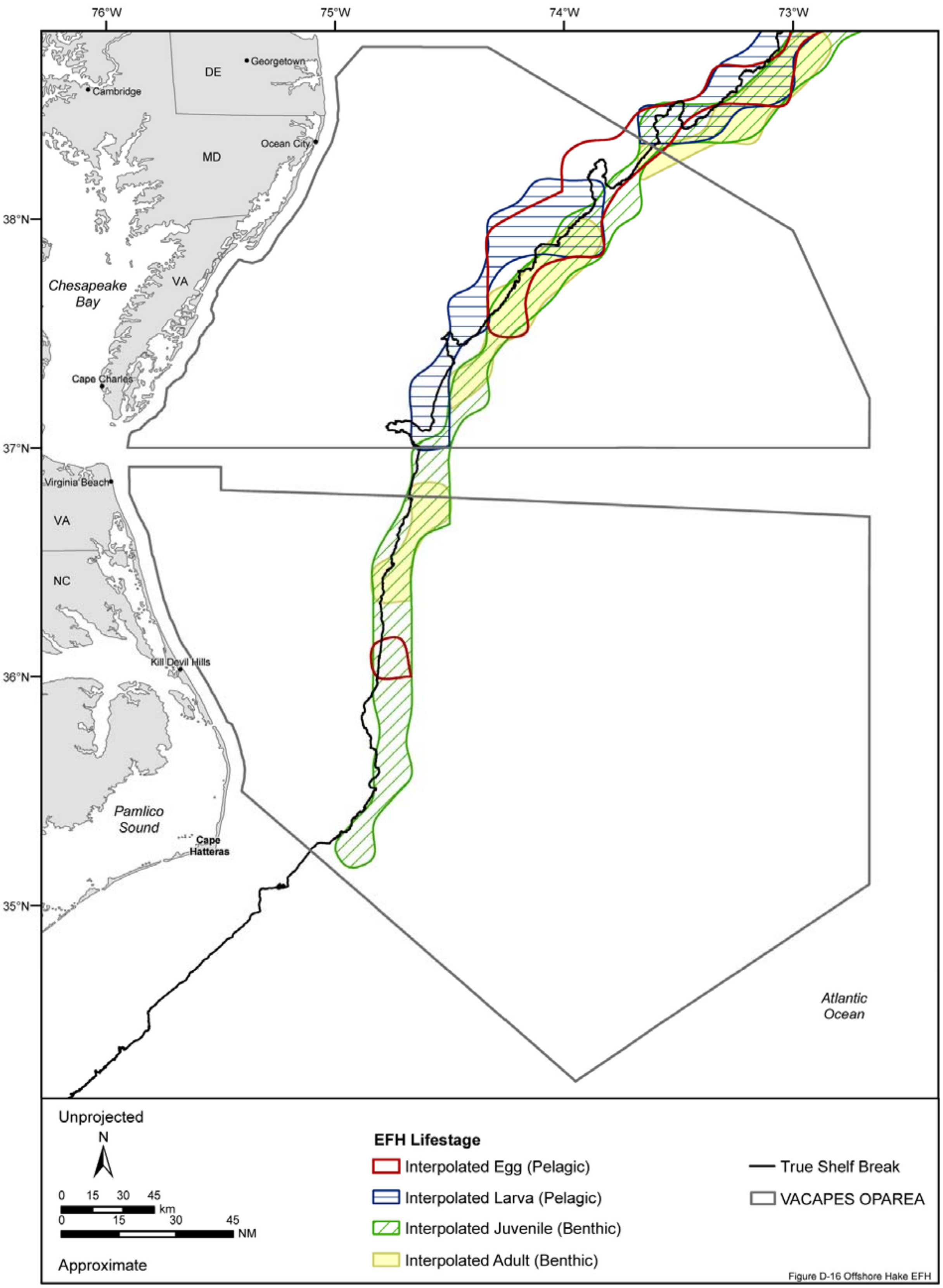

Figure D-16. Essential fish habitat and habitat for all lifestages of the offshore hake designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1999).

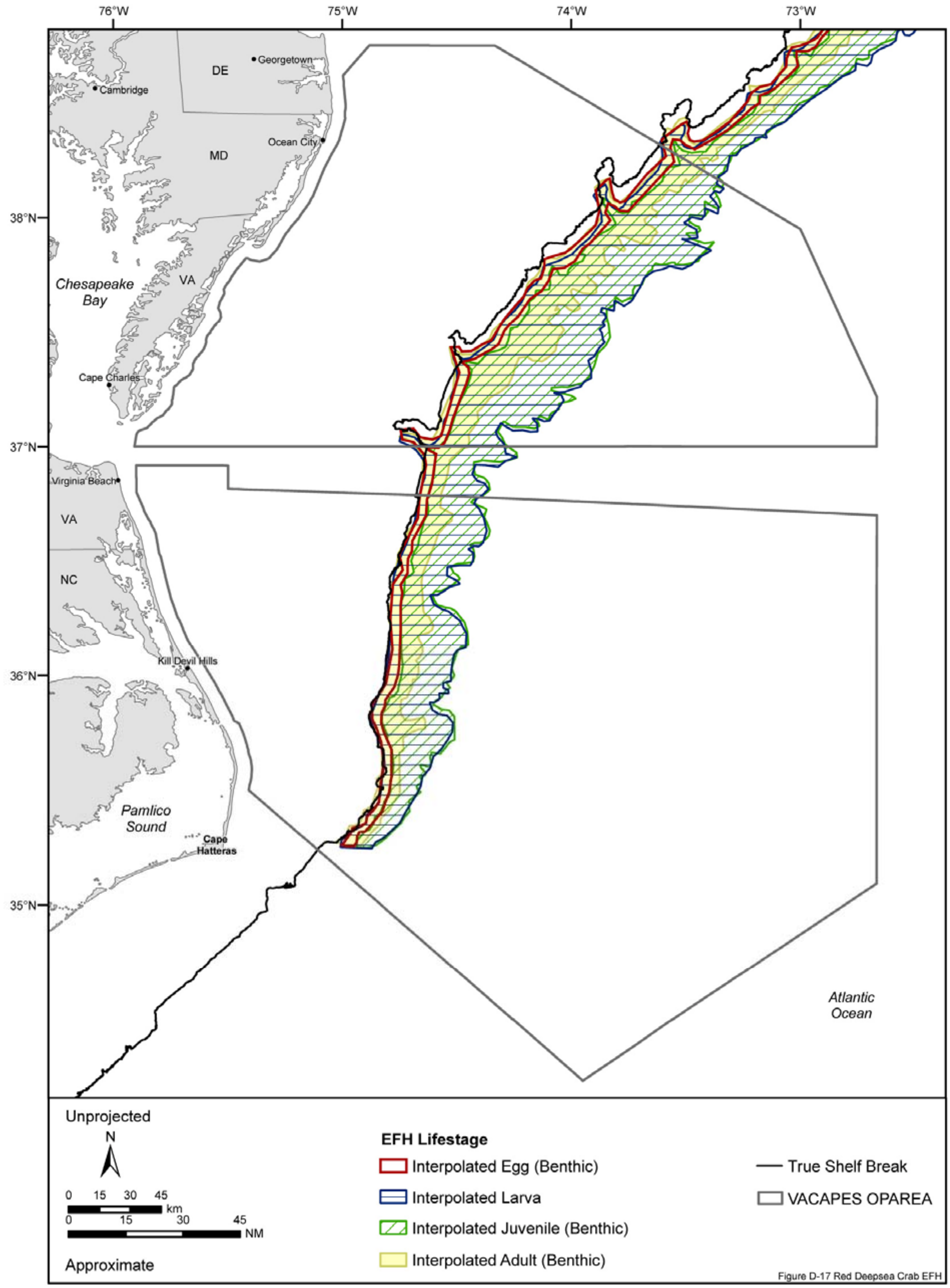

Figure D-17. Essential fish habitat for all lifestages of the red deepsea crab designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (2002).

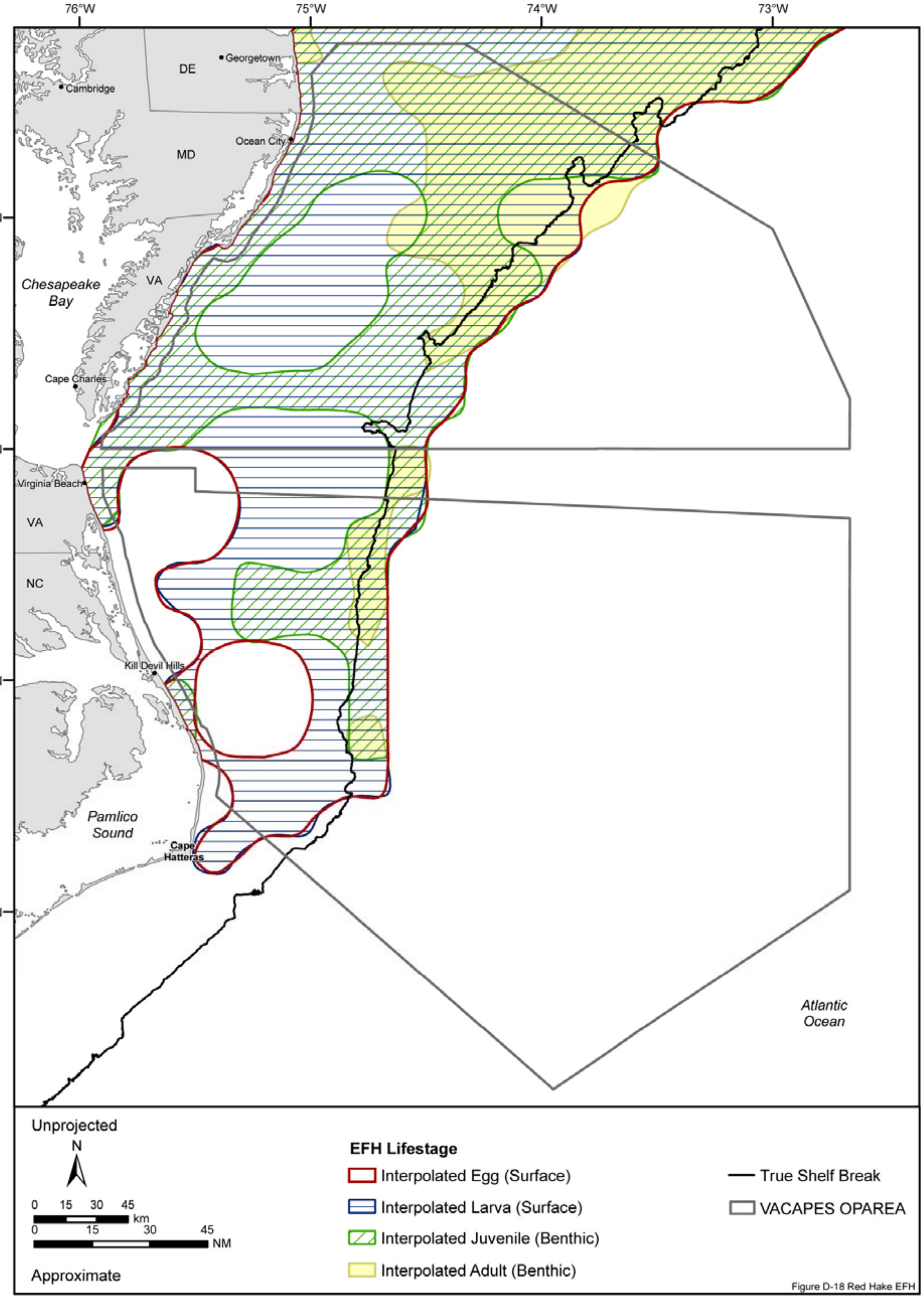

Figure D-18. Essential fish habitat for all lifestages of the red hake designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

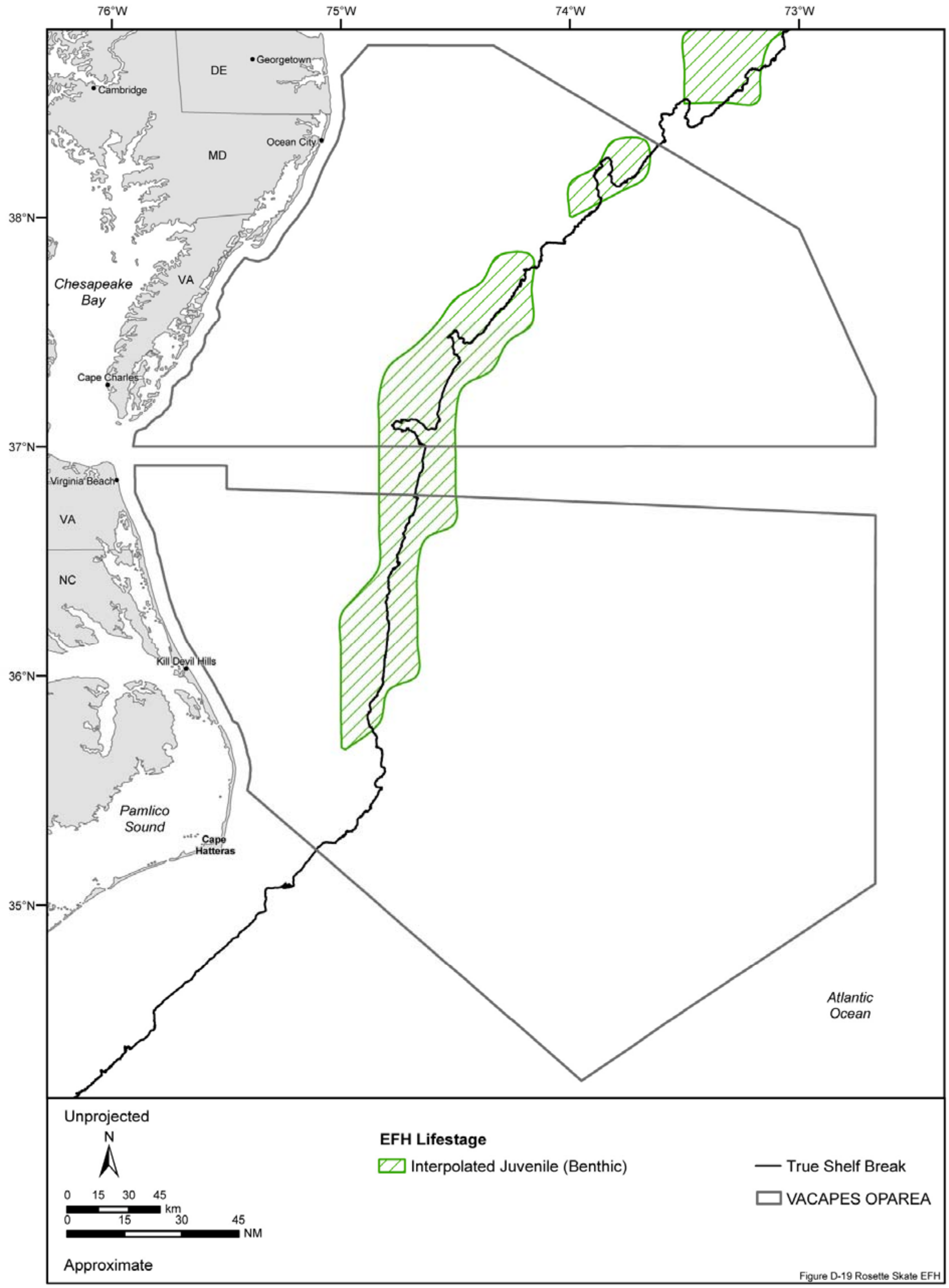

Figure D-19. Essential fish habitat for all lifestages of the rosette skate designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (2003a).

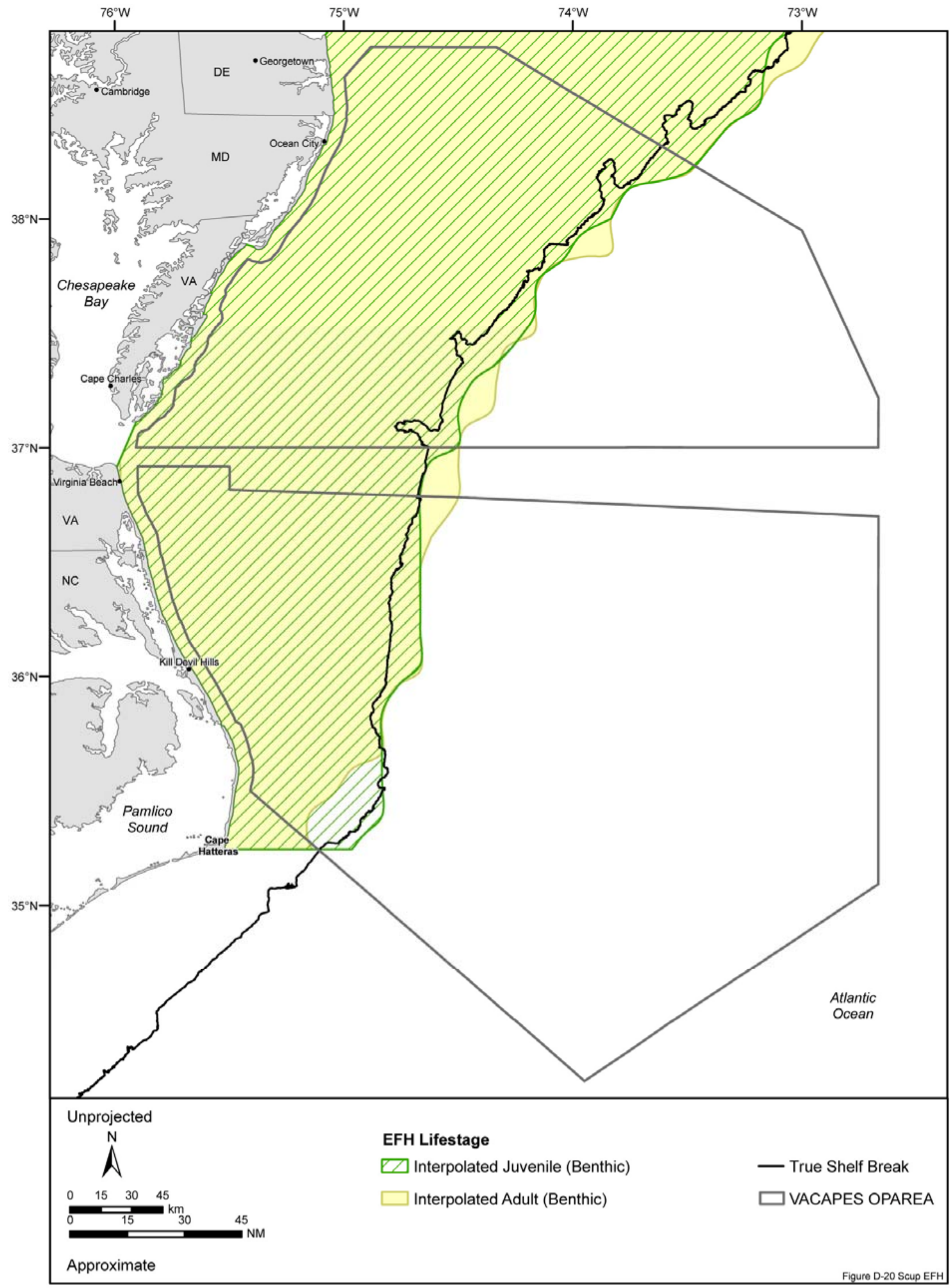

Figure D-20. Essential fish habitat and habitat for all lifestages of the scup designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC and ASMFC (1998a).

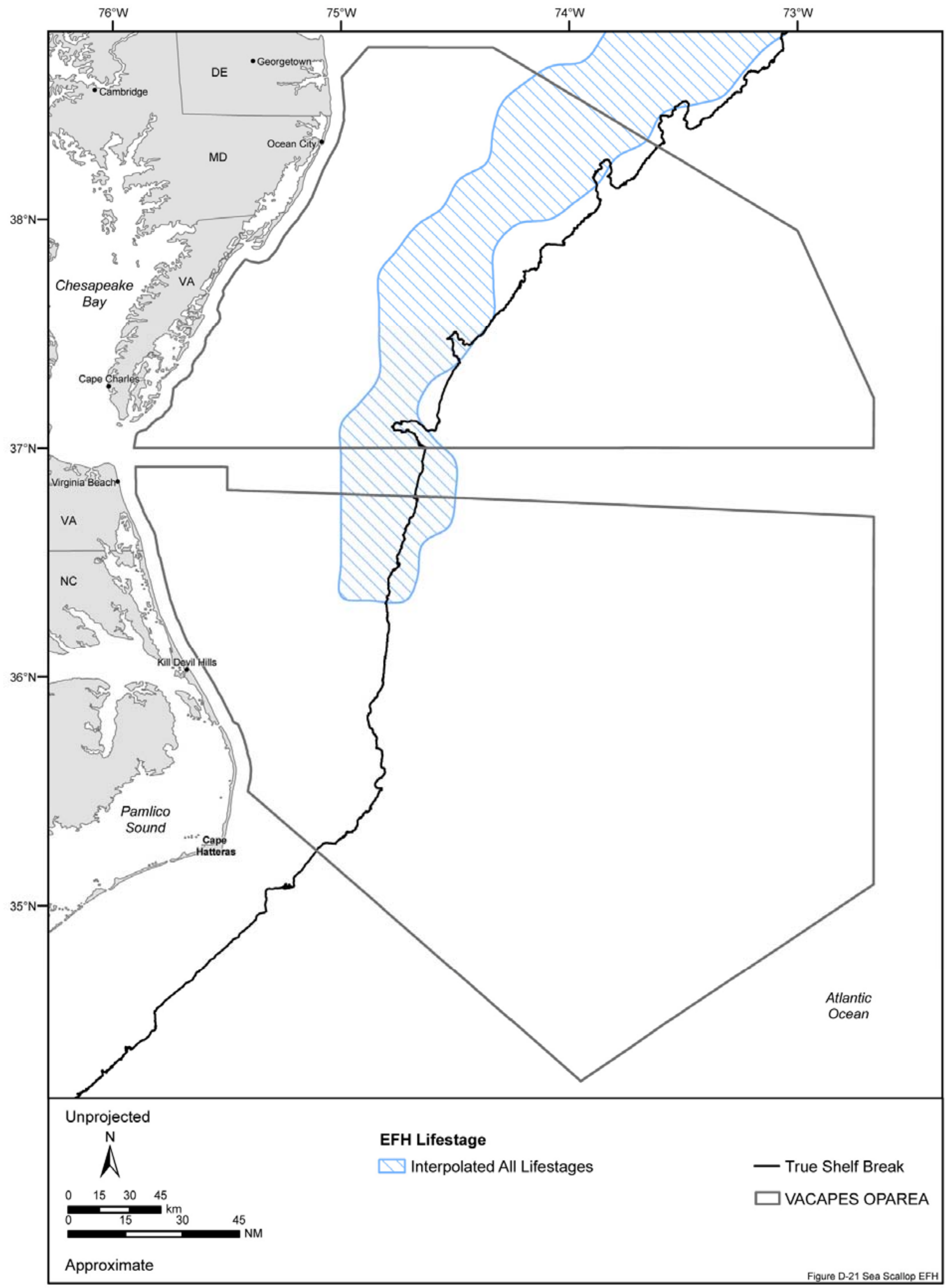

Figure D-21. Essential fish habitat for all lifestages of the sea scallop designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): NEFMC (1998).

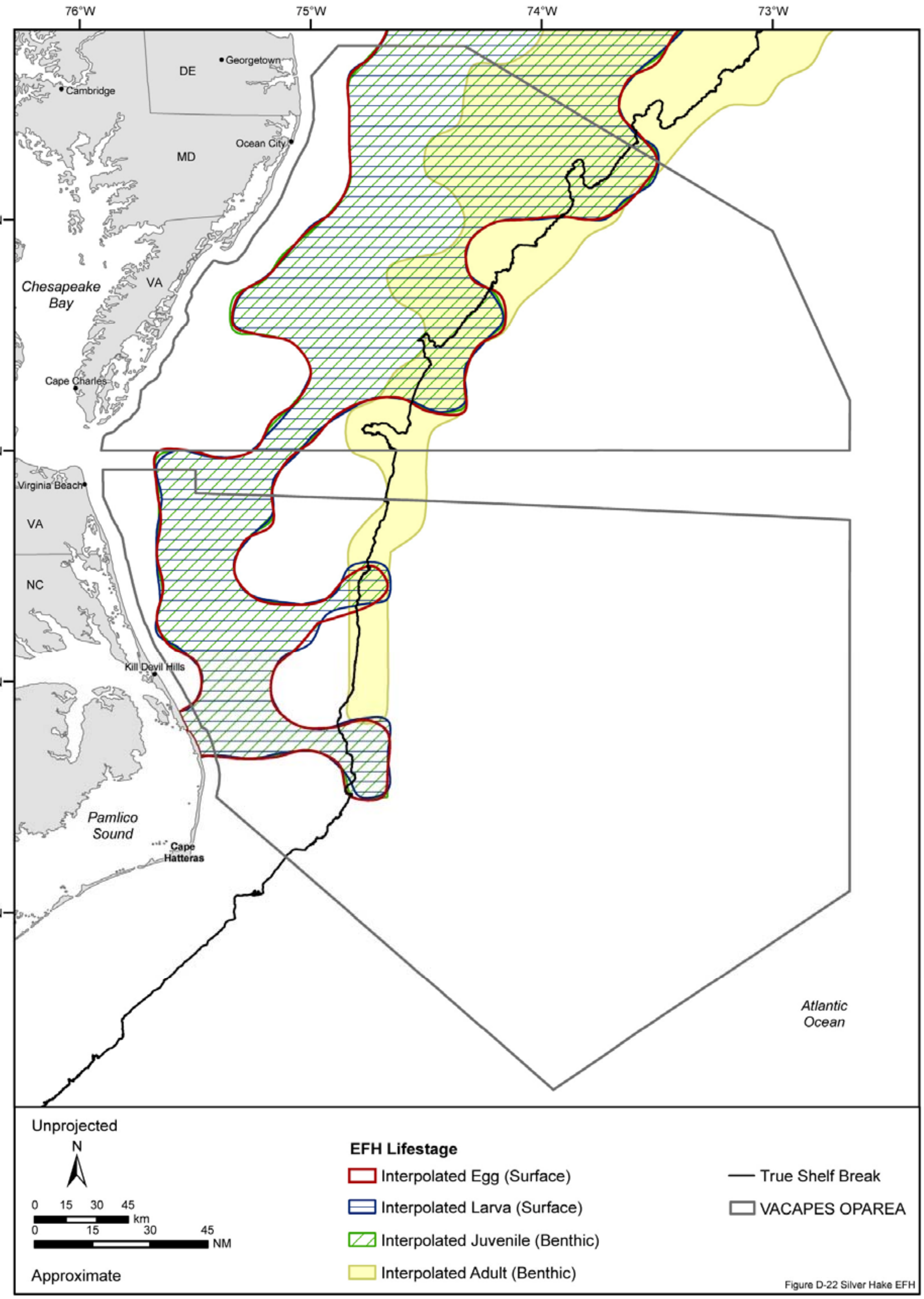

Figure D-22. Essential fish habitat for all lifestages of the silver hake designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

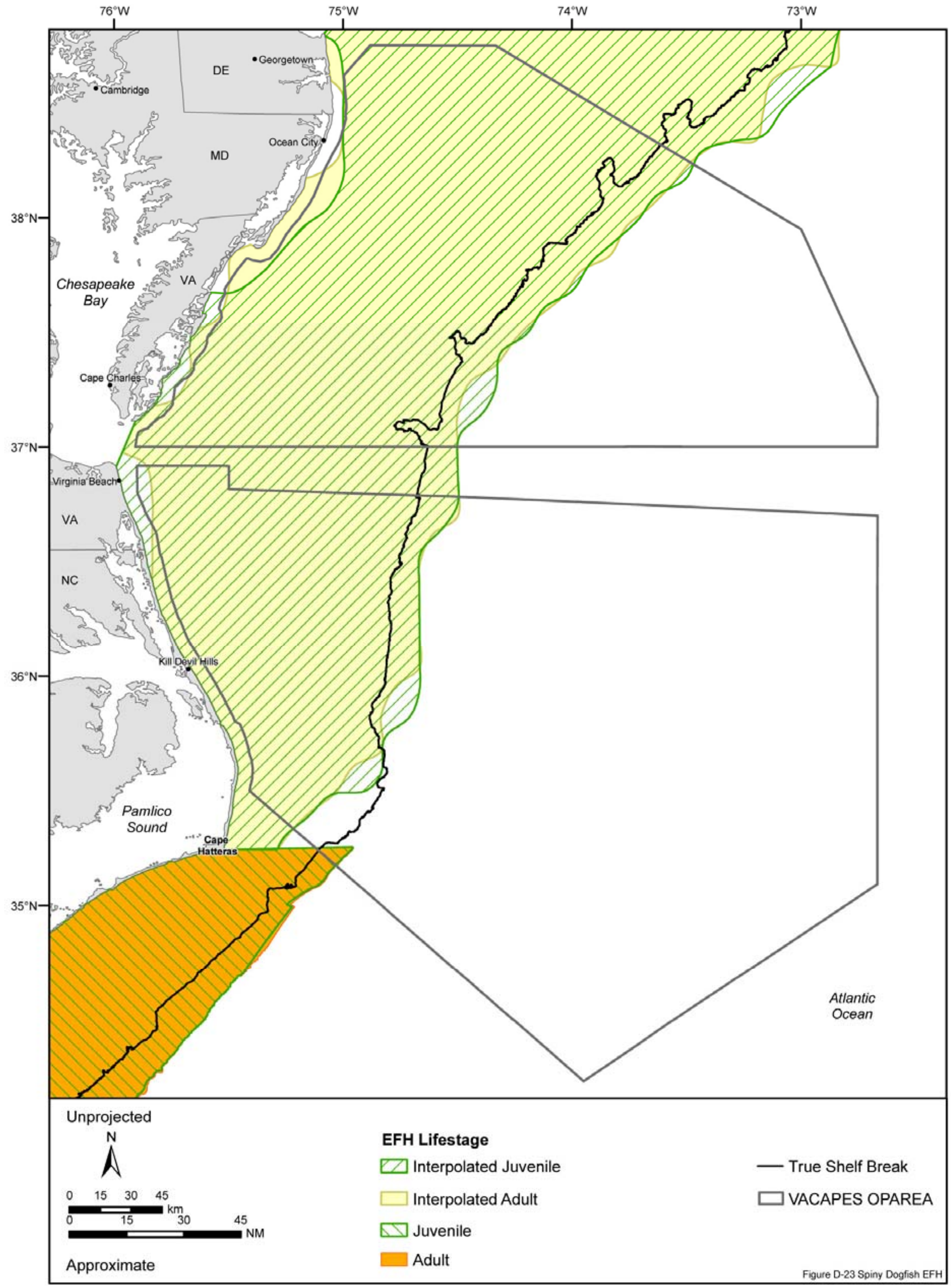

Figure D-23. Essential fish habitat for all lifestages of the spiny dogfish designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC and NEFMC (1999). Source information: MAFMC and NEFMC (1999).

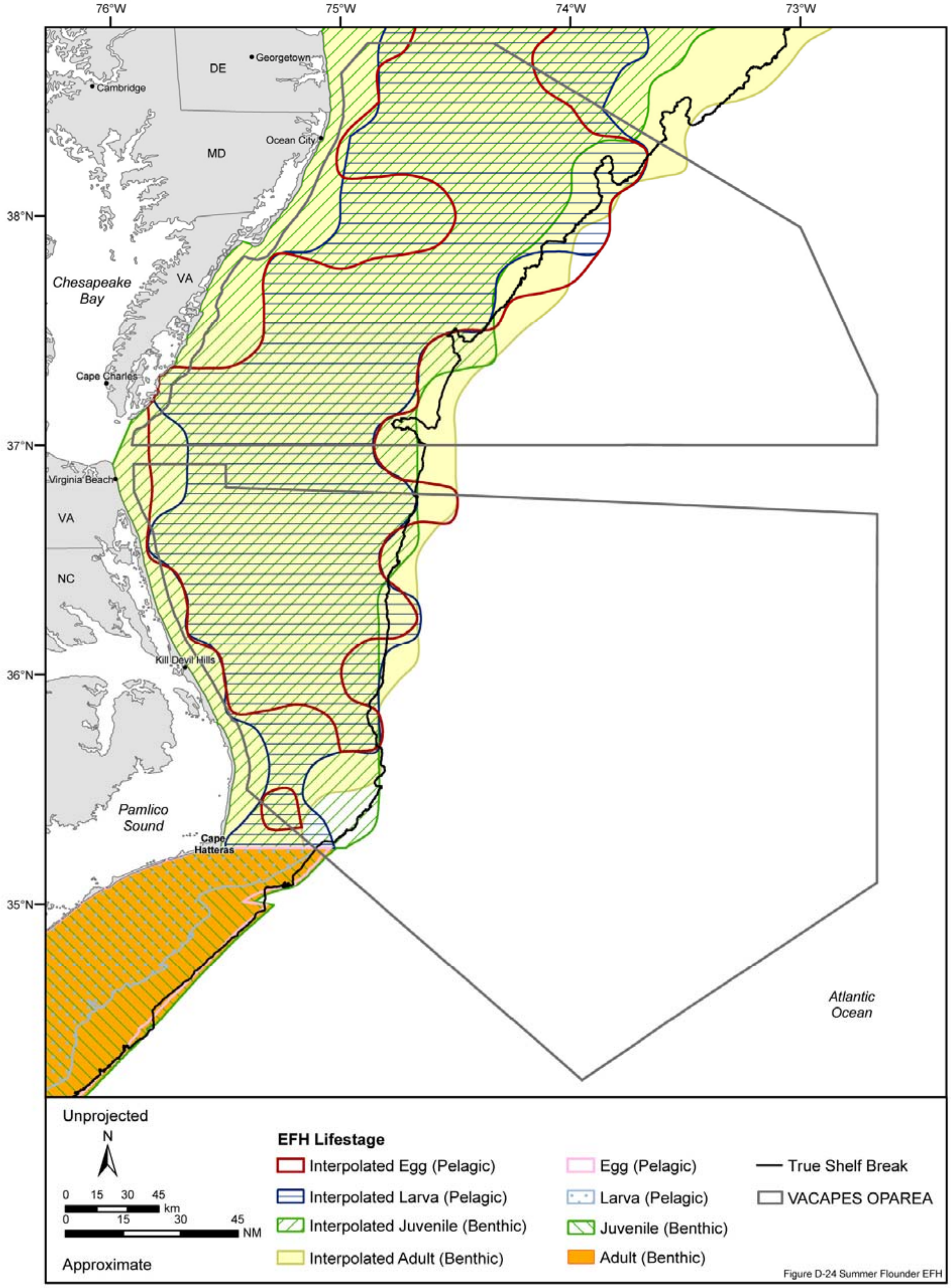

Figure D-24. Essential fish habitat for all lifestages of the summer flounder designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): MAFMC and ASMFC (1998a). Source Information: MAFMC and ASMFC (1998a).

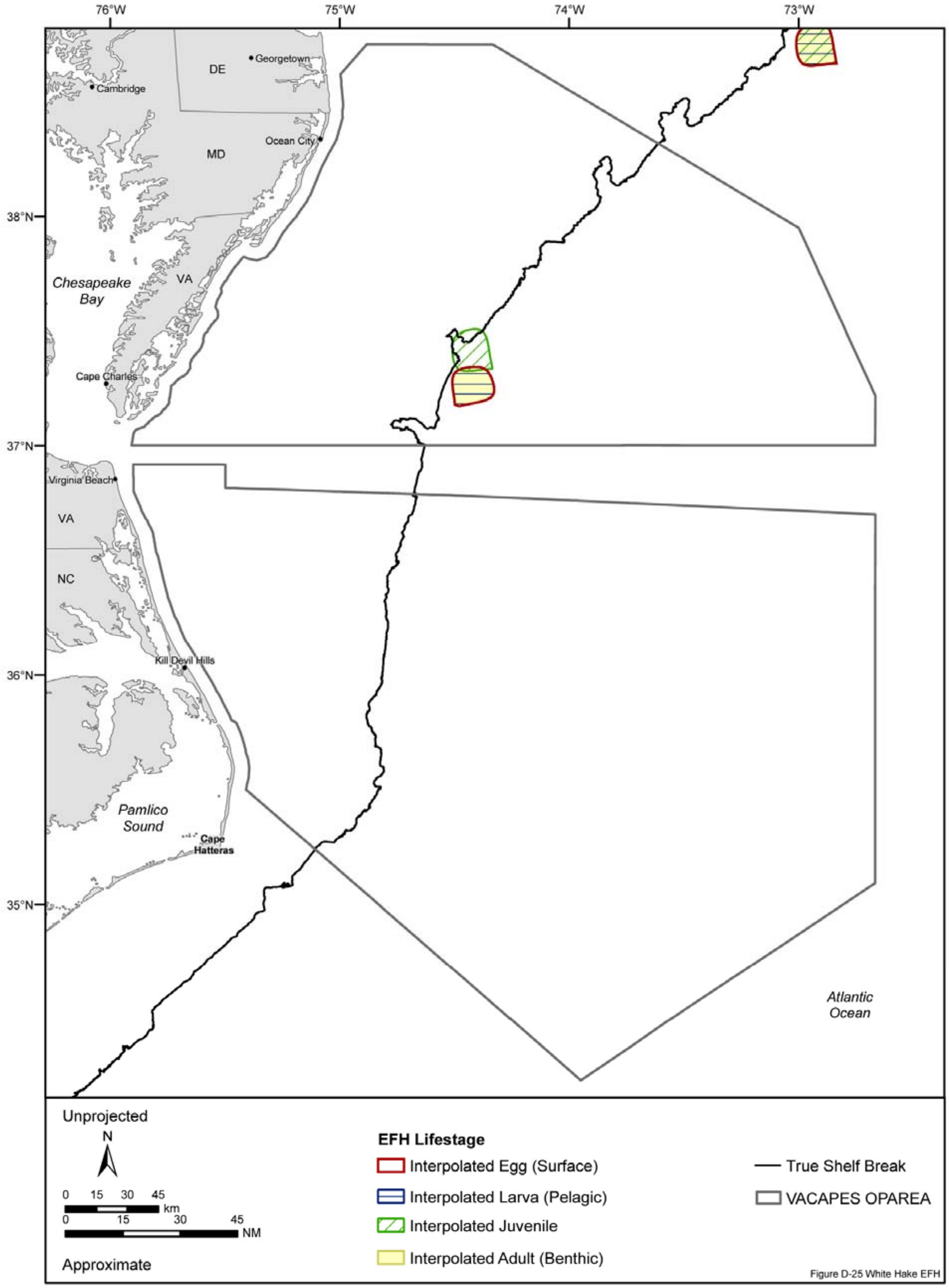

Figure D-25. Essential fish habitat for all lifestages of the white hake designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

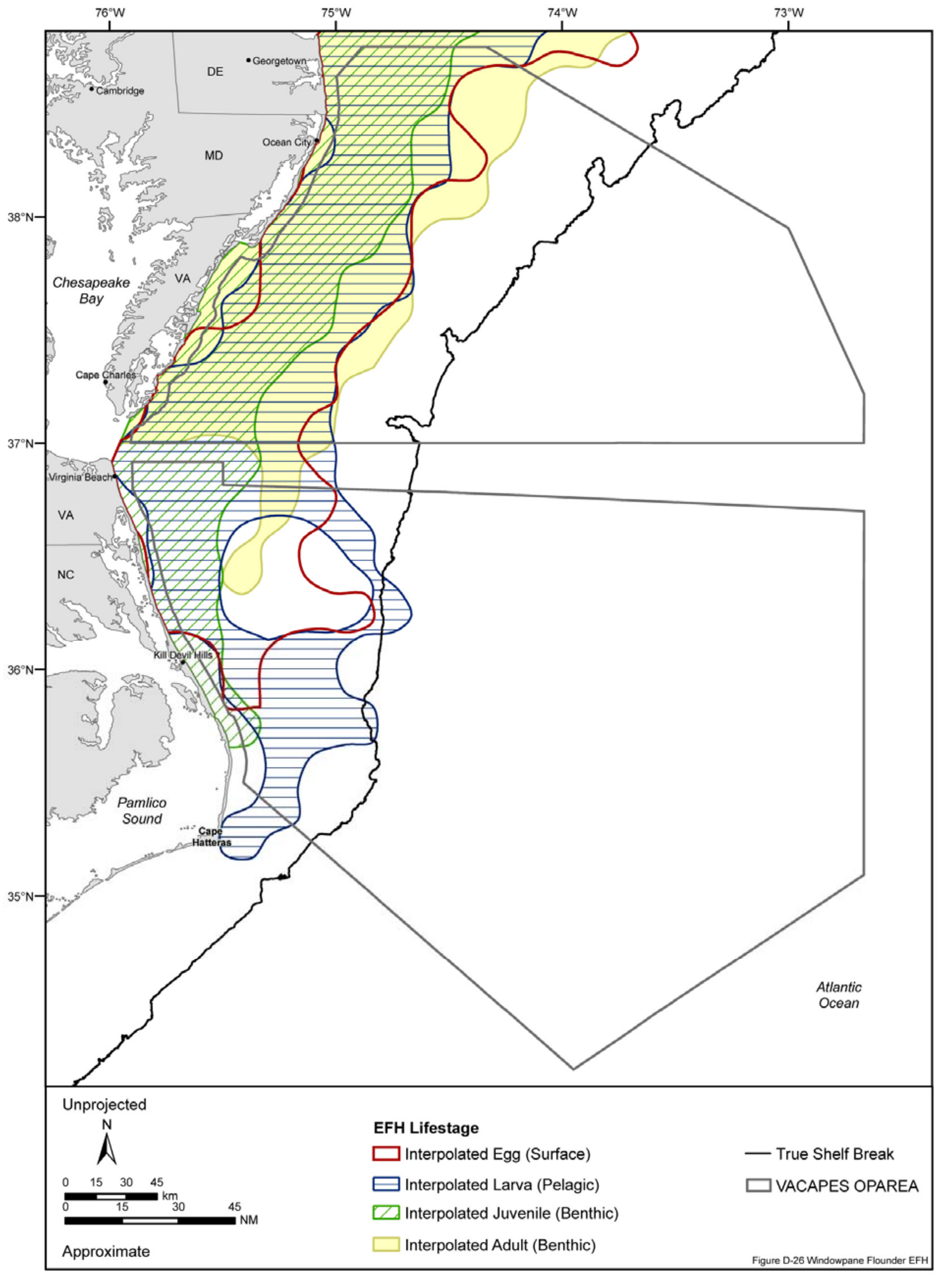

Figure D-26. Essential fish habitat for all lifestages of the windowpane flounder designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

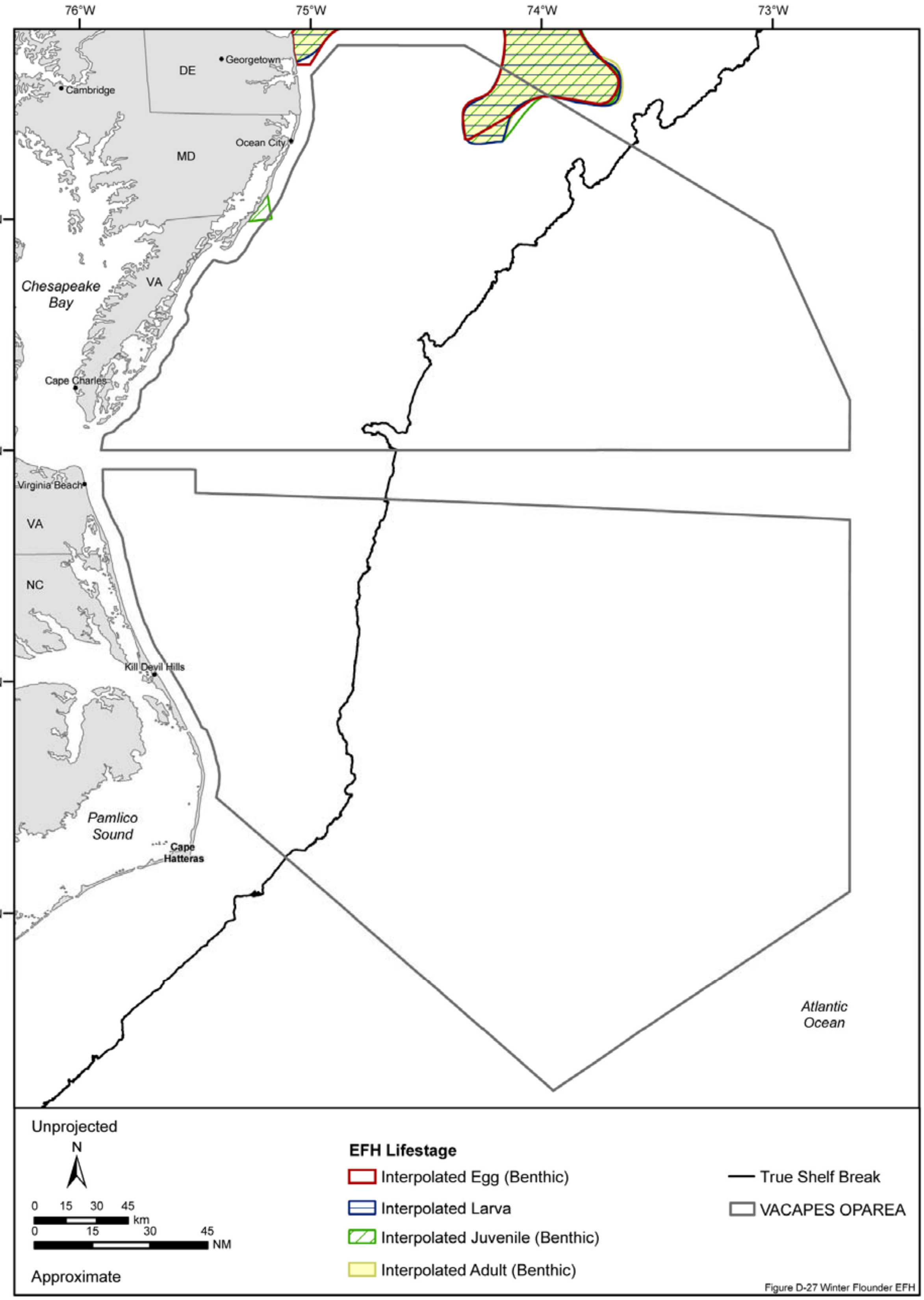

Figure D 27. Essential fish habitat for all lifestages of the winter flounder designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

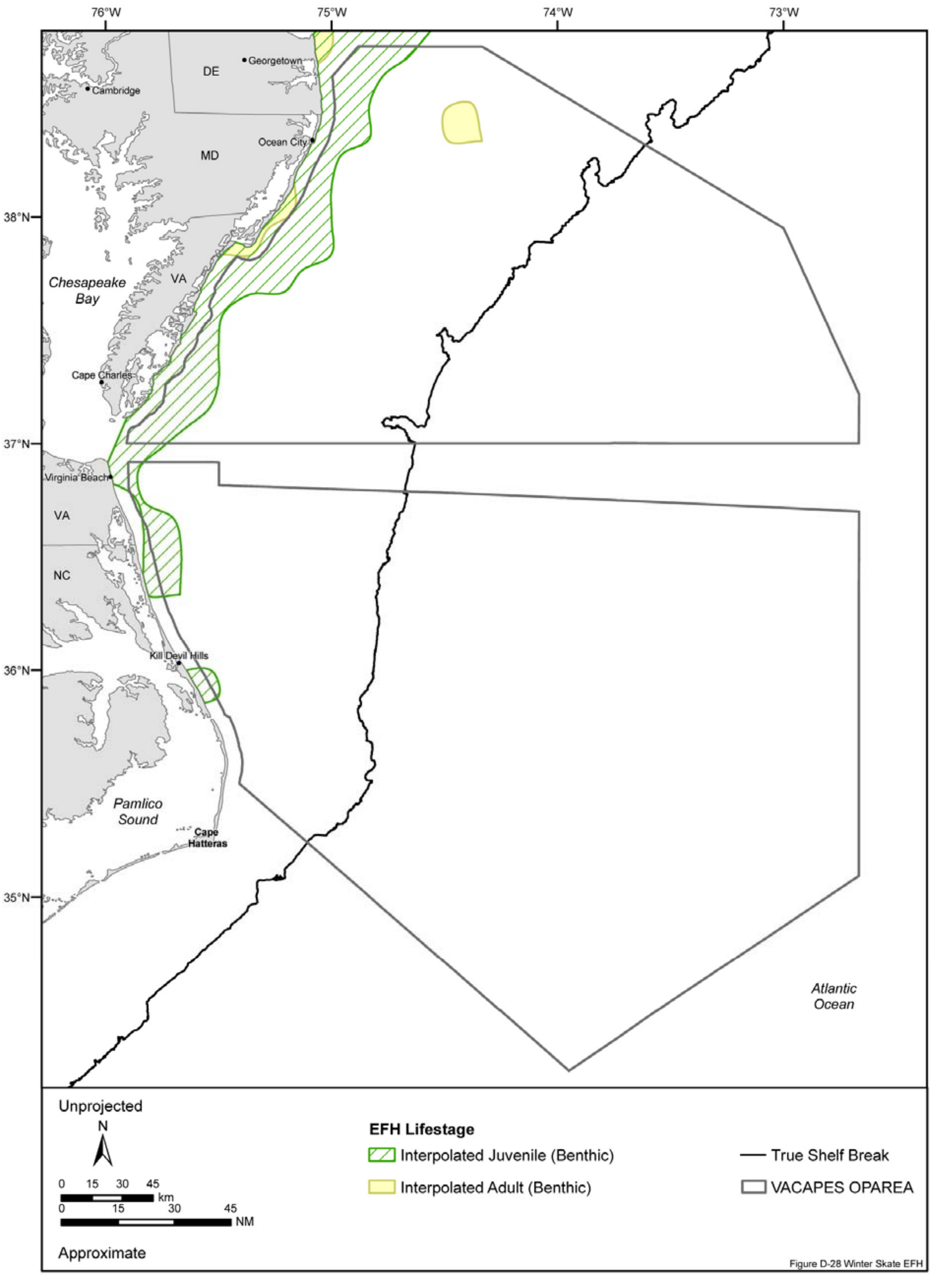

Figure D-28. Essential fish habitat for all lifestages of the winter skate designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (2003a).

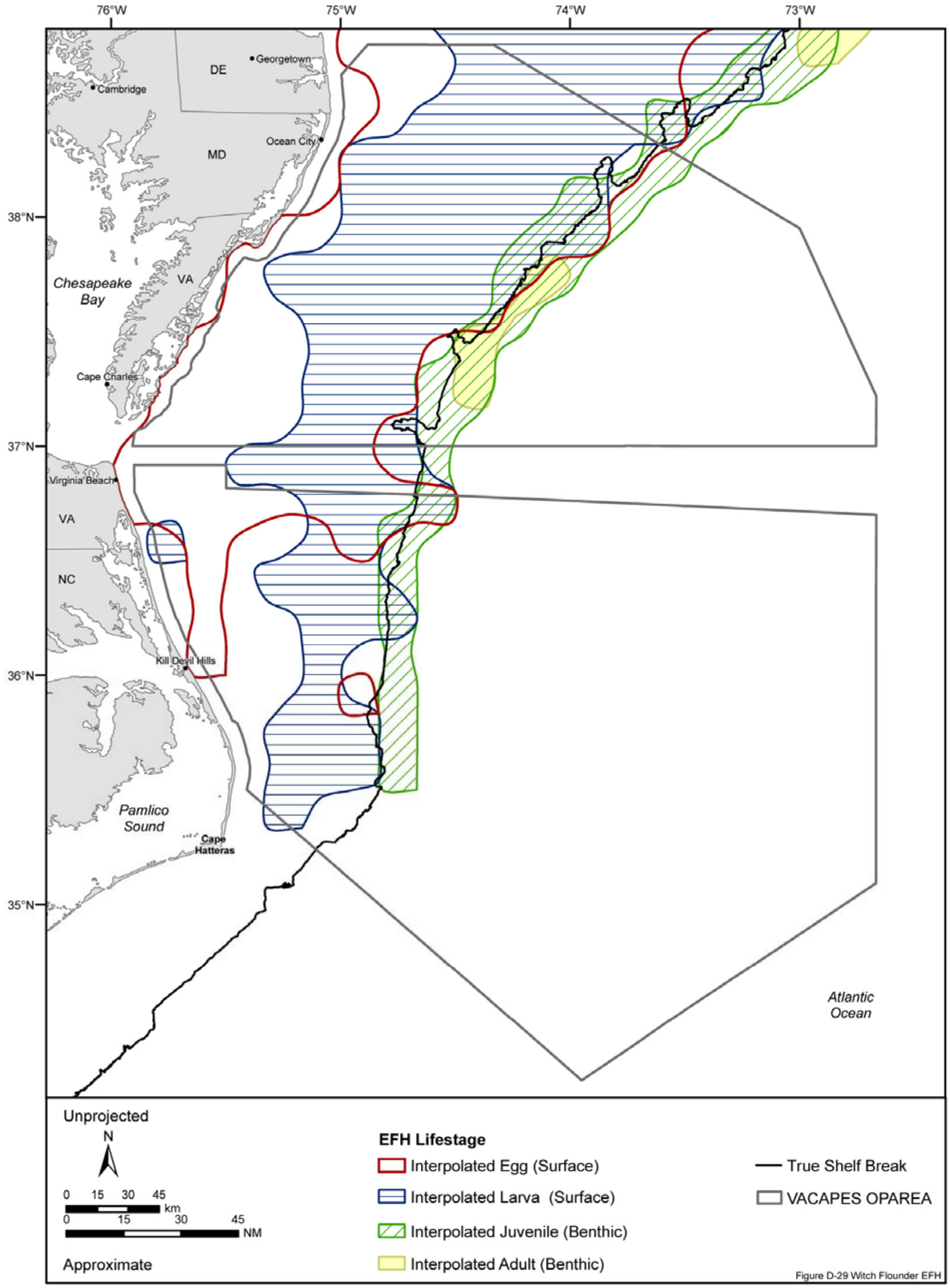

Figure D-29. Essential fish habitat for all lifestages of the witch flounder designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

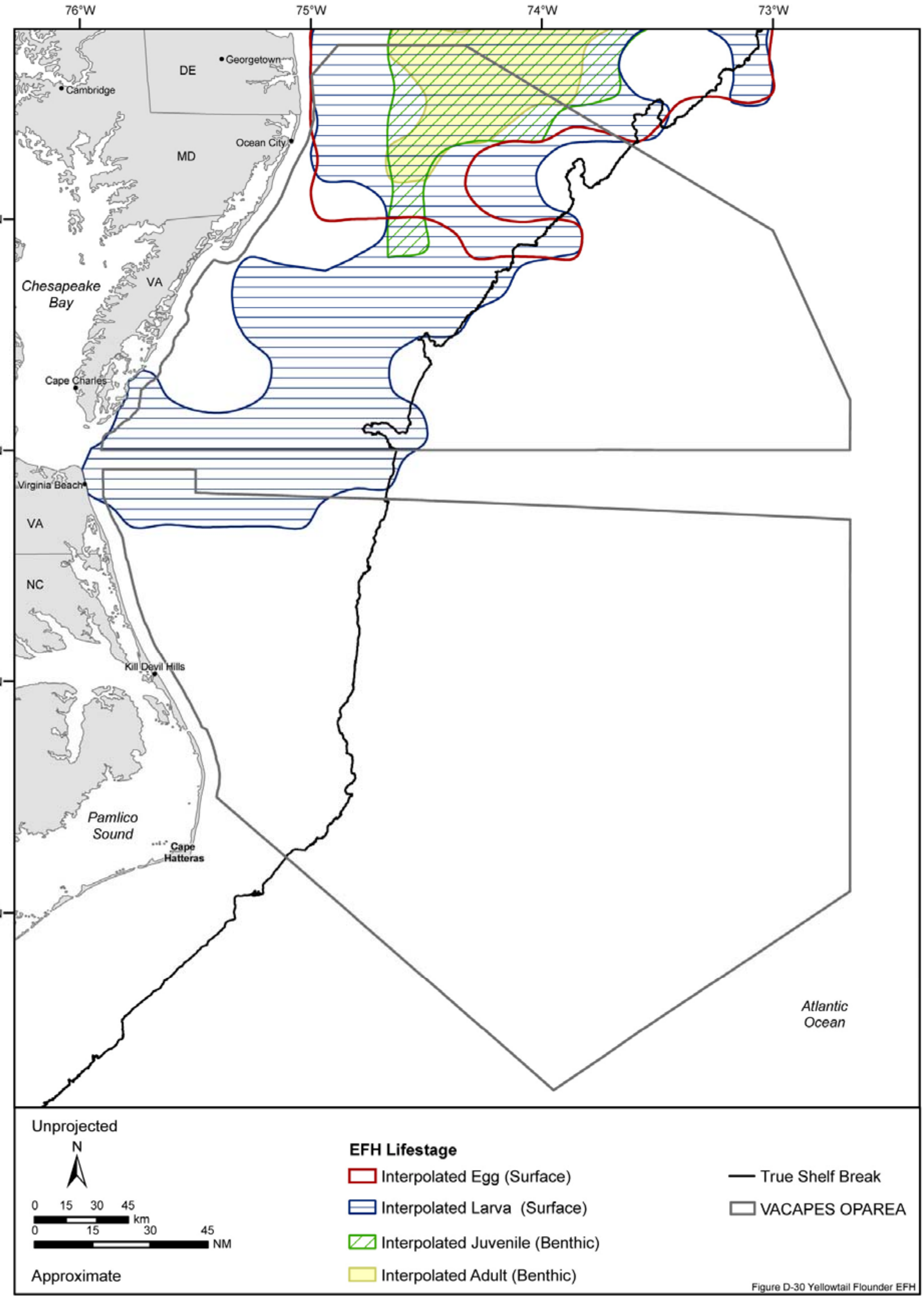

Figure D-30. Essential fish habitat for all lifestages of the yellowtail flounder designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): NEFMC (1998).

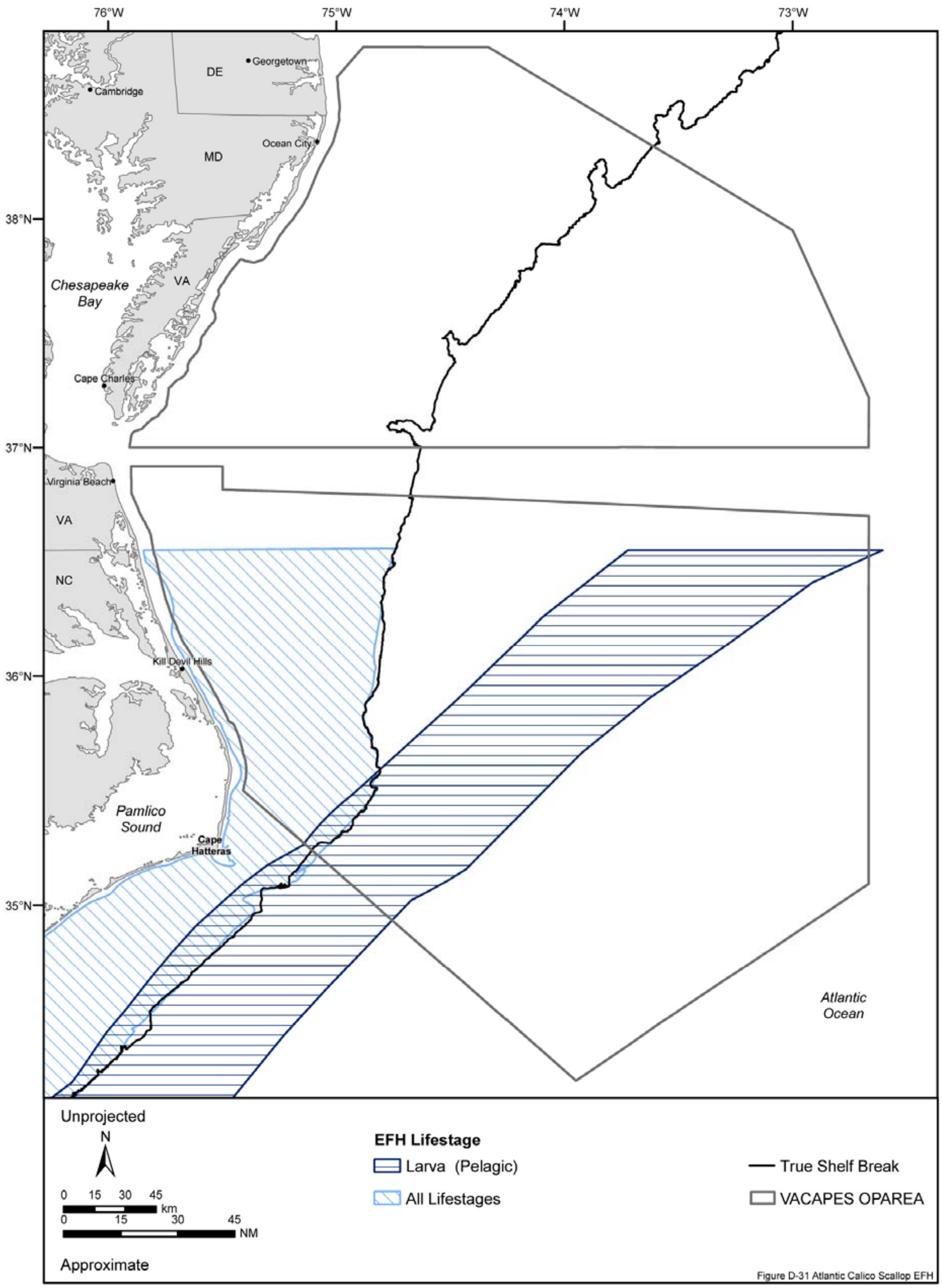

Figure D-31. Essential fish habitat for all lifestages of the Atlantic calico scallops designated in the Virginia Capes OPAREA and vicinity. Source maps (scanned): General Oceanics, Inc. (1986). Source information: SAFMC (1998).

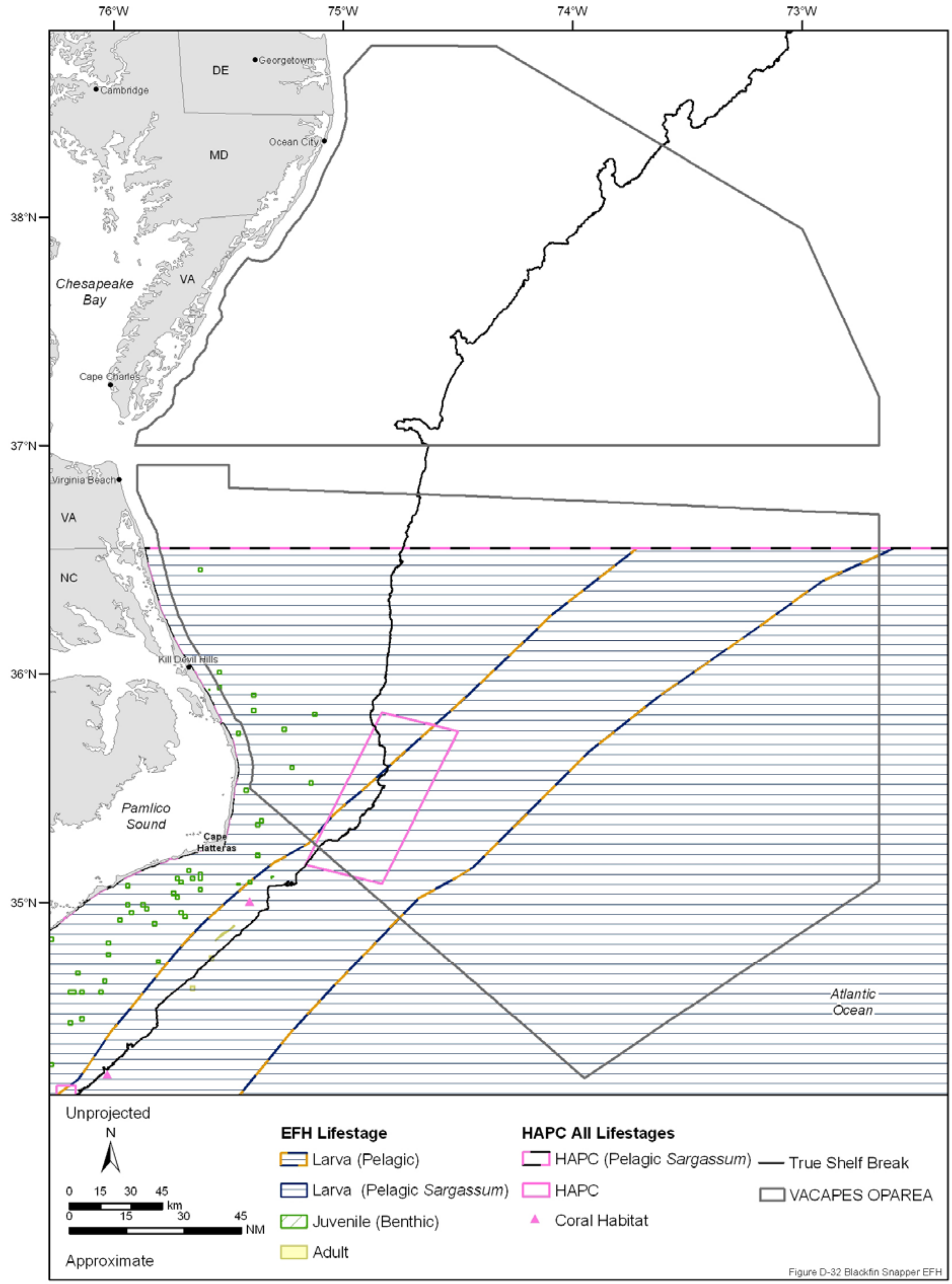

Figure D-32. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the blackfin snapper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

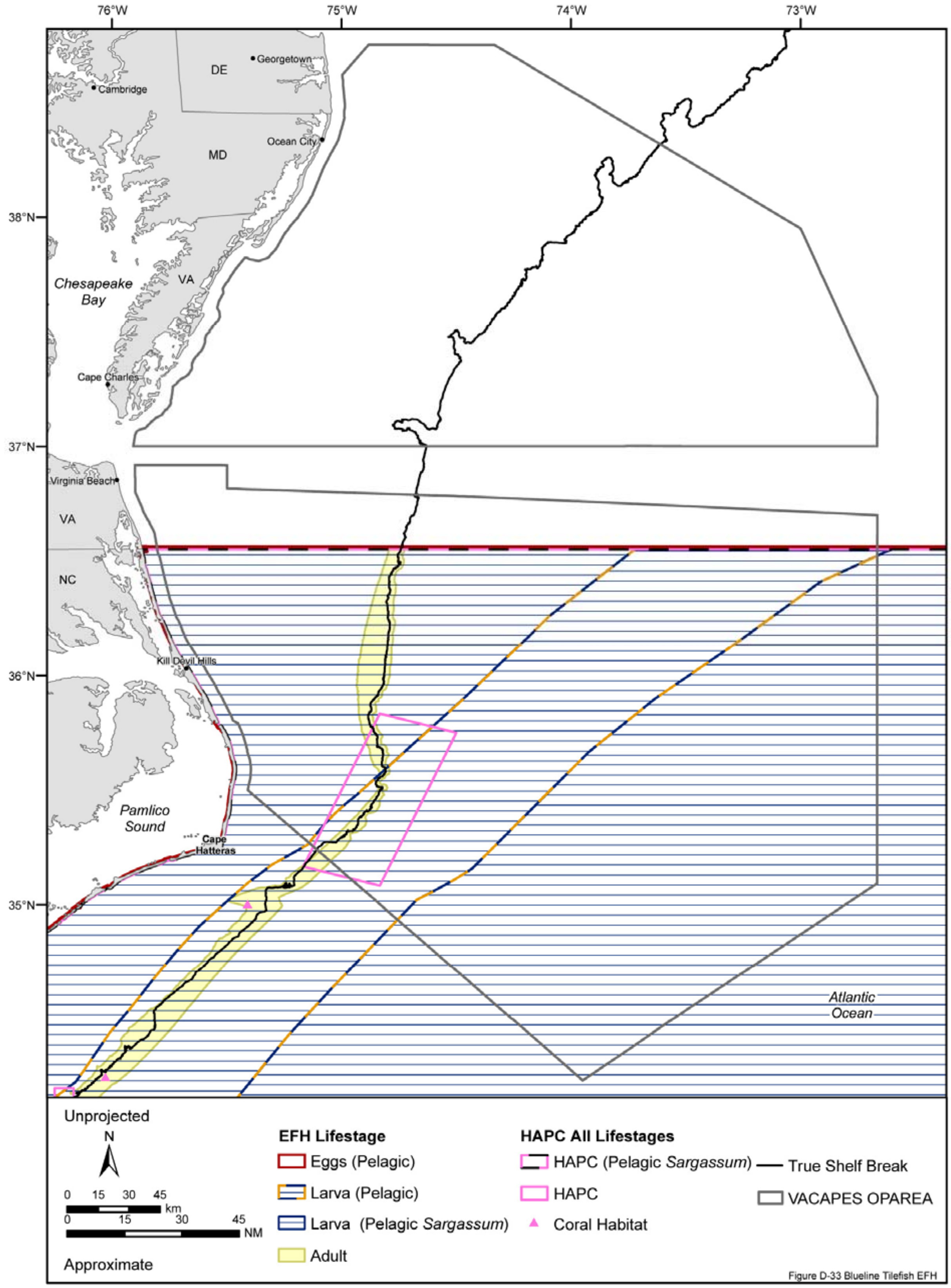

Figure D-33. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the blueline tilefish designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

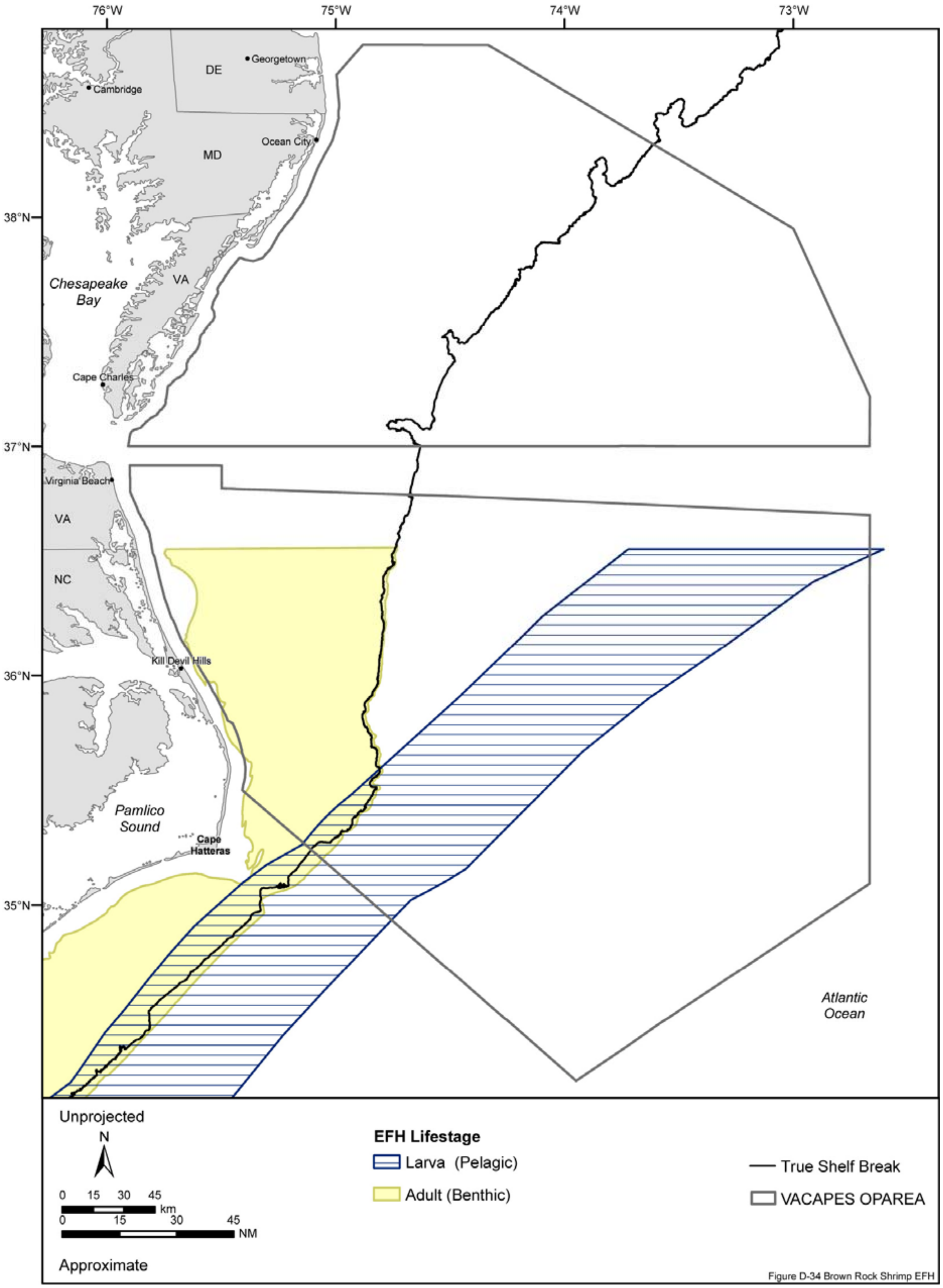

Figure D-34. Essential fish habitat for all lifestages of the brown rock shrimp designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): General Oceanics, Inc. (1986). Source information: SAFMC (1998) and NMFS (2002).

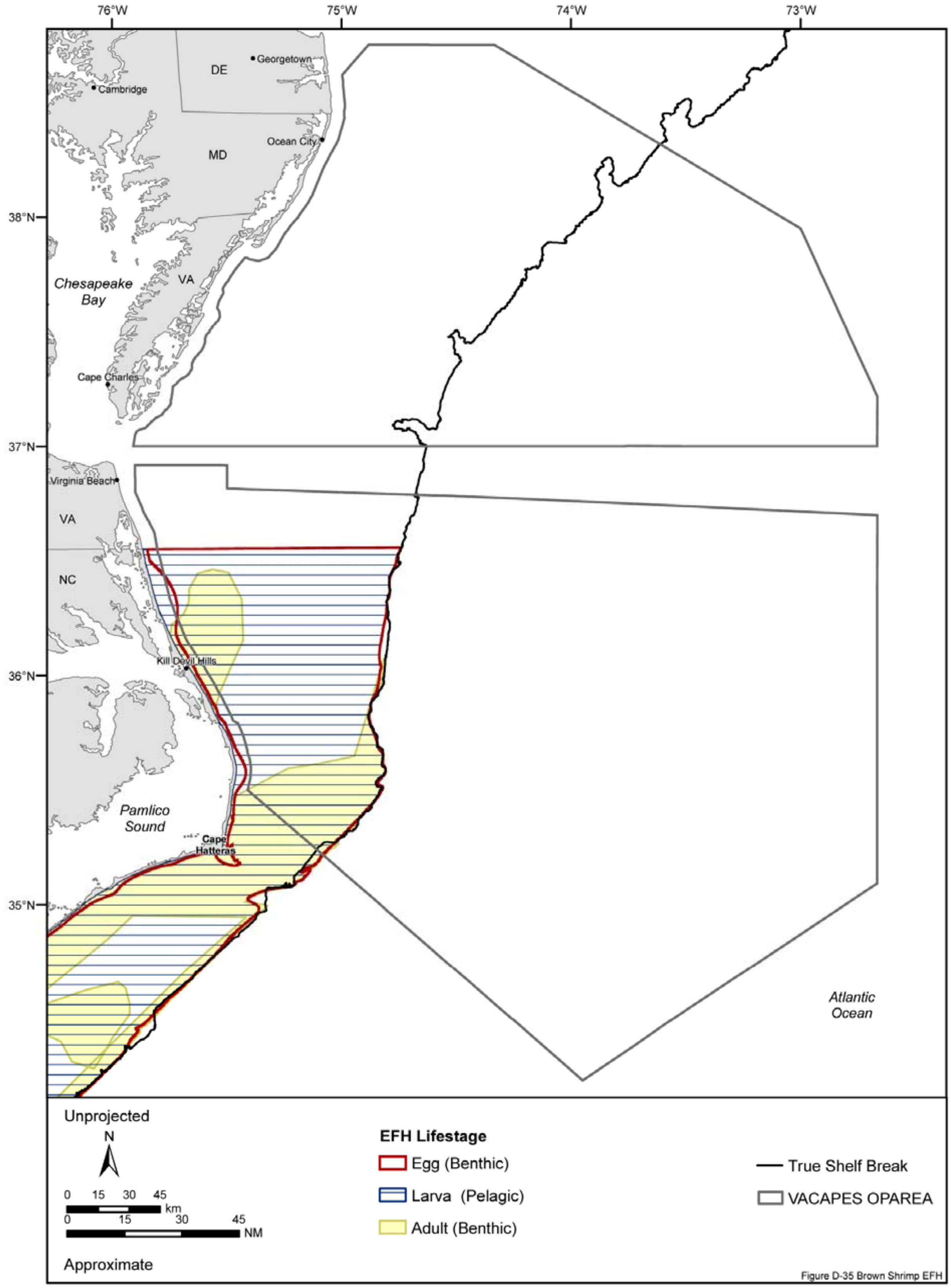

Figure D-35. Essential fish habitat for all lifestages of the brown shrimp designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): Amato (1994). Source information: SAFMC (1998) and NMFS (2002).

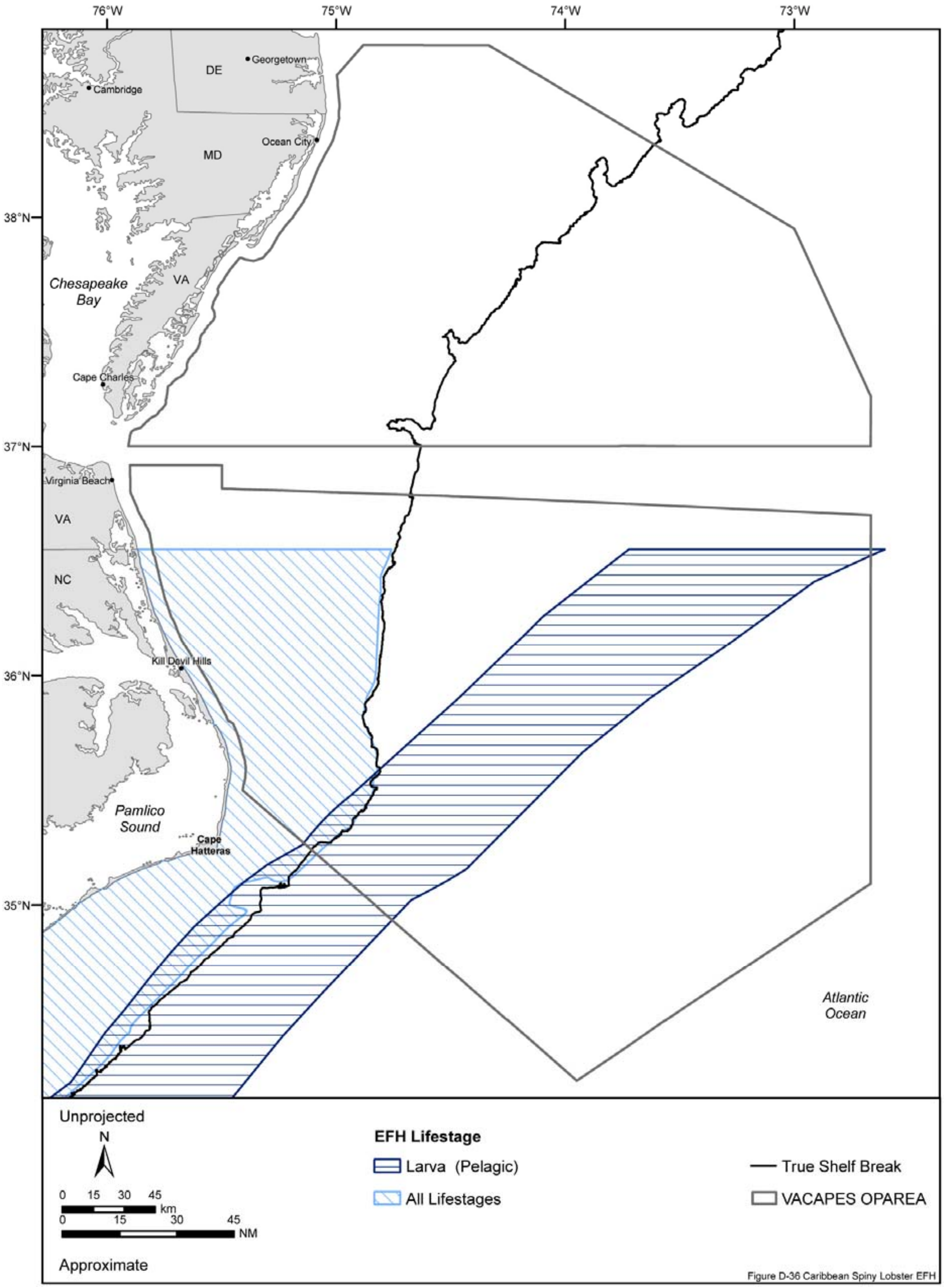

Figure D-36. Essential fish habitat for all lifestages of the Caribbean spiny lobster designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): General Oceanics, Inc. (1986). Source information: SAFMC (1998).

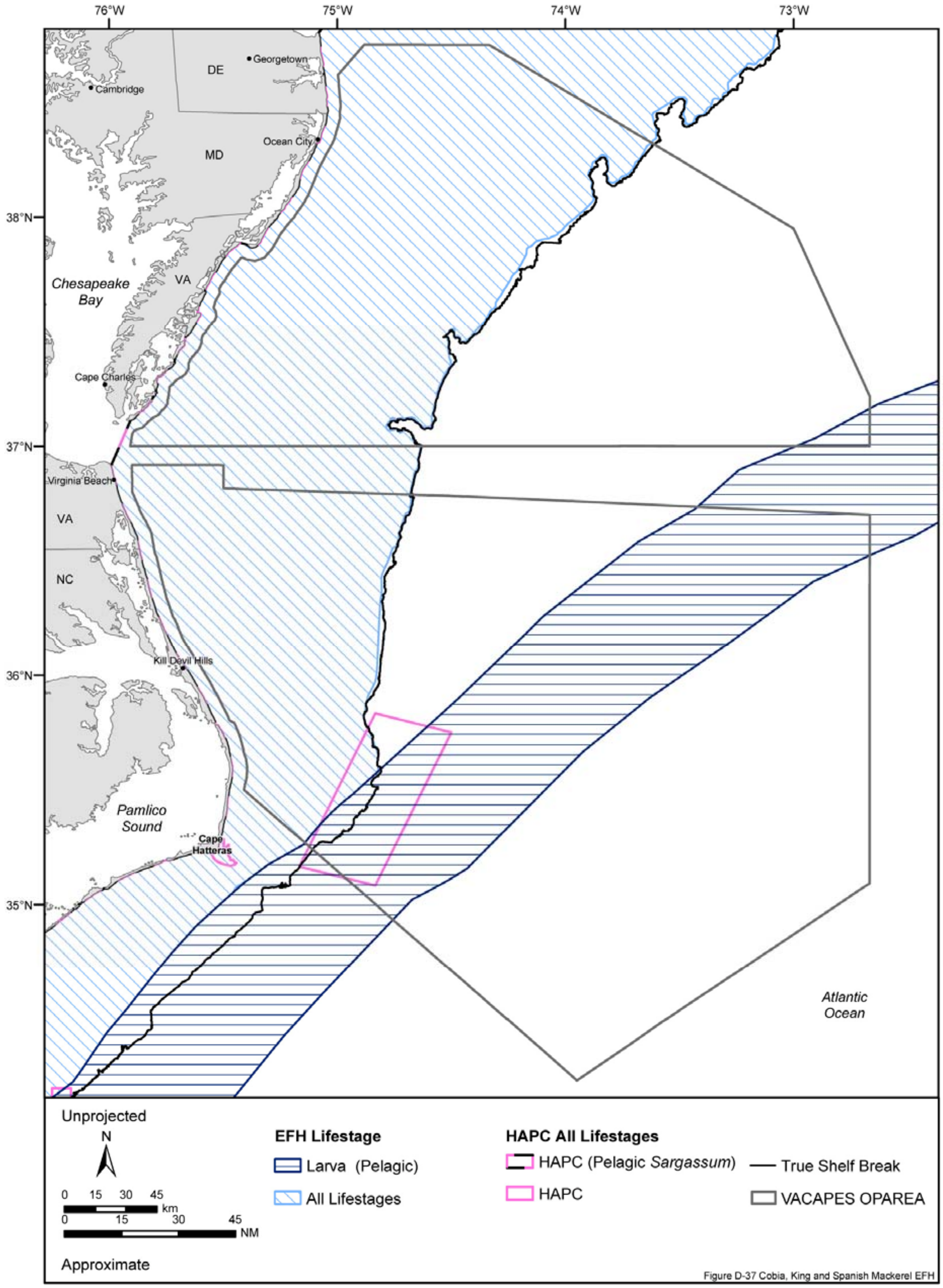

Figure D-37. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the cobia, king, and Spanish mackerel designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

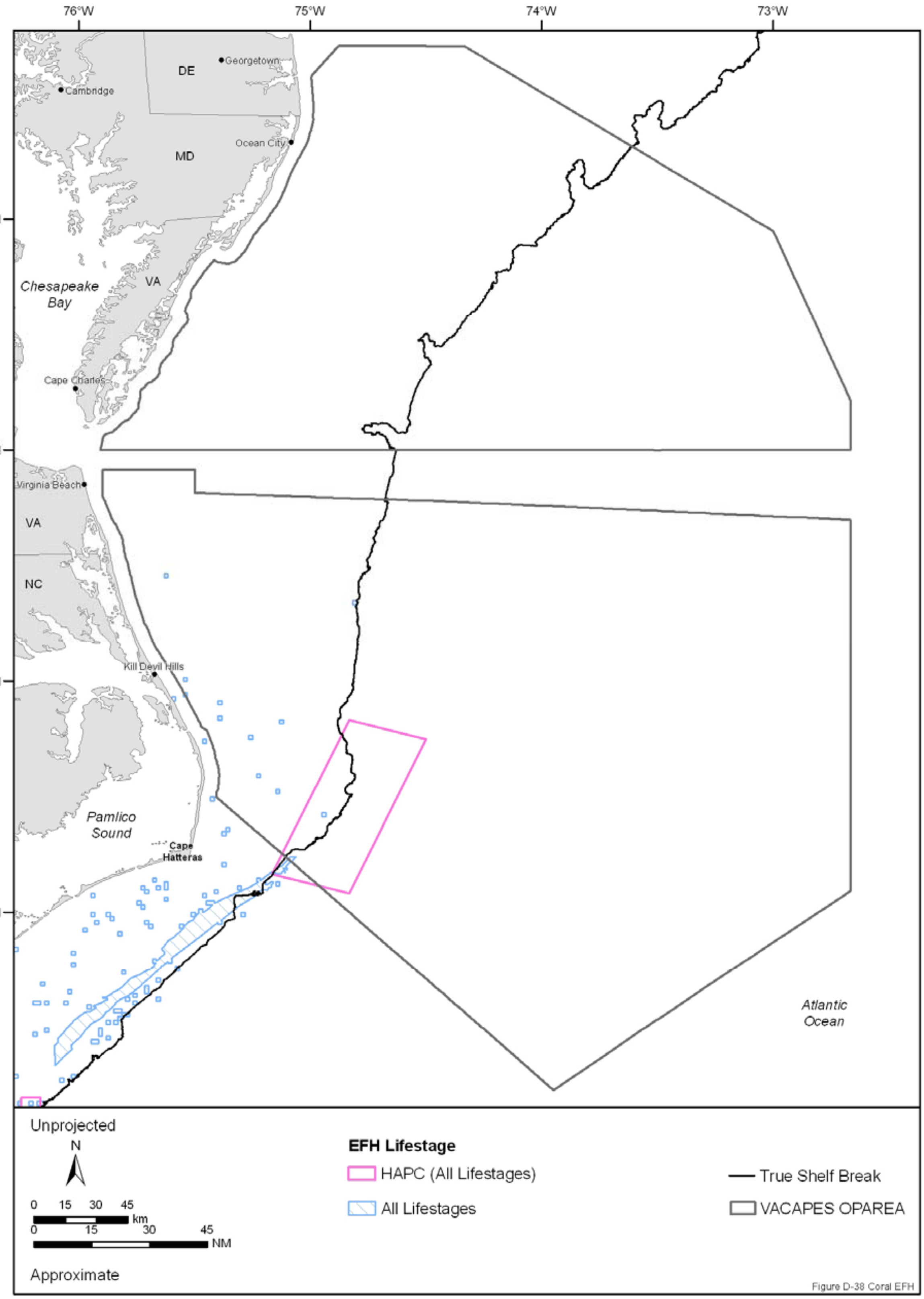

Figure D-38. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the coral designated in the Virginia Capes OPAREA and vicinity. Source data: SEAMAP (2001) and SAFMC (2003b). Source maps (scanned): BLM (1976) and Riggs et al. (1986). Source information: SAFMC (2003b).

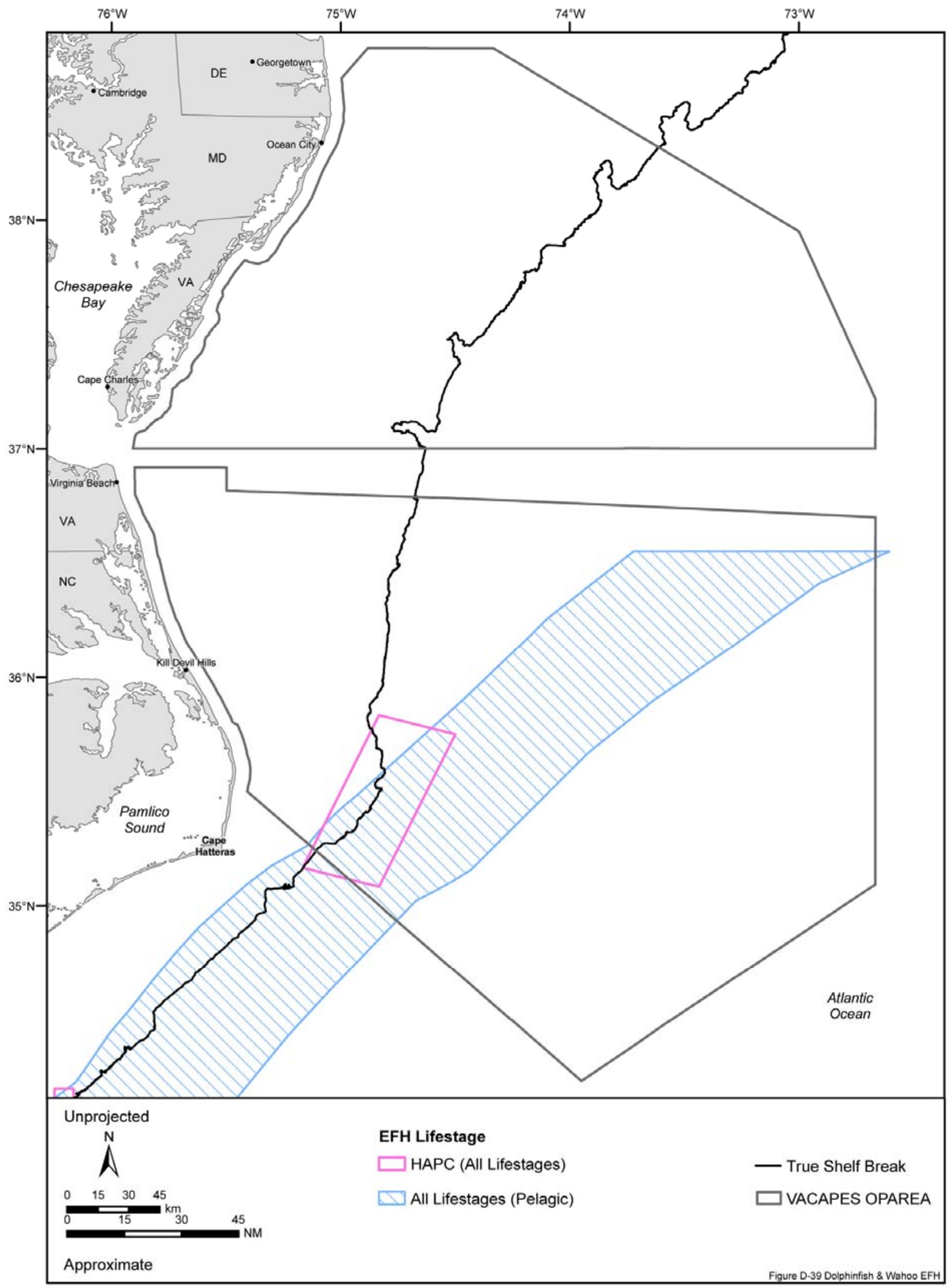

Figure D-39. Essential fish habitat for all lifestages of the dolphin and wahoo designated in the Virginia Capes OPAREA and vicinity. Source data: General Oceanics, Inc. (1986). Source information: SAFMC (2003b).

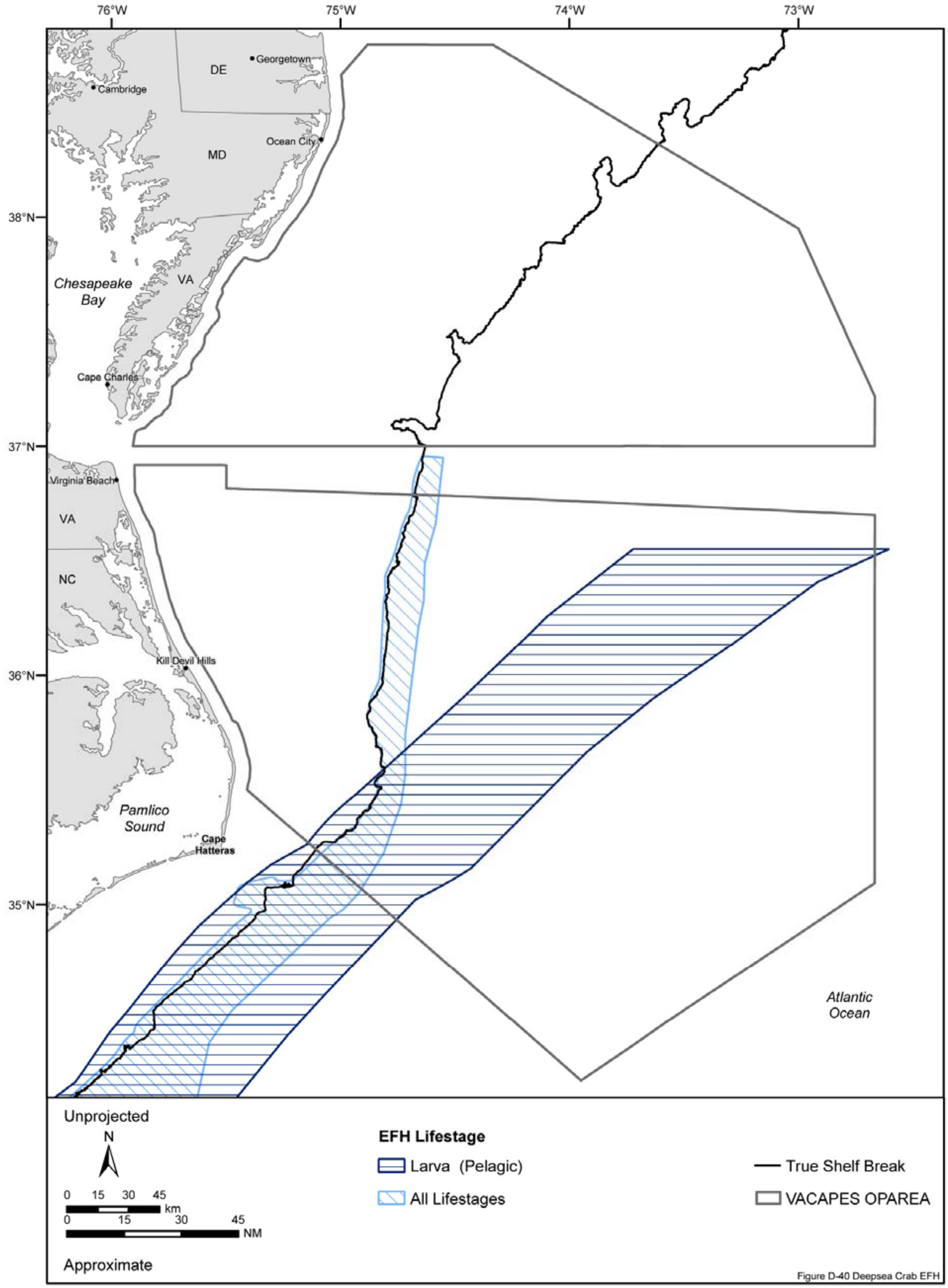

Figure D-40. Essential fish habitat for all lifestages of the golden deepsea crab designated in the Virginia Capes OPAREA and vicinity. Source map/source information: refer to Table D-1.

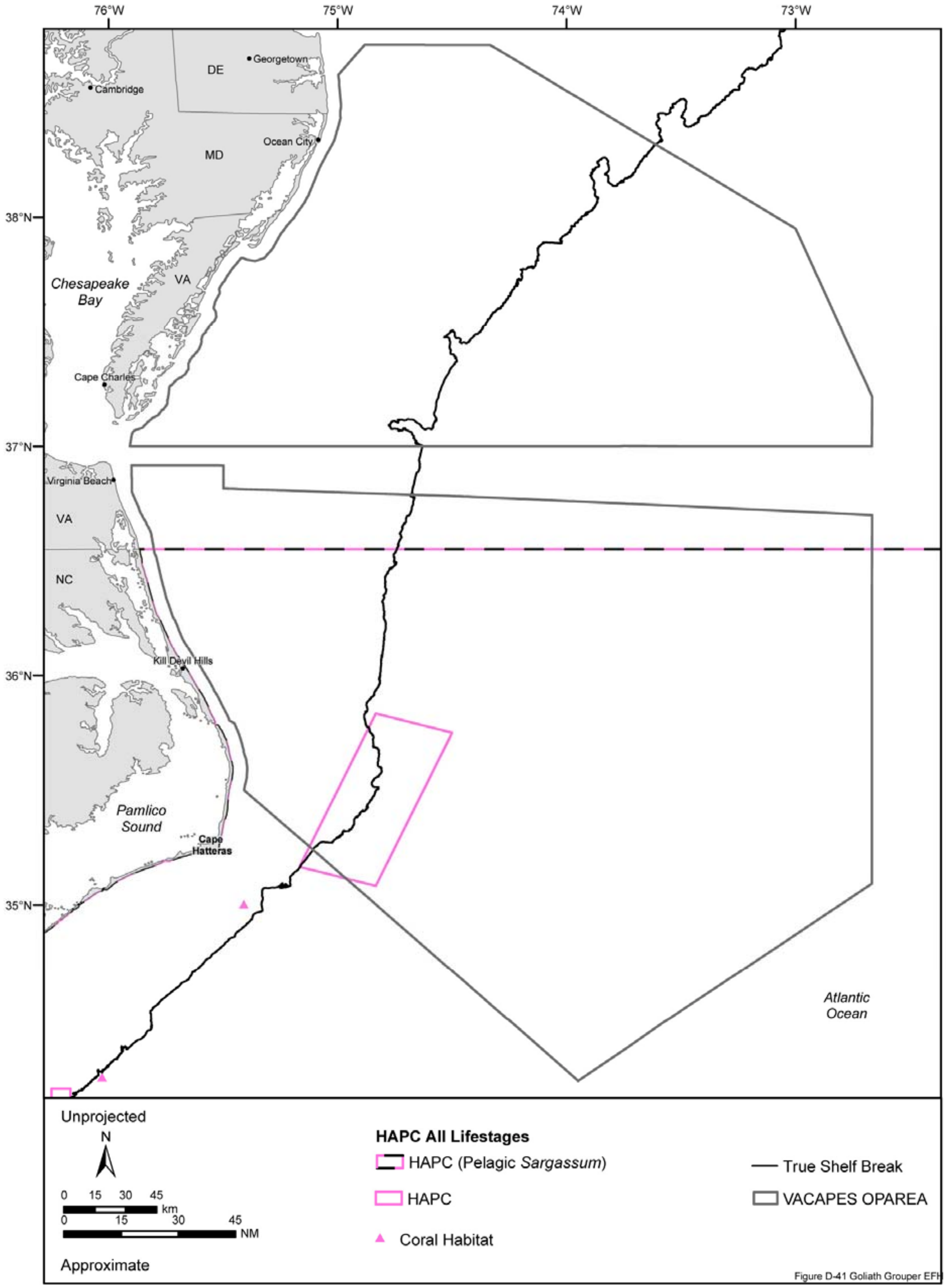

Figure D-41. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the goliath grouper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

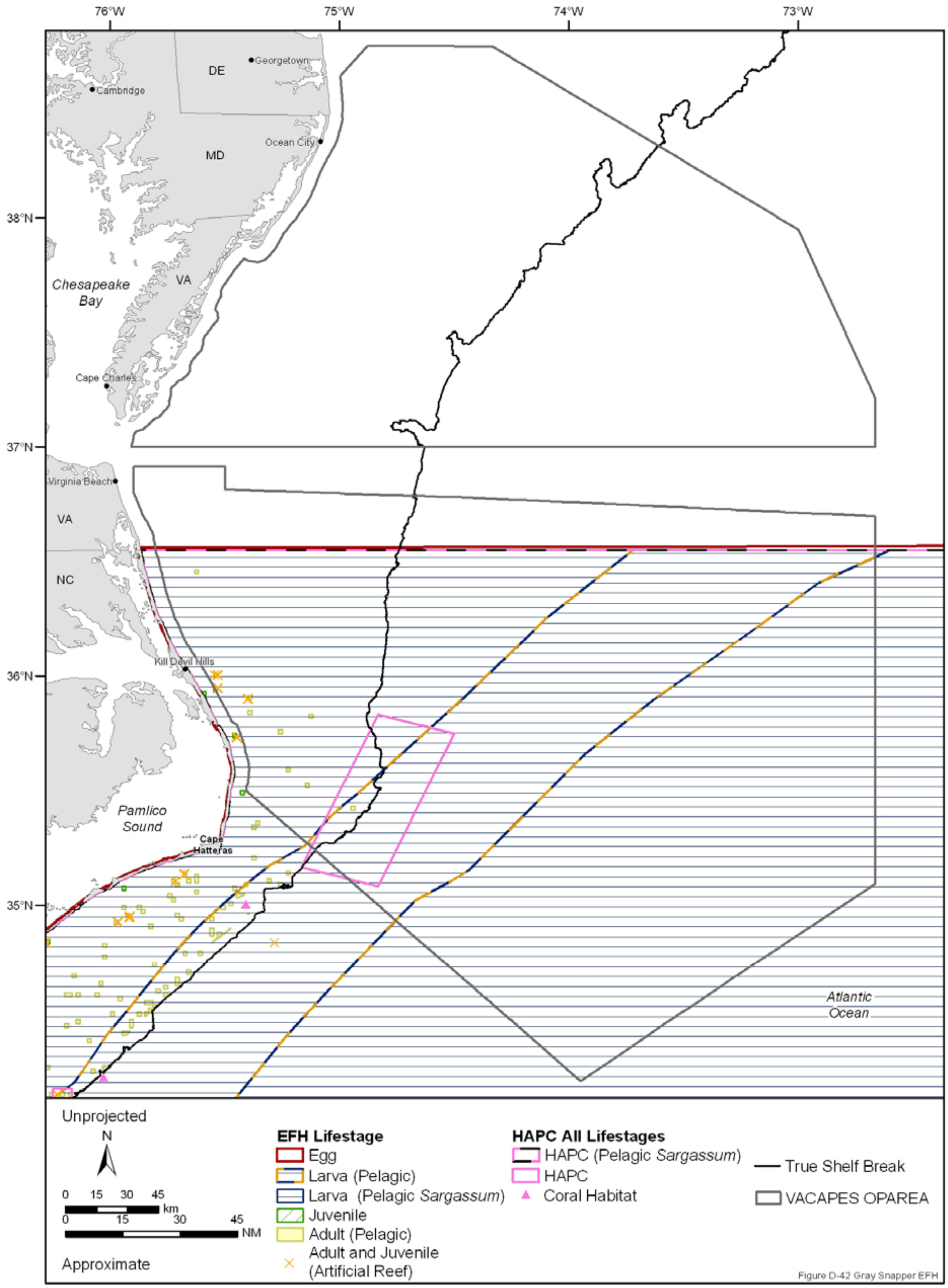

Figure D-42. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the gray snapper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

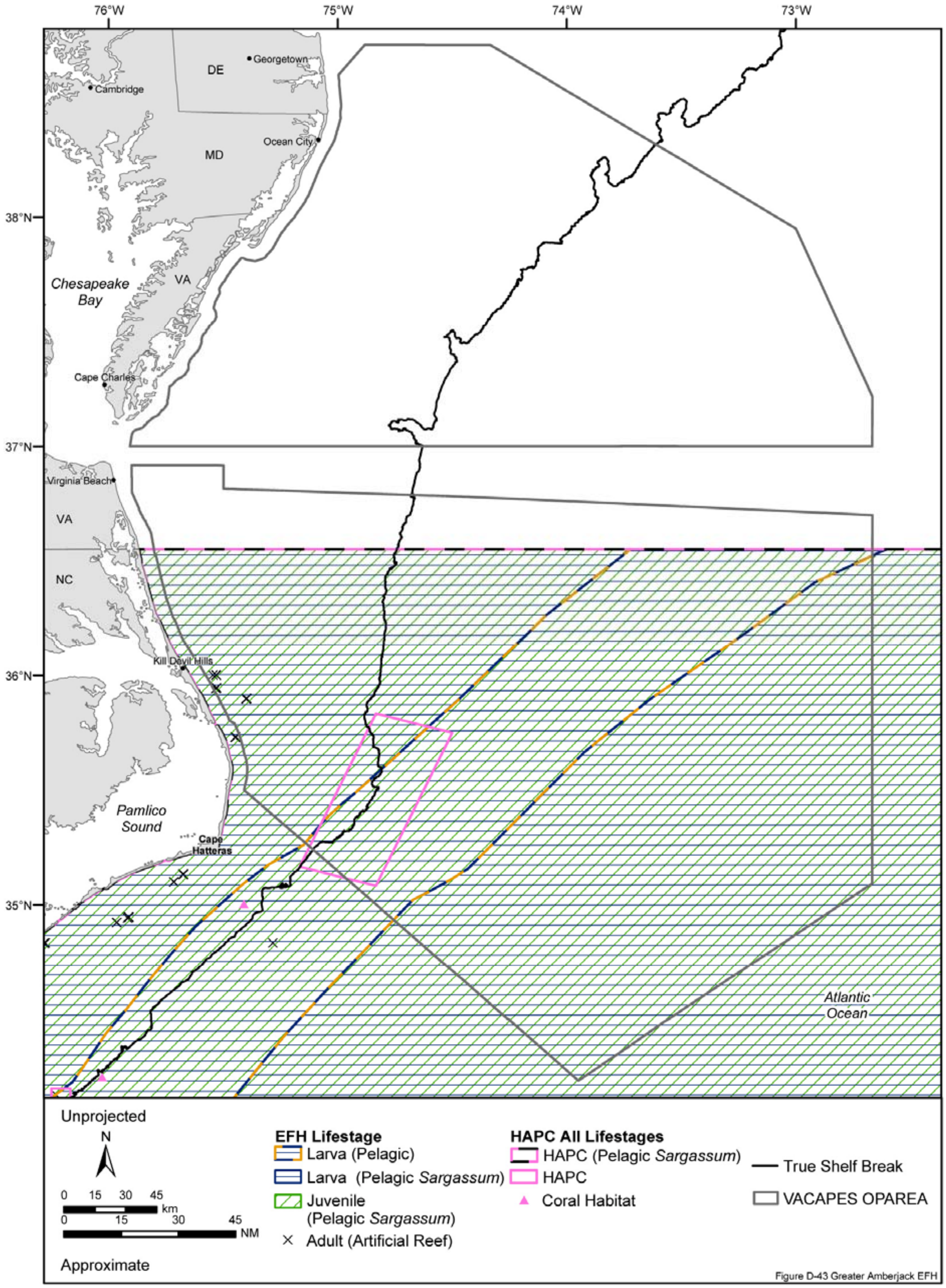

Figure D-43. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the greater amberjack designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

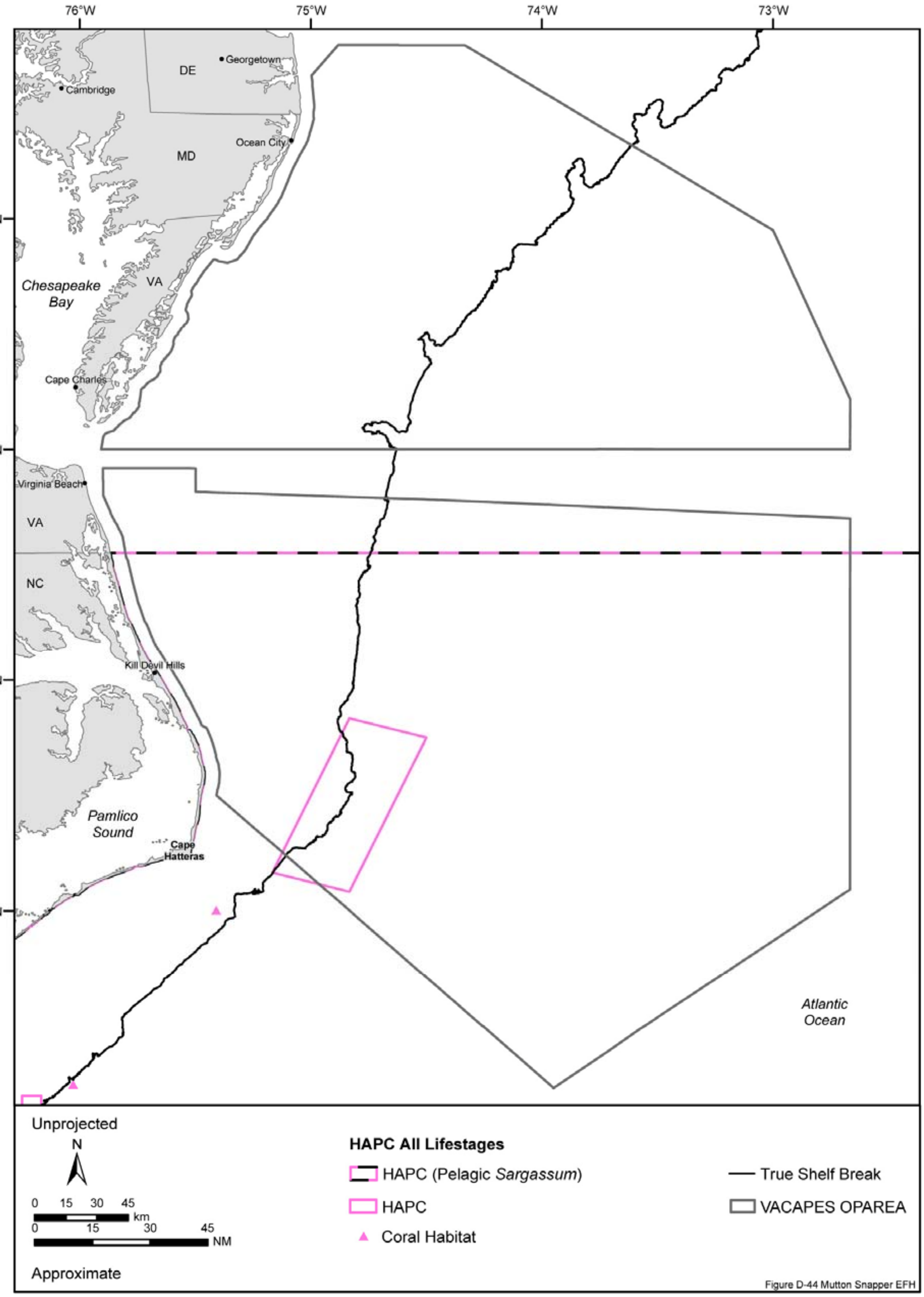

Figure D-44. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the mutton snapper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

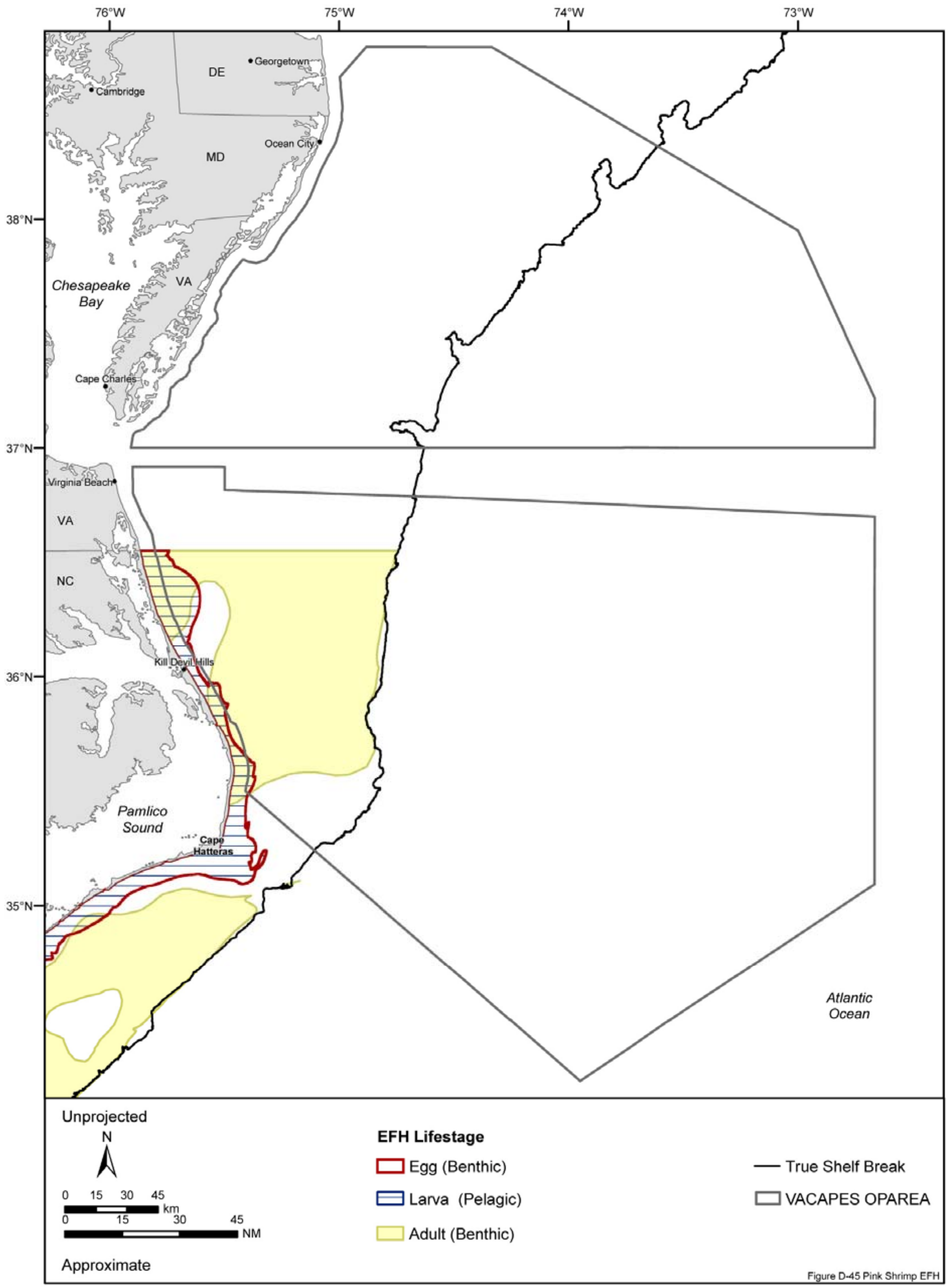

Figure D-45. Essential fish habitat for all lifestages of the pink shrimp designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): Amato (1994). Source information: SAFMC (1998) and NMFS (2002).

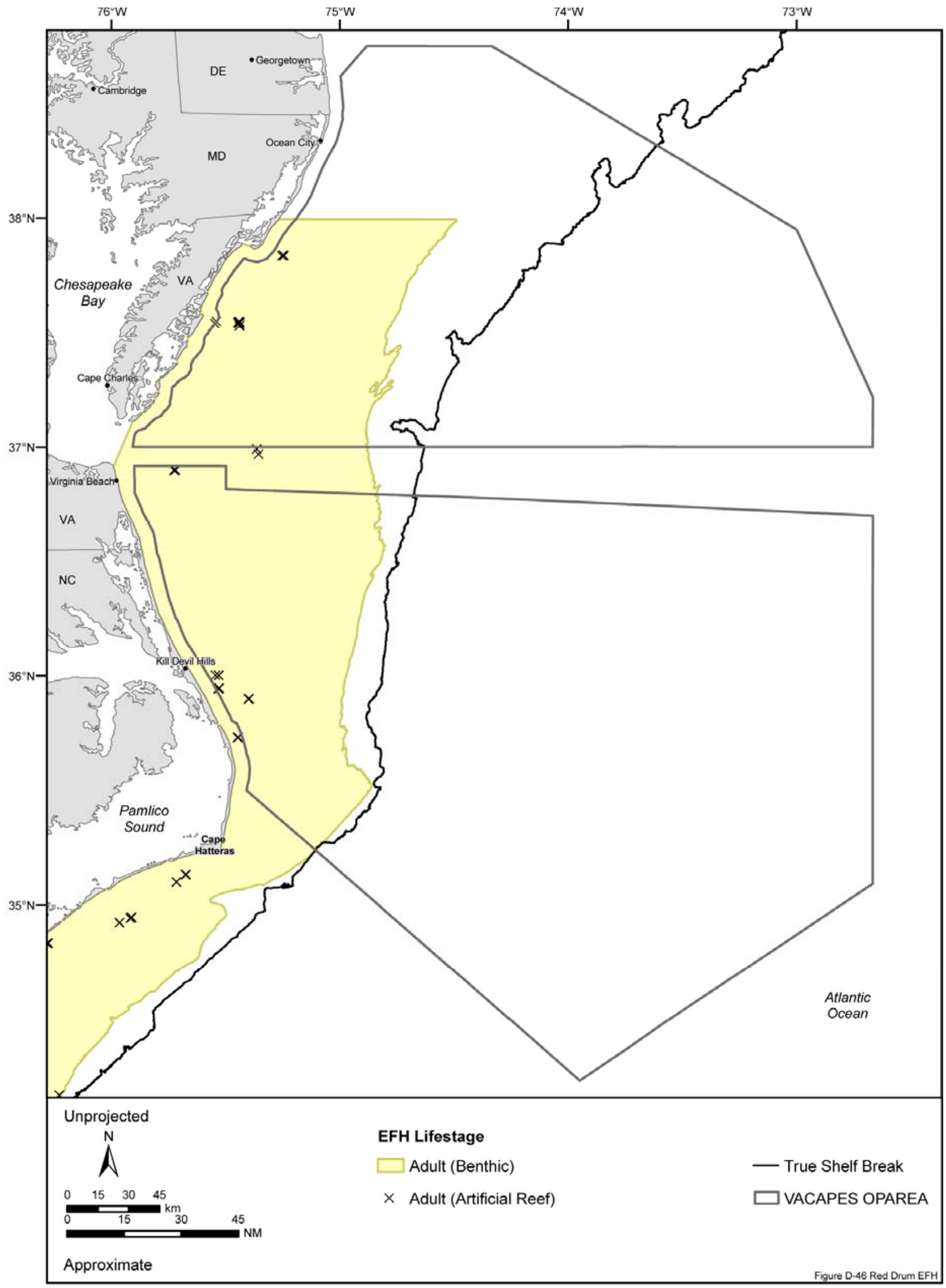

Figure D-46. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the red drum designated in the Virginia Capes OPAREA and vicinity. Source data/source information: refer to Table D-1.

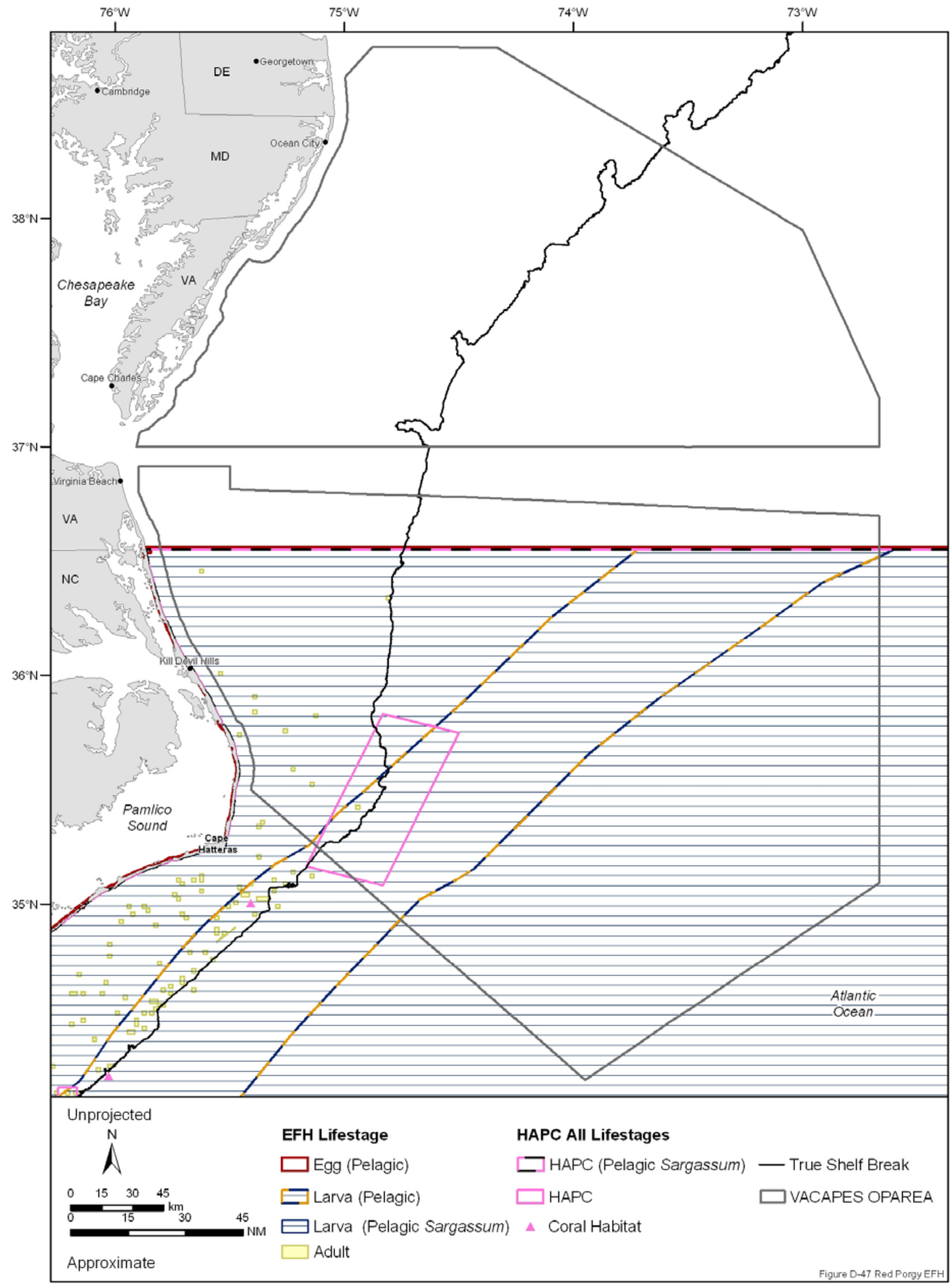

Figure D-47. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the red porgy designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

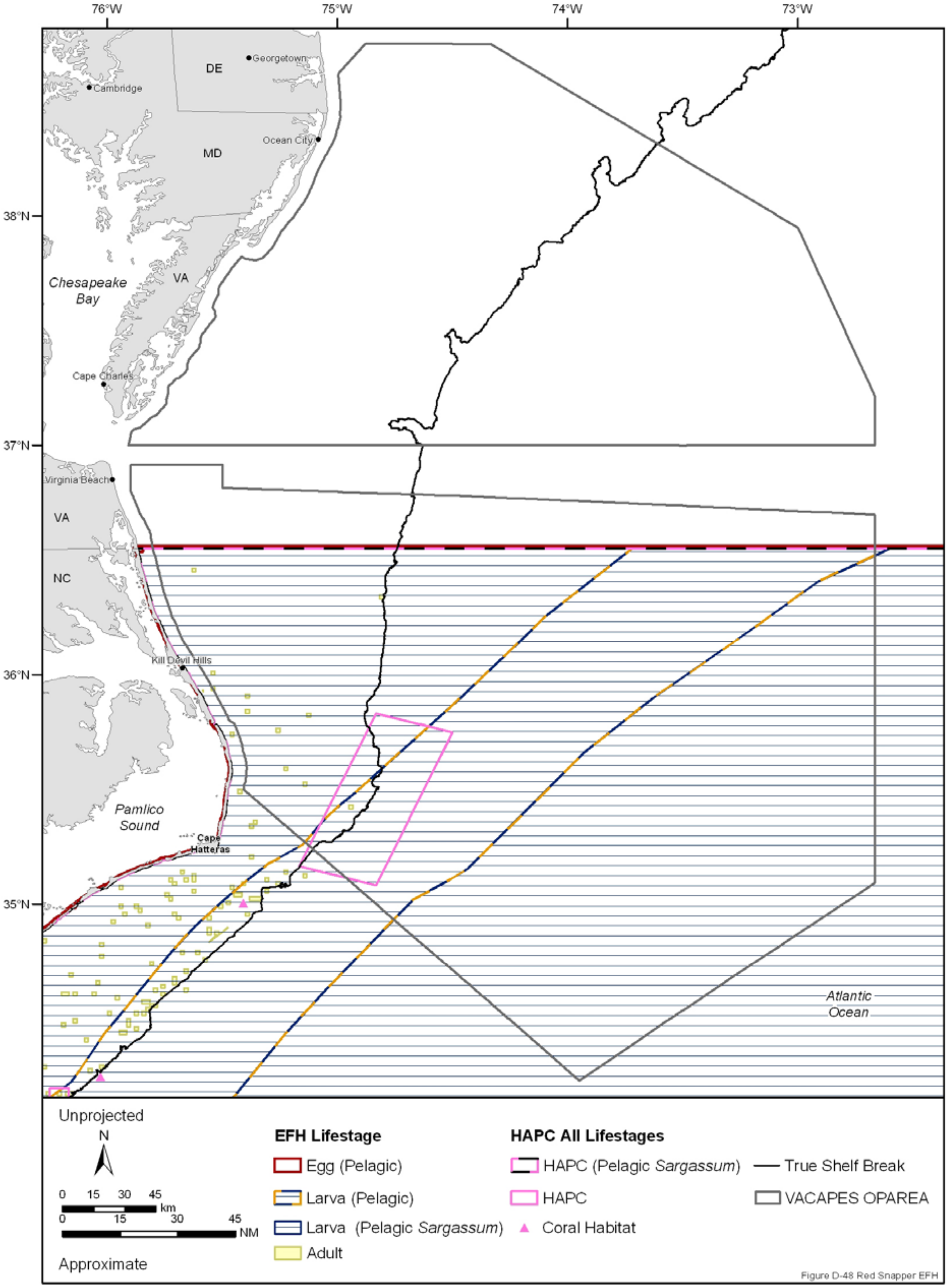

Figure D-48. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the red snapper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

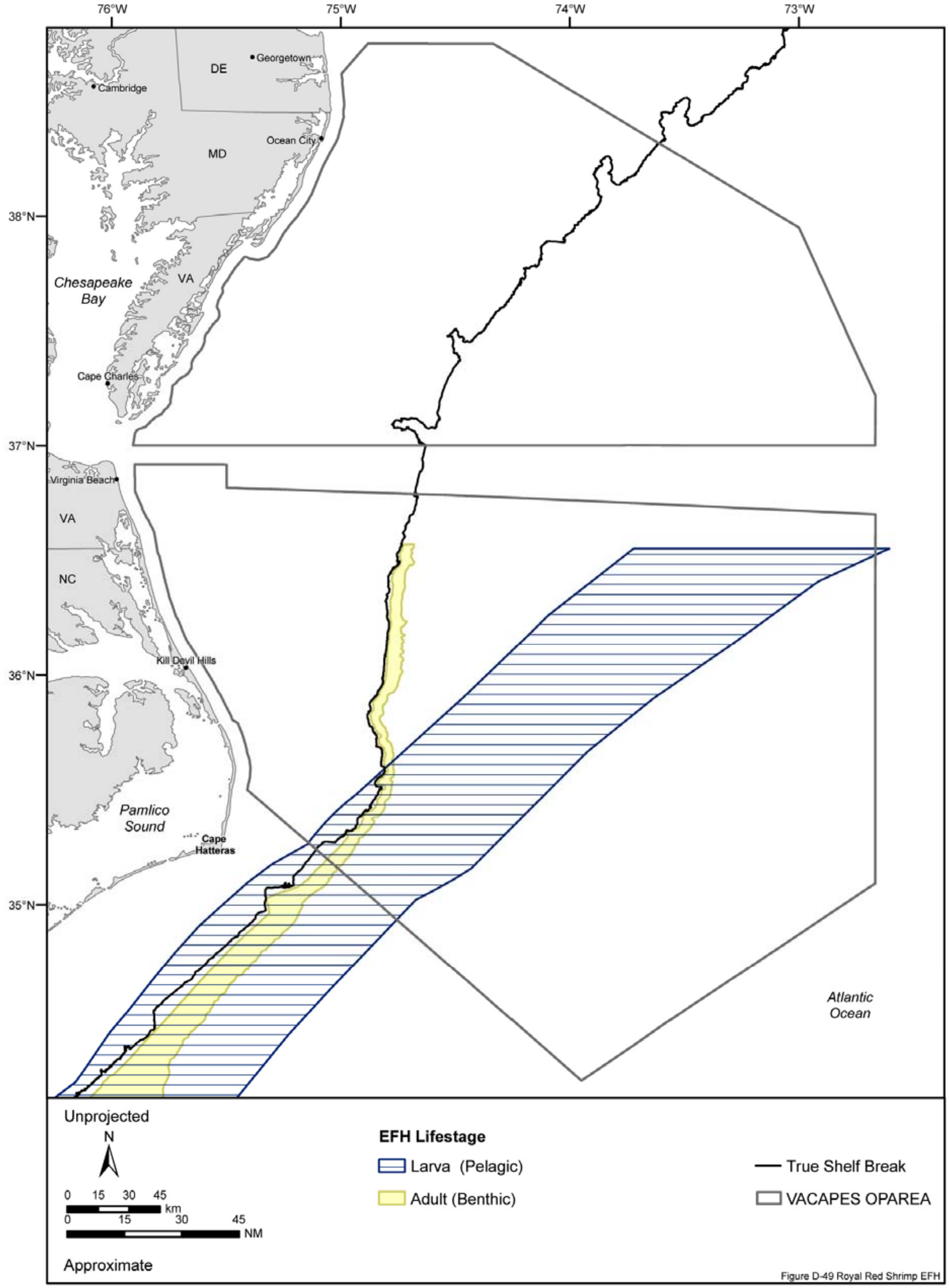

Figure D-49. Essential fish habitat for all lifestages of the royal red shrimp designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): General Oceanics, Inc. (1986). Source information: SAFMC (1998) and NMFS (2002).

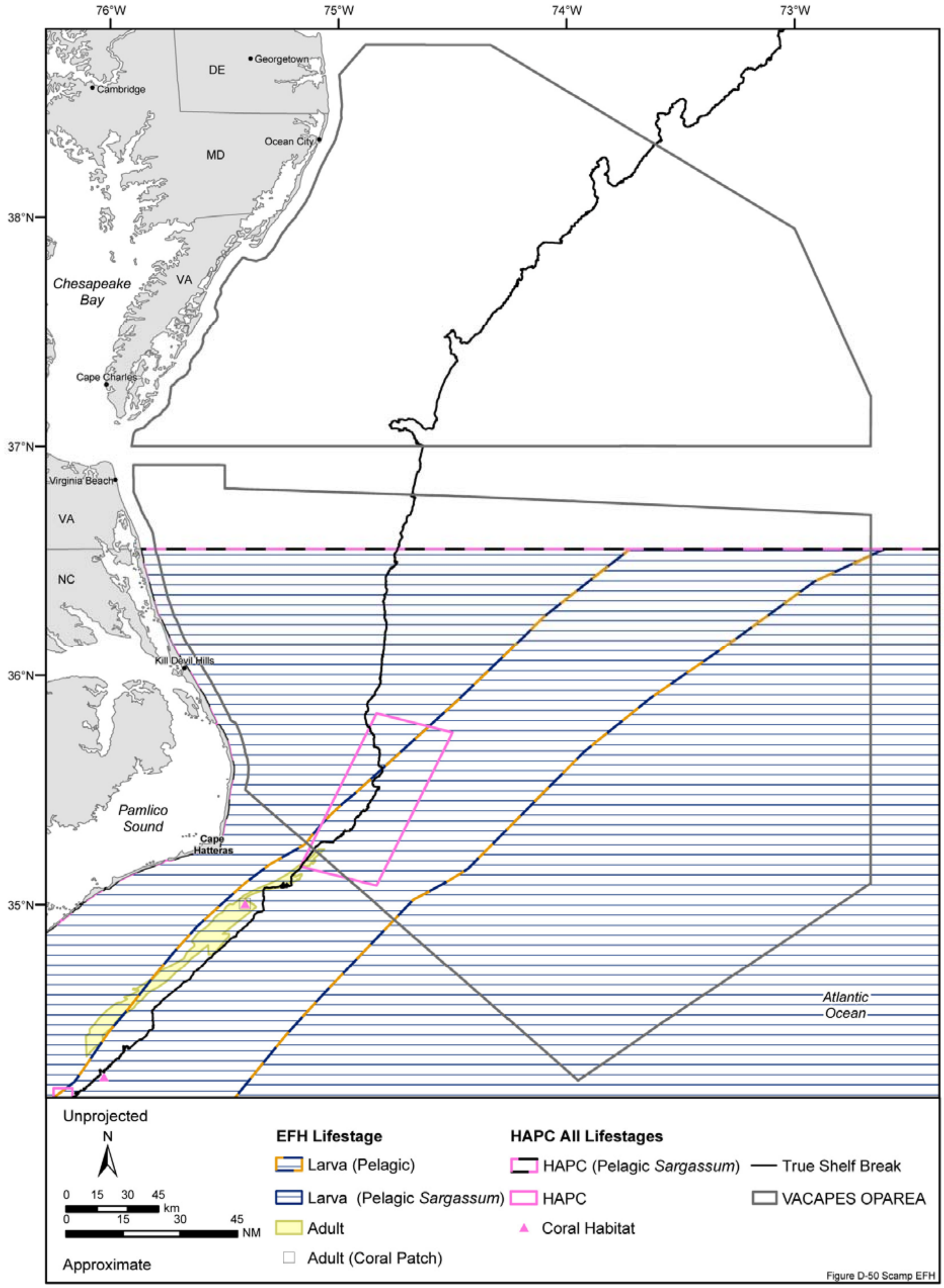

Figure D-50. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the scamp designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

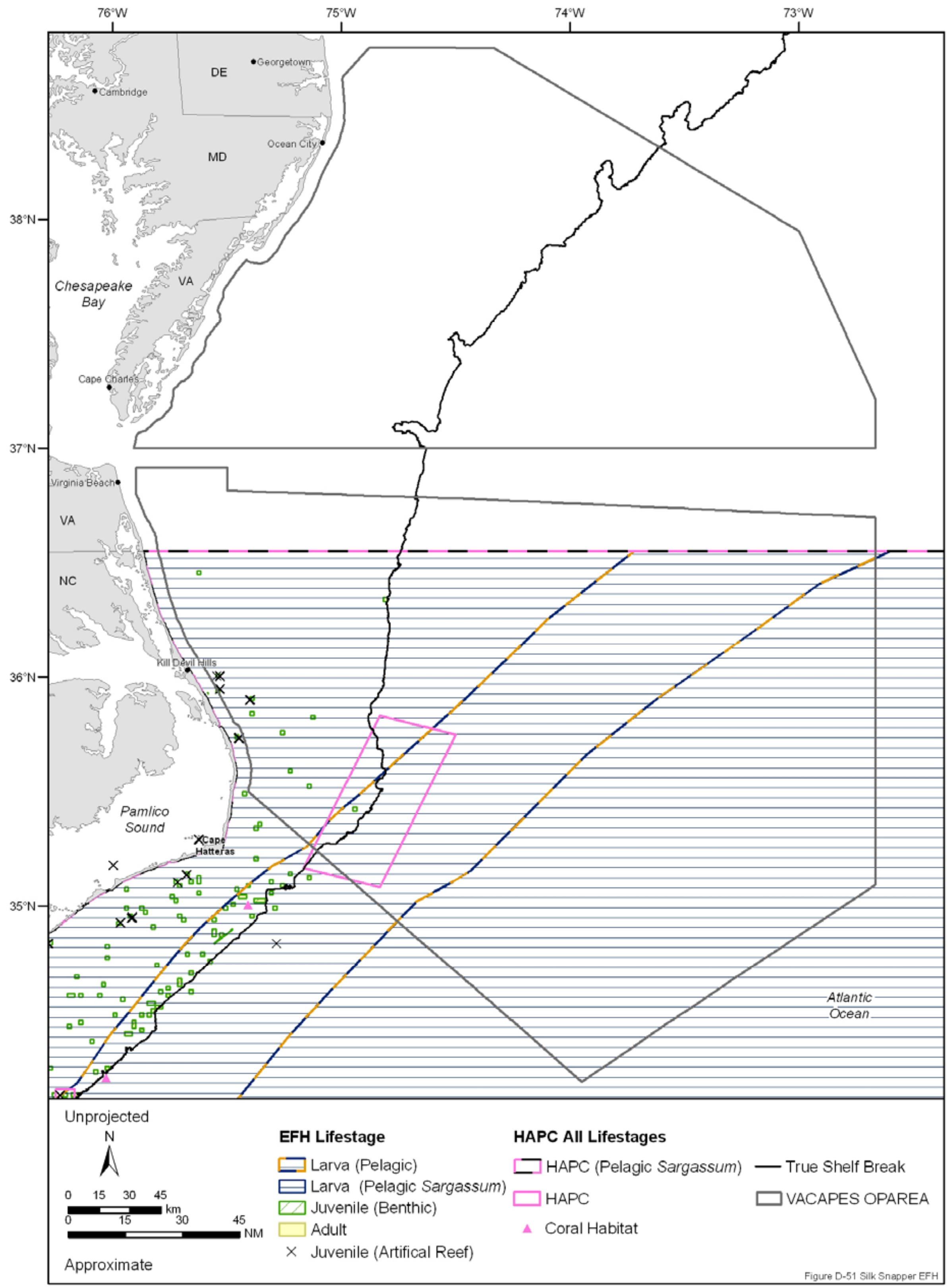

Figure D-51. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the silk snapper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

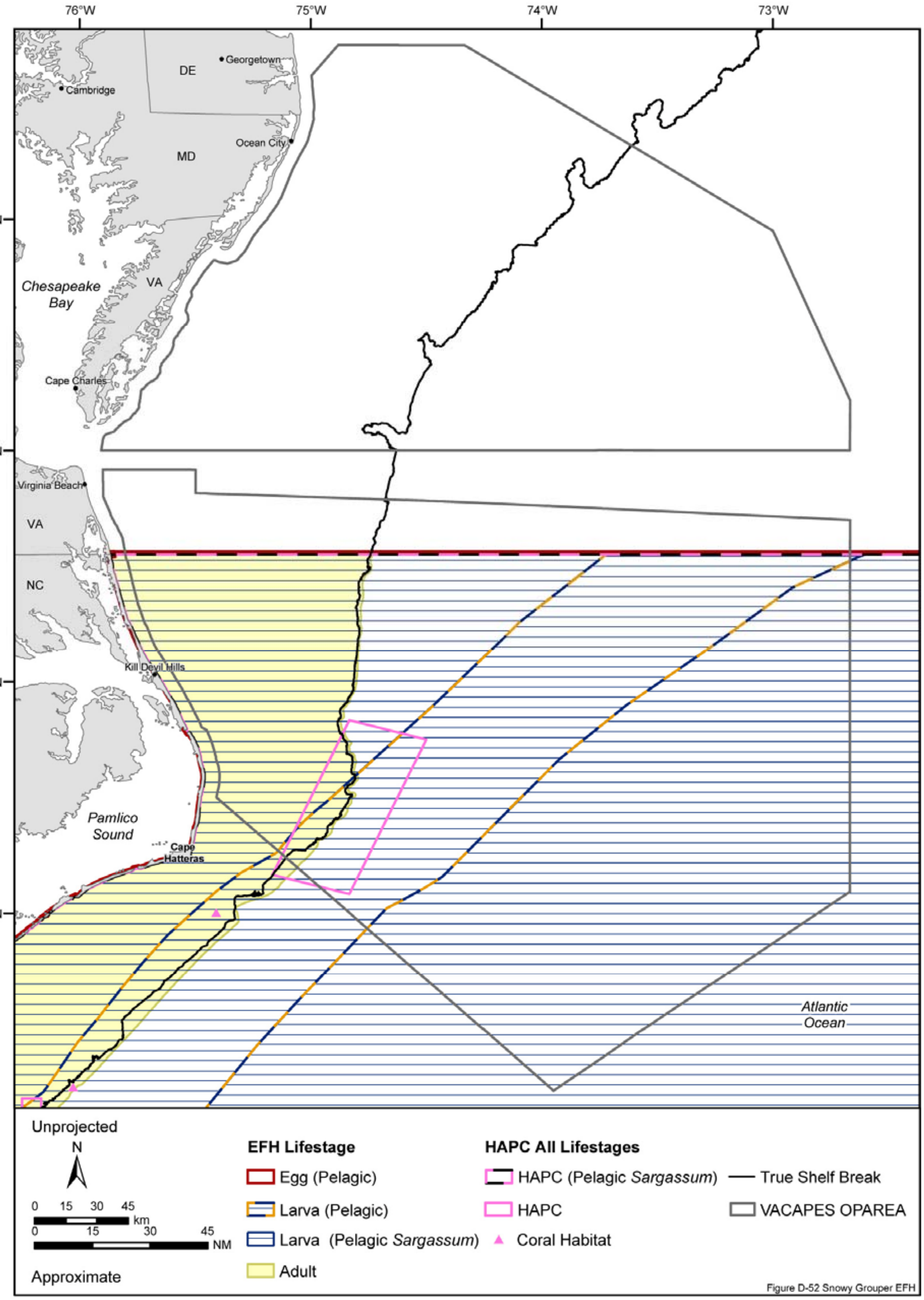

Figure D-52. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the snowy grouper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

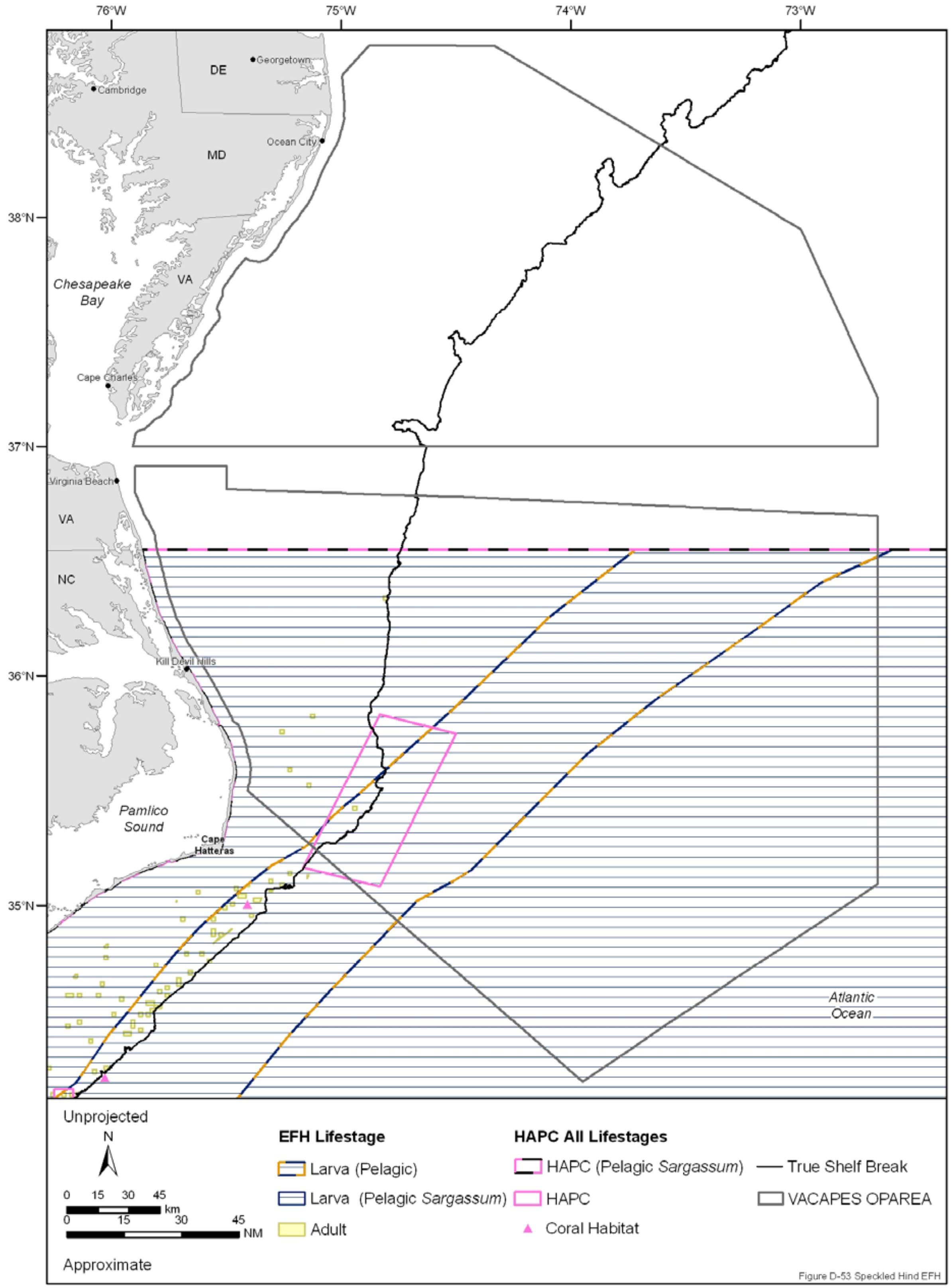

Figure D-53. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the speckled hind designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

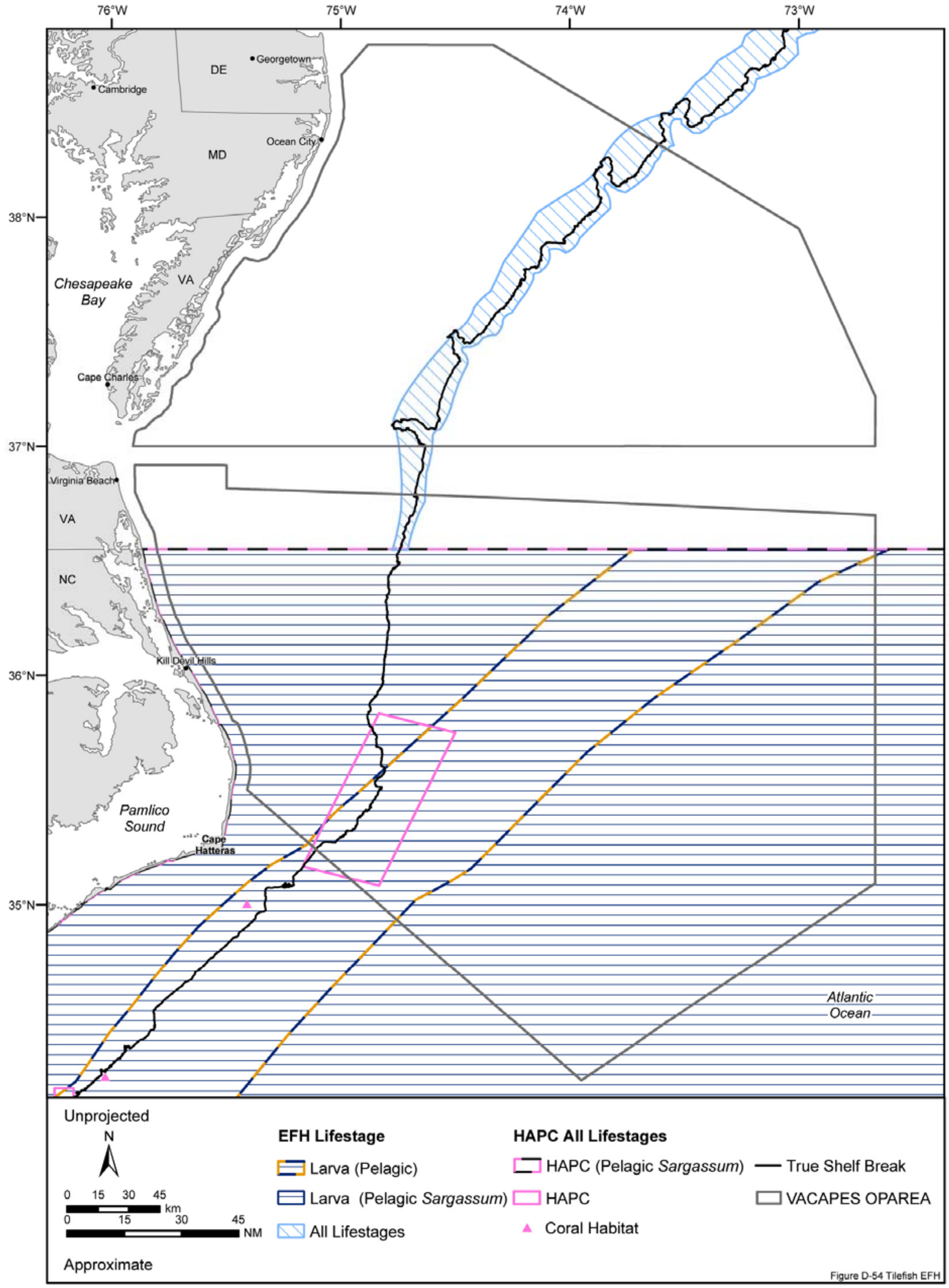

Figure D-54. Essential fish habitat and habitats of particular concern (HAPC) for all lifestages of the tilefish designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

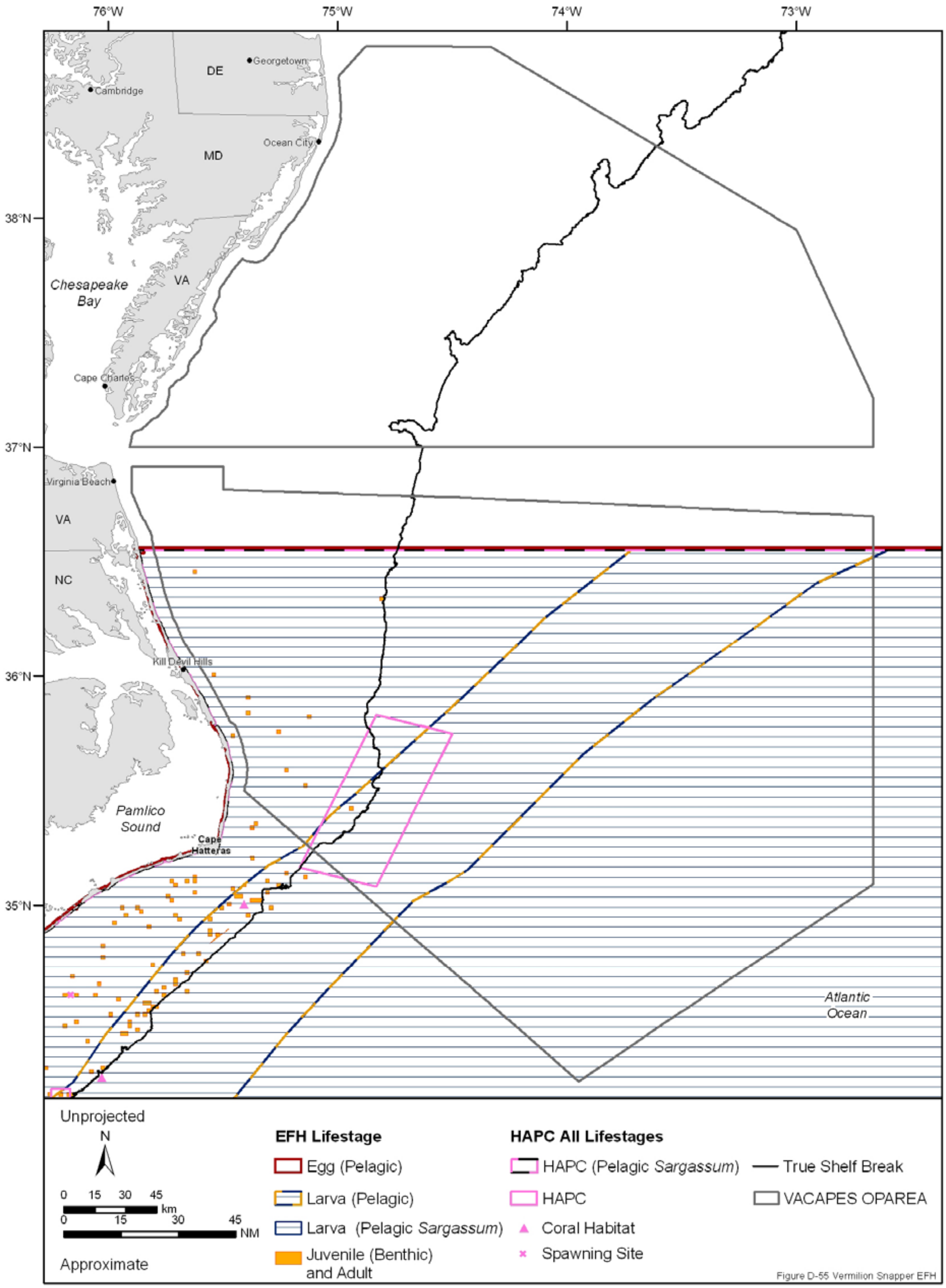

Figure D-55. Essential fish habitat and habitats of particular concern (HAPC) for all lifestages of the vermillion snapper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

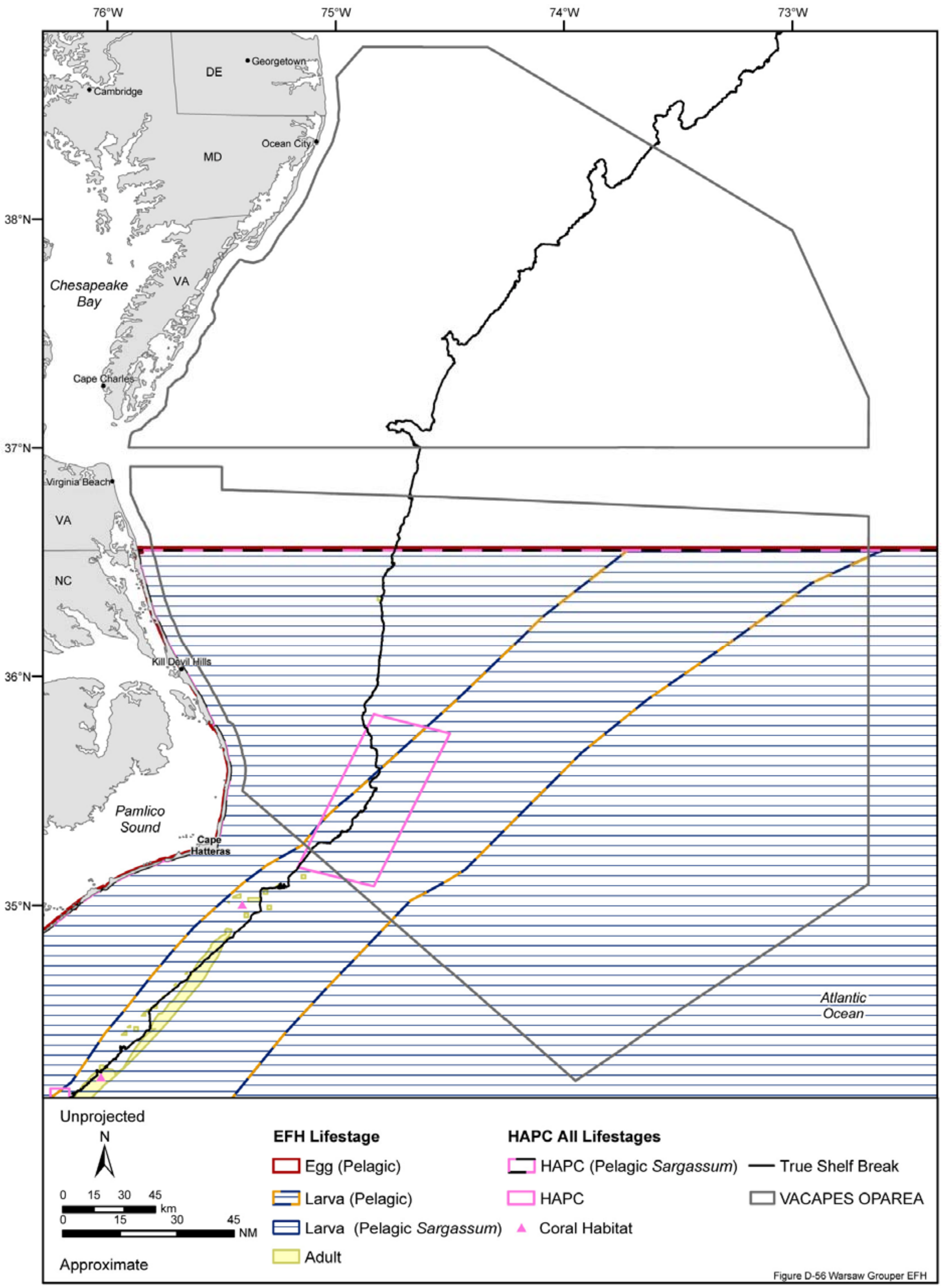

Figure D-56. Essential fish habitat and habitats of particular concern (HAPC) for all lifestages of the warsaw grouper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

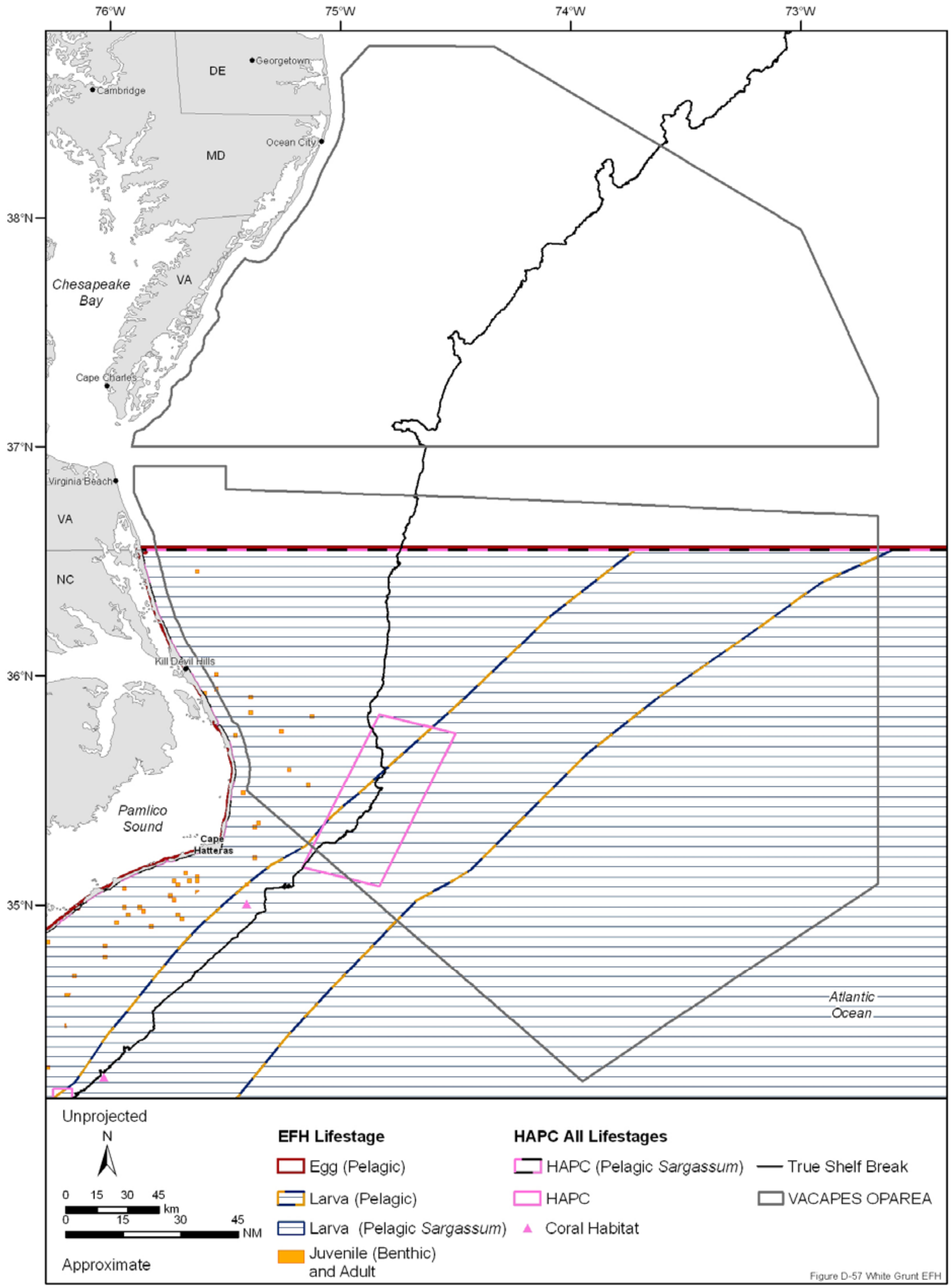

Figure D-57. Essential fish habitat and habitats of particular concern (HAPC) for all lifestages of the white grunt designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

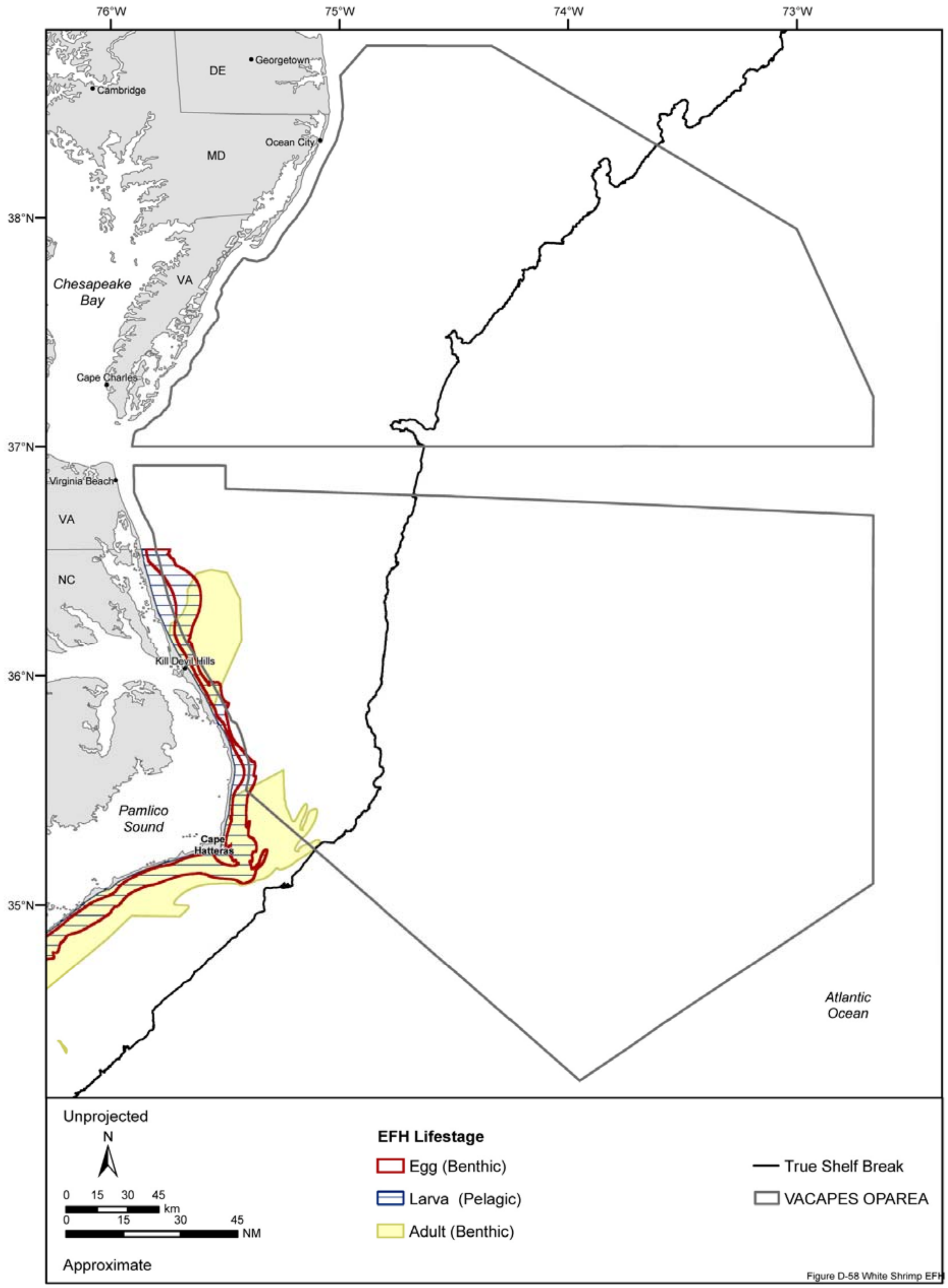

Figure D-58. Essential fish habitat for all lifestages of the white shrimp designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): Amato (1994). Source information: SAFMC (1998) and NMFS (2002).

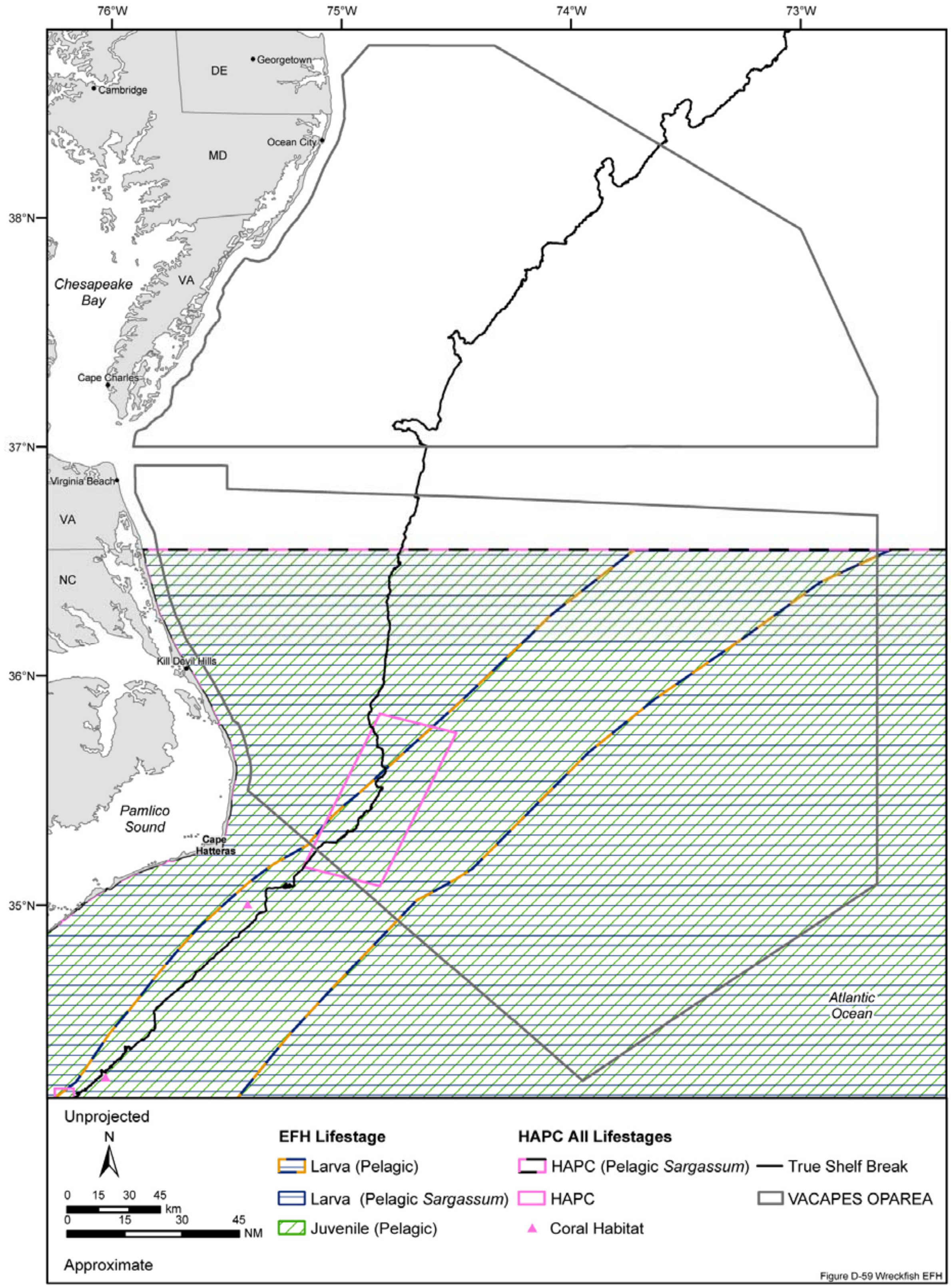

Figure D-59. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the wreckfish designated in the Virginia Capes OPAREA and vicinity. Floating debris is designated as EFH for the juvenile lifestage but was impossible to depict on the map. Source data/source maps/source information: refer to Table D-1.

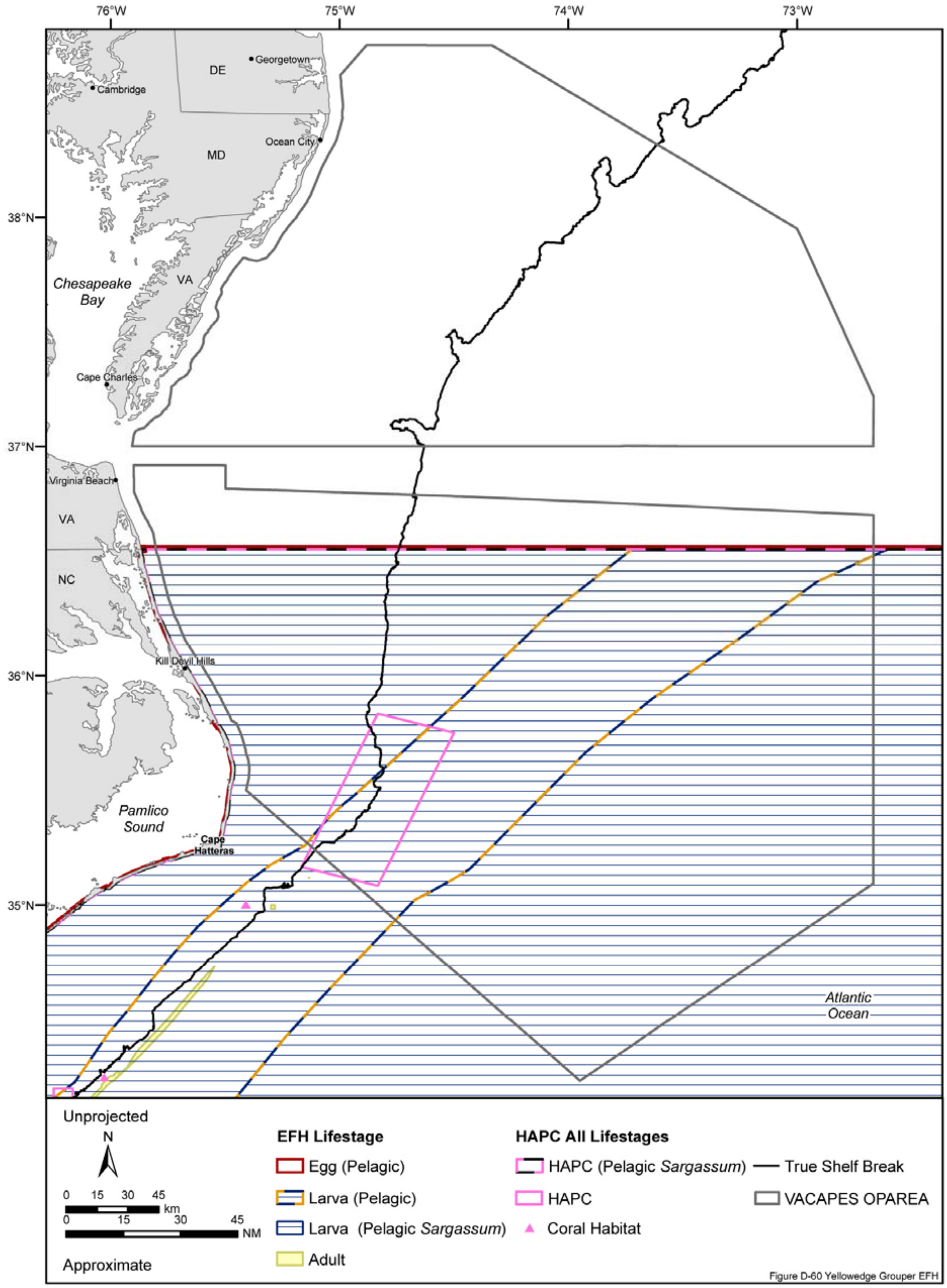

Figure D-60. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the yellowedge grouper designated in the Virginia Capes OPAREA and vicinity. Source data/source maps/source information: refer to Table D-1.

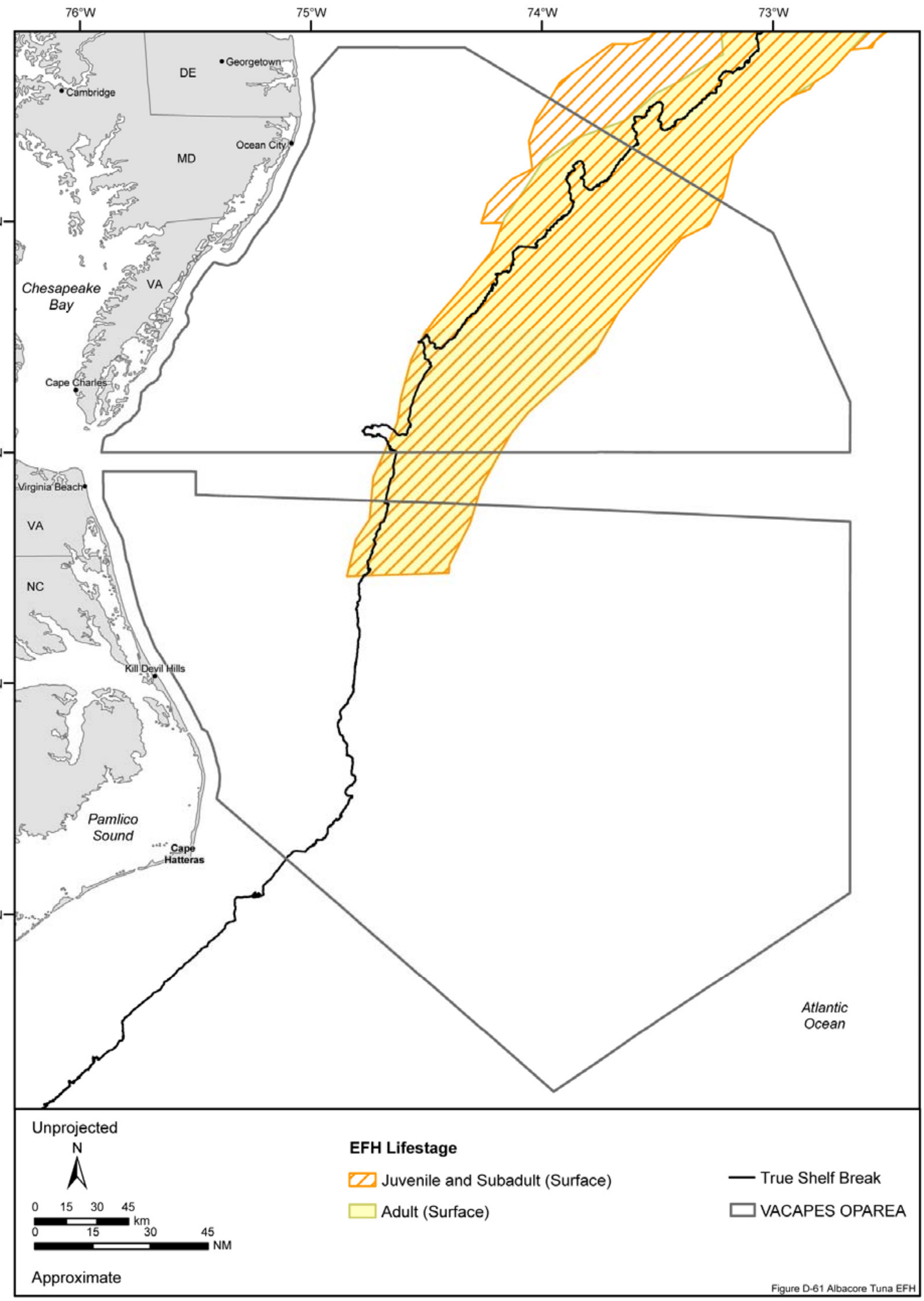

Figure D-61. Essential fish habitat for all lifestages of the albacore tuna designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

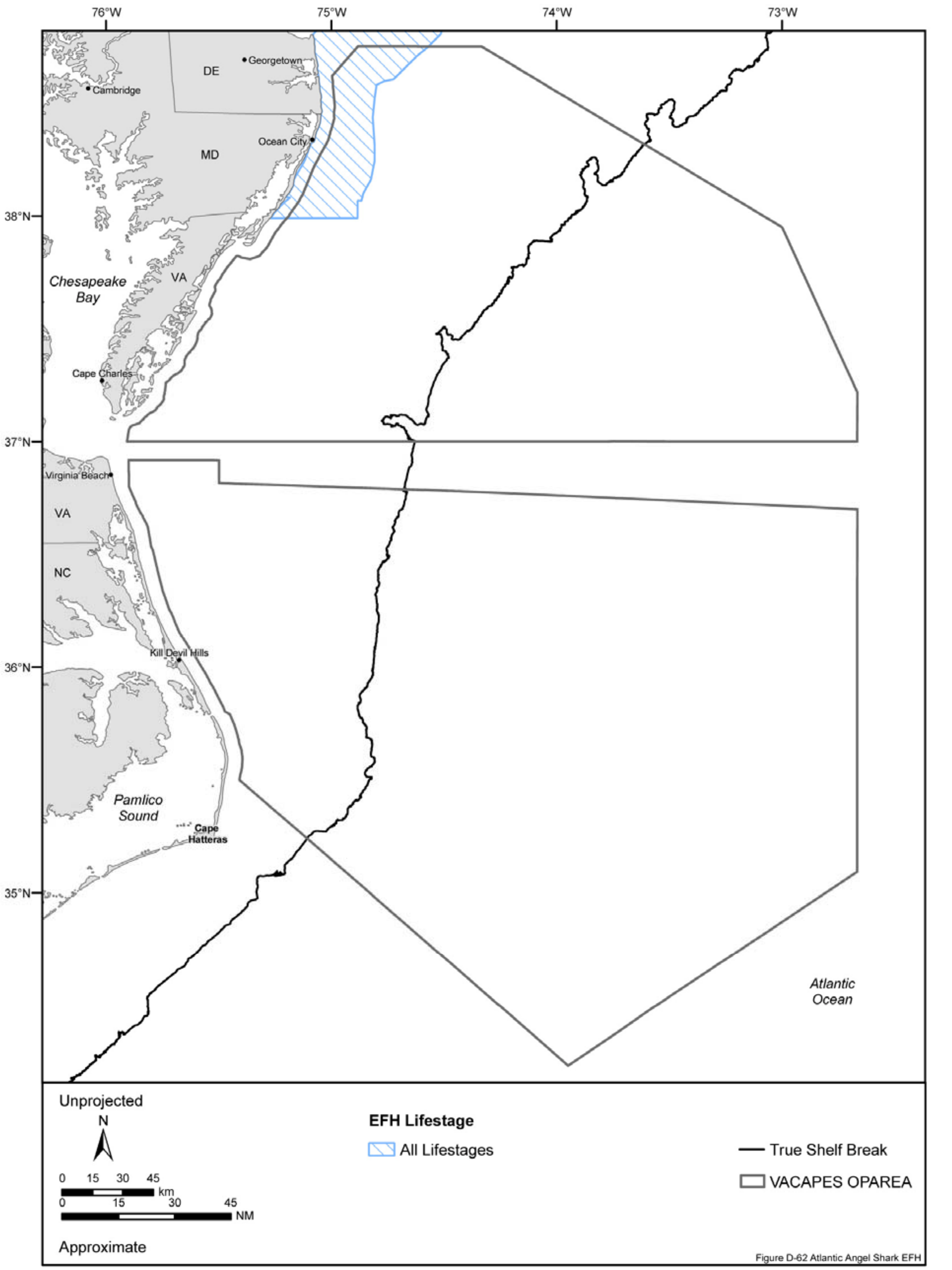

Figure D-62. Essential fish habitat for all lifestages of the Atlantic angel shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

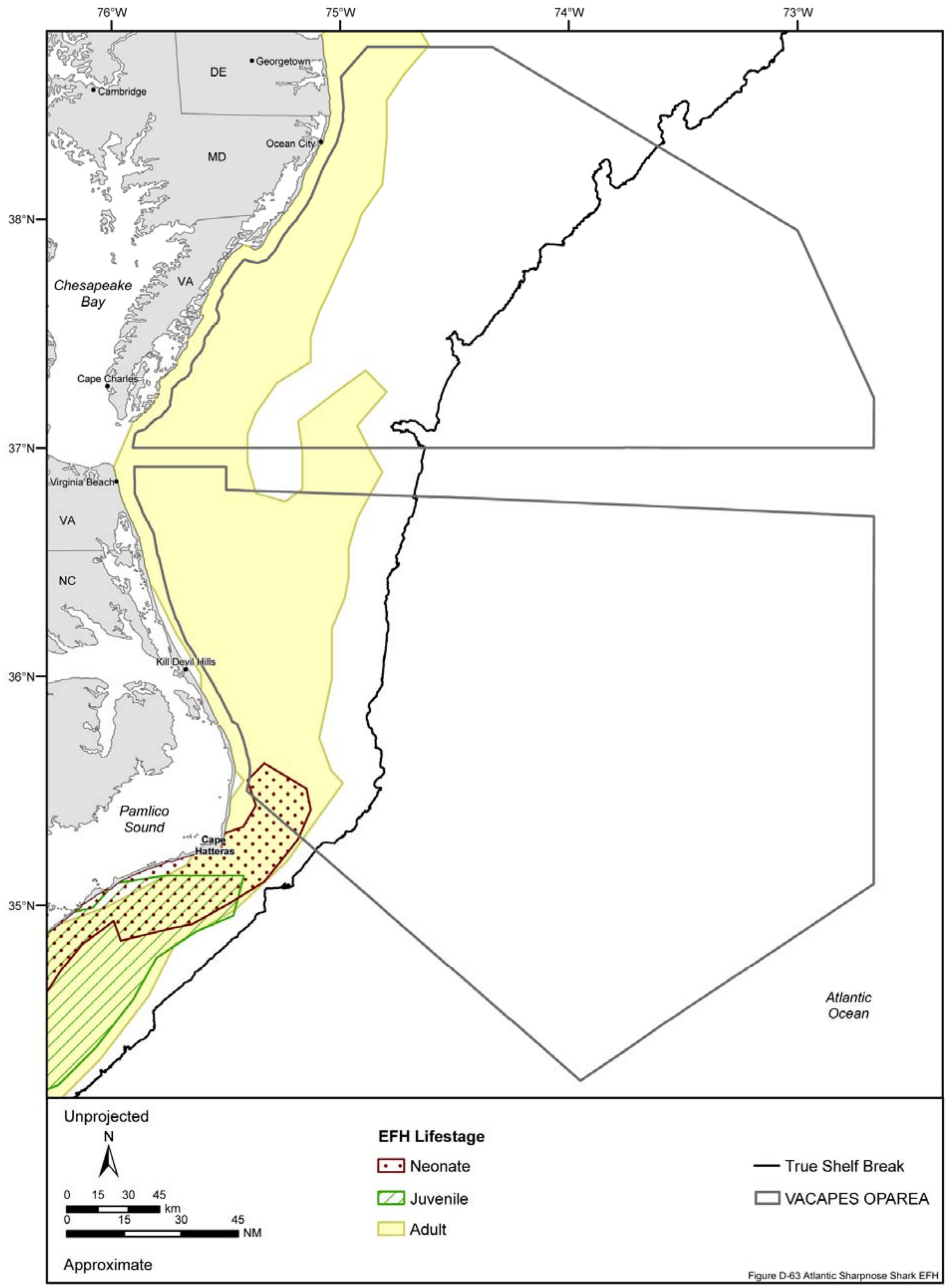

Figure D-63. Essential fish habitat for the neonate and juvenile lifestages of the Atlantic sharpnose shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

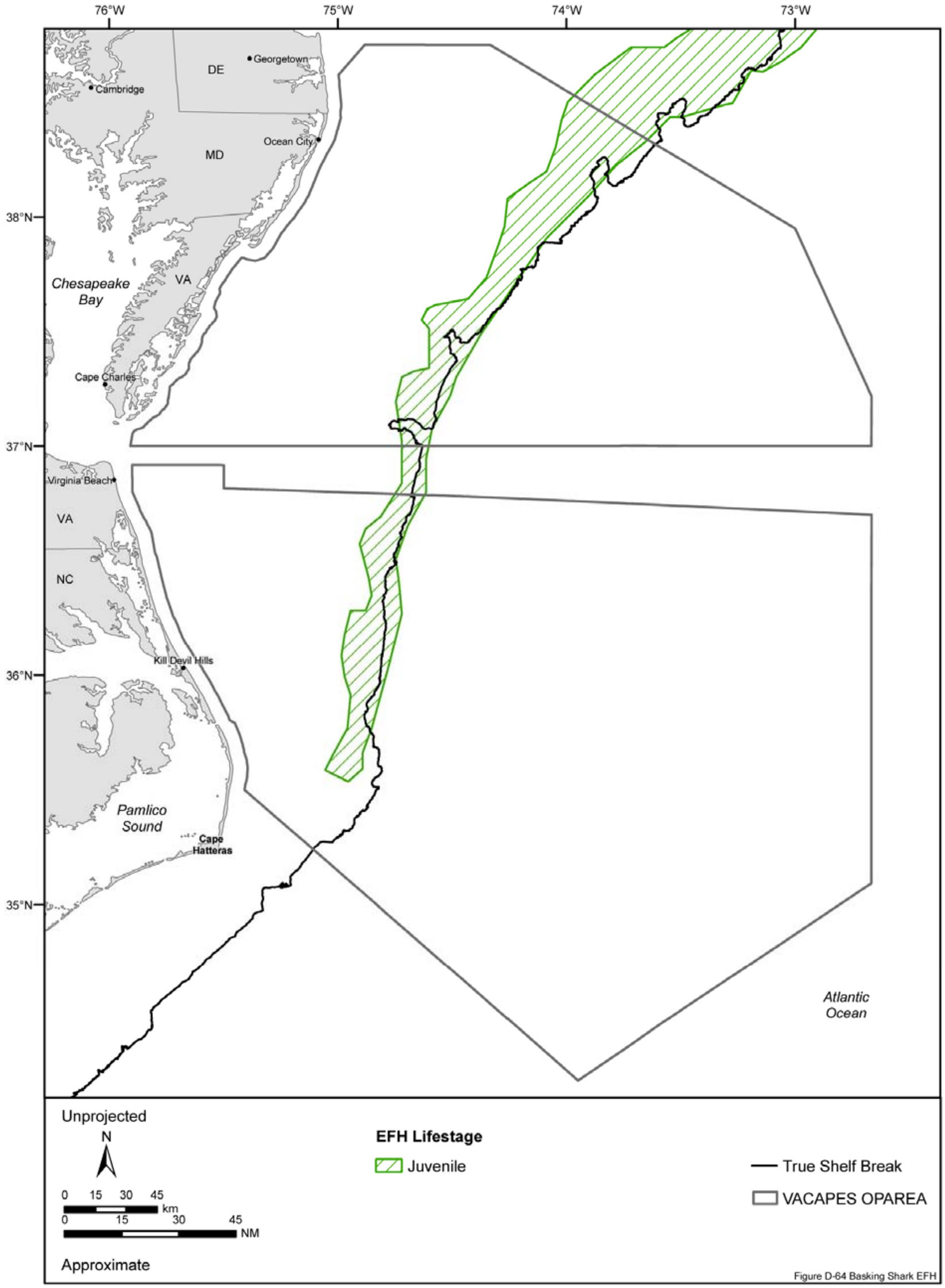

Figure D-64. Essential fish habitat for the neonate lifestages of the basking shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

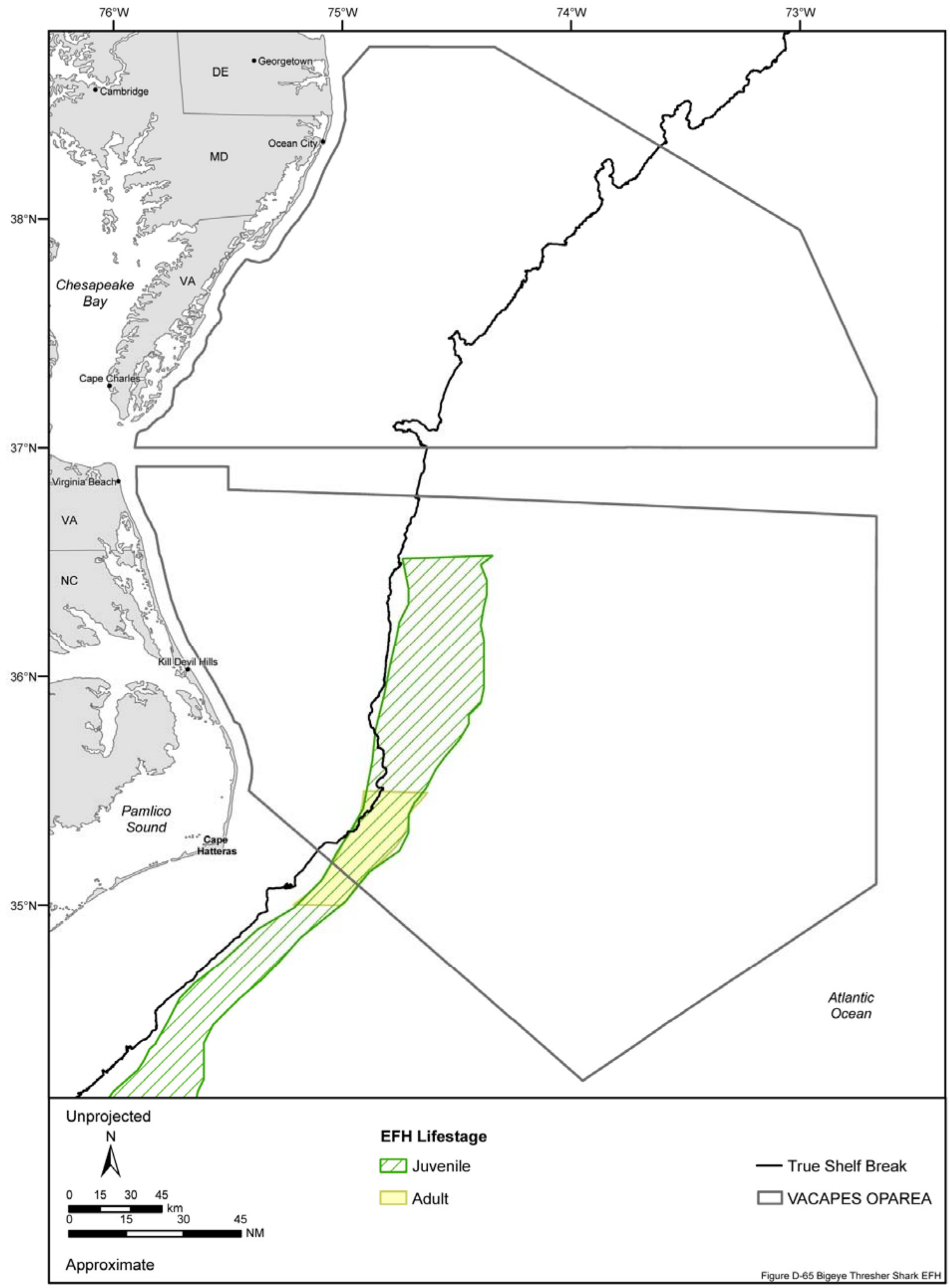

Figure D-65. Essential fish habitat for all lifestages of the bigeye thresher shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

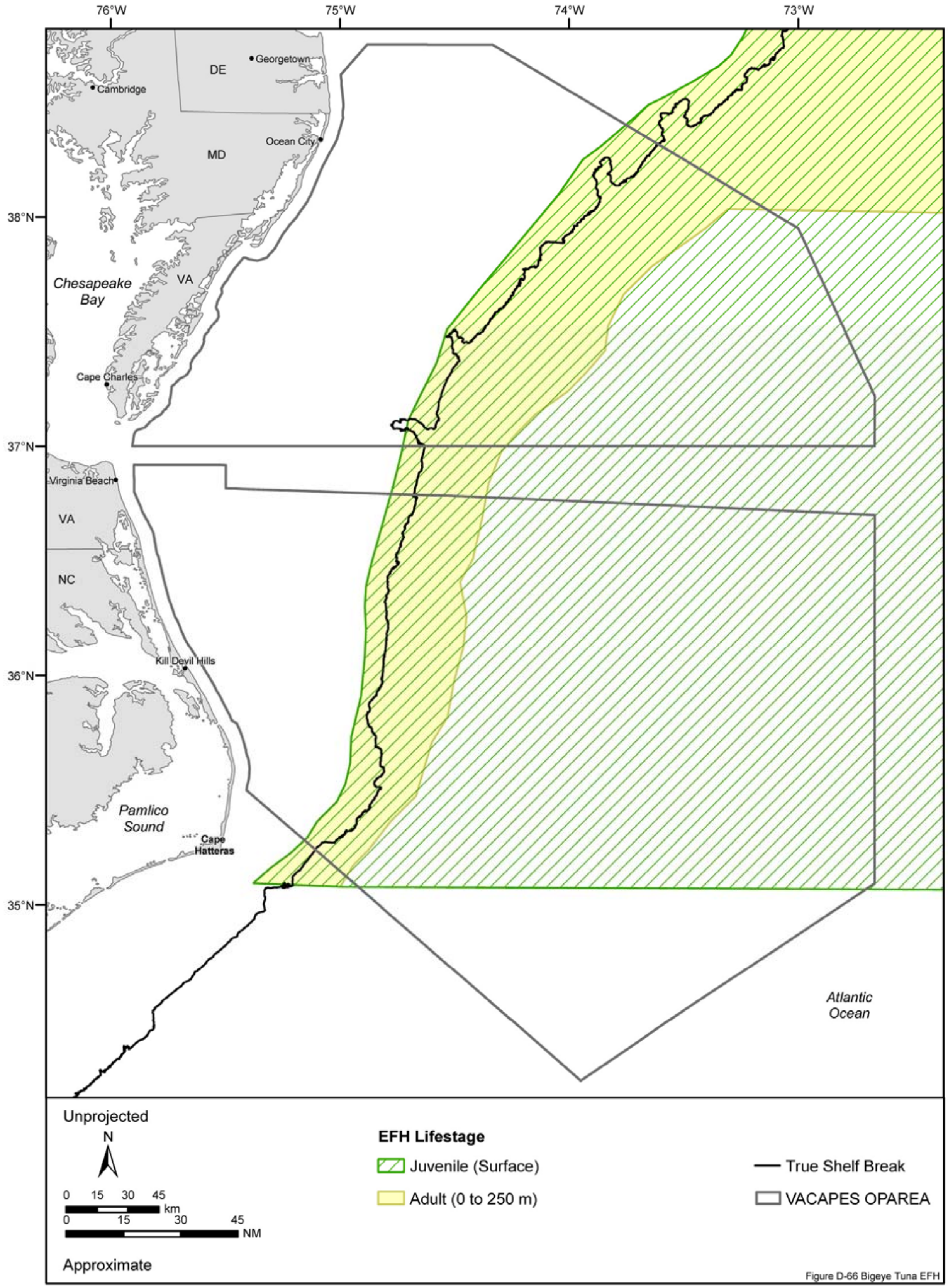

Figure D-66. Essential fish habitat for all lifestages of the bigeye tuna designated in the Virginia Capes OPAREA and vicinity. Source map (scanned): NMFS (1999a).

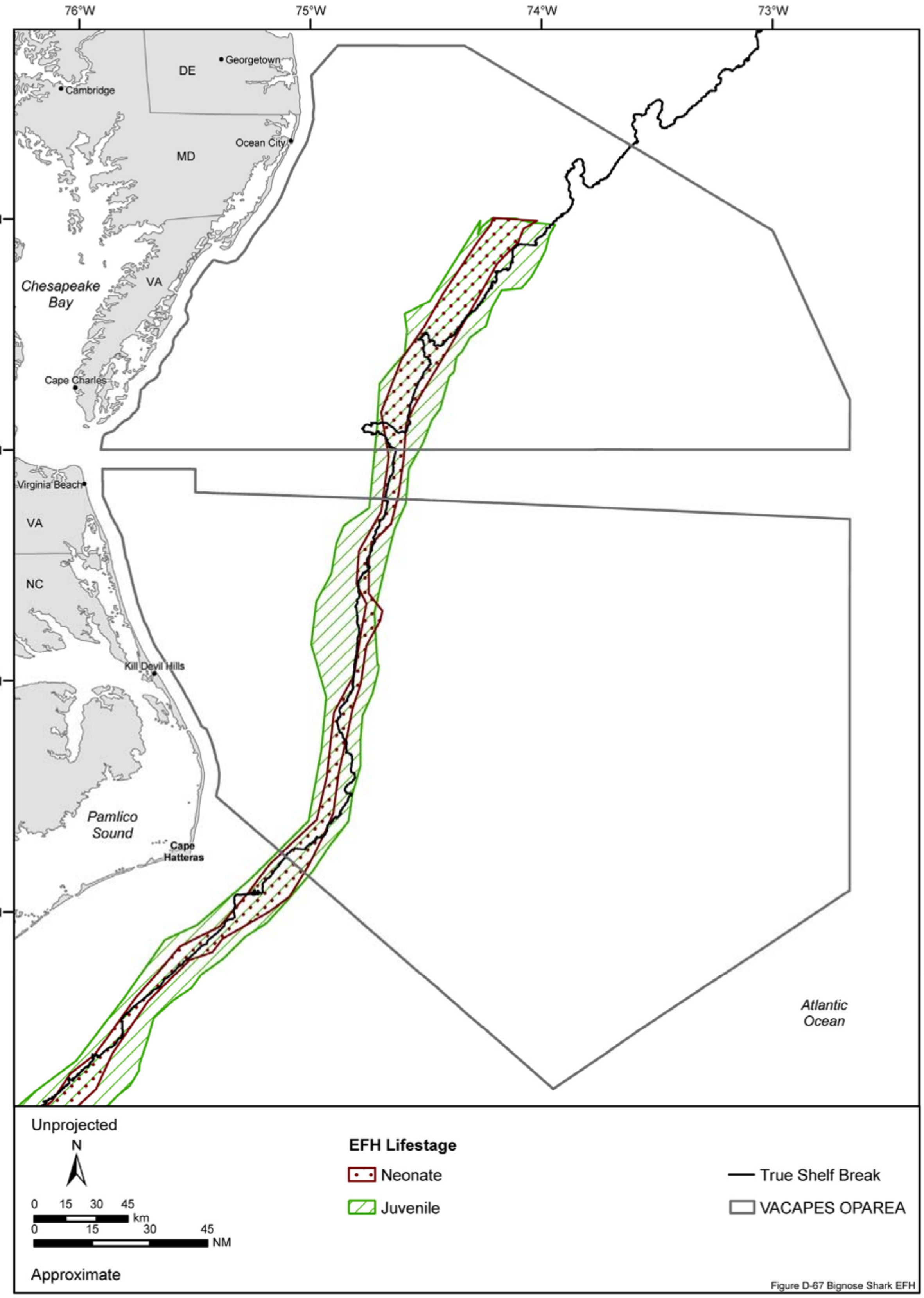

Figure D-67. Essential fish habitat for all lifestages of the bignose shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

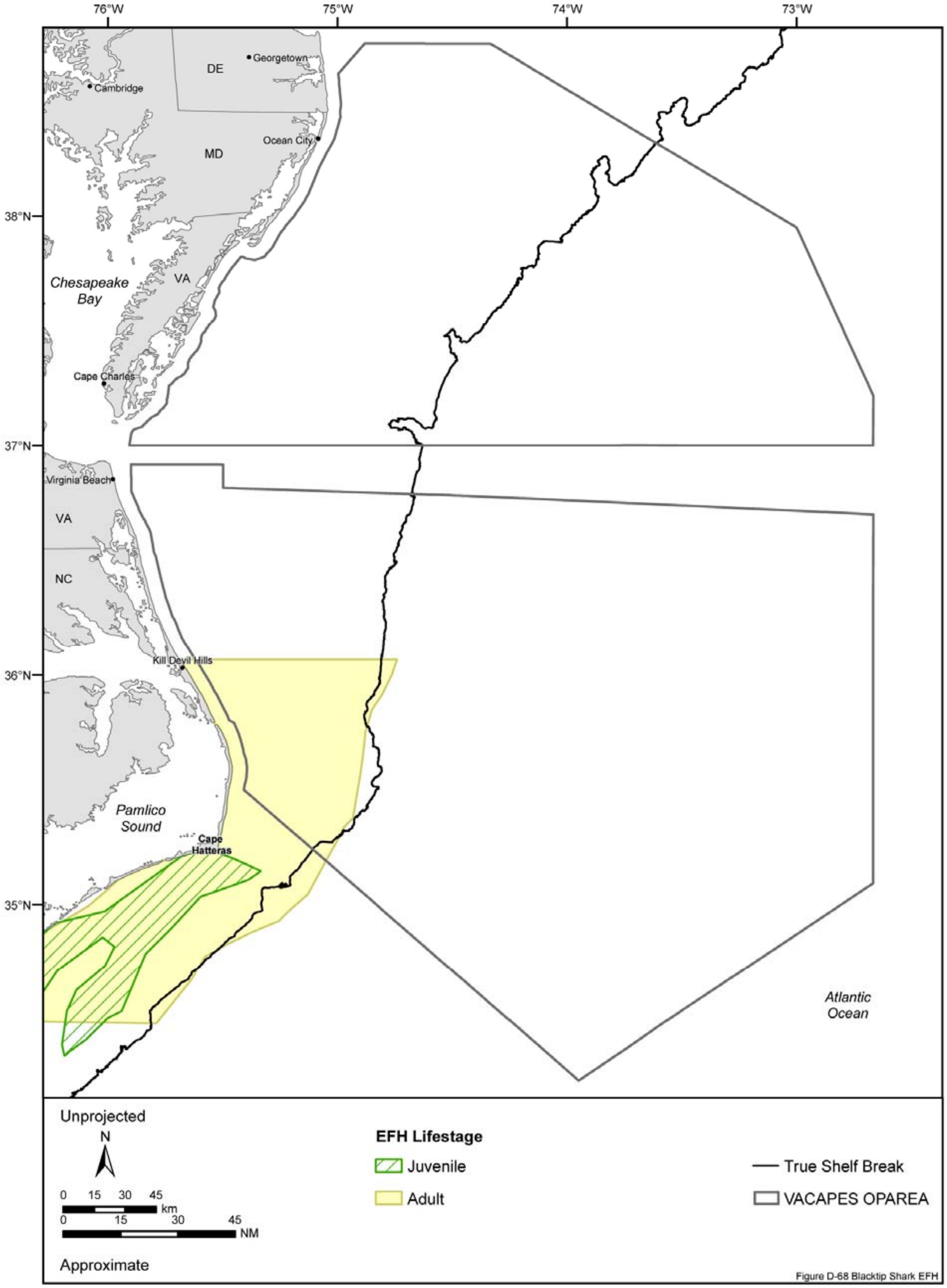

Figure D-68. Essential fish habitat for all lifestages of the blacktip shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

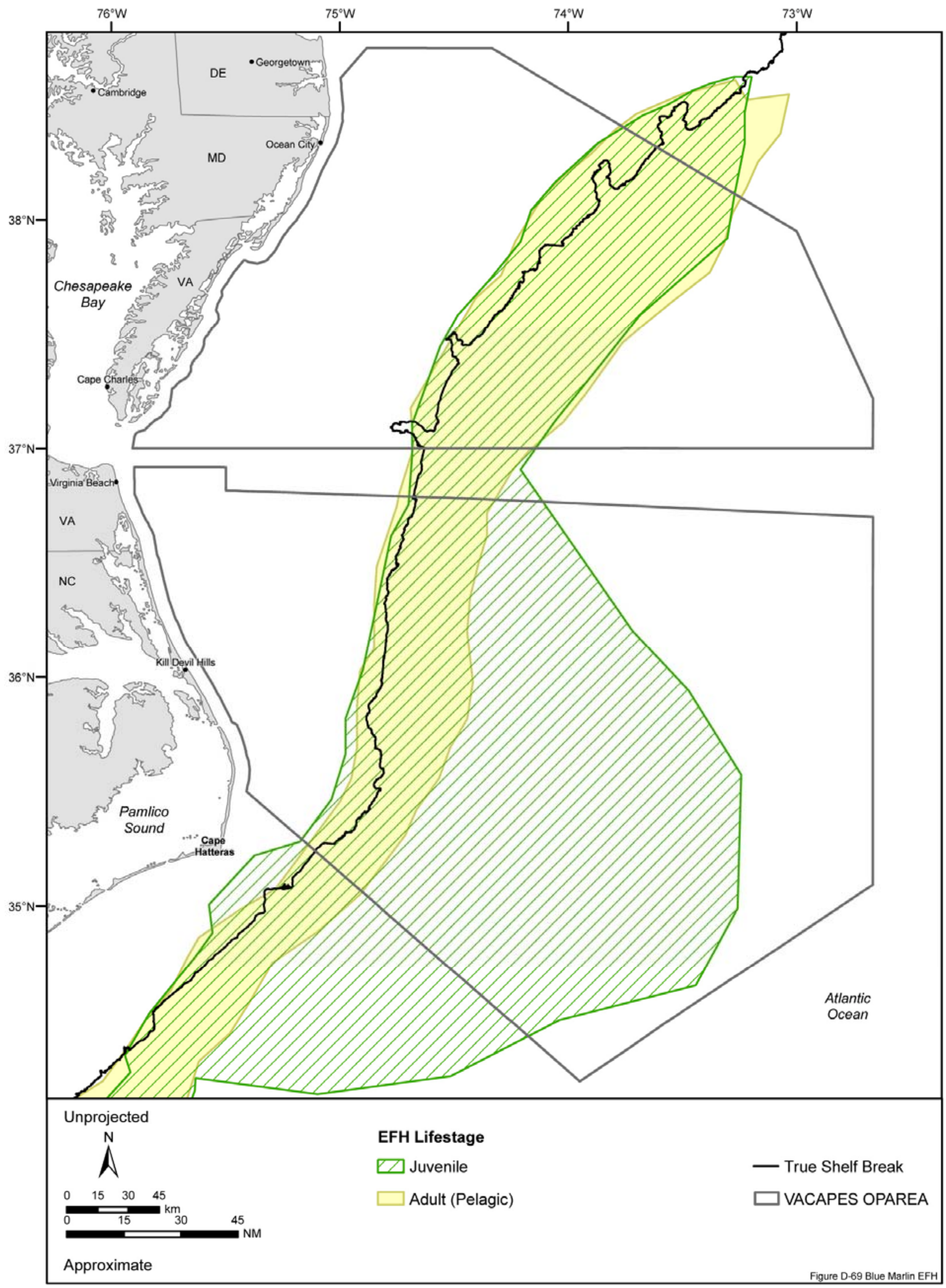

Figure D-69. Essential fish habitat for all lifestages of the blue marlin designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

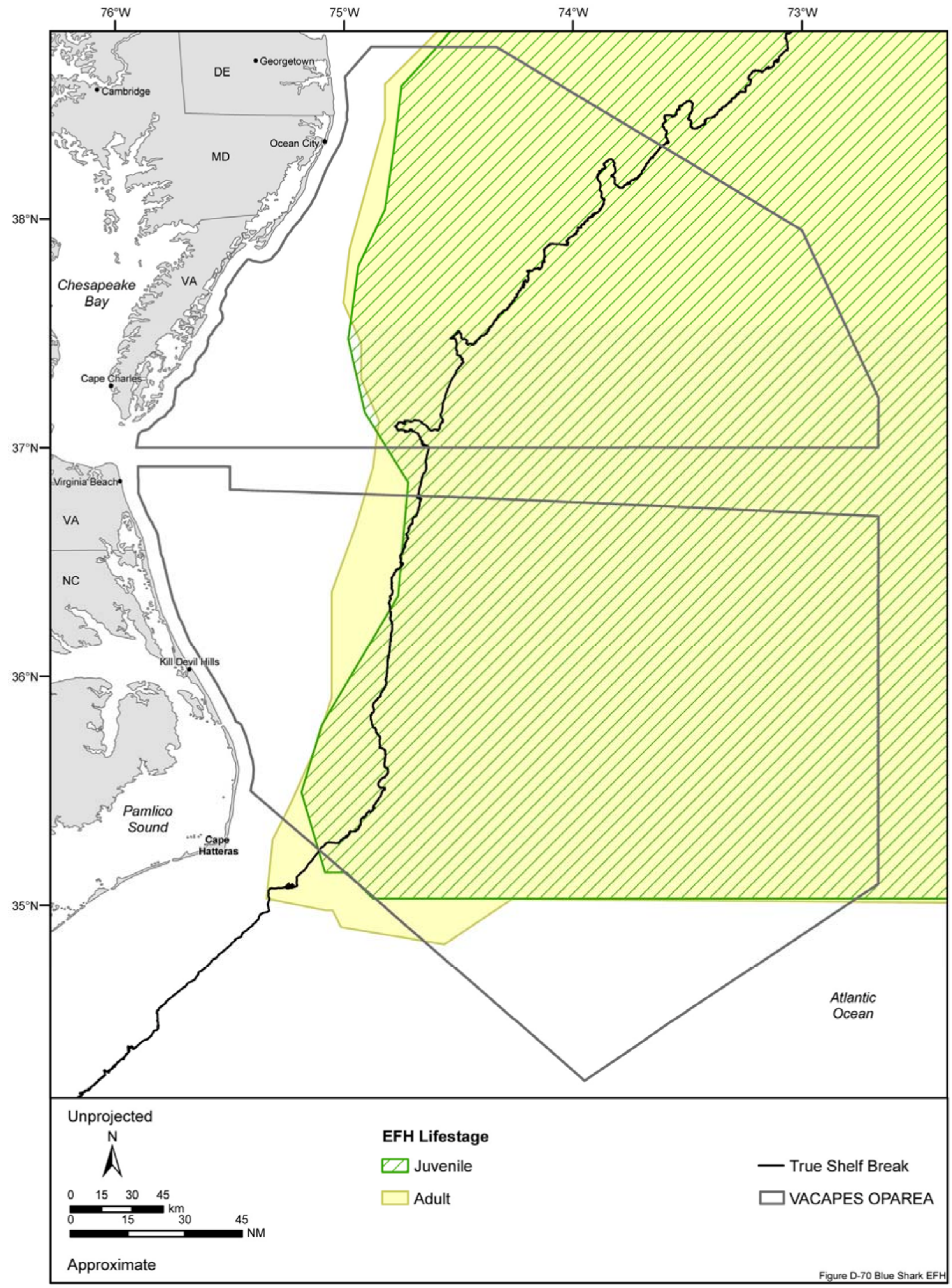

Figure D-70. Essential fish habitat for all lifestages of the blue shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

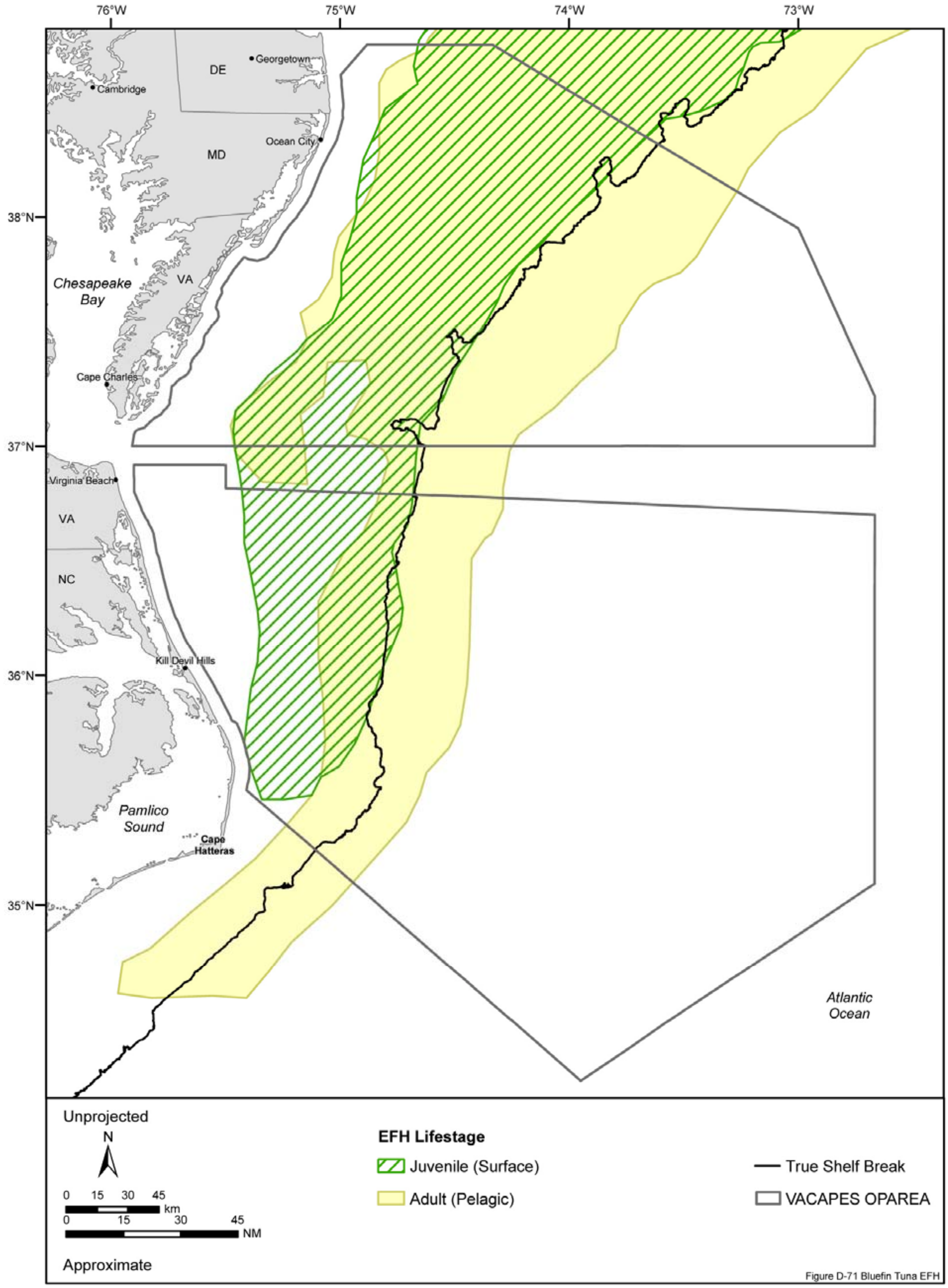

Figure D-71. Essential fish habitat for all lifestages of the bluefin tuna designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

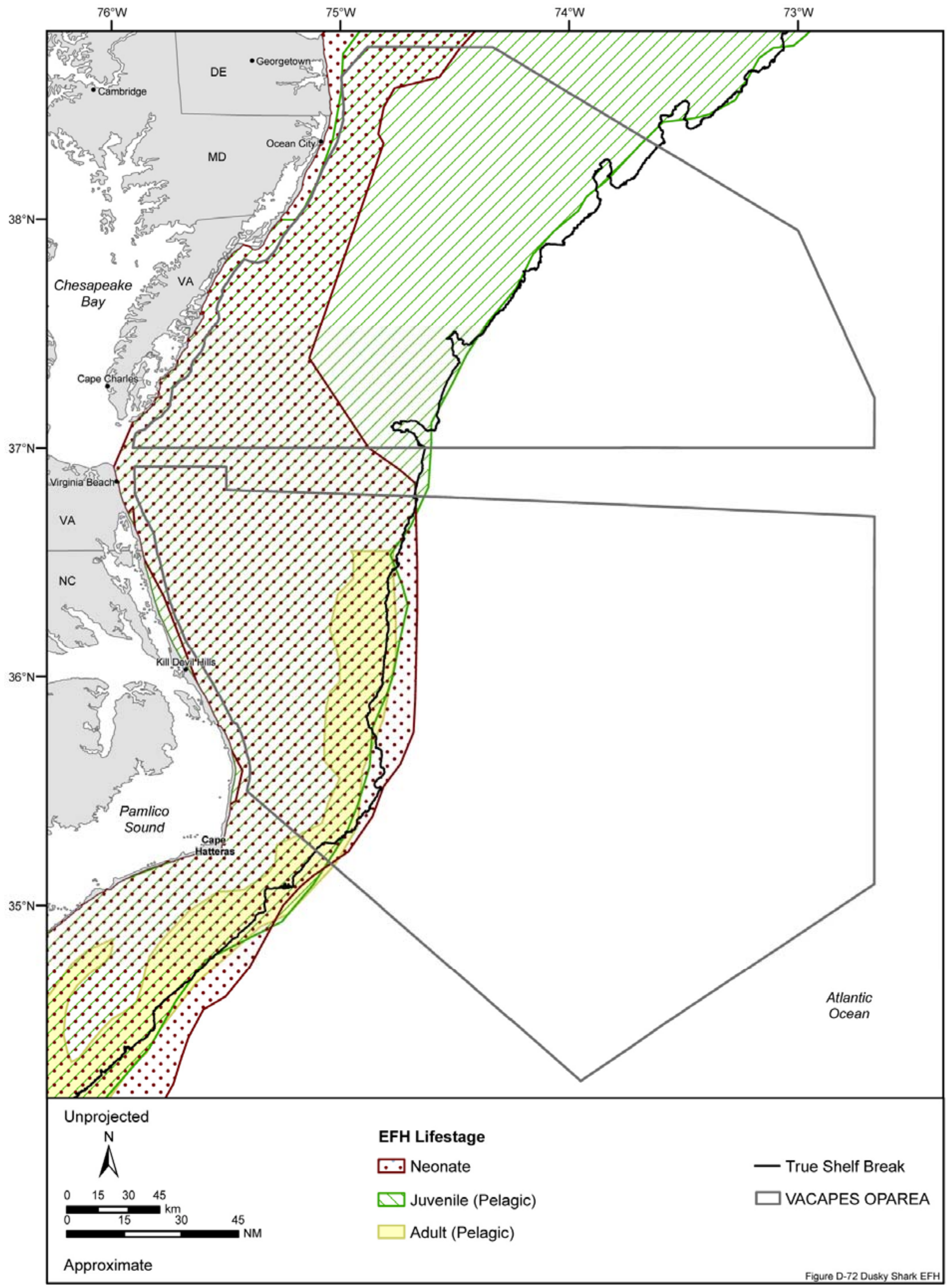

Figure D-72. Essential fish habitat for all lifestages of the dusky shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

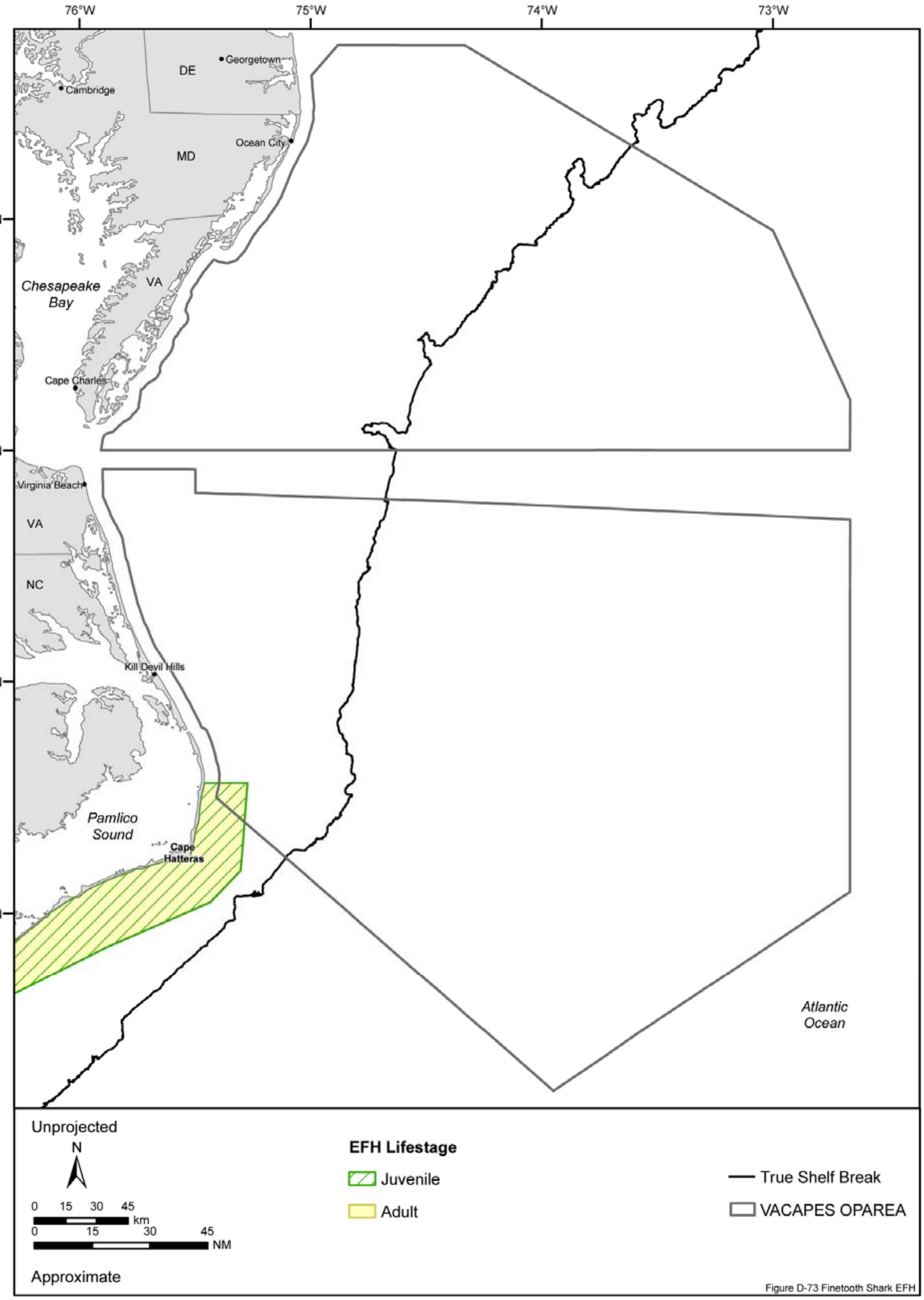

Figure D-73. Essential fish habitat for all lifestages of the finetooth shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

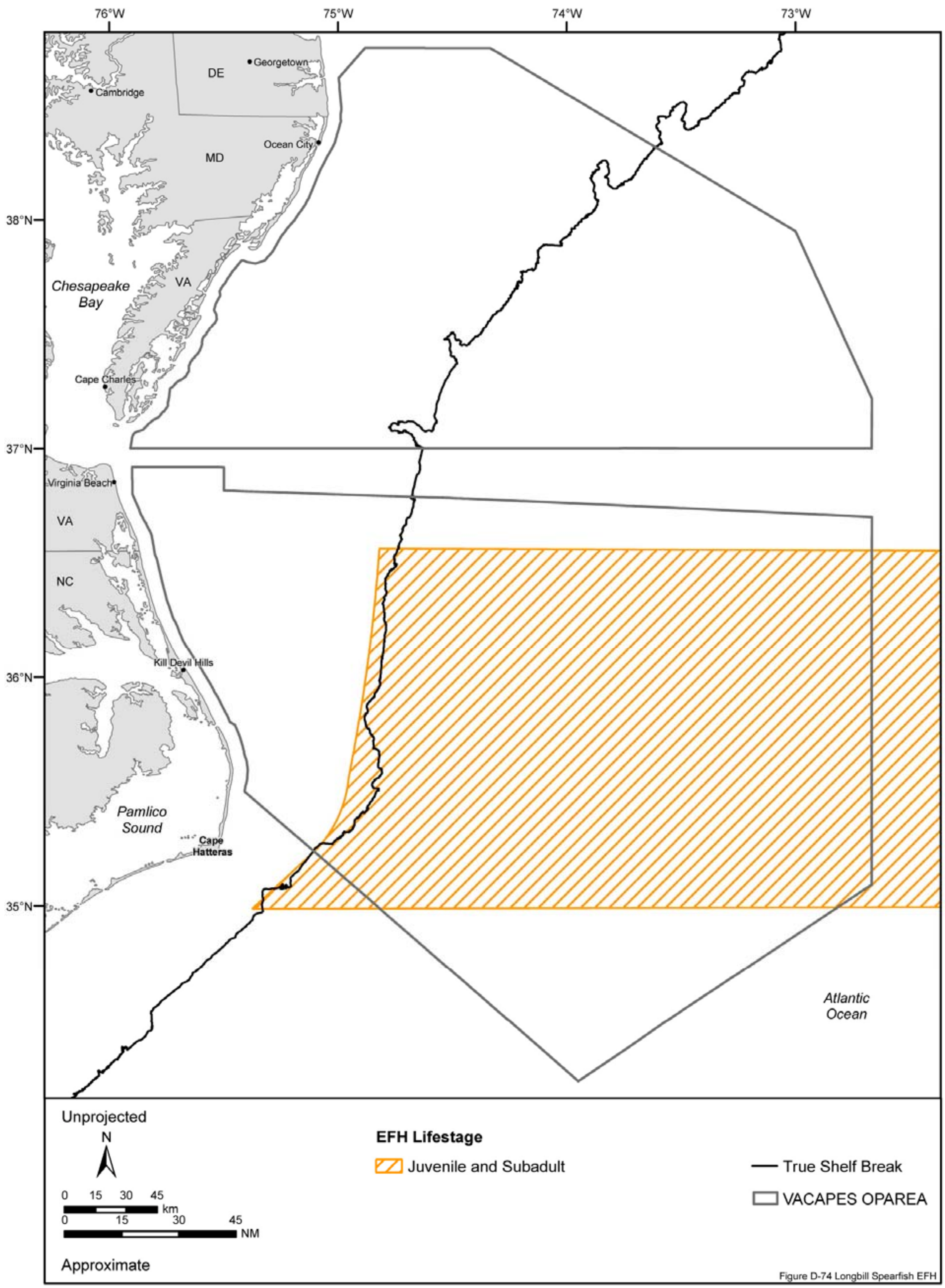

Figure D-74. Essential fish habitat for all lifestages of the Longbill spearfish designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

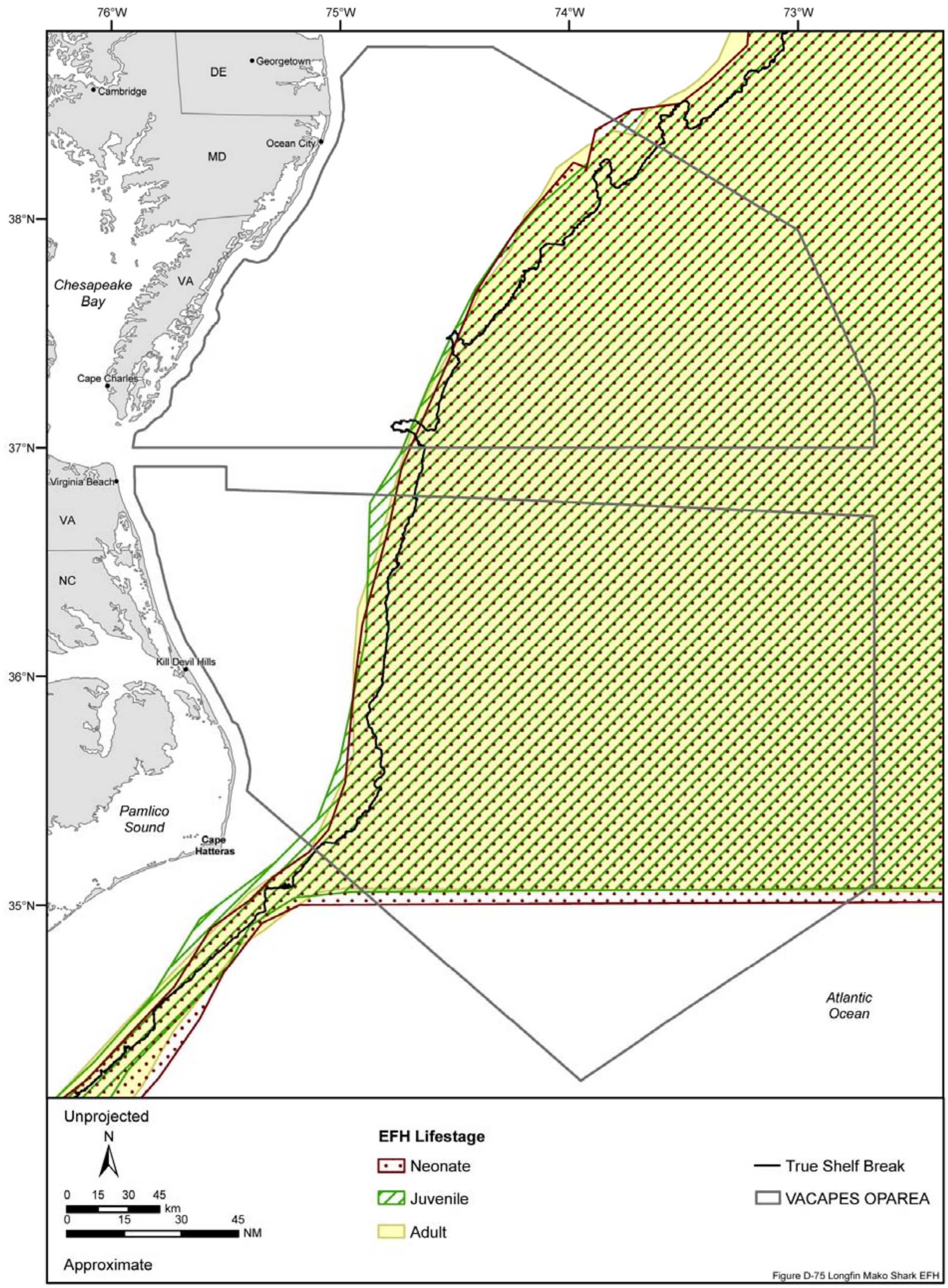

Figure D-75. Essential fish habitat for all lifestages of the Longfin mako shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

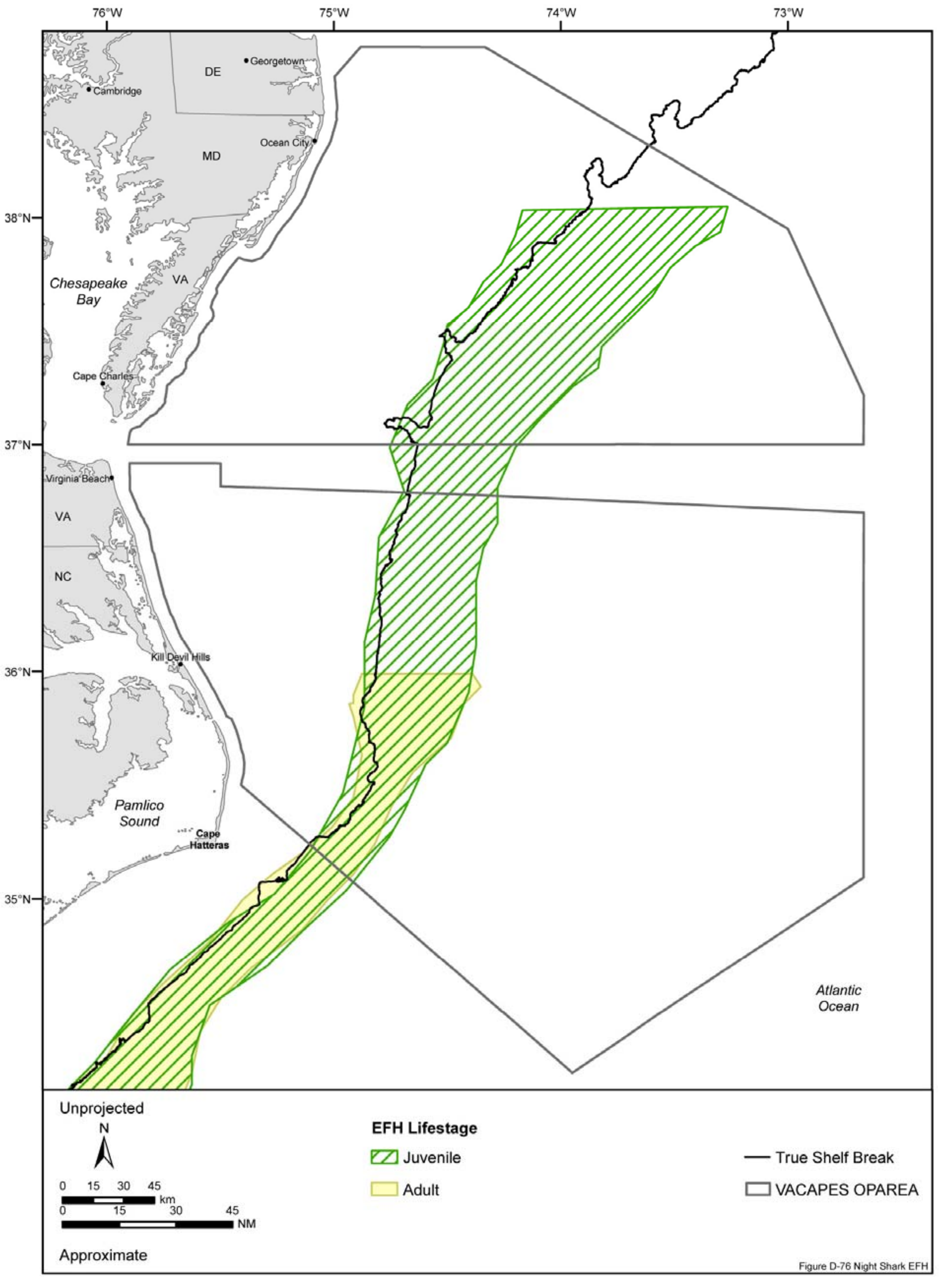

Figure D-76. Essential fish habitat for all lifestages of the night shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

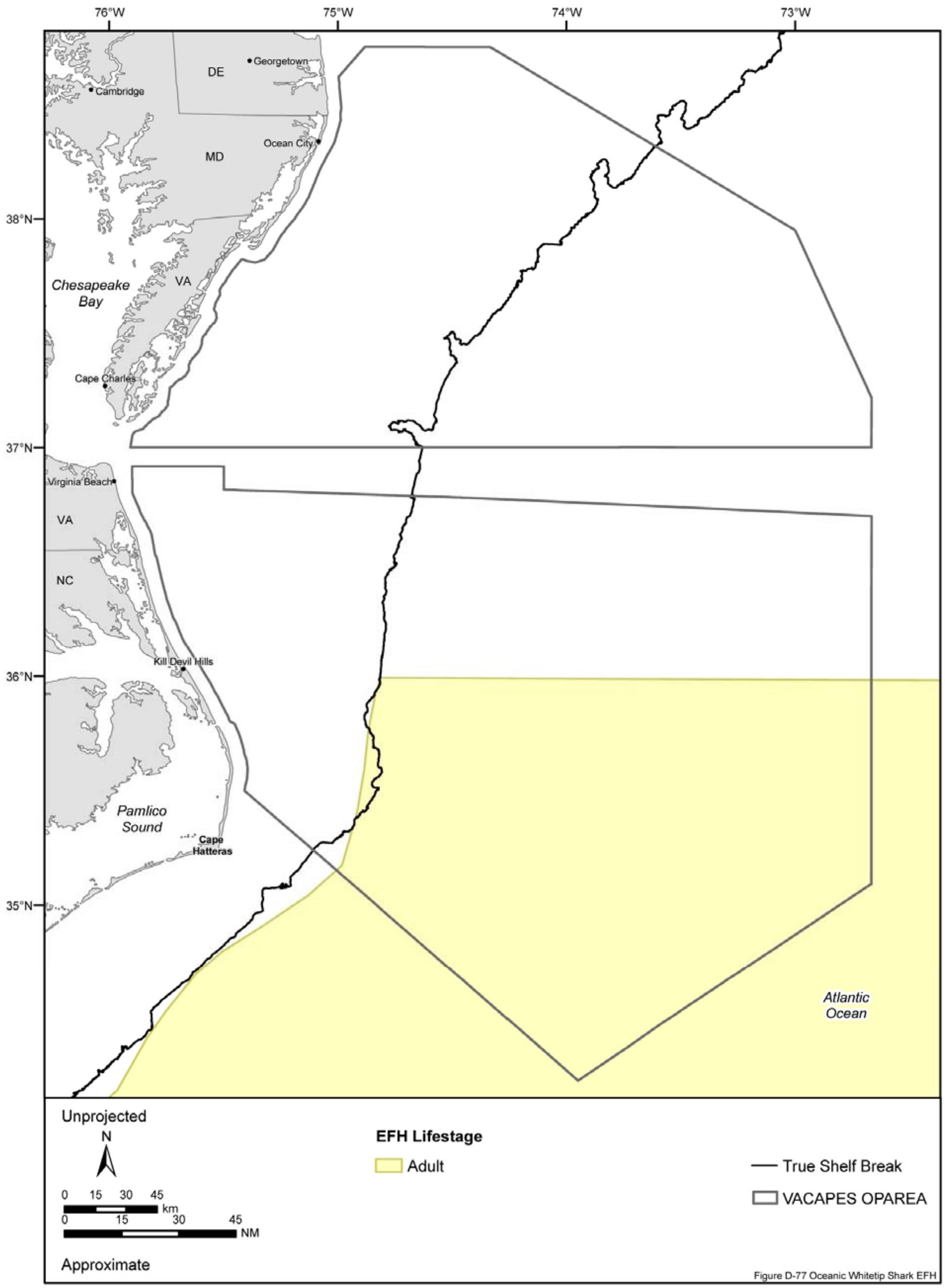

Figure D-77. Essential fish habitat for all lifestages of the oceanic whitetip shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

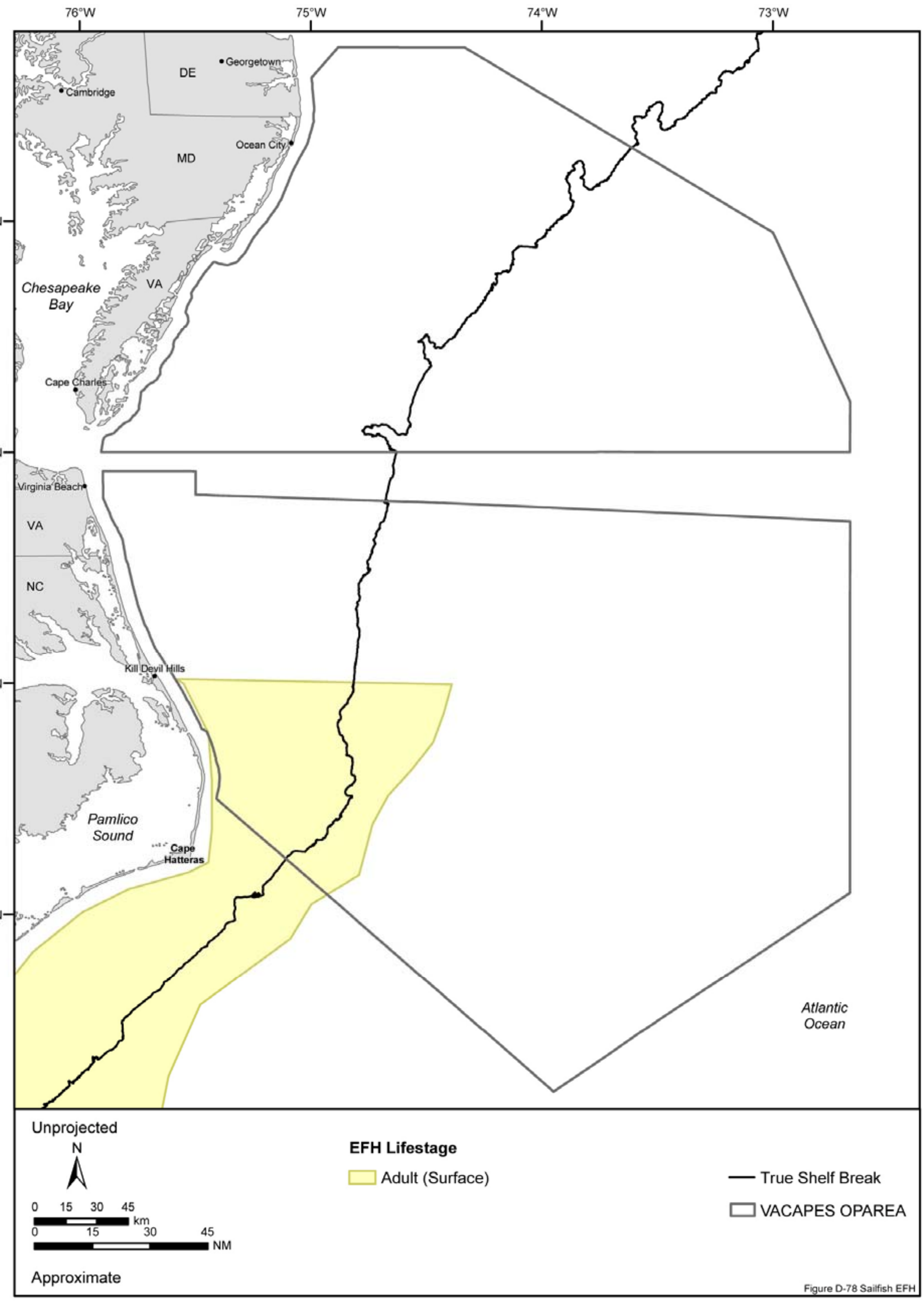

Figure D-78. Essential fish habitat for all lifestages of the sailfish designated in the Virginia Capes OPAREA and vicinity. Source map: NMFS (2003b).

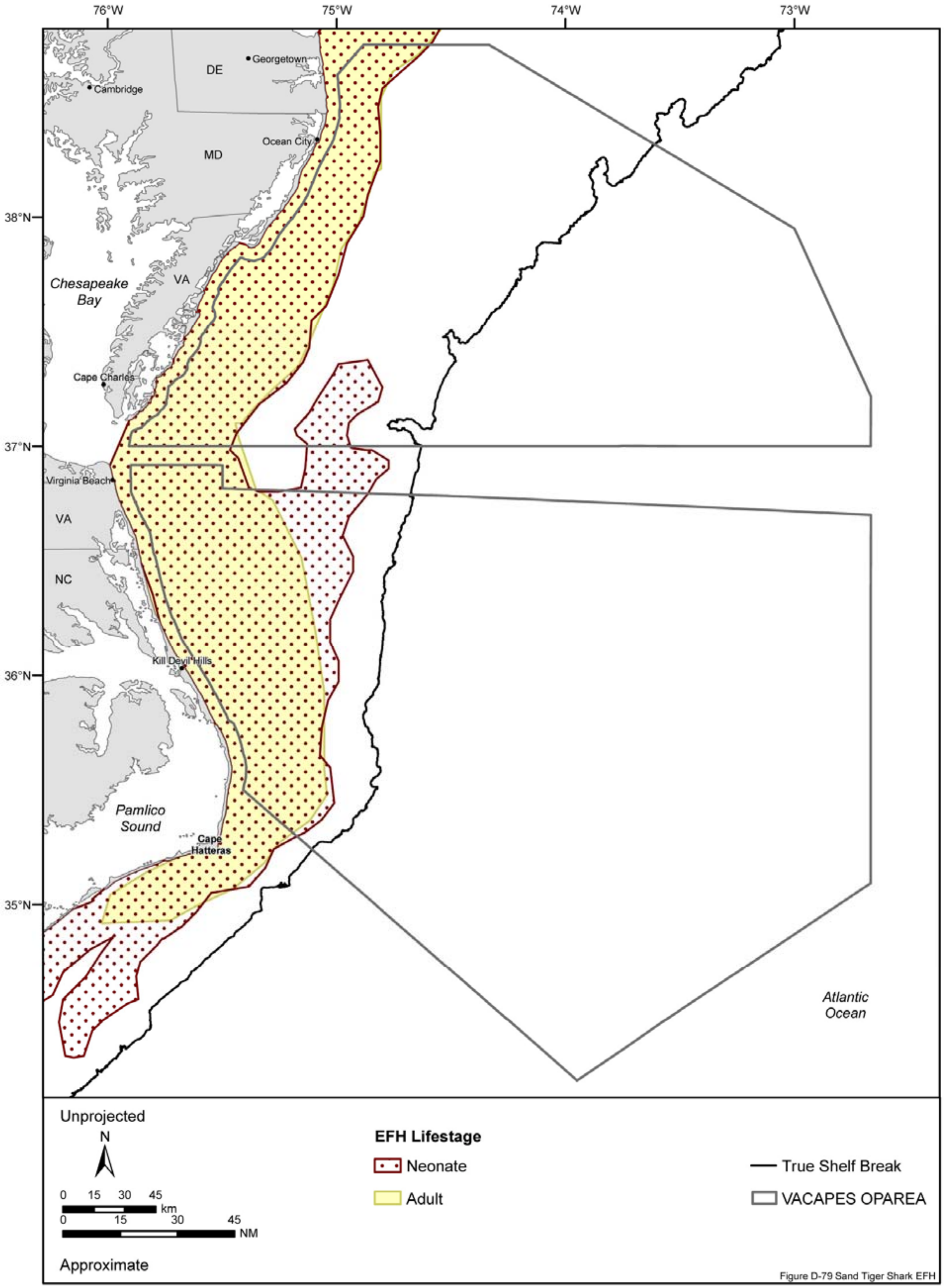

Figure D-79. Essential fish habitat for all lifestages of the sand tiger shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

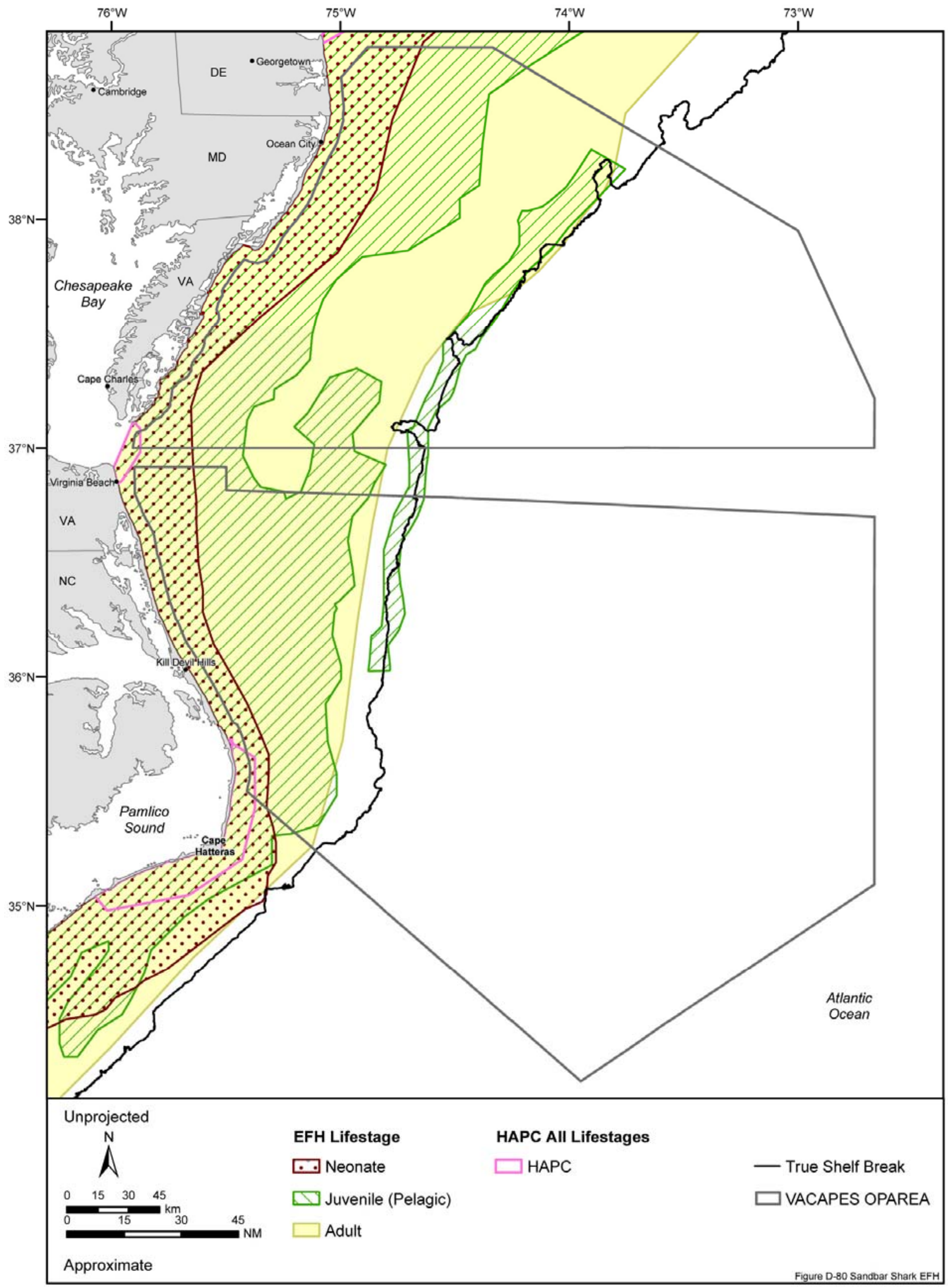

Figure D-80. Essential fish habitat for all lifestages of the sandbar shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

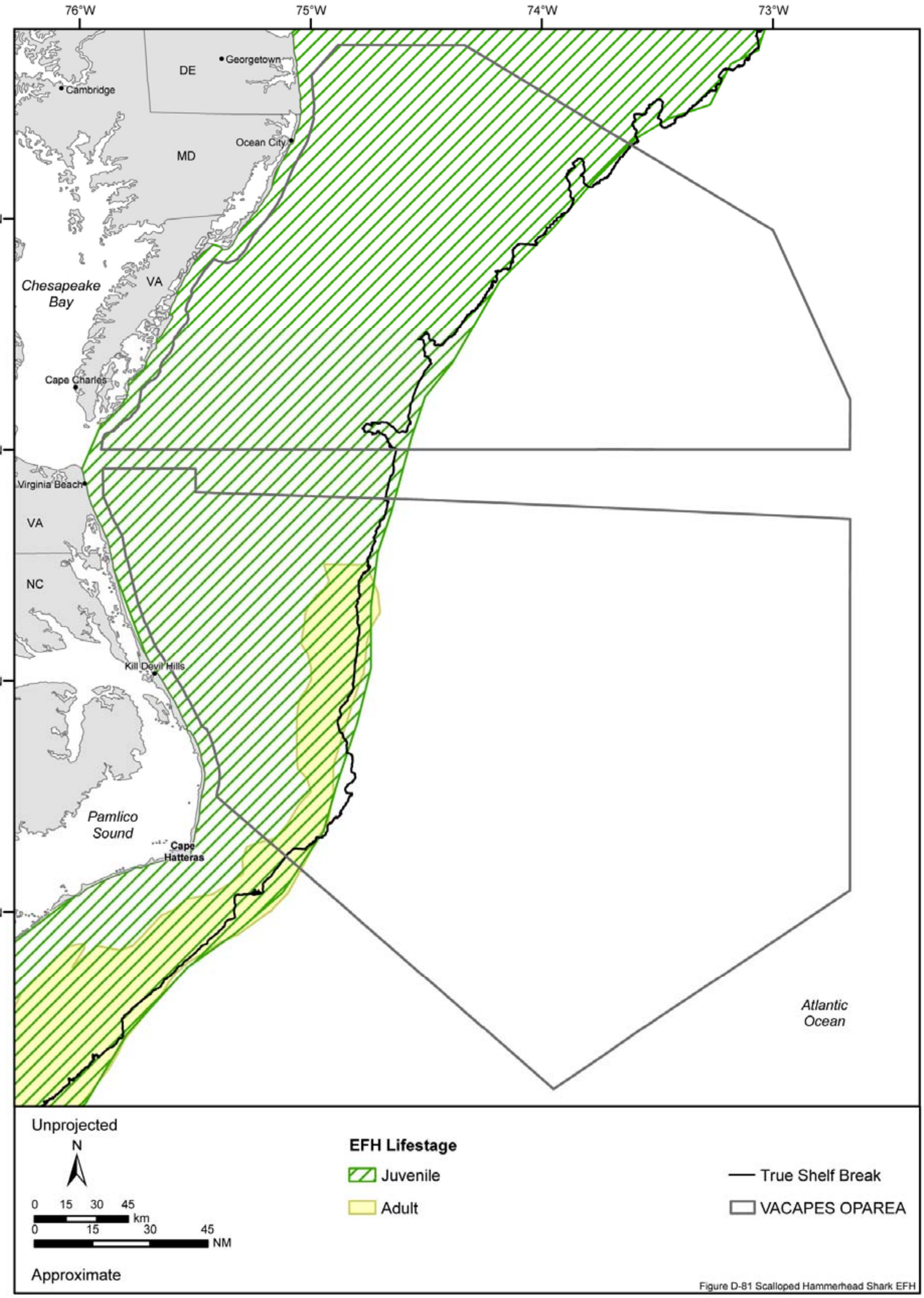

Figure D-81. Essential fish habitat for all lifestages of the scalloped hammerhead shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

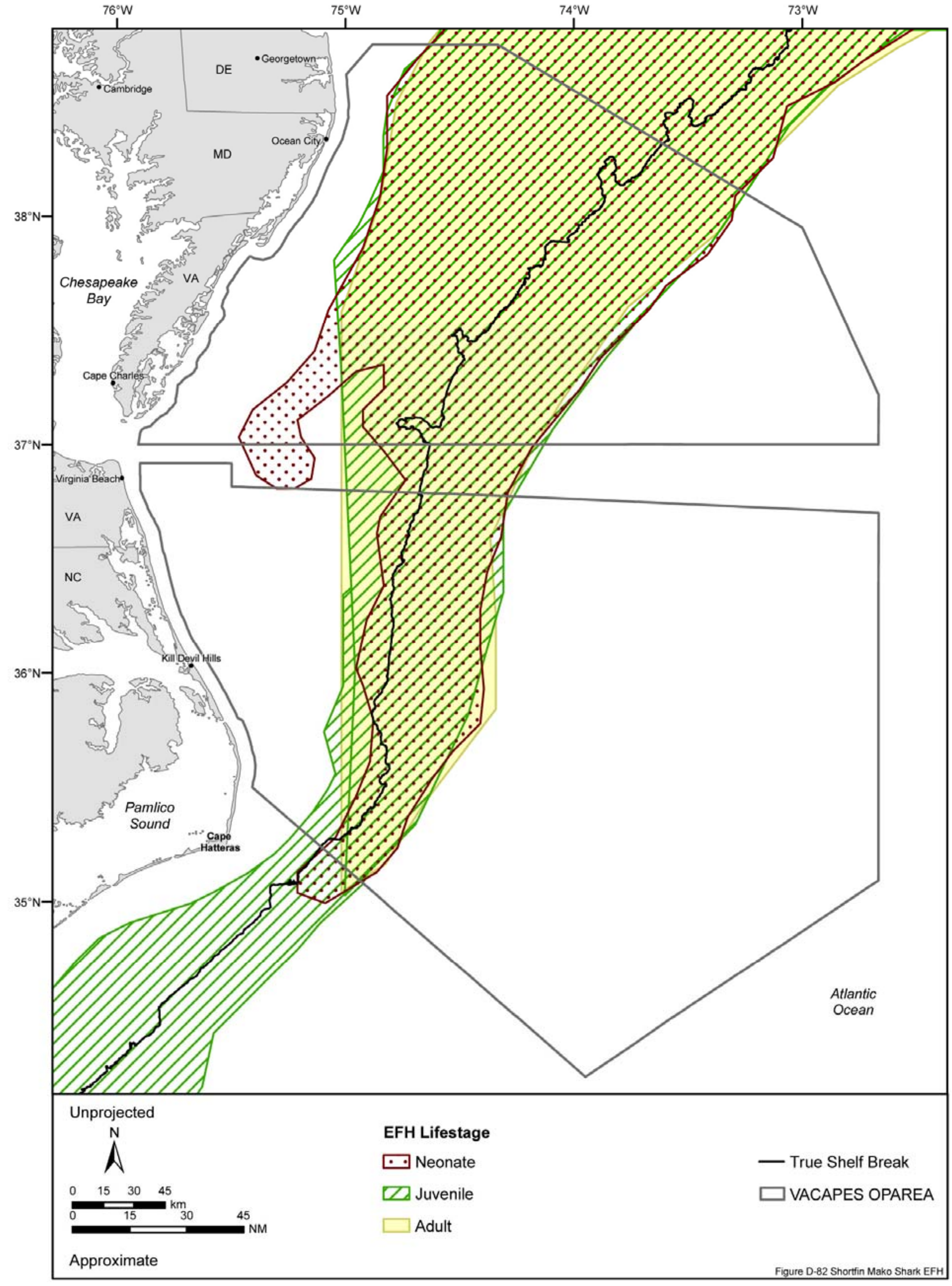

Figure D-82. Essential fish habitat for all lifestages of the shortfin mako shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

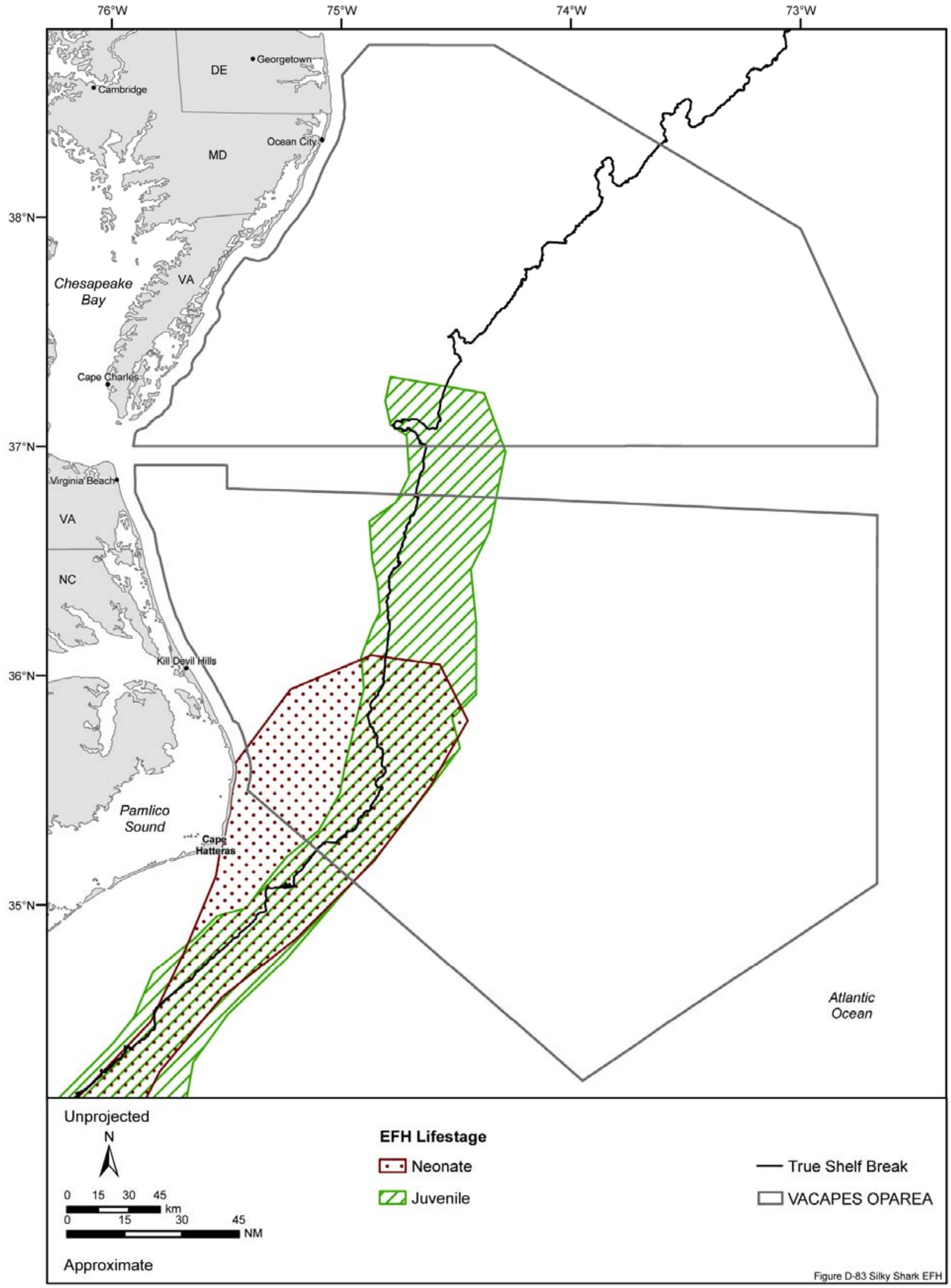

Figure D-83. Essential fish habitat for all lifestages of the silky shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

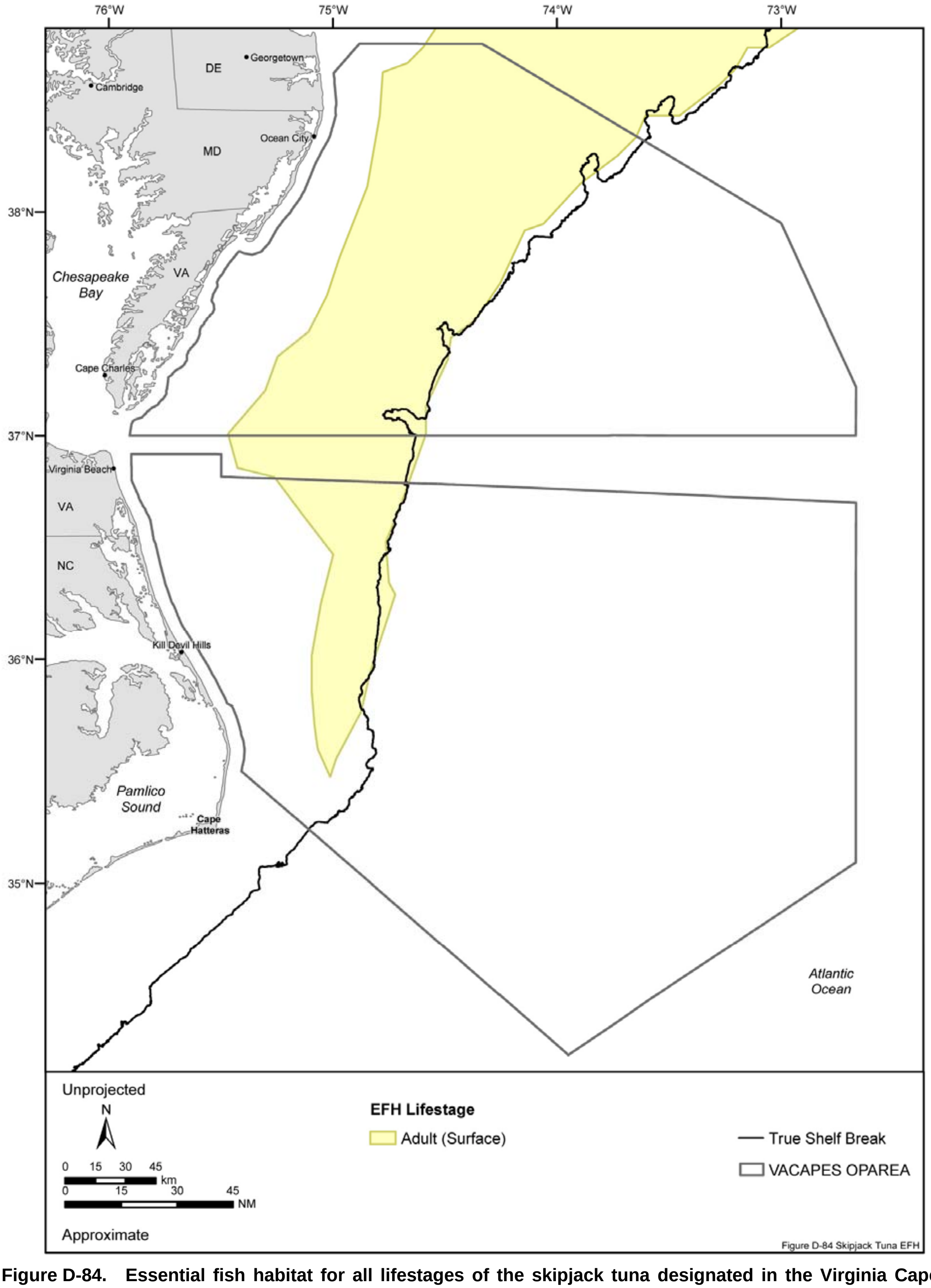

Figure D-84. Essential fish habitat for all lifestages of the skipjack tuna designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

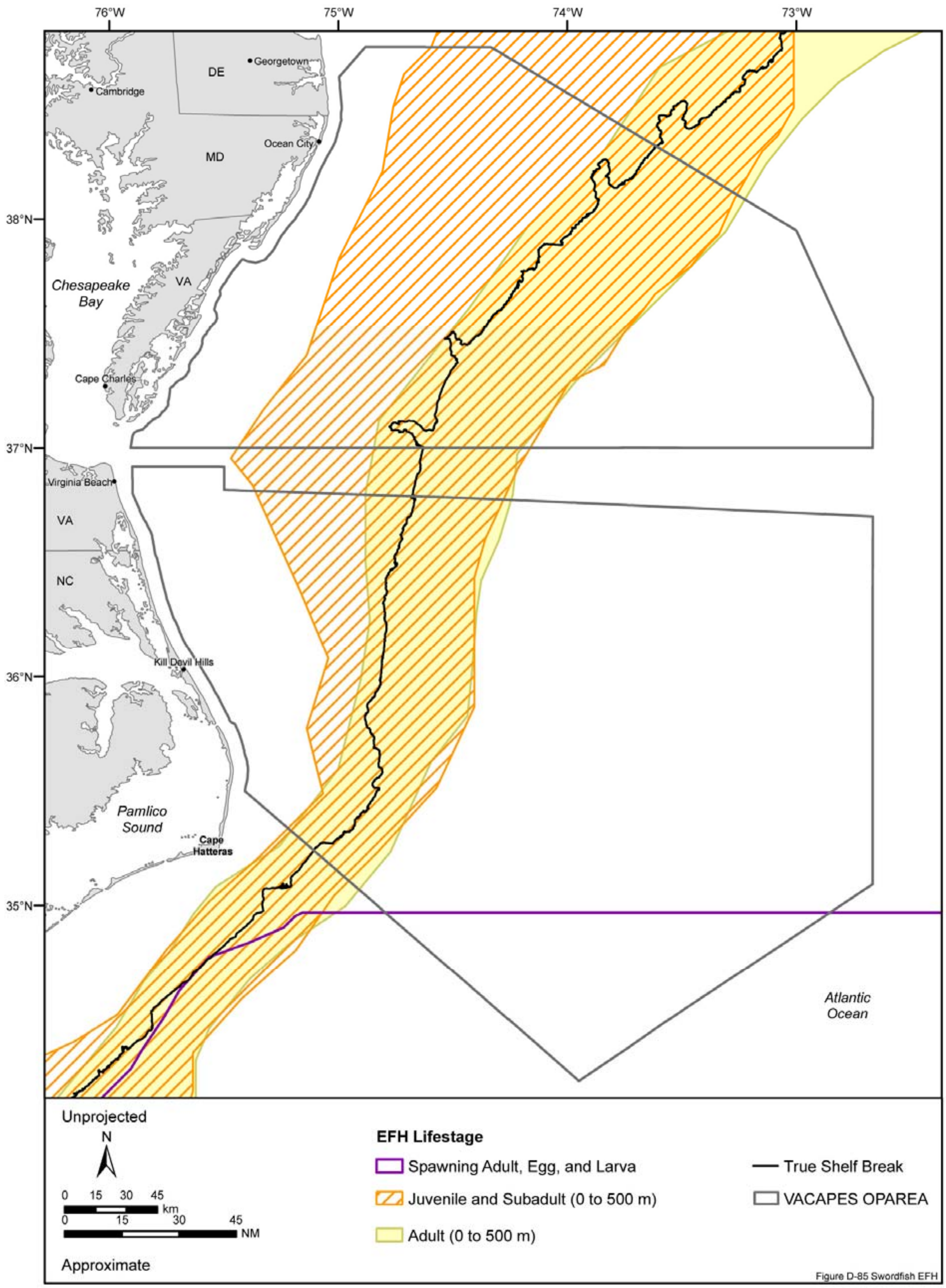

Figure D-85. Essential fish habitat for all lifestages of the swordfish designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

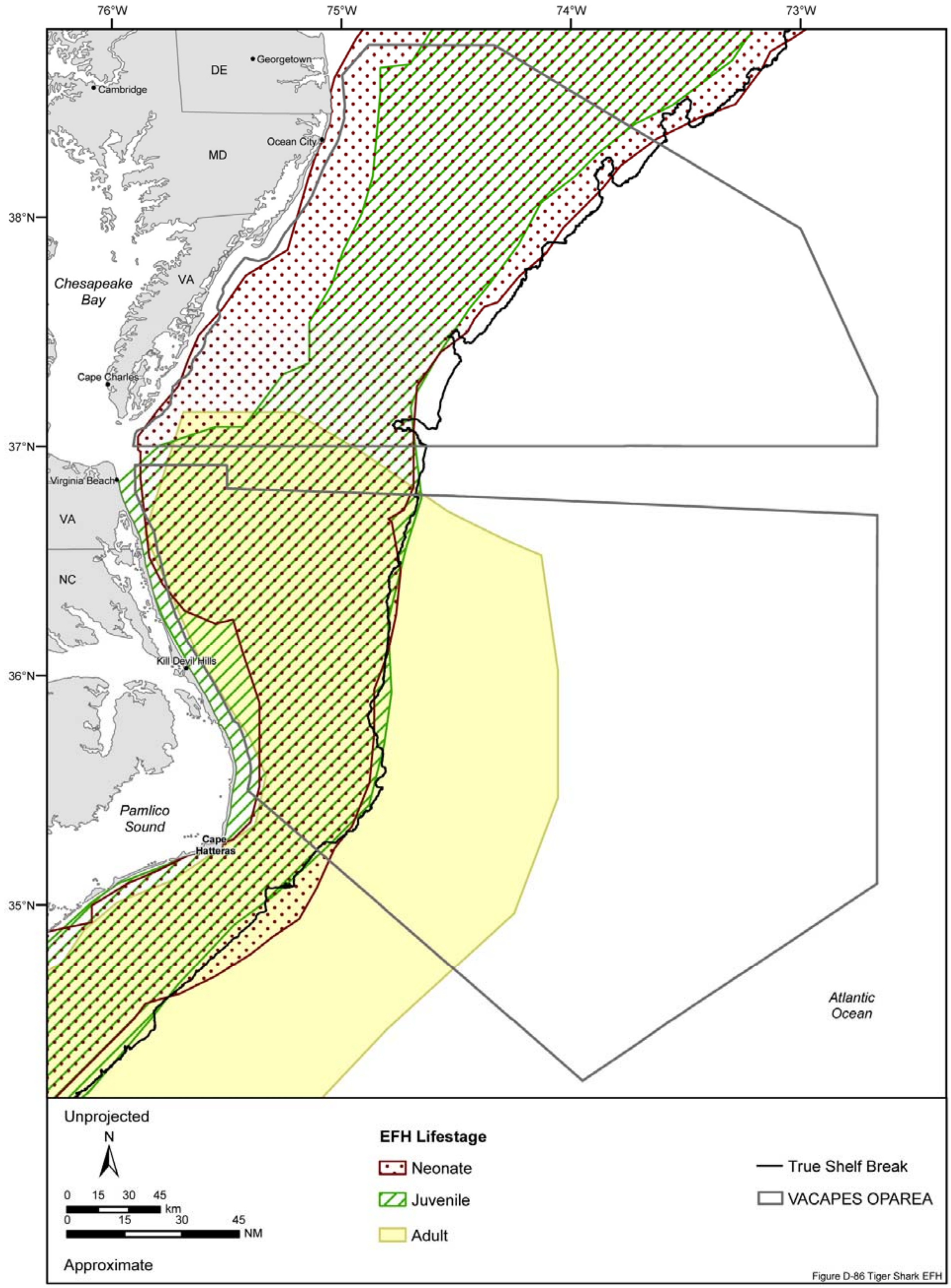

Figure D-86. Essential fish habitat for all lifestages of the tiger shark designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

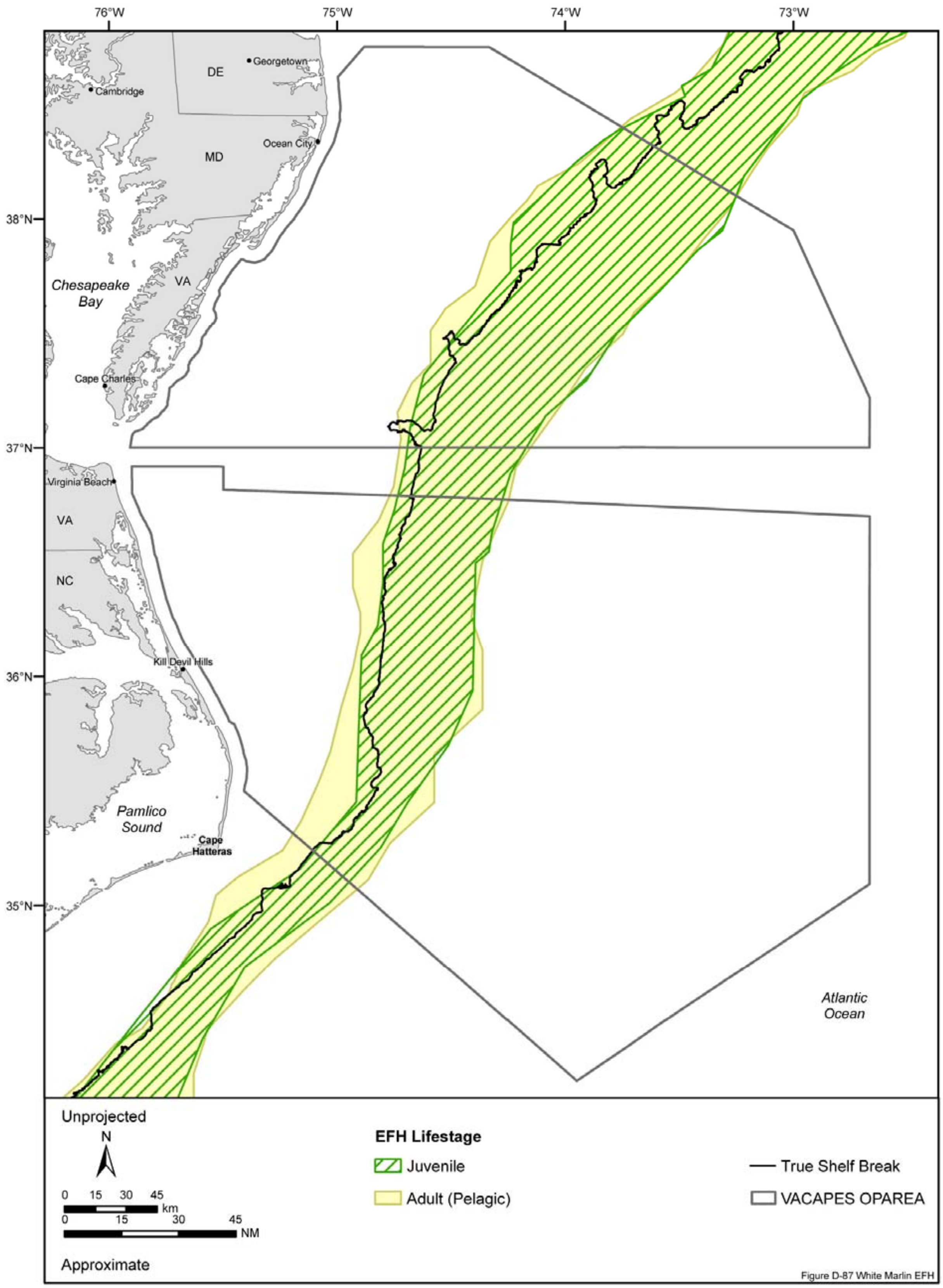

Figure D-87. Essential fish habitat for all lifestages of the white marlin designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).

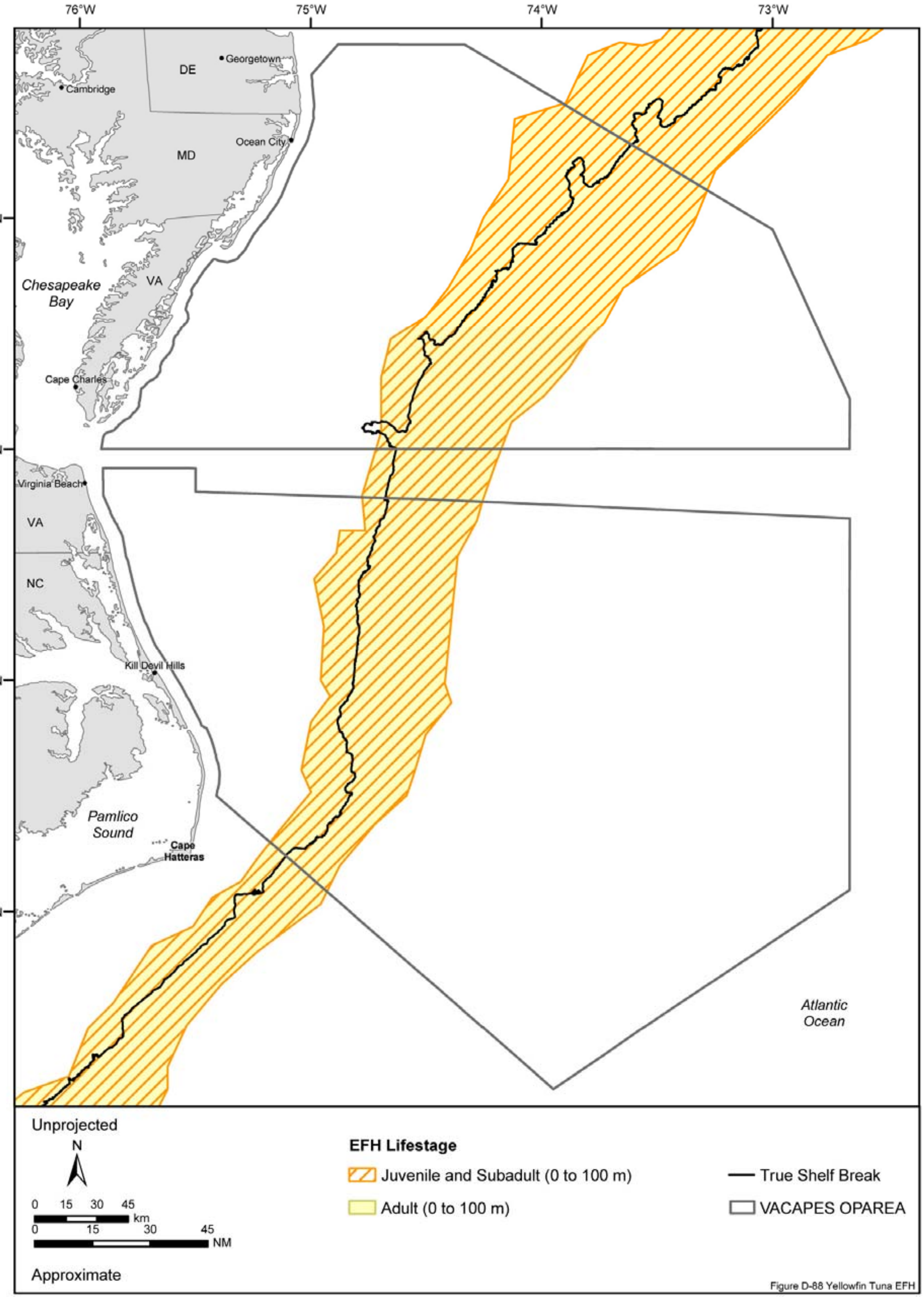

Figure D-88. Essential fish habitat for all lifestages of the yellowfin tuna designated in the Virginia Capes OPAREA and vicinity. Source data: NMFS (2003b).