MARINE RESOURCES ASSESSMENT FOR THE CHESAPEAKE BAY

JUNE 2009

FINAL REPORT

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

Contract: N62470-02-D-9997
Task Order: 0127

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STATEMENT OF PURPOSE

The United States (U.S.) Navy's (Navy) Commander, U.S. Fleet Forces Command (UFFC) implemented the Marine Resources Assessment (MRA) Program to establish a comprehensive source for information (which could include published information and consultations with regional and/or subject matter experts) concerning the protected and managed resources found in its various marine operating areas (OPAREAs). The information found within a MRA is vital for environmental planning and for use in environmental compliance documentation, for example the description of the affected environment. A MRA is not intended to be used in the place of a National Environmental Policy Act (NEPA) document. MRAs are reviewed by subject matter experts familiar with the region.

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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 (EO) 13089 on Coral Reef Protection. The Commander, United States (U.S.) Fleet Forces Command (FFC) implemented the marine resources 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 Chesapeake Bay MRA reports on the marine resources in the Chesapeake Bay (**Figure ES-1**) and vicinity and incorporates recent data and relevant research information. An overview of the 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 are included. Seasonal occurrence patterns of these protected species are identified, mapped, and described along with likely associated factors (behavioral, climatic, or oceanographic). Marine communities including oyster beds, seagrasses, and artificial habitats are investigated. An overview of the fish assemblages in the Chesapeake Bay and information on the 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 for which it is designated in the Bay is provided, including status, distribution, and EFH by lifestage. Additional relevant information includes locations of federal maritime boundaries, navigable waters, marine managed areas, and recreational SCUBA (self-contained underwater breathing apparatus) dive sites in the Chesapeake Bay.

Geographical representations of marine resource occurrences in the Chesapeake Bay are a major tool of this MRA. A geographic information system (GIS) was used to enter, store, manipulate, analyze, and visualize the spatial data and information accumulated for this update report. Data layers associated with the maps generated consist of bathymetry, sea-surface temperature, protected and managed species' sightings, military installations, habitats, as well as many others. Metadata, or documentation of GIS data, were also prepared for each GIS figure.

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 Environment**—describes the physical environment of the Chesapeake Bay, 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, seabirds, and fish found in the Chesapeake Bay, with detailed narratives of their morphology, status, habitat preferences, distribution, behavior, life history, acoustics, and hearing;

- **Chapter 4 Habitats of Concern**—describes seagrasses, oyster beds, and artificial habitats occurring in the Chesapeake Bay;

- **Chapter 5 Fish and Fisheries**—investigates fish assemblages, EFH, and fishing activities (commercial and recreational) that occur within the Chesapeake Bay;

- **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 report;

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

- **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;

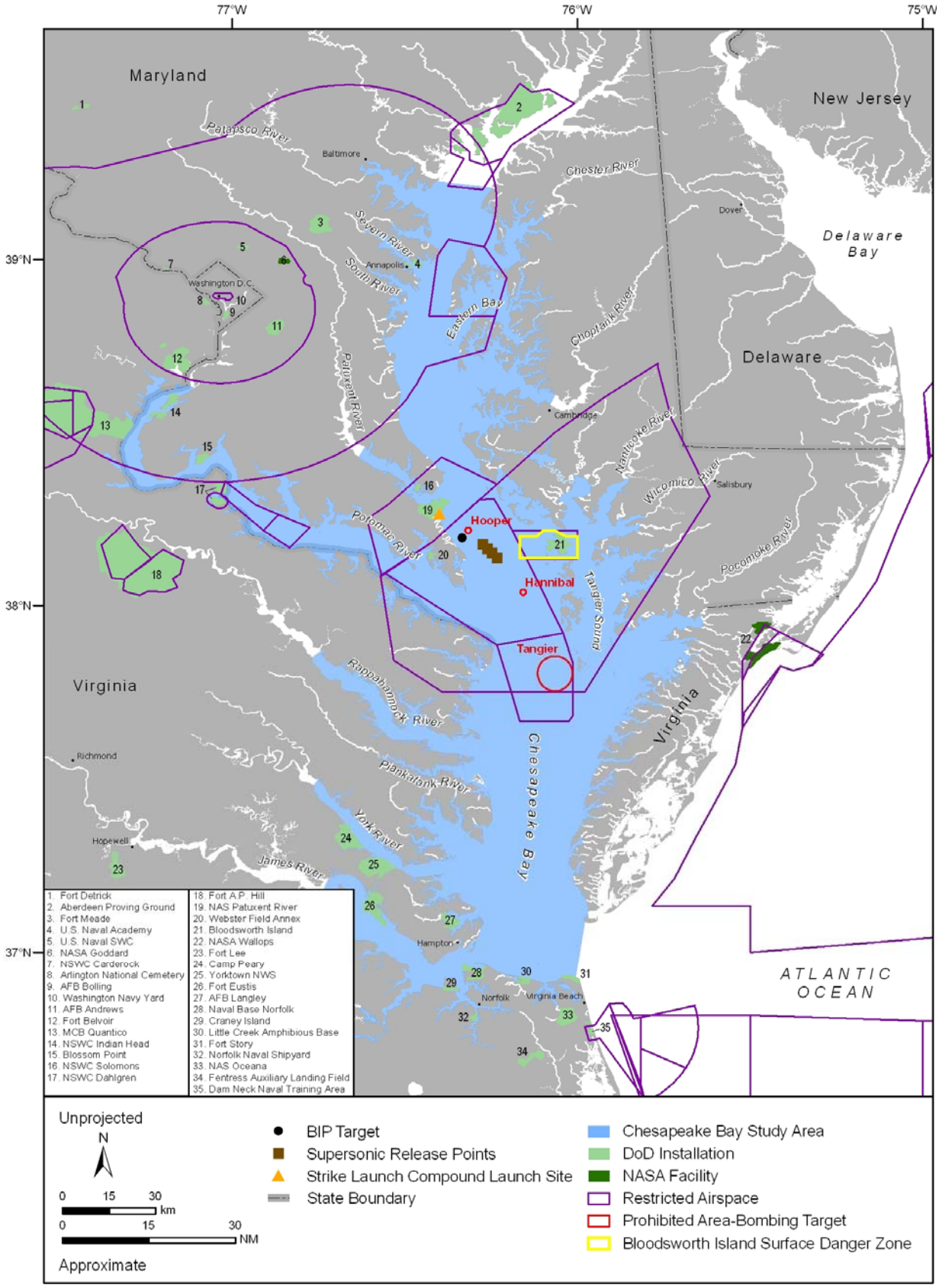

Figure ES-1. Chesapeake Bay with nearby military installations.

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We are especially grateful to Christopher Jarboe and Brandi Simpson at Naval Air Station Patuxent River as well as Dr. Christopher Tanner and Dr. Robert Paul from St. Mary's College at Historic St. Mary's City for their input on the direction of the Marine Resource Assessment and environmental issues in the Chesapeake Bay.

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LIST OF ACRONYMS AND ABBREVIATIONS

%	Percent
°	Degree(s)
µm	Micron(s)
3-D	Three-Dimensional
ACFCMA	Atlantic Coastal Fisheries Cooperative Management Act
AEP	Auditory-Evoked Potential
ALWTRP	Atlantic Large Whale Take Reduction Plan
AM	Amplitude-Modulated
AOU	American Ornithologists' Union
ASFA	Aquatic Sciences and Fisheries Abstracts
ASMFC	Atlantic States Marine Fisheries Commission
AVHRR	Advanced Very High-resolution Radiometer
BBNWR	Back Bay National Wildlife Refuge
C	Celsius
C&D	Chesapeake and Delware
CBIBS	Chesapeake Bay Interpretive Buoy System
CBOS	Chesapeake Bay Observation System
CBP	Chesapeake Bay Program
CBPO	Chesapeake Bay Program Office
CBRA	Costal Barrier Resources Act
CCC	Caribbean Conservation Corporation
CCL	Curved Carapace Length
CCPO	Center for Coastal Physical Oceanography
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
ChesMMAP	Chesapeake Bay Multispecies Monitoring and Assessment Program
chl *a*	Chlorophyll *a*
cm	Centimeter(s)
CNO	Chief of Naval Operations
COL	Cooperative Oxford Lab
CRCA	Coral Reef Conservation Act
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
D.C.	District of Columbia
dB	Decibel(s)
dB re: 1 µPa	Decibels with a Reference Pressure of One Micropascal
dB re: 1 µPa-m	Decibels with a Reference Pressure of One Micropascal at One Meter
dB re: 1µPa^{2}s	Decibels with a Reference Pressure of One Squared Micropascal-Second
DCFWD	District of Columbia Fisheries and Wildlife Division
DDT	Dichlorodiphenyltrichloroethane
DNA	Deoxyribonucleic Acid
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DoC	Department of Commerce
DoD	Department of Defense
DoI	Department of the Interior
DoN	Department of the Navy
DPS	Distinct Population Segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone

LIST OF ACRONYMS AND ABBREVIATIONS
(*continued*)

EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ELMR	Estuarine Living Marine Resources
EO	Executive Order
EPA	Environmental Protection Agency
ERA	Estuary Restoration Act
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute, Inc.
EWS	Early Warning System
FCMA	Fishery Conservation and Management Act
FCSP	False Cape State Park
Fe	Iron
FEMAP	Fisheries Ecosystem Modeling and Assessment Project
FHCZ	Fisheries Habitat Conservation Zone
FL	Fork Length
FM	Frequency-Modulated
FMC	Fishery Management Council
FMP	Fishery Management Plan
FMZ	Fishery Management Zone
FR	Federal Register
FWPCA	Federal Water Pollution Act
g	Gram(s)
GIS	Geographic Information System
GMFMC	Gulf of Mexico Fishery Management Council
GMI	Geo-Marine, Inc.
GPS	Global Positioning System
ha	Hectare(s)
HAB	Harmful Algal Bloom
HABHRCA	Harmful Algal Bloom and Hypoxia Research and Control Act
HAPC	Habitat Area of Particular Concern
HMS	Highly Migratory Species
HTML	Hypertext Markup Language
Hz	Hertz
IMFC	Interstate Marine Fisheries Commission
IMO	International Maritime Organization
INRMP	Integrated National Resources Management Plan
ISFMP	Interstate Fishery Management Plan
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
kg	Kilogram(s)
kHz	Kilohertz
km	Kilometer(s)
km^2	Square Kilometer(s)
km/hr	Kilometer(s) per Hour
kt	Knot(s)
m	Meter(s)
m/s	Meter(s) Per Second
m^3	Cubic Meter(s)
m^3/s	Cubic Meter(s) Per Second
MAB	Middle Atlantic Bight
MAFMC	Mid-Atlantic Fishery Management Council
MARPOL	International Convention for the Prevention of Pollution from Ships
MATS	Mid-Atlantic *Tursiops* Surveys

LIST OF ACRONYMS AND ABBREVIATIONS
(*continued*)

MEDASSET	Mediterranean Association to Save the Sea Turtles
MES	Maryland Environmental Service
mg/L	Milligram(s) per Liter
mg/m^3	Milligram(s) per Cubic Meter
mi	Mile(s)
min	Minute(s)
mm	Millimeter(s)
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MPPRCA	Marine Plastic Pollution Research and Control Act
MPRSA	Marine Protection, Research, and Sanctuaries Act
MRA	Marine Resources Assessment
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSX	Multinucleated Sphere Unknown
mt	Metric Ton(s)
MTSG	Marine Turtle Specialist Group
MU	Management Unit
NAIB	National Aquarium in Baltimore
NAO	North Atlantic Oscillation
NAP	Natural Area Preserve
NARP	National Artificial Reef Plan
NARWC	North Atlantic Right Whale Consortium
NASA	National Aeronautics and Space Administration
NCBO	National Oceanic and Atmospheric Administration Chesapeake Bay Office
NDAA	National Defense Authorization Act
NDBC	National Data Buoy Center
NE	Northeast
NEA	New England Aquarium
NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NFEA	National Fishing Enhancement Act
NISC	National Invasive Species Council
nm	Nanometer(s)
NM	Nautical Mile(s)
NMBCA	Neotropical Migratory Bird Conservation Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuaries Act
NMSP	National Marine Sanctuary Program
NOAA	National Oceanic and Atmospheric Administration
NP	National Park
NPS	Nonpoint Source/National Park Service
NRFCC	National Recreational Fisheries Coordination Council
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
NWS	National Weather Service
OBIS	Ocean Biogeographic Information System
OCSLA	Outer Continental Shelf Lands Act
OCSLAA	Outer Continental Shelf Lands Act Amendments

LIST OF ACRONYMS AND ABBREVIATIONS
(*continued*)

ODU	Old Dominion University
OPA	Oil Pollution Act
OPAREA	Operating Area
P.L.	Public Law
PBR	Potential Biological Removal
PCE	Primary Constituent Element
PDF	Portable Document Format
PFBC	Pennsylvania Fish and Boat Commission
PODAAC	Physical Oceanography Distributed Active Archive Center
PRFC	Potomac River Fisheries Commission
psu	Practical Salinity Unit(s)
RFRCP	Recreational Fishery Resources Conservation Plan
rkm	River Kilometer
rms	Root-Mean-Square
s	Second(s)
S.D.	Standard Deviation
S.E.	Standard Error
SAB	South Atlantic Bight
SAFMC	South Atlantic Marine Fisheries Council
SAR	Stock Assessment Report
SAV	Submerged Aquatic Vegetation
SCL	Straight Carapace Length
SCUBA	Self-Contained Underwater Breathing Apparatus
SECDEF	Secretary of Defense
SFA	Sustainable Fisheries Act
SL	Sensation Level
SLA	Submerged Lands Act
SNE/MA	Southern New England/Mid-Atlantic
SOSUS	Sound Surveillance System
SP	State Park
spp.	Species
SST	Sea Surface Temperature
STMIS	Sea Turtle Mapping and Information System
STSSN	Sea Turtle Stranding and Salvage Network
SWFSC	Southwest Fisheries Science Center
t	Ton(s)
T&E	Threatened/Endangered
TL	Total Length
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UFFC	United States Fleet Forces Command
UMCBL	University of Maryland Chesapeake Biological Lab
UMHPL	University of Maryland Horn Point Lab
UNCW	University of North Carolina at Wilmington
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USMC	United States Marine Corps
USVI	United States Virgin Islands
VACAPES	Virginia Capes

LIST OF ACRONYMS AND ABBREVIATIONS
(*continued*)

VAQS	Virginia Aquarium and Marine Science Center Foundation Stranding Response Center
VDGIF	Virginia Department of Game and Inland Fisheries
VHF	Very High Frequency
VIMS	Virginia Institute of Marine Science
VIMS ESL	Virginia Institute of Marine Science Eastern Shore Lab
VMRC	Virginia Marine Resources Commission
WA	Wildlife Area
WMA	Wildlife Management Area
XML	Extensible Markup Language
YOY	Young-of-the-Year

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1.0 INTRODUCTION

This Marine Resources Assessment (MRA) was contracted by the United States (U.S.) Navy's (Navy) Commander, U.S. Fleet Forces Command (UFFC) to extend data and information collection concerning the protected and commercial marine resources found in the Chesapeake Bay (**Figure 1-1**).

1.1 PURPOSE AND NEED

This assessment describes and documents the marine resources in the Chesapeake Bay and vicinity, including both protected and commercially important marine species, and provides a compilation of recent data and information on resource distribution and occurrence. A synopsis of environmental data for the Chesapeake Bay 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 [self-contained underwater breathing apparatus] diving sites) are also addressed.

Information provided herein will serve as a baseline from which the Navy can 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.

Extensive searches and reviews of relevant literature and data were conducted to summarize marine features pertinent to the Chesapeake Bay and vicinity, protected species occurrence patterns, and distributions of important marine habitats occurring in the region. To describe the physical environment of the Chesapeake Bay, 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 Chesapeake Bay and vicinity are included.

1.2 LOCATION OF THE CHESAPEAKE BAY STUDY AREA

The Chesapeake Bay is located inshore of the Atlantic coastline and borders Maryland, Virginia, and the District of Columbia (D.C.) and covers an area of approximately 11,500 square kilometers (km^2). The waters of the Chesapeake Bay fall entirely under the jurisdiction of either Maryland or Virginia. The mouth of the Chesapeake Bay opens into the neighboring Virginia Capes (VACAPES) Operating Area (OPAREA), which begins where state waters end at 3 nautical miles (NM) from shore. The region surrounding the Chesapeake Bay is diverse and encompasses a wide variety of habitats from densely populated urban areas to undeveloped, isolated wetlands (**Figure 1-2**). All of these habitats contribute to the Chesapeake Bay environment and affect the physical, chemical, and biological makeup.

Data supporting this MRA were collected for the entire Chesapeake Bay, including relevant sections of major tributaries (e.g., York River, James River, and Potomac River) and in some cases extend beyond the mouth of the bay; however, the focus of this MRA is on the main body of the Chesapeake Bay and the three major tributaries that have prominent Navy installations located along their shorelines, namely the Potomac, York, and James rivers (**Figure 1-1**).

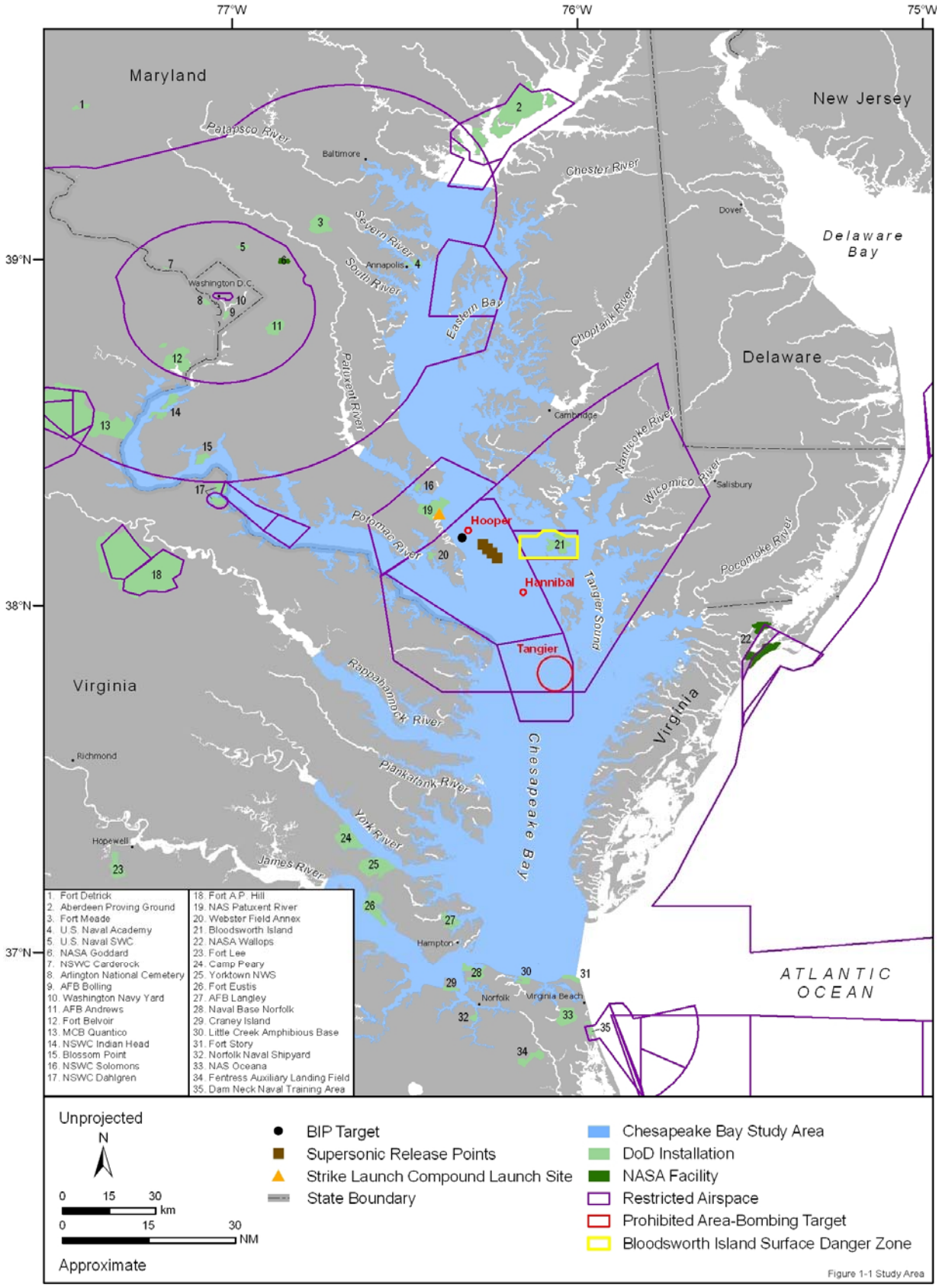

Figure 1-1. The Chesapeake Bay Study Area and surrounding DoD installations.

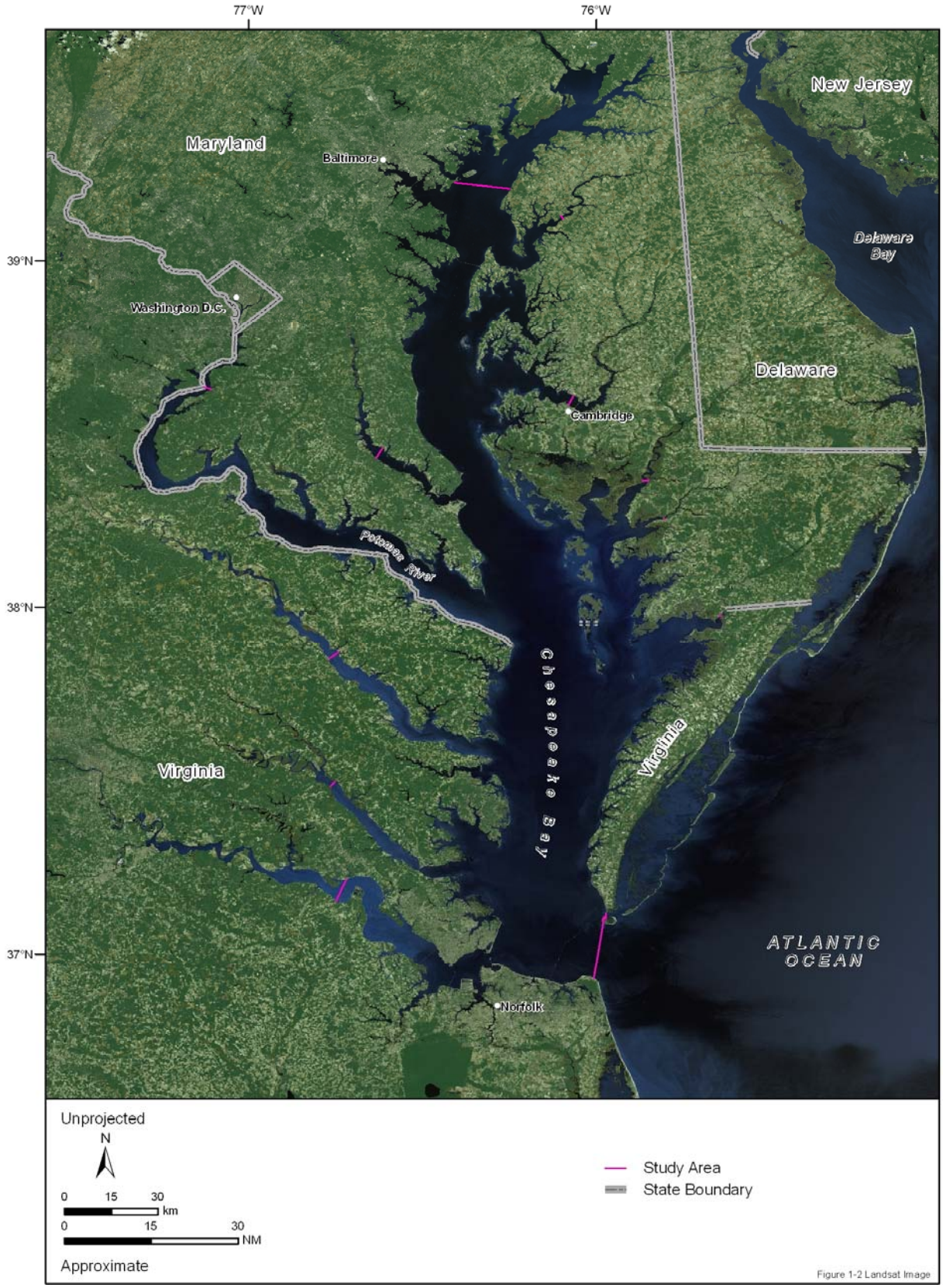

Figure 1-2. Composite image of the Chesapeake Bay and surrounding region compiled from data acquired by the Landsat-7 satellite between 1999 and 2002. Source data: NASA (2008).

1.3 APPLICABLE LEGISLATION

The primary environmental laws that govern Navy activities in the marine environment include the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). In addition to these federal acts, there are several other federal mandates and executive orders (EOs) that deal with resource conservation and management in ocean waters under U.S. jurisdiction and in foreign waters (**Table 1-1**). Relevant environmental laws at the state level are also discussed since the Chesapeake Bay Study Area encompasses coastal and estuarine areas across jurisdictions.

1.3.1 Federal Resource Laws

1.3.1.1 General

- The **National Environmental Policy Act (NEPA)** of 1969 (42 U.S. Code [U.S.C.] §§ 4321-4370[f]) establishes national policies and goals for the protection of the environment. The NEPA aims to encourage harmony between people and the environment, to promote efforts to prevent or eliminate damage to the environment and the biosphere, and to enrich the understanding of ecological systems and natural resources important to the country. To this end, the NEPA stipulates that environmental factors must be given appropriate consideration in all decisions made by federal agencies. This includes all major federal actions, including state or private actions which benefit from federal funding, that occur within the U.S. (its lands, territories, and possessions out to 12 nautical miles [nm] from the coastline).

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

  Section 102(2) of the NEPA contains "action-forcing" provisions that ensure that federal agencies act according to the letter and the spirit of the law. These procedural requirements direct all federal agencies to give appropriate consideration to the environmental effects of their decision-making by evaluating the environmental impact, irreparable environmental effects, alternatives, and short-term and long-term impacts of the proposed action. Where a determination of significant impact (or potential significant impact) to the human environment is made, the NEPA requires federal agencies take a hard look at the environmental consequences of the proposed action, usually through the preparation of an environmental impact statement (EIS). Section 102(2) also requires the development and evaluation of alternatives to the proposed action.

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

  Congress passed the **Rivers and Harbors Appropriation Act** of 1899 (33 U.S.C. § 403) to restrict the building of structures over or in U.S. navigable waterways. Under Section 9, no bridge, dam, dike, or causeway may be constructed without Congress' approval. Structures contained within a state that have been approved by the state legislature may be built with the approval of the Secretary of Transportation or the Chief of the U.S. Army Corps of Engineers (USACE) and the Secretary of the Army. Section 10 prohibits the building of wharfs, piers, and jetties over or in navigable waterways without the approval of Congress. The Chief of Engineers and the Secretary of the Army must approve both construction and excavation in navigable waters.

Table 1-1. Timeline detailing the passage of federal resource laws and executive orders affecting marine resources in the Chesapeake Bay Study Area and vicinity.

1899	**Rivers and Harbors Appropriation Act** restricts the building of structures over or in the navigable waterways of the U.S.
1918	**Migratory Bird Treaty Act** prohibits the taking, transporting, and harming of migratory birds
1953	**Submerged Lands Act** grants to coastal states and territories jurisdiction over submerged offshore lands within 3 nm (9 nm for Texas, the gulf coast of Florida and the territory of Puerto Rico)
1953	**Outer Continental Shelf Lands Act** (and its amendments of 1978) grants to the federal government jurisdiction over the resources of submerged lands seaward of state waters
1960	**Sikes Act** provides for the conservation of fish and wildlife resources on U.S. military lands
1969	**National Environmental Policy Act** establishes national policies and goals for the protection of the environment within U.S. jurisdiction
1972	**Marine Mammal Protection Act** establishes protection for marine mammals under U.S. jurisdiction
1972	**Marine Protection, Research, and Sanctuaries Act** establishes guidelines for the dumping of toxic materials into the ocean and for the designation and regulation of marine sanctuaries
1972	**Coastal Zone Management Act** establishes a voluntary national program through which U.S. states and territories may develop and implement coastal zone management plans
1973	**Endangered Species Act** establishes protection for threatened and endangered species and the ecosystems upon which they depend, as well as guidelines for conservation and recovery of these species
1976	**Fishery Conservation and Management Act** establishes management scheme for the sustainable use of fishery resources
1977	**Executive Order 11990 on Protection of Wetlands** issued to guide federal agencies on their use of wetlands throughout the U.S.
1977	**Clean Water Act** takes the first step toward establishing a comprehensive solution to the country's serous water pollution problems
1979	**Executive Order 12114 on Environmental Effects Abroad of Major Federal Actions** extends the principles of the NEPA to federal actions occurring outside U.S. territory
1984	**National Fishery Enhancement Act** recognizes the social and economic value of artificial reefs in enhancing fishery resources
1987	**Marine Plastic Pollution Research and Control Act** prohibits the discharge of any plastic materials into the ocean and regulates the discharge of other refuse
1990	**Oil Pollution Act** details new policies for oil spill prevention and clean-up
1992	**National Marine Sanctuaries Act** 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
1995	**Executive Order 12962 on Recreational Fisheries** promotes the protection and enhancement of recreational fisheries
1996	**Sustainable Fisheries Act** amends the Fishery Conservation and Management Act, renaming it the **Magnuson-Stevens Fishery Conservation and Management Act**, and mandates the identification of EFH for each federally managed species
1996	**National Invasive Species Act** addresses the movement of invasive species into the lands and waters of the U.S. and outlines methods for mitigation, monitoring, and restoration of damaged ecosystems
1998	**Executive Order 13089 on Coral Reef Protection** seeks to protect the biodiversity and health of coral reefs as well as the social and economic value reefs possess
1998	**Harmful Algal Bloom and Hypoxia Research and Control Act** is passed in response to growing harmful algal bloom (HAB) and hypoxia problems, mandating national assessments on the effects of HABs and hypoxia in U.S. waters
1999	**Executive Order 13112 on Invasive Species** is issued to further recognize and address the economic, ecologic, and human health problems of invasive species, both terrestrial and aquatic
2000	**Executive Order 13158 on Marine Protected Areas** creates a framework for a national system of MPAs
2000	**Neotropical Migratory Bird Conservation Act** increases the protection of migratory bird species
2000	**Estuary Restoration Act** increases estuary protection and creates interagency council to develop national strategy for wetland restoration
2000	**Coral Reef Conservation Act** sets in motion the development of a national coral reef action strategy
2001	**Executive Order 13189 on the Responsibilities of Federal Agencies to Protect Migratory Birds** directs executive departments and agencies to increase protection of migratory birds

- The **Submerged Lands Act (SLA)** of 1953 (43 U.S.C. §§ 1301-1315) grants to coastal states and territories jurisdiction over the offshore lands within their historic boundaries. Texas, the gulf coast of Florida, and the territory of Puerto Rico lay claim to the seabed underlying waters within 9 NM of shore, while the rest of U.S. coastal states and territories hold 3-NM claims. It also grants the rights to the natural resources on or in these lands. The federal government relinquishes its claims to the lands and resources, but maintains the right to regulate offshore activities for national defense, international affairs, navigation, and commerce.

  Passed at the same time as the SLA was the **Outer Continental Shelf Lands Act (OCSLA)** of 1953 (43 U.S.C. §§ 1331-1356) which was substantially amended in 1978 as the **OCSLA Amendments (OCSLAA)** (Public Law [P.L.] 95-372). The OCSLAA grants to the federal government jurisdiction over submerged lands of the outer continental shelf from the seaward boundary of state/territorial waters to the shelf break. The primary goal of the OCSLAA is to manage the oil and gas resources found within the continental shelf underlying U.S. offshore waters, as well as to preserve and develop these stores for use by the U.S. The act also directs the lead agency, the Minerals Management Service (MMS), to preserve and develop offshore oil and gas in accordance with stewardship of associated marine and coastal environments and to cancel leases if activity will result in environmental damage. The MMS is to consult with relevant agencies when necessary as well as undergo consistency review in accordance with the Coastal Zone Management Act (CZMA).

1.3.1.2 Protected Species

- The **Marine Mammal Protection Act (MMPA)** of 1972 (16 U.S.C. §§ 1361-1407) established a moratorium on the taking of marine mammals in waters or on lands under U.S. jurisdiction. Marine mammals as defined by the MMPA are cetaceans (whales, dolphins, and porpoises), pinnipeds (walruses, seals, and sea lions), sirenians (manatees and dugongs), sea otters, and polar bears. The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) jointly administer the MMPA, each with responsibility over certain of the marine mammals; NMFS is charged with managing cetaceans and pinnipeds and USFWS manages manatees, sea otters, and polar bears. The MMPA defines taking as "harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. § 1362[3][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 (USFWS) or the Secretary of Commerce (NMFS).

  In the 1994 amendments to the MMPA, two levels of harassment were defined. Level A 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 B harassment is defined as 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. **The National Defense Authorization Act for Fiscal Year 2004** (P.L. 108-136) altered these definitions of 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 (16 U.S.C. § 1362[3][18][B]). The National Defense Authorization Act for Fiscal Year 2004 also allows for military readiness exemptions from the MMPA. See **Section 1.4.2**.

  Section 101(a)(5)(A) of the MMPA directs the responsible Secretary, upon request, to authorize the unintentional taking of small numbers of marine mammals incidental to activities (other than commercial fishing) when, after notice and opportunity for public comment, the Secretary: (1) determines that total takes during a 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 Secretary determines that the takes will have a negligible impact on the affected species or population stock. Section 101(a)(5)(A) also specifies that the Secretary has the right to deny permission to take marine mammals if, after notice and opportunity for public comment, the Secretary finds: (1) that applicable regulations regarding taking, monitoring, and reporting are not being followed, or (2) that takes are, or may be, having more than a negligible impact on the affected species or stock.

- The **Endangered Species Act (ESA)** of 1973 (16 U.S.C. §§ 1531-1599) establishes protection over 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 all or a significant portion of its range, while a threatened species is one that is likely to become endangered within the foreseeable future throughout all or in a significant portion of its range. All federal agencies are required to implement protection programs for threatened and endangered species and to use their authority to further the purposes of the ESA. NMFS and USFWS jointly administer the ESA and are 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 NMFS or USFWS has determined that listing may be or is warranted (NMFS 2004). 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 NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA (NMFS 2004). Neither listing as candidate nor informal status such as species of concern provides protection under the ESA; such protection comes only from formal threatened or endangered status.

  NMFS and USFWS may also propose distinct population segments (DPSs) for listing under the ESA. A DPS is a subset of a given species that meets certain criteria and may be protected by the ESA regardless of the status of the remainder of that particular species. In this case, the term “species” as used in the ESA may refer to all individuals of a species or to a subset of individuals defined as a DPS by federal rule. Listing as a DPS is the driver behind USFWS’ designation of the interior least tern breeding population as endangered though other breeding populations remain unlisted.

  A species may become a candidate for listing as a threatened or endangered species due to any of the following five factors: (1) current/imminent destruction, modification, or curtailment of its habitat or range; (2) overuse of the species for commercial, recreational, scientific, or educational purposes; (3) high levels of disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or human-induced factors affecting its continued existence.

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

  Section 4 of the ESA provides for 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 (primary constituent elements [PCEs]) are included in the habitat designation. Designation of critical habitat affects only federal agency actions and federally funded or permitted activities. Certain military lands may be exempt from critical habitat designation (see **Section 1.4.2**). It is also possible under Section 3(5)(A)(i) of the ESA for lands other than military lands to be exempted on the basis of an already established management plan if the Secretary of the Interior determines that the management plan benefits the species for which critical habitat designation is sought (i.e., the area does not need “special management considerations or protection”).

There are four marine mammals, five sea turtles, three birds, and one fish in the Chesapeake Bay and vicinity listed as threatened or endangered (**Table 1-2**). Of the marine mammals, NMFS has jurisdiction over cetaceans and pinnipeds while USFWS has jurisdiction over the West Indian manatee in U.S. territorial waters. NMFS has jurisdiction over sea turtles while they are in the water, and USFWS has jurisdiction over nesting individuals. USFWS has sole jurisdiction over the birds and the anadromous shortnose sturgeon.

Table 1-2. Endangered Species Act (ESA)-designated species with potential occurrence in the Chesapeake Bay Study Area and vicinity.

Taxon Group	Scientific Name	ESA Status
Marine Mammals		
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Fin whale	*Balaenoptera physalus*	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
Birds		
Piping Plover (shorebird)	*Charadrius melodus*	Threatened
Roseate Tern	*Sterna dougallii*	Endangered
Least Tern	*Sternula antillarum*	Endangered[2]
Fish		
Shortnose sturgeon	*Acipenser brevirostrum*	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.
[2] Interior breeding population of the least tern is listed as endangered; other populations are not listed.

- The **Migratory Bird Treaty Act (MBTA)** of 1918 (16 U.S.C. §§ 703-712) prohibits the taking, transporting, and harming of migratory birds and their parts, eggs, nests, and young unless permitted by federal regulations. This act implements provisions from the 1916 convention between the U.S. and Great Britain addressing the protection of migratory birds. Provisions from later conventions with Mexico, Japan, and the former Soviet Union are also implemented as amendments to the MBTA. USFWS has the authority to enforce the act's provisions, which includes determining periodically when the taking of migratory birds may occur. Federal agencies, including the military, must obtain take permits if their actions have the potential to harm birds as defined in the MBTA. State governments may pass laws that increase migratory bird protection as long as open seasons do not extend beyond those set at the national level (16 U.S.C. § 708).

  In 2000, Congress furthered the protection of migratory birds by passing the **Neotropical Migratory Bird Conservation Act (NMBCA)** (16 U.S.C. §§ 6101-6109). This act sets aside funds used to finance projects that assist in the conservation of North American migratory birds in the U.S., Latin America, and the Caribbean. Project proposals are submitted to the Secretary of the Interior who determines which projects will receive federal funding. Not more than 25 percent (%) of a project's funds can come from the federal government. At least 75% of the funds must be used on projects outside the U.S. Congress may appropriate as much as $5 million each year for use in NMBCA initiatives (16 U.S.C. § 6109).

- Congress passed the **Coral Reef Conservation Act (CRCA)** of 2000 (16 U.S.C. §§ 6401-6409) in recognition of the importance of coral species and in furtherance of EO 13089. The purpose of the CRCA is to advance the conservation and restoration of coral reef ecosystems through the application of sound science, sustainable use management, and support and financing to programs and organizations in both the governmental and private sectors. Responsibility for the CRCA is vested in the Administrator of the National Oceanic and Atmospheric Administration (NOAA), who was ordered to produce a national coral reef action strategy in consultation with the Coral Reef Task Force established per EO 13089 (NOAA 2005). The CRCA is currently in the process of reauthorization.[2]

1.3.1.3 Fisheries

- The **Fishery Conservation and Management Act (FCMA)** of 1976 (16 U.S.C. §§ 1801-1882), later renamed the **Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)**, established a 200-NM fishery conservation zone in U.S. waters and a network of regional Fishery Management Councils (FMCs). The FMCs are comprised of federal and state officials who oversee fishing activities within the fishery management zone. The act also establishes national standards (e.g., optimum yield, scientific information, allocations, efficiency, and costs/benefits) for fishery conservation and management. In 1977, the multifaceted regional management system began allocating harvesting rights, with priority given to domestic enterprises. A substantial portion of fishery resources in offshore waters had been allocated for foreign harvest, so these foreign allocations were reduced as domestic fish harvesting and processing industries expanded under the domestic preference authorized by the FCMA. Exclusive federal management authority over U.S. domestic fisheries resources is vested in NMFS.

  In 1996, the FCMA was reauthorized, renamed the MSFCMA, and amended by the **Sustainable Fisheries Act (SFA)** (P.L. 104-297). Authority to implement the SFA is given to the Secretary of Commerce through NMFS. The SFA provides a new habitat conservation tool in the form of the EFH mandate. 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 SFA 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 define “waters” as aquatic areas and their biological, chemical, and physical properties, while “substrate” refers to the associated biological communities that make these areas suitable fish habitat (50 CFR § 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 2002). 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 temporal and spatial scales. Habitat requirements also must be identified, described, and mapped for all life stages of each species. NMFS and regional FMCs determine the species distributions by life stage and characterize associated habitats, including habitat areas of particular concern (HAPCs). The SFA requires federal agencies to consult with NMFS on activities that may adversely affect EFH. For actions that affect a threatened or endangered species, its critical habitat, and its EFH, federal agencies must initiate ESA and EFH consultations.

  In 2002, NMFS issued a final rule that simplified EFH regulations (NMFS 2002). Significant changes delineated in this final rule are: (1) clearer standards for identifying and describing EFH, such as the inclusion of the geographic boundaries and a map of the EFH, as well as guidance for the FMCs to distinguish EFH from other habitats; (2) more guidance for the FMCs on evaluating the impact of fishing activities on EFH and clearer standards for deciding when FMCs should act to minimize the adverse impacts; and (3) clarification and reinforcement of the EFH consultation procedures (NMFS 2002). The process by which federal agencies can integrate MSFCMA EFH consultations with ESA Section 7 consultations is also included in the final rule (NMFS 2002).

The authority to place observers on commercial fishing and processing vessels operating in specific geographic areas is also provided by the MSFCMA (16 U.S.C. § 1881b[403]). The data collected by the National Observer Program, which is overseen by NMFS, is often the best means to get current data on the status of many fisheries. Without observers and observer programs, there would not be sufficient fisheries data for effective management. 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 (16 U.S.C. § 1826[206][b][3]).

The MSFCMA was amended most recently in 2007; these amendments include measures to maintain sustainable fish stocks and mitigate the effects of overfishing. The amendments mandate annual catch limits by 2010 for stocks classified as "overfished" and by 2011 for all other stocks (16 U.S.C. § 1853[303 note][1][A-B]) as well as limited access programs to promote market-based management throughout U.S. fisheries (16 U.S.C. § 1853a[303A]). In addition, the 2007 amendments will improve enforcement of the MSFCMA to mitigate illegal, unreported and unregulated fishing practices (16 U.S.C. § 1826j[609]); NMFS is developing certification procedures to help prevent the import into the U.S. of products from unsustainable or poorly managed international fisheries.

- In 1984, Congress passed the **National Fishing Enhancement Act (NFEA)** (33 U.S.C. §§ 2101-2106) in recognition of the social and economic value of artificial reefs in enhancing fishery resources. Under this act, the Secretary of Commerce and the USACE are responsible for encouraging and regulating artificial reefs in the navigable waters of the U.S. (NOAA 2003). One of the primary directives of the NFEA was the preparation of a long-term National Artificial Reef Plan (NARP) (33 U.S.C. § 2103). Section 202 of the act recognizes the harmful effects of overfishing on fishery resources and proposes that properly designed, constructed, and located artificial reefs can enhance the habitat and diversity of these fishery resources. The NARP, which underwent revision in 2007, was implemented in November 1985 to provide guidance and criteria on various aspects of artificial reef use, including types of construction materials and planning, siting, designing, permitting, installing, maintaining, and managing artificial reefs (NOAA 2007). One of the most significant recommendations in the NARP encourages the development of state-specific artificial reef plans (Gordon 1993).

1.3.1.4 Management

- The **Sikes Act of 1960** (16 U.S.C. § 670[a]-670[o]) directs the Secretary of Defense to carry out a program for the cooperative development and implementation of Integrated Natural Resources Management Plans (INRMPs) to provide for the conservation and rehabilitation of fish and wildlife resources on U.S. military installations. The main purpose of an INRMP is to integrate conservation of natural resources on military lands with military operations and to ensure consistency with both the spirit and the letter of federal resource laws. As required by the **Sikes Act Improvement Act of 1997**, an INRMP must, to the extent appropriate and applicable, provide for: 1) fish and wildlife management, land management, forest management, and fish- and wildlife-oriented recreation; 2) fish and wildlife habitat enhancement or modification; 3) wetland protection, enhancement, and restoration, where necessary for support of fish, wildlife, or plants; 4) integration of, and consistency among, the various activities conducted under the plan; 5) establishment of specific natural resource management goals and objectives and time frames for proposed actions; 6) sustainable public use of natural resources to the extent that the use is not inconsistent with the needs of fish and wildlife resources; 7) public access to the installation that is necessary or appropriate for the sustainable use of natural resources, subject to requirements necessary to ensure safety and military security; 8) enforcement of applicable natural resource laws; 9) no net loss in the capability of the installation's lands to support the military mission of the installation; and 10) such other activities as the military has determined appropriate.

- The **Coastal Zone Management Act (CZMA)** of 1972 (16 U.S.C. §§ 1451-1466) establishes a voluntary national program through which U.S. states and territories can develop and implement coastal zone management plans. The NOAA, under the Secretary of Commerce, administers this act. States and territories 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 or territory can implement the plan. The plan must include defined boundaries of the coastal zone, the uses of the area that the state or territory 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 34 U.S. states and territories with federally approved coastal zone management plans. These states and territories manage over 153,500 kilometers (km) (99.9%) of U.S. shoreline along the Atlantic, Pacific, and Arctic Oceans as well as the Great Lakes.[3]

The CZMA also instituted a federal consistency requirement, which provides federal agencies with restrictions concerning their behavior in relation to state and territory managed coastal zones. Federal agency actions that affect any land or water use or natural resource of the coastal zone (e.g., military operations, offshore oil and gas development, dredging projects, and developments on federal lands or in protected areas) must be "consistent to the maximum extent practicable" with the enforceable policies of a state or territory's coastal management program. These effects may be direct or indirect, adverse or not and must be evaluated for consistency regardless of whether they originate within state waters. Consistency reviews may be integrated with NEPA procedures. The federal consistency requirement was enacted as a mechanism to address coastal effects, to ensure adequate federal consideration of state and territory coastal management programs, and to avoid conflicts between states or territories and federal agencies by fostering early consultation and coordination (NOAA 2000). Within each state or territory's coastal zone management plan is a list of the federal agency activities for which consistency determinations must be prepared.

- The **Marine Protection, Research, and Sanctuaries Act (MPRSA)** (33 U.S.C. §§ 1401-1445), often referred to as the "Ocean Dumping Act," was enacted in 1972. The MPRSA regulates the dumping of toxic materials beyond U.S. territorial waters and provides guidelines for the designation and regulation of marine sanctuaries. 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 (33 U.S.C. 1402[f]).

  During the reauthorization of the MPRSA in 1992, Title III of the MPRSA was designated the **National Marine Sanctuaries Act (NMSA)** (16 U.S.C. §§ 1431-1445[c]). 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 (NMSs). 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. NMSs are similar to underwater parks and 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 (NMSP).

- To protect undeveloped coastal barrier landforms, Congress passed the **Coastal Barrier Resources Act (CBRA)** in 1982. This statute created the John H. Chafee Coastal Barrier Resources System, which consists of various undeveloped coastal barriers, such as barrier islands, barrier spits, sea islands, tombolos, bay barriers (baymouth bars), and fringing mangroves. Any development on these coastal barriers cannot receive new federal financial assistance unless it falls within one of the exceptions, such as fish and wildlife research and military activities essential to national security. The Secretary of the Interior maintains the set of maps that defines the system, which must be reevaluated at least every five years to determine if the coastal barrier boundaries should be altered.

  The most significant amendment to the CBRA was the Coastal Barrier Improvement Act of 1990. This act added additional undeveloped coastal barriers to the system, altered the definition of "coastal barrier" to include more areas, such as the Florida Keys, and provided additional exemptions from the funding prohibitions.[4] 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.[4]

- The **National Invasive Species Act** of 1996 (16 U.S.C. §§ 4701-4751) was in large part a result of concern over the spread of zebra mussels throughout the inland waters of the U.S., especially the Great Lakes. This act outlines specific guidelines for identifying ways in which non-native species enter the lands and waters of the U.S., as well as methods for mitigation, restoration, and monitoring of invasive species and the degree to which they have or will spread. Sections 4711 et seq. particularly addresses aquatic invasive species; Section 4713 mandates that the Department of Defense (DoD), in cooperation with the International Maritime Organization (IMO), develop and implement a ballast water management program for its seagoing vessels to minimize the potential for introduction of non-native species via ballast water discharge and exchange.

- The federal government increased estuary protection by passing the **Estuary Restoration Act (ERA)** of 2000 (33 U.S.C. §§ 2901-2909). This act establishes the Estuary Habitat Restoration Council, a federal interagency council that was ordered to develop a national estuary habitat restoration strategy, published in 2002. Private entities propose projects to the council, which then makes recommendations to the USACE; projects are selected for implementation based on specific criteria. The federal government pays up to 65% of the project costs, excluding operation and maintenance costs. These projects are tracked in an online database developed and maintained by the NOAA. The ultimate goal of the act is to restore one million acres of estuary habitat by 2010.[5]

1.3.1.5 Pollution

- In 1977, Congress addressed heightening concern over water pollution by amending the **Federal Water Pollution Control Act (FWPCA)** of 1948 as the **Clean Water Act (CWA)** (33 U.S.C. §§ 1251-1376). For a synopsis of initiatives prior to 1977, see the USFWS *Digest of Federal Resource Laws* entry for the FWPCA.[6]

  The CWA took the first step towards establishing a comprehensive solution to the country's serious water pollution problems.[7] Through standards, technical tools, and financial assistance, the CWA works towards the accomplishment of 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 CWA 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. Section 319 of the CWA describes the control of nonpoint source (NPS) pollution, assigning to states the responsibility to implement best management practices for the control of NPS pollution. States also are granted the authority to ensure that federal activities are consistent with state programs. Section 401 of the CWA requires that all applicants for a federal permit or license for activities that may result in a discharge to a water body obtain State Water Quality Certification. Section 403 sets out permit guidelines specific to the discharge of contaminants into the territorial sea, the contiguous zone, and waters further offshore, while Section 404 establishes permit guidelines for the discharge of dredged or fill material into U.S. navigable waters at specified disposal sites. The USACE, through issuance of CWA Section 401 and 404 permits, is the regulatory agency that approves all discharge of dredge or fill material into U.S. waters, especially water bodies with high resource value such as wetlands, riparian areas, and headwaters.

  In addition to regulating pollution in offshore waters, the CWA, under the amendment known as the **Water Quality Act** of 1987, also requires state and federal agencies to devise programs and management plans that aim to maintain the biological and chemical integrity of estuarine waters. In estuaries of national significance, the NOAA is permitted to conduct water quality research in order to evaluate state and federal management efforts. Sensitive estuarine habitats, such as seagrass beds and wetlands, are protected from pollution under this act.

- The **Act to Prevent Pollution from Ships** of 1980, as amended by the **Marine Plastic Pollution Research and Control Act** of 1987 **(MPPRCA)**, (33 U.S.C. §§ 1901-1915) implements the provisions set forth in Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL). Like the CWA, the MPPRCA 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 meters (m) in length, as well as all manned, fixed, or floating platforms subject to U.S. jurisdiction, keep records of garbage discharges and disposals.

- In 1980 Congress passed the **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)**, which was substantially amended in 1983 (42 U.S.C. §§ 9601-9675). CERCLA establishes liability to the federal government for damage to natural resources under U.S. jurisdiction, directs the federal government to provide officials to act as trustees for natural resources, and provides funds for natural resources damage assessments. CERCLA deals specifically with hazardous waste disposal and clean-up and provides a national contingency plan, in conjunction with the CWA, for response to oil or hazardous waste spills.

- Passage of the **Oil Pollution Act (OPA)** of 1990 (33 U.S.C. §§ 2701-2761) further increased the protection of our nation's oceans. In addition to amending the CWA, this act details new policies relating to oil spill prevention and cleanup methods. Any party that is responsible for a vessel, offshore facility, or deepwater 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 (33 U.S.C. § 1321[d]). 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 established the Interagency Coordinating Committee on Oil Pollution Research, whose purpose is to research and develop plans for natural resource restoration and oil spill prevention.

- In response to growing harmful algal bloom (HAB) and hypoxia problems, Congress passed the **Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA)** of 1998 (P.L. 105-383). This statute formed the Interagency Task Force on Harmful Algal Blooms and Hypoxia. The task force was instructed to compose a national assessment on the ecological and economic impacts of HABs, the same type of assessment for hypoxia, and a separate assessment for hypoxia in the Gulf of Mexico. These assessments include recommendations for mitigation and detail the socioeconomic consequences of such solutions. The act appropriates a certain amount of funds to the Secretary of Commerce to use for the education, research, and monitoring needed to carry out the act's directives. In 2000, the National Science and Technology Council Committee on Environment and Natural Resources released its *National Assessment of Harmful Algal Blooms in U.S. Waters* (Luttenberg et al. 2000). The HABHRCA was reauthorized in 2004 with new mandates for research and vertical integration of management efforts.[8]

1.3.2 Executive Orders

- **EO 12114 on Environmental Effects Abroad of Major Federal Actions** (44 Federal Register [FR] 1957) was issued in 1979 to further environmental objectives consistent with U.S. foreign and national security policies by extending the principles of the NEPA to the international stage. Under EO 12114, federal agencies that engage in major actions with the potential to significantly affect the environment outside of U.S. jurisdiction (i.e., not on or in U.S. territorial soil or waters) must prepare or consult appropriate documents to determine the effect(s) such actions may have on the environment. These documents may include an EIS, an overseas EIS, relevant bilateral or multilateral environmental studies in which the U.S. is a participant, environmental assessments (EAs), summary environmental analyses, or any other document relevant to the issue at hand. The type of document that must be consulted or prepared is dependent upon where the major federal action is set to take

place (i.e. on the global commons or within the boundaries of a foreign nation). 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 and foreign environments.

- **EO 11990 on Protection of Wetlands** (42 FR 26961) was issued in 1977 in furtherance of NEPA. The order aims to mitigate both short and long-term effects on wetlands resulting from destruction or modification and to limit new construction in wetlands. Federal agencies are ordered to preserve wetlands, take specific action to minimize impacts to them and to avoid new construction where there is a practicable alternative. In taking action to minimize destruction and degradation of wetlands, agencies are ordered to consider relevant socioeconomic and ecologic factors. Pursuant to this order, the federal government implemented its policy of "no net loss" of wetlands.

- **EO 12962 on Recreational Fisheries** (60 FR 30769) was issued 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.[9]

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

- **EO 13158 on Marine Protected Areas (MPAs)** (65 FR 34909) of 2000 is a furtherance of EO 13089. It creates the framework for a national system of MPAs. 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." This EO strengthens 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 timeline and in-depth discussion on the process of redefining MPAs are included in **Chapter 6**.

- **EO 13112 on Invasive Species** (64 FR 6183) was issued in 1999 to help prevent the introduction of invasive species, both terrestrial and aquatic, into the U.S. as well as to address the economic, ecological, and human health problems posed by invasive species. EO 13112 builds upon the goals

set forth in the National Invasive Species Act of 1996 but does not affect the obligation of the DoD to manage its seagoing vessels as mandated in 16 U.S.C. § 4713. When practicable, federal agencies are ordered to avoid actions which may introduce or spread invasive species, to mitigate the effects of invasive species and to restore native species and habitats. In addition, this EO establishes a National Invasive Species Council (NISC) that is directed to encourage planning and management, to make recommendations, and to facilitate communication on the problem of invasive species. The council was also ordered to produce a *National Invasive Species Management Plan*, the final draft of which was issued in 2001 (NISC 2001).

- **EO 13186 on the Responsibilities of Federal Agencies to Protect Migratory Birds** (66 FR 3853) was issued in 2001 to support the efforts of the MBTA and other acts. The order directs executive departments and agencies that detrimentally affect migratory birds to increase their protection of these birds. Each department or agency must develop and implement a Memorandum of Understanding (MOU) through USFWS. The MOU must incorporate a variety of efforts set out in the order that promote the conservation of migratory bird populations. These efforts include restoring migratory bird habitats and preventing pollution in environments important to migratory birds. The departments and agencies have two years to implement their MOUs, but the order encourages them to implement the order's policies immediately. Such practices can be implemented through activities already established or incorporated into new plans. The order also formed the Interagency Council for the Conservation of Migratory Birds, which administers the order.

1.3.3 State Legislation/Agreements

- The Chesapeake Bay Agreement—In the late 1970s and early 1980s, the U.S. Congress funded research in the Chesapeake Bay designed to address toxic pollution, nutrient over-enrichment, and decreasing abundance of seagrasses. In 1983, the governors of Maryland, Virginia and Pennsylvania; the mayor of the District of Columbia; and the U.S. EPA signed The Chesapeake Bay Agreement of 1983. In 1987, the agreement was extended with the efforts to reduce nitrogen and phosphorus inputs to the Chesapeake Bay by 40% by the year 2000. In 1992, the signing partners agreed to extend the 40% reduction goal beyond 2000 and to address upland nutrient sources in the tributaries of the Chesapeake Bay. In June 2000, the "Chesapeake 2000" agreement was adopted. This agreement was established to guide watershed restoration activities throughout the region through the year 2010. In addition, the Chesapeake 2000 agreement provided additional opportunities for Delaware, New York, and West Virginia to become more involved in the regional partnership. These newly added states are working to decrease the input of nutrients and sediment to the Chesapeake Bay.

1.4 DEPARTMENT OF DEFENSE ENVIRONMENTAL COMPLIANCE

1.4.1 At-Sea Compliance

Chapter 22—Environmental Compliance Afloat—of the U.S. Navy's *Environmental and Natural Resources Program Manual* (OPNAVINST 5090.1C) applies to U.S. Navy ships and floating drydocks worldwide and, as appropriate, to the boats and other craft carried by these ships (DoN 2007). Chapter 22 lays out Navy policy for environmental stewardship and compliance for its vessels operating both within U.S. waters and abroad. The discharge of waste, including blackwater, graywater, hazardous and medical wastes, plastics and other trash, as well as procedures for oil spill response and ballast water control are included in this chapter along with relevant regulatory drivers. The U.S. Navy is required to comply with U.S. federal policy when operating within U.S. waters or on the high seas. This includes abiding by relevant international agreements to which the U.S. is a signatory or conforming to international agreements if it is the practice of the U.S regardless of whether the U.S. has officially ratified the agreement. The Navy is required to assess the impacts of its actions both within U.S. waters and abroad per the mandates of the NEPA and EO 12114. It is the policy of the Navy to provide for national defense in a manner consistent with federal environmental policy and to utilize the systematic approach of the NEPA as an effective decision-making tool. To this end, NEPA processes are integrated with U.S. Navy and U.S. Marine Corps (USMC) actions as early as possible to protect, enhance, and restore

environmental quality within a framework consistent with the mission of the Navy, stated national policy and security requirements.

Due to the protection afforded marine mammals by the MMPA, Navy vessels are prohibited from deliberately harassing a marine mammal. Per Navy policy, vessels must report all instances of shipstrikes (i.e., the collision between a vessel and a marine mammal for any reason) to the Chief of Naval Operations (CNO). Navy policy also mandates that those in authority plan and act to protect marine mammals during operations (DoN 2007). The Navy employs monitoring and mitigation activities during its operations to guard against adverse effects to marine mammals; these activities do not cease upon invocation of a military readiness exemption.

1.4.2 Federal Agency Exemptions

Federal agencies are required to comply with environmental legislation; however, there are provisions within several major federal resource laws for the exemption of certain DoD lands or activities if such exemption is necessary for national security. These exemptions come either from wording in the original legislation or from amendments and are related primarily to protected species laws. Military readiness exemptions most relevant to the marine environment are authorized by the **National Defense Authorization Act for Fiscal Year 2004 (NDAA)** (P.L. 108-136). The NDAA includes specific exemptions from the MMPA and the ESA for DoD lands and activities.

The MMPA affords protection to all marine mammals as defined in 16 U.S.C. § 1372(6), prohibiting the take of marine mammals by any person or vessel under U.S. jurisdiction. The MMPA allows for the issuance of incidental take permits for both levels of harassment defined in Section 1372(6)(A-D). The NDAA modified these definitions for actions involving military readiness. The NDAA also empowers the Secretary of Defense (SECDEF) to exempt actions involving military readiness from compliance with the MMPA when the SECDEF determines an exemption necessary for national security. The exemption can apply to a single action or to a group of actions, and may be applied to the same action more than once. The duration of a military readiness exemption from the MMPA is determined by the SECDEF, but cannot be longer than two years. The SECDEF must submit the details of and reasons for the exemption to the House and Senate Armed Services Committees within 30 days of the issuance of an exemption. The NDAA also strikes certain language in the MMPA in relation to take authorizations for military readiness activities such that there is no restriction on the geographic scope of the authorization. As of early 2008, the military readiness exemption from the requirements of the MMPA has been invoked twice – once for a period of 6 months and once for a period of two years.

Exemptions to the ESA for military activities exist in two forms. The first pertains to military lands and the designation of critical habitat as mandated by Section 4(3) of the ESA. The Sikes Act of 1960 and the Sikes Act Improvement Act of 1997 (see **Section 1.3.1.4**) mandate the development of INRMPs to provide for the conservation and rehabilitation of fish and wildlife resources on U.S. military installations. Section 318 of the NDAA allows an INRMP to substitute for critical habitat designation if that INRMP provides a “benefit” to the species. This “benefit” must be determined in writing by the Secretary of the Interior. Section 318 also orders the Secretary of the Interior to take into account the impacts on national security before making a critical habitat determination. Critical habitat exemptions for DoD lands and activities do not affect the obligation to comply with the NEPA or with interagency consultation required by Section 7 of the ESA.

The second type of exemption from the requirements of the ESA applies to federal agency actions related to national defense and is found in the language of the ESA. Section 7(j) of the ESA directs the Endangered Species Committee to exempt federal agency actions from Section 7 consultation if the SECDEF determines that an exemption is necessary for national security. Such an exemption, when granted, will not trigger the NEPA process except in certain situations. This clause has never been invoked.

Two other of the major pieces of environmental legislation that govern federal agency actions have an escape clause. Under certain circumstances, the President is authorized to exempt specific activities from

the federal consistency requirement of the CZMA if (s)he determines that the activities are in the paramount interest of the U.S. (16 U.S.C. § 1456[a][1][B]). Under the CEQ's implementing regulations for the NEPA, federal agency actions with significant environmental impact and occurring under "emergency circumstances" may proceed without NEPA review (40 C.F.R. § 1506.11).

1.5 METHODOLOGY

1.5.1 Literature and Data Search

Exhaustive and systematic searches for relevant scientific literature and data were conducted. All lines of evidence available through published and unpublished sources were considered. 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 (SARs), 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 Chesapeake Bay and vicinity. A large collection of research into the biological, chemical, physical, and socioeconomic resources of the Chesapeake Bay had previously been compiled. Some of this information had been previously collected for integration into previous Marine Resources Assessment for the Virginia Capes Operating Areas (DoN 2008).

Electronic literature searches were conducted using the Library of Congress' First Search and Dissertation Abstracts databases, SCOPUS, Ingenta, Web of Science, Blackwell-Science, and Cambridge Abstract's Aquatic Sciences and Fisheries Abstracts (ASFA) database services. In addition, general internet searches were conducted through the Google web search engine to identify additional reports not collected through the previous database searches. Prior experience has demonstrated that electronic searches produce a low number of false positive (references produced by a search that are not relevant) and false negative (references not produced by a search that are relevant) results when combinations of search keywords are used. Keywords for this report typically combined a subject matter (e.g., marine mammal, dolphin, whale, porpoise, sea turtle, fish, fishery, life history, dive sites, seagrass, oyster bed, artificial reef, marsh, marine protected area, marine reserve, estuary, climate, precipitation, sediment type, bottom substrate, circulation, phytoplankton, bloom, zooplankton, shipping lane, state legislation) paired with a geographic descriptor (e.g., Chesapeake Bay, Mobjack Bay, York River, James River, Elizabeth River, Virginia Beach). The results of these electronic searches were supplemented by investigating and acquiring the references gathered that, based on a reading of their titles or abstracts, appeared to provide relevant information for this narration. This process was continued until a majority of the relevant references cited by the introduction, results, and discussion sections of the gathered references had been obtained. Hand searches of published journals were not conducted.

Results of these searches were indexed using commercial bibliographic software for ease of recall for inclusion in the document. From each document obtained, information relevant to the distribution and abundance of marine resources for the lower expanses of the Chesapeake Bay were extracted and integrated into the narrative of relevant sections.

Digital data sources were obtained by searching the digital databases available through Ocean Biogeographic Information System (OBIS), U.S. Geological Survey (USGS), Mid-Atlantic Fishery Management Council (MAFMC), NOAA-Coastal Services Center, 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, FishBase, College of William and Mary (including the Virginia Institute of Marine Science [VIMS]), and the Chesapeake Bay Program. When unavailable through the internet, individual scientists or organizations were contacted to obtain electronic data sets for inclusion in the report (e.g., Virginia Aquarium and Marine Science Center, the Virginia Marine Resource Commission, and the Nature Conservancy). For this report, additional data points for the sightings of marine mammals and sea turtles were also entered

into the database manually from published literature in which a species identification, date, latitude, and longitude were provided.

1.5.2 Spatial Data Representation—Geographic Information System

The geographical representation of marine resource occurrences in the Chesapeake Bay 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 Chesapeake Bay. For this project, Environmental Systems Research Institute, Inc.'s (ESRI's) ArcView® (versions 9.1, 9.2, and 9.3) 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 Chesapeake Bay 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 Chesapeake Bay 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 (GMI = Geo-Marine, Inc.). For example, the field that was added to the main dataset to indicate the origin (source) of the data is indicated by the field name "GMI_source."

GIS data are displayed as layers for which scale, extent, and display characteristics can be specified. Multiple themes are represented on an individual map figure. 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.

1.5.2.1 Physical Environment Maps

Sea Surface Temperature (SST)—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). Seasons were defined with the same monthly derivations used throughout the MRA report (winter: 22 December through 19 March, spring: 20 March through 19 June, summer: 20 June through 21 September, fall: 22 September through 21 December). 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 (PODAAC 2004).

Data for the Chesapeake Bay Study Area 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:

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

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).

Chlorophyll a (Chl a) Concentrations—Seasonal averages of chl *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 Chesapeake Bay Study Area (NASA 2005a). Pixel data for the Study Area from 1997 to 2005 were extracted and converted to chlorophyll *a* values using MATLAB® and the following function:

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

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 chl *a* concentrations increasing from blue to red.

1.5.2.2 Biological Resource Maps—Species of Concern

Marine mammal and sea turtle occurrence data were accumulated from every available source; however, it was impossible to obtain every data source in existence for the Chesapeake Bay Study Area. An overview of known marine mammal and sea turtle data sources for the Chesapeake Bay is found in **Appendix A-3**. Marine mammal and sea turtle data that were provided for use in this MRA are listed in **Table A-1** and are displayed in **Figures 3-3**, **3-5**, **3-6**, **3-7**, **3-9**, and **3-10** through **3-23**. The data described in **Table A-1** include occurrence data from aerial and shipboard (sighting) surveys, stranding records, incidental fisheries bycatch records, and other sources (e.g., opportunistic sighting programs and species occurrence databases). Sighting, stranding, and bycatch records available from the scientific literature or through personal communications with regional experts were also used in this MRA.

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

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

In conjunction with regional experts and hired subcontractors, sea turtle areas of occurrence were defined and then drawn for each species known to occur in the Chesapeake Bay Study Area. The areas of occurrence are based upon expert opinion (i.e., many years of survey experience in the area); known habitat associations and distribution patterns of the animals; and the available sighting, stranding, bycatch, and nesting data. The following occurrence information may be displayed on each sea turtle species map: areas of **primary occurrence** (areas and habitats where a species is primarily found), areas of **secondary occurrence** (areas and habitats where a species may be found, especially during anomalous environmental conditions or seasonal migrations), and areas of **rare occurrence** (areas and habitats where a species is not expected to be found with any regularity). An underlying premise used during the map creation process was that a conservative approach to delineating the areas of occurrence for sea turtles was necessary since all five sea turtle species are listed as either threatened or endangered under the ESA. These maps are located in **Section 3.2**.

Areas of usage were designated for the bottlenose dolphin (*Tursiops truncatus*) which is considered the most common marine mammal occurring in the Chesapeake Bay Study Area. The areas depicted are as

follows: **high area usage** (includes important areas and habitats such as nursery areas), **moderate area usage** (areas utilized by some bottlenose dolphins), and **low area usage** (areas utilized by fewer bottlenose dolphins). These areas do not take into account any seasonality and area based on anecdotal observations by regional experts and stranding response efforts but not directed research. These maps are included in **Section 3.1**.

As a supplement to the above-mentioned maps, figures were also created to depict known movement patterns, critical habitats, and conservation zones for certain marine mammals that occur within the Chesapeake Bay Study Area. **Section 3.1** of this MRA includes migration maps for the humpback and North Atlantic right whales, which are summaries of the vast amount of data and information that have been collected on long distance movement patterns of these whale species in the North Atlantic Ocean.

Section 3.4 includes a map of the capture sites of shortnose sturgeon during the Atlantic Sturgeon Reward Program.

1.5.2.3 Habitats of Concern Maps

Multiple sources of data and information were used in the creation of maps for the estuarine and coastal habitats located in the Chesapeake Bay Study Area and vicinity. The maps displaying wetlands and marshes, tidal flats, submerged aquatic vegetation, and shipwrecks and artificial reefs (see **Chapter 4.0**) are all examples of multiple data sources used in the creation of a single map. These maps were created using scanned images, coordinate data, GIS shapefiles, and other information available in the scientific literature and technical reports.

1.5.2.4 Biological Resource Maps—Essential Fish Habitat

Maps displaying the EFH for all lifestages of temperate, sub-tropical, and highly migratory species found within the Chesapeake Bay Study Area were created from official FMP maps or habitat descriptions produced by the NMFS and the regional FMCs (New England, Mid-Atlantic, or South Atlantic). The EFH designations of estuaries and embayments were based on the NOAA Estuarine Living Marine Resources (ELMR) program (Jury et al. 1994; Stone et al. 1994). Complete EFH/HAPC designation descriptions and maps are provided along with the text in **Chapter 5 – Fish and Fisheries**.

All of the EFH data were not available in a usable electronic format. As a result, the locations of EFH were determined by developing polygons based on jurisdictional limits or encompassing known temperature/salinity ranges, physical habitats, or bathymetric ranges occupied by each species or lifestage. Some of this data were only available as graphical representations or “source maps.” These data were scanned, imported into ArcView, and geo-referenced after which significant information was digitized into a shapefile format. Materials acquired as Adobe PDF files were also treated as scanned source maps (i.e., they were geo-referenced and pertinent information was digitized), since they were already in a digital form.

The source type and associated references for all EFH data presented in the map figures are listed in the caption of each figure. The full reference citations for map source data or information may be found in the Literature Cited section of **Chapter 5**. The primary type of spatial information used in preparing the EFH figures were scanned maps which are less reliable than numerical or authentic data.

1.5.2.5 Additional Considerations Maps

Information regarding the locations of commercially navigable waterways/shipping lanes, SCUBA diving sites, and research stations in the Chesapeake Bay Study Area was gathered from a wide array of sources. The map displaying the major commercial shipping lanes in the Chesapeake Bay was created from data available at U.S. government agency websites (**Figure 6-1**). Due to low visibility, the Chesapeake Bay has a limited number of popular SCUBA diving sites. Therefore, these sites were not depicted in **Chapter 6**. The geographical locations of major research stations and buoys in the

Chesapeake Bay were acquired from Chesapeake Bay Observation System (CBOS) and NOAA (**Figure 6-2**).

1.5.2.6 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 extensible markup language (XML) format, so the same metadata can be viewed in many different ways using different styles. Metadata created to accompany this MRA report are provided in both XML and hypertext markup language (HTML) formats, so that the metadata can be viewed in many types of viewers and are accessible within the GIS environment by other users.

1.5.3 Limitations of Marine Sighting Survey Data

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 undersample (underestimate) the total number of sea turtles in a given area by as much as an order of magnitude (Shoop and Kenney 1992; Renaud and Carpenter 1994). While scientists have devised mathematical formulas to account for animals not observed at the surface, the diving behavior may vary even within the same species. Even though marine mammals and sea turtles are obligated to breathe at the surface, many individuals will not surface within an observer's field of view. This is of particular concern when attempting to sight species that dive for extended periods of time, do not possess a dorsal fin, or are known to exhibit cryptic behavior, such as beaked whales, *Kogia* species (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 do not provide adequate information for scientists to accurately describe the seasonal occurrence of marine mammals and sea turtles in expansive areas, such as the Atlantic Ocean. Marine mammal and sea turtle occurrences in an area often change seasonally in response to changes in water temperature, the movement and availability of prey, or in response to aspects of individual life history (e.g., 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.

1.5.4 Limitations 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.

1.6 REPORT ORGANIZATION

This report consists of seven major chapters and four associated appendices.

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

- **Chapter 2—Physical Environment** describes the physical environment of the Chesapeake Bay, 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** covers all protected species, including marine mammals, sea turtles, and fish. For these species, detailed narratives of their morphology, status, habitat preferences, distribution, behavior, life history, and acoustics and hearing (if known) have been provided.

- **Chapter 4—Habitats of Concern** describes coastal wetlands, non-vegetated tidal flats, submerged aquatic vegetation, oyster reefs, artificial habitats, and MPAs occurring in the Chesapeake Bay.

- **Chapter 5—Fishes and Fisheries** investigates fishes, EFH, and fishing activities (commercial and recreational) that occur within the Chesapeake Bay.

- **Chapter 6—Additional Considerations** navigable waterways and commercial shipping lanes, SCUBA diving sites, and research institutions and organizations in the vicinity of the Chesapeake Bay.

- **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**

- **Chapter 9—Glossary**

- **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;

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

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2.0 PHYSICAL ENVIRONMENT OF THE CHESAPEAKE BAY

2.1 INTRODUCTION

The Chesapeake Bay is a large, elongated estuary located along the mid-Atlantic coastal region of the U.S., and is the largest estuarine system in the U.S. (Langland and Cronin 2003; Reshetiloff 2004; Kemp et al. 2005). The Chesapeake Bay spans almost 300 km in length, with a relatively deep (20 to 30 m) and narrow (1 km) channel down the axis (**Figures 2-1** and **2-2**) (Kemp et al. 2005). The width of the Chesapeake Bay varies from 5.5 km near Aberdeen, Maryland, to 56.3 km at its widest point at the mouth of the Potomac River. Including the broad shallow areas that flank each side of the long central channel, the surface of the Chesapeake Bay covers over 11,500 km^2 (Kemp et al. 2005).

2.2 CLIMATE AND WEATHER

The climate in the Chesapeake Bay is influenced by several factors including prevailing winds, warm Gulf Stream waters of the Atlantic coastline, 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 Chesapeake Bay. 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 the 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.[1] 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]) 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) and drier weather conditions in the region (Adams et al. 1993)[1].

Overall, the climate of the Chesapeake Bay region can be described as moderate. A long-term record of atmospheric and oceanographic conditions at several sites within the region is available from oceanographic buoys maintained by NOAA's National Data Buoy Center (NDBC).[2] Average temperature for the region is 14 degrees (°) Celsius (C), with wide variability along the north to south axis of the Chesapeake Bay (Marshall et al. 2005). Air temperature measured in the northerly region of the Chesapeake Bay averaged 24.0°C in August and 4.0°C in February over a eight-year period.[3] 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.[4] The large differences in average summertime and wintertime temperatures for the southern and northern ends of the Chesapeake Bay is partially a result of the warm Gulf Stream waters that flow off the coastline of North Carolina, influencing the climatic regime of the lower part of the bay; the separation of the Gulf Stream from the coast does not allow these waters to temper the climate in the more northern reaches of the Chesapeake Bay; however, most of the difference is more than likely due to the cooler flow of freshwater coming into the northern half of the Chesapeake Bay from the rivers.

Precipitation also varies significantly between the northern and southern halves of the Chesapeake Bay. Total annual precipitation averaged 108 centimeters (cm) from 1948 through 2005 near the northern boundary of the Chesapeake Bay (Aberdeen, Maryland) (Marshall et al. 2005)[5]. Near the mouth of the Chesapeake Bay (Norfolk, Virginia), total precipitation averaged 115 cm during the same time period.[6] Precipitation in the form of snow or freezing rain occurs more frequently in the north and can be attributed in part to the warm, moist air transported by the Gulf Stream.

Weather systems pass rapidly through the southeastern U.S. approximately every two to five days throughout the year, and their effects are superimposed on the seasonal cycling of the Bermuda Azores

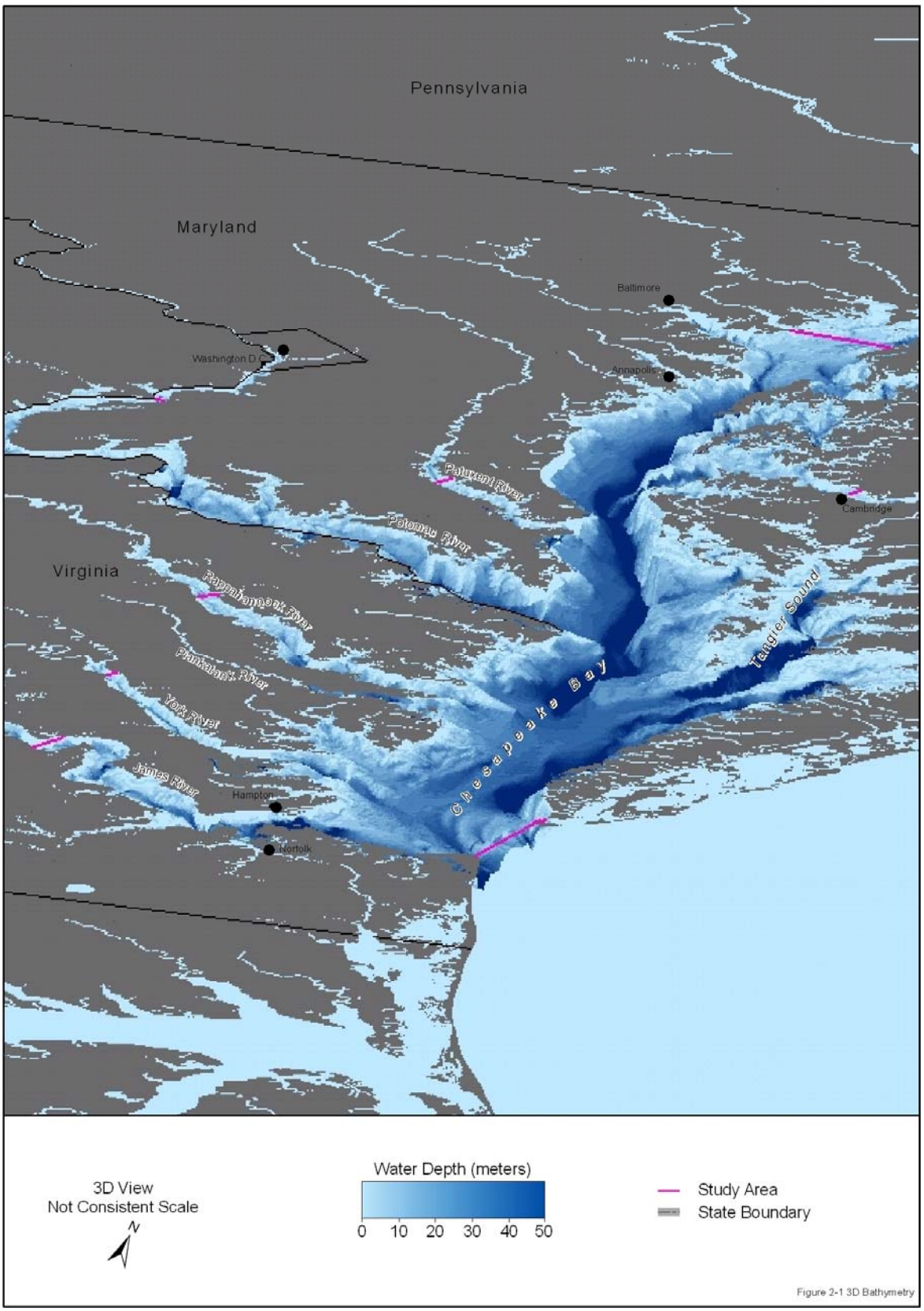

Figure 2-1. Three-dimensional depiction of the bathymetry in the vicinity of the Chesapeake Bay Study Area. Source data: NASA (2005) and NOAA (2006).

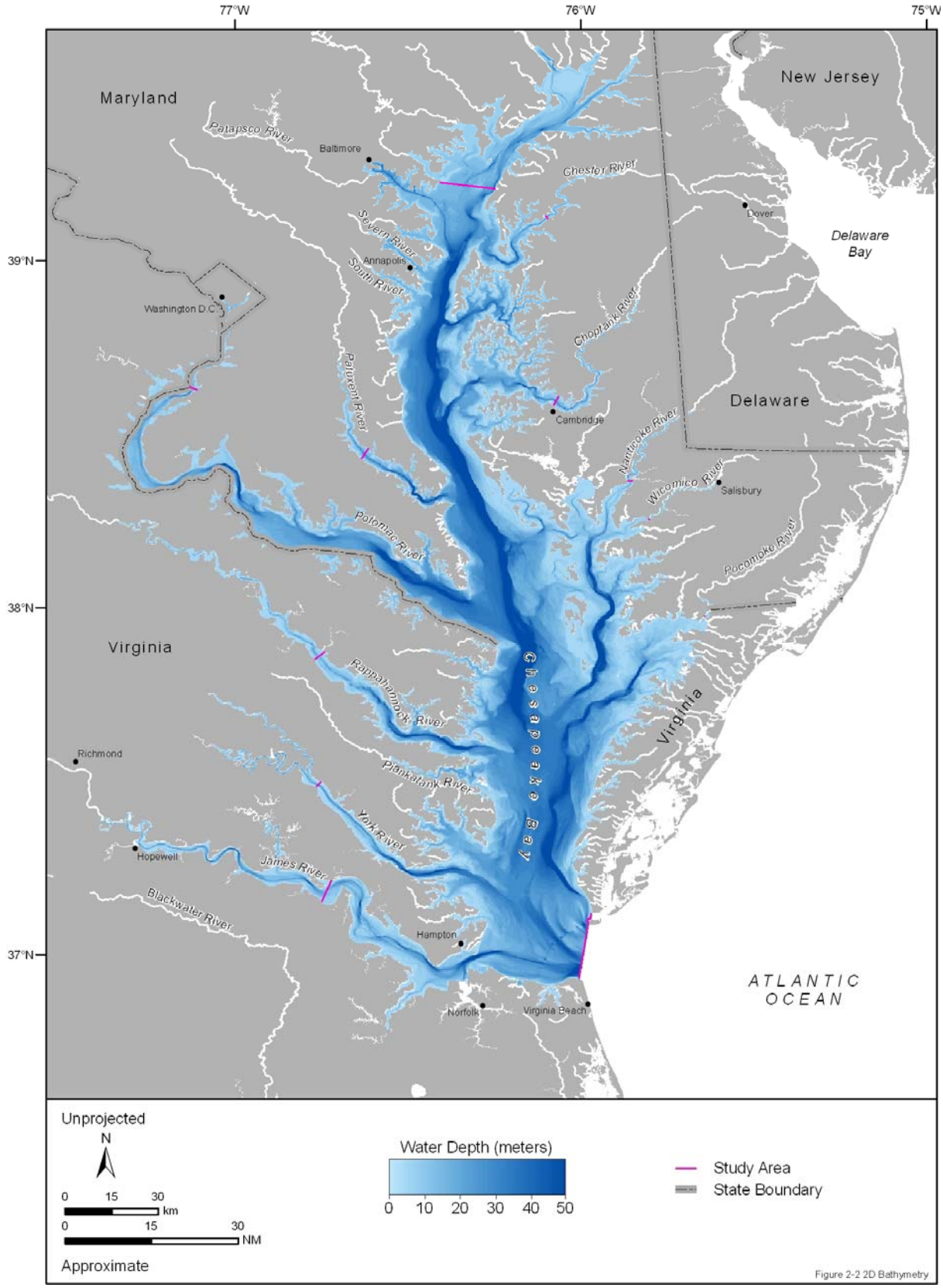

Figure 2-2. Two-dimensional depiction of the bathymetry in the vicinity of the Chesapeake Bay Study Area. Source data: NASA (2005) and NOAA (2006).

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 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). 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).[7] 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.[8] Hurricanes Carol and Emily made landfall in North Carolina just north of Cape Hatteras. Even though the coastline adjacent to the Chesapeake Bay has experienced only two hurricane first landfalls over the past 55 years, a number of powerful tropical storms and hurricanes have passed through the region, including, most recently, hurricanes Isabel (2003), Alex (2004), and Ophelia (2005).[9] 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.[10]

The strength and number of named storms (including hurricanes) developing in the North Atlantic and potentially impacting coastal regions of the U.S. 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.[11,12] 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).[12]

2.3 MARINE GEOLOGY

2.3.1 Geologic Setting

Approximately one million years ago, the region that now encompasses the Chesapeake Bay was alternatively submerged and exposed as glaciers advanced and retreated across the continent of North America. Sea levels rose and fell as these massive glaciers melted and re-froze. The most recent retreat occurred approximately 18,000 years ago, resulting in the formation of the current Chesapeake Bay. Rising sea level from the melting glaciers reached the mouth of the Chesapeake Bay approximately 10,000 years ago. The Chesapeake Bay reached its current dimensions approximately 3,000 years ago (Reshetiloff 2004).

2.3.2 Physiography and Bathymetry

The Chesapeake Bay occupies an area of approximately 11,500 km^2 (**Figures 2-1** and **2-2**). Despite its size, the Chesapeake Bay is relatively shallow with an average depth of only 4.5 m; depths exceeding 10 m constitute only 24% of the entire surface area (Hagy et al. 2004; Reshetiloff 2004). Overall, the Chesapeake Bay is shaped like a shallow tray with the exception of the large channel (believed to be remnants of the ancient Susquehanna River) that runs the entire length of the Chesapeake Bay. As the channel reaches the mouth of the Chesapeake Bay, it terminates into a shallow sill that can restrict deeper water flow into and out of the bay (Reshetiloff 2004; Kemp et al. 2005).

Fifty major tributaries empty into the Chesapeake Bay with 80 to 90% of the water draining from the western shore. These rivers drain a watershed that encompasses New York, Pennsylvania, Maryland, West Virginia, Virginia, Delaware, and the District of Columbia; in total the watershed covers an area of approximately 164,200 km^2 (**Figure 2-3**) (Kemp et al. 2005).

2.3.3 Bottom Substrate

Since the formation of the Chesapeake Bay, the shoreline has undergone consistent modification by coastal erosion, transport, and deposition of sediments. In this process, areas such as headlands and peninsulas are eroded and smoothed and the eroded materials are deposited in other parts of the Chesapeake Bay such as channels, along the margins, or carried up tributaries by the tides (Reshetiloff 2004).

A large proportion of the sediment entering the Chesapeake Bay is derived originally from erosion in the watershed; the erosion from upland land surfaces and erosion of stream banks comprise the two most important sources of sediment coming from the watershed (Langland and Cronin 2003). In addition, a large proportion of sediment also enters the Chesapeake Bay from oceanic input at the mouth of the bay and internal production of skeletal and organic material (Langland and Cronin 2003). Geographically, the Susquehanna River is the dominant source of sediment influx to the northern bay. In the central bay, the majority of sediment influx comes from shoreline erosion and biological processes. Influx from the ocean along with shoreline erosion is the dominant sediment sources in the southern portion of the Chesapeake Bay. This shift in sources results in a pattern of silty, more terrestrial and river derived sediments on the seafloor of the northern and western regions of the Chesapeake Bay, while sandy coastal sediments make up the majority of the sediments in the southern and eastern expanses (Langland and Cronin 2003) (**Figure 2-4**).[15]

2.4 HYDROGRAPHY

Hydrography is the scientific study of the measurement and description of oceanic physical features. The following sections describe in detail the temperature of water at the sea surface, the extent of hypoxia on the sea bottom, and the distribution of salinity, all within the Chesapeake Bay. The hydrography of the Chesapeake Bay is one of the important features influencing the health of the ecosystem.

As an estuary, the Chesapeake Bay has an extremely narrow opening in comparison to its overall length. This results in poor mixing due to limited tidal flow within the Chesapeake Bay, resulting in extreme stratification of the water column, which in turn influences temperature, salinity, and hypoxia.

2.4.1 Water Quality

A region's water quality is often assessed to determine the chemical, physical, and biological characteristics of water with respect to its suitability for a particular use. The water quality of the Chesapeake Bay is a critical issue to maintaining the health and vitality of its living resources.

2.4.1.1 Pollution

In 2000, representatives from local states and the U.S. passed the Chesapeake 2000 agreement to "ensure the public's right to clean water and a healthy and productive resource" (CBP 2000). Water quality was one of many issues addressed in the agreement. The states sought to, "Achieve and maintain the water quality necessary to support the aquatic living resources of the Chesapeake Bay and its tributaries and to protect human health" by reducing nutrient and sediment loading, reducing or eliminating the input of chemical contaminants from all controllable sources, reducing the input of pesticides to the bay, and reducing pollution (CBP 2000).

Each year the health of the Chesapeake Bay (its tributaries, habitats, and the living resources that occur in the Chesapeake Bay), is given a score by the Chesapeake Bay Foundation. For 2007, water quality received an overall score of 'F' (which equals 'Failing') with all parameters scored (including nutrient

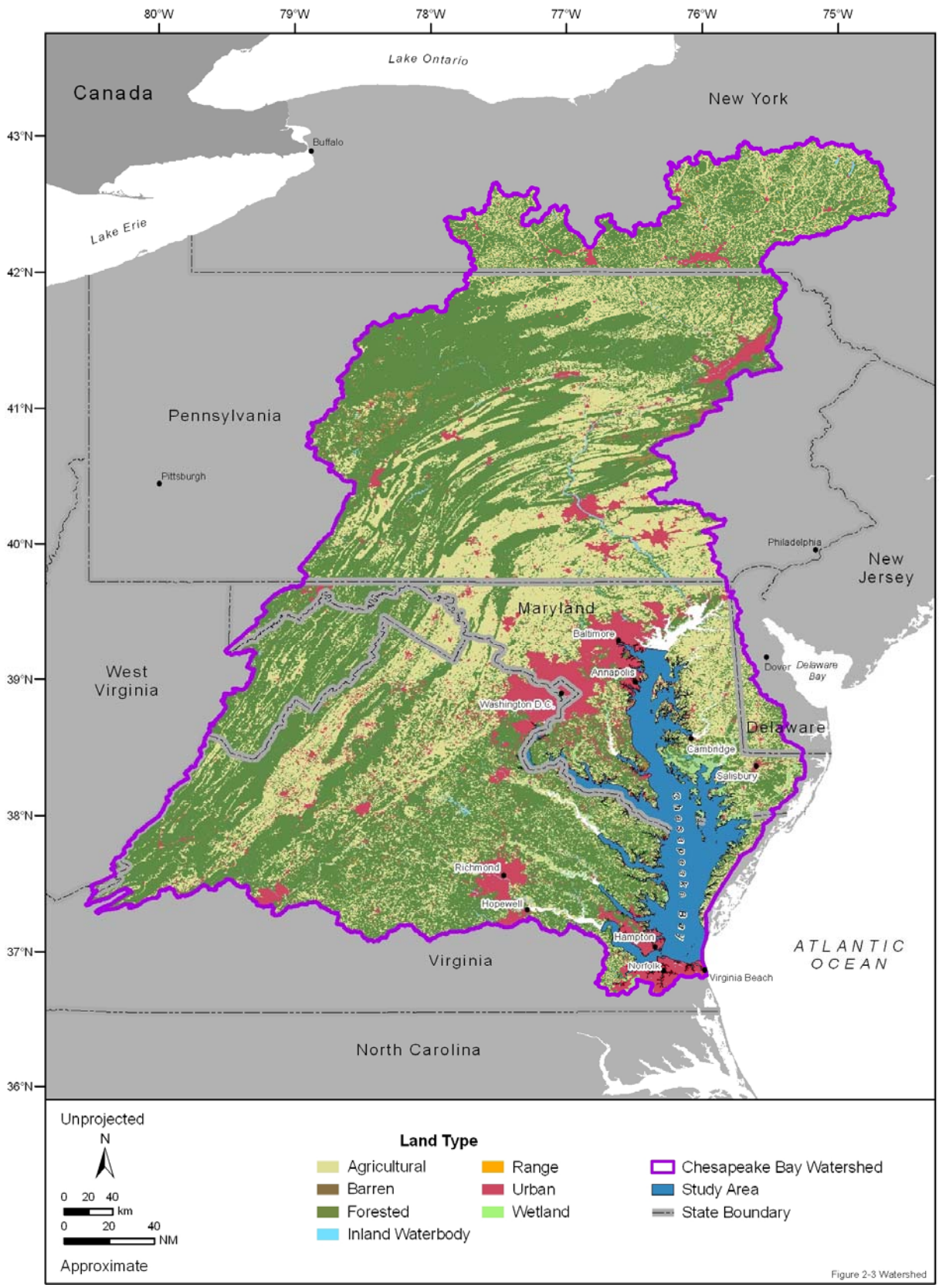

Figure 2-3. Watershed of the Chesapeake Bay and Land Cover Class for those regions. Source data: NOAA (2007) and CBP (2008).

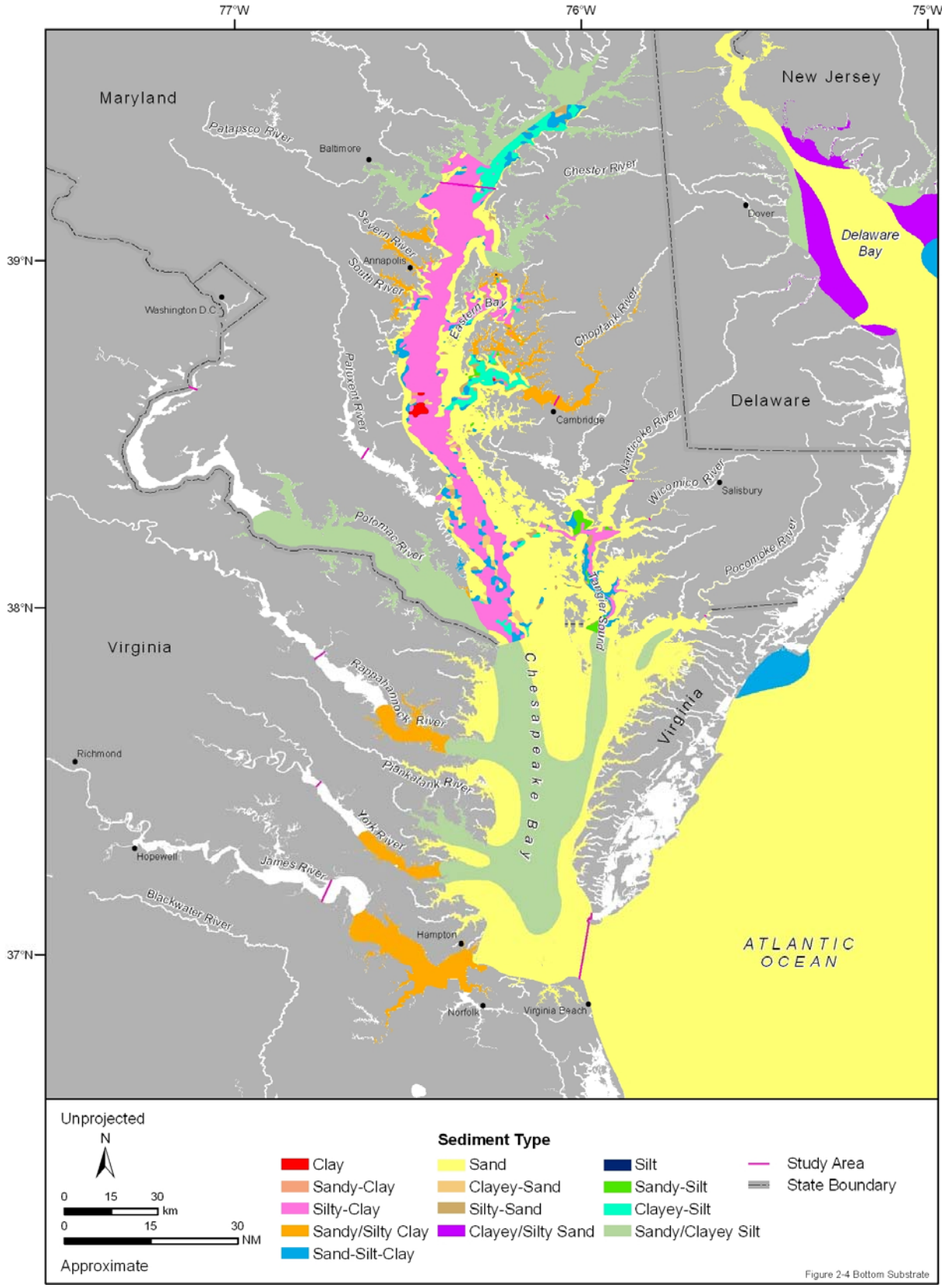

Figure 2-4. Seafloor sediment types occurring in the vicinity of the Chesapeake Bay Study Area. Source data: USGS (2000) and MGS (2004).

loading, water clarity, toxins, and dissolved oxygen) receiving no change or decreased scores from 2006, indicating that water quality remains a critical issue for the Chesapeake Bay. Also for 2007, a level of 21% progress in meeting the Chesapeake 2000 agreement goals was reached, down from 23% progress in 2006 (CBF 2007).

2.4.1.2 Hypoxia

The depletion of dissolved oxygen (DO) from deep waters is a common feature in estuaries and other coastal systems where seasonal or permanent stratification of the water column restricts aeration of bottom waters by the atmosphere (e.g., Chesapeake Bay, (Officer et al. 1984) Black Sea,(Zaitsev 1992); Baltic Sea, (de Jonge et al. 1994); Long Island Sound, (Welsh et al. 1994); Gulf of Mexico, (Rabalais et al. 1991; Rabalais 2001; Rabalais et al. 2002). Hypoxia occurs when concentrations of DO become so low that they begin to harm biota or adversely affect a region's ecology (Hagy et al. 2004).

A continuous spectrum of effects has been observed as DO declines from just below saturation to anoxic conditions (complete absence of DO). Behavioral and physiological responses can occur with moderate depression of DO, resulting in detrimental effects on individuals and populations (Breitburg et al. 1997; Breitburg 2002).

Annual extent of the hypoxia in the Chesapeake Bay is correlated to riverine input and nutrient loading (Boicourt 1992; Hagy et al. 2004). The timing and spatial extent of hypoxia are relatively predictable in the southern Chesapeake Bay (Kuo and Nielson 1987). Hypoxic conditions occur in the York River in the summer months but tend to dissipate in the fall; hypoxic conditions rarely develop in the James River. Moderate hypoxia (DO <2 milligrams per liter [mg/L]) to anoxia presently affects much to all of the deeper waters (encompassing 20.8 x 10^{18} cubic meters [m^3]) in the central third of the Chesapeake Bay for most or all of the summer (**Figure 2-5**) (Newcombe et al. 1939; Officer et al. 1984; Hagy et al. 2004); normal conditions tend to return to this region in September or October when stratification begins to break down and oxygen is reintroduced to these waters (Officer et al. 1984). Wind and tides in the Chesapeake Bay can bring hypoxic waters into shallow areas or to the surface in the mesohaline part of the bay (Breitburg 1990) often resulting in fish kills (Breitburg 2002) and degraded benthic communities (Hagy et al. 2004).

2.4.2 Sea Surface Temperature

Due to its relatively shallow bathymetric profile, the Chesapeake Bay is much more sensitive to temperature fluctuations than offshore regions (Reshetiloff 2004). As a result, the SST undergoes dramatic fluctuations throughout the year (1.1 to 28.9°C) (**Figure 2-6**). Despite this wide range, changes in SST are relatively predictable. During spring and summer, surface and shallow shoal waters warm, creating a two-layer stratified system with colder waters lying closer to the bottom. Localized weather events, strong winds, and cooling of the air during autumn and winter can help break down this stratification (Reshetiloff 2004).

2.4.3 Salinity

Salinity is one of the primary factors influencing the physical make up of the Chesapeake Bay. Along its north–south axis, salinity ranges between tidal freshwater inputs (salinity <0.5 practical salinity units [psu]) in the upstream regions of tributaries to polyhaline (salinity >18 psu) conditions near the mouth of the Chesapeake Bay (**Figure 2-7**) (Marshall et al. 2005). In addition, as the majority of freshwater enters the Chesapeake Bay from tributaries located on the western shores, isohalines (i.e., salinity contours) tend to show a southwest to northeast tilt (Reshetiloff 2004). This gradient is strongest during the spring season when input of fresh river water is at its maximum and decreases throughout the remainder of the year when the inflow of saltwater from the Atlantic Ocean is predominant. In addition to inflow, the rotation of the earth also helps to maintain the southwest to northeast salinity gradients; Coriolis Force deflects incoming seawater to the eastern shores of the Chesapeake Bay while discharged river water is pushed to the western shores (**Figure 2-7**) (Reshetiloff 2004).

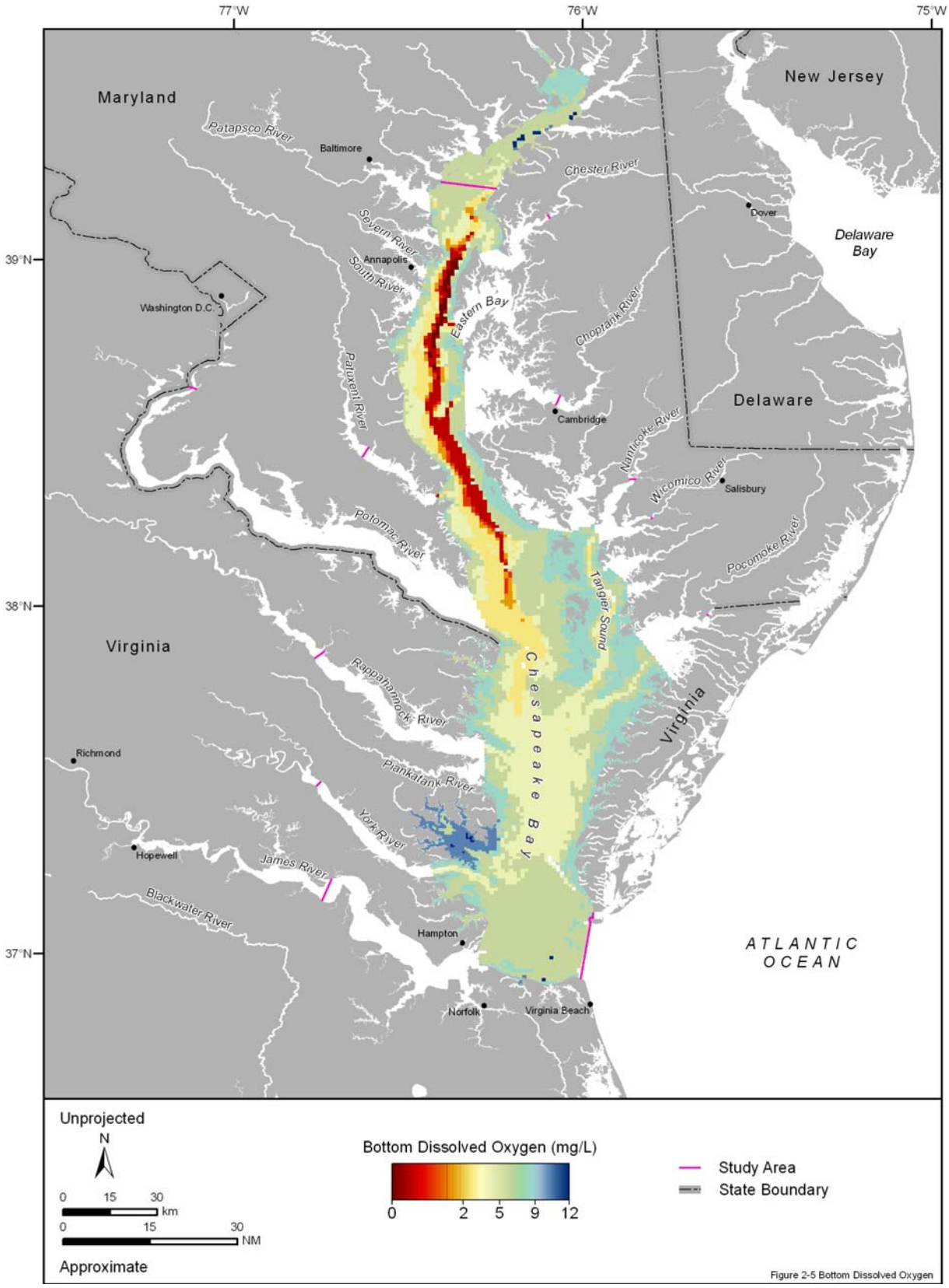

Figure 2-5. Sea bottom dissolved oxygen content in the Chesapeake Bay in 2007. Source data: CBP (2007).

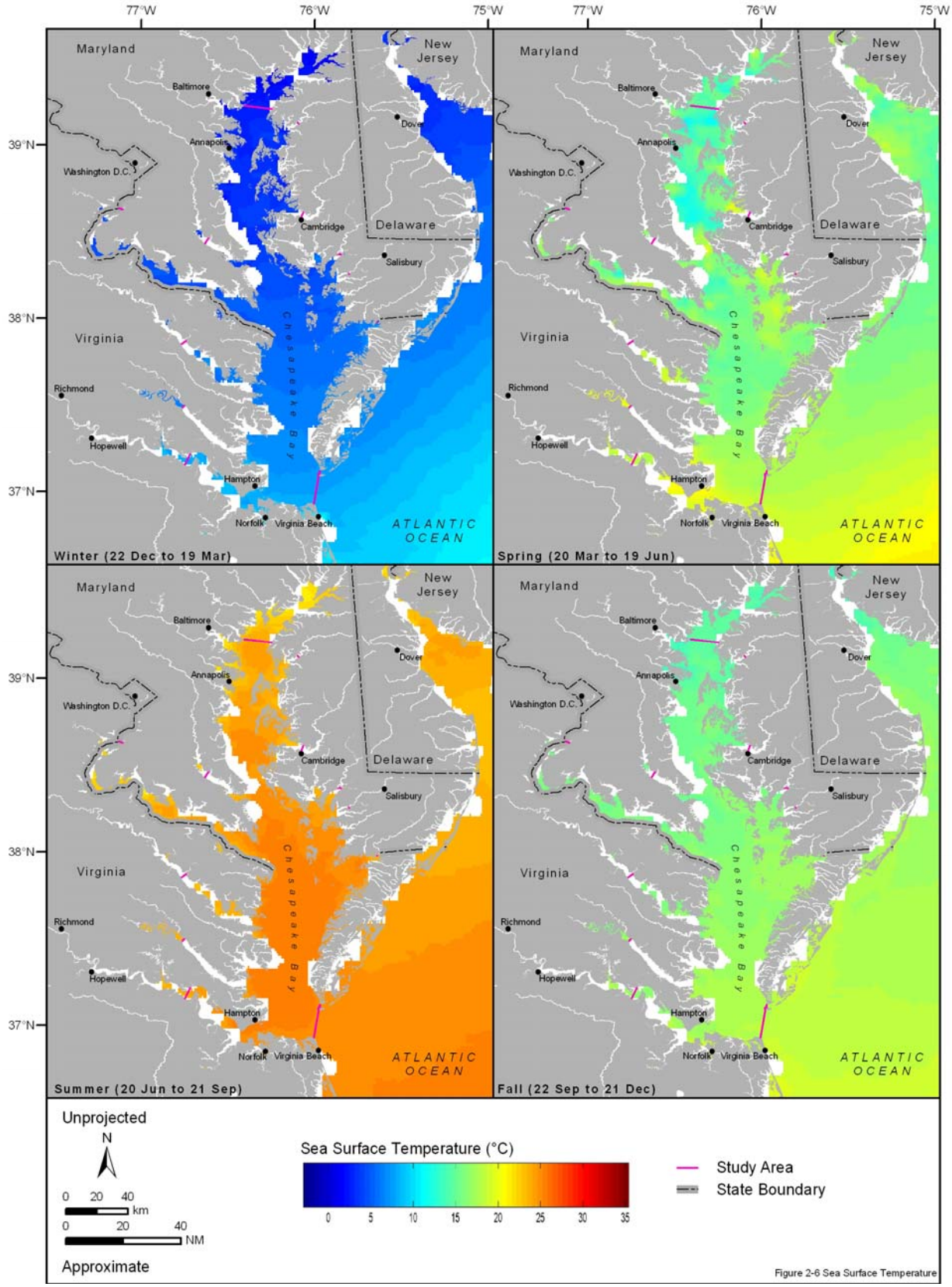

Figure 2-6. Mean seasonal sea surface temperature (SST) occurring in the vicinity of the Chesapeake Bay Study Area from 1985 through 2004. Source data: PODAAC (2004).

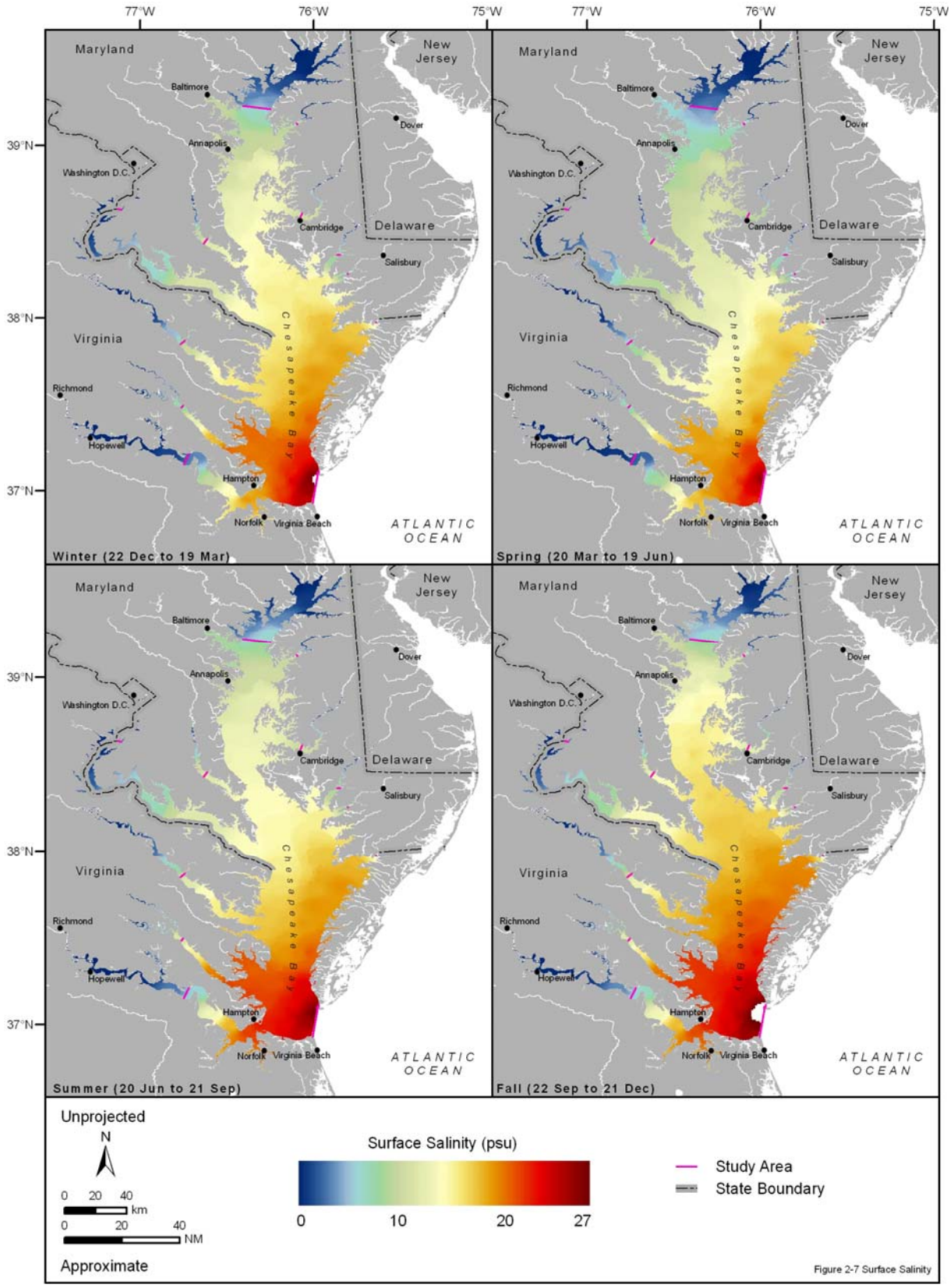

Figure 2-7. Mean seasonal surface salinity distribution occurring in the Chesapeake Bay. Source data: CBP (2008).

Salinity also displays a vertical gradient in the Chesapeake Bay. The upper waters tend to be less saline and are separated from saltier water at depth by a seasonally strong pycnocline. This is due to the net seaward surface flow of riverine water out the Chesapeake Bay and a net bottom flow of higher salinity ocean waters into it (Pritchard 1952).

2.5 PHYSICAL OCEANOGRAPHY

2.5.1 General Circulation

The Chesapeake Bay exhibits a classic estuarine circulation in which there occurs a net seaward motion in a surface layer and net landward flow in a bottom layer (e.g., Goodrich and Blumberg 1991; Li et al. 2005) and is driven primarily by the movements of freshwater from the northern reaches of the bay and the input of seawater from the Atlantic Ocean. An average of 2,300 cubic meters per second (m^3/s) of water flows into the Chesapeake Bay from the regional watershed; the Susquehanna River at the head of the Chesapeake Bay provides more than half of this flow (Kemp et al. 2005). Freshwater input from the rivers is less dense than the incoming seawater due to the lack of dissolved salts in the water. This results in a more buoyant layer of freshwater sitting atop a denser layer of saltwater restricting the vertical mixing of water masses in the Chesapeake Bay (Kemp et al. 2005). Vertical profiles of the water column confirm this fact by the presence of a strong pycnocline (i.e., salinity gradient) located at a depth of 4 to 8 m below the surface (Reshetiloff 2004).

River flow drives the estuarine circulation of the Chesapeake Bay while seawater entering the bay from the adjacent Atlantic Ocean at depth acts to retain particulate and dissolved materials within it. The two layer circulation results in relatively long residence times for water in the Chesapeake Bay (90 to 180 days) for freshwater and nutrients which can result in enhanced levels of eutrophication (or excessive nutrient concentration that can induce plant growth) (Kemp et al. 2005).

Weather can either remove or enhance the two-layer circulation occurring in the Chesapeake Bay. Strong winds and storms can mix the surface layer and the bottom layers and if strong enough, the flow of surface water can be reversed. These destratifications tend to be short-lived as a restratification of the water column is rapidly reestablished. Rotation of the earth results in a generalized counterclockwise flow of waters in the Chesapeake Bay. As seawater enters the Chesapeake Bay, the Coriolis Force pushes the incoming waters to the east while river waters flowing south are pushed to the west. A three-dimensional (3-D) model of fluid flow in the Chesapeake Bay has been developed and is being widely used to predict physical and biological occurrences there (Zhong and Li 2006).

2.5.2 Thermocline

The thermocline is located between the surface and deepwater circulation zones; it is a transition region where water temperatures change rapidly from warmer surface waters to colder deep waters. During warmer months the Chesapeake Bay is strongly stratified with a well developed thermocline. This thermocline is typically located in the Chesapeake Bay and its tributaries at a depth of 5 to 10 m (Ducklow 1982; Reshetiloff 2004). Cooling of surface waters as well as wind turbulence and storms can aid in the erosion of the thermocline, allowing nutrients from deeper waters to be mixed into the surface waters (Goodrich et al. 1987; Blumberg and Goodrich 1990; Reshetiloff 2004; Kemp et al. 2005; Li et al. 2006).

2.5.3 Tides

Tides are the most predictable oceanic motions; the gravitational pull of the moon (and to a lesser extent of the sun) creates "bulges" of water on opposite sides of the earth (Thurman 1997). Each region of the earth passes through these bulges twice a day, resulting in semi-diurnal (half daily) components to the tidal cycle. Furthermore, the moon and the sun do not generally lie over the equator; this displacement creates one tidal bulge larger than the other, thus leading to a diurnal (daily) component to the tides. The mean tidal range of the Chesapeake Bay ranges from 0.9 m at the bay’s entrance to 0.3 m at Annapolis, Maryland; the range then increases again to 0.7 m at the head of the Chesapeake Bay (Thurman 1997; Whitford 1999; Zhong and Li 2006) with a larger tidal amplitude on the eastern shore (e.g., Hicks 1964).

Additionally, the geomorphology of coastlines and bays affects the timing and range of tides in any given area. There is also a great deal of dissipation of tidal energy that mostly occurs in the Chesapeake Bay in four different areas; the Chesapeake Bay mouth region, the area close to the Rappahannock sill, the area near the Chesapeake Bay Bridge where constriction occurs, and the area north of Baltimore where constriction occurs (Zhong and Li 2006).

2.6 BIOLOGICAL OCEANOGRAPHY

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

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

2.6.1 Primary Production

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

Chlorophyll *a* is the principal pigment that enables phytoplankton to photosynthesize. (Mann and Lazier 1991; Lalli and Parsons 2000; Schalles 2006). Measuring chl *a* concentrations over large spatial scales is often accomplished using satellite-based detectors of ocean color. Translating the measurements of ocean color into estimates of primary production is a complex process involving multiple steps, each of which can contribute to error in the estimate. Sophisticated algorithms are developed to address these complexities, which include: uncertainty in the contribution of other pigmented compounds to the measured chl *a* reflectance, particularly in turbid coastal regions; filtering atmospheric scatter from the water column response; and applying a single algorithm that must account for chl *a* concentrations ranging over five orders of magnitude from low levels in the world's open oceans to much higher levels in coastal waters and estuaries (**Figure 2-8**) (Mann and Lazier 1991; Schalles 2006). Nevertheless, satellite-based measurements of ocean color provide an excellent, global-scale assessment of primary production in the world's oceans (Schalles 2006).

The Chesapeake Bay is one of the most productive estuarine systems in the U.S. (Weiss et al. 1997; Langland and Cronin 2003); however, during the 400 years since European settlement in the region, the watershed, and in turn discharge into the bay, have undergone significant changes. The number of people in the watershed has grown exponentially and the watershed currently contains approximately 16 million people (Smith et al. 2003; Kemp et al. 2005). Due to an increase in the use of commercial fertilizers in the Chesapeake Bay watershed, as well as a general increase in human activity in and around the bay, nutrient loading has increased, which in turn has resulted in an increase in primary production (Kemp et al. 2005). While increased primary productivity initially provides more resources, in the form of food, to other organisms, over-production can have negative impacts on the health of the ecosystem.

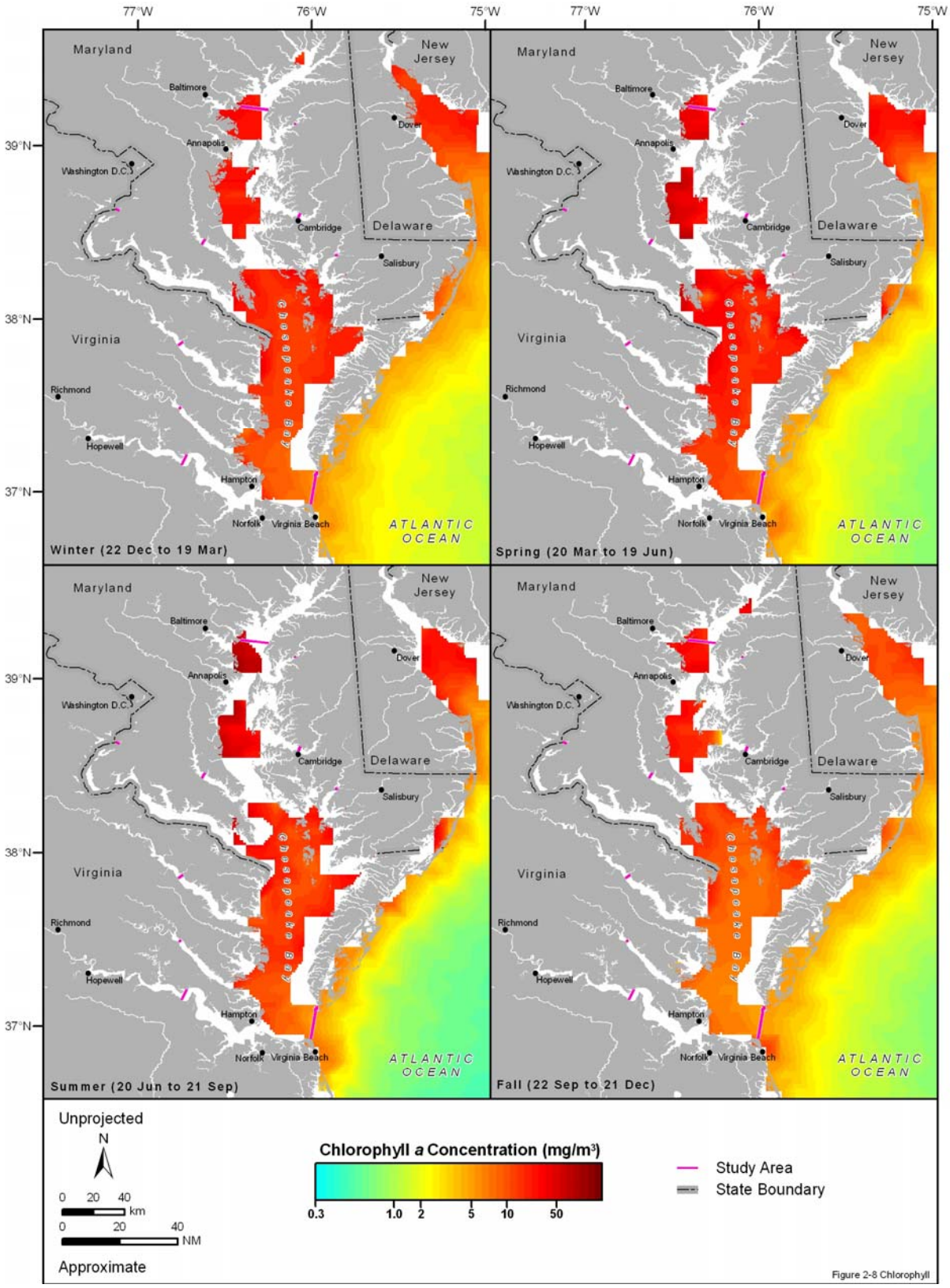

Figure 2-8. Mean seasonal chlorophyll *a* concentrations occurring in surface waters along the southeastern U.S. coast and in the Chesapeake Bay from September 1997 through October 2005. Source data: NASA (2005a).

2.6.1.1 Phytoplankton

Phytoplankton are single-celled organisms that are similar to plants because they photosynthesize using sunlight and chlorophyll to generate energy. Phytoplankton growth and distribution throughout the marine environment is influenced by several factors, the most important of which are temperature (Eppley 1972), light (Yentsch and Lee 1966), and nutrient concentration (Goldman et al. 1979). To a lesser degree, other factors such as pH, salinity, and iron (Fe) concentration have also been observed to affect the growth of phytoplankton (Parsons et al. 1984; Moore et al. 2006). When one of these essential factors is in short supply, growth is said to be limited by that factor. In general, the concentration of phytoplankton will be higher in nearshore areas where nutrients are discharged from land sources, such as rivers and areas of urban runoff. The principal nutrients phytoplankton use for growth and photosynthetic processes are dissolved nitrogen (nitrate/nitrite/ammonia), phosphorous (phosphate), and silica (silicate). Phosphorous limitation is more typical of freshwater systems, whereas marine systems are more likely to be nitrogen limited (Mann and Lazier 1991; Lalli and Parsons 2000).

Localized tidal action, major storm events, and other conditions influence flow within the Chesapeake Bay and can influence daily and seasonal changes in the vertical stratification as well as the homogeneity of the water column. The large variability within the Chesapeake Bay results in a phytoplankton assemblage composed of freshwater, estuarine, and nearshore taxa (Marshall 1980, 1994; Marshall and Burchardt 1998, 2004). Sampling of the Chesapeake Bay, local estuaries, and tributaries have identified over 1,450 different taxa local to the region (Marshall et al. 2005).

Freshwater flow into the Chesapeake Bay is maximal in winter–spring; dominated by the freshet of the Susquehanna River; this flow largely determines gradients of light and nutrients along the north–south axis of the bay (**Figure 2-8**) (Glibert et al. 1995). The timing, position, magnitude, and extent of a large winter–spring diatom bloom located in the Chesapeake Bay are determined in large part by this concentrated flow of freshwater into the bay (Harding 1994; Miller and Harding 2007). In addition, regionalized variability of phytoplankton in the Chesapeake Bay is primarily observed between frontal regions, in cross-bay (lateral) gradients (Malone et al. 1986), and in patchy, short-lived dinoflagellate blooms (Tyler and Seliger 1978). In the productive mid-bay, cross-bay gradients in chlorophyll, nutrients, and hydrographic properties are often resulting in higher levels of phytoplankton biomass and productivity along the western shoal regions, where the bathymetry and local circulation patterns provide an area of retention for the accumulation of phytoplankton (Malone et al. 1986; Weiss et al. 1997).

Phytoplankton have been used as an indicator of the Chesapeake Bay's water quality (Magnien et al. 1995). Due to increased levels of eutrophication in the Chesapeake Bay, there has been an increased abundance of phytoplankton in the bay (Harding and Perry 1997; Kemp et al. 2005). Microscope analyses of the Chesapeake Bay waters (especially coastal environments) have demonstrated a general shift in phytoplankton community dominance from larger to smaller cells (e.g., Marshall 1980). Few historical direct observations are available to examine possible shifts in phytoplankton community structure; however, there appear to be shifts in diatom communities (Cooper and Brush 1991, 1993), and increases in the relative abundances of dinoflagellates, cyanobacteria, and small flagellates (Zimmerman and Canuel 2002).

Increased eutrophication in the Chesapeake Bay has also been related to the enhanced growth of harmful algal species; these species can cause direct harmful effects to local communities through the production of toxins, noxious discoloration of waters, and the production of floating mucilage (e.g., Paerl 1988; Anderson et al. 2002). As many as 34 harmful or toxin-producing species have been identified in the Chesapeake Bay (Cronberg et al. 2003; Fryxell and Hasle 2003; Marshall et al. 2005). When these blooms dominate the water, a red or mahogany tide may be produced that can last for several months (Reshetiloff 2004). Factors that create these HABs are complex; however, many have been associated with nutrient enrichment (e.g., Smayda 1997). Numerous HABs have been reported in the Chesapeake Bay and its tributaries; several appear to be related directly to nutrient inputs (Glibert et al. 2001; Heil 2005; Kemp et al. 2005).

2.6.2 Secondary Production

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

2.6.2.1 Zooplankton

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

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

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

The Chesapeake Bay undergoes large seasonal changes in temperature, salinity, nutrient input, DO, primary production, and the abundance of predators. As a result, local zooplankton populations change throughout the year with different species becoming dominant during the differing seasons. Throughout the year, copepods tend to dominate the local zooplankton community (Heinle 1966; White and Roman 1992) with polychaete, barnacle, and bivalve larvae dominating the community for short periods. Smaller microzooplankton (20 to 200 µm in size) are generally dominated by protozoa and rotifers; however, copepod nauplii can be the most abundant members during spring and summer months.

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3.0 SPECIES OF CONCERN

This chapter provides detailed information on protected marine mammals as well as sea turtles, birds, and fish that are federally-listed as endangered, threatened, or as species of concern. These species are of particular interest to the Navy due to their protected status and potential to be impacted by Navy activities.

Marine mammals, which include cetaceans (whales, dolphins, and porpoises); pinnipeds (seals, fur seals, sea lions, and walruses); and sirenians (manatees and dugongs), are the taxon group with the largest number of federally-protected species in the Chesapeake Bay Study Area. **Section 3.1** of this chapter provides information on the 10 marine mammal species with regular or rare occurrence in the Chesapeake Bay Study Area and vicinity. Extralimital species are noted in **Table 3-1**; available records of these species in the Chesapeake Bay are listed at the end of this section. All marine mammals are protected by the MMPA; three cetacean and one manatee species are also listed as endangered under the ESA. An overview of marine mammals, as well as a brief introduction to acoustics and hearing, is included. A detailed narrative has been prepared for each marine mammal species (excluding extralimital species), consisting of a species' description, status, habitat associations, distribution (including a focus on the Chesapeake Bay Study Area), behavior and life history, and vocalizations and hearing capabilities when available. Migration and critical habitat maps are embedded within this section (**Figures 3-1**, **3-2**, and **3-4**). Maps depicting the seasonal occurrence records for all regular/rare marine mammal species and extralimital species in the Study Area are found embedded in the section (**Figures 3-3** and **3-5** through **3-7**). A map displaying the areas of usage of bottlenose dolphins (*Tursiops truncatus*) in the Study Area is also included in this section (**Figure 3-6**).

Five sea turtle species are known or have the potential to occur in the Chesapeake Bay Study Area, and all are listed as threatened or endangered under the ESA. **Section 3.2** of this chapter consists of an overview of sea turtle biology and life history and provides basic information on the hearing capabilities of these animals. Each of the sea turtle species is described in detail by its physical description, status, habitat associations, distribution (including a focus on the Chesapeake Bay Study Area), and behavior and life history characteristics. Maps depicting the seasonal occurrence records and predicted areas of occurrence for sea turtle species in the Study Area are embedded in this section (**Figures 3-9** through **3-23**).

Three bird species that may occur in the Chesapeake Bay Study Area and vicinity are discussed in this **Section 3.3**. Two species, the Roseate Tern (*Sterna dougallii*) and Least Tern (*Sternula antillarum*), are listed as endangered while the Piping Plover (*Charadrius melodus*) is listed as threatened under the ESA. **Section 3.3** provides information about the physical description, status, habitat associations, distribution (including a focus on the Chesapeake Bay Study Area), and behavior and life history characteristics of these species.

The shortnose sturgeon (*Acipenser brevirostrum)* is the only ESA threatened or endangered fish species occurring in the Chesapeake Bay Study Area. **Section 3.4** of this chapter includes a discussion of the physical description, status, habitat associations, distribution (including a focus on the Chesapeake Bay Study Area), and behavior and life history characteristics of this species. A map depicting the locations of shortnose sturgeon captures in the Study Area and vicinity is included in this section (**Figure 3-24**).

Marine species of particular interest to Navy operations that are listed as endangered or threatened at the state level are provided in a table in **Section 3.5**. Detailed information on these species' life histories is not given for species that are not federally-protected.

The locations of literature citations in Chapter 3 differ from other MRA chapters. Literature cited in the marine mammal section is found at the end of **Section 3.1**, literature cited in the sea turtle section is found at the end of **Section 3.2**, and so forth.

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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).

Cetaceans (whales, dolphins, and porpoises) 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 Chesapeake Bay. 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 (*Trichechus manatus*) 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 making the ability to detect sound paramount in the underwater environment (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 (AM) and tonal (frequency-modulated [FM]) 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, AM broadband “clicks” with peak energy between 10 and 200 kHz; individually variable “burst pulse” click trains; and constant frequency or 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 and Miller 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 clicks 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 behaviors. 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 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; Xitco Jr. et al. 2004; Gőtz et al. 2005; Gregg et al. 2008), which could represent another avenue for these animals to share 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 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 1998b; 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 1998b; 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 1998b; 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. (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 (in particular, cetacean) distribution (e.g., Jaquet 1996; Jaquet et al. 1996; Gregr and Trites 2001; Hamazaki 2002; Ferguson 2005). Marine mammals may not instantaneously respond to changes in ocean conditions. Instead, there is likely 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 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 days to weeks, whereas the lag might be considerably greater for sperm whales where the primary prey (cephalopods) are removed from primary production by approximately four months (Gregr and Trites 2001). Integrated approaches are underway in some areas to examine the temporal and spatial relationship of marine mammals to the structure and variability of their habitat (e.g., Croll et al. 1998). Efforts are also underway in habitat modeling, which predicts potential habitat in unsurveyed areas based on the relationships between species' presence and the environmental parameters observed in surveyed areas (e.g., Gregr and Trites 2001; Hamazaki 2002; Ferguson 2005; Hastie et al. 2005; Kaschner et al. 2006; Redfern et al. 2006; Becker 2007).

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. For instance, some individual fin whales may stay in a specific area year-round (Notarbartolo-di-Sciara et al. 2003).

Cetacean movements can also reflect the distribution and abundance of prey (Gaskin 1982; Payne et al. 1986; Kenney et al. 1996; Stevick et al. 2008). 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). Physical oceanographic features such as banks have also

been associated with concentrations of prey species, including euphasiids and herring, resulting in higher cetacean associations with these features (Stevick et al. 2008)

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 SST 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 sort of niche partitioning occurs among *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 (*Eubalaena glacialis*) 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.

Long-ranging movements are quite common in pinnipeds; hooded seals (*Cystophora cristata*) and northern elephant seals (*Mirounga angustirostris*) are both good examples since they make extensive movements (Stewart and Huber 1993; Kovacs 2002). The abundance and quality of prey, as well as its' seasonal distribution, are 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 in the northeastern U.S. since the late 1980s (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 current 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 (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; Le Boeuf and Crocker 2005; Learmonth et al. 2006). Large-scale climatic events may affect the distribution and abundance of marine mammal species, either directly or indirectly, through alterations of habitat characteristics and distribution (Harwood 2001; Forcada et al. 2005; Keiper et al. 2005; MacLeod et al. 2005; Shelden et al. 2005; Simmonds and Isaac 2007) or prey availability (MacLeod et al. 2007). In the North Atlantic, climate variability has been directly linked to the North Atlantic Oscillation (NAO), which influences the abundance of marine mammal prey such as zooplankton and fish. In years when the NAO Index was positive, the average sea surface temperature 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 North Atlantic right whale calving grounds (Kenney 2007b).

3.1.2 Marine Mammals of the Chesapeake Bay

Forty marine mammal species have confirmed or potential occurrence in the nearby VACAPES OPAREA (DoN 2008). These include 35 cetacean, four pinniped, and one sirenian species. Only 10 of those species (six cetacean, three pinniped, and one sirenian species) have regular or rare occurrences in the Chesapeake Bay (**Table 3-1**). Any occurrences of other species would be considered extralimital (**Table 3-1**; Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007).

The bottlenose dolphin and harbor porpoise (*Phocoena phocoena*) are expected to be the most common species in the Chesapeake Bay (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). The majority of large whale (North Atlantic right, fin, and humpback) sightings near the mouth of the Chesapeake Bay occur between January and March (Cornejo et al. 2000; Knowlton et al. 2002). Historically, some small-scale whaling occurred within the Chesapeake Bay but was not considered to be organized shore whaling and was largely abandoned by the 1850s with little information available on the actual species taken (Reeves and Mitchell 1988). For example, on 11 August 1858, a 19.5 m whale was captured and killed at Mobjack Bay. As noted by Reeves and Mitchell (1988), there was some confusion about the species identification (various reports suggested that it was a North Atlantic right, humpback, or even a blue whale). This record was finally corrected to be either a fin or sei whale. The authors noted that a few more individuals were taken during whaling operations, but not enough information was available to identify the species.

Table 3-1. Marine mammal species of the Chesapeake Bay and nearby ocean waters and their status under the Endangered Species Act (ESA). Naming convention matches that used in the NOAA stock assessment report (SAR) (Waring et al. 2009).

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

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

Chesapeake Bay experiences extreme seasonal temperature changes in contrast to offshore regions (Reshetiloff 2004). As a result, the SST undergoes dramatic fluctuations throughout the year (1.1° to 28.9°C). Marine mammal movements in and out of the Chesapeake Bay may be affected by these temperatures directly or indirectly if these fluctuations affect the movement of prey. Bottlenose dolphin migrations out of the Chesapeake Bay waters in the fall are typically triggered when surface temperatures drop. Most bottlenose dolphin sightings in the Chesapeake Bay occur in waters with SST above 16°C (Barco et al. 1999; Hayden 2007). In contrast, the harbor porpoise, which favors cool-temperate waters, is found in the Chesapeake Bay when water temperatures are cooler (late winter to early spring) (Blaylock 1985; Morgan et al. 2002).

A significant increase in stranded ice seals has occurred since the late 1980s in the northeastern and mid-Atlantic U.S. (McAlpine et al. 1999a; Slocum et al. 2003; Harry et al. 2005). The harbor seal and gray seal were once considered very uncommon in Virginia (Potter 1991) but now occur regularly in the Chesapeake Bay (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). Sporadic occurrences of the harp seal have also been recorded in the Chesapeake Bay (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007).

The 10 species that have a regular or rare occurrence are discussed below with description, status, habitat association, distribution (including location and seasonal occurrence in the Chesapeake Bay), and basic behavior and life history information. Information on the acoustic and hearing abilities of these species is also included. Threatened and endangered marine mammals with a regular or rare occurrence are discussed in **Section 3.1.2.1** while non-threatened and non-endangered regular/rare marine mammals are found in **Section 3.1.2.2**. Marine mammal species that occur farther offshore or farther north or south of these waters along the Atlantic coast are considered extralimital based on known habitat associations and are briefly discussed in **Section 3.1.2.3**. For a complete description of these extralimital species, please refer to the VACAPES MRA (DoN 2008). The listing of species in each section follows the taxonomic order presented in **Table 3-1**.

Records for all species considered regular or rare, other than the bottlenose dolphin and West Indian manatee, are displayed in **Figure 3-3**. In addition to North Atlantic right whale, humpback whale, fin whale, short-beaked common dolphin, harbor porpoise, harbor seal, gray seal, and harp seal, **Figure 3-3** also has records for unidentified cetaceans, unidentified dolphins, and unidentified pinnipeds. West Indian manatee sighting and stranding records are displayed in **Figure 3-5**. Bottlenose dolphin sighting, stranding, and bycatch records are displayed in **Figure 3-6** along with estimated areas of usage. Sighting, stranding, and bycatch records for extralimital species in Chesapeake Bay are depicted in **Figure 3-7**. All marine mammal data are presented by season (winter=January through March; spring=April through June; summer=July through September; fall=October through December).

3.1.2.1 Threatened and Endangered Marine Mammals of the Chesapeake Bay Study Area

Four marine mammal species with regular or rare occurrence in the Chesapeake Bay are listed as endangered under the ESA. These include three baleen whale species (North Atlantic right, humpback, and fin whale) and one sirenian species (West Indian manatee).

- **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 2008a).

  Adults are robust and may reach 18 m in length (Jefferson et al. 2008). There is no dorsal fin on the broad back. The head may reach one-fourth to one-third of total body length and is covered in whitish areas of roughened skin called ‘callosities’ which have whale lice attached (Jefferson et al. 2008).

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 2008a) and, therefore, considered a strategic stock (Waring et al. 2009). According to the North Atlantic right whale report card released annually by the North Atlantic Right Whale Consortium, 393 individuals are thought to occur in the western North Atlantic (NARWC 2007). The final 2008 NOAA SAR states that, from a review of the photo-id recapture database for May 2007, 325 individually recognized whales were known to be alive during 2003 (Waring et al. 2009). 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). In recent years, there has been an increase in the number of catalogued individuals (Waring et al. 2009); 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 area (off Georgia and northern Florida) and two feeding areas (Cape Cod Bay and Great South Channel, Massachusetts) in U.S. waters are designated as critical habitat for North Atlantic right whales (NMFS 1994; NMFS 2005; **Figure 3-1**).

In an effort to reduce ship collisions with critically endangered North Atlantic right whales, the Early Warning System (EWS) was started in 1994 for the calving region along the southeastern U.S. coast. This system, known as the Northeast U.S. Right Whale Sighting Advisory System in the northeast, was extended in 1996 to the feeding areas off New England.[5].

In 1999, the U.S. Coast Guard implemented a Mandatory Ship Reporting System (USCG 1999; USCG 2001). This reporting system requires specified vessels (Navy ships are exempt) to report their location while in the calving 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 exempt from ship reporting, the Navy makes a large investment 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 farther north 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 2006). These routes are voluntary at this time and are included on the updated NOAA nautical charts (http://www.noaa.gov/charts.html) (NOAA 2006).

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. On July 1, 2007, the USCG and NOAA modified key shipping routes into Boston in an effort to significantly reduce the risk of ship collisions with right whales (NOAA and USCG 2007). These shipping lanes were moved northeast slightly and narrowed to avoid areas that may support high densities of right whales (NOAA and USCG 2007). A speed restriction of 10 knots (kt) or less applies during certain times of the year in specified locations along the U.S. east coast; these restrictions only apply to vessels greater than 19.8 m in length (NMFS 2008b; NMFS 2008c).

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.

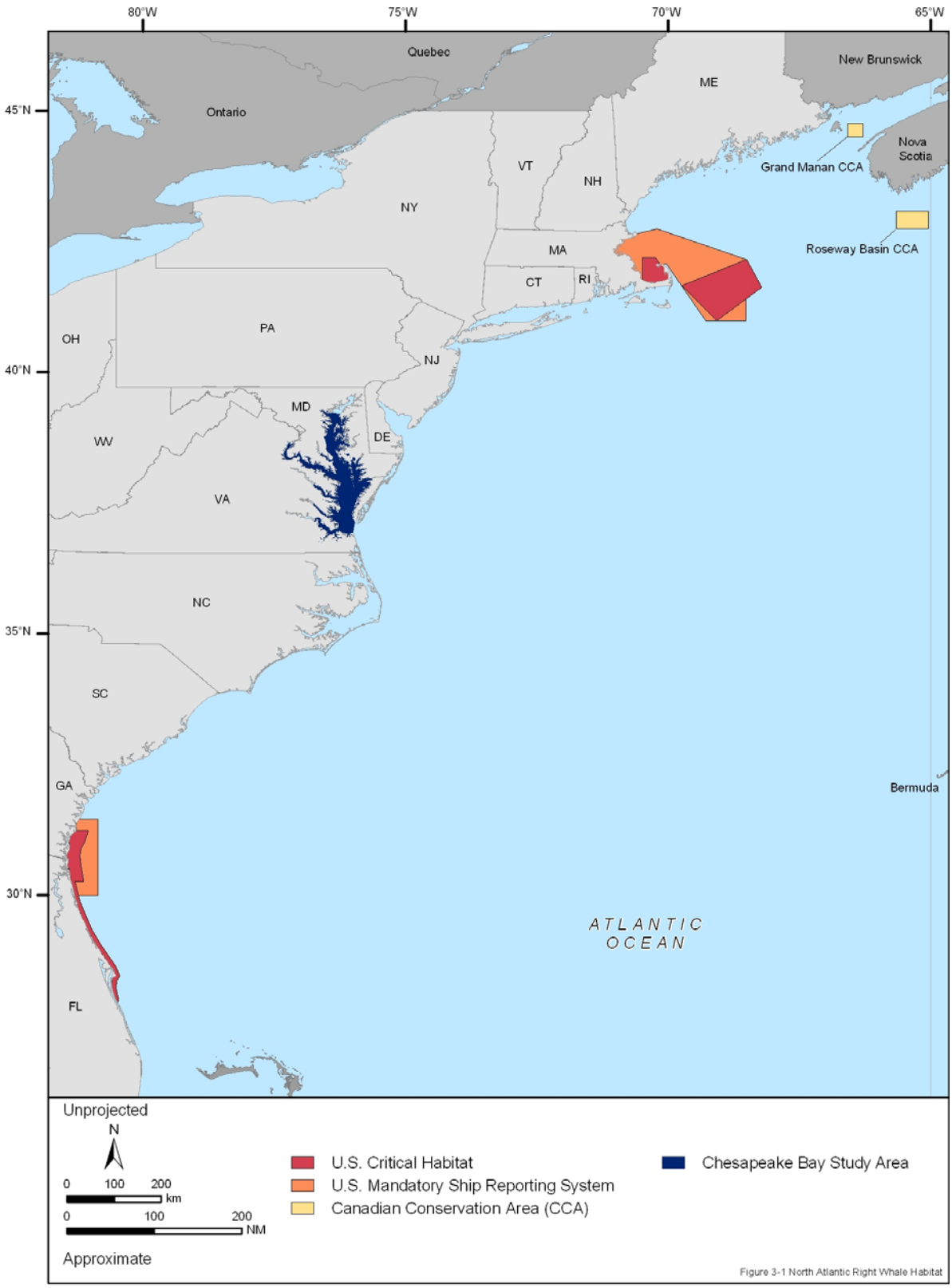

Figure 3-1. Designated critical habitat, conservation areas, and mandatory ship reporting zones for the North Atlantic right whale in the vicinity of the Chesapeake Bay Study Area. Source information: NMFS (1994), USCG (1999), and DFO (2003b).

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 (North Atlantic right, fin, humpback, and minke whales) 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/.

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 farther north 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, 2007b). 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, 2007b). 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 2006b; 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 also

records of this species in the Gulf of Mexico; cow-calf pairs have been sighted as far west as Texas (Zoodsma, B. National Marine Fisheries Service, Southeast Regional Office, pers. comm., 28 February 2006).

Most North Atlantic right whale sightings generally 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 (Jacobsen et al. 2004) and the Azores (Steiner, L., Whale Watch Azores, pers comm., 7 January 2009) have been documented which suggests a possible offshore migration path.

The population migrates as two separate components although some individuals may remain on the feeding grounds throughout the winter (Winn et al. 1986; Kenney et al. 2001). Pregnant females and some juveniles migrate from the feeding grounds to the calving grounds off the southeastern U.S. in late fall to winter. The cow-calf pairs return northward in late winter to early spring. The majority of the right whale population leave the feeding grounds for unknown habitats in the winter but return 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 generally be found in Cape Cod Bay December through May, with peak occurrence in February through April (Winn et al. 1986; Hamilton and Mayo 1990; Nichols et al. 2008). In the Great South Channel east of Cape Cod right whales occur 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 cow-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 North Atlantic right whales, with extended whale residences; Weinrich et al. (2000) suggested that this area may be an important feeding area during the fall and nursery area during summer. 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 (**Figure 3-1**). 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. 1986).

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 data sources between 1950 and 1992 found that wintering right whales were observed widely along the coast from Cape Hatteras, North Carolina, to Miami, Florida (Kraus et al. 1993). Sightings off the Carolinas were comprised of single individuals that appeared to

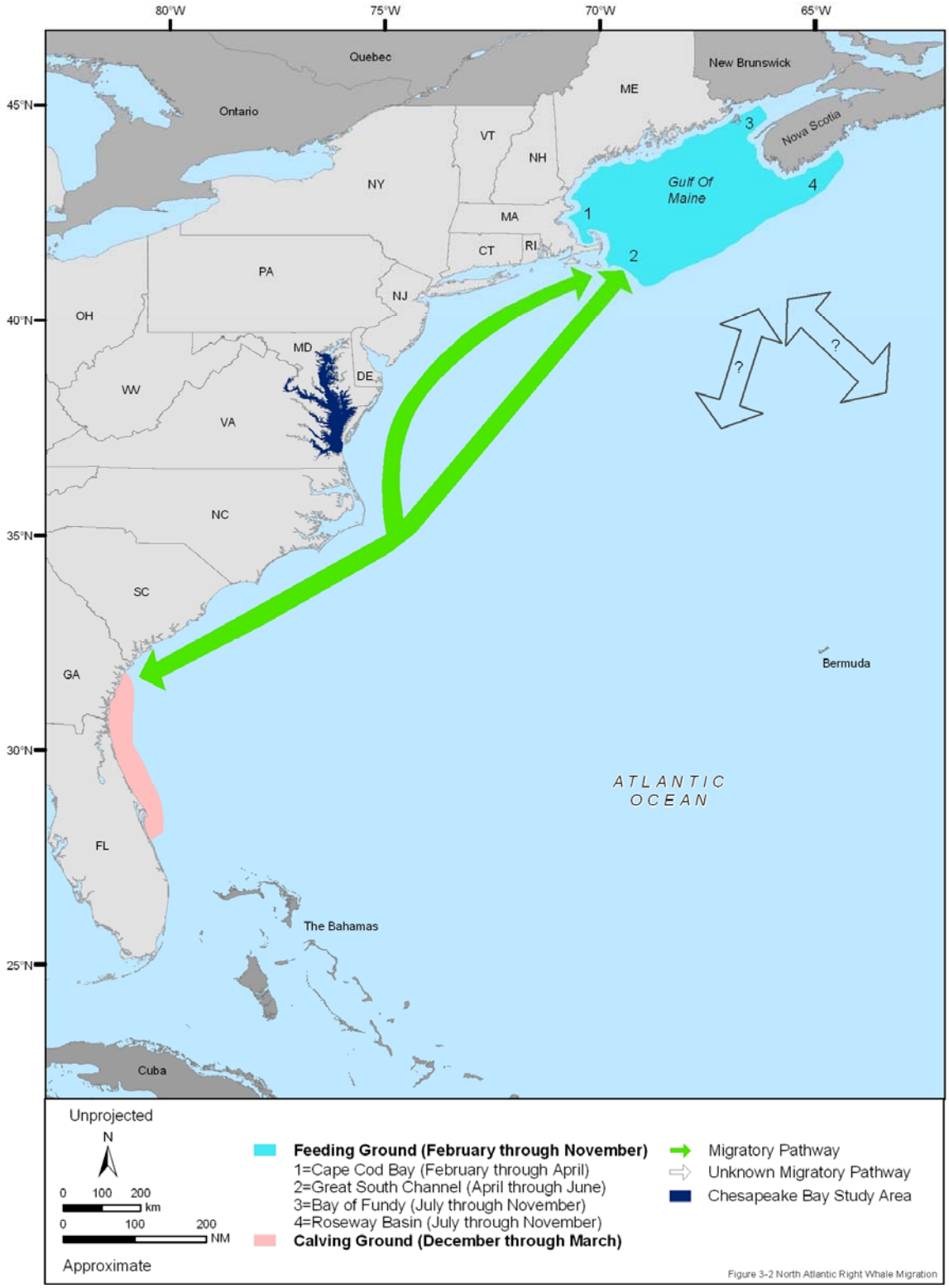

Figure 3-2. North Atlantic right whale migration patterns. This species migrates along at least two distinct pathways, though some whales may remain on the feeding grounds throughout the winter. Pregnant females and some juveniles migrate to the calving grounds in late fall to winter, returning northward 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).

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 5 NM (9 km) from shore, and 94% of all sightings were within 30 NM (56 km) 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, Arctic Norway, and the Azores have been documented (Knowlton et al. 1992; IWC 2001b; Steiner, L. Whale Watch Azores, pers comm., 7 January 2009). 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.[7] The longest tracking of a right whale is of an adult female which migrated 1,928 km in 23 days (mean=3.5 kilometers per hour [km/hr]) from 40 km west of Browns Bank (Bay of Fundy) to Georgia (Mate and Baumgartner 2001).

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 Chesapeake Bay—North Atlantic right whales may occur year-round near the mouth of the Chesapeake Bay based on available sighting data from the mid-Atlantic region and known habitat associations of this species; however, North Atlantic right whales primarily occur farther north on their feeding grounds during the summer. Only one record, a sighting reported in October 1876, is displayed in **Figure 3-3**. Jensen and Silber (2003) reported a dead individual, presumably the victim of a collision with a vessel, east of Cape Charles on December 31, 1993; however, not enough information was available to plot this incident. Although these are the only records reported in the Study Area, several records exist offshore of the mouth of the Chesapeake Bay (see DoN 2008). Knowlton et al. (2002) reported that sightings near the Chesapeake Bay primarily occur in October through December, February, and March, and noted that the slight peaks they detected in November, December, and March coincide with the migratory time frame.

  Knowlton et al. (2002) reported a sighting in May 2002 of a female and calf who had been in northern waters, came south to the Chesapeake Bay, and then returned north; however, analysis of North Atlantic Right Whale Consortium data reveals that the record is actually near Delaware Bay. The proximity of the sighting, however, does indicate that cow-calf pairs could be sighted in the mid-Atlantic region possibly at any time of the year.

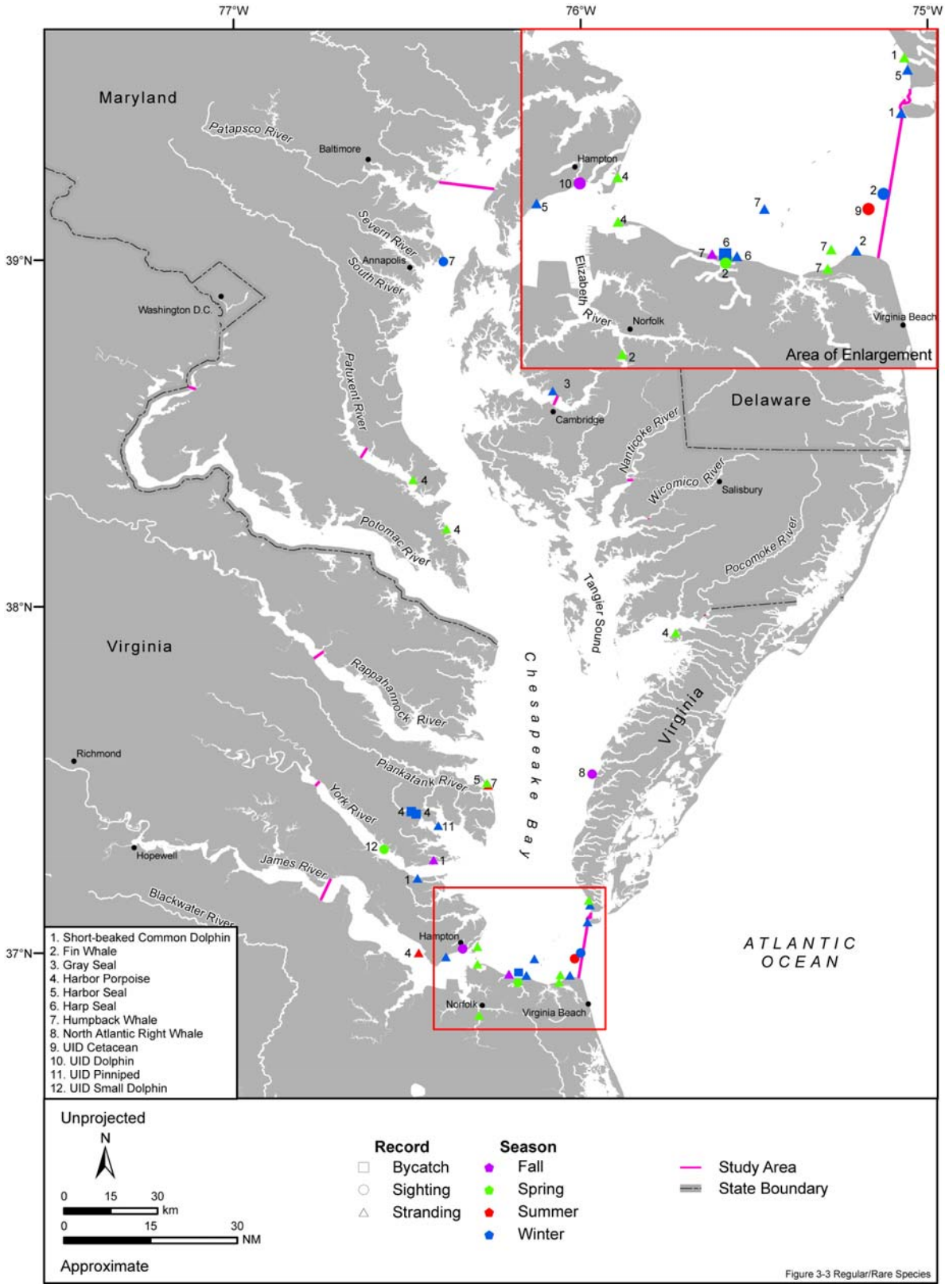

Figure 3-3. Sighting, stranding, and incidental fisheries bycatch records of regular and rare marine mammal species (excluding the bottlenose dolphin and West Indian manatee) or species group in the Chesapeake Bay Study Area. Source data: refer to Table A-1.

Behavior and Life History—Right whales are most often seen as individuals or pairs (Jefferson et al. 2008). 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, there are significantly more all-juvenile groups (Parks et al. 2007b).

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, C. New England Aquarium. pers. comm. 1 August 2002).

Dives of 5 to 15 minutes (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, FM, 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 decibels at the reference level of one micropascal at one meter (dB re: 1 μPa-m) root-mean-square (rms) (Parks et al. 2005; Parks and Tyack 2005). In certain regions (i.e., 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. 2007a). 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 (Clapham and Mead 1999; Jefferson et al. 2008). 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 by 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. 2009). 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 stocks based on the following feeding locations: Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland (Katona and Beard 1990; Waring et al. 2009). 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 (Waring et al. 2009). The minimum population estimate is 549 individuals (Waring et al. 2009). 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). In the Gulf of St. Lawrence, humpback whale occurrence is associated with thermal fronts (Doniol-Valcroze et al. 2007). The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving. Breeding grounds are in tropical or subtropical waters, generally with shelter created by islands or reefs. Optimal calving conditions are warm water (24° to 28°C) and relatively shallow, low-relief ocean bottom in protected areas (i.e., behind reefs) (Sanders et al. 2005). These areas provide calm seas and minimize the possibility of predation by sharks and harassment by male humpbacks (Smultea 1994; Clapham 2000; Craig and Herman 2000). Females with calves occur in significantly shallower waters than other groups of humpback whales, and breeding adults use deeper, more offshore waters (Smultea 1994; Ersts and Rosenbaum 2003).

Distribution—Humpback whales are globally distributed in all major oceans and most seas. They are generally found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts where calving occurs. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep water during migration (Clapham and Mattila 1990; Calambokidis et al. 2001).

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 non-migratory 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. 2009). 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. 1996; MMS 2001; Pitchford, T. Florida Marine Research Institute. pers. comm. 28 August 2006). None of these occurrences are fully understood. They might be due to shifts in distribution, increases in 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).

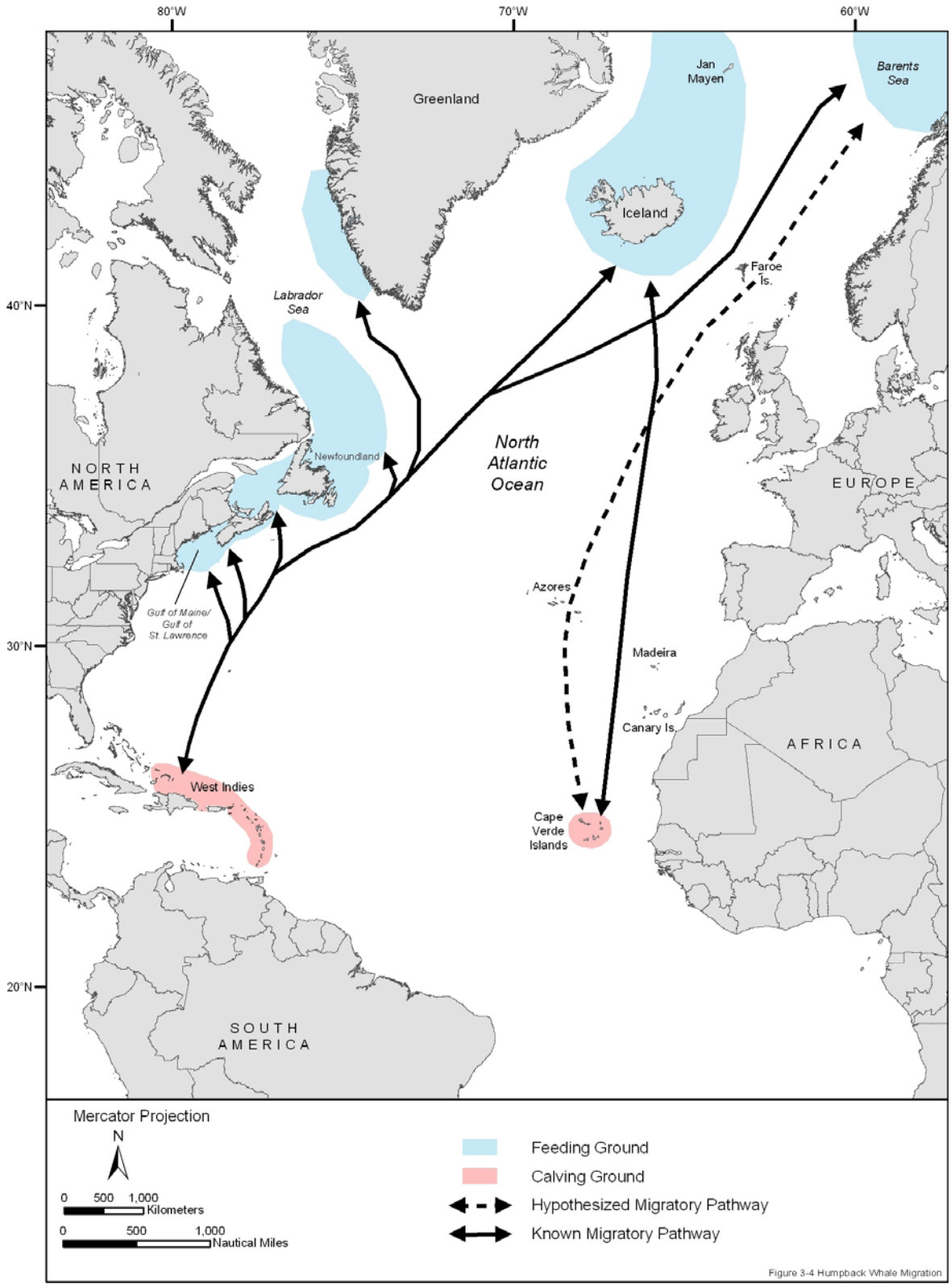

Figure 3-4. Current knowledge of the migration pathways of humpback whales in the North Atlantic Ocean. Current feeding and calving grounds and general migratory pathways are depicted. Note that humpback whales also occur outside these areas. Source information: Stevick et al. (1998), Jann et al. (2003),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

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 Chesapeake Bay—An increase in the number of humpback whale sightings in the vicinity of the Chesapeake Bay was noted in the early 1990s (Swingle et al. 1993) along with increases in strandings in the mid-Atlantic region (Wiley et al. 1995; Barco et al. 2002). Mid-Atlantic waters are now considered a possible supplemental feeding ground for juvenile and adult humpback whales, primarily during January through March (Swingle et al. 1993; Barco et al. 2002).

  One sighting and several strandings are documented in the Study Area. The winter sighting in the northern portion of the Study Area is an individual known as “Bulls Eye” that was observed lunge-feeding at the Chesapeake Bay Bridge near Annapolis, Maryland, in March 1992, a distance of over 200 km northwest into the Chesapeake Bay (Swingle et al. 1993; **Figure 3-3**). Movement into the Chesapeake Bay prior to the 1990s is supported by a gillnet entanglement at Cape Henry in February 1975 (Perkins and Beamish 1979). Additional sightings have been recorded just offshore of the mouth of the Chesapeake Bay Study Area (see DoN 2008). Swingle et al. (1993) observed juvenile humpback whales feeding near the mouth of the Chesapeake Bay, within 4 km of shore.

  As noted earlier, humpback whales are most likely to occur in the Chesapeake Bay between January and March; however, year-round usage of the area is possible based on sighting and stranding data in both mid-Atlantic waters and the Chesapeake Bay itself from the fall and summer (Barco et al. 2002; Swingle et al. 2007). For example, strandings are recorded in the Study Area in June 1990 (Wiley et al. 1995) and August 1995 (**Figure 3-3**). Additional strandings are recorded in the Chesapeake Bay in February 1992 and April 1996 (**Figure 3-3**). Photo-identification data support repeated use of the mid-Atlantic region by individual humpback whales (Barco et al. 2002). Barco et al. (2002) suggested that the mid-Atlantic region might be a place where some mother humpbacks wean and separate from their calves; however, there is currently no way to test this hypothesis.

  There are several documented instances of human encounters with humpback whales in or near the Chesapeake Bay. Wiley et al. (1995) reported a November 1990 stranding at Little Creek and noted that entanglement marks were found on the individual (**Figure 3-3**). Two incidents of ship strikes involving humpback whales have taken place near the mouth of the Chesapeake Bay during February 1992 (**Figure 3-3**) and June 2003 (Jensen and Silber 2003; Glass et al. 2008).

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 (Clapham and Mead 1999). These whales are lunge feeders, taking in huge batches of prey items as they lunge laterally, diagonally, or vertically through aggregations of prey (Clapham 2002). Feeding behavior is highly diverse, and humpbacks employ unusual behaviors, such as bubble netting, to corral prey (Jurasz and Jurasz 1979; Weinrich et al. 1992). This is the only species of baleen whale that shows some evidence of cooperation when feeding in large groups (D'Vincent et al. 1985). Humpback whales are not typically thought to feed on the breeding grounds; however, some feeding behavior has been observed there (Salden 1989; Gendron and Urbán R. 1993).

Female humpbacks become sexually mature at four to nine years of age (Clapham 1996). Gestation is approximately one year. Calves are weaned before one year of age. Calving intervals are usually two to three years although females occasionally give birth to calves in successive years (Clapham 1996). Males compete for access to receptive females by aggressive, sometimes violent interactions, as well as vocal displays (Clapham 1996; Pack et al. 1998).

Humpback whale diving behavior depends on the time of year (Clapham and Mead 1999). In summer, most dives last less than 5 min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min; dives of greater than 30 min have been recorded (Clapham and Mead 1999). Although humpback whales have been recorded to dive as deep as 500 m (Dietz et al. 2002), on the feeding grounds they spend the majority of their time in the upper 120 m of the water column (Dolphin 1987; Dietz et al. 2002). Recent D-tag work revealed that humpbacks are usually only a few meters below the water's surface while foraging (Ware et al. 2006). On wintering grounds in Hawaii, 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 whale song is an incredibly elaborate series of patterned vocalizations which are hierarchical in nature (Payne and McVay 1971). There is geographical variation in humpback whale song, with different populations singing different songs and all members of a population using the same basic song; however, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983).

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

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

Description—The fin whale is the second-largest whale species, with adults from the Northern Hemisphere reaching 24 m in length (Jefferson et al. 2008). Fin whales have a very sleek body with pale, V-shaped chevrons on the back just behind the head. The dorsal fin is prominent, usually falcate, and rises out of the back at a very shallow angle (Jefferson et al. 2008). 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 2006a).

Status—Fin whales are classified as endangered under the ESA (NMFS 2006a) and, therefore, are considered a strategic stock (Waring et al. 2009). The most recent best estimate of abundance is 2,269 individuals in the western North Atlantic stock while the minimum population estimate is 1,678 (Waring et al. 2009). No critical habitat is designated for this species. NMFS recently initiated a five-year review for the fin whale under the ESA (NMFS 2007).

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. 1986; 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, Rhode Island, 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 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 (MAB). 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. 2005). 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. Analysis of sighting data from the Gulf of St. Lawrence indicates that fin whale sightings are associated with the presence of thermal fronts in this region (Doniol-Valcroze et al. 2007).

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 1998). 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 1985; NMFS 1998). 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).

- Information Specific to the Chesapeake Bay—The Chesapeake Bay region is considered to be a normal part of the range of the fin whale. Blaylock (1985) noted that the fin whale was probably the most abundant large whale in Virginia's waters. Occurrences of the fin whale in the Chesapeake Bay area have been documented from January through May; however, sighting records for the species in the VACAPES OPAREA suggest that fin whales could be encountered in this region throughout the year (DoN 2008).

  Several historical records of fin whales have been documented in the Chesapeake Bay. A fin whale at Mobjack Bay was recorded in May 1866; however, the record type was not noted (Bailey 1948). A fin whale was sighted and then live-stranded in the entrance channel to Little Creek Harbor during May 1947 (Bailey 1948; **Figure 3-3**). Morgan et al. (2002) reported a stranding in April 1947 at Portsmouth in the Elizabeth River (**Figure 3-3**). Miller (1927) reported a stranding of an immature fin whale during March 1923 at Walnut Point; however, based on an examination of photographs and baleen bristles, Mead (1977) later determined this specimen to be a Bryde's whale (see **Figure 3-7**).

  More recent records of the fin whale in the Chesapeake Bay Study Area include a February 2001 stranding near the mouth of the York River and a March 2007 stranding near the Norfolk/Portsmouth area (Virginia Aquarium and Marine Science Center Foundation Stranding Response Center [VAQS] Marine Mammal Stranding Database [1988-2008]).[1] In addition to a 1976 sighting at the mouth of the Chesapeake Bay (CETAP 1982; **Figure 3-3**), Swingle et al. (1993) reported sighting a mixed-species aggregation of humpback and fin whales in February 1991 off Virginia Beach.

  Worldwide, the fin whale is the species most frequently involved in ship collisions (Laist et al. 2001). Several incidents of fin whale strandings attributed to ship strikes have been recorded in the Chesapeake Bay including two in which carcasses were carried into Norfolk on the bow of ships in March 1981 and January 1983 (Laist et al. 2001). Other strandings determined to result from ship strikes include another January 1983 stranding near Norfolk and a March 1994 stranding (**Figure 3-3**) near Cape Henry (Laist et al. 2001; Jensen and Silber 2003).

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 2006a). Single fin whales are most commonly sighted, 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/calving grounds in the North Atlantic 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-s 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 s 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.

- **West Indian Manatee (*Trichechus manatus*)**

Description—The West Indian manatee is a rotund, slow-moving animal, which reaches a maximum length of 3.5 m (Jefferson et al. 2008). 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 in January 2009 and produced a preliminary count of 3,807 individuals for Florida (1,654 along Florida's Gulf Coast and 2,153 on the Atlantic coast).[9] Based on these results and population models, the West Indian manatee population seems to be increasing in Florida.[9]

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, D.W. Marine Mammal Commission. pers. comm. 21 May 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, D.W. Marine Mammal Commission. pers. comm. 21 May 2002). There are two types of manatee protection areas in the state of Florida: manatee sanctuaries and manatee refuges (USFWS 2001; USFWS 2002a; USFWS 2002b). Manatee sanctuaries are areas where all waterborne activities are prohibited while manatee refuges are areas where activities are permitted but certain waterborne activities may be regulated (USFWS 2001; USFWS 2002a; USFWS 2002b).

Habitat 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 C., U.S. Geological Survey, Sirenia Project. pers. comm. 6 September, 27 October 2006). Shallow seagrass beds close to deep channels are preferred feeding areas in coastal and riverine habitats (e.g., Lefebvre et al. 2000; USFWS 2001). West Indian manatees are frequently located in secluded canals, creeks, embayments, and lagoons near the mouths of coastal rivers and sloughs. These areas serve as locations of feeding, resting, mating, and calving (USFWS 2001). Estuarine and brackish waters, including natural and artificial freshwater sources, are typical West Indian manatee habitat (USFWS 2001). West Indian manatees rarely occur in offshore waters, where abundant seagrass and vegetation are not available (Reynolds III and Odell 1991). When ambient water temperatures drop below about 20°C in fall and winter, migration to natural or anthropogenic warm-water sources takes place (Irvine 1983). Effluents from sewage treatment plants are important sources of fresh water for West Indian manatees in the Caribbean Sea (e.g., 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 (e.g., 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 1951b; 1951a; Beck C. U.S. Geological Survey, Sirenia Project. pers. comm. 6 September, 27 October 2006). 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, Florida, 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). A Florida manatee sighted extensively along the northwest coast of Florida between 1979 and 2005 was recently documented with a calf on the northern coast of Cuba near a power plant in January 2007 (Alvarez-Alemán et al. 2007). 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, Florida, wandered offshore and then apparently drifted south with offshore currents and was "rescued" in deep water 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, Florida, 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.[6] In early September 2001, "Chessie" was once again sighted in Virginia.[6] In August 2006, a West Indian manatee was sighted in waters off Rhode Island, Delaware, New Jersey, Massachusetts, and in the Hudson River (Beck 2006; Kenney 2007a). More recently, in March/April 2008, an emaciated manatee was rescued three miles (mi) offshore of Fort Pierce, Florida (Beck, C., U.S. Geological Survey, Sirenia Project, pers. comm., 10 April 2008).

- Information Specific to the Chesapeake Bay—Individual manatees are known to make long distance movements up the Atlantic coast, as noted previously. The manatee is considered to be a regular part of the marine fauna of the Chesapeake Bay (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). Historical records include a manatee captured in a seine net in late September 1908 at Ocean View (Duncan 1908; Rathbun et al. 1982). One of the first records of manatees in Chesapeake was a sighting in 1676; however, not enough information was available to determine the date or exact location of its occurrence (McAtee 1950). Occurrences of manatees have been documented in Virginia during May through November (**Figure 3-5**). Based on this species' sensitivity to cold waters, manatees are not likely to occur in the Chesapeake Bay during the winter months, and no records have been reported here during this time. All sightings in the northern three-quarters of the Chesapeake Bay are from the summer (**Figure 3-5**).

  The manatee is known to make its way into rivers, including up tributaries and creeks. One sighting in the Chesapeake Bay is from the Potomac River at Washington, D.C., just north of the Study Area, during August 1980 (Rathbun et al. 1982). During late June 2002, a manatee made its way up the James River and was sighted in Richmond (McAllister 2002). Schwartz (1995) mentioned a sighting of three individuals during August/September 1993 in the Elizabeth River Intracoastal Canal to Currituck Sound in North Carolina. Movements by manatees might take place either in nearshore waters or through inland waterways. Only one stranding is depicted in the Study Area in **Figure 3-5** – an October 1980 stranding at Buckroe Beach (Blaylock 1985). At least four other strandings have been reported in the Study Area. These strandings are included in the VAQS Marine Mammal Stranding Database (1998-2008) from September 1992/1995, October 1992, and June 1996.[1]

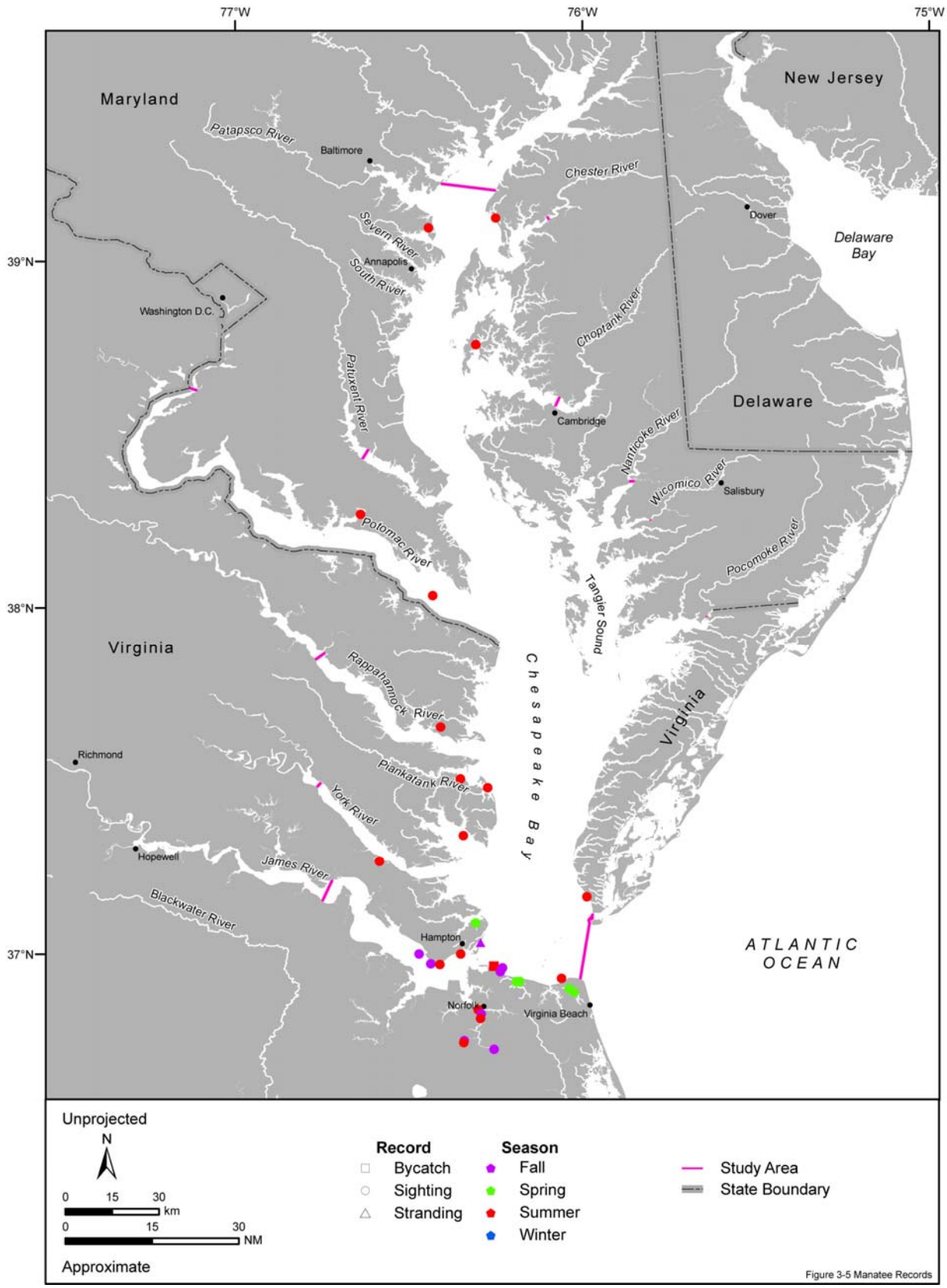

Figure 3-5. Sighting, stranding, and incidental fisheries bycatch records for the West Indian manatee in the Chesapeake Bay Study Area. Source data: refer to Table A-1.

As previously noted, one of the most famous long distance movements of any West Indian manatee were exhibited by the animal known as "Chessie," named for his affinity for the Chesapeake Bay, who gained fame in the summer of 1995 by swimming to Rhode Island, returning to Florida for the winter, and traveling north again to Virginia where he was seen in 1996.[4] In early September 2001, "Chessie" was once again sighted in Virginia.[6]

Recent sightings include a manatee reported in late July 2007 at Rock Hall Marina in the upper Chesapeake Bay (Beck, C., Sirenia Project, pers. comm., 24 July 2007) and two individuals cited in September 2008 near Baltimore (Dittmar, J., National Aquarium in Baltimore, pers. comm., 25 September 2008; **Figure 3-5**).

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 refugia (Hartman 1979).

West Indian manatees are not gregarious and are most often observed alone (Hartman 1979); however, in Florida, manatees 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, S. University of South Florida. pers. comm. 11 January 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 recently shown to possess nonlinear dynamic characteristics (e.g., subharmonics or abrupt, unpredictable transitions between frequencies), which could aid in individual recognition and cow-calf communication (Mann et al. 2006). Average source levels for vocalizations have been calculated to range from 90 to 138 decibels with a reference pressure of one micropascal (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 of the Chesapeake Bay Study Area

Six marine mammal species with regular or rare occurrence in the Chesapeake Bay area are not listed under the ESA. These include three toothed whale species and three seal species.

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

Description—Bottlenose dolphins are large and robust and vary in color from light gray to charcoal. The genus *Tursiops* has a short, stocky snout that is distinct from the melon (Jefferson et al. 2008). The dorsal fin is tall and falcate. There is striking regional variation in body size; adult body length ranges from 1.9 to 3.8 m (Jefferson et al. 2008).

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 been made.

Status—Two forms of bottlenose dolphins are recognized in the western North Atlantic Ocean: nearshore (coastal) and offshore morphotypes. NMFS refers to each morphotype as a stock. There is a complex mosaic that comprises the coastal stock (NMFS-SEFSC 2001). NMFS recognizes the mosaic to be seven discrete management units (MU) (or stocks) that have distinct spatial and temporal components: Northern Migratory MU, Southern Migratory MU, Southern North Carolina MU, South Carolina MU, Georgia, Northern Florida MU, and Central Florida MU (Waring et al. 2009).

NMFS provides abundance estimates based on data from summer aerial surveys conducted in 2002 and 2004. The best estimates of abundance/minimum population estimates are as follows: Northern Migratory (7,489/5,582), Southern Migratory (10,341/7,889), Southern North Carolina (4,818/3,241), South Carolina (1,952/1,548), Georgia (5,996/4,434), Northern Florida (3,064/2,502), and Central Florida (6,317/5,109) (Waring et al. 2009). The MUs making up the coastal stock are considered depleted under the MMPA and classified as a strategic stock (Waring et al. 2009).

Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km from the U.S. coastline (Waring et al. 2009). The minimum population estimate for this stock is 70,775 individuals; best population estimate is 81,588 individuals (Waring et al. 2009). 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 of the coastal morphotype (NMFS 2006c).

Habitat Associations—The bottlenose dolphin lives in coastal areas of all continents except Antarctica, 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. 2003a); individuals may exhibit either resident or migratory patterns in coastal areas (Kenney 1990; Waring et al. 2009).

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 the North Carolina-Virginia border, corresponding to water temperatures less than 9.5°C (Garrison et al. 2003a), 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, Southern Migratory, 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). Evidence suggests that there is a distinct spatial separation of the coastal and offshore stocks during the summer; however, the morphotypes overlap in the winter (Garrison et al. 2003a; Torres et al. 2003). During Cetacean and Turtle Assessment Program (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 45º, except around the United Kingdom, northern Europe, and southern New Zealand (Jefferson et al. 2008). Climate changes can contribute to range extensions as witnessed in association with the 1982/83 El Niño event when the range of some bottlenose dolphins known to the San Diego, California area was extended 600 km northward to Monterey Bay (Wells et al. 1990). Bottlenose dolphins continue to occur in Monterey Bay since this El Niño event.

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 deoxyribonucleic acid (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) and travel as far north as New York in summer and as far south as central Florida in winter (K. Urian et al. 1999). During the summer, the Southern Migratory MU is distributed from Cape Lookout, North Carolina, to just north of the mouth of Chesapeake Bay, and the Northern Migratory MU occurs farther north from the North Carolina/Virginia border to the New York/New Jersey border (Waring et al. 2009). In the winter months, the Southern Migratory MU overlaps with the Northern Florida, Georgia, South Carolina, and Southern North Carolina MUs while the Northern Migratory MU moves south and occurs off North Carolina north of Cape Hatteras (Waring et al. 2009). The latitudinal boundaries of the other MUs do not change seasonally (Waring et al. 2009).

Coastal bottlenose dolphins along the western Atlantic coast may exhibit either resident or migratory patterns (Waring et al. 2009). 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 (K.W. Urian et al. 1999). 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 Chesapeake Bay—Bottlenose dolphins occurring in the Chesapeake Bay are part of the coastal migratory stock. Virginia is the southernmost state on the Atlantic coast whose nearshore population consists exclusively of this stock (Swingle 1994). Within the Chesapeake Bay, the bottlenose dolphin is less abundant and more dispersed in contrast to the observed occurrence along the ocean coast of Virginia (Swingle 1994). The bottlenose dolphin is known to use the entire bay but is especially common in the mouth of the Chesapeake Bay (Blaylock 1988; Swingle 1994; Barco et al. 1999).

  Few systematic surveys have been conducted in the Chesapeake Bay; these include the 1995, 2002, and 2004 Mid-Atlantic *Tursiops* Surveys (MATS), aerial surveys of the lower Chesapeake Bay and coastal waters of Virginia prior to the 1987 to 1988 mass mortality event that affected that stock (1988), and boat and aerial surveys conducted in the lower Chesapeake Bay and Virginia Beach areas in July through October 1980 and May through June 1981 (Blaylock 1984; Garrison et al. 2003b; NMFS-SEFSC 2004). Bottlenose dolphin occurrence in the Chesapeake Bay is mostly known from opportunistic sightings and personal observations. Available data from surveys, opportunistic sightings from the North Atlantic Right Whale Consortium (NARWC) database, and sightings documented by other entities are included in **Figure 3-6**. See **Appendix A-3** for more information about these data sources.

  Individuals are sighted regularly in the Chesapeake Bay beginning in about mid-April (Swingle 1994) and are prevalent in the lower Chesapeake Bay from May through October (Swingle 1994; Foss and Reed 2003). By mid-November, bottlenose dolphins do not generally occur within the Chesapeake Bay (Barco et al. 1999); however, during winter 1996 to 1997, a lone dolphin was documented in Broad Bay, a shallow water bay connected to the Chesapeake Bay in Virginia Beach (Marchant et al. 1998). The dolphin remained in Broad Bay, was seen with a calf that summer, and continued to overwinter in the area accompanied by additional individuals (Marchant et al. 1998). Swingle (1994) reported that bottlenose dolphins can be found during December and January along the Virginia ocean-side coast; however, there were no bottlenose dolphin sightings north of Cape Henry on the southern edge of the mouth of the Chesapeake Bay during the 2002 winter MATS (Garrison et al. 2003b). Three winter records (all strandings) of bottlenose dolphins are displayed in **Figure 3-6**.

  Bottlenose dolphins appear to be present in the vicinity of Virginia Beach (including the Chesapeake Bay) only when water temperatures exceed 16°C (Barco et al. 1999; Armstrong et al. 2005). As water temperatures increase, dolphins expand their range into the upper portion of the Chesapeake Bay (Swingle 1994); McAlear Baker (2000) reported sighting bottlenose dolphins in the upper bay in Maryland during mid-May through mid-July, with a peak in sightings

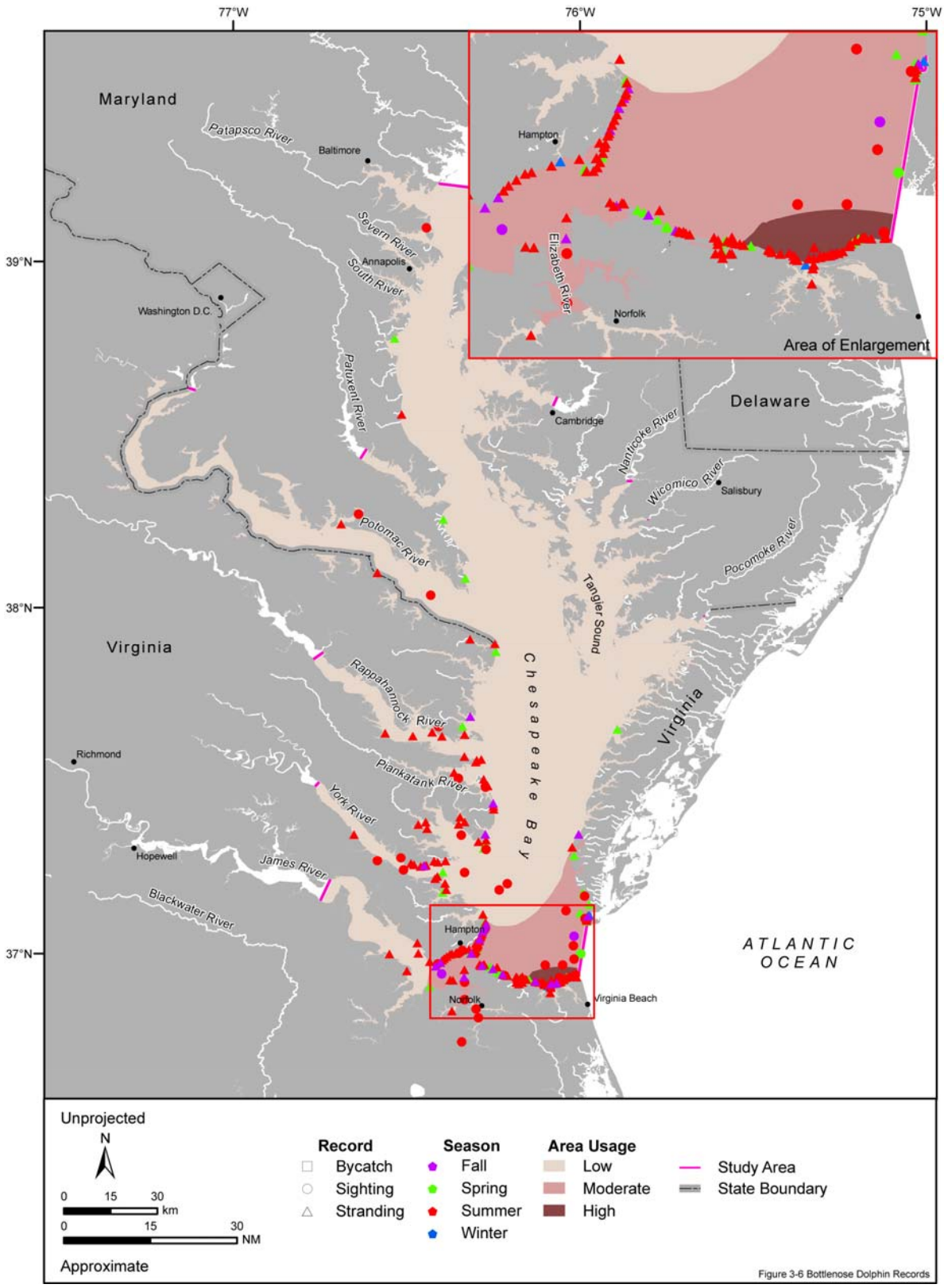

Figure 3-6. Bottlenose dolphin predicted habitat usage in the Chesapeake Bay Study Area. Available sighting, stranding, and incidental fisheries bycatch data are shown. Source data: refer to Table A-1.

during June. Swingle (1994) reported that a lone dolphin was sighted in the upper Chesapeake Bay from May to mid-July 1992 and then occasionally until September 1992. Most records in the upper reaches of the Chesapeake Bay and the more northern rivers such as the Potomac are from the spring and summer months (**Figure 3-6**). Only a few strandings north of the York River are from the fall and none are recorded in the winter (**Figure 3-6**). Additional strandings records not depicted in **Figure 3-6** are included in the VAQS Marine Mammal Stranding Database (1988-2008).[1]

The bottlenose dolphin has been seen in Virginia tributaries and creeks as shallow as 0.91 m and salinities of 10 to 15 psu (Swingle 1994). Blaylock (1988) observed a lone, apparently healthy, individual in 1980 24.14 km up Cypress Creek, a James River tributary.

Depicted in **Figure 3-6** are patterns of area usage by bottlenose dolphins based on regional expert opinion. It should be noted that this does not take into account any seasonality and is based on anecdotal observations by the expert and stranding response efforts but not directed research (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). The area around Cape Henry is designated as high usage by bottlenose dolphins (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). This area serves as a important "nursery area" for bottlenose dolphins in the Chesapeake Bay (Swingle 1994; Jones 1995; Swingle et al. 1995; Barco et al. 1999) with noted calving peaks in May, June, and July (Barco et al. 1999; Foss and Reed 2003). After August, calves are relatively absent from the entire Chesapeake Bay (Barco et al. 1999). The lower portion of the Chesapeake Bay Study Area from the vicinity of the Monitor-Merrimack Bridge-Tunnel north to Cape Charles/Fisherman Island is designated as an area of moderate use by bottlenose dolphins; some individuals disperse throughout this area. Farther up in the remainder of the Chesapeake Bay and its tributaries it is possible that a low number of bottlenose dolphins occur (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007).

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. Group sizes in the Chesapeake Bay surveys averaged between 25.7 and 43.5, but groups of up to 120 were observed during boat surveys (Blaylock 1984).

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 (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. Calf abundance in the Chesapeake Bay peaks in July (Barco et al. 1999). Foss and Reed (2003) noted a calving peak in May and June in the Elizabeth River. 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. 2003b). 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 more shallow and of a much shorter duration. Mean dive durations of Atlantic bottlenose dolphins typically range from 20 to 40 s 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 1998b). 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, S. National Marine Fisheries Service, Southeast Fisheries Science Center. pers. comm. 31 August 2006). For example, preliminary research indicates that characteristics of whistles from populations in the northern Gulf of Mexico significantly differ (i.e., in frequency and duration) from those in the western North Atlantic (Zaretsky et al. 2005; Baron, S. National Marine Fisheries Service, Southeast Fisheries Science Center. pers. comm. 31 August 2006).

Bottlenose dolphins can typically hear within a broad frequency range of 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 some lower (10 kHz) and higher (80 and 100 kHz) frequencies (Finneran and Houser 2006).

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

Description—The short-beaked common dolphin is a moderately-robust dolphin, with a moderate-length beak, and a tall, slightly falcate dorsal fin. The beak is shorter than in long-beaked common dolphins, *Delphinius capensis*, 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. 2008). 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. Individuals from the northeast Atlantic tend to be larger than those in other regions reaching 2.5 m in length (sometimes longer) (Jefferson et al. 2008).

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. 2009). There is no information available for western North Atlantic common dolphin stock structure (Waring et al. 2009).

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 2002), 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 1992b).

- Information Specific to the Chesapeake Bay—Records of short-beaked common dolphins in the Chesapeake Bay region are documented from December through June (Morgan et al. 2002; Swingle et al. 2007). Westgate (2005) lists common dolphin records, including strandings and biopsy efforts, for the North Atlantic during approximately this same time period. Stranding records of common dolphins have increased dramatically in the last 10 years in the Chesapeake

Bay area; this is now one of most commonly stranded offshore species in the Chesapeake Bay region (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 6 August 2007).

Opportunistic sightings of groups of common dolphin have been reported at the mouth of the Chesapeake Bay on a few occasions (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007); however, these data were not available for inclusion in this report. Although no other sightings have been documented in the Study Area, at least 17 strandings have been reported here in December, February, March, April, and June between 1999 and 2008. Most of these strandings are part of the VAQS Marine Mammal Stranding Database (1988-2008)[1] which was not available for this MRA. Four of the strandings are listed in Westgate (2005) and are depicted in **Figure 3-3**.

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; in the eastern North Atlantic Ocean and Mediterranean Sea it has been reported to be during spring and summer (Di Natale 1983; Murphy et al. 2005); however, calving peaks and locations of breeding areas in the western North Atlantic 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). Specific dive information for the western North Atlantic is not available.

Acoustics and Hearing—Recorded *Delphinus* spp. vocalizations include whistles, chirps, barks, and clicks (Ketten 1998b). 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 1998b; Oswald et al. 2003). Maximum source levels averaged approximately 180 dB re: 1 μPa-m 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 s.

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 common dolphin's hearing range extended from 10 to 150 kHz and was most sensitive from 60 to 70 kHz.

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

Description—Harbor porpoises are the smallest cetaceans in the North Atlantic with a maximum length of 2.0 m (Jefferson et al. 2008). The body is stocky, medium to dark gray 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 (Jefferson et al. 2008).

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 1992a) with additional studies supporting this hypothesis (Wang et al. 1996; Rosel et al. 1999c). The Gulf of Maine and Gulf of Fundy harbor porpoises are currently recognized as a single management stock separate from the populations in the Gulf of St. Lawrence, Newfoundland, and Greenland. 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. 2009).

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 1992a). Harbor porpoises are generally scarce in areas without significant coastal fronts or topographically-generated upwellings (Gaskin 1992a; Skov et al. 2003). Harbor porpoises occur most frequently over the continental shelf (Read 1999; Jefferson et al. 2008); 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 unequivocally support 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 extend to northern Florida (Polacheck 1995; Read 1999), but the general distribution of this species is likely limited to coastal waters of North Carolina during the colder months. Genetic evidence suggests limited trans-Atlantic movement (Rosel et al. 1999a).

From July through September, harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy, generally in waters less than 150 m deep (Palka 1995), with a few sightings in the upper Bay of Fundy and on the northern edge of Georges Bank (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. 2009), 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.[8] During this time of year, significant numbers of porpoises occur along the mid-Atlantic shore from New Jersey to North Carolina (Waring et al. 2009), 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. 2009). 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 may explain 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/Bay of Fundy stock (Rosel et al. 1999b).

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).

- Information Specific to the Chesapeake Bay—Inland waters of Virginia and North Carolina are considered to be part of the normal habitat of the harbor porpoise (Polacheck et al. 1995). The harbor porpoise occurs regularly in the Chesapeake Bay (Prescott and Fiorelli 1980; Polacheck et al. 1995). The vast majority of harbor porpoise strandings in Virginia waters (including the Chesapeake Bay) are between January and May, with a peak between March and May (Polacheck et al. 1995; Cox et al. 1998; Morgan et al. 2002; Swingle et al. 2007); this is when water temperatures are coldest. **Figure 3-3** shows eight records (six strandings and two bycatch) within the Chesapeake Bay; most of these were recorded in the winter or spring. A few records are documented in or near the Chesapeake Bay in the summer. For instance, two mid-July 1984 sightings are recorded outside the mouth of the Chesapeake Bay (Canadian Wildlife Service 2006)[1], and an early July 1996 stranding is documented on the shore of the James River. Only the latter summer record is included in the Chesapeake Bay Study Area and, therefore, depicted in **Figure 3-3**.

  At least 27 harbor porpoise strandings are documented in the Chesapeake Bay Study Area between 1994 and 2008 based on the VAQS Marine Mammal Stranding Database (1988-2008).[1] Most of these strandings are from the winter or spring; however, one was recorded in July. This database was not available for inclusion in this MRA.

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. 1998). At four to seven months of age (Read and Hohn 1995), harbor porpoise calves begin feeding on small, slow-moving krill and juvenile fishes (Smith and Read 1992; Gannon et al. 1998).

Harbor porpoises make brief dives, generally lasting less than 5 min (Westgate et al. 1995). Tagged harbor porpoise individuals spend 3 to 7% of their time at the surface and 33 to 60% in the upper 2 m of the water column (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 s (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 1998b), 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 1998a; 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 kilograms (kg); females reach 1.7 m in length and weigh between 60 and 110 kg (Jefferson et al. 2008). The harbor seal has a dog-like head with nostrils that form a broad V-shape; this is one of the characteristics that distinguishes them from immature gray seals (Baird 2001). Adult harbor seals exhibit considerable variability in the color and pattern of their pelage; the background color is tannish-gray overlaid by small darker spots, ring-like markings, or blotches (Bigg 1981).

Status—Five subspecies of *Phoca vitulin*a are recognized; *Phoca vitulina concolor* is the form found in the western North Atlantic (Rice 1998). Harbor seals are the most common and frequently reported seals in the northeastern U.S. (Katona et al. 1993). Currently, harbor seals along the eastern U.S. and Canadian coasts are considered a single population (Temte et al. 1991; Waring et al. 2009).

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 for the western North Atlantic stock is 99,340 individuals (Waring et al. 2009). The minimum population estimate of 91,546 seals is based on corrected total counts along the coast of Maine in 2001 (Waring et al. 2009). 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—Harbor seals are a coastal species, usually found near shore and frequently occupying bays, estuaries, and inlets (Baird 2001). Individual harbor seals have also been observed miles upstream in coastal rivers (Baird 2001).

Although primarily aquatic, harbor seals also utilize terrestrial environments where they haul out periodically. 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 Sea 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. 2009).

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. Harbor seals tagged 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 Chesapeake Bay—The harbor seal is considered a regular part of the marine fauna of the Chesapeake Bay, and healthy individuals are often reported in this region (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). Occurrences of harbor seals in the mid-Atlantic region are becoming more frequent in fall and winter months (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 2 September 2008). Harbor seals haul out at Virginia Beach, in Linkhorn Bay, and even at Hopewell up the James River (Blaylock 1985). Infrequently, small groups of harbor seals may be found near the islands of the Chesapeake Bay Bridge-Tunnel (Blaylock 1985). The three strandings depicted in **Figure 3-3** were recorded in the Study Area in May 1996 and February 1998. Several other strandings have also been documented in the Study Area in winter and summer between 1991 and 2003 but were not available for inclusion in this MRA (VAQS Marine Mammal Stranding Database [1998-2008]).[1] A large number of records, predominantly strandings, are documented just outside of the Study Area boundaries in the nearshore waters of Virginia (see DoN 2008).

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 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 cephalopods, crustaceans, and fishes, (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 s to 11 s) (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 1 kHz 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). Temporary threshold shift (TTS) for the harbor seal was assessed at 2.5 kHz and 3.53 kHz, with 80 and 95 decibels (dB) sensation level (SL, 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 decibels with a reference pressure of one squared micropascal-second (dB re: 1μPa^{2}s) (Kastak et al. 2005).

- **Gray Seal (*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. 2008). This species is sexually dimorphic (Jefferson et al. 2008). 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. 2008). Pelage color and pattern are individually variable, with most gray seals seen in shades of gray, slightly darker above than below (Jefferson et al. 2008). 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. 2009). 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 2003). 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; however, surveys of the Maine coast in 2001 counted 1,731, and a 1999 estimate of the Massachusetts population indicated 5,611 animals (Baraff and Loughlin 2000; Waring et al. 2009); however, gray seal abundance appears to be increasing in the U.S. Atlantic exclusive economic zone (EEZ) (Waring et al. 2009). 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 gravel/sand sediment, which is the preferred 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).

Historically, gray seals were 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. 2009). 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). Resident colonies and pupping have been observed in Maine since 1994, on a few islands (Seal and Green) in Penobscot Bay (Waring et al. 2009). 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. 2009). 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 Chesapeake Bay—Sporadic occurrences of the gray seal are observed in the Chesapeake Bay, including sightings of healthy individuals (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 3 August 2007). Records from the Mid-Atlantic Bight are typically from winter and spring. Reports of young gray seals from December through April in inshore and nearshore mid-Atlantic waters are increasing (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 2 September 2008). NMFS recorded a stranding in March 1998 in the upper Chesapeake Bay (**Figure 3-3**). Other strandings have been reported in the Study Area in March 2003, April 2003, and June 2007 (see VAQS Marine Mammal Stranding Database [1988-2008]).[1] Two incidences of pupping in the vicinity of the Chesapeake Bay were recorded at Assateague Island in 1986 and 1989 (Katona et al. 1993).

Behavior and Life History—Gray seals are gregarious at haulout sites but are usually solitary or in small, dispersed groups while at sea (Jefferson 2008). Gray seals are observed spending long periods of time resting submerged in the water next to haulout 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 comes 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 1998b); the maximum energy is between 0.1 to 10 kHz (Asselin et al. 1993; Ketten 1998b). The source level is unknown.

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 1.9 m and 135 kg for males and 1.8 m and 120 kg for females (Jefferson et al. 2008). 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 (Jefferson et al. 2008). Newborn pups, called "whitecoats", have a long, white coat that is replaced soon after weaning (at about three to four 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 grounds in the White Sea, the Greenland Sea north of Jan Mayen, and the western North Atlantic (Gulf of St. Lawrence and Newfoundland) (Ronald and Healey 1981). The western North Atlantic population (also known as the Front/Gulf 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 (Waring et al. 2009). The best estimate of abundance for the western North Atlantic stock is 5.5 million seals; data are insufficient to calculate the minimum estimate for this stock (Waring et al. 2009).

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 2003).

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 widely distributed in the North Atlantic and Arctic oceans mainly from Hudson Bay and Baffin Island east to northern Russia (Jefferson 2008). 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. 2009). 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. 2009). Occurrences as far south as South Carolina are reported (McFee, W., National Ocean Service. pers. comm., 20 November 2006).

- Information Specific to the Chesapeake Bay—Sporadic occurrences of the harp seal are documented in the Chesapeake Bay region. This species has become more common in recent years (Barco, S., Virginia Aquarium and Marine Science Center, pers. comm., 2 September 2008). Occurrences in the mid-Atlantic region are from December through June. Goodwin (1954) discussed two individuals found within the Chesapeake Bay: an adult caught in a fisherman's net on 12 March 1945 at Little Creek and a baby harp seal that came ashore at Little Creek and died on 13 March 1945 (**Figure 3-3**). For additional strandings in the lower Chesapeake Bay were reported in April 1996, March 2004, February 2007, and April 2007 (VAQS Marine Mammal Stranding Database [1988-2008]).[1]

  There are also several records that fall just outside of the Study Area. On 22 February 2007, a harp seal was found in the dunes at First Landing State Park on Cape Henry.[2] She was released on 30 March 2007 from First Landing State Park with a satellite tag.[3] Another animal stranded on 20 April 2007 in Chincoteague National Wildlife Refuge and was released on 19 May 2007 from First Landing State Park.[3]

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). Haulout durations observed in the Gulf of St. Lawrence averaged 21 min (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 that 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 ± 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).

3.1.2.3 Extralimital Species of the Chesapeake Bay Study Area

Extralimital occurrences of 10 marine mammal species have been documented in the Chesapeake Bay region. Stranding records are not necessarily indicative of the presence of animals in the Chesapeake Bay as currents, oceanographic features, and/or other influences (i.e. ships; Laist et al. 2001) may transport a previously dead animal from other areas into the Chesapeake Bay. Below is a list of available records of extralimital species reported in the Chesapeake Bay. Comprehensive species descriptions and distributions in the mid-Atlantic can be found in the VACAPES MRA (DoN 2008). Other species included in **Table 3-1** but not discussed here are considered extralimital to the Study Area based on occurrences near the Chesapeake Bay (see DoN 2008).

- The VAQS Marine Mammal Stranding Database (1988-2008) includes one stranding of a sei whale near the mouth of the James River in February 2003.[1] In addition, a sei whale in the Chesapeake Bay was documented in May 1998 when a dead individual was brought into Baltimore on the bow of a ship (Laist et al. 2001).

- At least six strandings of the minke whale have been reported in the Chesapeake Bay Study Area. Schwartz (1962) reported a stranding of an immature minke whale in the upper Chesapeake Bay at Dares Beach, Maryland during July 1959 (**Figure 3-7**). Two additional strandings were both documented during June; one in 1995 and one, north of the Chesapeake Bay-Tunnel Bridge, in 1999 (**Figure 3-7**). There was also a ship strike incident that involved a minke whale in Hampton Roads, Virginia, during August 1994 (Jensen and Silber 2003; **Figure 3-7**); it is unlikely that the animal was struck at that location but rather was struck offshore and carried inshore on the bow of a ship. Two other strandings, which are included in the VAQS Marine Mammal Stranding Database (1988-2008), were recorded in the Chesapeake Bay in December 2003 and May 2004.[1]

- A Bryde's whale was found stranded during winter 1927 at Walnut Point just within the Potomac River in the Chesapeake Bay (Mead 1977; **Figure 3-7**). Miller (1927) erroneously identified this specimen as an immature fin whale, but Mead (1977) corrected the identification based on examination of photographs and baleen.

- A few *Kogia* records are documented in the Study Area. Morgan et al. (2002) provides a listing of stranding and bycatch records for *Kogia* impacted by human interactions in Virginia waters. This list includes a stranding of a pygmy sperm whale at Capahosic in the York River during October 1975, a sighting of two pygmy sperm whales that involved a boat collision and subsequent mortality of one of the individuals near Hampton, and an August 1988 pygmy sperm whale entanglement in a crab pot line at Hampton (**Figure 3-7**). Additionally, a pygmy sperm whale stranded in the Elizabeth River during November 1995 (**Figure 3-7**). A *Kogia* species stranded in

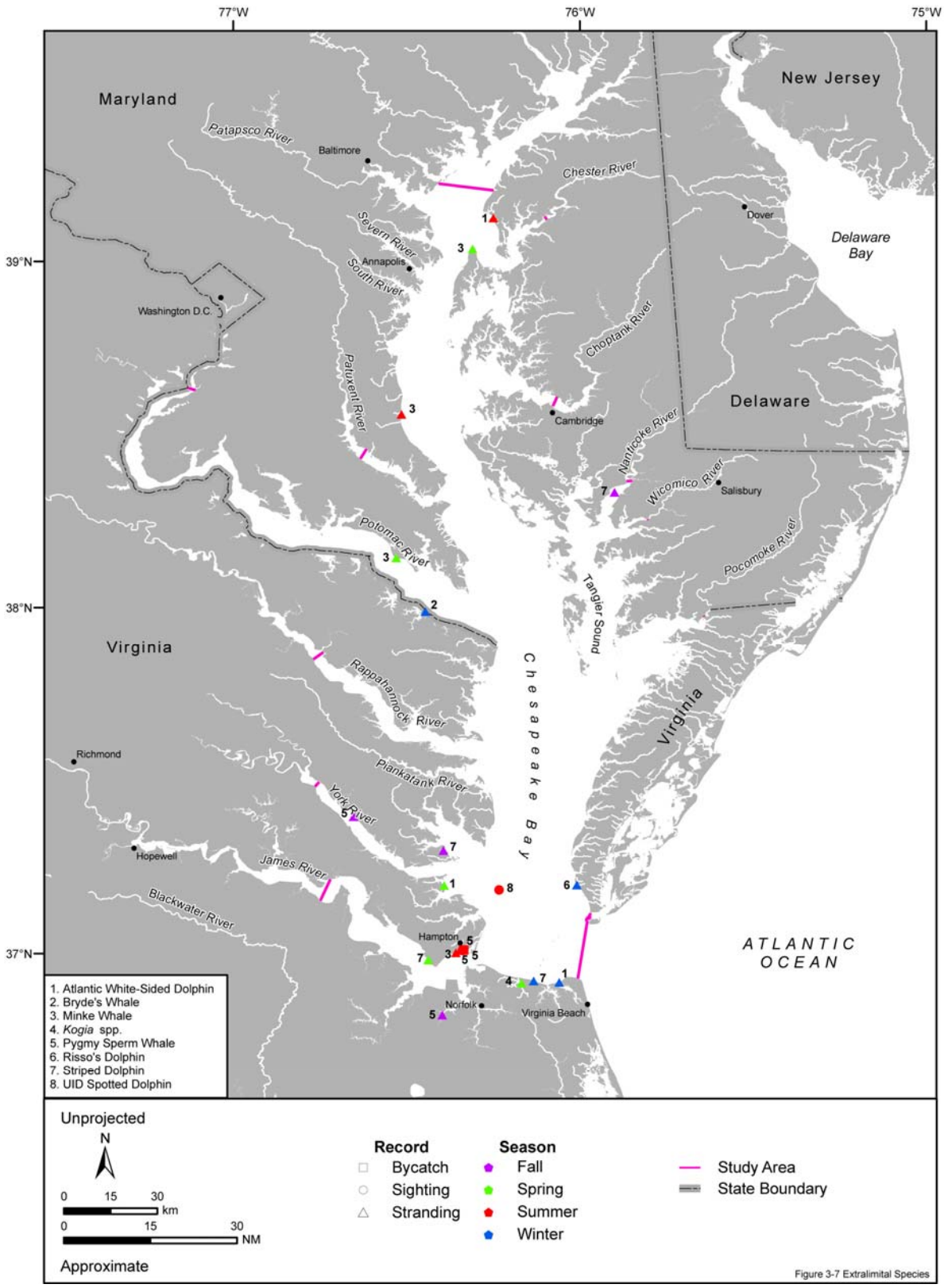

Figure 3-7. Sighting, stranding, and incidental fisheries bycatch records of extralimital marine mammal species or species group in the Chesapeake Bay Study Area. Source data: refer to Table A-1.

April 2006 at Little Creek (Swingle et al. 2007; **Figure 3-7**). This record is listed in Swingle et al. (2007) as a sperm whale, but this was an inadvertent truncation of the data field in the report (Swingle, M., Virginia Aquarium and Marine Science Center, pers. comm., 17 July 2007). Two other strandings are recorded in the Study Area in February 1994 and May 2001 but were not available to be plotted (see VAQS Marine Mammal Stranding Database [1988-2008]).[1]

Morgan et al. (2002) also included records that did not provide enough detail to map such as an August 1987 incidental capture of a pygmy sperm whale in a pound net in the York River. In addition, Morgan et al. (2002) reviews records that may fall just outside of the Study Area, including several records of dwarf sperm whales, an incidental capture of a pygmy sperm whale in Northampton in July 1988, and a May 1989 stranding of a pygmy sperm whale in Northampton with a gunshot wound. A pygmy sperm whale also stranded just outside the mouth of the Chesapeake Bay in October 2007 (see VAQS Marine Mammal Stranding Database [1988-2008]).[1]

- There is one opportunistic sighting of eight spotted dolphins made in July 1979 in the York River (**Figure 3-7**; Kenney, R.D., University of Rhode Island, pers. comm., 18 July 2007). Based on the known habitat associations of the two spotted dolphin species, as well as the fact that the vast majority of spotted dolphin strandings along the Atlantic coast of northeastern and mid-Atlantic states are of the Atlantic spotted dolphin, it is likely that the sighting was of an Atlantic spotted dolphin (Kenney, R.D., University of Rhode Island, pers. comm., 18 July 2007). The VAQS Marine Mammal Stranding Database (1988-2008) includes a pantropical spotted dolphin stranding in the Chesapeake Bay in October 1994.[1]

- Wilson et al. (1987) reported a striped dolphin stranding during December 1980 in the upper Chesapeake Bay and two in the lower Chesapeake Bay (January and April 1979) (**Figure 3-7**). NMFS recorded a stranding at Mobjack Bay in December 1997 (**Figure 3-7**). Additional strandings were documented in May 1995, November 2001, August 2005, and September 2005 but are not included in **Figure 3-7** (VAQS Marine Mammal Stranding Database [1988-2008]).[1]

  O'Hara et al (1986) report the capture of one individual in a gillnet fishery in the Chesapeake Bay area which Morgan et al. (2002) listed as a stranding in their review of Virginia records. Morgan et al. (2002) also discussed two January strandings from Northampton County in 1986 and 1987.

  Blaylock (1985) mentioned that an extremely rare group of striped dolphins was sighted near the mouth of the Chesapeake Bay in the 1960s, but no further details were provided. Likewise, Morgan et al. (2002) reported that “large herds” of striped dolphins were recorded off the mouth of the Chesapeake Bay with no further details provided.

- Three Atlantic white-sided dolphin strandings have been recorded within the Chesapeake Bay Study Area. Two were reported in the lower Chesapeake Bay (**Figure 3-7**): one was a stranding on the Chesapeake Bay side of Cape Henry during March 2006 (Swingle et al. 2007) while the other was near the Poquosan River during May 2006 (Swingle et al. 2007). The other stranding was reported in the upper Chesapeake Bay in August 1998 at Rock Harbor, Maryland (**Figure 3-7**).

- NMFS reported a Risso’s dolphin stranding on Cape Charles during mid-February 1998 (**Figure 3-7**). Based on the VAQS Marine Mammal Stranding Database (1988-2008),[1] at least three other strandings are documented in the Study Area (May 1992, August 1998, and August 2003) but were not available for inclusion in **Figure 3-7**.

- One melon-headed whale was reported stranded in the lower Chesapeake Bay in June 2008 (VAQS Marine Mammal Stranding Database [1988-2008]).[1] This is the only record of this species in the Study Area.

- Morgan et al. (2002) discuss several pilot whale stranding records for the Chesapeake Bay region, including within the Chesapeake Bay. For example, a short-finned pilot whale was reported to have stranded in Hampton in January 1983 (Morgan et al. 2002). Additionally, a long-finned pilot whale stranded in May 1985 in Northampton, in July 1989 in Mathews County, and in July 1935 on Smith Island (Morgan et al. 2002). A pilot whale which could not be identified to the species level stranded in Northampton in July 1983 (Morgan et al. 2002). Exact locations of these records are unknown; therefore, they could not be plotted.

- Extralimital occurrences of the hooded seal are recorded year-round in the mid-Atlantic region. Allen (1880) reported on a hooded seal captured in the Chesapeake Bay during 1865 near Cambridge, Maryland. Other records of hooded seals are documented near the Chesapeake Bay Study Area and include the following: a February 1996 stranding on the ocean side of Cape Henry; five live-strandings in July, August, and October 2006; and one dead-stranding in July 2006 (Swingle et al. 2007; DoN 2008).

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3.2 SEA TURTLES

Sea turtles are long-lived, highly migratory reptiles found throughout the world's tropical, subtropical, and temperate seas (Lutz and Musick 1997). There are seven living species of sea turtles from two distinct families: the Dermochelyidae (one species, leatherback sea turtle [*Dermochelys coriacea*]) and the Cheloniidae (hard-shelled sea turtles; six species). Sea turtles in these two families are distinguished from one another based upon their carapace structure (upper shell) and other morphological characteristics. 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). Sea turtle populations have declined dramatically in the last few centuries due to anthropogenic activities such as coastal development, oil exploration, commercial fishing, marine-based recreation, pollution, and over-harvesting (NRC 1990; Eckert 1995). As a result, all six species of sea turtles found in U.S. waters are currently listed as either threatened or endangered under the ESA of 1973.

3.2.1 Introduction

Modifications to the body and limbs from the terrestrial turtle anatomy 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 external 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; sea turtle size, particularly among adults, limits the type of predators who can successfully consume a sea turtle. 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: NOAA Fisheries - Office of Protected Resources (http://www.nmfs.noaa.gov/pr/species/turtles/), Marine Turtle Specialist Group (MTSG; http://www.iucn-mtsg.org/), Mediterranean Association to Save the Sea Turtles (MEDASSET) (http://www.medasset.org/medas.htm), seaturtle.org (http://www.seaturtle.org), the Caribbean Conservation Corporation (CCC; 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 (http://www.nmfs.noaa.gov/pr/species/turtles/symposia.htm), Bjorndal (1995), Lutz and Musick (1997), Bolten and Witherington (2003), and Lutz et al. (2003).

3.2.1.1 Sea Turtle Life History

Sea turtles are dependent on both marine and terrestrial habitats during different life stages. Although specialized for life at sea, sea turtles begin their lives on land. Their brief terrestrial period lasts approximately 40 to 70 days as embryos and an additional few minutes to few hours as hatchlings scrambling from the beach to the ocean (Miller 1997). 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 sea turtle 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

(Balazs 1980; Whittow and Balazs 1982; 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 or on the same beach where they hatched (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 (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, often exhibiting strong site fidelity to specific beaches (Papi et al. 1995; Addison 1996; Miller 1997; Papi et al. 1997). 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 nest 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 (by 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 have a strong tendency to 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; Witherington and Martin 2003). 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 reach maturity and reproduce (Frazer 1986).

3.2.1.2 Sea Turtle Distribution and Behavior

Existing dispersal models suggest that post-hatchlings, neonates, and smaller juveniles spend the first few to many years of their lives in oceanic waters. Based on in-water observations some species of sea turtle post-hatchlings will drift in convergence zones and *Sargassum* rafts where they find refuge and food (pelagic invertebrates and other items that accumulate in surface circulation features) (Carr 1987; Witherington 2007). Originally labeled the "lost year" this stage in a sea turtle's life history is now known to be much longer than one year, possibly lasting a decade or more (Chaloupka and Musick 1997; Bjorndal et al. 2000a). Upon leaving the nesting beach, post-hatchlings are likely picked up by the nearest major current (Carr 1987). Available evidence now indicates that this lost year involves at least several years of drifting in oceanic gyre systems in a semi-passive migration that may circumnavigate entire ocean basins (Bowen et al. 1995; Bolten et al. 1998; Lahanas et al. 1998). Recent tagging work has demonstrated that young turtles (small juveniles) are not passive drifters in major ocean currents, but are able to move all directions through energetic and complex habitats (e.g., Bolten 2003b; Polovina et al. 2006; Kobayashi et al. 2008). Sea turtles spend nearly a decade growing in the oceanic "early juvenile nursery habitat" before migrating to neritic feeding grounds, which are known as the "later juvenile developmental habitats" (Musick and Limpus 1997). Later juvenile or sub-adult developmental habitat for hard-shelled (non-leatherback) sea turtles is commonly shallow near shore and inshore waters. Some of these larger coastal juveniles may also seasonally migrate between spring/summer foraging grounds and winter habitats (Musick and Limpus 1997). Depending upon the season, leatherback turtles use coastal feeding areas in temperate waters or offshore feeding areas in tropical waters as later developmental habitat (Frazier 2001). Late juvenile/sub adult hard shelled 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, macroalgae, and seagrasses (Bjorndal 1997). An exception is

the leatherback turtle, which feeds on pelagic soft-bodied invertebrates at both the surface and at depth (S.A. Eckert et al. 1989). A sea turtle's diet varies according to its feeding habitat and its preferred prey. 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).

Immature and adult sea turtles are known to exhibit strong site fidelity to discrete foraging areas; some species will return year after year to their established foraging grounds after long seasonal migrations between summer and winter foraging habitats (Avens et al. 2003; Mansfield 2006). Sea turtles undergo complex seasonal movements influenced by changes in ocean currents, turbidity, salinity, food availability, and perhaps most importantly, water temperature (Epperly et al. 1995c; Davenport 1997; Coles and Musick 2000; Luschi et al. 2003). Most sea turtles become lethargic at temperatures below 10°C and above 40°C (Spotila et al. 1997), and may even become cold-stunned in extremely cold waters when rapid temperature drops occur. One strategy to avoid cold water temperatures is for animals to migrate to warmer waters. This has been observed among turtles in the northeastern U.S. (Keinath 1993; Musick and Limpus 1997; Mansfield 2006). Alternatively, in some locales (such as the Mediterranean and off Florida), some individual green and loggerhead turtles escape cold conditions by resting on the seabed or burying themselves in the bottom sediment and brumating (Ogren and McVea 1995; Hochscheid et al. 2005), conducting very long dives, sometimes more than five hours in duration (Hochscheid et al. 2005; Hawkes et al. 2007). 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 thermoregulate (Spotila et al. 1997; Southwood et al. 2005; Wallace et al. 2005). Leatherback turtles can remain active even in very cold water, down to at least 0.4°C (James et al. 2006a). It is important to note that most sea turtle movement and population data are limited to information obtained from either in-water captured juvenile/sub-adult sea turtles or adult female turtles captured on nesting beaches. Few data exist on the movements of adult male sea turtles or the movements and population estimates of oceanic juveniles and post-hatchlings.

Aside from latitude and season, sea temperatures also vary based on depth. Vertical differences in temperatures may influence sea turtle diving behavior (Byles 1988; Keinath 1993; Nelson 1996; Mansfield 2006). In temperate regions like the U.S. Mid-Atlantic and northeast, sea turtle dive behavior may vary with season, particularly during the cooler seasons when the water column may be highly stratified (Keinath 1993; Nelson 1996; Mansfield 2006). Immature loggerheads (*Caretta caretta*) observed in Georgia and South Carolina spent more time at the surface in the spring due to colder sea temperatures (Keinath et al. 1995; Nelson 1996; Mansfield 2006). Nelson (1996) observed seasonal variations in surfacing behavior among immature loggerheads tracked in Georgia: turtles spent a greater percentage of their time (19.0%) at the surface in the spring compared to later in the season. Mansfield (2006) observed similar differences in Virginia where immature loggerheads and Kemp's ridley turtles spent 10% to 50% of their time at the surface compared to 5% of the time during the warmer summer months (Byles 1988; Mansfield 2006). Nelson (1996), Keinath et al. (1995), and Mansfield (2006) attributed this difference to the colder stratified spring water temperatures.

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 (James et al. 2006a; McMahon and Hays 2006). Large-scale climatic events may affect turtles by loss of nesting beaches as sea levels rise (Vagg and Hepworth 2006). Nesting biology of sea turtles is strongly affected by temperature both in timing and in the sex-ratio of hatchlings. The effects of climate change may upset the natural ratio of male to female hatchlings, as higher temperatures during incubation tend to produce more females (e.g., Hays et al. 2003; Hawkes et al. 2007). Earlier nesting and longer nesting seasons are also being correlated with warmer SSTs (e.g., 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 nanometers [nm]), with peak sensitivity for loggerhead and green turtles occurring at 580 nm (yellow) (Bartol and Musick 2003; Levenson et al. 2004). Leatherback spectral sensitivity is primarily at shorter wavelengths 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. (1972b) 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. These throat movements appear to be a means to pump water through the nasal cavities so the turtle can smell underwater (Manton et al. 1972b). Upon a chemical release, flipper movements increased and approaches towards the cue were quite violent (Manton et al. 1972b). Constantino and Salmon (2003) also found that turtles have responses to chemical stimuli and will orient themselves into currents towards the stimuli when food is not directly visible; however, when food is visible, sea turtles ignore the chemical stimuli and head towards the food source. 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 (Manton et al. 1972b, 1972a; Grassman et al. 1984; Owens et al. 1986).

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). Although auditory data have never been collected for the leatherback turtle, there is an anecdotal observation of this species responding to the sound of a boat motor (ARPA 1995). It is unclear what frequencies of the sound this species was detecting. In terms of sound production, nesting leatherback turtles have been recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Mrosovsky 1972; Cook and Forrest 2005).

Adult loggerheads have also been observed to initially respond to (i.e., increase swimming speeds) and avoid air guns when received levels range from 151 to 175 decibels at the reference level of one micropascal (dB re: 1 μPa), but they eventually habituate to these sounds (Lenhardt 2002). One turtle did exhibit TTS for up to two weeks after exposure to these levels (Lenhardt 2002). Juveniles loggerheads were found to avoid low-frequency sound (less than 1,000 Hz) produced by air guns (O'Hara and Wilcox 1990). In a separate study, green and loggerhead sea turtles exposed to seismic air guns began to noticeably increase their swimming speed, as well as swimming direction, when received levels reached 155 dB re: 1 $\mu Pa^2 s$ for green turtles and 166 dB re: 1 $\mu Pa^2 s$ for loggerhead turtles (McCauley et al. 2000).

3.2.2 Sea Turtles of the Chesapeake Bay Study Area

Five species of sea turtles have been recorded in the Chesapeake Bay Study Area. These include the leatherback, loggerhead, Kemp's ridley, green, and hawksbill (*Eretmochelys imbricata*) turtles (**Table 3-2**). Of these, the loggerhead is the most common followed by the Kemp's ridley. The loggerhead is also the most widely distributed species encountered in the Chesapeake Bay and is the only species that nests on Virginia's beaches (e.g., Lutcavage and Musick 1985; Byles 1988; Keinath 1993; Broderick et al. 2002; Mansfield 2006). The leatherback occurs less frequently, while the green is a relatively rare visitor in these waters. Since 1979, only three hawksbills have been encountered within the Study Area. Critical habitat has not been designated for any species of sea turtle in the Chesapeake Bay.

Table 3-2. Sea turtle species with known or potential occurrence in the Chesapeake Bay Study Area. Taxonomy follows Pritchard (1997).

Classification	Scientific Name	Status	Occurrence[1]
Order Testudines (turtles)			
Suborder Cryptodira (hidden-necked turtles)			
Family Dermochelyidae			
Leatherback Turtle	*Dermochelys coriacea*	Endangered	Rare
Family Cheloniidae (hard-shelled turtles)			
Loggerhead Turtle	*Caretta caretta*	Threatened	Regular
Kemp's Ridley Turtle	*Lepidochelys kempii*	Endangered	Regular
Green Turtle	*Chelonia mydas*	Threatened[2]	Rare
Hawksbill Turtle	*Eretmochelys imbricate*	Endangered	Extralimital

[1] A species' occurrence in the Study Area can be described as one of the following: Regular-occurs as a regular or normal part of the fauna in the Study Area, regardless of how abundant or common it is; Rare-occurs in the Study Area sporadically; or Extralimital-does not normally occur in the Study Area and occurrences there are considered beyond the species' normal range.

[2] Although this species as a whole is listed as threatened, the Florida nesting stock of green turtles is listed as endangered. Since the nesting area for green turtles encountered at sea often cannot be determined, a conservative approach to management requires the assumption that all green turtles found in the Study Area are endangered.

Sea turtles enter the Chesapeake Bay on a seasonal basis. Due to cold winter temperatures well below those associated with cold stunning, sea turtles cannot live within the Chesapeake Bay waters year-round. Sea turtles enter the Chesapeake Bay each spring when the sea temperatures begin to warm (Lutcavage and Musick 1985; Byles 1988; Musick 1988; Keinath 1993; Coles 1999; Mansfield 2006). Virginia's aquatic sea turtle habitat includes all coastal waters and extends through the entire main-stem Chesapeake Bay including at least five to ten miles up the tributaries; however, recent satellite telemetry indicates that some individual turtles may travel beyond the 5-mi tributary limit into fresher waters (Lutcavage and Musick 1985; Byles 1988; Musick 1988; Mansfield 2006). Nesting habitat includes beaches along the Atlantic side of the Eastern Shore and beaches south of the Chesapeake Bay mouth from the Virginia Beach oceanfront south to the North Carolina border. Virginia's beaches represent the northern extent of loggerhead nesting in the United States.

The majority of sea turtles found in the Chesapeake Bay are either immature loggerhead or Kemp's ridley sea turtles utilizing the bay as a seasonal foraging ground (Lutcavage and Musick 1985; Musick 1988). The Chesapeake Bay is considered an important juvenile developmental habitat for loggerhead sea turtles (Musick and Limpus 1997). Approximately 5% of the sea turtles found in the Chesapeake Bay are adults (Lutcavage and Musick 1985; Musick and Limpus 1997). Sea turtles found in the Chesapeake Bay undertake migrations that are correlated to seasonal temperature fluctuations (Byles 1988; Musick 1988; Keinath 1993; Coles 1999; Mansfield 2006). Turtles are resident in Virginia waters from May through October or early November, though a few strandings have been recorded as early as April or as late as

December (Byles 1988; Keinath 1993; Coles 1999). Aerial and stranding data indicate that springtime SSTs must typically warm to approximately 18°C before turtles will migrate into the Chesapeake Bay waters (Lutcavage and Musick 1985; Keinath et al. 1987b; Byles 1988; Musick 1988; Keinath 1993; Coles 1999). Similarly, when SSTs drop again in the fall, turtles begin their southern migration out of the Chesapeake Bay to their winter habitats south of Cape Hatteras, North Carolina (Keinath 1993; Mansfield 2006). Turtles found foraging in the Chesapeake Bay will over-winter in waters ranging from North Carolina south to Florida and the Gulf of Mexico (Keinath 1993; Mansfield 2006).

Each year, as many as 500 sea turtle stranding deaths are recorded within Virginia's waters. The majority (55%-60%) of these strandings occur during the spring migration late May or early June (Mansfield 2006). This phenomenon has been documented by the Virginia Sea Turtle Stranding Network since 1979. During this peak stranding event, mean water temperatures typically range between 18° and 22°C (Coles 1999). There is an additional, minor peak in strandings during the fall migratory period (October and November) as temperatures begin to drop (Lutcavage and Musick 1985; Musick 1988). Within the last 10 to 15 years, sea turtle stranding reports have risen upwards of 200%, possibly due to increased effort within the state stranding network and/or an increase in mortality among turtle populations in the region (Mansfield 2006).

The majority of turtle strandings washing up on Virginia beaches are moderately to severely decomposed individuals. As a result, evidence of illness or human-induced mortality is difficult to impossible to determine. Probable causes of death that have been identified include: propeller strikes, ingested fishing gear, cold stunning, and possible net entanglement (Mansfield et al. 2002b; Mansfield et al. 2002a; Mansfield 2006). Virginia's turtles have also been known to interact with some fishing gear and commercial vessels such as pound nets, pot gears, larger mesh gillnets, longline and trawling gear, and hopper dredges (Mansfield 2006).

Mark-recapture population modeling in the early 1980s indicated that a minimum of 3,000 sea turtles enter the Chesapeake Bay each year (Lutcavage and Musick 1985). Aerial survey data from the mid-1980s (1982-1985) and early 1990s (1991-1992) indicated that 6,500 to 9,700 turtles could be found in the lower Chesapeake Bay waters within any given season (Byles 1988; Keinath 1993). High numbers of sea turtles were observed during the spring of the year, implying that the greatest sea turtle abundances occurred within the spring (Byles 1988; Keinath 1993; Mansfield 2006); however, recent data indicate that turtles entering the Chesapeake Bay in the spring may be spending more time at the sea surface within the warmer surface waters, and are therefore much more likely to be counted by aerial observers (Mansfield 2006).

Telemetry studies in the 1980s indicated that sea turtles spend approximately 5.3% of their time at the surface while foraging in the Chesapeake Bay during the summer months (Byles 1988). Byles (1988) observed that many loggerhead turtles passively drifted with the tides as they foraged within tidal channels of the Chesapeake Bay's tributaries; however, when migrating, loggerhead sea turtles are likely to spend more time at the surface due to the metabolic costs of swimming. Mansfield (2006) found that the time spent at the surface varies with season or geographic location. When temperatures are cooler or more stratified, loggerheads spent between 10% and 25% of their time at the surface; Kemp's ridleys spent up to 50% of their time at the surface (Mansfield 2006). Thus, springtime sea turtle abundance estimates from the 1980s and early 1990s were likely overestimated by 50% to 80% (Mansfield 2006).

Sea turtle population estimates for the Chesapeake Bay were not continuously quantified between the 1980s and 2000s. Surveys conducted from 2001 through 2004 indicate a significant drop in abundances (65%-75%) over time, despite correcting spring time abundances for seasonal detectability (Mansfield 2006). Between 2,500 and 5,000 sea turtles currently enter the lower Chesapeake Bay each year compared to 6,500 to 9,700 in the 1980s, the majority of which are loggerheads; only a few hundred Kemp's ridley sea turtles are estimated in the Chesapeake Bay during any given year (Lutcavage and Musick 1985; Byles 1988; Mansfield 2006). This drop may partially be attributed to relatively smaller observed springtime peaks in aerial sea turtle observations over time (Mansfield 2006). During the 1980s and to some extent in the 1990s, large numbers of turtles were observed during the spring flights relative to the observations later in the summer. This spring peak was proportionally smaller during the 2001-

2004 flights. These spring peaks may in part be attributed to an influx of transient turtles stopping briefly in the lower Chesapeake Bay as they wait for sea temperatures to warm so they can continue their seasonal migration into waters further north. Thus, the proportional drop in springtime estimates may be due to a) an actual decline in the sea turtle population; and/or b) fewer transient turtles briefly entering the Chesapeake Bay waters on their northern migration (Mansfield 2006). One of the primary prey items for both loggerhead and Kemp's ridley sea turtles found foraging in the Chesapeake Bay is, historically, the blue crab (*Callinectes sapidus*) (Lutcavage and Musick 1985; Musick 1988; Seney 2003; Seney and Musick 2005, 2007). There has been a documented decline in the blue crab over the last 20+ years due to heavy fishing pressure (Lipcius and Stockhausen 2002). Seney and Musick (2007) documented a shift in the diet of loggerheads in the Chesapeake Bay over this time period from mostly blue crabs in the 1980s to fewer crabs and more fish in more recent years (Seney 2003). It is possible that with fewer available prey items, fewer transient loggerheads may select to enter the Chesapeake Bay during their initial spring migrations (Mansfield 2006).

Satellite telemetry data from immature and adult female loggerheads, and immature Kemp's ridleys captured in Virginia, indicate that many individuals establish significant site fidelity to relatively discrete foraging areas within the Chesapeake Bay and waters south of the bay mouth to Cape Hatteras and the Outer Banks, North Carolina (Mansfield 2006). Based on historic mark-recapture data, some individuals returned to the same foraging areas over subsequent seasons (Mansfield 2006). Long-term (1979-2002) mark-recapture data from a pound net study in the western Chesapeake Bay indicate that many individual sea turtles exhibit strong philopatry to specific foraging grounds within the bay (Mansfield 2006). These data include strong inter-annual site fidelity with more than 20% of individual loggerheads recaptured in study nets over one to eleven seasons (Mansfield 2006). Very few Kemp's ridleys were recaptured during this study, possibly due to gear selectivity and/or differing foraging strategies from loggerheads. Mansfield (2006) used satellite telemetry to track the movements of one adult loggerhead captured multiple times in study nets within the Potomac River tributary between 1999 and 2002. Track data resulted in an approximate 74% overlap in the home range for this animal over a three-year period indicating very strong fidelity to one particular region (Mansfield 2006).

Southern migrations out of the Chesapeake Bay in the fall are typically triggered when surface temperatures drop below 20°C (Mansfield 2006). The waters south of Cape Hatteras, North Carolina, along the outer continental shelf and the western edge of the Gulf Stream serves as wintering habitat for most loggerheads tracked from Virginia waters (Mansfield 2006). Some turtles migrate as far south to Florida and the Gulf of Mexico; however, a few turtles were observed to be transported by the Gulf Stream to the North Atlantic and the Grand Banks, indicating some plasticity in habitat selection (Mansfield 2006). The relatively short seasonal migrations from the North Carolina wintering grounds to the Chesapeake Bay foraging habitat may contribute to the strong inter-annual site fidelity observed in the telemetry and mark-recapture studies (Mansfield 2006).

The distribution of all available sea turtle occurrence records (including unidentified turtles) in the Chesapeake Bay Study Area and vicinity is presented in **Figures 3-9**, **3-10**, and **3-11**. Sea turtle occurrence records include sightings (green square), strandings (green triangle), incidental fisheries bycatch records (green circles), and nesting events (orange stars). The greatest number of sea turtle strandings in the Chesapeake Bay occurs during the spring and are predominately loggerheads (**Figure 3-8**). Maryland waters see significantly less strandings than Virginia's but also peak in the spring. It should be noted that the number of sea turtle records in a given season or portion of the Study Area 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 sightings records. The hard-shelled sea turtles (green, loggerhead, 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 the observers do not have a high level of experience (Kenney, R.D., University of Rhode Island, pers. comm., 24 February 2005). Species identification is less reliable when individuals from the general public (e.g., commercial and recreational fishermen, beachgoers) sight sea turtles (Lund 1985).

A listing and description of data sources used to determine each species' occurrence in the Chesapeake Bay Study Area and vicinity is found in **Appendix A-3**, while the process used to create the map figures is described in **Section 1.5.2.2**. On the map figures, various types of shading and terminology designate the areas of occurrence for each sea turtle species. Areas of "primary" occurrence (shaded in dark blue) are defined as areas and habitats where a species is primarily found. Areas of "secondary" occurrence (shaded in medium blue) are areas and habitats where a species may be found, especially during anomalous environmental conditions (e.g., El Niño events). Areas of "rare" occurrence (shaded in light blue) are areas and habitats where a species is not expected to be found with any regularity. Protected species biologists with the NMFS-Southwest Fisheries Science Center (SWFSC) ultimately devised these qualitative terms.

- Information Specific to the Chesapeake Bay Study Area—The mainstem of the Chesapeake Bay is designated as an area of primary occurrence during May and June (**Figure 3-9**). Sea turtles enter the Chesapeake Bay during this time as sea surface temperatures rise above 18°C (Lutcavage and Musick 1985; Keinath et al. 1987a; Byles 1988; Musick 1988; Keinath and Musick 1993; Coles 1999). The upper tributaries are designated as an area of secondary or rare occurrence as sea turtles generally do not travel into freshwater habitats, although one satellite tracked Kemp's ridley was tracked up the York River as far upstream as West Point (Mansfield 2006). The entire mainstem of the Chesapeake Bay is designated as an area of primary occurrence during July and August (**Figure 3-10**). SSTs during this time are optimal for sea turtles in the Chesapeake Bay, and both loggerhead and Kemp's ridleys use the bay as developmental foraging habitat. The entire mainstem of the Chesapeake Bay is designated as an area of primary occurrence in September and October (**Figure 3-11**); however, during this time, SSTs start to drop and turtles are most likely moving away from the upper reaches of the Chesapeake Bay and towards the bay mouth on their southern migration to overwintering grounds ranging from North Carolina south to Florida.

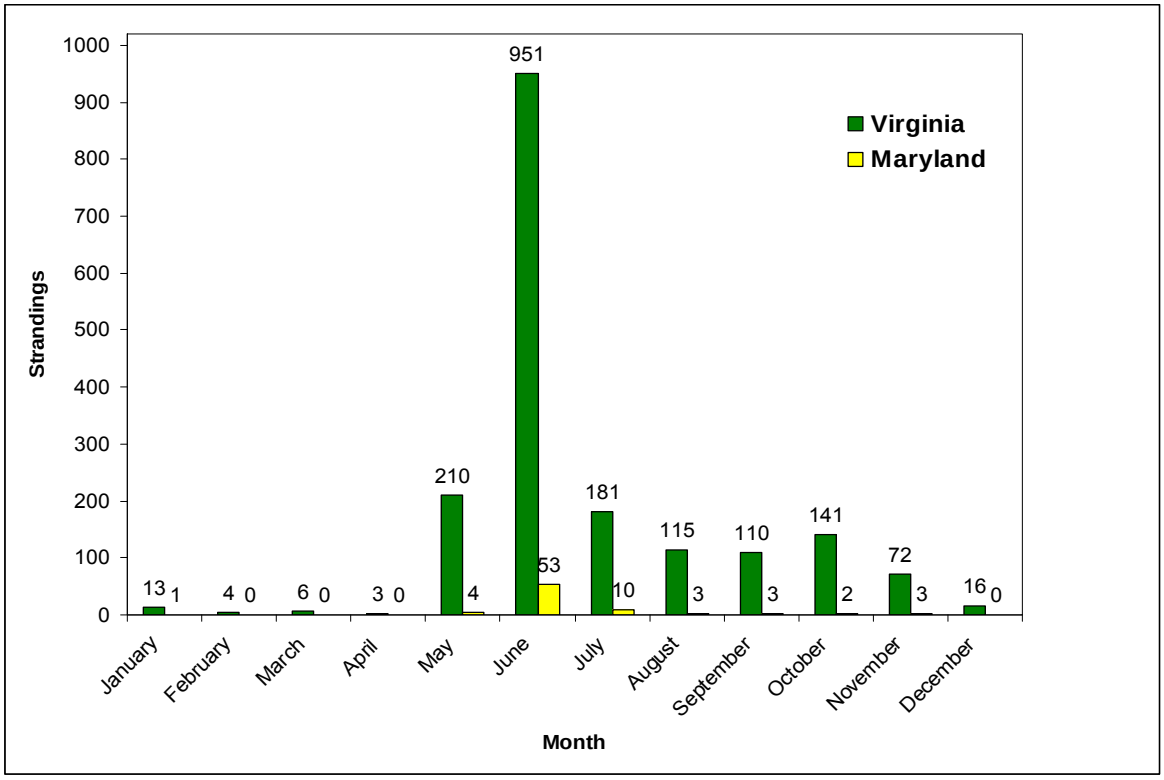

Figure 3-8. Sea turtle strandings reported within the Chesapeake Bay by month between 1998 and 2007. Strandings that occurred along the Atlantic coast (i.e., outside of the Chesapeake Bay) are not reflected in this graph. Source data: MDNR (2008) and VIMS (2008).

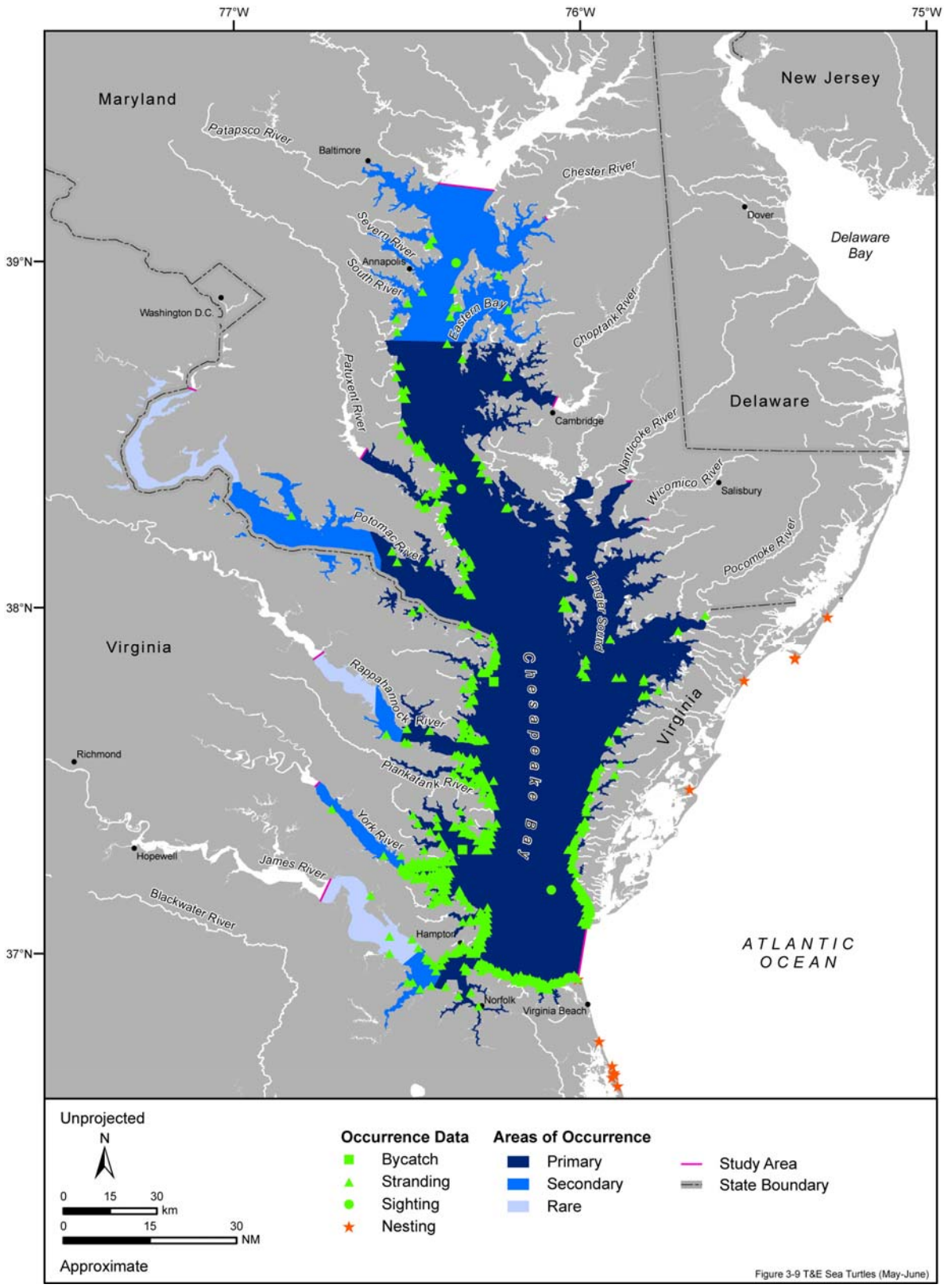

Figure 3-9. Areas of occurrence for all sea turtles in the Chesapeake Bay Study Area during May and June. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

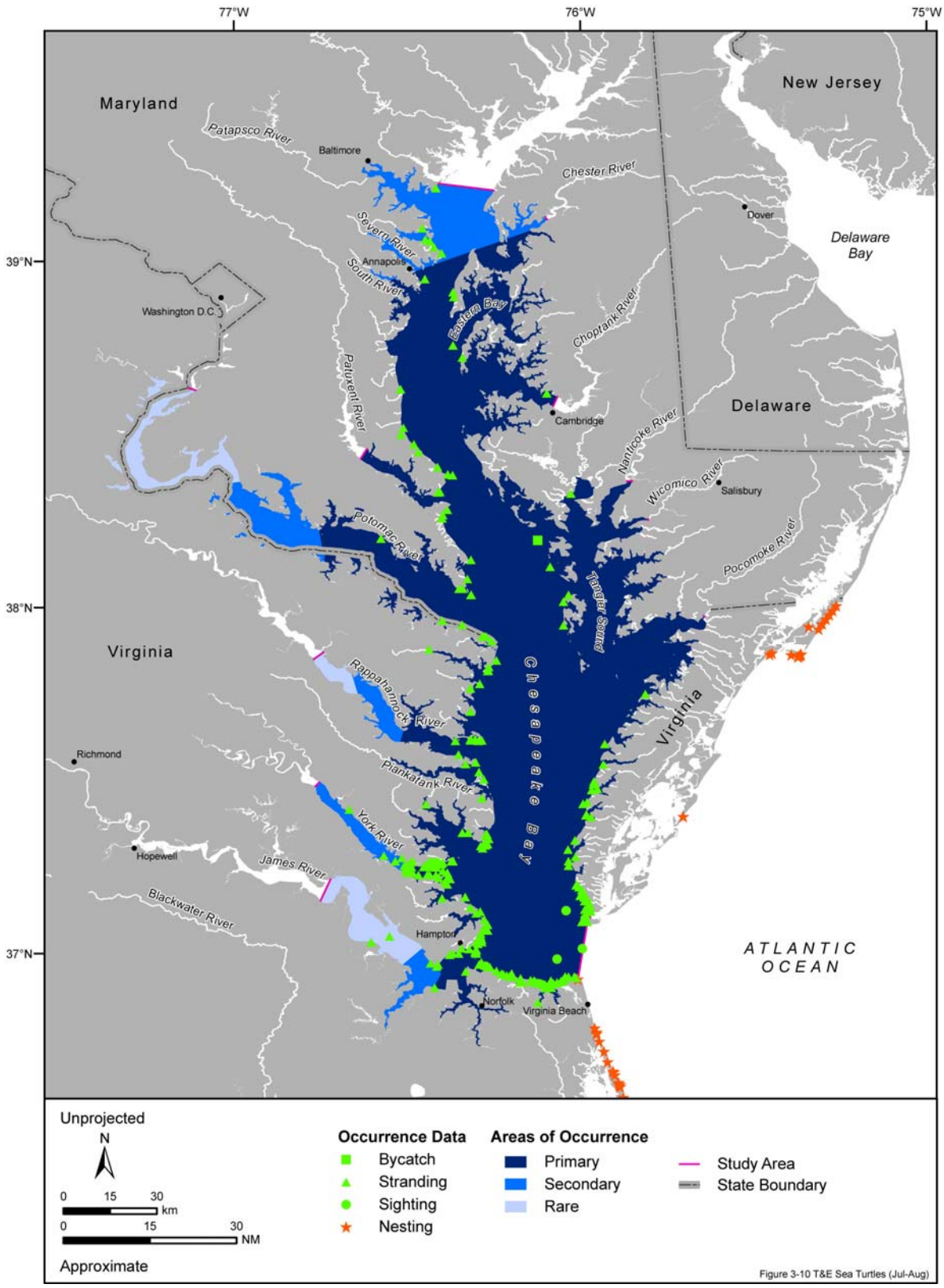

Figure 3-10. Areas of occurrence for all sea turtles in the Chesapeake Bay Study Area during July and August. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

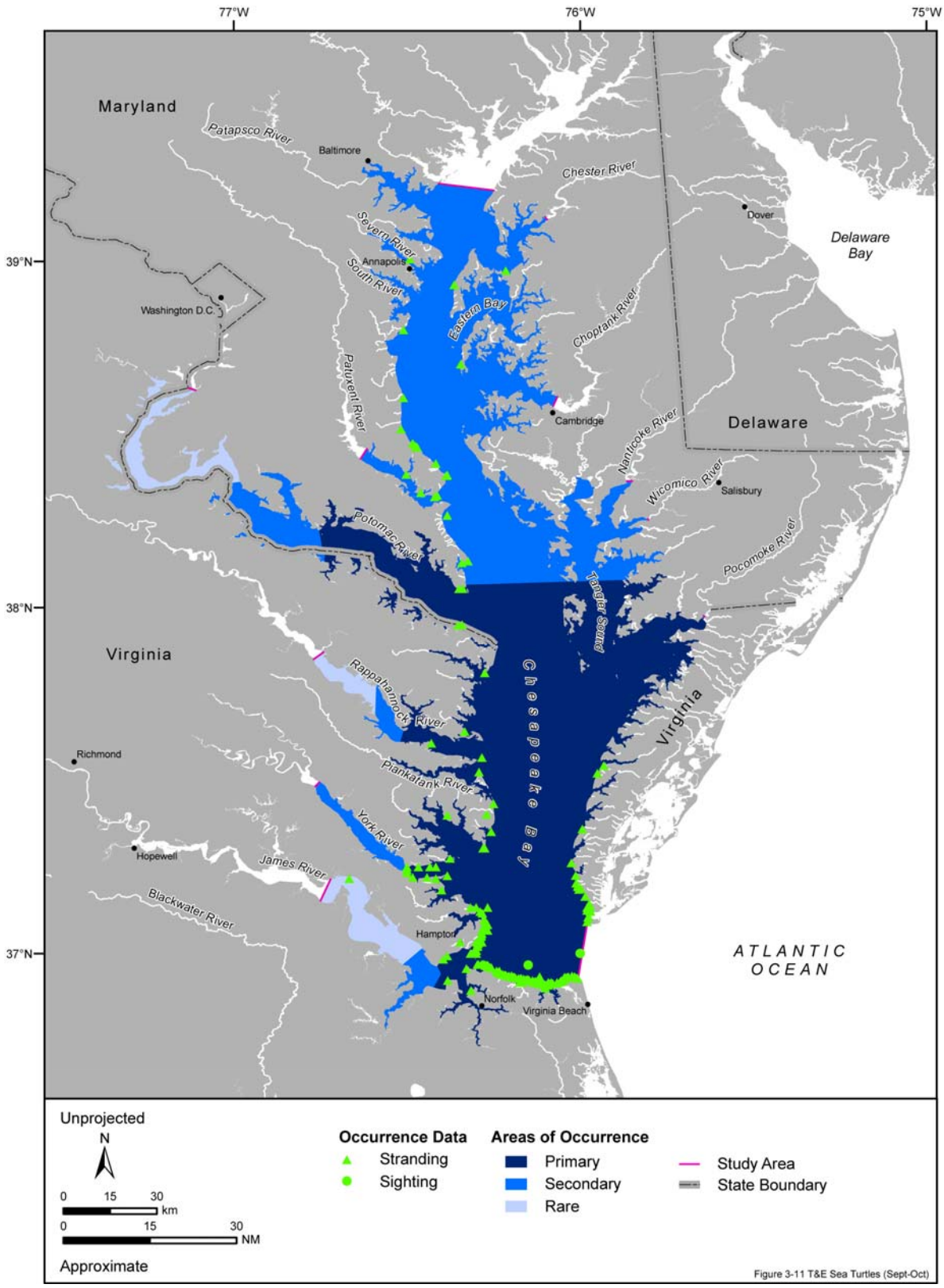

Figure 3-11. Areas of occurrence for all sea turtles in the Chesapeake Bay Study Area during September and October. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

Each sea turtle species is listed below in the order of its appearance in **Table 3-2**, with its description, status, habitat association, distribution (including location and seasonal occurrence in the Chesapeake Bay), and basic behavior and life history information. Species appearance within the text follows the taxonomic order as presented in **Table 3-2**. For information on sea turtle occurrence in offshore waters adjacent to the Chesapeake Bay, please refer to the Final MRA for the VACAPES OPAREA (DoN 2008).

- **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). Critical habitat for leatherbacks is designated in the Caribbean at Sandy Point, St. Croix, U.S. Virgin Islands (USVI) (NMFS 1979). Counts of nesting females typically provide the best available index of leatherback sea turtle population status; the largest leatherback populations are currently 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 two to three decades indicate increases in the nesting population (TEWG 2007). Spotila (1996) estimated a global population of 34,500 adult females; however, recent estimates for adult leatherbacks range from 34,000 to 94,000 in North Atlantic waters alone (NMFS 2007; TEWG 2007). Leatherback nesting that was once considered rare in Florida has increased over time and is now a significant nesting population in the western Atlantic (Meylan et al. 2006). Populations nesting in Culebra, Puerto Rico, and St. Croix, 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).

Habitat Associations—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 2002). 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 (James et al. 2006a). 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 typically sighted in the lower Chesapeake 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, subtropical, and warm-temperate waters throughout the year and into cooler temperate waters during warmer months (NMFS and USFWS 1992; James et al. 2005a) as far north as Nova Scotia, Newfoundland, Labrador, Iceland, the British Isles, and Norway (Bleakney 1965; Brongersma 1972; Threlfall 1978; Goff and Lien 1988). The leatherback is the most oceanic and wide-ranging of sea turtles, undertaking extensive migrations along distinct depth contours for hundreds to thousands of kilometers (Morreale et al. 1996; Hughes et al. 1998). Adult leatherback turtles forage in temperate and subpolar regions in all oceans and migrate to tropical nesting beaches between 30°N and 20°S. Trans-Atlantic movements have been reported (Thompson et al. 2001; Ferraroli et al. 2004; Hays et al. 2004a; Billes et al. 2006; Hays et al. 2006).

The wide distribution of leatherbacks is likely due to their highly evolved thermoregulatory capabilities. Adult leatherbacks possess the ability to maintain an elevated internal body temperature well above ambient water temperature (Frair et al. 1972; James and Mrosovsky 2004). For example, a leatherback caught off Nova Scotia in water that was 7.5°C had a body temperature of 25.5°C (Frair et al. 1972). As juveniles grow in size, it is expected that this ability is enhanced, allowing leatherbacks to expand their ranges into the cooler waters that are considered their primary habitat (Eckert 2002). A variety of studies have shown that leatherbacks have a range of anatomical and physiological adaptations that enable them to regulate internal body temperatures (Mrosovsky and Pritchard 1971; Greer et al. 1973; Neill and Stevens 1974; Paladino et al. 1990; Bradshaw et al. 2007). The high oil content of leatherback flesh may also aid thermoregulatory functions by slowing the process of heat loss from the body (Goff and Stenson 1988).

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. 2004a).

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. Few leatherbacks are observed in the Chesapeake Bay during any given year. The maximum number of leatherback strandings recorded in Virginia was 17 during 2003, the majority of which were found along coastal beaches, outside of bay waters. The typical number of leatherback strandings in Virginia is usually less than ten. Live leatherbacks have been reported in the upper Chesapeake Bay and in the Severn River in the Mobjack Bay system (Musick 1988; Keinath and Musick 1990). A few reports of live entanglements in crab pots were documented in the York River and Mobjack Bay during 2003 (Mansfield, K., University of Miami, pers. comm., 23 August 2007).

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. No leatherback nesting occurs in Virginia. The most significant nesting populations occur at French Guiana, Suriname, Guyana, Colombia, Panama, Costa Rica, and Trinidad (Thompson et al. 2001). In the U.S., 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).

- Information Specific to the Chesapeake Bay Study Area—Leatherbacks are occasionally observed in Chesapeake Bay, but do not appear to be regular inhabitants. Hardy (1969) noted that individuals appear to enter the Chesapeake Bay between June and mid-September. Barnard et al. (1989) reported that most leatherback strandings in Virginia occur between May and July. Aerial surveys off the Virginia coastline have documented leatherbacks congregating off the mouth of the Chesapeake Bay, especially May to July, presumably to feed on abundant jellyfish (Musick 1988; Barnard et al. 1989; Keinath and Musick 1990). Therefore, the area of primary occurrence in **Figures 3-12** and **3-13** occurs near the mouth of the Chesapeake Bay. This area extends further into the bay during the summer months (**Figure 3-13**) as available prey may be found further up the mainstem. Leatherbacks are not typically sighted north of the Potomac River or extremely far up the tributaries (no more than 5 to 10 mi up a tributary) (Lutcavage and Musick 1985; Byles 1988; Musick 1988; Mansfield 2006). Therefore, these areas are designated as an area of rare occurrence. Leatherback occurrences decrease in the fall (**Figure 3-14**), likely due to the fact that prey abundance has decreased. Therefore, the area near the mouth of the Chesapeake Bay is designated as an area of secondary occurrence and the rest of the bay is designated as an area of rare occurrence.

Behavior and Life History—Leatherbacks feed throughout the epipelagic and into the mesopelagic zones of the water column (Eisenberg and Frazier 1983; Davenport 1988; S.A. Eckert et al. 1989; Grant and Ferrell 1993; Salmon et al. 2004; James et al. 2005c). Prey is predominantly gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas) (NMFS and USFWS 1992; Grant and Ferrell 1993; Bjorndal 1997; James and Herman 2001; Salmon et al. 2004). Diel patterns in dive behavior off St. Croix (at night, more time was spent diving and dives tended to be shallow, while, during the day, less time was spent diving but dives tended to be deeper), suggest an interaction between leatherback diving and vertical movements of the deep scattering layer, but the details of this interaction remain unclear (S.A. Eckert et al. 1989). It also is not known whether this is a widespread phenomenon. Leatherbacks have been observed congregating at the entrance to the Chesapeake Bay, likely to feed upon the influx of jellyfish flowing out of the Chesapeake Bay's mouth (Barnard et al. 1989).

Eighty percent of the leatherback's time at sea is spent diving (e.g., Fossette et al. 2007). The leatherback is the deepest diving sea turtle with a recorded maximum depth of 1,230 m (Hays et al. 2004b), though most dives are much shallower than this (usually <200 m) (e.g., Hays et al. 2004b; Sale et al. 2006). Leatherbacks spend the majority of their time in the upper 65 m of the water column regardless of their behavior (Jonsen et al. 2007). The aerobic dive limit for the leatherback turtle is estimated between 33 and 67 min (e.g., (Southwood et al. 1999; Hays et al. 2004c; Wallace et al. 2005). Tagging data has revealed that changes in individual turtle diving activity appear to be related to water temperature, suggesting an influence of seasonal prey availability on their diving behavior (e.g., Hays et al. 2004c).

Leatherbacks dive deeper and longer in the lower latitudes versus the higher (south versus the north) (James et al. 2005c). In northern waters, they are also known to dive to waters with temperatures just above freezing (James et al. 2006a; Jonsen et al. 2007). James et al. (2006b) noted that there is considerable variability in surface time both within and among leatherbacks. Dives in the north are punctuated by longer surface intervals (equating to much more time spent at the surface per 24-hour period), with individuals spending up to 50% of their time at or near the surface in northern foraging areas, perhaps in part to thermoregulate (i.e., bask). There is no information available regarding leatherback turtle diving behavior in the Chesapeake Bay. While transiting, leatherbacks make longer, deeper dives (e.g., Jonsen et al. 2007). It is suggested that leatherbacks make scouting dives while transiting as an efficient means for sampling prey density and perhaps also feed opportunistically at these times (e.g., James et al. 2006b; Jonsen et al. 2007).

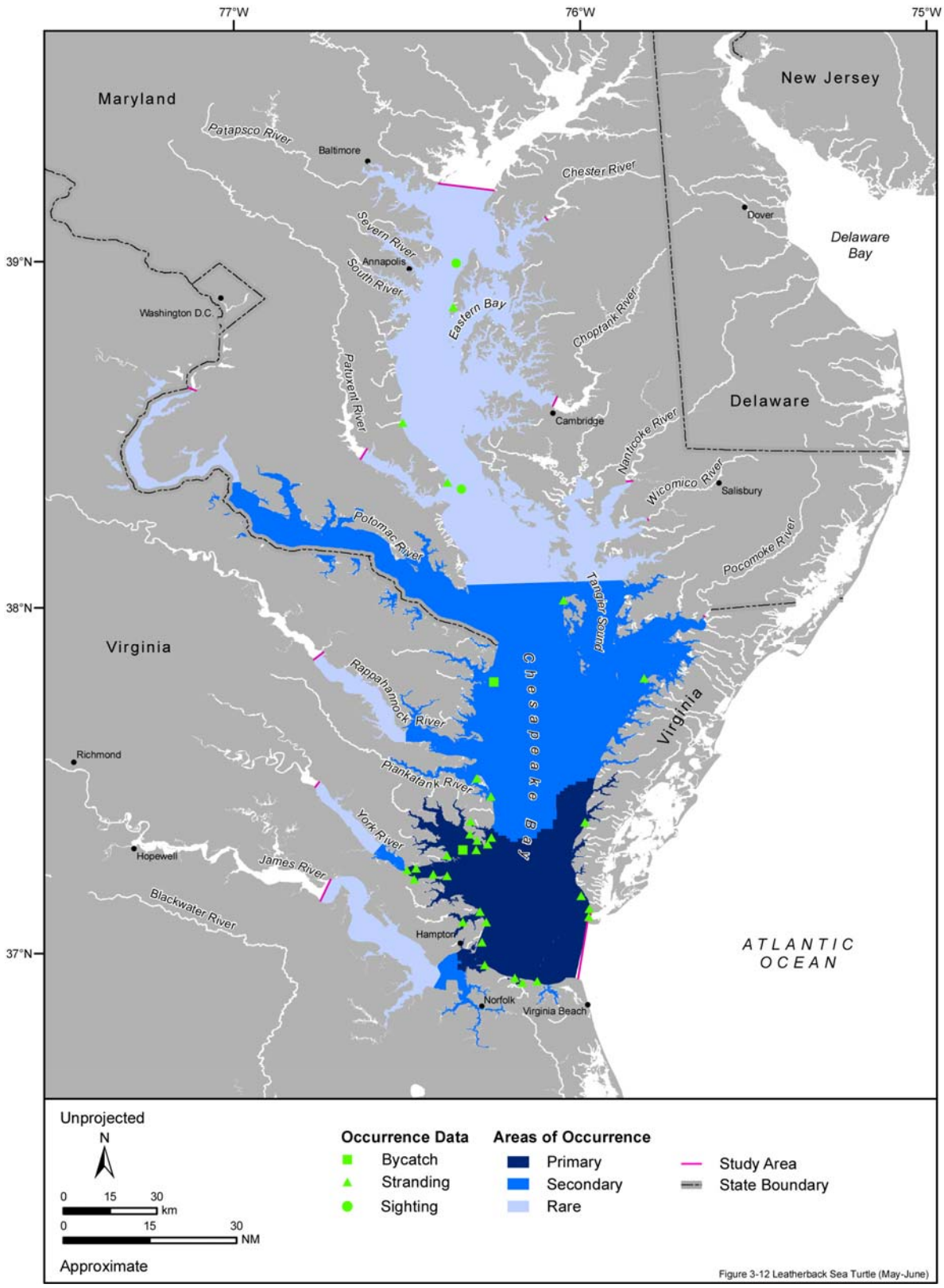

Figure 3-12. Areas of occurrence for the leatherback turtle in the Chesapeake Bay Study Area during May and June. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

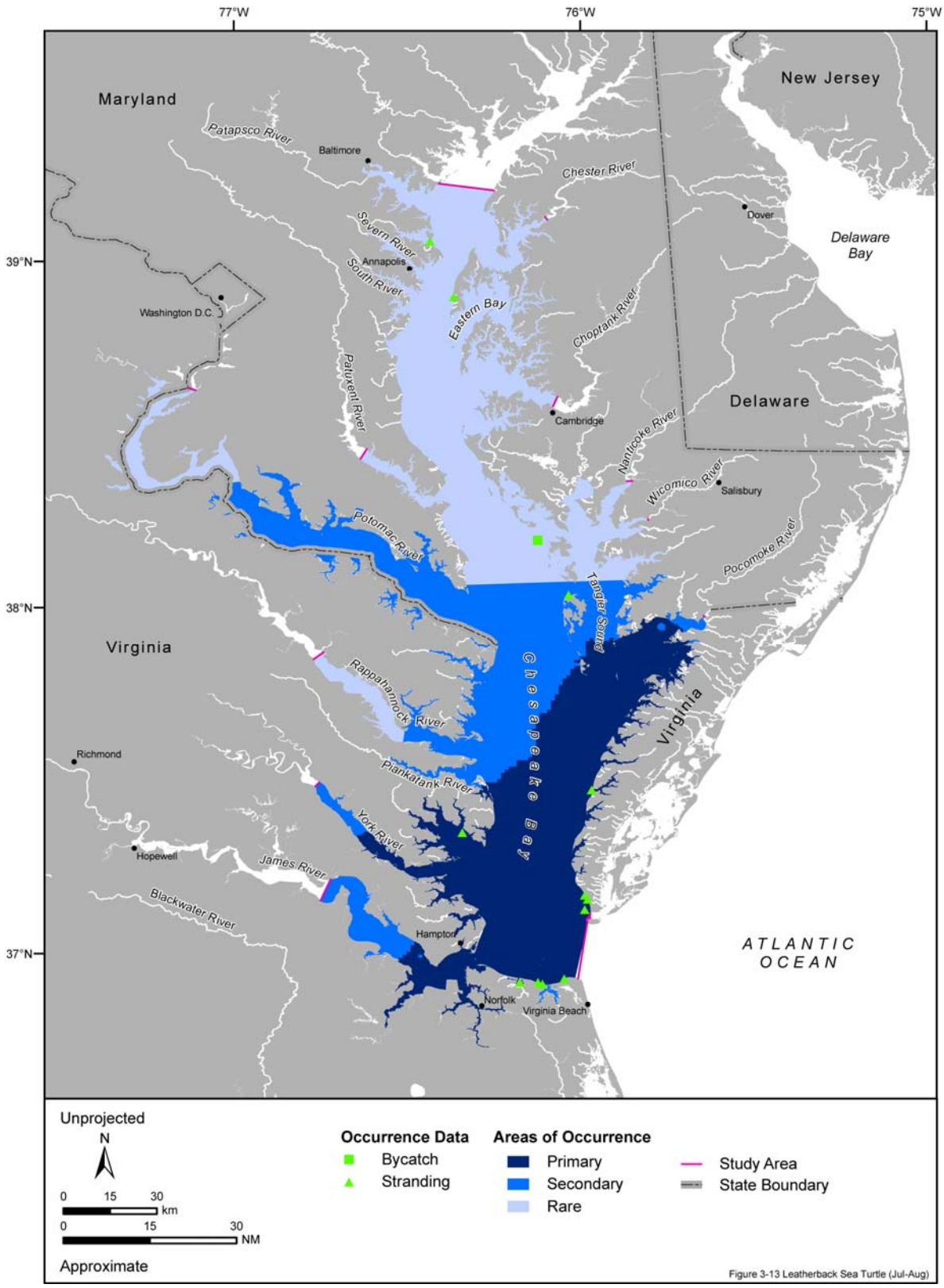

Figure 3-13. Areas of occurrence for the leatherback turtle in the Chesapeake Bay Study Area during July and August. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

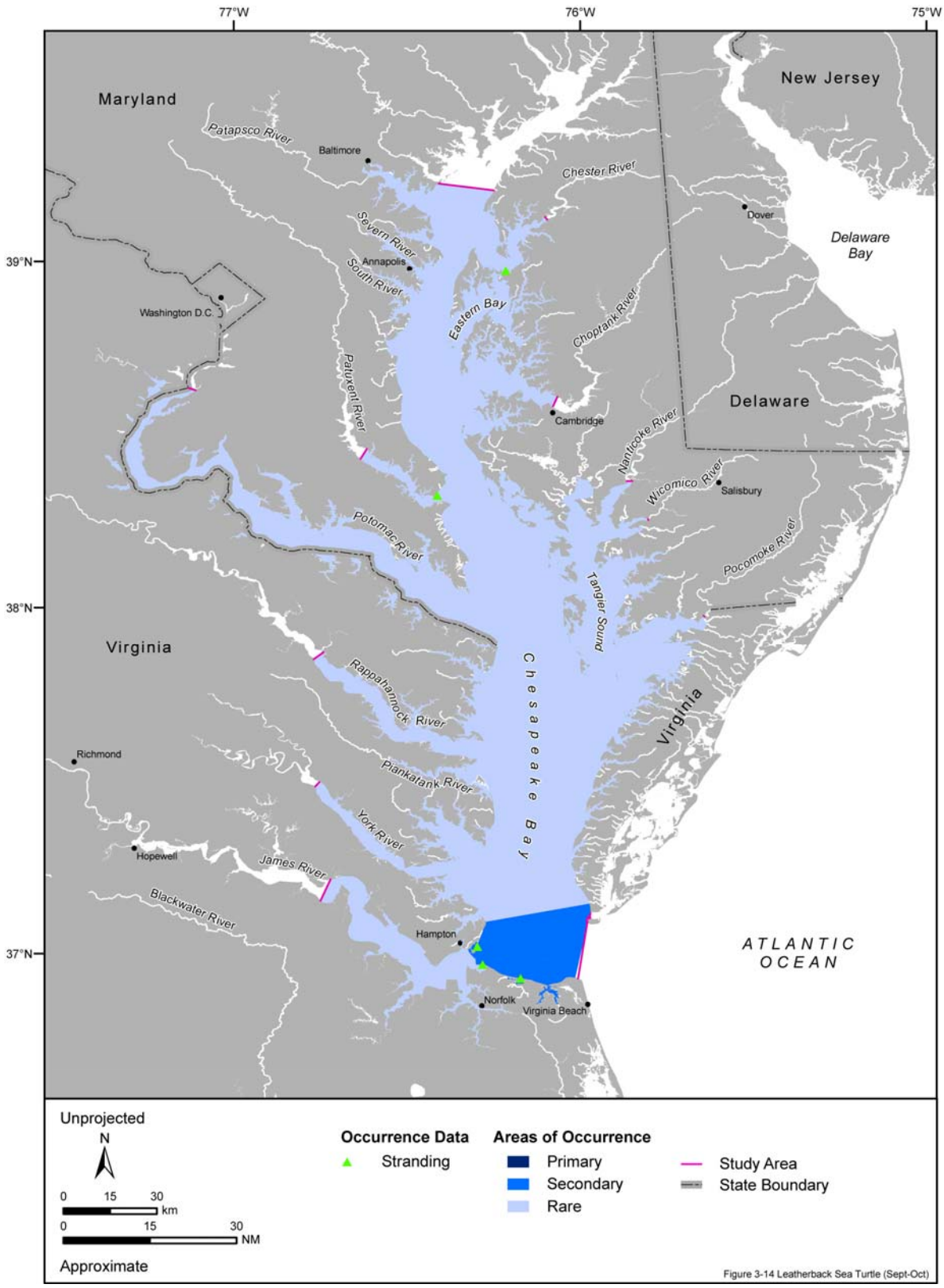

Figure 3-14. Areas of occurrence for the leatherback turtle in the Chesapeake Bay Study Area during September and October. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

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 1 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 internesting 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 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 1991a). Adult loggerheads usually possess a reddish-brown carapace with scutes that are bordered with yellow (NMFS and USFWS 1991a).

Status—Loggerhead turtles are listed as threatened under the ESA (NMFS and USFWS 1991a). The loggerhead is the most abundant sea turtle occurring in U.S. waters. In the continental U.S. 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 DNA data, all breeding populations in the entire southeastern U.S. 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. 2009). This subpopulation also contributes significantly to loggerheads off the Carolinas (66%) and in North Carolina's Albemarle-Pamlico Estuarine Complex (Epperly et al. 2001).

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). 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 14 years), some individuals begin to recruit to the neritic zone (benthic habitat in shallow coastal waters) close to their natal area,

while others remain in the oceanic habitat or move back and forth between the two (e.g., Musick and Limpus 1997; Laurent et al. 1998).

Turtles either may utilize the same neritic developmental habitat all through maturation, or they may move among different areas and finally settle in an adult foraging habitat. At sexual maturity (about 25 to 30 years old), adults switch from subadult to adult neritic foraging habitats (Musick and Limpus 1997; Godley et al. 2003). The neritic juvenile stage and adult foraging stage both occur in the neritic (near shore) zone. The turtles here are active and feed primarily on the bottom (epibenthic/demersal), though prey is also captured throughout the water column (Bjorndal 2003; Bolten 2003a). As stated earlier, the Chesapeake Bay is considered an important developmental habitat for neritic juvenile loggerheads originating from the genetic stocks found within the eastern U.S. (Norrgard 1995; Musick and Limpus 1997). In direct contrast with the accepted life-history model for this species, satellite tracking studies of neritic juvenile loggerheads from Virginia and North Carolina indicate that neritic turtles may return to an oceanic environment for significant periods (Keinath 1993; Mansfield 2006; McClellan and Read 2007). Hawkes et al. (2006) recently reported that tagging work at the Cape Verde Islands (Africa) revealed two distinct adult foraging strategies that appear to be linked to body size. The larger turtles foraged in coastal waters, whereas smaller individuals foraged oceanically. Likewise, off Japan, epipelagic foraging has been recorded for adult female loggerheads (Hatase et al. 2002). Hawkes et al. (2006) also found that movements of adult loggerheads off Cape Verde were in part driven by local surface currents, with active movement by individuals to remain in areas of high productivity.

Distribution—Loggerhead turtles are widely distributed in subtropical and temperate waters throughout the Atlantic, Pacific, and Indian oceans, and Mediterranean Sea (NMFS and USFWS 1991a). Loggerheads (post-hatchlings/oceanic-stage juveniles and adults) are commonly found foraging in eastern North Atlantic waters around and north of the Azores to about 42°N, eastward to the Atlantic coast of Spain, and in the waters around the Madeira, Canary, and Cape Verde islands, as well as the Mediterranean Sea (Brongersma 1972; Ehrhart et al. 2003; Bowen et al. 2004). 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 brumating (Carr et al. 1980; Ogren and McVea 1995; Hochscheid et al. 2005).

After reaching a certain size, early juvenile loggerheads in the Atlantic will make a trans-oceanic crossing back towards the western Atlantic Ocean (Musick and Limpus 1997; Bolten 2003b), actively swimming to neritic feeding grounds such as the Chesapeake Bay, the Pamlico or Albemarle Sounds in North Carolina, or near their natal beach of origin (Bowen et al. 2004). Along the east coast of the U.S. among subpopulations found within the more temperate U.S. waters, there is seasonal north-south movement between foraging and wintering habitat south of Cape Hatteras, North Carolina, and spring/summer foraging habitat within the northeast region from Virginia to Cape Cod.

Along the east coast of the U.S., few turtles are observed in coastal waters north of Cape Hatteras during the winter months. Thus, during the spring migration period, turtles heading to foraging grounds throughout the northeastern U.S. must first pass through Virginia's waters (Mansfield 2006). The coastal region of the eastern U.S. to the outer continental shelf is identified as an important seasonal migratory route for sea turtles (Shoop and Kenney 1992; Keinath 1993; Morreale and Standora 1998; Plotkin and Spotila 2002; Mansfield 2006). Telemetry studies conducted on post-nesting female loggerheads from mid-Atlantic nesting beaches suggest that many turtles migrate to waters north of Cape Hatteras, including the Chesapeake Bay, after nesting (Bell and Richardson 1978; Plotkin and Spotila 2002). The internesting and post nesting movements of Virginia's nesting loggerheads include establishing foraging areas within the Delaware and Chesapeake Bays (Mansfield 2006). Most juvenile and adult loggerheads tracked from the Chesapeake Bay also exhibit strong seasonal philopatry to discrete foraging areas within the Chesapeake Bay, or along the coast

of Virginia south to Cape Hatteras (Mansfield 2006). The Chesapeake Bay provides important developmental habitat for foraging juvenile loggerheads from the southern and northern nesting stocks, and important post-nesting habitat for adult females from the northern nesting stock (Norrgard 1995; Mansfield 2006).

Loggerhead nesting beaches are distributed throughout warm, temperate, and subtropical regions (between 40°N and 40°S), with some scattered nesting in the tropics (The SWOT Team 2007) Loggerheads are the only marine turtles that nest predominantly outside of the tropics (Ehrhart et al. 2003). Loggerheads typically nest on 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 1991a). Nest site selection tends to depend more upon beach slope and width than temperature, moisture, or salinity (Wood and Bjorndal 2000). Adult loggerheads exhibit strong site fidelity to nesting beaches and typically return to their natal beaches or nearby areas to nest (Addison 1996; 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 1991a). While the rare nest may occur north of Virginia, Virginia is the northernmost nesting area regularly used by loggerheads along the east coast of the United States (Musick 1988). Between two and ten nests are documented annually in Virginia (BBNWR 1993; Mansfield et al. 2001) (**Table 3-3**). Virginia's nesting season begins in late May/early June, continuing through mid- to late August. Almost all nesting activity occurs on the beaches of BBNWR and False Cape State Park (FCSP) (BBNWR 1993). Occasional nesting activity has also been documented along Virginia Beach and the Eastern Shore (**Table 3-3**). Adult loggerheads are known to utilize the Chesapeake Bay as an internesting or foraging habitat, and compose approximately 5% of the turtle population within the Chesapeake Bay (Lutcavage and Musick 1985; Mansfield 2006).

Table 3-3. Nesting beaches and status of the loggerhead turtle nesting in the vicinity of the Chesapeake Bay Study Area.

Nesting Beach	Status[1]
Virginia	
Virginia Beach	<Discrete
Sandbridge	<Discrete
Back Bay National Wildlife Refuge	<Discrete
False Cape State Park	<Discrete
Eastern Shore (General—Ocean)	<Discrete
Assateague/Chincoteague National wildlife Refuges	<Discrete

[1] Major nesting beaches are those with an average of >100 nests/year; moderate are those with an average of >20, discrete refers to diffuse nesting of an average of <20 nests/year]. Table source information from: Lutcavage and Musick (1985); BBNWR (1993); Cross et al. (2001).

- Information Specific to the Chesapeake Bay Study Area—The loggerhead is by far the most common and most widely distributed species encountered in the Chesapeake Bay. Loggerheads are also known to nest on Virginia beaches, although no regular nesting occurs within the Study Area (**Figures 3-15** and **3-16**) (Musick 1988; BBNWR 1993; Mansfield et al. 2001). The residency season for loggerhead turtles in the Chesapeake Bay occurs from May to late October/early November. The mainstem of the Chesapeake Bay is designated as an area of either primary or secondary occurrence during May and June (**Figure 3-15**) as loggerheads move in to the bay to discrete foraging areas. Once loggerheads are within the Chesapeake Bay, they likely remain within the mainstem and lower tributaries (Byles 1988; Mansfield 2006) (Mansfield, K., University of Miami, pers. comm., 23 August 2007). This is based on aerial survey effort, which has focused

on the mouths of tributaries, but does not venture far up any river, so no further assessment is currently available (Mansfield, K., pers. comm., 23 August 2007). Therefore, the entire mainstem and lower portions of the tributaries are designated as primary occurrence during July and August (**Figure 3-16**). Mansfield (2006) observed that satellite-tagged loggerheads commenced directed movement out of the Chesapeake Bay when SST dropped below 15° to 20°C. The occurrence pattern designated for loggerheads in **Figure 3-17** illustrates the directed movement out of the Chesapeake Bay as SSTs start to fall.

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 25 and 30 years of age (Snover 2002; Snover and Hohn 2004). 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 internesting 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 influence 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 temperatures 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; Mansfield and Musick 2006). In the Chesapeake Bay and coastal Virginia waters, Mansfield (2006) found juvenile loggerheads in Virginia spent approximately 9.9% of their time at the surface in the spring and 25% of their 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. 1996); Mansfield (2006) also found juvenile loggerheads to have higher surfacing times in the deeper and cooler waters of the Chesapeake Bay. The maximum known swimming speed for loggerheads is 6 km/hr (Keinath 1993; Braun and Epperly 1996). Mansfield (2006) found loggerheads in the Chesapeake Bay and coastal Virginia waters travel at an average speed ranging from 2.3 to 4.2 km/hr.

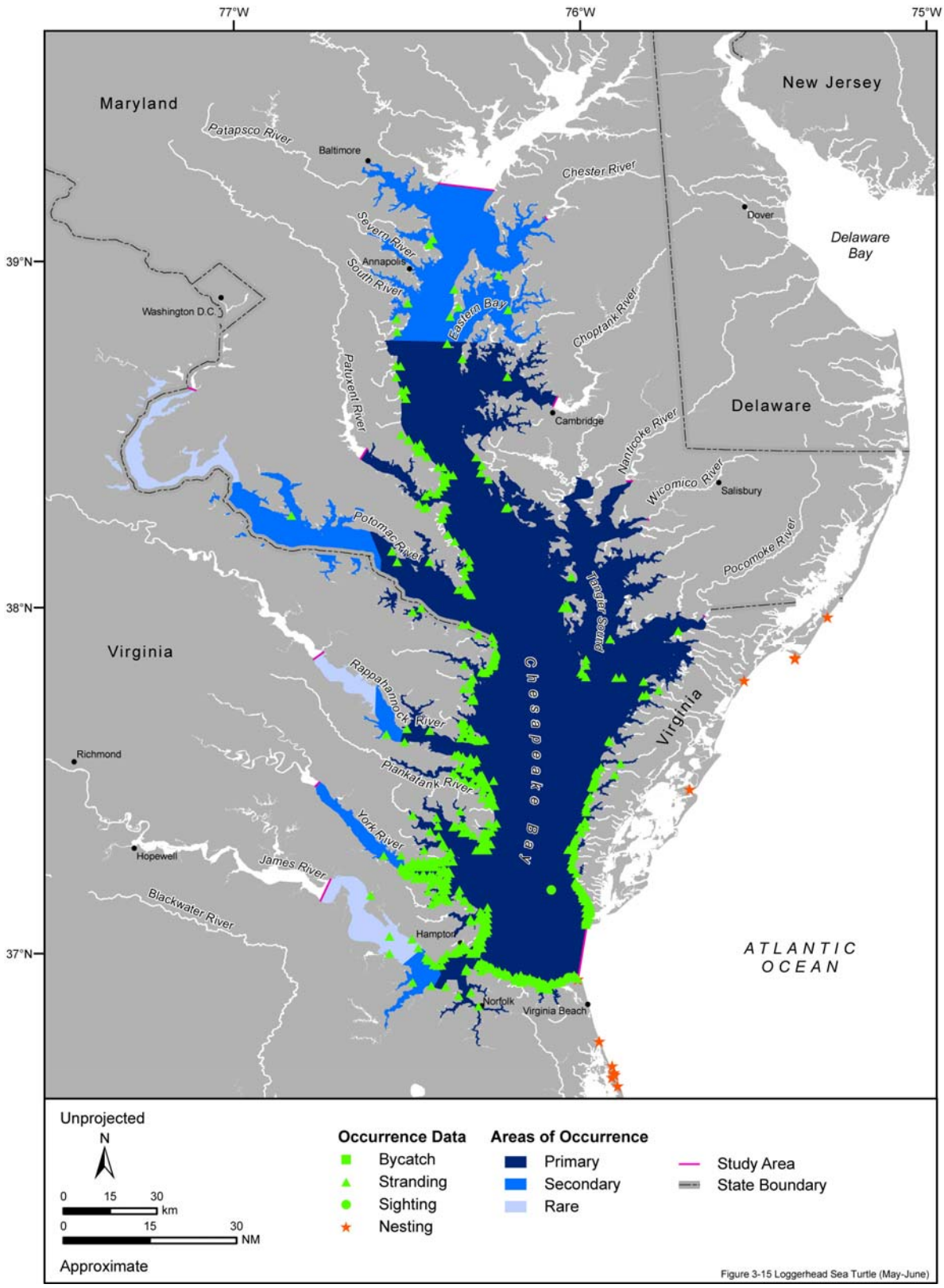

Figure 3-15. Areas of occurrence for the loggerhead turtle in the Chesapeake Bay Study Area during May and June. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

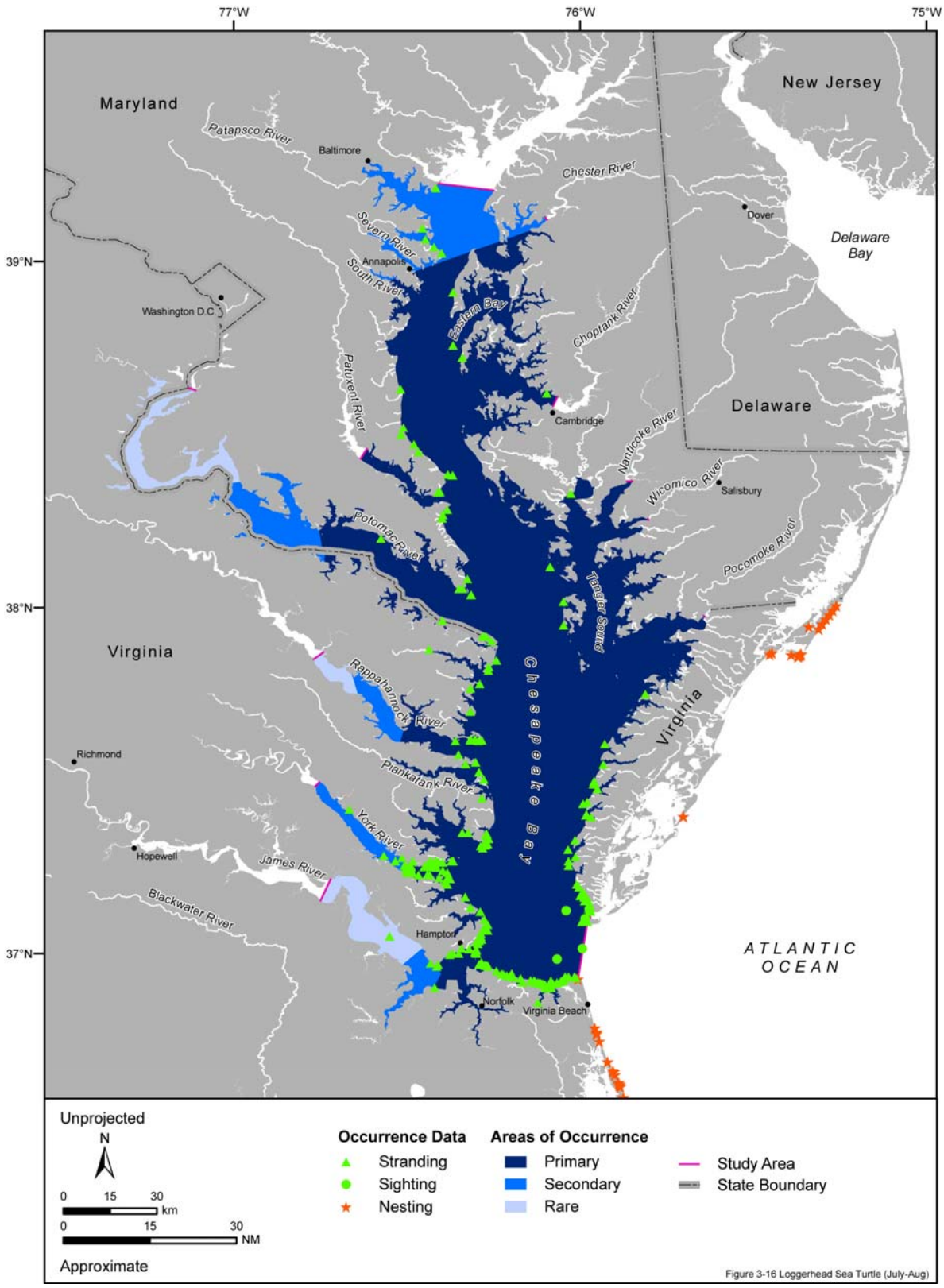

Figure 3-16. Areas of occurrence for the loggerhead turtle in the Chesapeake Bay Study Area during July and August. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

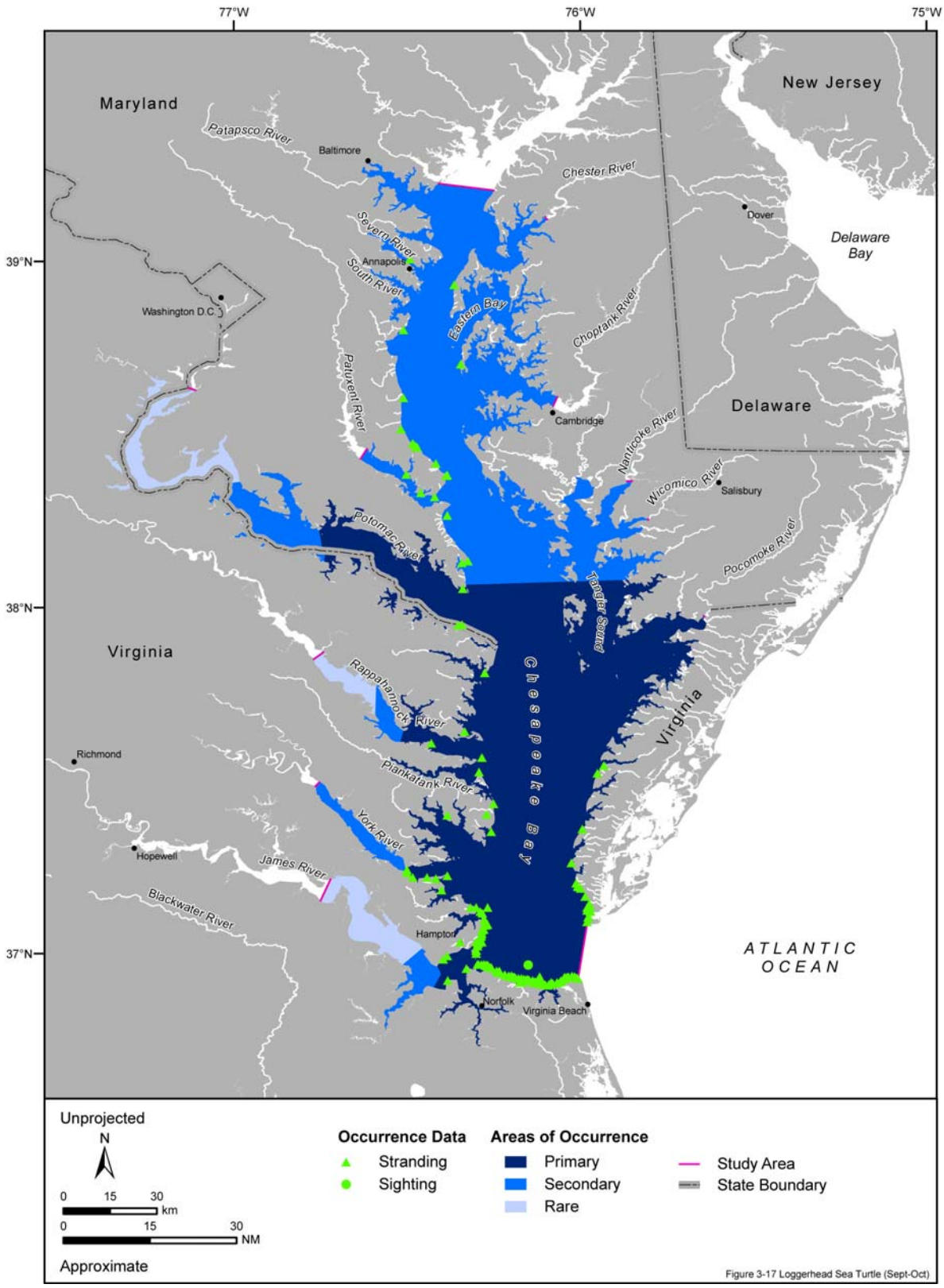

Figure 3-17. Areas of occurrence for the loggerhead turtle in the Chesapeake Bay Study Area during September and October. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

- **Kemp's Ridley Turtle (*Lepidochelys kempii*)**

Description—The Kemp's ridley is the smallest living sea turtle. This species has a straight carapace length (SCL) 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 2005a). 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).

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; Witherington and Hirama 2006). 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 preferred food, including the blue crab, occurs (Lutcavage and Musick 1985; Landry and Costa 1999; Seney and Musick 2005). Kemp's ridleys utilize the Chesapeake Bay and coastal Virginia waters, in particular, as summer developmental habitat (May through November) (Lutcavage and Musick 1985). Individuals may prefer the shallow seagrass habitats in the Chesapeake Bay and adjacent waters due to the presence of their preferred prey, the blue crab, in this region (Lutcavage and Musick 1985; Keinath et al. 1994).

Offshore water temperatures play a major role in determining the number of Kemp's ridleys present in the North Atlantic Ocean. Temperature is a limiting factor in their distribution; in temperatures less than 13°C they tend to float, make awkward movements (Marquez-M. 1994), and may even die of cold-stunning (Burke et al. 1991). 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 Chesapeake Bay Study Area varies seasonally. From May to early October, the Chesapeake Bay's waters exhibit habitat factors optimal for Kemp's ridleys. It is during these months that the highest number of Kemp's ridleys are observed (Lutcavage and Musick 1985; Keinath 1993; Coles 1999; Mansfield 2006). Satellite data indicates that Kemp's ridleys establish discrete foraging areas within the Chesapeake Bay and remain within these foraging areas for the duration of the sea turtle residency period (May through October) (Keinath 1993; Mansfield 2006). From November to April, the Chesapeake Bay does not exhibit suitable habitat for Kemp's ridleys due to SSTs ranging below the known Kemp's ridley preferences.

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 at least two 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 eastern U.S. coast as far north as Nova Scotia (Lazell 1980; Morreale et al. 1992). Isolated occurrences are noted for the

eastern North Atlantic Ocean, Caribbean, and the Mediterranean region (e.g., Brongersma 1995; Tomás et al. 2003; Renaud and Williams 2005). Virginia serves as a seasonal developmental habitat for this species. The majority of Kemp's ridleys found in Virginia waters are immature; Chesapeake Bay population numbers are estimated in the few hundreds (Lutcavage and Musick 1985).

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).

During the winter, Kemp's ridleys are prompted by cooler water temperatures to leave northern developmental habitats and migrate south to warmer waters in Florida (Marquez-M. 1994). Individuals are known to over winter in areas south of Cape Hatteras, North Carolina, although the majority of Kemp's ridleys stay in Florida near Cape Canaveral (Henwood and Ogren 1987). Individuals that over winter in southern North Carolina may subsequently move into warmer waters (e.g., Gulf Stream or areas off South Carolina) during the mid-winter (Renaud 1995; Morreale and Standora 2005). 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 (Keinath 1993; Morreale and Standora 2005; Mansfield 2006; Morreale et al. 2007); juvenile and adults typically travel inshore of the 18-m isobath (Renaud and Williams 2005). Concentrations of Kemp's ridleys increase during fall and spring migrations, especially near Cape Hatteras, North Carolina, where the migration corridor becomes constricted (Morreale and Standora 2005). This migratory corridor is a narrow band running within continental shelf waters, possibly spanning the entire length of the U.S. Atlantic Coast (Morreale and Standora 2005; Morreale et al. 2007).

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). 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[1]). In 1978, a head-starting and imprinting program for Kemp's ridleys was initiated on South Padre Island, Texas, 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. Kemp's ridleys do not nest in Virginia.

- Information Specific to the Chesapeake Bay Study Area—In the Chesapeake Bay, the Kemp's ridley is resident from May through October. Population estimates for the Kemp's ridley in the Chesapeake Bay range only in the few 100s (Lutcavage and Musick 1985; Musick 1988). It is generally assumed that when the species is found in the Chesapeake Bay, it may also be found in the tributaries (Mansfield 2006) (Mansfield, K., University of Miami, pers. comm., 23 August 2007). Kemp's ridleys are known to forage is shallow water areas within the Chesapeake Bay, generally staying in waters 10 m or less (Byles 1988; Musick 1988; Mansfield 2006). Therefore, primary occurrence occurs along the shore of the mainstem (10 m or less) and up the tributaries of the Chesapeake Bay during May and June (**Figure 3-18**). Secondary occurrence occurs in the

mainstem of the Chesapeake Bay (areas deeper than 10 m) (**Figure 3-18**). The entire mainstem of the Chesapeake Bay is considered an area of primary occurrence during July and August (**Figure 3-19**); foraging areas during this time are well established and turtle may utilize the entire mainstem as they move from one foraging area to another. The upper tributaries are designated as an area of rare occurrence as sea turtles generally do not travel into freshwater habitats, except the York River where one satellite tracked Kemp's ridley was tracked up as far as West Point (Mansfield 2006). The occurrence pattern for September and October (**Figure 3-20**) is similar to the occurrence pattern seen in the spring. As temperatures start to cool, sea turtles begin their southern migration to overwintering grounds in North Carolina and south to Florida. Therefore, higher concentrations of Kemp's ridleys are expected near the mouth of the Chesapeake Bay.

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; Frick et al. 1999). 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).

Few data are available on the maximum dive duration of Kemp's ridley sea turtles. 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. Over a 12 hour period, Kemp's ridleys may stay submerged between 92% and 96% of the time (Byles 1989; Renaud and Williams 2005; Sasso and Witzell 2006). The maximum dive time observed among radio tracked Kemp's ridleys in the Chesapeake Bay was 69 minutes (Mansfield 2006). Kemp's ridleys observed in the Chesapeake Bay mouth during the spring and early summer spent between 7.2% and 59.8% of their time at the surface (Mansfield 2006).

Kemp's ridleys reach sexual maturity between 10 and 20 years with an average length of 60 cm CCL (Shaver et al. 2005; Snover et al. 2007). 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). 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).

- **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 1991b). 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 1991b). 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 1991b). From 2001 to 2005, an average 5,055 green turtles nested in Florida; this estimate suggests Florida has 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. 1995b). Recent population estimates for green turtles in the western Atlantic area are not available (NMFS 2006).

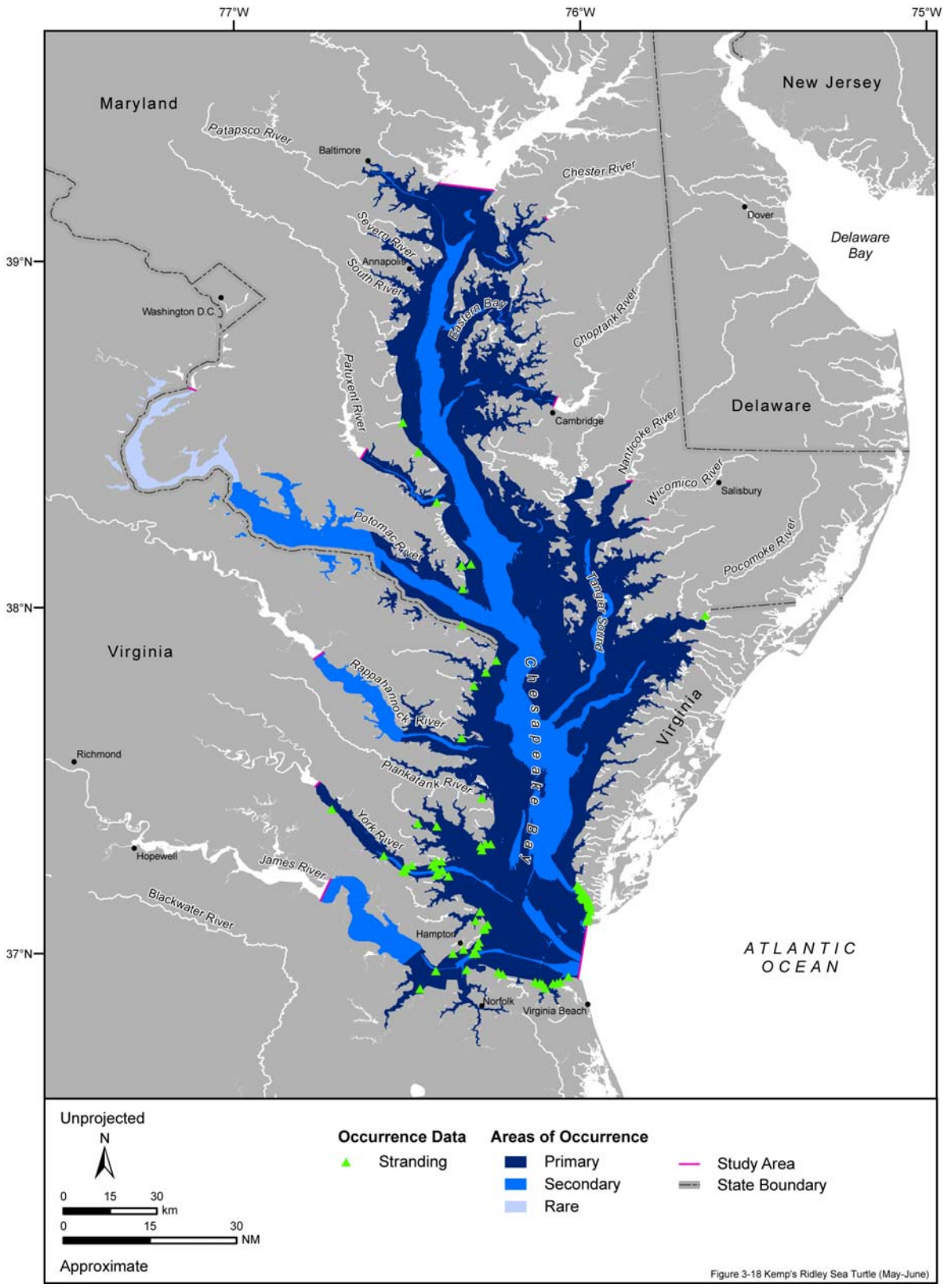

Figure 3-18. Areas of occurrence for the Kemp's ridley turtle in the Chesapeake Bay Study Area during May and June. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

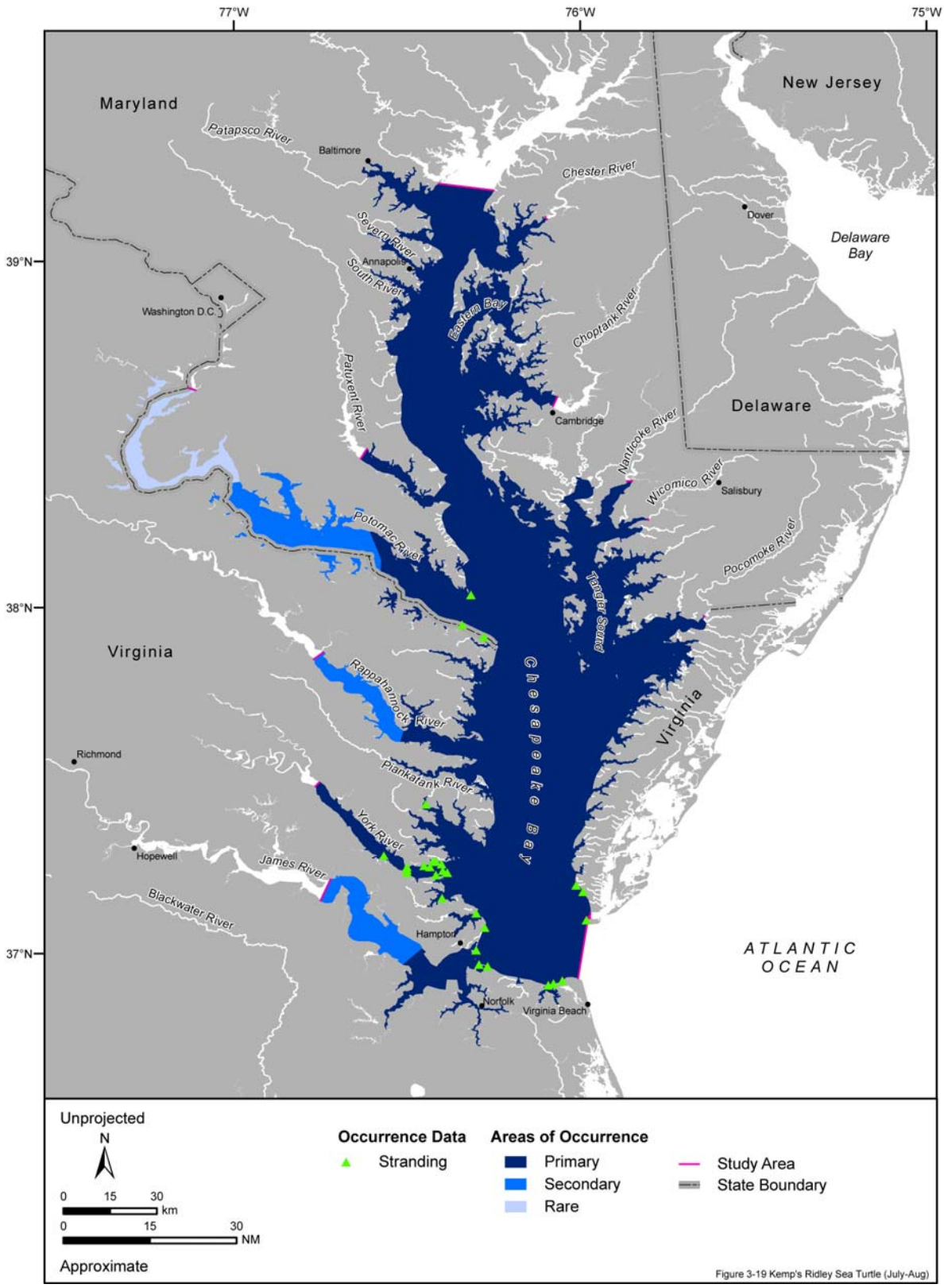

Figure 3-19. Areas of occurrence for the Kemp's ridley turtle in the Chesapeake Bay Study Area during July and August. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

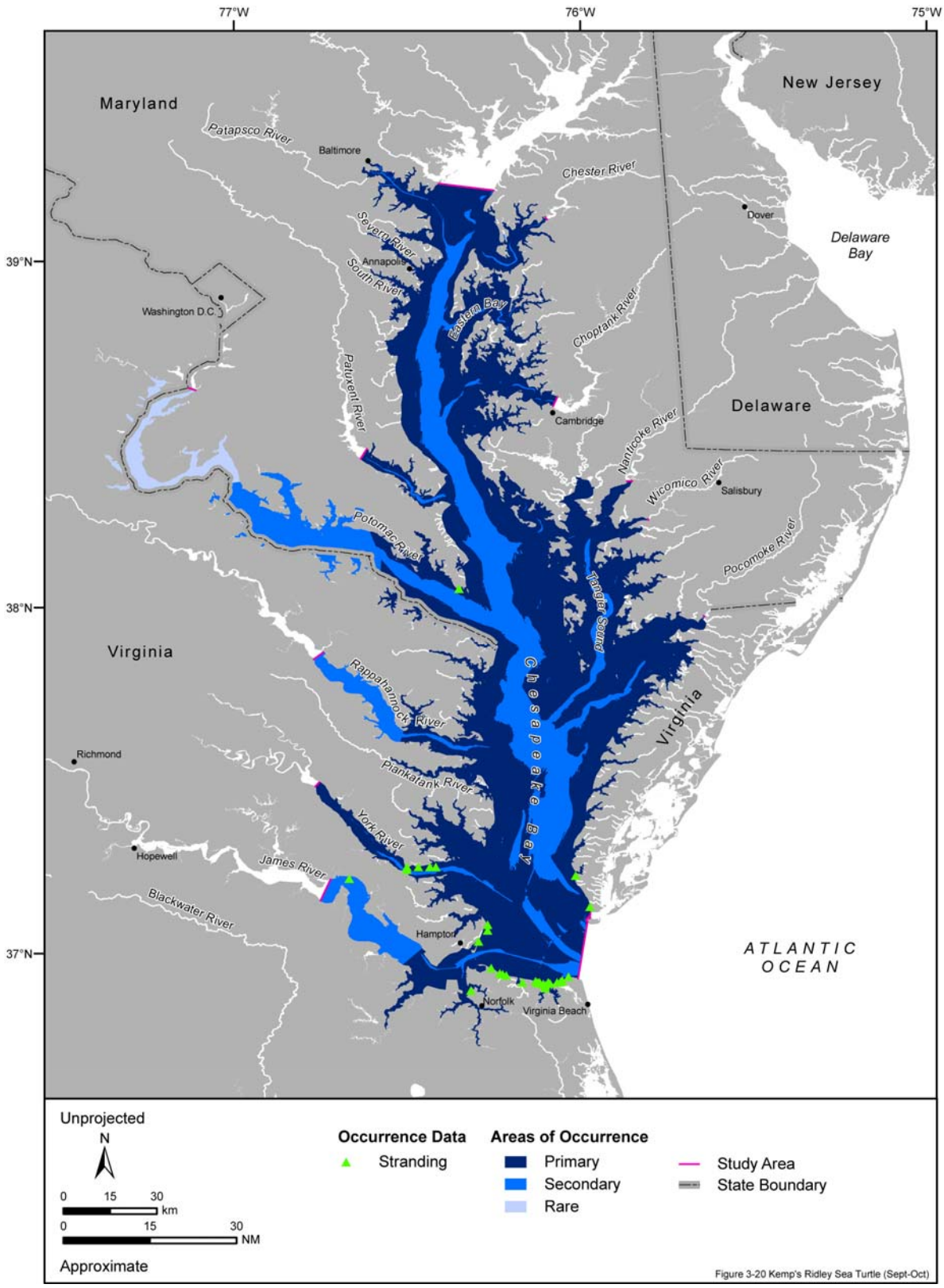

Figure 3-20. Areas of occurrence for the Kemp's ridley turtle in the Chesapeake Bay Study Area during September and October. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

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). The distinct coloration patterns of hatchling and early-juvenile greens, a darker dorsal surface and lighter ventral surface, are ideal for an oceanic lifestyle. In laboratory experiments, Mellgren et al. (1994) found that hatchling green turtles did not orient to or congregate in artificial weed beds or in real seaweeds; however, Carr and Meylan (1980) found green turtle hatchlings taking refuge in and around *Sargassum* rafts off Panama, and Witherington and Hirama (2006) reported captures in *Sargassum* off the U.S. Mellgren et al. (1994) found green turtle post-hatchlings to spend a greater amount of time in the open ocean than other species known to associate with *Sargassum*. The suggested green turtle-*Sargassum* association may be due to the juveniles and *Sargassum* being passively brought together by convergence zones (Carr 1995).

Once green turtles reach a carapace of 30 to 40 cm, they leave the pelagic habitat and enter benthic foraging areas in coastal waters where they spend the majority of their lives as late juveniles and adults (Bjorndal 1997; Hirth 1997; Musick and Limpus 1997). Both the developmental habitat for late juveniles and the feeding grounds for both adults (typically) and juveniles are shallow, coastal waters (3 to 5 m in bottom depth). Some green turtles are known to maintain distinct home ranges or site fidelity within foraging grounds (e.g., Musick and Limpus 1997). Little is known on habitat usage by the green turtle in the Chesapeake Bay. The occurrence of greens in the Chesapeake Bay is very rare, with only one or two individuals recorded every few years. Those that are recorded are typically live incidental captures from pound net fishermen located along the western Chesapeake Bay (Mansfield, K., University of Miami, pers. comm., 26 July 2007).

Distribution—Green turtles are distributed worldwide in tropical and subtropical waters and prefer temperatures above 20°C (NMFS and USFWS 1991b; Seminoff and MTSG Green Turtle Task Force 2004). 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 USVI, Puerto Rico, and the continental U.S. from Texas to Massachusetts (NMFS and USFWS 1991b). Juvenile green turtles utilize estuarine waters along the U.S. Atlantic coast as summer developmental habitat, as far north as Long Island Sound, the Chesapeake Bay, and North Carolina sounds (Epperly et al. 1995a; Epperly et al. 1995b; Musick and Limpus 1997). As adults, green turtles are restricted to more southern latitudes (Epperly et al. 1995b), and are only occasionally found north of Florida. During non-breeding periods, adults and juvenile distributions may overlap in coastal feeding areas (Hirth 1997). Juvenile green turtles are known to move through a series of developmental feeding habitats. These developmental feeding habitats are often separated by thousands of kilometers (Hirth 1997; Musick and Limpus 1997). Mixed-stock analyses on juvenile foraging populations have revealed that developmental feeding habitats likely contain green turtles from multiple stocks (Dutton and McDonald 1990; Nichols et al. 2000); however, nothing is known regarding the stock composition of the few juveniles observed foraging in the Chesapeake Bay.

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 1991b). 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 1991b). 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 2005b). 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 Chesapeake Bay Study Area—Little is known on habitat usage by the green turtle in the Chesapeake Bay (Mansfield, K., University of Miami, pers. comm., 26 July 2007). The occurrence of greens in the Chesapeake Bay is very rare, with only one or two individuals recorded every few years. Those that are recorded are typically live incidental captures from pound net fishermen located along the western Chesapeake Bay (Mansfield, K., University of Miami, pers. comm., 26 July 2007). Late juvenile and adult green turtles feed primarily on seagrasses and generally stay in waters shallower than 10 m within the Chesapeake Bay. Therefore, the areas within the Chesapeake Bay where seagrasses occur and that are 10 m or less are designated as areas of primary occurrence from May through October (**Figures 3-21**, **3-22**, and **3-23**). The rest of the mainstem area is considered an area of secondary occurrence. Green turtles are not known to travel very far up the tributaries; therefore, that area is considered an area of rare occurrence. The first ever green turtle nest in Virginia was documented in 2005 at Back Bay National Wildlife Refuge (USFWS 2005b) and is depicted on **Figure 3-22**.

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 coast of Palm Beach, Florida, were found to forage continuously throughout the day (Makowski et al. 2006).

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). Green turtles have been known to forage and also rest at depths of 20 to 50 m (Balazs 1980; Brill et al. 1995). In 1997, a maximum dive depth of 164.5 m was recorded for a post-nesting female from Japan's Ogasawara Islands (Matsuzawa, Y., STAJ, pers. comm., 18 August 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).

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 SCL. Females nest from one to seven times in a season (two to three is typical) at approximately two-week intervals, and reproduce every two to four years (NMFS and USFWS 1991b). 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).

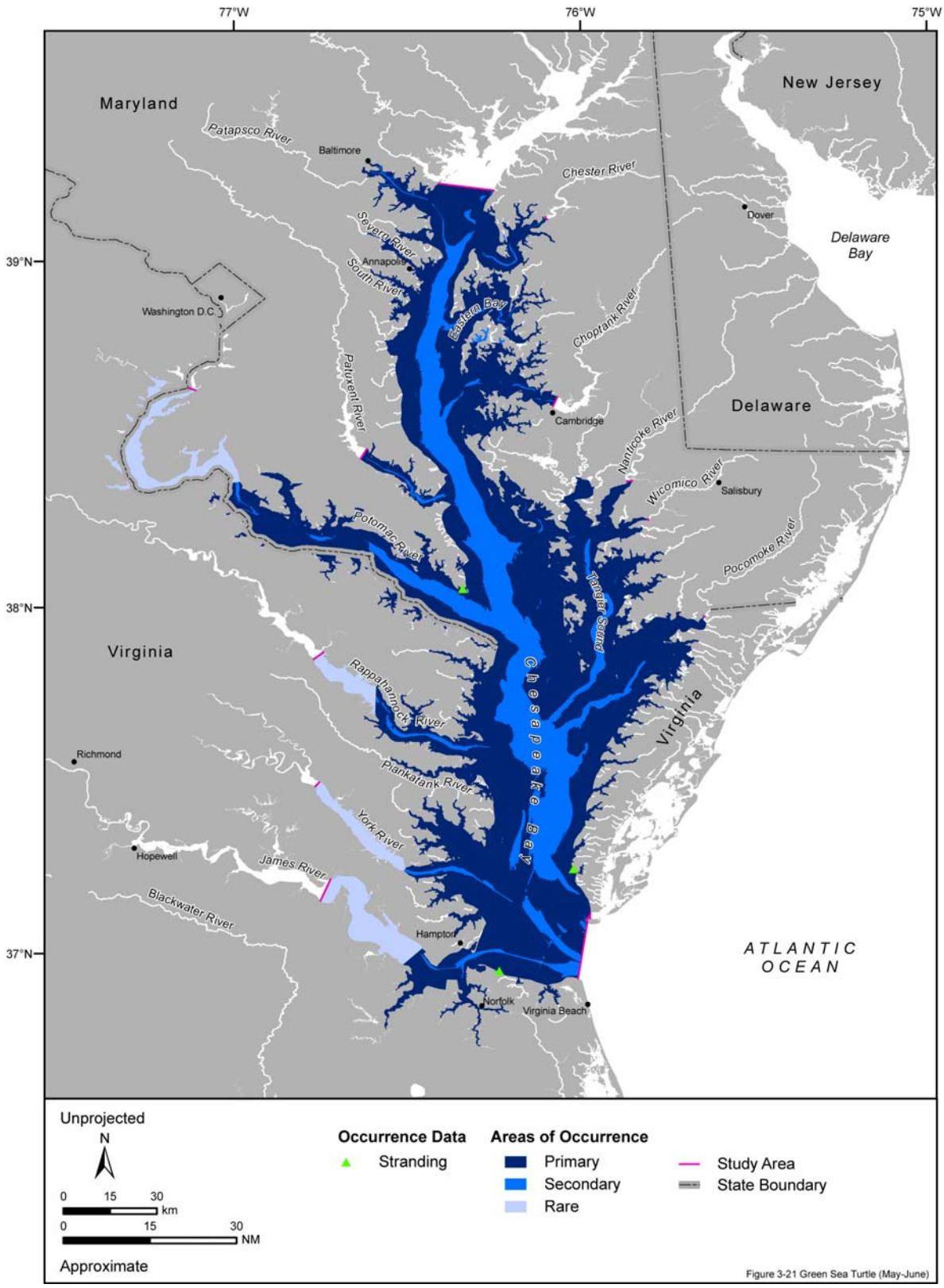

Figure 3-21. Areas of occurrence for the green turtle in the Chesapeake Bay Study Area during May and June. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

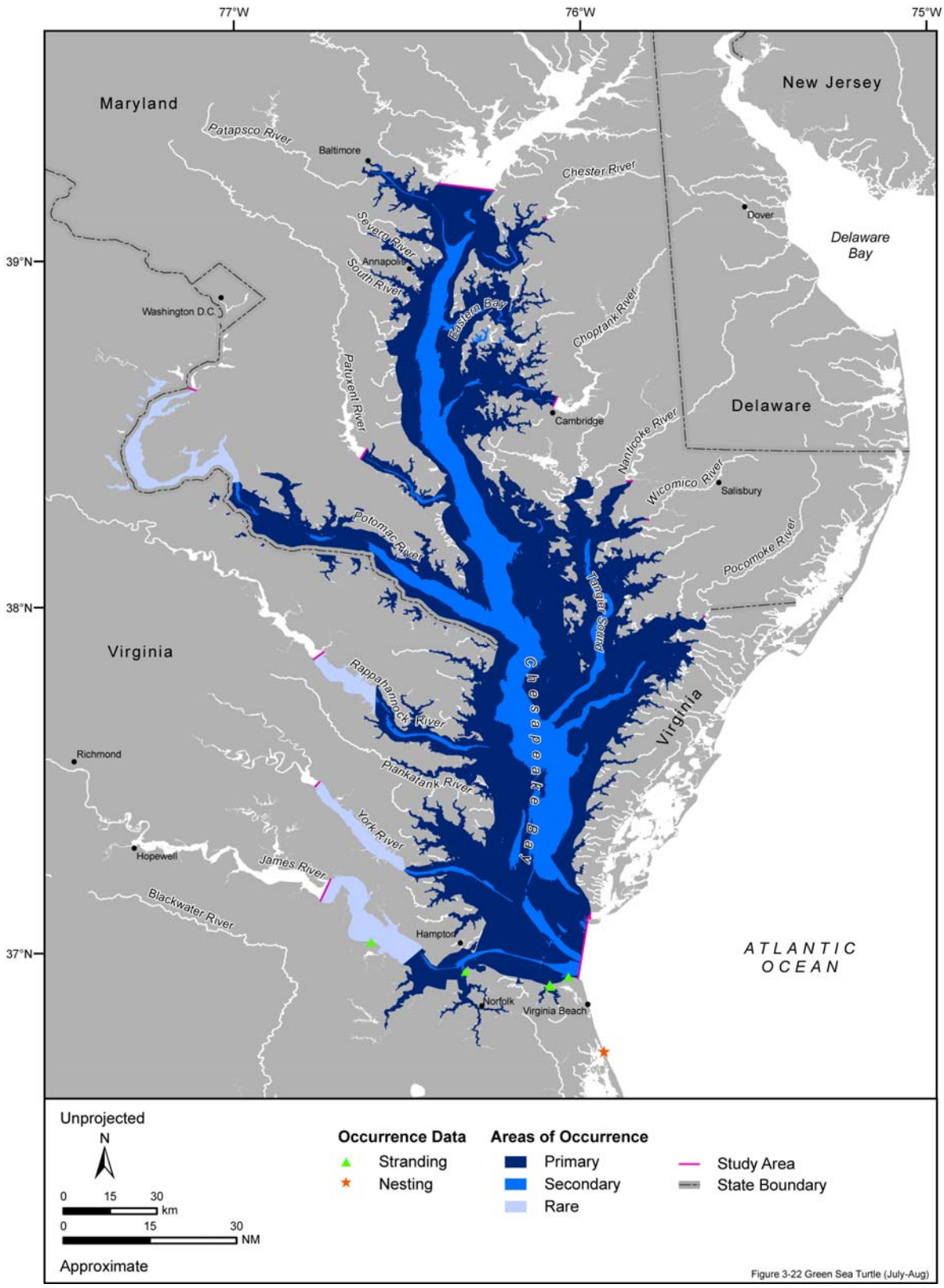

Figure 3-22. Areas of occurrence for the green turtle in the Chesapeake Bay Study Area during July and August. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

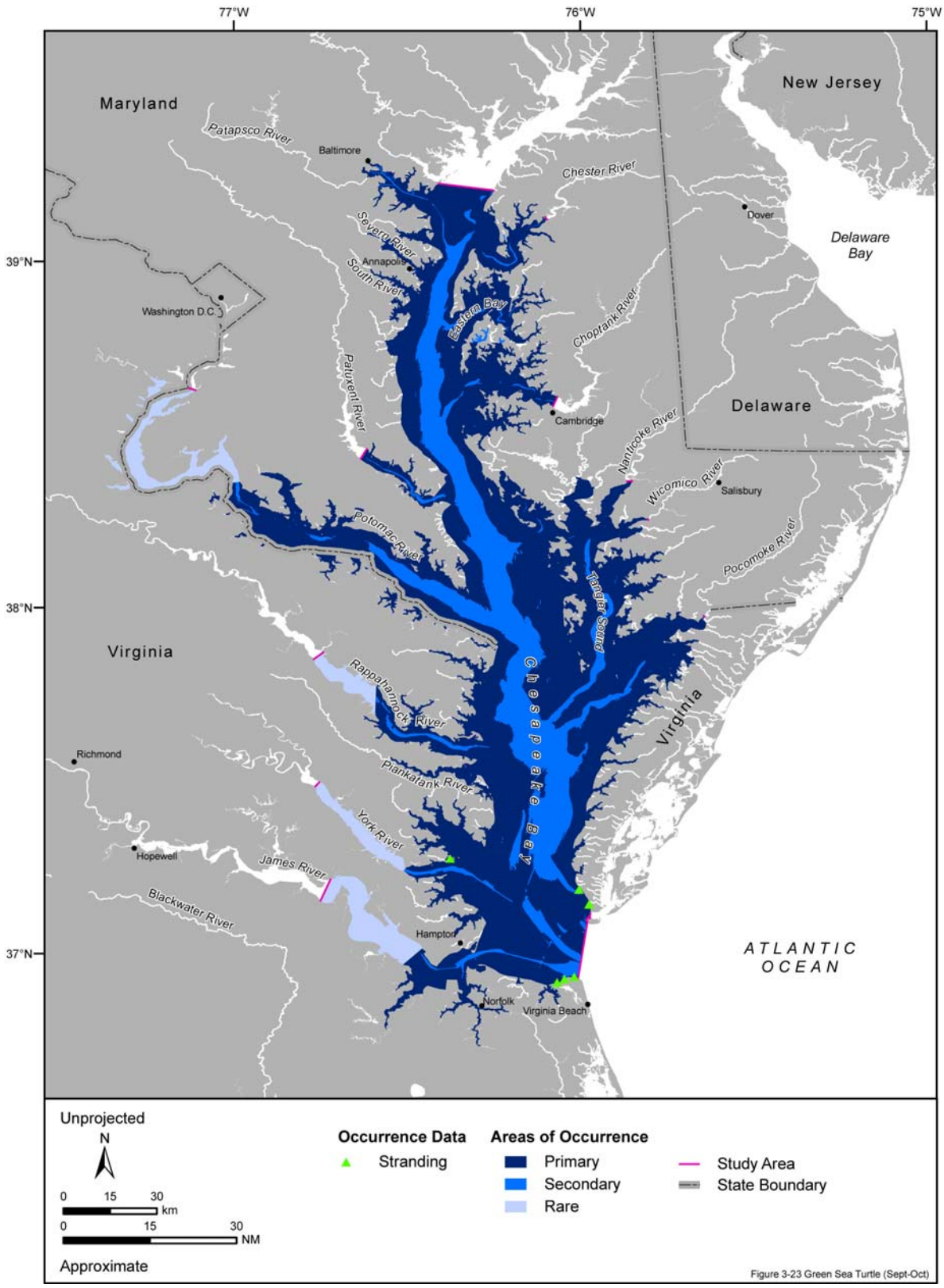

Figure 3-23. Areas of occurrence for the green turtle in the Chesapeake Bay Study Area during September and October. Available sighting, stranding, and incidental fisheries bycatch records during indicated months are represented. Source data: refer to Table A-1.

- **Hawksbill Turtle (*Eretmochelys imbricata*)**

  Hawksbill turtles are a tropical species that are circum-tropical in distribution, generally occurring from 30°N to 30°S within the Atlantic, Pacific, and Indian oceans (Witzell 1983). The hawksbill turtle has only rarely been recorded away from the tropics as coral reefs are recognized as optimal habitat for juveniles, sub-adults, and adults (NMFS and USFWS 1993). Hawksbill turtles are considered extralimital in the Chesapeake Bay. Please refer to the VACAPES MRA (DoN 2008) for an in-depth write-up of the hawksbill sea turtle.

  - Information Specific to the Chesapeake Bay Study Area—The first verified account of a hawksbill turtle in the Chesapeake Bay occurred in November 1991 (Keinath et al. 1991). A commercial fisherman caught the juvenile hawksbill at the mouth of the James River, which was later released in Florida (Keinath et al. 1991). Since then, there have only been two additional reports of hawksbill sea turtles in the Chesapeake Bay; one in December 2000 and one in November 2004 (VIMS 2008). These individuals were also juveniles and were both cold-stunned.

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3.3 SEABIRDS

3.3.1 Introduction

The Chesapeake Bay is the largest estuary in the U.S. and the majority of the bay is relatively shallow with an average depth of only 6.4 m (21 ft).[1] The Chesapeake Bay is an area of importance to numerous resident and migratory avian species traveling along the Atlantic Flyway in the eastern U.S. The diverse habitats of the Chesapeake Bay utilized by avian species include open and shallow marine water environments, wetlands (marshes, swamps, and bogs), tributaries, and upland habitats. Approximately one million waterfowl consisting of twenty-nine different species winter in the shallow nearshore marine waters of the Chesapeake Bay (Chesapeake Executive Council 1990). During the summer, large numbers of coastal shorebirds, seabirds, wading birds, and raptors nest on bay islands, barrier islands, and wooded tributary habitats (Erwin 1996). The Chesapeake Bay also serves as critical stopover habitat for large numbers of shorebird species that feed on the eggs of horseshoe crabs to fuel their migration between nesting and wintering areas.

3.3.2 Seabirds of the Chesapeake Bay

Seabird species that are listed under the ESA as endangered or threatened and that are known to occur in the Chesapeake Bay include the least tern, piping plover, and roseate tern (**Table 3-4**). Information on the description, status, habitat associations, distribution (including location and seasonal occurrence in the Chesapeake Bay), and behavior and life history of each species is discussed below.

Table 3-4. Threatened and endangered seabirds of the Chesapeake Bay. Taxonomy is consistent with the American Ornithologists' Union (AOU) (AOU 1998; Banks et al. 2006).

Common Name	Scientific Name	Status	Occurrence*
Piping Plover (shorebird)	*Charadrius melodus*	Threatened[2]	Rare
Roseate Tern	*Sterna dougallii*	Endangered[3]	Extralimital
Least Tern	*Sternula antillarum*	Endangered[4]**	Regular

* **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 occurs in the area only sporadically;
Extralimital = A species that does not normally occur in the area.
** Interior breeding population of the least tern is listed as endangered; other populations are not listed.

- **Least Tern (*Sternula antillarum*)**

  Description—Least tern (formerly in *Sterna*), the smallest of North America's 15 breeding tern species, is about 21 to 23 cm long. There are five named subspecies of least tern; the validity of most has been questioned (Massey 1976; Thompson et al. 1992; Palacios and Mellink 1993; Olsen and Larsson 1995), but Johnson et al. (1998) provide data supporting three subspecies in the U.S. The form occurring in the Study Area is nominate *antillarum*. Its general appearance is like that of most terns, with a white body, pale gray back and upper side of wings (with variably contrasting dark wingtips), and a pale tail. In alternate (breeding) plumage, the crown is black, strongly contrasting with the rest of the white head and with the white forehead surrounded by black; at other times of the year, the dark crown patch is less extensive and brownish, the bill is black, and the leading edge of the wing is dark. Unlike most other North American terns, least tern has a yellow bill, variably tipped in black. Juveniles have head patterns similar to basic-plumaged adults, a blackish bill, pale tan back and wings with each feather with dark subterminal and white terminal fringes. In their pre-formative molt (first post-juvenal molt), they become quite adult-like (Olsen and Larsson 1995).

  Status—The interior breeding populations of least tern were designated as endangered in 1985; the Atlantic coastal breeding populations remain unlisted by USFWS. This listing status is due primarily to

water-management issues causing loss of appropriate nesting habitat in the Mississippi River system. Coastal populations, though not federally listed, are negatively impacted by beach development and all of its subsidiary effects (predation by various human-commensal and associated mammal and bird species, disturbance of colonies, and loss of colony sites due to construction of sand-control structures). There is no designated critical habitat for interior least tern populations.[4,5]

Habitat Associations—Atlantic coast least terns are summer residents of coastal and estuarine areas, nesting in colonies on sand substrate on beaches and appropriate islands in places relatively free of mammalian predators and near consistent and adequate food supplies. Colonies are placed above mean high-tide line but are susceptible to washing out by abnormal high-tide events.[6]

Major loafing and roosting habitat is in similar situations, but such sites are less-dependent upon being predator-free. Least terns also utilize anthropomorphic structures (e.g., pilings, jetties, and piers) for roosting and loafing. Foraging occurs primarily in relatively shallow estuarine and nearshore marine waters; in the breeding season, nesting adults usually range <3.2 km from colonies (Atwood and Minsky 1983).

Distribution—Nominate least tern breeds from Maine south along the Atlantic and Gulf of Mexico coasts to eastern Mexico and south through the West Indies to coastal Venezuela. Other named races occupy breeding ranges in the North American interior (locally in the Mississippi and Rio Grande drainages), along the Pacific coast from San Francisco Bay to Baja California, Mexico, and in the Gulf of California (Sea of Cortez) south along the Pacific coast to Chiapas, Mexico. The species winters in marine coastal areas south of the U.S. (though rarely along the U.S. Gulf of Mexico coast).

- Information Specific to the Chesapeake Bay Study Area—Least terns breed locally in the Study Area, with colonies known on both the western and eastern shores (Robbins and Blom 1997a; Rottenborn and Brinkley 2007), being present here late April through late September, with extreme dates of 16 April through 12 November (Rottenborn and Brinkley 2007). There is very little in the way of local population data other than those derived from colony counts. More than half the Maryland Chesapeake Bay colonies are situated on artificial sites, such as dredge-spoil islands, rooftops, and parking lots (Robbins and Blom 1997a), probably a response to the loss and/or human disturbance of natural sites (Buckley and Buckley 1976). Most nest sites share three features: light-colored substrate (usually sand and shell mix or small white stone <1 cm diameter), proximity to water, and sparse vegetation (Robbins and Blom 1997a).

  Maryland-breeding least terns were studied in the late 1980s, with the contents of 1,002 nests recorded. The mean clutch size was 1.8, with 759 nests containing two eggs and 46 nests containing three. The early date for hatching is 8 June. In 1987, reproductive success ranged from 0.0 to 0.4 fledglings/nest. All data are from the Maryland Colonial Waterbird Project and presented in Robbins and Blom (1997a).

Behavior and Life History—Of several scrapes made by both sexes, the female of the pair selects the scrape that gets used as the nest to which are added bits of shell or light-colored pebbles (Thompson et al. 1997). Egg-laying begins in Maryland in late May, with normal clutch size being two eggs (Robbins and Blom 1997a). Incubation lasts 19 to 25 days (Thompson et al. 1997), with young beginning to hatch in mid-June. The species is single-brooded, but pairs will renest if nest loss happens early in cycle (Thompson et al. 1997).

Chicks typically leave the nest at two days of age in order to find shelter and to thermoregulate and initiate flight at around 15 to 20 days of age (Robbins and Blom 1997a; Thompson et al. 1997). Juveniles are still at least somewhat dependent upon parents for feeding until the commencement of fall migration (Tomkins 1959). Some immature least terns return to the breeding grounds at 11 to 12 months of age [many spend their first summer on the winter grounds (Haverschmidt 1972)], but they delay first breeding until after their second winter, with most not breeding for the first time until three to four years old (Massey and Atwood 1978).

Annual reproductive success varies greatly among years and locations (Thompson et al. 1997 and references therein). Average annual reproductive success, however, was fairly high at about 0.5 fledglings/nest, with similar values obtained from three meta-populations (Thompson et al. 1997). Lifetime reproductive success has not been well-studied, but California adults were calculated to have a rate of 1.49 fledglings/adult, with adults living 9.6 years (Massey et al. 1992).

Least terns plunge dive for fish, their primary prey, though they have been also known to catch shrimp and other small invertebrates (Atwood and Kelly 1984), occasionally catching flying insects over land (McDaniel and McDaniel 1963) and water and skimming the water surface to catch swimming insects (Wilson et al. 1993).

- **Piping Plover (*Charadrius melodus*)**

Description—Piping plover, one of two temperate-zone-breeding pale plovers in the U.S., is 17 to 18 cm long and weighs 43 to 63 grams (g) (O'Brien et al. 2006). Flighted individuals exhibit pale gray-brown upperparts with the crown isolated from the back by a white half-collar; the underparts are white. The species can be readily separated from the similar snowy plover (*C. alexandrinus*) by the current species' orange legs and thicker bill (O'Brien et al. 2006). In breeding condition, a distinct and variably-complete black collar separates the white half-collar from the back, a black bar demarcates the white forehead from the gray-brown crown, and the base of the bill becomes bright orange (O'Brien et al. 2006). Juveniles are similar in plumage to basic-plumaged adults, though with vague pale fringes to the upperparts feathers (O'Brien et al. 2006). In flight, all ages sport obvious white wing stripes and rumps that are mostly pale (O'Brien et al. 2006). Juveniles acquire partial adult plumage in their first winter/spring (and usually breed in that plumage) but complete the transition to adult plumage in their second fall (Pyle 2008).

Status—USFWS listed the Great Lakes population of piping plover as endangered and the Great Plains and Atlantic Coast populations as threatened in 1985, and there has been no official status change since. U.S. coastal Atlantic populations have trended upward since listing, though with some areas' breeding populations remaining at depressed levels (USFWS 2002a) and showing little or no increase in size. As of 2001, breeding numbers from New York north were some 325% (290 to 950 pairs) higher than in 1986, but south of New York, that figure is only just over 200% (160 to 330), with a large portion of that increase (about 21%; 36 pairs) due to a single management change at Assateague Island, Maryland (Kumer 2004), and with the situation south of Maryland essentially unchanged (133 to 132) (USFWS 2002a). In 2002, the U.S. Atlantic coastal population size was estimated at 1280 (up from 550 in 1986), a bit over 75% of the population goal (USFWS 2002a). Critical habitat has been listed for both breeding (Great Plains population) and wintering areas (USFWS 2001; 2002b).

Habitat Associations—Coastal-breeding piping plovers are primarily an inhabitant of sandy shorelines, though inland and Great Lakes breeders utilize a wider variety of open, non-vegetated habitats (O'Brien et al. 2006). In winter, the species is only found in coastal areas. During this time they use a wide variety of habitats, including mudflats and dredge spoil areas, and, most commonly, sandflats (O'Brien et al. 2006).

Distribution—This species breeds in the interior on playas, lakeshores, and rivers of North America from western Alberta across Canada to southwestern Ontario, south through the plains to the Platte River drainage in Nebraska, with small, isolated colonies in southeast Colorado, eastern New Mexico, and the panhandle of Texas, and locally on Great Lakes shorelines (Elliott-Smith and Haig 2004). The Atlantic coastal breeding range extends from Nova Scotia and Prince Edward Island south to North Carolina, with sporadic nesting in South Carolina (USFWS 2002a; Elliott-Smith and Haig 2004). The winter range is considerably smaller, extending along the coast of the southeastern U.S. from central North Carolina to southern Texas, with small disjunct populations also found in the Bahamas, Cuba, Gulf coastal Mexico, and at the head of the Gulf of California (Sea of Cortez) (Elliott-Smith and Haig 2004).

- Information Specific to the Chesapeake Bay Study Area—Piping plover has never been known to breed (Robbins and Blom 1997b) or winter in the Study Area, though it has been found as a rare migrant in the spring (29 April - 2 May) and fall (13 August - 15 September). Fall migrants are probably from Great Lakes populations. As of 2008, there were fewer than 10 acceptable records for Maryland's Chesapeake Bay waters.[7]

Behavior and Life History—Pair formation begins shortly after arrival – mid-March in Virginia (Elliott-Smith and Haig 2004) and late March in Maryland (Robbins and Blom 1997b) – and males initiate making nest scrapes (Elliott-Smith and Haig 2004). The typical clutch is four eggs, with the incubation period lasting around 28 days (Elliott-Smith and Haig 2004) and hatching taking place in June. Downy young dates from Maryland range from 21 May to 23 July (Robbins and Blom 1997b). At one to two days after hatching, adults and hatchlings may move from the nest area though they stay typically on the same territory unless disturbed (Elliott-Smith and Haig 2004). Chicks attain sustained flight in 21 to 35 days, at which point they usually become independent of the parents (Elliott-Smith and Haig 2004). Some immatures breed in their first year (Elliott-Smith and Haig 2004), the percentage of which is probably variable from year to year depending on the availability of territories and/or mates.

There are no estimates of lifetime breeding success in this species (Elliott-Smith and Haig 2004), despite numerous recent studies of the species. Annual success (mean number of chicks fledged/ pair/year) in given areas is highly variable due to predation intensity and, particularly, weather and its effects (Burger 1987), ranging from 0.3 to 3.0 in breeding areas with larger populations (Elliott-Smith and Haig 2004). North Dakota adult survival was estimated at 73.7% and juvenile survival at 31.8% (Larson et al. 2000); Great Lakes adult survival was identical (Wemmer et al. 2001).

Piping plover is a predator of marine and terrestrial invertebrates, particularly various worm taxa and insects (Elliott-Smith and Haig 2004). They hunt visually using a start-and-stop running method and gleaning prey from the substrate. Data from Great Lakes breeders indicate a preponderance of prey was of insects, particularly Hymenoptera (32%), Coleoptera (29%), Diptera (28%), and Hemiptera and Homoptera (10%) (Cuthbert et al. 1999).

- **Roseate Tern (*Sterna dougallii*)**

Description—A pale and elegant species, roseate tern is typical of *Sterna* terns, having a black crown patch, white body, pale gray upperparts, and a white tail. In alternate plumage, the black on the crown is more extensive, extending from the forehead through the nape, and the underparts often exhibit a rosy hue, whence the species' name is derived. The bill is blackish or black with a reddish suffusion through most of the year, but in breeding condition it can have as much as the basal half scarlet (Olsen and Larsson 1995). The tail in this species is particularly long and forked. Juveniles are similar to juveniles of other *Sterna* terns but with a full dark crown patch (extending through the forehead) and a paler and grayer back comprised of pale feathers with dark terminal fringes (Olsen and Larsson 1995). Juveniles conduct a complete pre-formative molt and become fairly adult-like in their first fall/winter; however, they do not achieve full adult plumage until two to three years old and usually do not breed until then (Gochfeld et al. 1998).

Status—In 1987, USFWS listed roseate tern as threatened in its Caribbean breeding range and endangered in its northeastern North American range (Gochfeld et al. 1998). The status is due to declining numbers of both colonies and individuals, with contamination by dichlorodiphenyltrichloroethane (DDT) by-products and various metals being the prominent suggested causes of these declines (Gochfeld et al. 1998). There is no designated critical habitat for roseate tern.

Habitat Associations—Roseate tern is a strictly coastal species, with colony sites located on rocky offshore islands, barrier beaches, and saltmarsh islands with relatively low predator populations and that are close to shallow-water foraging areas with sandy bottoms, bars, and shoals (Gochfeld et al. 1998). Nests are placed on the ground in a variety of situations but often with some overhead cover (Gochfeld et al. 1998) in places readily using inverted boxes or half-tires (Spendelow 1982). The

species roosts in dense flocks in areas that are typically flat and open. At colonies, breeding individuals often roost immediately adjacent to colony or, in places, in nest territory.

Distribution—Roseate tern breeding distribution in the New World is strongly disjunct with about 20 colonies scattered from coastal New York north to Quebec and from the Florida Keys south through the West Indies to islands off Venezuela (Gochfeld et al. 1998). At least 80% of the northeastern population breeds on two islands (Great Gull Island, New York, and Bird Island, Massachusetts). The species winters in coastal South America, particularly in the northeast; it is found only rarely in migration in intermediate locations in the U.S.

- Information Specific to the Chesapeake Bay Study Area—Roseate tern is an extralimital migrant in the Study Area (e.g., <10 acceptable records in Maryland's part of the Chesapeake Bay[7]). The species apparently bred at one site in Maryland (coastal Worcester County) in the 1930s, but has not done so since 1938. Though it may occur more often than it has been found in the Study Area due to observational biases and the difficulty of identification of *Sterna* terns, the facts remain that all U.S. breeding colonies are strictly coastal, the breeding range is very local, and the northeastern breeders apparently winter in coastal South America (Hays et al. 1997; Gochfeld et al. 1998) and probably move between breeding and wintering areas primarily over the Atlantic Ocean (Gochfeld et al. 1998). Therefore, it is unlikely that the Chesapeake Bay is an important habitat for this species.

Behavior and Life History—Spring arrival in the northeast begins in late April into mid-May (depending on latitude) and egg-laying commences some three weeks later. The typical clutch is of two eggs. Both parents share incubation duties, as is typical of terns, for the duration of incubation (21 to 31 days) (Gochfeld et al. 1998). Chicks that remain undisturbed stay on or within 10 cm of the nest until nearly fledged, which takes 22 to 30 days (Gochfeld et al. 1998). Fledglings leave the colony with their parents 5 to 15 days upon achieving sustained flight, gathering in large mixed-species tern flocks at favored foraging areas and being fed by their parents at least until the onset of southward migration (Gochfeld et al. 1998). As in many temperate- and arctic-breeding tern species, many immatures probably spend their first summer on the winter grounds.

The species enjoys relatively high hatching success (possibly due to hidden nests) relative to other similar tern species (Gochfeld et al. 1998). Annual reproductive success rates are difficult to obtain at many colonies, as nest sites are inaccessible at some sites and/or because chicks hide in vegetation or among rocks (Gochfeld et al. 1998); however, calculated rates vary – due to a large number of factors – from 0 to 1.6 chicks fledged/nest (Gochfeld et al. 1998 and references therein). Low productivity values typically come from small colonies (Gochfeld et al. 1998), so the concentration of most breeding individuals at two colonies in the northeast probably accounts for some portion of the species' high reproductive rates. Annual survival rates have been calculated for adults from the northeast at 0.74 to 0.84, a rate that is lower than those of similar species (Spendelow et al. 1995). Site fidelity is high, with >90% of surviving adults returning to the same colony in any subsequent year (Spendelow et al. 1995).

Like most tern species, roseate tern captures fish by plunge diving, their primary food in the northeast being sand eels (*Ammodytes* spp.) (Gochfeld et al. 1998). In poor food years, some pairs apparently do not attempt breeding (Gochfeld et al. 1998).

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3.4 FISH

3.4.1 Introduction

The Chesapeake Bay supports more than 350 species of fish at some point in their lifecycles (Murdy et al. 1997).[1] Their overall distribution is dependent on temperature, salinity, available habitat and food, and annual migratory cycles (Lippson and Lippson 1997). All these fish can be classified as resident or migratory. Resident species tend to be smaller in size and remain in shallower waters than the migratory species. The migratory species are categorized into two groups: those that spawn in the ocean and live most of their life in the Chesapeake Bay, and those that spawn in the Chesapeake Bay's freshwater tributaries and spend most of their life in the ocean. Approximately 32 fish species are residents, whereas the remainder are migratory species whose lifecycles are defined by the salinity regime of the waters in which they inhabit (Reshetiloff 2004).[1]

3.4.2 Fish of Chesapeake Bay

Of the 350 fishes that occur in the Chesapeake Bay, only one species, shortnose sturgeon (*Acipenser brevirostrum*), is listed under the ESA. The shortnose sturgeon inhabits both the Maryland and Virginia waters of the Chesapeake Bay with more frequent encounters (99%) occurring in Maryland waters (USFWS 2008). Information on the description, status, habitat associations, distribution (including location and seasonal occurrence in the Chesapeake Bay), and behavior and life history of this species is discussed below.

- **Shortnose Sturgeon (*Acipenser brevirostrum*)**

  Description—The shortnose sturgeon has a small eye, an inferior protrusible mouth preceded by four small barbels (less than one-half the width of the mouth), a heterocercal tail with the upper lobe longer than the lower lobe, and a body covered with five rows of large, bony plates (scutes) on the head, back, and sides (Gilbert 1989).[2] Coloration varies from yellowish pink to yellowish brown dorsally and creamy white ventrally (Matthews 1991). In salt water, the upper parts are yellow brown with a green or purple cast and in freshwater are very dark (Burkhead and Jenkins 1991). Adults range from 44 to 109 cm in length and weigh up to 42 kg (Gilbert 1992; Rohde et al. 1994). The shortnose sturgeon is also easily confused with a related species, Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), from which it differs by having a wider mouth (mouth width >62% interorbital width); shorter, round (blunt V-shaped) snout; and no row of bony plates along the base of the anal fin (Ross et al. 1988; NMFS 1998).

  Status—On March 11, 1967, the shortnose sturgeon was originally listed as an endangered species throughout its range under the Endangered Species Preservation Act of 1966 (USFWS 1967). The shortnose sturgeon remained on the endangered species list with the enactment of the ESA (NMFS 1998) under a 1974 government reorganization plan (38 FR 41370). This species is also listed as endangered by the states of Virginia and Maryland (VDGIF 2006; MDNR 2007).

  The shortnose sturgeon is managed by NMFS (1998). The current population consists of the following DPSs occurring in each of the following riverine/estuarine areas: one population in the Saint John River, New Brunswick, Canada; Merrimack River, Massachusetts; Connecticut River, Massachusetts/Connecticut; Hudson River, New York; Delaware River, New York/Delaware/ Pennsylvania; the Chesapeake Bay/Potomac River, Maryland/Virginia; and Cape Fear River, North Carolina; two populations in both the Penobscot River/Kennebec System (Sheepscot/Kennebec/ Androscoggin rivers), Maine and the St. Marys/St. Johns rivers, Florida; and four populations each in the Winah Bay (Waccamaw/Pee Dee/Black rivers), South Carolina/North Carolina and Santee (Santee River/Lake Marion) and Cooper Rivers/ACE Basin (Ashepoo, Combahee, and Edisto rivers) and Savannah River, South Carolina, and Ogeechee/Altamaha/Satilla rivers, Georgia (NMFS 1998; Musick et al. 2000). All populations from the Chesapeake Bay north are considered "northeast" while those south of the Chesapeake Bay are considered "southeast" population segments. Population estimates are currently unavailable for the Chesapeake Bay (NMFS 1998).

Habitat Associations—Shortnose sturgeons inhabit rivers and estuaries, occasionally moving short distances to the mouths of estuaries and the nearby coastal waters, with populations confined mostly to natal rivers and estuarine habitats. The species appears to be estuarine anadromous in the southern part of its range, but in some northern rivers it is "freshwater amphidromous" (adults spawn in freshwater but regularly enter saltwater habitats during their life) (NMFS 1998). In estuarine systems, the shortnose sturgeon occurs in areas with little or no current over a bottom comprised primarily of mud and sand. Sturgeons associate with freshwater swamps or areas with fast flows and gravel-cobble bottoms in the riverine areas (Gilbert 1992). Adults are found in deep water (10 to 30 m) in winter and in shallow water (2 to 10 m) in summer. Juveniles are nonmigratory, typically inhabiting deep channels of swiftly flowing river above the salt wedge (Burkhead and Jenkins 1991).

The majority of shortnose sturgeons found in the Chesapeake Bay through the USFWS Atlantic Sturgeon Reward Program have been captured in relatively shallow water (<7.6 m). This is also consistent with some studies which have found that shortnose sturgeons tend to stay in the top of 2 m of the water column when traveling and come into shallow waters to feed. From this data, it can be deduced that shortnose sturgeons are using water depths of 1.2 to 18.3 m in at least the months of December through June each year. Thus, it is probable that the Howell to Grove Point sections of the upper Chesapeake Bay provides an over wintering habitat for the shortnose sturgeon due to the water depth (USACE 2008).

Channels with moderate flow (0.8 m/s) are important for spawning shortnose sturgeons in many rivers. The preferred spawning substrate mixture consists of gravel, rubble, and large boulders with little sand or silt (NMFS 1998). Spawning begins from late winter/early spring (southern rivers: January to March) to mid- to late spring (northern rivers: April to May) when water temperatures increase to 8° to 9°C. Spawning usually ceases when water temperatures reach 12° to 15°C (O'Herron et al. 1993; Kynard 1997). No spawning habitat has been identified in the Chesapeake Bay (USACE 2008).

In the Potomac River, Kynard et al. (2009) reported that shortnose sturgeons used the channel or channel edge habitats consisting of mud (81%) and sand-mud (16%) substrates. Shortnose sturgeons were found in water ranging from 4.1 to 21.3 m encompassing a wide range of physical parameters: water temperature (1.8° to 32.0°C), DO (4.8 to 14.6 mg/L), and salinity (0.1 to 5.6 psu).

Distribution—Historically, the range of the shortnose sturgeon extended along the Atlantic coast from Saint John River, New Brunswick, Canada to Indian River, Florida (Gruchy and Parker 1980). Currently, NMFS recognizes 19 DPSs of shortnose sturgeons inhabiting 25 river systems from Saint John River, New Brunswick, Canada to St. Johns River, Florida (NMFS 1998). Migrational patterns of the shortnose sturgeon vary with fish size and home river location. Pre-spawners generally move upstream to spawning grounds in spring and summer and post-spawners move back downstream in fall and winter to wintering areas, with movements usually restricted to the areas above the saltwater/freshwater interface. Adults exhibit freshwater amphidromy in the northern part of their range but are generally estuarine anadromous in their southern range. Shortnose sturgeons are not known to participate in coastal migrations (NMFS 1998).

- Information Specific to the Chesapeake Bay—The first published account of the shortnose sturgeon in the Chesapeake Bay system was an 1876 record from the Potomac River. Based on its occurrence north and south of the Chesapeake Bay, it was likely a resident of the Chesapeake Bay and occupied all four major riverine estuaries of Virginia (Burkhead and Jenkins 1991). Other historical records support this observation; this species was reported in the upper Chesapeake Bay near the mouth of the Susquehanna River in the early 1980s and in the lower Chesapeake Bay near the mouths of the James and Rappahannock rivers in the late 1970s (NMFS 1998).

  Since the implementation of the USFWS Atlantic Sturgeon Reward Program in 1996, more than 80 shortnose sturgeons have been captured in the Maryland waters of the upper Chesapeake Bay north of Hart-Miller Island by commercial fisherman between 1996 and 2008 (**Figure 3-24**) (Litwiler 2001; Mangold, M., USDFW, pers. comm., 1 October 2008). It is generally believed that

they were infrequent transients, non-resident adults that had traveled through the Inland Waterway or the Chesapeake and Delaware (C&D) Canal from the Delaware River where a well-documented population (12,047 individuals) currently exists (Murdy et al. 1997; Welsh et al. 2002; NMFS 2006).[3] Wirgin et al. (2005) conducted genetic assessments of the shortnose sturgeon captures in the Chesapeake Bay and the Delaware River population and found that the Chesapeake Bay specimens were genetically similar to the Delaware River population. According to the Virginia Department of Game and Inland Fisheries (VDGIF), this species is believed to be extirpated from Virginia coastal rivers[4]; however, a single species was collected from the Rappahannock River in 1997 through the Atlantic Sturgeon Reward Program for Virginia's major tributaries (James, York, and Rappahannock rivers) (Spells, A., USFWS, pers. comm., 1 October 2008). This species should still be considered extremely rare in Virginia waters.[4] Distribution and movements of this species in the Chesapeake Bay is poorly understood in part because it is often confused with the Atlantic sturgeon (NMFS 2004a; NMFS 2004b; NMFS 2006).

Behavior and Life History—Shortnose sturgeons can live 30 to 40 years with one female reported to have attained 67 years of age (Murdy et al. 1997). The shortnose sturgeon exhibits sexual and latitudinal differences in age of maturity and periodicity of spawning. Males reach maturity faster than females with individuals in southern rivers (males: two to five years, females: six years) growing faster than those in northern rivers (males: 10 to 11 years, females: 7 to 18 years) (Burkhead and Jenkins 1991). Shortnose sturgeons are open substrate spawners exhibiting no parental care (Balon 1975). Eggs are broadcast into the water and are demersal and adhesive, becoming attached to rocks, weeds, and other submerged objects (Gilbert 1989, 1992). Fecundity ranges from about 10,000 to 16,000 eggs per kg of body weight, or about 27,000 to 208,000 eggs per fish (Burkhead and Jenkins 1991). Males spawn more frequently (two-year intervals) than females (three- to five-year intervals), with the spawning period lasting from a few days to several weeks (NMFS 1998).

The shortnose sturgeon is a benthic or plant-surface feeder; feeding varies according to the species life stage. Juveniles feed mostly on small benthic crustaceans and insect larvae while individuals of 20 to 30 cm fork length (FL) often feed exclusively on cladocerans. Adults in freshwater feed mostly on crustaceans, insect larvae, and mollusks; in estuaries, adults mainly eat polychaetes, crustaceans, mollusks, and small benthic fish (Burkhead and Jenkins 1991; Gilbert 1992). In addition, they also ingest quantities of sediment, vegetation, and detritus (Ross et al. 1988). Shortnose sturgeons apparently feed mostly at night or on windy days when turbidity is high (Gilbert 1989). It appears that feeding activity of the shortnose sturgeon is greatly reduced with reduction in water temperature (Gilbert 1992).

Feeding patterns of the shortnose sturgeon vary seasonally between northern and southern river systems. Foraging occurs in northern rivers within highly vegetated, shallow freshwater regions during the summer and over sand-mud bottoms in the lower estuary during fall, winter, and spring (NMFS 1998). Productive reaches of the upper Chesapeake Bay (e.g., near the saltwater/freshwater interface and channel areas bordering mud flats or emergent macrophyte bed) are potential feeding areas from April to October (USACE 2008). In contrast, probable foraging activity in southern rivers occurs at or just downstream of the saltwater/freshwater interface. During the summer, the shortnose sturgeon in these southern systems appears to reduce activity, fast, and lose weight (NMFS 1998). Most activity of larvae, juveniles, and adults appears to occur at night (Richmond and Kynard 1995).

From 2005 to 2007, shortnose sturgeons were found to use a 124-km stretch of the Potomac River. This stretch included a 78-km long saltwater/freshwater reach from river kilometer (rkm) 63 to 141 (near Craney Island) as a summering (foraging)-wintering concentration area and a one-step short pre-spawning migration to rkm 187 (Chain Bridge, Washington, D.C.) (Kynard et al. 2009). Both the foraging-wintering reach and the one-step short pre-spawning movement was similar to the lower river concentrations areas found in north-central populations (Delaware to Merrimack rivers), but not similar to southern populations, which use high salinity in winter (Kynard 1997).

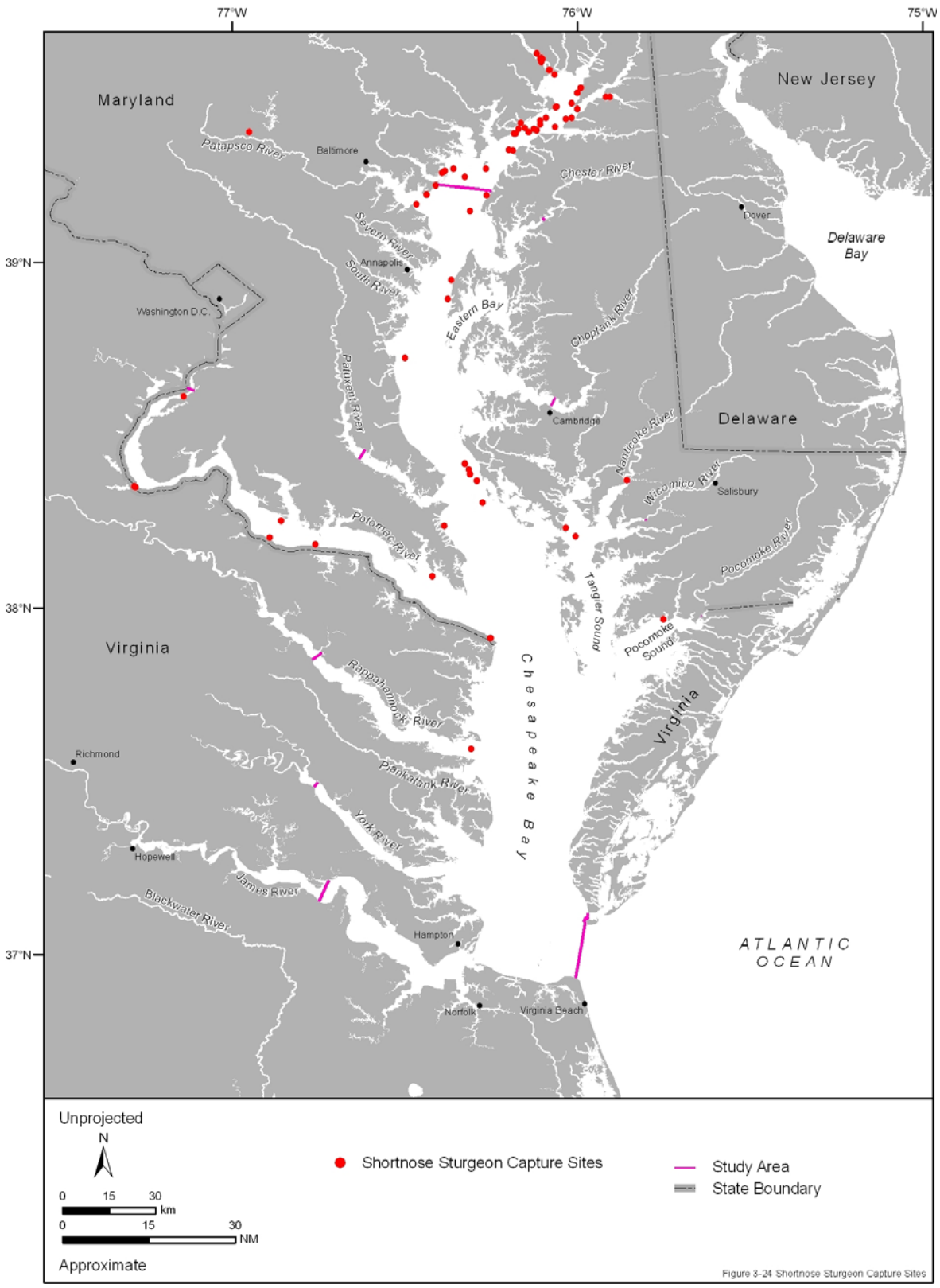

Figure 3-24. Locations of shortnose sturgeons in Maryland and Virginia waters of the Chesapeake Bay captured via the Atlantic Sturgeon Reward Program between April 1996 and April 2008. Source data: USFWS (2008).

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3.5 STATE-LISTED SPECIES

There are a number of species that occur in the Chesapeake Bay Study Area and vicinity that are considered threatened or endangered at the state level. These species may not necessarily be protected at the federal level nor may they be afforded protection in all the states in which they occur. The following table lists species that are protected at the state level in Virginia and/or Maryland and the level of protection provided. Federal ESA status is also noted where applicable.

Occurrence in each state is provided where at least one record of the species is known from that state within the last fifty years. A 'yes' or 'no' determination of occurrence is provided based on available information. Determination of occurrence does not indicate frequency, seasonality, or expected continued occurrence in the state, nor does unknown or negative occurrence indicate that a species may never occur there.

Table 3-5. State-listed species with known occurrence in the Chesapeake Bay Study Area and vicinity. Occurrence of marine mammals and non-nesting sea turtles refers to state waters of the Chesapeake Bay. Common and Scientific names are listed per the convention for each taxon. E – Federally Endangered; T – Federally Threatened; SE – State Endangered; ST – State Threatened.

Species Name	Federal Status	Known to occur in Virginia	Virginia Status	Known to occur in Maryland	Maryland Status
MAMMALS					
Order Cetacea					
Suborder Mysticeti					
Family Balaenidae					
North Atlantic right whale (*Eubalaena glacialis*)	E	Yes	SE	Yes	SE
Family Balaenopteridae					
Humpback whale (*Megaptera novaeangliae*)	E	Yes	SE	Yes	SE
Sei whale (*Balaenoptera borealis*)	E	Yes	SE	Yes	SE
Fin whale (*Balaenoptera physalus)*	E	Yes	SE	Yes	SE
Blue whale (*Balaenoptera musculus*)	E	Yes	SE	Yes	SE
Suborder Odontoceti					
Family Physeteridae					
Sperm whale (*Physeter macrocephalus*)	E	Yes	SE	Yes	SE
Order Sirenia					
Family Trichechidae					
West Indian manatee (*Trichechus manatus*)	E	Yes	SE	Yes	--
BIRDS					
Order Falconiformes					
Family Accipitridae					
Bald Eagle (*Haliaeetus leucocephalus*)	--	Yes	ST	Yes	ST
Northern Goshawk (*Accipiter gentilis*)	--	Yes	--	Yes	SE

Table 3-5 (*continued*). State-listed species with known occurrence in the Chesapeake Bay Study Area and vicinity. Occurrence of marine mammals and non-nesting sea turtles refers to state waters of the Chesapeake Bay. Common and Scientific names are listed per the convention for each taxon. E – Federally Endangered; T – Federally Threatened; SE – State Endangered; ST – State Threatened.

Species Name	Federal Status	Known to occur in Virginia	Virginia Status	Known to occur in Maryland	Maryland Status
BIRDS					
Order Falconiformes					
Family Falconidae					
Peregrine Falcon (*Falco peregrinus*)	--	Yes	ST	Yes	--
Order Gruiformes					
Family Rallidae					
Black Rail (*Laterallus jamaicensis*)	--	Yes	--	Yes	SE
Order Charadriiformes					
Family Charadriidae					
Piping Plover (*Charadrius melodus*)	T	Yes	ST	Yes	SE
Wilson's Plover (*Charadrius wilsonia*)	--	Yes	SE	Yes	SE
Family Scolopacidae					
Upland Sandpiper (*Bartramia longicauda*)	--	Yes	ST	Yes	SE
Family Laridae					
Black Skimmer (*Runchops nigra*)	--	Yes	--	Yes	SE
Gull-billed Tern (*Sterna nilotica*)	--	Yes	ST	Yes	SE
Least Tern (*Sternula antillarum*)	--	Yes	--	Yes	ST
Roseate Tern (*Sterna dougallii dougallii*)	E*	Yes	SE	Yes	--
Royal Tern (*Thalasseus maximus*)	--	Yes	--	Yes	SE
Order Strigiformes					
Family Strigidae					
Short-eared Owl (*Asio flammeus*)	--	Yes	--	Yes	SE
Order Piciformes					
Family Picidae					
Red-cockaded Woodpecker (*Picoides borealis*)	E	Yes	SE	Yes	--
Order Passeriformes					
Family Tyrannidae					
Olive-sided Flycatcher (*Contopus cooperi*)	--	Yes	--	Yes	SE
Family Laniidae					
Loggerhead Shrike (*Lanius ludovicianus*)	--	Yes	ST	Yes	SE

Table 3-5 (*continued*). State-listed species with known occurrence in the Chesapeake Bay Study Area and vicinity. Occurrence of marine mammals and non-nesting sea turtles refers to state waters of the Chesapeake Bay. Common and Scientific names are listed per the convention for each taxon. E – Federally Endangered; T – Federally Threatened; SE – State Endangered; ST – State Threatened.

Species Name	Federal Status	Known to occur in Virginia	Virginia Status	Known to occur in Maryland	Maryland Status
BIRDS					
Order Passeriformes					
Family Troglodytidae					
Bewick's Wren (*Thryomanes bewickii*)	--	Yes	SE	Yes	SE
Sedge Wren (*Cistothorus platensis*)	--	Yes	--	Yes	SE
Family Parulidae					
Blackburnian Warbler (*Dendroica fusca*)	--	Yes	--	Yes	ST
Mourning Warbler (*Oporornis philadelphia*)	--	Yes	--	Yes	SE
Swainson's Warbler (*Limnothlypis swainsonii*)	--	Yes	--	Yes	SE
Family Emberizidae					
Bachman's Sparrow (*Aimophila aestivalis*)	--	Yes	ST	No	--
Henslow's Sparrow (*Ammodramus henslowii*)	--	Yes	ST	Yes	--
REPTILES					
Order Testudines					
Suborder Cryptodira					
Family Dermochelyidae					
Leatherback sea turtle (*Dermochelys coriacea*)	E	Yes	SE	Yes	SE
Family Cheloniidae					
Loggerhead sea turtle (*Caretta caretta*)	T	Yes	ST	Yes	ST
Kemp's ridley sea turtle (*Lepidochelys kempii*)	E	Yes	SE	Yes	SE
Green sea turtle (*Chelonia mydas*)	T	Yes	ST	Yes	ST
Hawksbill sea turtle (*Eretmochelys imbricata*)	E	Yes	SE	Yes	SE
Family Emydidae					
Eastern chicken turtle (*Deirochelys reticularia reticularia*)	--	Yes	SE	No	--
Map turtle (*Graptemys geographica*)	--	Yes	--	Yes	SE
Bog turtle (*Glyptemys muhlenbergii*)	T	Yes	SE	Yes	ST

Table 3-5 (*continued*). State-listed species with known occurrence in the Chesapeake Bay Study Area and vicinity. Occurrence of marine mammals and non-nesting sea turtles refers to state waters of the Chesapeake Bay. Common and Scientific names are listed per the convention for each taxon. E – Federally Endangered; T – Federally Threatened; SE – State Endangered; ST – State Threatened.

Species Name	Federal Status	Known to occur in Virginia	Virginia Status	Known to occur in Maryland	Maryland Status
FISHES					
Order Acipenseriformes					
Family Acipenseridae					
Shortnose sturgeon (*Acipenser brevirostrum*)	E	Yes	SE	Yes	SE

*Roseate Tern is listed as endangered in all states of the northern U.S. where it is known to occur south to North Carolina. It is listed as threatened except where endangered. http://ecos.fws.gov/docs/life_ histories/B07O.html.

4.0 HABITATS OF CONCERN

4.1 INTRODUCTION

An estuary is defined as a semi-enclosed coastal body of water which has an open connection to the ocean, and within which freshwater from rivers mixes with saltwater. The Chesapeake Bay is the nation's largest estuary stretching about 322 km long from north to south, from Havre de Grace, Maryland, to Norfolk, Virginia, and about 56 km across in width at its widest point. Its average depth is about 6 m, with the deeper portions of the Chesapeake Bay being potentially highly stratified due to the mixings of freshwater with saltwater (Paul et al. 1998; Paul 2001; Reshetiloff 2004). Half of the Chesapeake Bay's water comes from the Atlantic Ocean while the rest comes from a 165,759 km^2 watershed that stretches from New York to Virginia. There are approximately 6,070 km^2 of wetlands in the watershed. Around 90% of the Chesapeake Bay's freshwater comes from the Susquehanna, Potomac, Rappahannock, York, and James rivers (Reshetiloff 2004).

Estuaries are a prized ecological resource. They serve many functions which include filtering sediments, nutrients, and pollutants, providing sheltered nursery areas for the larvae and juveniles of various fish and invertebrate species, providing shelter and food sources for migratory fish and bird species, as well as serving as recreational and commercial fishing areas for humans (Reshetiloff 2004). The Chesapeake Bay estuary is part of an extremely productive ecosystem that provides an array of marine, coastal, and aquatic habitats for over 3,000 animal species which are involved in a complex food web (Reshetiloff 2004). Plankton in the water column provide an energy source for small fish and invertebrates. Clams and oysters filter particulates out of the water. The Chesapeake Bay's freshwater tributaries provide fish spawning and nursery sites for species such as white and yellow perch, striped bass, herring, and shad. During the warmer months, bluefish, weakfish, croaker, menhaden, flounder, and spot enter the Chesapeake Bay for feeding purposes. In addition, waterfowl and migratory birds find food and shelter within the Chesapeake Bay's shoreline habitats as an important stopover on the Atlantic Flyway (Reshetiloff 2004). The Chesapeake Bay is the richest in the nation in resources (Paul 2001). There are 16 million people who use the watershed in some way. It is a major provider of seafood as well as a crucial area for shipbuilding (Reshetiloff 2004). The six major Chesapeake Bay habitats that will be discussed in this assessment include the open bay, coastal wetlands, non-vegetated tidal flats, submerged aquatic vegetation, oyster reefs, and artificial habitats.

4.2 OPEN BAY

Estuarine systems, such as the Chesapeake Bay, are comprised of a water composition that offers substantial physical and chemical variability, which in turn supports a wide variety of plants and animals (Reshetiloff 2004). Suspended sediments, dissolved gases, nutrients, inorganic salts, trace elements, metals, and chemicals, are constantly transported throughout the water column of the Chesapeake Bay. This chemical composition, along with physical characteristics such as temperature and circulation, plays a role in determining the Chesapeake Bay's nature (Reshetiloff 2004). The three most important physical and chemical characteristics of the Chesapeake Bay water column that determine the stability of its ecosystem are salinity, temperature, and circulation (Reshetiloff 2004).

Due to the constant mixing of saltwater and freshwater, the Chesapeake Bay is mostly brackish, having a salinity ranging from 0.5 to 25 psu. The salinity is greatest near the mouth of the Chesapeake Bay and then lessens toward the northwest. Throughout the Chesapeake Bay, salinity levels constantly change from year to year, as well as seasonally. Salinity is dependent on the amount of freshwater that flows into the Chesapeake Bay during a specified period of time (Reshetiloff 2004). Since the average depth of the Chesapeake Bay is relatively shallow (approximately 6 m), the water temperature constantly fluctuates throughout the year, ranging from 1.1° to 28.9°C. This variability in temperature impacts the behavior of the plants and animals in the Chesapeake Bay (Reshetiloff 2004). During spring and summer, a strong thermocline develops and the surface water of the Chesapeake Bay becomes warmer than the bottom water; however, wind and turbulence, cooler temperatures, along with the shallow depth of the Chesapeake Bay, can cause the thermocline to disappear (Reshetiloff 2004).

There is circulation in the Chesapeake Bay that results from the southward movement of freshwater from the rivers and the northward movement of saltwater from the Atlantic Ocean. This circulation transports nutrients, plankton, sediments, minerals, dissolved oxygen, fish eggs, and shellfish larvae, and creates a nutrient-rich zone which is ideal as a nursery ground for marine animals, especially fish (Reshetiloff 2004). In addition, during high wind episodes, wind-driven circulation can cause high and low tides, with strong northwest winds forming extremely low tides and strong northeast winds forming extremely high tides (Reshetiloff 2004).

Salinity, temperature, and circulation together create a pycnocline in the water column. It is caused by the formation of a light, warm layer of freshwater flowing downstream over a dense, cool layer of saltwater flowing upstream. This stratification is highest in the spring when freshwater flow is the most abundant, and is maintained in the summer due to warmer surface water temperatures (Reshetiloff 2004). In the fall, the cool surface waters, which are heavier, sink and mix with the bottom waters, which are then upwelled, bringing nutrients to the surface and oxygen to the bottom. The temperature and salinity stay pretty constant throughout the water column during the winter(Reshetiloff 2004).

The open Chesapeake Bay acts as a home for many different marine animal species. Many fish species, such as striped bass, bluefish, Atlantic croaker, weakfish, Atlantic menhaden, American shad, hickory shad, alewife, and bay anchovy, live in the open, pelagic, water column of the Chesapeake Bay. Bacteria, plankton, and jellyfish also inhabit the Chesapeake Bay habitat (Reshetiloff 2004).

4.3 COASTAL WETLANDS

Coastal wetlands undergo frequent and periodic flooding and as a result produce distinct species of plants and unique soil types. The plants that coastal wetlands contain are hydrophytic, meaning they are adapted to water saturated soil (or hydric soil). These ecosystems represent a transition between land and sea in that they contain elements of both terrestrial and marine communities (Tiner 1993; Reshetiloff 2004).[1] Coastal wetlands form in protected, low energy environments, such as in the Chesapeake Bay estuary or behind barrier islands. In the entire Chesapeake Bay, there are 6,070 km^2 of coastal wetland habitat (Reshetiloff 2004).[1]

Within the watershed of the Chesapeake Bay, there are two types of wetlands (tidal and nontidal). Tidal wetlands make up 13% of the total wetlands in the Chesapeake Bay. Tidal wetlands contain mostly herbaceous plants that endure tidal flooding such as *Spartina* spp. (cordgrass), *Distichlis spicata* (saltgrass), and *Pontederia cordata* (pickerel weed). This type of wetland contains water that is fresh, brackish, and salty. They are located along the tidal rivers and shores of the Chesapeake Bay. Estuarine and freshwater marshes typically fall under this category of wetlands (Reshetiloff 2004).[1] Nontidal wetlands make up 87% of the total wetlands in the Chesapeake Bay and contain woody vegetation (*Acer rubrum* [red maple], *Salix nigra* [black willow], etc.), and other types of plants such as *Scirpus* spp. (bulrush), *Impatiens capensis* (jewel weed), and *Carex* spp. (sedges). These wetlands do not endure tidal flooding, and they are mostly freshwater; usually obtaining their flooding from precipitation, groundwater, or neighboring streams. They are located on the floodplains of streams and rivers and the flat areas close to sea level that tend to collect water easily, such as on the Delmarva peninsula. Scrub-shrub wetlands typically fall within this category (Reshetiloff 2004).[1]

Coastal wetlands of the Chesapeake Bay are extremely productive ecosystems:

- Coastal wetlands act as nurseries for invertebrates, particularly shrimp and killifish, as well as for various finfish species. They are known for their value as either spawning or nursery grounds for fish such as menhaden, bluefish, flounder, sea trout, mullet, croaker, and striped bass. Species with both commercial and ecological value utilize this area as juveniles (Bertness 1999). In fact, the Chesapeake Bay is the major spawning and nursery ground for striped bass on the East Coast.[2]

- Predators, such as blue crabs, large fish species, and birds, use coastal wetlands to forage for food (Reshetiloff 2004). The birds (waterfowl, shorebirds, and wading birds) are top-level

consumers and they play an important role in transporting energy and nutrients throughout the shoreline habitat, as well as between land and shore (Erwin 1996; Reshetiloff 2004). They are particularly abundant in the shoreline ecosystem during the winter before many of them start migrating north in the spring. Migratory birds are also attracted to these areas during May and August to feed on invertebrates and small fish (Erwin 1996).

- Wetlands reduce erosion. The highly vegetated soil of wetlands slows down the flow of water into the Chesapeake Bay. They also serve as buffers, or filters, and reduce the amount of sediments and nutrients that flow into the Chesapeake Bay. In the same way, they also trap nutrients which are important for the wetland vegetation. When the vegetation decomposes, the nutrients then flow into the Chesapeake Bay (Reshetiloff 2004).[1]

- Wetlands serve the human population economically as well as recreationally. They are great areas for hunting, fishing, bird watching, hiking, and many other activities (Reshetiloff 2004).

Less than 50% of the coastal wetlands in the Chesapeake Bay that were here during colonial times remain here today (Reshetiloff 2004). Between 1982 and 1989, the Chesapeake Bay experienced a net loss of approximately 2 km^2 of marsh habitat in particular. Much of this loss occurred via draining and/or filling for upland areas, or conversion to ponds and lakes (Magnien et al. 1995). A recent study found that there was a 11 km^2 loss of wetlands as a whole between 1996 and 2005, from 1160 km^2 in 1996 to 1149 km^2 in 2005.[1] Human impacts, such as the introduction of invasive species and property development, and weather related factors, such as sea level rise and storms, are a few of the main factors that most researchers agree are contributing to the declines.[1] In the case of property development, wetlands are usually filled or drained and made into roads, farms, housing developments, or used for other commercial purposes (Reshetiloff 2004). The loss of coastal wetland communities in the Chesapeake Bay is a big threat to the commercial fishing industry and to the Chesapeake Bay ecosystem as a whole (Meyer et al. 2001).

4.3.1 Estuarine Marshes

Estuarine marshes are typically dominated by a single plant species (Wiegert et al. 1981). The Chesapeake Bay estuarine marshes (**Figure 4-1**) are dominated by herbaceous vegetation such as *Spartina alterniflora* (smooth cordgrass) (Schafale and Weakley 1990; Reshetiloff 2004). These marshes have three characteristic vegetation-zones that are governed by the amount of inundation: low marsh (flooded by every high tide), high marsh (flooded by extremely high tides), and the upland border (very rarely inundated by tides). The low marsh produces the foundation of the estuarine food web and is the most productive, self-sustaining habitat (Ursin 1972; Patrick 1994).

Smooth cordgrass occurs in both the low and high marsh, but is densest in the low marsh. Although smooth cordgrass dominates the lower zone, *Sarcocornia perennis* (perennial glasswort) and *Limonium sinuatum* (sea lavenders) may also be found (Tiner 1993; Bertness 1999). In the high marsh, other than smooth cordgrass, the dominant plants include *Juncus roemerianus Scheele* (black needlerush), *Spartina patens* (saltmeadow cordgrass), saltgrass, *Sporobolus virginicus* (coastal dropseed), *Scrirpus robustus* (salt marsh bulrush), and *Spartina cynosuroides* (big cordgrass) (Schafale and Weakley 1990; Tiner 1993; SAFMC 1998). The upland border is characterized by terrestrial grasses, herbaceous plants, and shrubs. It is in the upland border where land mammals such as raccoons and foxes venture into the marsh to feed.

4.3.2 Freshwater Marshes

Freshwater marshes within the Chesapeake Bay (**Figure 4-1**) support a greater diversity of plant species than estuarine marshes. Freshwater marshes have a low marsh that is dominated by emergent plants including *Peltandra virginica* (arrow arum), pickerel weed, *Nuphar lutea* (yellow pond lily), *Sagittaria latifolia* (big-leafed arrowhead), and *Iris versicolor* (blue flag). In the high marsh and in shallower waters,

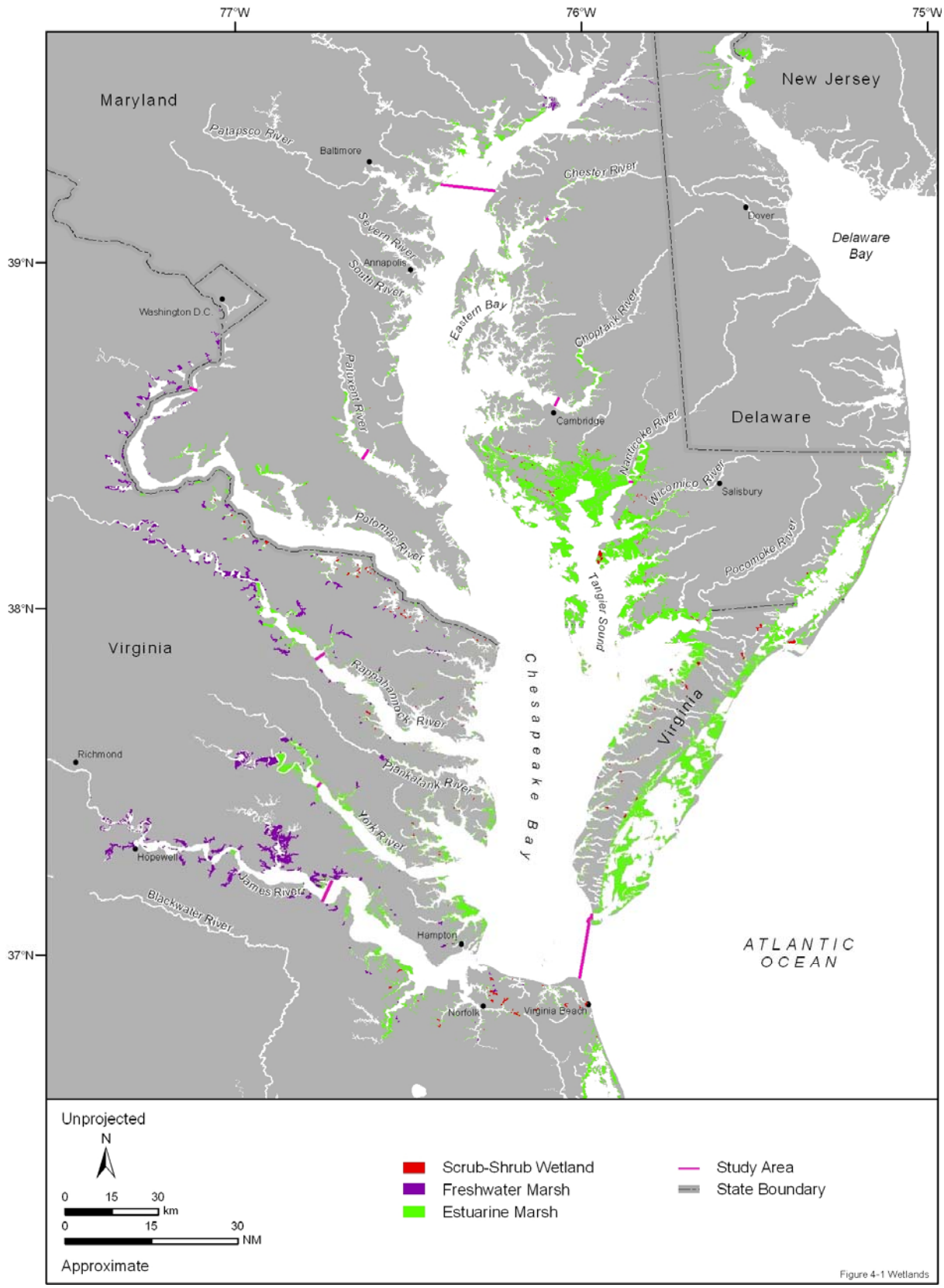

Figure 4-1. Distribution of estuarine marshes, freshwater marshes, and scrub-shrub wetlands in the vicinity of the Chesapeake Bay Study Area. Source data: NOAA (2008).

Typha spp. (cattail), and various species of sedges dominate the vegetation. These marshes are home to various animal species such as frogs and muskrats and they also help improve water quality and reduce flooding.[3]

4.3.3 Scrub-Shrub Wetlands

Woody vegetation less than 6 m tall (shrub) accounts for 25% to 100% of the vegetative cover in scrub-shrub wetlands. *Alnus* spp. (alders), *Salix* spp. (willows), *Cephalanthus occidentalis* (buttonbush), *Rosa palustris* (swamp rose), and *Cornus amomum* (silky dogwood), are the most prominent species found in this type of wetland within the Chesapeake Bay.[4] Scrub-shrub wetlands within the Chesapeake Bay (**Figure 4-1**) are minimal.[5] They serve as a home and nursery habitat for various species of amphibians, reptiles, fish, and birds, and they also help prevent erosion and improve water quality.[4]

4.4 NON-VEGETATED TIDAL FLATS

Tidal flats can be described as unvegetated (no macroalgae or seagrasses), intertidal, soft-sediment habitats. They lie between the low and high tide lines and usually consist of substrates consisting of mud or fine sand. Tidal flats are exposed to the atmosphere during only part of the day. Their soil, when muddy, is made up of a combination of clay, silt, and organic material. In the Chesapeake Bay, tidal flats usually border the lower edge of tidal marshes, smaller estuaries, and river mouths (**Figure 4-2**) (Peterson and Peterson 1979; Bertness 1999).[6]

Even though tidal flats are not vegetated, they are used by a wide range of organisms including bacteria, fungi, microflora (e.g., benthic diatoms, benthic dinoflagellates, filamentous greens, and blue-green algae), macrophytes, phytoplankton, burrowing worms, crabs, fishes, and wading birds (Bertness 1999).[6] Fishes that utilize the tidal flats for nursery grounds happen to be among the most important to the commercial and sport fishery as well as for baitfish. Flatfishes (e.g., flounder, sole, and tonguefish) are characteristic of tidal flats and are important in both commercial and recreational fisheries (Peterson and Peterson 1979). Organized by their foraging strategy, birds that can be found utilizing these habitats include wading birds, shallow- and deep-probing birds, aerial searching birds, floating or diving water birds, and birds of prey. Wading birds and shorebirds are dependent on tidal flats as their main foraging habitat. There are several endangered species that use tidal flats; for example, the piping plover seasonally forage on tidal flats (Peterson and Peterson 1979). Tidal flats are important for birds during the same times of the year that the marshes are. They are usually present during the winter before continuing their migration north, and then in May and August to feed (Erwin 1996).

Three categories of benthos inhabit tidal flats: infauna, epifauna, and mobile epibenthos. Infauna can be described as organisms that burrow and live in the sediment bed, which usually includes mollusks, gastrotriches, turbellarians (flat worms), and gnathostomulids (jaw worms), amphipods, and copepods (Peterson and Peterson 1979). Epifauna are sessile animals that subsist on the surface of the tidal flats, such as bivalves and cnidarians. Mobile epibenthos move on top of the substrate, such as fiddler crabs, insect larvae, and nematodes (Peterson and Peterson 1979; Lippson and Lippson 1997). In the Chesapeake Bay, the eastern oyster grows on tidal flats, and blue crabs and whelks are common foragers there (Peterson and Peterson 1979). Diamondback terrapins and horseshoe crabs use tidal flats for depositing their eggs.[7]

Tidal flats depend upon the surrounding habitats, such as seagrasses and marshes, for primary production (Bertness 1999). Therefore, the declining trends seen in seagrasses and marshes have had a direct impact on the existence of tidal flats. Since tidal flats serve important functions as nurseries, feeding grounds, and refuge from predation and adverse physical conditions for various species, degradation of tidal flats may affect the entire Chesapeake Bay ecosystem (SAFMC 1998).

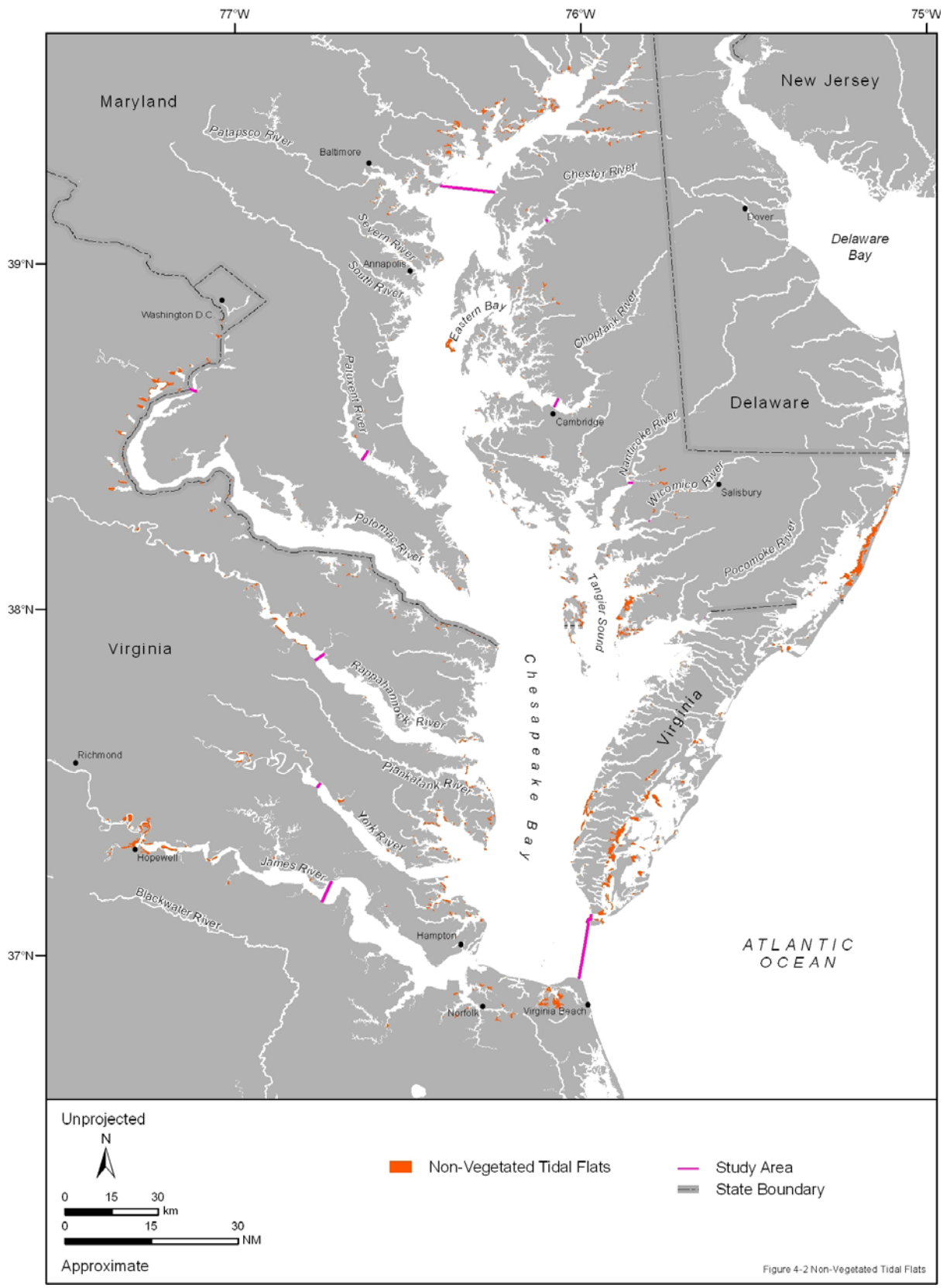

Figure 4-2. Distribution of non-vegetated tidal flats in the vicinity of the Chesapeake Bay Study Area. Source data: NOAA (2008).

4.5 SUBMERGED AQUATIC VEGETATION

Submerged aquatic vegetation (SAV) refers to benthic macroalgae and seagrasses that grow in or attach to soft sediments or hard substrates in coastal habitats (**Figure 4-3**) (Dennison et al. 1993). SAV beds can be continuous as well as patchy in their layout on the sea floor (Thayer et al. 1997). Since SAV depends on sunlight for growth, they usually exist in relatively clear water. For the Chesapeake Bay, in particular, this is typically characterized by waters generally 3 m or less in depth (within the photic zone). Disturbances of the substrate (e.g., suspended sediments), phytoplankton blooms (nutrient loading), and epiphyte coverage, can reduce light attenuation (Schneider 1976; Stevenson and Confer 1978; Searles 1984; Ferguson and Wood 1994; Batiuk et al. 2000). Since the Chesapeake Bay SAV, particularly seagrass, is not harvested and its health is largely determined by water quality, it is an accurate measure of the Chesapeake Bay's overall health.[8] Within the Chesapeake Bay, the total biomass of SAV reaches its maximum in July and falls to its minimum in December and January (Moore et al. 2000).

SAV is important to the faunal diversity of highly productive coastal and estuarine ecosystems. Many ecologically and commercially important faunal species utilize SAV beds at some point in their life cycle (SAFMC 1998). A study conducted in 2002 showed that fish species diversity had a direct correlation to SAV abundance within the Chesapeake Bay (Wyda et al. 2002). SAV beds provide food and protective habitat for animals, substrate for epiphytes, and sediment/shoreline stabilization (Hemminga and Duarte 2000).

The roots and rhizomes of seagrasses hold sediments in place, preventing erosion of nearshore habitats. The blades of seagrasses and macroalgae dissipate wave energy, reducing the water velocity, further reducing erosion. Detritus and sediments collect around the base of seagrasses and macroalgae, ridding the water column of excessive sediments and enabling the recycling of nutrients back into the water column (SAFMC 1998; Hemminga and Duarte 2000). Like their land counterparts, SAV species use sunlight for photosynthesis and release DO; however, in this case the oxygen is released into the water column to be used by aquatic species for respiration and decomposition. They also reduce the levels of nitrogen and phosphorous within the water column by taking them in (Stevenson and Confer 1978; Hemminga and Duarte 2000; Reshetiloff 2004).

SAV beds provide an important food source for fish, waterfowl, sea turtles, and sea urchins, and shelter for the juvenile and larval stages of many fish and invertebrate species (SAFMC 1998; Reshetiloff 2004). Seasonal reproduction in several fish species has been linked to seasonal abundance in SAV (SAFMC 1998). In the lower Chesapeake Bay, seagrass beds are important for fishes brooding eggs (e.g., silverstripe halfbeak, *Hyporhamphus unifasciatus*) and for fishes with demersal eggs (e.g., rough silverside, *Membras martinica*). Because of SAV habitat seasonality, Winter-spring spawners lack a seagrass habitat; however, larvae of spring-summer spawners such as anchovies (*Anchoa* spp.), gobies (*Gobiosoma* spp.), northern pipefish (*Syngnathus fuscus*), weakfish (*Cynoscion regalis*), southern kingfish (*Menticirrhus americanus*), red drum (*Sciaenops ocellatus*), silver perch (*Bairdiella chrysoura*), rough silverside, feather blenny (*Hypsoblennius hentz*), and halfbeaks, are able to utilize the abundant SAV habitat (Thayer et al. 1997). Blue crabs use SAV in the entirety of the Chesapeake Bay for nursery habitat; primarily the southern portion (Heck Jr. and Thoman 1984; Laney 1997). Several avian species use the SAV habitats for feeding, including egrets, herons, sandpipers, terns, gulls, swans, geese, ducks, and osprey (Ferguson and Wood 1994). Zooplankton feed on decaying grasses and are in turn food for larger organisms (Reshetiloff 2004). In this way, SAV in the Chesapeake Bay supports diverse pelagic fish populations (Wyda et al. 2002).

Climatic events, the introduction of herbicides, eutrophication, dredging, and reductions in light availability have contributed to declines of SAV in the Chesapeake Bay, with eutrophication being the most prominent factor. Other factors such as changes in salinity, pH, temperature, and fauna interference, can cause declines in SAV as well (Stevenson and Confer 1978; Paul et al. 1998; Batiuk et al. 2000; Reshetiloff 2004). SAV started declining in the Chesapeake Bay in the 1960s, reaching a low point in 1984, and since then rebounding (Orth and Moore 1983; Batiuk et al. 2000; Reshetiloff 2004). From 1985 to 1991 there was a 66% increase in SAV biomass followed by a period of stabilization from 1991 to 1996. There was a 49% increase from 1989 to 1993 (Moore et al. 2000).

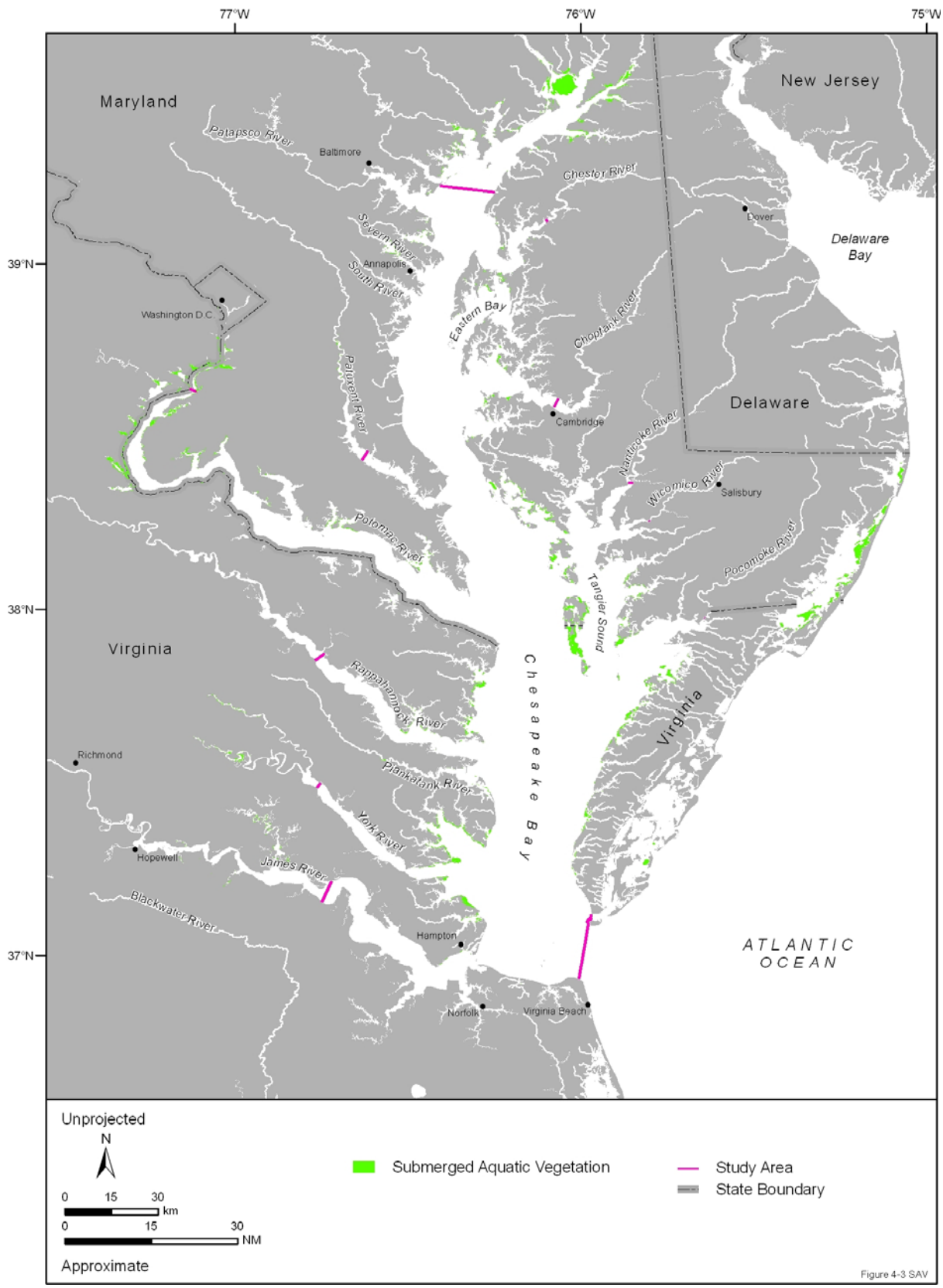

Figure 4-3. Distribution of submerged aquatic vegetation (macroalgae and seagrass) in the vicinity of the Chesapeake Bay Study Area. Source data: VIMS (2006).

Recently, in 2006, a VIMS study mapped 239 km^2 of seagrass within the Chesapeake Bay and its tributaries. A 25% decrease was found between 2005 and 2006, from 317 km^2 in 2005 to 239 km^2 in 2006. SAV was found to decline in all 3 regions of the Chesapeake Bay (Upper, Middle, and Lower). In the Upper region, extending from the Susquehanna River to the Chester and Magothy rivers, there was a 20% decrease, from 79 km^2 to 63 km^2. In the Middle Zone, which extends from the Chesapeake Bay Bridge south to the Rappahannock River and Pocomoke Sound, there was a 23% decrease, from 160 km^2 to 124 km^2. In the Lower Chesapeake Bay, which extends from the Rappahannock River to the mouth of the Chesapeake Bay, there was a 33% decrease from 78 km^2 to 52 km^2 (VIMS 2006).

4.5.1 Seagrass

Seagrasses are vascular, rooted, flowering plants that are adapted to the saline environment and grow fully submerged (Dennison et al. 1993). Twenty-six species of seagrass can be found within the Chesapeake Bay and its tidal tributaries (VIMS 2006). Only 17 species, however, are commonly found. These include *Zostera marina* (eelgrass), *Myriophyllum spicatum* (eurasian watermilfoil), *Stuckenia pectinata* (sago pondweed), *Potamogeton perfoliatus* (redhead grass), *Potamogeton crispus* (curly pondweed), *Potamogeton pusillus* (slender pondweed), *Zannichellia palustris* (horned pondweed), *Vallisneria americana* (wild celery), *Elodea canadensis* (common elodea), *Ceratophyllum demersum* (coontail), *Hydrilla verticillata* (hydrilla), *Heteranthera dubia* (water stargrass), *Najas guadalupensis* (southern naiad), *Najas minor* (no common name), *Najas gracillima* (slender naiad), *Najas* sp., and *Ruppia maritima* (widgeon grass) (see **Table 4-1** for a listing of all seagrass species found in the Chesapeake Bay) (VIMS 2006).

The distribution of each species within the Chesapeake Bay depends on environmental variances in salinity, water depth, and bottom sediment type, and each individual species' preferences and requirements. Water quality and salinity are the two dominant factors that influence the distribution of seagrass in the Chesapeake Bay (Reshetiloff 2004; VIMS 2006).[8] Eelgrass and widgeon grass are the two most common types of seagrass that exist near the mouth of the Chesapeake Bay because they require the higher salinity waters of the Atlantic Ocean. Widgeon grass has a higher tolerance for lower salinities and can be found as far north as the Susquehanna Flats (Ferguson and Wood 1994; SAFMC 1998; Hovel et al. 2002; Reshetiloff 2004; VIMS (Virginia Institute of Marine Science) 2006).[8] Sago pondweed and redhead grass can tolerate a wide range of salinities and are common in the general estuarine mainstem part of the Chesapeake Bay. Wild celery, eurasian watermilfoil, curly pondweed, slender pondweed, horned pondweed, common elodea, coontail, hydrilla, water stargrass, southern naiad, *Najas minor*, slender naiad, and *Najas* sp. tend to be most common in the freshwater tributaries (Ferguson and Wood 1994; Reshetiloff 2004; VIMS 2006).[8]

4.5.2 Macroalgae

Macroalgae are multicellular, eukaryotic algae held to the substrate by holdfasts (root-like structures) (Dennison et al. 1993). Jetties, retaining walls, and other man-made structures become colonized by macroalgae and provide artificial habitat. Abundant nutrients from sewage and runoff can cause an excessive growth of algae; however, blue-green algae are the most likely to occur when there are extremely high levels of pollution. In general, there is not much knowledge on the Macroalgae taxa that exist in the Chesapeake Bay (Ott 1972). Though not often, under certain conditions such as abnormal levels of water clarity, higher temperatures, or higher levels of nitrogen, macroalgae can sometimes bloom extensively, and even potentially deprive seagrass of sunlight. In the Chesapeake Bay such blooms are very rare and only occur in small areas. Under such circumstances in the Chesapeake Bay, macroalgae can sometimes cause problems for the commercial fishing industry as well, by covering crabpots and gill nets (Hauxwell et al. 2001; MDNR 2004).

4.6 OYSTER REEFS

Oyster reefs consist of densely packed live and dead oysters that exist in small clumps or large mounds (up to 10 m in diameter) on river or estuarine floors (Bahr and Lanier 1981).[9] They are generally found in 3 to 10 m of water depth, but can in some cases be found down to 30 m of water depth (Bahr and Lanier

1981; Burrell 1986).[9,10] Within the Chesapeake Bay, oyster reefs are generally made up of the eastern oyster species (*Crassostrea virginica*); these species are found in the subtidal areas and lower tributaries (**Figure 4-4**).[10] They grow best on clean, hard surfaces, such as on rock, hard sand, or mud, or on other oyster shells, and in either brackish or high salinity (0.5 to 30 psu) waters (Reshetiloff 2004).[10] Oyster reefs make up the largest surface area of hard bottom within the Chesapeake Bay.[9]

Since oyster reefs contain more surface area than a regular sand or mud bottom, they provide habitat for a number of sessile and motile organisms ranging from juvenile to adult life stages (Bahr and Lanier 1981; Meyer and Townsend 2000; Rodney and Paynter 2006).[9] The topographic complexity of oyster reefs provides organisms with substrates upon which they can settle, seek refuge and food, as well as breed and nest (Bahr and Lanier 1981). In the Chesapeake Bay, they potentially serve as both important and optimal habitat for certain species of finfishes as well as for certain benthic species (Harding and Mann 2001; Reshetiloff 2004).[10] Oyster reefs, both natural and restored, attract a greater number and diversity of fish species than normal, flat, sandy bottoms and serve as good habitat for the recruitment of juvenile fishes (Lenihan et al. 2001). Harding and Mann (2001) proposed that these reefs perhaps have a higher abundance, diversity, and quality of prey and food items as well.

Table 4-1. Seagrass species that can be found in the vicinity of the Chesapeake Bay Study Area.

Common Name	Species
American Pondweed	*Potamogeton nodosus*
Burreed	*Sparganium species* (sp.)
Common Elodea	*Elodea canadensis*
Coontail	*Ceratophyllum demersum*
Curly Pondweed	*Potamogeton crispus*
Eelgrass	*Zostera marina*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Horned Pondweed	*Zannichellia palustris*
Hydrilla	*Hydrilla verticillata*
Leafy Pondweed	*Potamogeton epihydrus*
Muskgrass	*Chara braunii*
Muskgrass	*Chara zeylanica*
No common name	*Najas minor*
Northern Naiad	*Najas flexilis*
Redhead Grass	*Potamogeton perfoliatus*
Sago Pondweed	*Stuckenia pectinata*
Slender Naiad	*Najas gracillima*
Slender Pondweed	*Potamogeton pusillus*
Southern Naiad	*Najas guadalupensis*
Stonewort	*Nitella flexilis*
Water Chestnut	*Trapa natans*
Water Stargrass	*Heteranthera dubia*
Water-Starwort	*Callitriche* sp.
Water-Weed	*Egeria densa*
Widgeon Grass	*Ruppia maritima*
Wild Celery, Tapegrass	*Vallisneria americana*

Source: VIMS 2006.

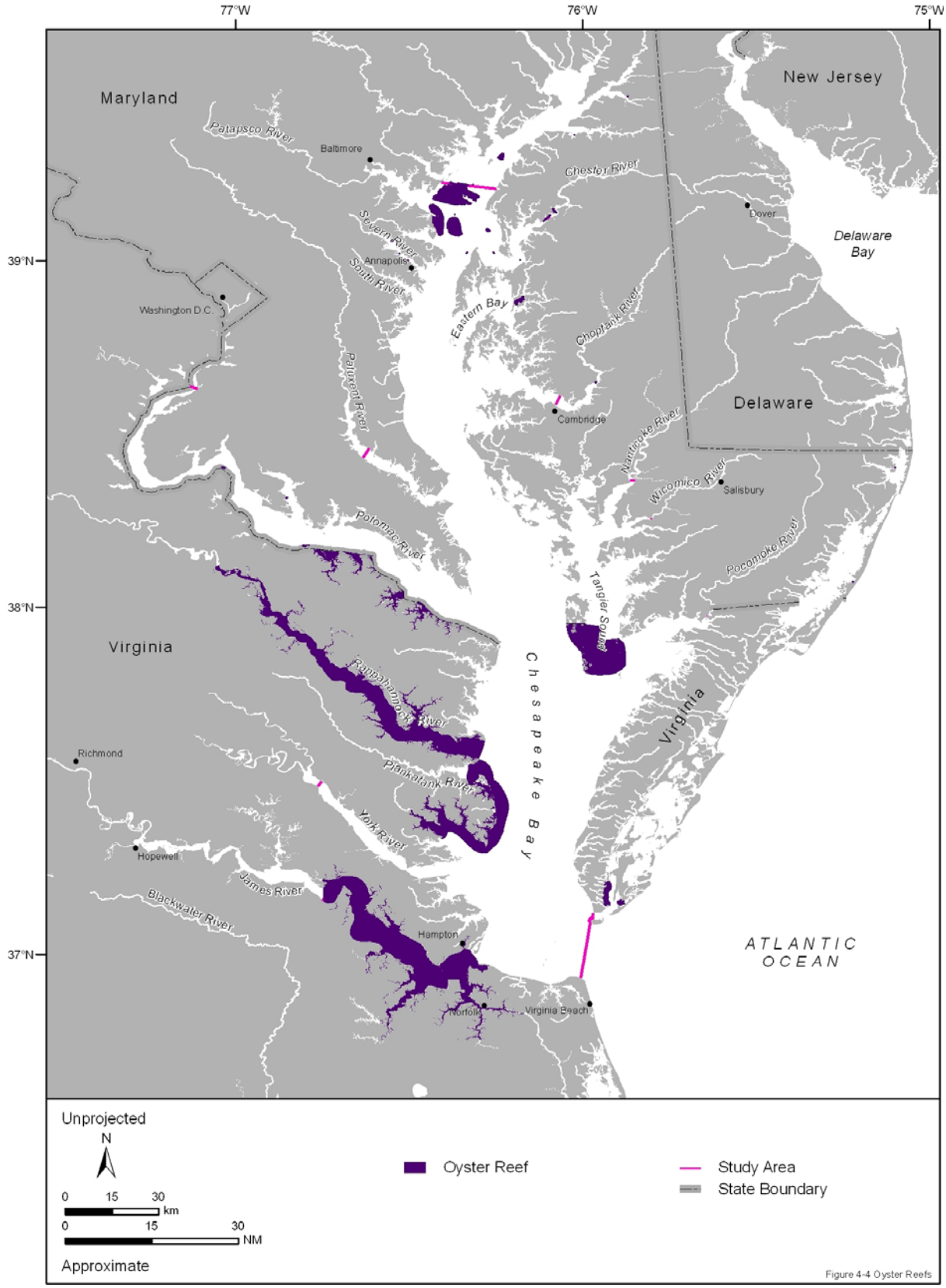

Figure 4-4. Distribution of oyster reefs in the vicinity of the Chesapeake Bay Study Area. Source data: NOAA (2008).

In the Chesapeake Bay, over 40 species of macrofauna can be found in oyster reefs; these include bivalves (eastern oyster, hard shell clam, ribbed mussel, hooked mussel, soft-shelled clam, amethyst gem clam, and false angel wings), gastropods, several species of barnacles, crabs (in particular mud crab and flat mud crab), amphipods and isopods, a number of species of polychaetes, sponges, and tunicates (Bahr and Lanier 1981). Finfish on oyster reefs include resident species (gobies, blennies, and toadfish), facultative resident species (black sea bass and pipefish), and transient species (weakfish, striped bass, bluefish, Atlantic croaker, and spot).[9] Even during low tide, oyster reefs attract raccoons and certain bird species that like to forage for oysters (McCormick-Ray 2005).

Oysters help to improve the water quality of the Chesapeake Bay by consuming phytoplankton, water-borne nutrients, small diatoms, bacteria, and detritus, and thereby increasing light penetration through the water column (Newell et al. 2002; McCormick-Ray 2005). Oysters are filter feeders in that they pump water through their gills and obtain food from the water.[10] They also filter organic matter and sediments out of the water column, thus reducing the amount of pollutants (Reshetiloff 2004).[9] They produce fecal matter that is rich in organic matter; this provides an energy source for other organisms in the oyster reef community. When oysters die, their shell becomes a substrate for younger oysters (McCormick-Ray 2005). Oyster reefs in the Chesapeake Bay are also important for the commercial and recreational fishing industries, in that they provide an abundant supply of eastern oysters, blue crabs, as well as various finfish species.[9]

Oyster reefs of the Chesapeake Bay have, for hundreds of years, grown into structurally, ecologically, and economically complex habitats, benefiting the Chesapeake Bay in many ways.[9,11] Two hundred years ago, some of these reefs were large enough to be navigational hazards (Rothschild et al. 1994).[11] Yet intensive mechanized fishing practices and stock overfishing during the 19th and 20th centuries caused severe losses of oyster reef habitat in the Chesapeake Bay (Rothschild et al. 1994). In particular, large oyster dredges authorized during the 19th century led to substantial mechanical damages to the physical integrity of oyster reefs over a broad depth range. The use of hydraulic-powered patent tongs starting in 1950 caused even greater mechanical damages (Rothschild et al. 1994). Additional causes of the degradation of oyster reefs starting at that time were water pollution (algal blooms, toxic chemicals and metals), epizootic diseases (*Perkinsus marinus* [Dermo] during the 1950s and *Haplosporidium nelsoni* [Multinucleated Sphere Unknown (MSX)] starting in 1959) invasion, and siltation (runoff from land development, agriculture, and forest harvests) (Andrews and Wood 1967; Rothschild et al. 1994).

The substantial deterioration of the oyster stock in the Chesapeake Bay prior to 1910 caused bay-wide changes in water quality and affected oyster reproduction, recruitment, and growth, and increased the susceptibility of the eastern oyster to disease and mortality. Mechanically flattened oyster bars became covered with silt and sediments (Rothschild et al. 1994). From 1884 to 1992, the catch of oysters in the Chesapeake Bay declined by 98% (from 615,000 tons [t] to 12,000 t) (Rothschild et al. 1994). The native oyster population is currently believed to be 1% of what it was 200 years ago (Rothschild et al. 1994).[11] These declines in the total oyster population have negatively impacted the Chesapeake Bay ecologically, economically, as well as culturally.[11]

Restoration on a large scale and support for research on oyster diseases in the Chesapeake Bay is being carried out by the NOAA Chesapeake Bay Office (NCBO), with the help of federal, state, and local partners in the states of Maryland and Virginia. NOAA had up to 24 projects supporting oyster restoration in the Chesapeake Bay in 2004.[11] Since 2004, the NCBO has continued to fund specific projects within each state. The NCBO is currently in charge of a federal investment in hatchery production of oysters in Maryland and Virginia. In 2006, it funded $4 million for restoration and $2 million for disease research. The survivability of hatchery-raised triploid oysters and other types of oyster aquaculture is also being researched.[11] In 2000, the NOAA Chesapeake Bay Stock Assessment Committee and the U.S. EPA Chesapeake Bay Program played a role in the Chesapeake 2000 Agreement which was set up to increase the Chesapeake Bay oyster population 10-fold from what it was in 1994 by the year 2010.[12] The states of Maryland and Virginia are also considering introducing an Asian oyster, *Crassostrea ariakensis* (Suminoe oyster), into the Chesapeake Bay to reestablish the oyster population. This Asian oyster species is known to be more tolerant of diseases that have negatively impacted the native oyster population.[12]

Since the early 1990s, the Virginia Marine Resources Commission (VMRC) Shellfish Conservation Division, VIMS, and the Virginia Oyster Heritage Program originated the construction of over 80 sanctuary oyster reefs in the Chesapeake Bay.[13] Despite the building of reefs and the planting of shells, the overall restoration potential of oyster reefs is limited considering the continued negative impacts of epizootic diseases (Berman et al. 2002); however, restored oyster reefs of the Chesapeake Bay can support 35 species with prevalent taxonomic groups (in order of decreasing abundance), amphipods, polychaetes, xanthid crabs (mud crabs), clams, and demersal fish (Rodney and Paynter 2006). The most abundant fouling organisms found on restored oyster reefs typically consist of *Ischadium recurvum* (recurved mussel) and *Balanus* spp. (balanoid barnacles). Other common organisms on restored reefs include *Diadumene leucolena* (white anemones), *Membranipora* spp. (encrusting bryozoans), and *Garveia fransiscana* (hydroids). Overall, Rodney and Paynter (2006) found that macrofauna and fouling organisms were 10 times more abundant on restored reefs compared to non-restored reefs. Further, compared to non-restored reefs, the high density of suspension feeders on restored reefs increased water filtration and consumption of plankton. It was inferred that the energy suspension feeders captured from the water column was then transferred to deposit feeders (as feces and pseudofeces) that in turn were preyed upon by carnivores and omnivores (including fish) (Rodney and Paynter 2006). In contrast to restored reefs, non-restored reefs do not support abundant suspension feeders. This potentially prevents the transfer of energy from the phytoplankton to higher trophic levels, hence the impoverished fish populations on physically damaged oyster reefs and the overall decline of fisheries in the Chesapeake Bay caused by the overexploitation of oyster reef habitat (Rodney and Paynter 2006).

4.7 ARTIFICIAL HABITATS

Artificial habitat can be described as any structure or object that is not native to the environment that provides habitat to organisms. There are two types of artificial habitats (those that are intentionally created and those that are unintentionally created). Within the Chesapeake Bay, intentionally created artificial habitats are usually called artificial reefs and consist of designed structures and materials of opportunity (Young 2003).[14] Unintentionally created artificial habitat consists mainly of shipwrecks and debris which are more abundant than dedicated artificial reefs in the Chesapeake Bay (Veridian Corporation 2001).[14] Artificial reefs are usually deliberately placed close to shore and in the mainstem of the Chesapeake Bay while shipwrecks can be located anywhere in the Chesapeake Bay watershed (**Figure 4-5**).

Artificial habitat (artificial reefs and shipwrecks) can ecologically benefit local benthic and fish communities in the Chesapeake Bay, as well as recreational and commercial fishing activities. The topographic complexity of artificial habitat creates relief and a three-dimensional substrate upon which benthic organisms may settle (algae, sponges, crustaceans, anthozoans, and hydroids, etc.) (Bohnsack et al. 1991). Artificial reefs provide perfect surfaces for small invertebrates, such as suspension feeders (barnacles and oysters) and macrofauna (sea stars, polychaetes, crabs, and other crustaceans), and marine vegetation. They serve as shelter from predation for crabs and juvenile fish (Young 2003). Macrofauna living on artificial reefs attract predatory fish including tautog, sea bass, amberjack, bluefish, king mackerel, cobia, striped bass, and sharks.[14] Further, successful artificial habitat may provide food for fish, settling areas for juvenile fish, and attract larger predatory game fishes of interest to both recreational and commercial fishermen.

4.7.1 Artificial Reefs

Artificial reefs have been deployed in the Chesapeake Bay since the 1950s.[14] In the Maryland portion of the Chesapeake Bay, there are currently 20 artificial reef sites that are permitted until 2015.[15] The reefs are managed by the Maryland Environmental Service (MES) as well as Maryland Department of Natural Resources (DNR) and are labeled as “State Reefs” and “fish havens” on nautical charts. They are being constructed mainly for the purpose of increasing the local fish communities but also to restore the oyster populations (Young 2003). Fishermen in the area have reported increasing numbers of striped bass and bluefish around some of the reef sites.[15] Artificial reefs are less likely than natural reefs (oyster reefs) in the area to be covered by sedimentation (Young 2003).[15] Over the years, there has been an increased accumulation of sedimentation on the floor of the Maryland portion of the Chesapeake Bay due to river

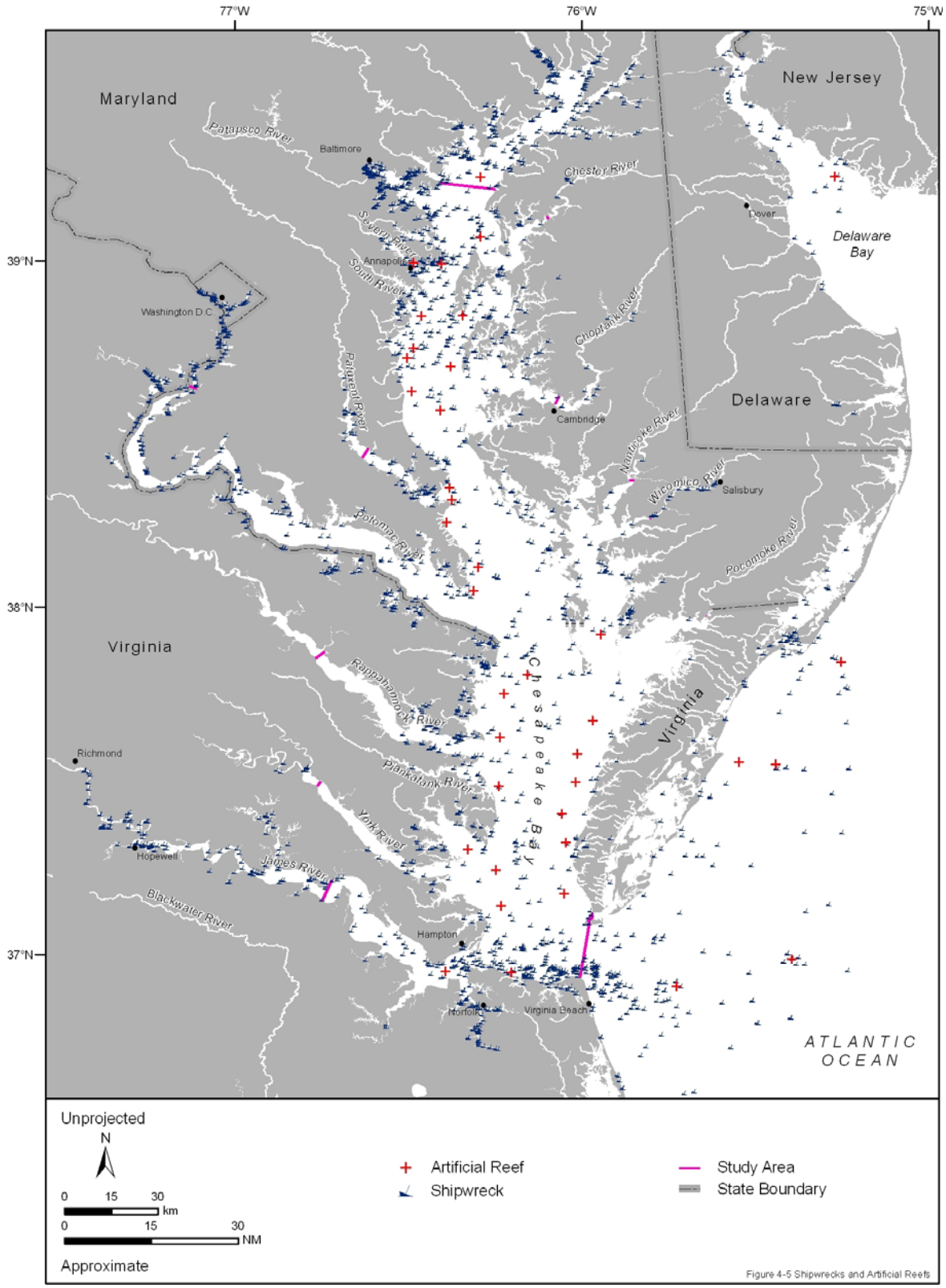

Figure 4-5. Distribution of artificial reefs and shipwrecks in the vicinity of the Chesapeake Bay Study Area. Source data: Veridian Corporation (2001). Source information: Loftus and Stone (2007), Day Break Fishing[14], and, VRMC[15].

runoff. Reef Balls™ which provide a great deal of internal and external surface area for attachment substrate, are among the structures used for the artificial reefs (Young 2003). Concrete rubble has also been used.[15]

In the Virginia portion of the Chesapeake Bay, the construction of artificial reefs started out under the private sector in the 1950s but then later became a state project in the 1970s. In this area, artificial reefs are designated as "obstruction" or "fish haven" on nautical charts and yellow VMRC buoys mark the centers of the sites.[14] There are currently 18 artificial reef sites within this portion of the Chesapeake Bay. The purpose of these reefs is to reestablish the fish population for sport fishermen. The materials used to build artificial reefs in the area include concrete pipe, bridge sections, rubble, Reef Balls™, concrete igloos, concrete tetrahedrons, girders, clusters, piles, tires in concrete, concrete blocks, T beams, concrete slabs, and concrete sinkers.[14]

4.7.2 Shipwrecks

There are over 1,800 shipwrecks in the Chesapeake Bay (**Figure 4-5**) (Veridian Corporation 2001).[16] The oldest known wreck dates back to the 16th century. The numerous shipwrecks in the Chesapeake Bay were caused by shipboard accidents (fires, explosions), navigational errors, natural obstructions (shoals, shifting sand bars, and ice), storms (hurricanes, nor'easter storms), and wars (Revolutionary War, War of 1812, and Civil War).[16] The Maryland portion of the Chesapeake Bay contains a great deal of U.S. Navy shipwrecks.[19] In the Virginia part of the Chesapeake Bay, ships of all kinds have wrecked in the area between capes Henry and Charles near the mouth of the Chesapeake Bay, where waters are potentially quite ruff. Willoughby Spit, located in the mouth of the James River, is another area where many ships have wrecked.[18]

The Chesapeake Bay shipwrecks are a great benefit for both the human population and the animal population of the area. They are a great attraction for recreational divers in the area.[20] The shipwrecks are also important for the environment in that they can potentially support both sessile and motile benthic organisms, as well as fish.

4.8 MARINE MANAGED AREAS AND MARINE PROTECTED AREAS

Many areas of the marine environment in the U.S. waters 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 MPA EO 13158 through the National MPA Center, a part of NOAA. Between 2001 and 2007, the National MPA Center compiled and archived 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 an MPA (NMPAC 2008). The current MPA inventory is based on the MMA inventory. The regulations associated with MMAs and MPAs are similar in that they both have conservation or management purposes, defined boundaries, and some legal authority to protect resources; however, the regulations associated with MMAs encompass a wider range of management intents than those associated with MPAs. MMAs may include areas of protection for geological, cultural, or recreational resources that might not meet the definition provided in the 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 calls for the development of a national system of MPAs. In order to clarify what specifically constitutes an MPA, the National MPA Center developed an MPA Classification System that provides definitions and qualifications for the various terms within EO 13158 (NMPAC 2005). The 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

These six criteria are designed to provide a clear picture of why the site was established, what the regulations are intended to protect, and how protection and management of the area may affect local ecosystems and their associated human uses (Agardy 1999; NRC 2000).

Within the U.S., there are currently 1,688 sites listed in the MPA inventory encompassing over 7 million km^2.[21] 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).

4.8.1 Federally Designated Marine Protected Areas

There are currently 17 U.S. federally designated MPAs located around or in the vicinity of the Chesapeake Bay (**Table 4-2**; **Figure 4-6**; NMPAC 2008).[21] Most of the MPAs (15) are National Wildlife Refuges (NWR). There is also a Fishery Management Zone (FMZ) and a National Park (NP) in the vicinity of the Chesapeake Bay (**Table 4-2**).

One of the many responsibilities of NMFS includes rebuilding and maintaining sustainable fisheries. To satisfy this responsibility, NMFS uses FMZs and fisheries habitat conservation zones (FHCZs) as tools to conserve both fish stocks and fish habitat. There is one FMZ located within the vicinity of the Chesapeake Bay. The Carl N. Shuster, Jr. Horseshoe Crab Reserve is centered in the waters off of the mouth of Delaware Bay and is intended to protect the stock of horseshoe crabs found within the Delaware Bay and adjacent waters (**Figure 4-6**) (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 (NMPAC 2008).

The National Park System (NPS) encompasses 388 sites that cover more than 341,000 km^2 in 49 states, the D.C., American Samoa, Guam, Puerto Rico, Saipan, and the USVI. NPs are generally large natural areas with a wide variety of attributes or significant historic assets. The American Antiquities Act of 1906 authorizes the President to publicly proclaim a landmark, structure, or other object of historic or scientific interest as a national monument if it is situated on lands owned or controlled by the federal government (16 U.S.C 431-433). There is one National Seashore located adjacent to the waters of the Chesapeake Bay (**Figure 4-6**). 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. It was founded in 1965 (NMPAC 2008).

USFWS protects over 388,000 km^2 of habitat through the National Wildlife Refuge System (NWRS). It has 544 established NWRs and 37 Wetland Management Districts under its jurisdiction.[22,23] The refuge system encompasses all types of habitat, including 162 refuges nation-wide that contain marine and estuarine habitat (NMPAC 2008). Within the Chesapeake Bay and vicinity there are 15 NWRs (**Figure 4-6**). The largest NWR in the vicinity of the Chesapeake Bay is Blackwater NWR in Maryland, covering 109 km^2 (**Table 4-2**). Bombay Hook NWR, Back Bay NWR, and Chincoteague NWR, are also large in area (86, 65, and 59 km^2, respectively) (**Table 4-2**). Bombay Hook NWR attracts geese, ducks, shorebirds, and songbirds during the fall and spring migration seasons. This NWR is made up of small pools,

swamps, forests, farms, and tidal saltmarshes.[24] 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).

Table 4-2. Summary of Federally Designated Marine Protected Areas in the vicinity of the Chesapeake Bay Study Area.

MPA Type	Federally Designated MPA (state)	Area (km^2)
Fishery Management Zone	Carl N. Shuster, Jr. Horseshoe Crab Reserve	4,132.2
National Park System	Assateague Island National Seashore (Maryland)	124.4
National Wildlife Refuge	Supawna Meadows National Wildlife Refuge (New Jersey)	17.9
	Susquehanna National Wildlife Refuge (Maryland)	<0.1
	Bombay Hook National Wildlife Refuge (Delaware)	85.7
	Eastern Neck National Wildlife Refuge (Maryland)	8.6
	Prime Hook National Wildlife Refuge (Delaware)	39.6
	Blackwater National Wildlife Refuge (Maryland)	109.3
	Chincoteague National Wildlife Refuge (Virginia)	59.4
	Wallops Island National Wildlife Refuge (Virginia)	26.0
	Martin National Wildlife Refuge (Maryland)	16.9
	Occoquan Bay National Wildlife Refuge (Virginia)	0.3
	Featherstone National Wildlife Refuge (Virginia)	1.3
	Plum Tree Island National Wildlife Refuge (Virginia)	11.5
	Eastern Shore of Virginia National Wildlife Refuge (Virginia)	5.7
	Fisherman Island National Wildlife Refuge (Virginia)	6.8
	Back Bay National Wildlife Refuge (Virginia)	64.8
Total		4,710.5

Source: NMPAC 2008.

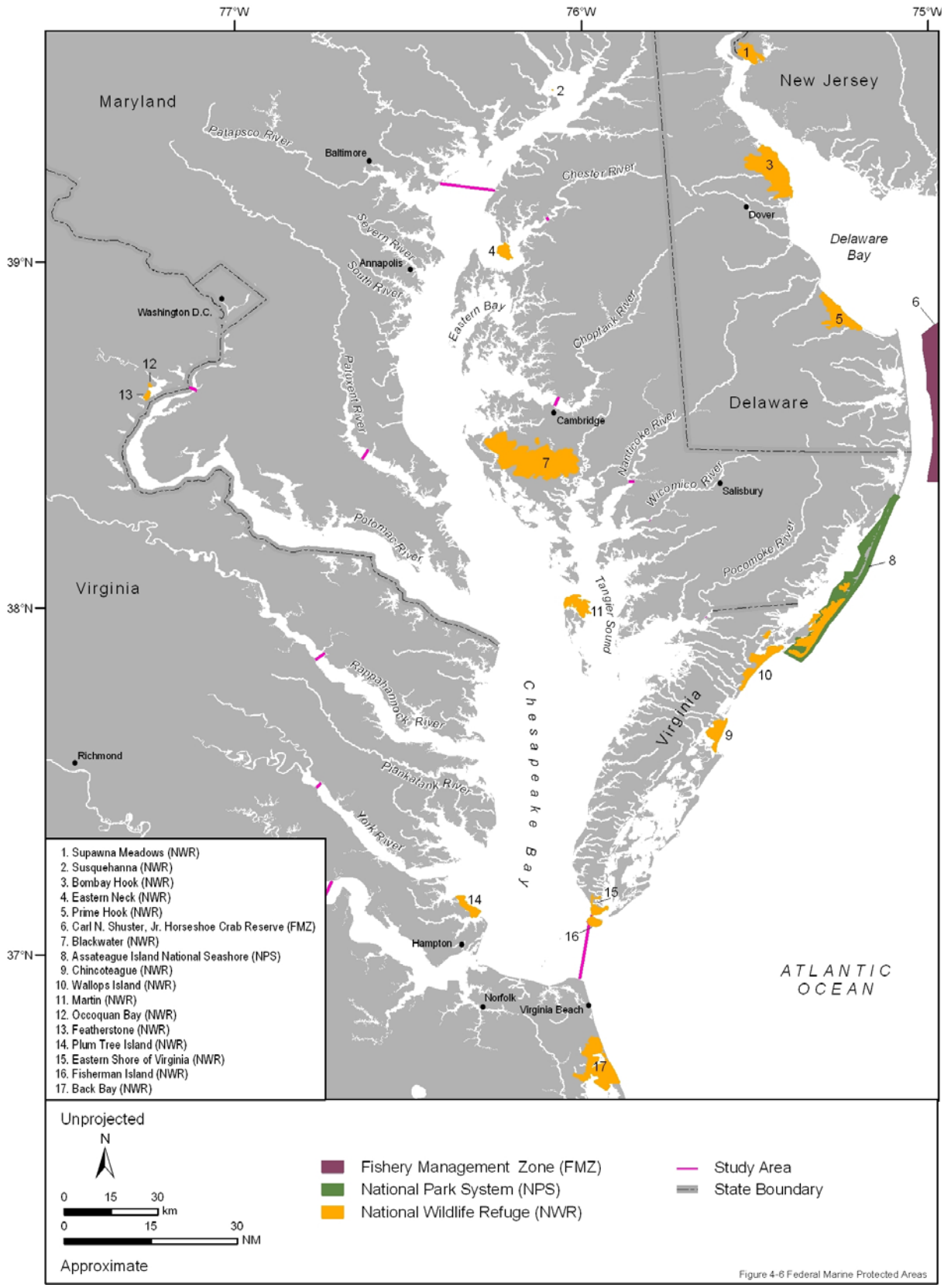

Figure 4-6. Federal marine protected areas in the vicinity of the Chesapeake Bay Study Area. Source data: NMPAC (2008).

4.8.2 State Designated Marine Protected Areas

There are currently 38 state designated MPAs located in the vicinity of the Chesapeake Bay (**Table 4-3**; **Figure 4-7**; NMPAC 2008). Because the state MPAs in the vicinity of the Chesapeake Bay are all located in the southern MAB and northern South Atlantic bight (SAB), they have similar subtropical coastal habitats (i.e., salt marshes, dunes, littoral forests) and support similar species of migrating birds, estuarine fish, and sea turtles. The MPAs mostly occur inland of the coastline within small estuaries, bays, and rivers, and along the coast, with the exception of the Blue Crab Sanctuary, located in the Virginia portion of the open Chesapeake Bay (**Figure 4-7**). The Blue Crab Sanctuary is the largest MPA in the vicinity of the Chesapeake Bay (**Table 4-3**).

Wildlife Management Areas (WMAs) make up the largest number (15) of MPAs in the vicinity of the Chesapeake Bay, and most of them are in New Jersey (**Figure 4-7**; **Table 4-3**). Mad Horse Creek, Egg Island, and Heislerville, are the three largest WMAs in the vicinity of the Chesapeake Bay (**Table 4-3**). These WMAs are administered by New Jersey's Division of Fish and Wildlife's Bureau of Land Management, and they help to preserve the state's many coastal marshes located on the Delaware Bay.[25]

There are also a good number (11) of Natural Area Preserves (NAPs) around the Chesapeake Bay and they are all located in Virginia (**Figure 4-7**). They are all <1 km^2 in area (**Table 4-3**). Most of the NAPs in Virginia are owned by the Department of Conservation and Recreation.[26]

There are six Wildlife Areas (WAs) and two State Parks (SPs) in the vicinity of the Chesapeake Bay (**Figure 4-7**; **Table 4-3**). There are also two Oyster/Shellfish Management Areas and one recognized marsh (Balthrope Marsh) in the Chesapeake Bay (**Figure 4-7**; **Table 4-3**).

Table 4-3. Summary of State Designated Marine Protected Areas in the vicinity of the Chesapeake Bay Study Area.

MPA Type	State Designated MPA (state)	Area (km^2)
Natural Area Preserve	Wreck Island (Virginia)	0.5
	Parkers Marsh (Virginia)	0.3
	Bush Mill Stream (Virginia)	<0.1
	Dameron Marsh (Virginia)	0.1
	Hughlett Point (Virginia)	<0.1
	Cumberland Marsh (Virginia)	0.4
	Bethel Beach (Virginia)	<0.1
	New Point Comfort (Virginia)	<0.1
	Savage Neck Dunes (Virginia)	<0.1
	William B. Trower Bayshore (Virginia)	<0.1
	North Landing River (Virginia)	0.3
Wildlife Management Area	Mockhorn Island (Virginia)	5.6
	Princess Anne (and Guard Shore) (Virginia)	0.5

Table 4-3 (*continued*). Summary of State Designated Marine Protected Areas in the vicinity of the Chesapeake Bay Study Area.

MPA Type	State Designated MPA (state)	Area (km^2)
Wildlife Management Area	Salem River (New Jersey)	1.4
	Abbotts Meadow (New Jersey)	2.7
	Mad Horse Creek (New Jersey)	32.5
	Cohansey River (New Jersey)	1.9
	Dix (New Jersey)	9.2
	New Sweden (New Jersey)	5.3
	Nantuxent (New Jersey)	5.2
	Fortescue (New Jersey)	4.0
	Egg Island (New Jersey)	32.1
	Heislerville (New Jersey)	21.4
	Saxis (and Guard Shore) (Virginia)	1.3
	Hog Island (Virginia)	2.0
	Ragged Island (Virginia)	0.4
Wildlife Area	Augustine (Delaware)	10.5
	Cedar Swamp (Delaware)	21.8
	Woodland Beach (Delaware)	25.3
	Little Creek (Delaware)	18.8
	Ted Harvey Conservation Area (Delaware)	10.5
	Assawoman (Delaware)	1.9
State Park	Fort Mott (New Jersey)	<0.1
	Cape Henlopen (Delaware)	21.8
Blue Crab Sanctuary	Blue Crab Sanctuary (Virginia)	2447.5
Marsh	Balthrope (Virginia)	<0.1
Oyster/Shellfish Management Area	Oyster Management Areas (Virginia)	34.8
	Shellfish Management Areas (Virginia)	18.1
Total		2,720.8

Source: NMPAC 2008.

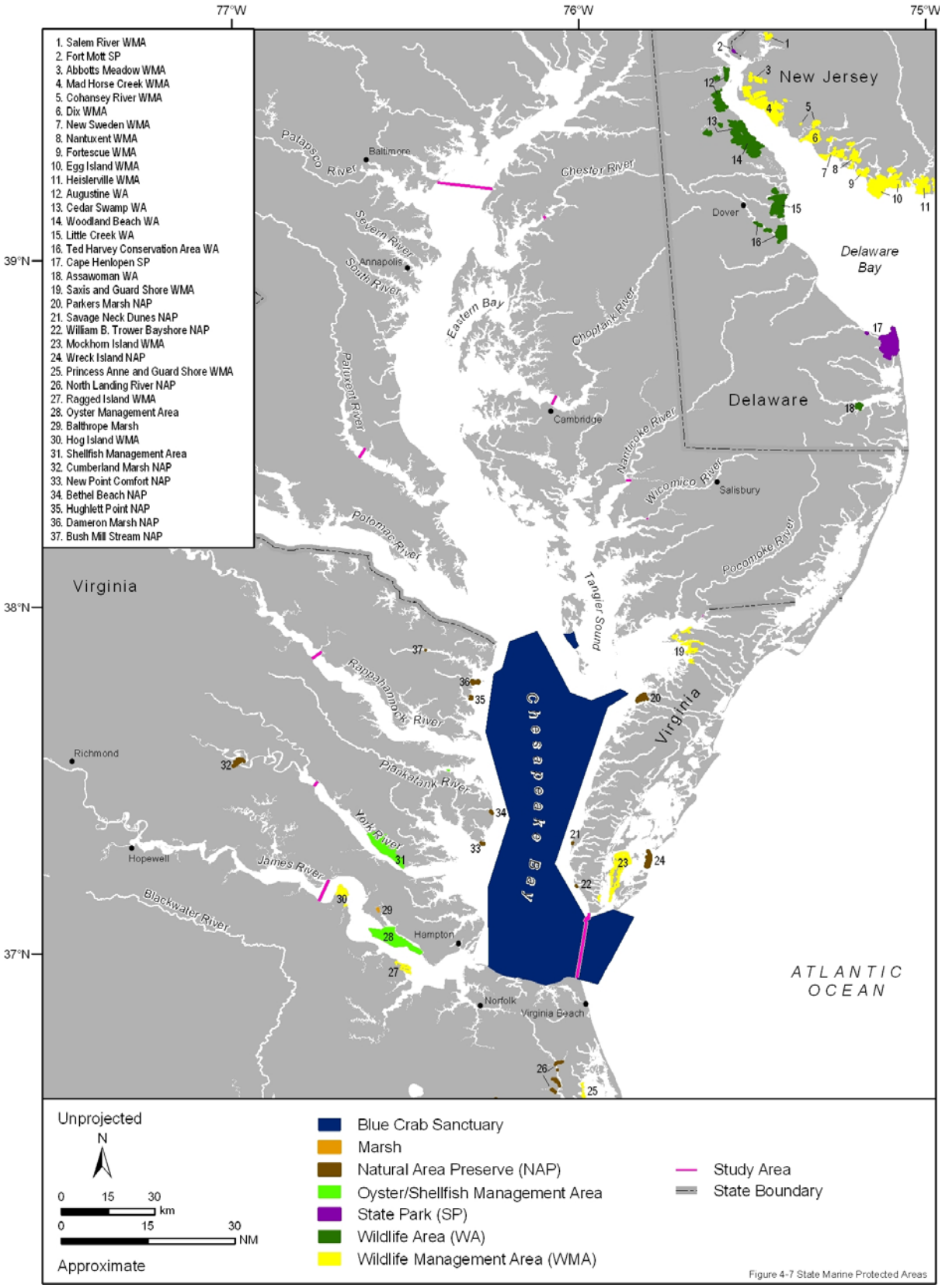

Figure 4-7. State marine protected areas in the vicinity of the Chesapeake Bay Study Area. Source data: NMPAC (2008).

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5.0 FISH AND FISHERIES

5.1 AFFECTED ENVIRONMENT

5.1.1 Regional Setting

The fish fauna of the Chesapeake Bay is extremely diverse and seasonally variable represented by more than 350 species; 32 are classified as year-round residents (e.g., killifishes, gobies, and silversides) (Murdy et al. 1997; Jung and Houde 2003).[1] This diverse ichthyofauna is divided into the five major groups: freshwater, estuarine, marine, anadromous/semi-anadromous, and catadromous. Freshwater species (e.g., gizzard shad, *Dorosoma cepedianum*) are distributed throughout the 20 or more major tributaries (i.e., Susquehanna River) that drain into the Chesapeake Bay. Many of these freshwater species can descend into the tidal freshwaters withstanding salinities as high as 10 psu. Estuarine fishes (e.g., bay anchovy, *Anchoa mitchilli*; weakfish, *Cynoscion regalis*) typically inhabit tidal waters with salinities ranging from 0 to 30 psu, whereas marine species (e.g., Atlantic menhaden, *Brevoortia tyrannus*, and spot, *Leiostomus xanthurus*) are found in coastal or oceanic waters with salinities averaging greater than 30 psu. Anadromous forms, represented by clupeids of the genus *Alosa* (shads and river herring) and Atlantic striped bass (*Morone saxatilis*), migrate from ocean waters to freshwater to spawn. Semi-anadromous fish move from waters of high salinity to low salinity waters to spawn. These fish include such species as the white perch (*Morone americana*) that move from brackish water to freshwater and the black drum (*Pogonias cromis*) that migrate from oceanic waters to the slightly reduced salinities just inside the Chesapeake Bay. Catadromous fish such as the American eel (*Anguilla rostrata*) display a migration pattern that allows them to travel to the high-salinity ocean waters (i.e., Sargasso Sea in the central North Atlantic) to spawn (CBP 1993; Murdy et al. 1997; Reshetiloff 2004).[1]

Ichthyofaunal distribution within the Chesapeake Bay is influenced by the diversity of the available habitats (e.g., river tributaries, coastal lagoons/estuaries, shallow water shorelines, wetlands: salt marshes, seagrasses, SAV, and tidal flats, live/hard bottom areas: aquatic [oyster] reefs, restored oysters bars, artificial structures, and open bay), and various physical processes (i.e., wind direction/currents, extreme seasonal temperature changes) (Olney and Boehlert 1988; Reshetiloff 2004; Rodney and Paynter 2006). These diverse habitats of the Chesapeake Bay influence the production of the fisheries by providing refuge, forage, and nursery areas to fish (e.g., Atlantic striped bass, spot, bluefish, *Pomatomus saltatrix*, naked goby, *Gobiosoma bosci*) and invertebrates (e.g., crustaceans: blue crab, *Callinectes sapidus*, horseshoe crab, *Limulus polyphemus*, and shellfish: eastern oyster, *Crassostrea virginica*). In addition, wind direction immediately adjacent to the Chesapeake Bay is critical since many of the marine species spawn in the coastal zone of the Chesapeake Bay region. Success from year to year often depends on seasonal wind direction patterns and when fish larvae (ichthyoplankton) are recruiting to nursery areas. If prevailing winds produce onshore currents, pelagic ichthyoplankton will be transported close to the mouth of the Chesapeake Bay where they will be moved by bottom currents up into the estuarine nursery grounds. Conversely, if prevailing winds produce offshore currents, then fish larvae will be swept away from estuarine nurseries within the Chesapeake Bay out to deeper waters over the continental shelf (Murdy et al. 1997; Reiss and McConaugha 1999).

The extreme seasonal temperature changes influence fish distribution within the Chesapeake Bay. Fish population diversity peaks during late summer and early autumn (August to September), when uncommon tropical species migrate and join the warm-temperate and subtropical summer residents. In early autumn, most marine species migrate to the south and/or offshore waters. Large numbers of smaller sciaenids, mullets, and Atlantic menhaden, followed by predators (i.e., sharks: sandbar, *Carcharhinus plumbeus*, dusky, *C. obscurus*), migrate south to around Cape Hatteras, North Carolina. Other species, such as clearnose skate (*Raja eglanteria*), black sea bass (*Centropristis striata*), scup (*Stentotomus chrysops*), butterfish (*Peprilus triacanthus*), sea robins (*Prionotus* spp.), and some summer flounders (*Paralichthys dentatus*) migrate eastward to the continental shelf edge to overwinter at depths of 90 to 180 m. The continental shelf is influenced by slope water and consists of moderate bottom temperatures between 8°C and 12°C. As autumn progresses, boreal species (i.e., hakes) enter the lower Chesapeake Bay to feed, but move out onto the continental shelf with the arrival of winter and colder temperatures. In mid-winter, many of the mobile estuarine resident species (e.g., white perch, Atlantic striped bass) move

into the deeper channels of the river tributaries where water temperatures become stable, density and diversity of the demersal fishes declines, and some boreal species (e.g., Atlantic herring, *Clupea harengus*, spiny dogfish, *Squalus acanthias*) visit the lower Chesapeake Bay. From February to March (late winter and early spring), anadromous species enter the Chesapeake Bay and ascend the tributaries to spawn. By late April, some of the sciaenids and summer flounder return to the lower Chesapeake Bay with most of the warm-temperate and subtropical summer residents returning by late May to complete the seasonal cycle (Murdy et al. 1997).

5.1.2 Commercial and Recreational Fisheries

A complex jurisdictional framework underlies fisheries management within the Chesapeake Bay. The management system must take into consideration many fish species which display migration and temporal patterns that cross jurisdictional boundaries within the Chesapeake Bay (NOAA-CBFEAP 2006). The Chesapeake Bay fisheries management consists of federal and state government approaches and components:

- The VMRC and Pennsylvania Fish and Boat Commission (PFBC), along with the state of Maryland DNR, the Potomac River Fisheries Commission (PRFC), and the District of Columbia Fisheries and Wildlife Division (DCFWD) separately regulate both commercial and recreational fisheries;

- Individual states of Virginia (VMRC) and Maryland (Maryland DNR) manage the blue crab fishery; and

- Fisheries for coastal species (e.g., Atlantic striped bass, bluefish, and Atlantic menhaden) are managed by the ASMFC through the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) and the FMCs (NEFMC, MAFMC, and SAFMC) authorized through the MSFCMA.

The focus of the ASMFC and its member states (Maine through Florida, including Pennsylvania), NMFS, and USFWS are to participate in the cooperative management and conservation of shared coastal fishery resources (i.e., FMPs) within state waters (inland waters and state territorial seas).

The geographical range of several managed Chesapeake Bay fish species also extends into the jurisdiction of various FMCs; therefore, some fish species are jointly managed. The ASMFC and MAFMC jointly manage the bluefish, and the summer flounder, scup, and black sea bass, while the red drum (*Sciaenops ocellatus*), which was jointly managed by the SAFMC and ASMFC, is now managed by the ASMFC (NMFS 2008a). The MAFMC also co-manages and serves as the lead on the spiny dogfish with the NEFMC (NOAA-CBFEAP 2006). Both the SAFMC and the GMFMC co-manage the coastal migratory pelagics, but only the SAFMC manages these species in the Mid-Atlantic region (i.e., Virginia through New York).

The VMRC's Fisheries Management Division and Maryland DNR manage commercial and recreational finfish and shellfish resources through conservation and enhancement. Methods and approaches consist of (1) data collection and estimation of fishery statistics to determine stock status; (2) participation in various management bodies (e.g., PRFC, ASFMC, and MAFMC) pertinent to its fisheries; and (3) development of FMPs for important valuable species (NOAA-CBFEAP 2006).

Currently, under the authority of the 1987 Chesapeake Bay Agreement, the Chesapeake Bay Program (CBP) has completed 15 FMPs for 21 species (NOAA-CBFEAP 2006). The CBP does not have any management authority over seasonal migratory fish species within the Chesapeake Bay that also range along the coast; however, the states (Virginia and Maryland) do have authoritative jurisdiction once these species migrate within their jurisdictional boundaries (NOAA-CBFEAP 2006).

5.1.3 Commercial Fishing

The Chesapeake Bay is the largest estuary (NOAA-CBFEAP 2006) and has the fifth most valuable commercial fishing port (Hampton Roads, Virginia) in the US.[2] In addition, the commercial fishing port of Reedville, Virginia, ranks second in commercial landings. In 2007, commercial landings in the Chesapeake Bay (Virginia and Maryland) were 241,478.2 metric tons (mt) and valued at $182,833,725 (**Figure 5-1**).[2] Overall, the Chesapeake Bay (Virginia and Maryland) ranked third in commercial landings and sixth in value. Individually, Virginia (219,716.10 mt; $130,561,765) ranked fourth and Maryland (22,032.10 mt; $52,271,960) ranked seventieth in total landings in 2007 (**Figure 5-1**). Commercial fisheries in the Chesapeake Bay are numerous and complex (see **Table 5-3**). Small-scale fisheries use various gears (e.g., gillnets, purse seines, pound nets, pots, and haul seines) to target year-round and seasonal migratory marine species. As such, fishing activities and primary commercial gear types are seasonal; changing with species abundance, availability, and expected earnings (Kirkley 1997). The Chesapeake Bay supports more than 41 different fisheries comprised of approximately 170 fish and shellfish species or products forms (NOAA-CBFEAP 2006). Fishery landings throughout this section are reported in mt and/or in kg since reporting landings using one standardized unit would be difficult to plot because of scale (i.e., large differences in landings among species).

Commercial landings in the Chesapeake Bay (Virginia and Maryland) are dominated by two species, Atlantic menhaden and blue crab. From 1998 to 2007, Atlantic menhaden represented 82% and blue crab 10% of the total landings (**Figure 5-2**).[2] In terms of market value, Atlantic menhaden represented 75% and blue crab 16% of the total value from 1998 to 2007 (**Figure 5-3**).[2] Although spiny dogfish, conch, and horseshoe crabs were never primary commercial species, these species were important commercial species in Maryland and Virginia (**Tables 5-1 and 5-2**) during the early to mid-1990s. Today, spiny dogfish commercial landings in the U.S., including the Chesapeake Bay, are minimal in comparison to previous years (McMillan and Morse 1999) mostly because stringent management measures were recently implemented to rebuild stocks.[3]

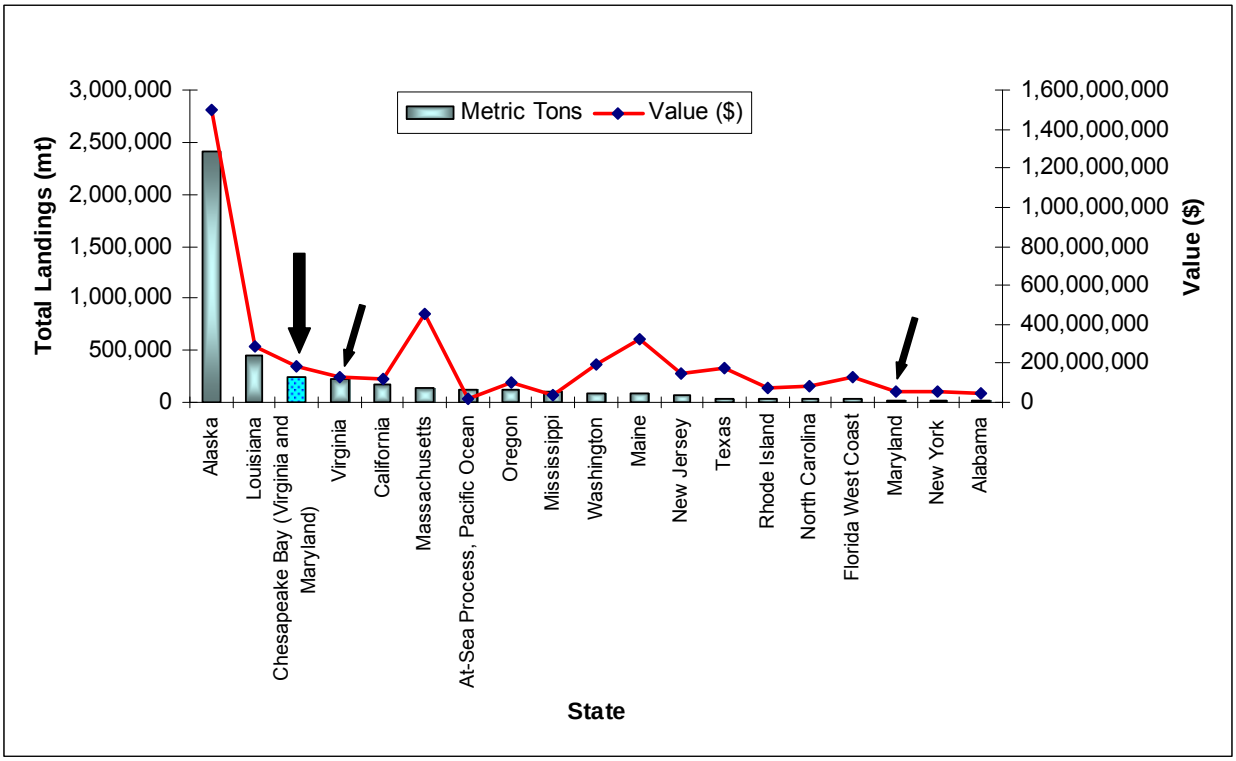

Figure 5-1. Total U.S. commercial fishing landings in 2007.[2]

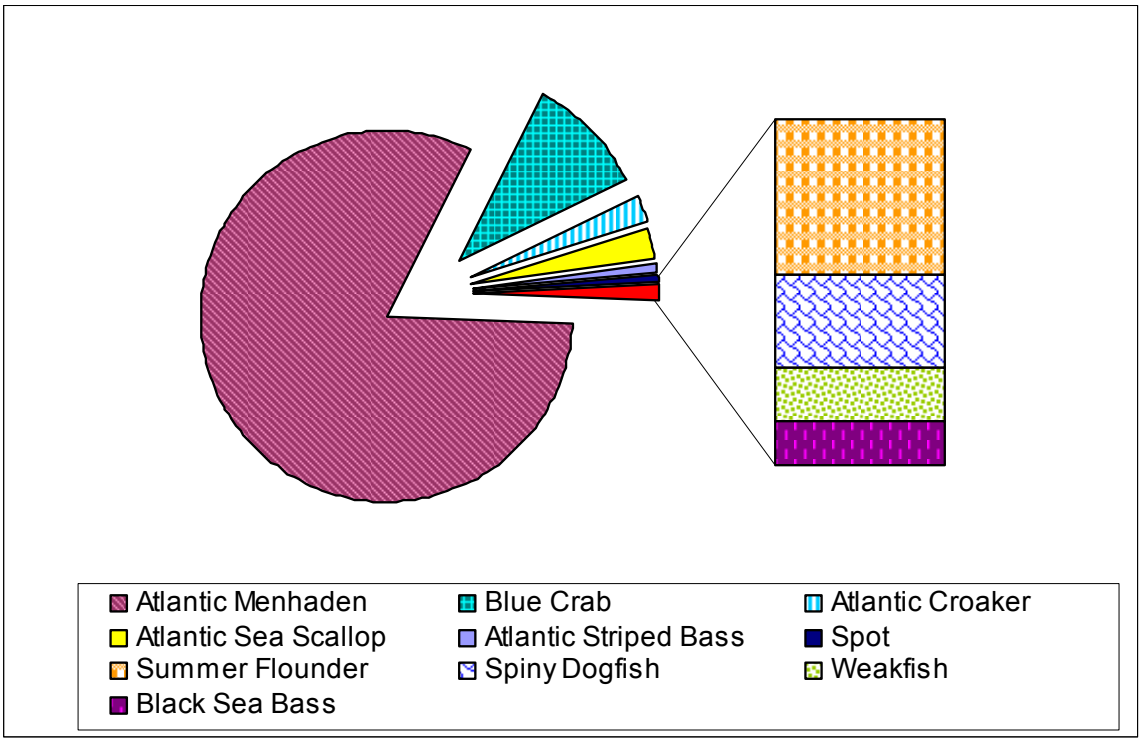

Figure 5-2. Total commercial fishing landings (kg) in the Chesapeake Bay (Virginia and Maryland) from 1998 to 2007.[2]

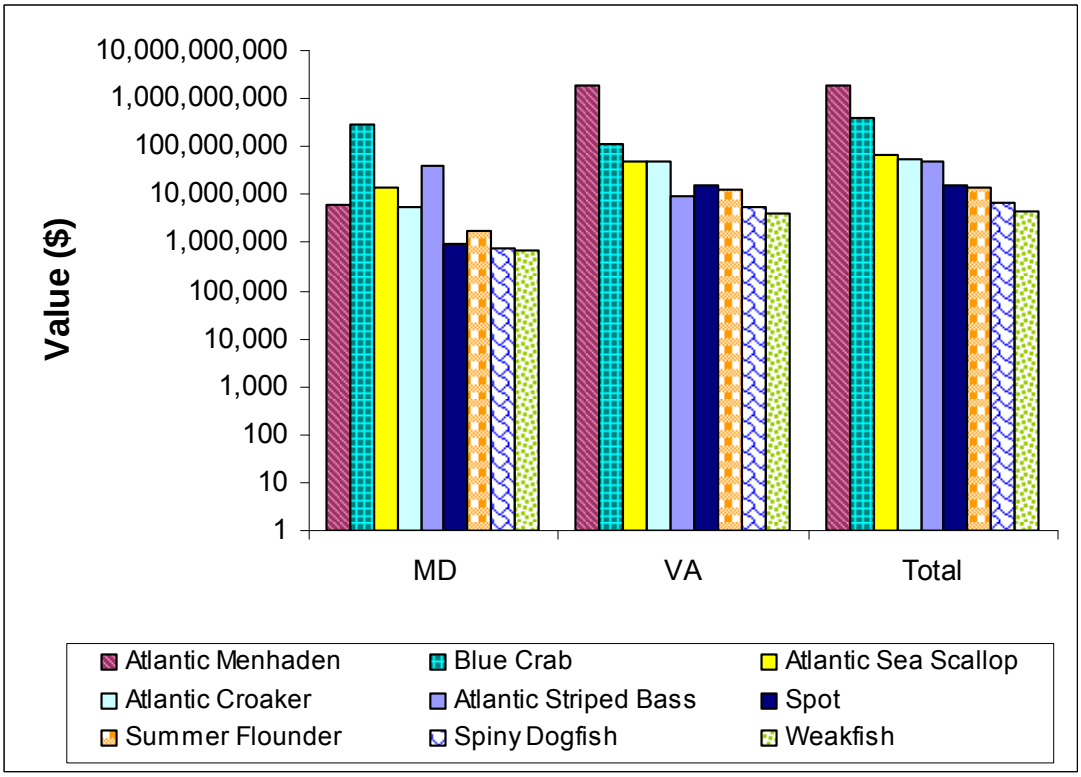

Figure 5-3. Commercial fishing value in the Chesapeake Bay (Virginia and Maryland) from 1998 to 2007.[2]

Table 5-1. The dominant commercial fishery species landed in Virginia from 1998 to 2007.[2]

Common Name	Total Landings (kg)									
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Atlantic menhaden	230,755,046	171,529,679	166,527,810	220,964,730	165,534,625	169,583,490	181,345,287	168,998,436	168,277,901	190,507,338
Blue crab	14,581,460	13,306,731	12,142,450	10,291,181	11,417,927	9,012,751	11,793,258	11,331,658	9,897,988	8,382,670
Atlantic sea scallop	1,609,263	2,527,562	4,162,311	5,739,707	7,343,418	7,954,285	8,923,780	5,186,753	3,770,180	4,546,589
Atlantic croaker	5,446,278	5,828,641	5,846,536	5,864,582	5,646,225	4,960,610	4,303,519	4,205,605	3,551,156	4,943,826
Spot	1,940,131	1,343,491	1,707,630	1,473,364	1,388,996	1,574,639	1,967,721	1,407,414	769,286	1,927,143
Summer flounder	1,186,484	996,013	1,000,949	1,206,368	1,347,290	1,597,507	1,771,812	1,755,026	1,250,532	842,231
Atlantic striped bass	841,439	843,421	1,001,980	929,642	834,954	954,250	965,054	1,126,600	649,116	892,119
Spiny dogfish	1,402,191	2,187,762	655,188	1,054	N/A	N/A	N/A	N/A	426,431	1,116,703
Weakfish	845,464	759,337	618,169	508,913	518,941	208,374	161,883	176,870	85,160	181,823
Conch	279,521	798,029	388,331	358,716	240,847	313,561	124,317	176,516	135,635	71,616
Horseshoe crab	1,230,129	791,985	181,543	65,965	45,819	116,849	105,265	92,572	124,156	74,652
Bluefish	360,600	223,077	241,698	358,774	215,611	171,527	217,933	233,508	252,294	326,833
Black sea bass	370,570	335,665	293,921	299,919	349,902	230,039	225,982	215,618	148,745	86,135
Squid	456,171	220,496	165,513	376,880	202,449	75,647	578,814	312,816	N/A	N/A
Crabs	N/A	N/A	N/A	702,732	17,992	10	N/A	20	38,034	301,990

Table 5-2. The dominant commercial fishery species landed in Maryland from 1998 to 2007.[2]

Common Name	Total Landings (kg)									
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Blue crab	13,402,048	15,340,791	9,715,708	10,986,935	11,447,692	11,893,330	14,686,804	15,263,621	12,832,901	9,700,566
Atlantic menhaden	2,024,784	2,595,098	2,209,374	2,094,965	2,200,100	1,919,449	1,513,266	7,169,435	2,387,483	5,185,212
Atlantic striped bass	1,307,870	1,102,370	1,227,032	929,533	945,787	994,898	406,761	1,061,092	1,127,053	1,191,627
Atlantic croaker	623,983	718,677	681,139	1,012,944	686,297	694,921	816,893	630,180	397,821	211,659
Eastern oyster	1,116,270	1,106,763	1,074,214	577,972	257,182	72,064	19,410	334,684	124,236	117,613
Gizzard shad	786,233	825,508	106,042	334,771	475,858	177,379	35,474	276,068	120,554	95,200
Spiny dogfish	1,088,168	949,257	202,747	N/A	N/A	N/A	N/A	N/A	9,344	N/A
American eel	212,122	189,586	181,344	188,666	132,629	198,204	62,445	207,246	155,333	145,593
Horseshoe crab	226,812	290,232	193,664	193,094	314,336	192,993	N/A	90,356	66,017	N/A
Black sea bass	142,780	199,253	138,313	68,152	126,956	141,930	N/A	149,751	158,932	N/A
Atlantic sea scallop	986	1,664	9,589	12,889	12,339	N/A	42,239	265,108	422,429	204,012
Spot	102,483	101,361	80,261	128,588	62,886	83,659	N/A	52,157	15,913	101,994
Weakfish	110,888	101,357	94,490	84,284	50,526	21,504	N/A	16,192	23,170	10,037
Alewife	72,613	68,007	72,106	106,724	33,604	34,239	4,019	17,403	16,085	26,091
Summer flounder	N/A	N/A	N/A	N/A	N/A	149,387	N/A	151,213	112,374	N/A

The Chesapeake Bay supports Virginia and Maryland state-managed marine fisheries (e.g., blue crab) and various federally managed species (e.g., Atlantic menhaden). In Virginia, the dominant species landed from 1998 to 2007 were Atlantic menhaden, blue crab, Atlantic sea scallop (*Placopecten magellanicus*), Atlantic croaker (*Micropogonias undulates*), spot, and summer flounder (**Figure 5-4**). In recent years, Atlantic striped bass, spiny dogfish, weakfish, conch, horseshoe crab, bluefish, black sea bass, squid, and crabs have also been landed in significant numbers (**Table 5-1**). The mean total Virginia commercial landings ranged from 187,517,043 to 255,518,662 kg and the mean was 207,699,726.6 kg (Standard Error [S.E.] ± 7,580,853.857 kg).[2] Although results from a one-sample Student's *t*-test showed that the mean annual commercial landings in Virginia were significantly different (t [9] = 56.33, P <0.001), while the moving average of commercial landings suggest landings were relatively stable from 1998 to 2007.

The primary species commercially landed in Maryland from 1998 to 2007 were blue crabs, Atlantic menhaden, Atlantic striped bass, Atlantic croaker, eastern oyster, and gizzard shad (**Figure 5-5**). In recent years, spiny dogfish, American eel, horseshoe crab, black sea bass, Atlantic sea scallop, spot, weakfish, alewife (*Alosa pseudoharengus*), and summer flounder have also been landed in significant numbers (**Table 5-2**). The mean total Maryland commercial landings ranged from 15,013,509 to 24,735,080 kg and the mean was 17,896,483 kg (S.E. ± 981,819 kg).[2] Similar to Virginia landings, results from a one-sample Student's *t*-test showed that the mean annual landings in Maryland were significantly different (t [9] = 37.95, P <0.001); however, the moving average suggest commercial landings slightly fluctuated from 1998 to 2007.

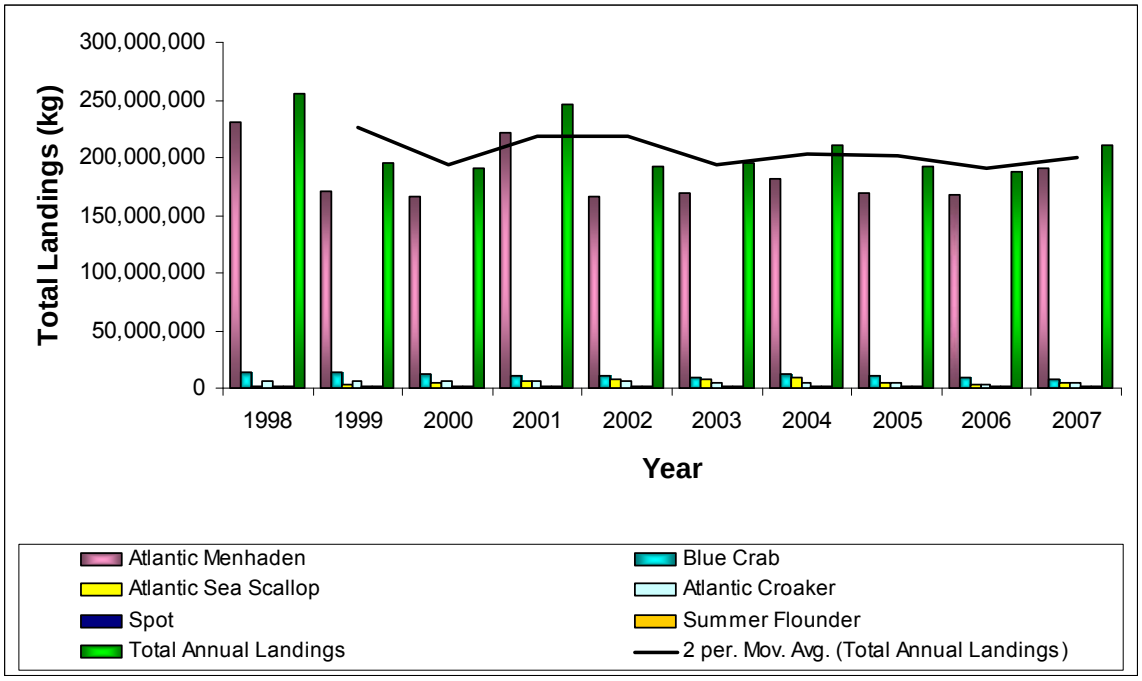

Figure 5-4. Total Virginia commercial fishing landings for primary species from 1998 to 2007.[2]

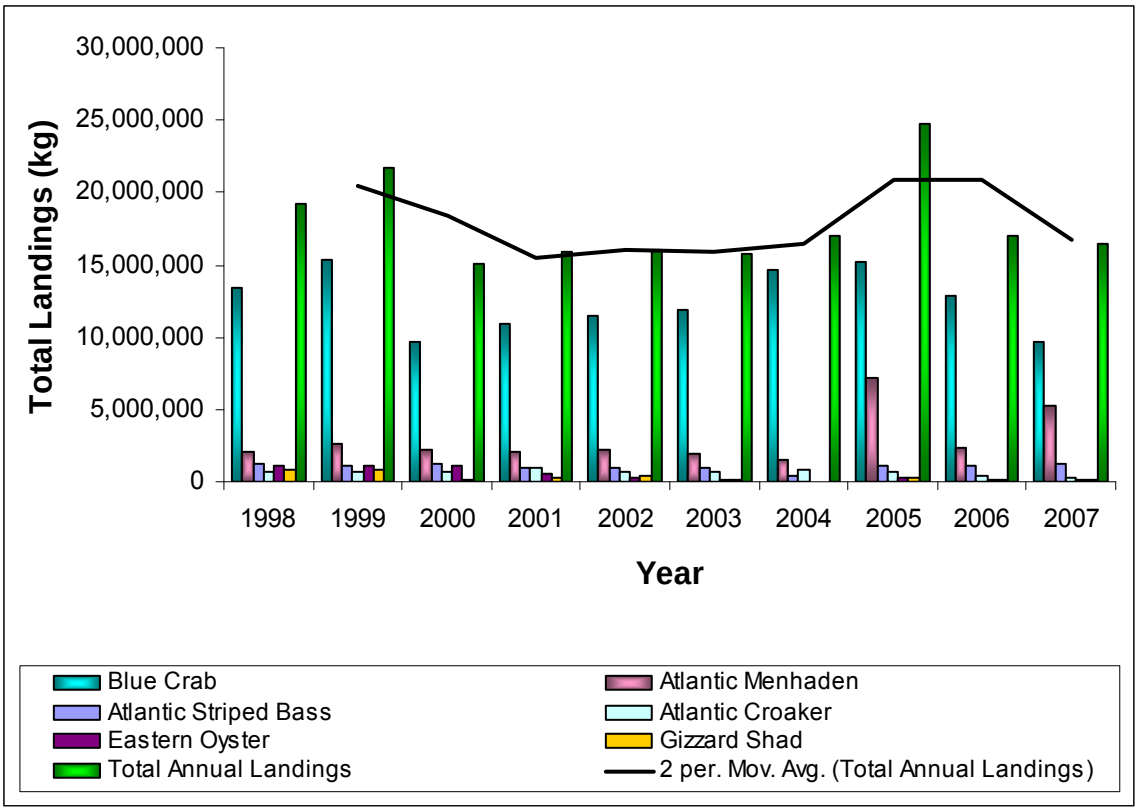

Figure 5-5. Total Maryland commercial fishing landings for primary species from 1998 to 2007.[2]

5.1.4 Commercial Species

In descending order, the most important commercial species landed in the Chesapeake Bay are Atlantic menhaden, blue crab, Atlantic croaker, and Atlantic sea scallop. Atlantic sea scallop ranked fourth in total landings and third in market value from 1998 to 2007. Historically, Atlantic menhaden has been the most important commercial species in the Chesapeake Bay. In the western North Atlantic Ocean, the species ranges from northern Florida to Nova Scotia. Besides being a valuable commercial species, Atlantic menhaden are an important forage fish for many fish (e.g., Atlantic striped bass, bluefish, and weakfish), sea birds, and marine mammals. Forming large schools, adult and juvenile Atlantic menhaden are common in estuaries and nearshore coastal waters during early spring through early winter.[3] Atlantic menhaden migrate south in the fall through winter and migrate north in spring. In the summer months, Atlantic menhaden schools segregate by size and age, with older and larger individuals found farther north. Atlantic menhaden sexual maturity initiates around age three and spawning occurs in offshore (32 to 48 km) waters during the fall through early winter. Spawning occurs along the U.S. east coast from the South Carolina to New Jersey (Murdy et al. 1997). Atlantic menhaden are targeted with purse gear for the reduction (fishmeal, oil, and fertilizer) and bait fisheries. Based on the 2006 SAR, the Atlantic menhaden population is not overfished and overfishing is not occurring.[3]

The Atlantic menhaden is one of the oldest and largest commercial fisheries along the U.S. Atlantic coast. In the Chesapeake Bay, Cheuvront (2004) reported that the use of Atlantic menhaden products (i.e., oil [Omega 3] and fertilizer) dates back to the development of the purse seine in 1870. In the past five decades, the fishery has continued to decline. In 1981 there were eight processing plants; however, by 2004, only two processing plants remained. One Atlantic menhaden processing plant (Omega Protein, Inc.) was located in Reedville, Virginia, and the other (Beaufort Fisheries) was in Beaufort, North Carolina. Today, 11 vessels target Atlantic menhaden for Omega Protein, Inc., which is the only remaining processing plant on the east coast of the U.S. In Virginia, commercial Atlantic menhaden

landings ranged from 165,536.3 to 230,757.4 mt and the mean was 183,404.3 mt (S.E. ± 7,513.1 mt) from 1998 to 2007 (**Figure 5-6**).[2] Results from a one-sample Student's *t*-test showed that there was a significant difference in the mean total landings among years (t [9] = 24.41, P <0.001). The overall market value of Atlantic menhaden in Virginia ranged from $22,113,124 to $40,744,067 and mean was $26,603,889 (S.E. ± $1,762,737). In general, market value has remained stable since reaching a low in 2002, but slightly decreased overall. In contrast to Virginia landings, Maryland's Atlantic menhaden landings are considerably less; however, Atlantic menhaden are still an important species. In Maryland, commercial Atlantic menhaden landings ranged from 1.5 to 7.1 mt and the mean was 2,929.95 mt (S.E. ± 568.2 mt) from 1998 to 2007 (**Figure 5-7**).[2] Results from a one-sample Student's *t*-test showed that there was a significant difference in the mean total landings among years (t [9] = 5.16, P <0.001). Results also showed that the total landings, in some years, were significantly greater than the mean landings (t [9] = 24.41, P <0.001). The overall market value of Atlantic menhaden in Maryland ranged from $232,186 to $1,513,728 and the mean was $611,237 (S.E. ± $130,605.61).[2] Similarly to Virginia, Atlantic menhaden market value slightly decreased from 1998 to 2004; but increased dramatically from 2004 to 2007.

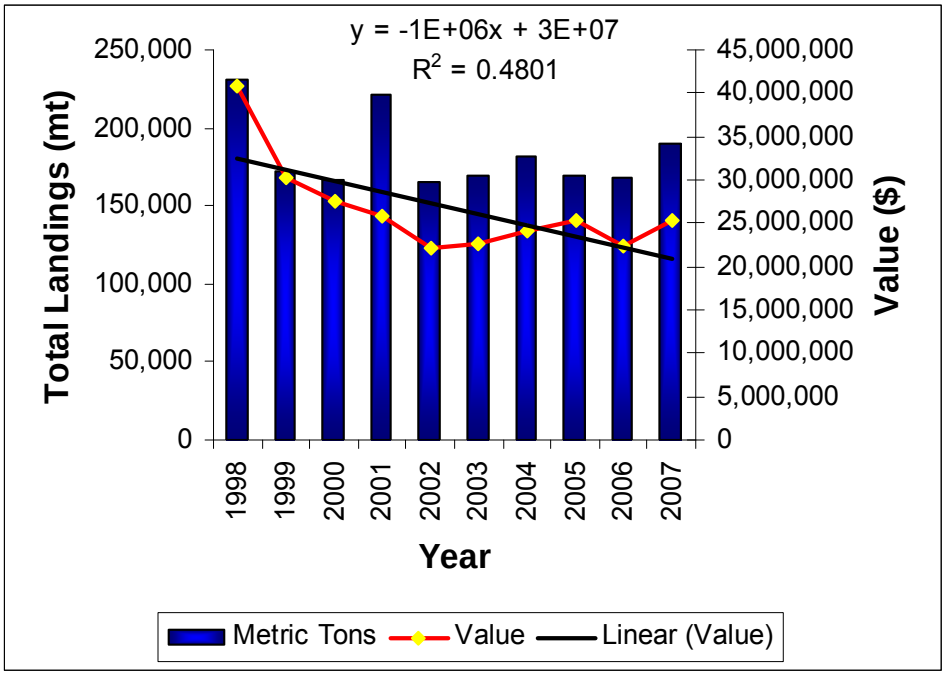

Figure 5-6. Total Virginia Atlantic menhaden commercial landings and value from 1998 to 2007.[2]

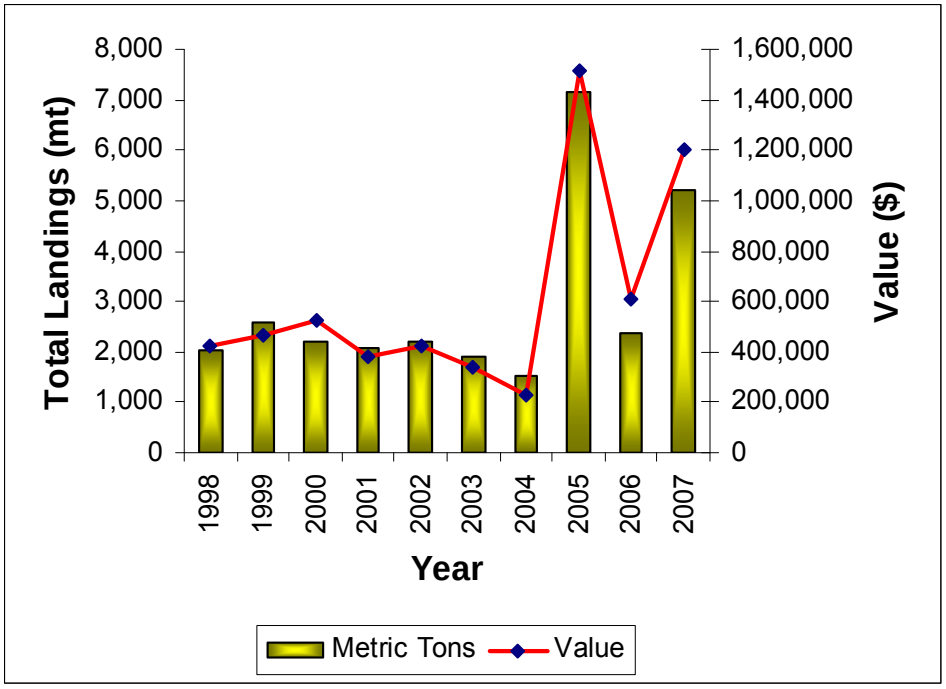

Figure 5-7. Total Maryland Atlantic menhaden commercial landings and value from 1998 to 2007. [2]

The second most important commercial species in the Chesapeake Bay is the blue crab. In the western Atlantic, blue crabs range from Nova Scotia to northern Argentina, including Bermuda and the Antilles.[3] The species has been reported in Europe; however, it was probably noted because of anthropogenic transportation (i.e., transported within ship ballasts) (Murdy et al. 1997). Ecologically, blue crabs are a valuable component of the local food web. Blue crabs are opportunistic benthic feeders with a diet consisting of fish, aquatic vegetation, mollusks, crustaceans, and annelids. Blue crabs are also important forage prey for mammals, birds, and fishes. Blue crabs are common in estuaries and nearshore coastal waters, but prefer brackish waters (Murphy et al. 2007). Because blue crabs molt, aging has been problematic; however, best available information indicates blue crabs can reach a maximum age of eight years.[3] Blue crabs are exploited by commercial fisheries around age two or three. The blue crab sexually matures around age one with spawning in the Mid-Atlantic (including the Chesapeake Bay) occurring from May until October. In contrast to most fish species, blue crabs are targeted with traps (Murphy et al. 2007). Blue crab populations have fluctuated (Lipcius and Stockhausen 2002) with the current stock status indicating that the population harvest levels are the lowest since 1945. Based on abundance estimates, blue crab populations are overfished. Because age one (i.e., adult) animals are at historical low abundance levels and more females were harvested than males, emergency harvest reduction regulations (34% reduction) were implemented in spring 2008; however, recently, NOAA declared the fishery a state of disaster. This was the first declaration of this type for any fishery in the Chesapeake Bay.[4]

In Virginia, commercial blue crab landings ranged from 8,382 to 14,581 mt and the mean was 11,216 mt (S.E. ± 600 mt) from 1998 to 2007 (**Figure 5-8**).[2] Results from a one-sample Student's *t*-test showed that there was a significant difference in the mean total landings among years (t [9] = 18.69, P <0.001). The overall market value of blue crab in Virginia ranged from $12,661,713 to $21,249,195 and mean was $17,436,531 (S.E. ± $887,245). In general, market value has steadily decreased as described by the following equation: Total Landings = -712402 (Year) + 2E +07 (r^2 = 0.59). In contrast, Maryland blue crab landings are relatively greater. In Maryland, commercial blue crab landings ranged from 9,700 to 15,341 mt and the mean was 12,527 mt (S.E. ± 673 mt) from 1998 to 2007 (**Figure 5-9**).[2] Results from a one-sample Student's *t*-test showed that there was a significant difference in the mean total landings among years (t [9] = 18.61, P <0.001). In comparison to Virginia, Maryland blue crab market values were

generally greater. The overall blue crab market value ranged from $23,949,838 to $31,663,636 and mean was $27,807,890 (S.E. ± $1,132,758). In contrast to Virginia, blue crab market value in Maryland was stable.

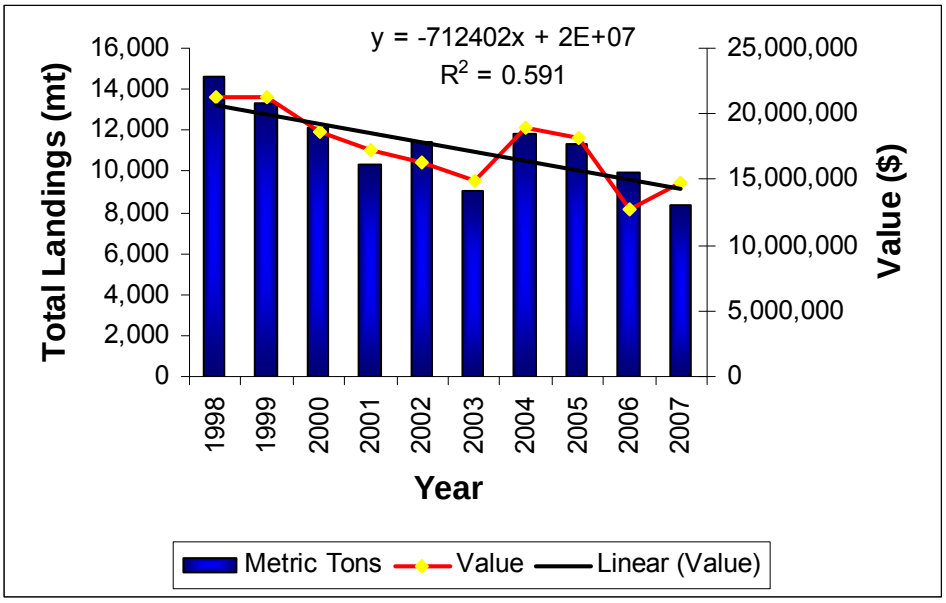

Figure 5-8. Total Virginia blue crab commercial landings and value from 1998 to 2007.[2]

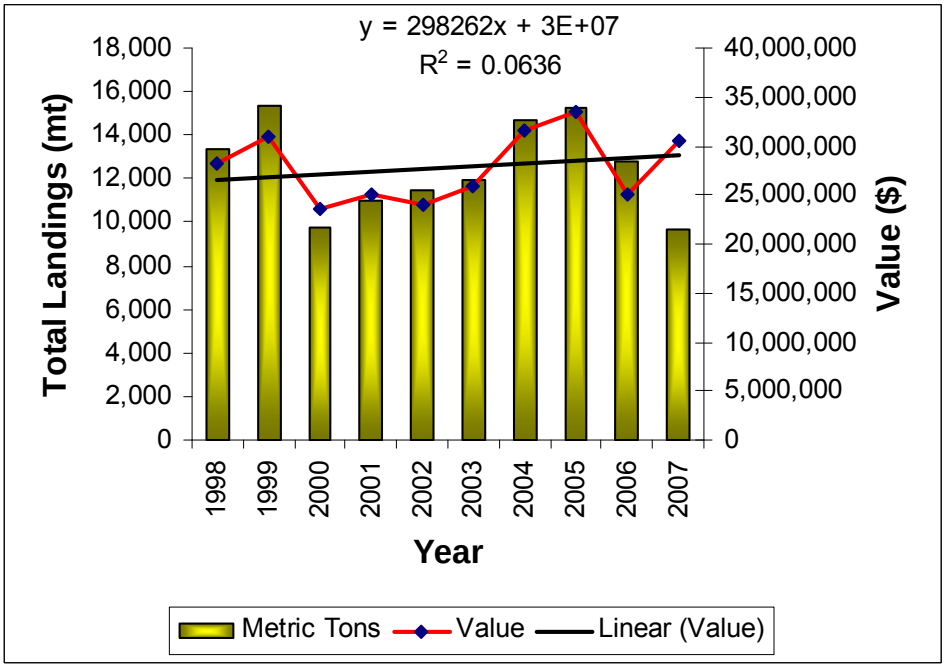

Figure 5-9. Total Maryland blue crab commercial landings and value from 1998 to 2007.[2]

The third most important commercial species in the Chesapeake Bay is the Atlantic croaker. In the western Atlantic, Atlantic croaker range from Maine to Argentina, but are not common north of New Jersey. The Atlantic croaker is an opportunistic benthic feeder with a diet consisting of various types of invertebrates, including polychaetes, mollusks, ostracods, copepods, amphipods, mysids, and decapods, and occasionally fish.[3] Atlantic croaker are a common demersal fish found in estuaries and nearshore coastal waters (Murdy et al. 1997). Similar to other species found in the Chesapeake Bay, Atlantic croaker migrate south during the colder winter months and north during the warmer summer months. Atlantic croaker mature around age two and three and spawning occurs from July to December (Murdy et al. 1997). Size at maturity is similar between the sexes (males = 18.3 cm and females = 17.3 cm). Atlantic croaker is considered a mixed-fishery that is taken using a variety of gears including haul seines, pound nets, gillnets, and trawls. The current stock status suggests the population is not overfished and overfishing is not occurring.[3]

In Virginia, commercial Atlantic croaker landings ranged from 3,551 to 5,864 mt and the mean was 5,060 mt (S.E. ± 257 mt) from 1998 to 2007 (**Figure 5-10**).[2] Results from a one-sample Student's *t*-test showed that there was a significant difference in the mean total landings among years (t [9] = 19.68, P <0.001). The overall market value of Atlantic croaker in Virginia ranged from $2,822,496 to $5,598,277and mean was $3,867,942 (S.E. ± $266,940). In general, market value has steadily decreased since 2003. In comparison to Virginia landings, Maryland Atlantic croaker landings were lower. In Maryland, commercial Atlantic croaker landings ranged from 212 to 1,013 mt and the mean was 647 mt (S.E. ± 68.7mt) from 1998 to 2007 (**Figure 5-11**).[2] Results from a one-sample Student's *t*-test showed that there was a significant difference in the mean total landings among years (t [9] = 9.42, P <0.001). In comparison to Virginia, Maryland Atlantic croaker market values were relatively lower. The overall Atlantic croaker market value ranged from $268,857 to $751,219 and mean was $527,077(S.E. ± $42,007). Similar to Virginia, Atlantic croaker market value in Maryland has decreased in recent years, since 2004.

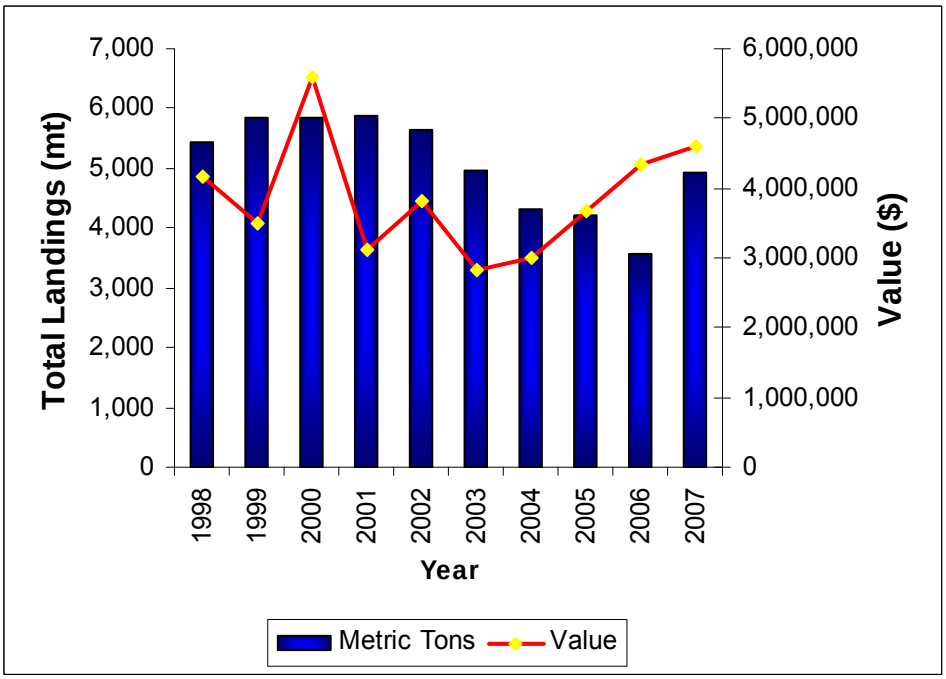

Figure 5-10. Total Virginia Atlantic croaker commercial landings and value from 1998 to 2007.[2]

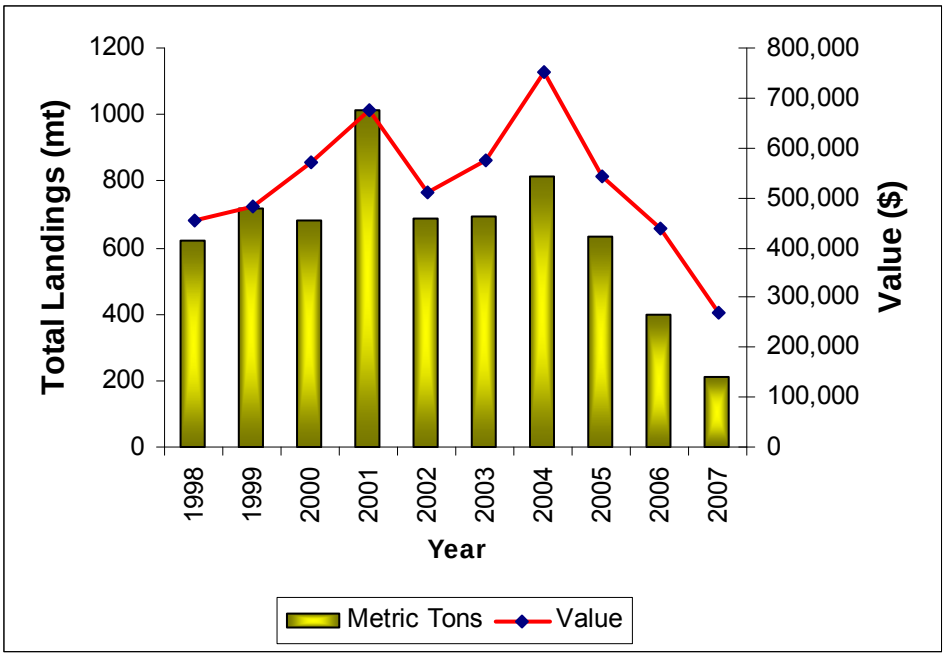

Figure 5-11. Total Maryland Atlantic croaker commercial landings and value from 1998 to 2007.[2]

5.1.5 Commercial Fishing Gears

Commercial species in the Chesapeake Bay are taken by a variety of gear types, including gillnets, pound nets, pots (traps), and purse seines (**Figure 5-12**).[2] **Table 5-3** identifies commercial fishing activities for target species by gear, management jurisdiction, and stock status, while **Table 5-4** identify gear, seasons, locations, and target species. Commercial fishery regulations are complex in terms of species, gears, and jurisdiction. As such, state and federal regulations are routinely amended. The current commercial fishery regulations can be found at either of the states' commercial fishery regulations websites, and/or at the ASMFC website.[3,5,6] From 2002 to 2007, four gear types accounted for 91% of the commercial fishery harvests in the Chesapeake Bay: purse seine-Atlantic menhaden (58%), purse seine-other (21%), pots and traps-blue crab (8%), and pound nets-fish (3%). In Virginia, the primary gears that landed commercial fisheries from 2002 to 2007 were purse seine Atlantic menhaden gear (65%), purse seine-other (23%), pots and traps-blue crab (4.7%), and gillnets-sink/anchor/other (2.7%) (**Figure 5-13**).[2] In Maryland the primary commercial fishing gears were pots and traps-blue crab (44%), lines trot with baits (19%), pound nets-fish (17%), and dredge clam (15%) (**Figure 5-14**).[2]

In Virginia tidal waters, commercial fishery regulations include seasonal closures (i.e., weakfish, blue crab), size, possession, catch limits, harvest quotas, and gear restrictions (e.g., gill nets, crabbing, and pound nets).[5] Of the various individual (i.e., fish species) commercial fisheries in the Chesapeake Bay, the weakfish (grey trout) and commercial crabbing fishery (blue crab) have the most stringent seasonal closures. The most complex gear regulated is gillnets. Gillnet restrictions in Virginia consist of gear-marking, season and time, mesh size and tending, length and depth (gear depth), deployment method (straight line), distance to other associated nets, distance to other objects (e.g., bridges), within various artificial reefs, and depending on gear deployment location, gear must abide by various specific federal protected species regulations (sea turtle and marine mammal regulations [Harbor Porpoise and Atlantic Large Whale Take Reduction Plans]).[7,8]

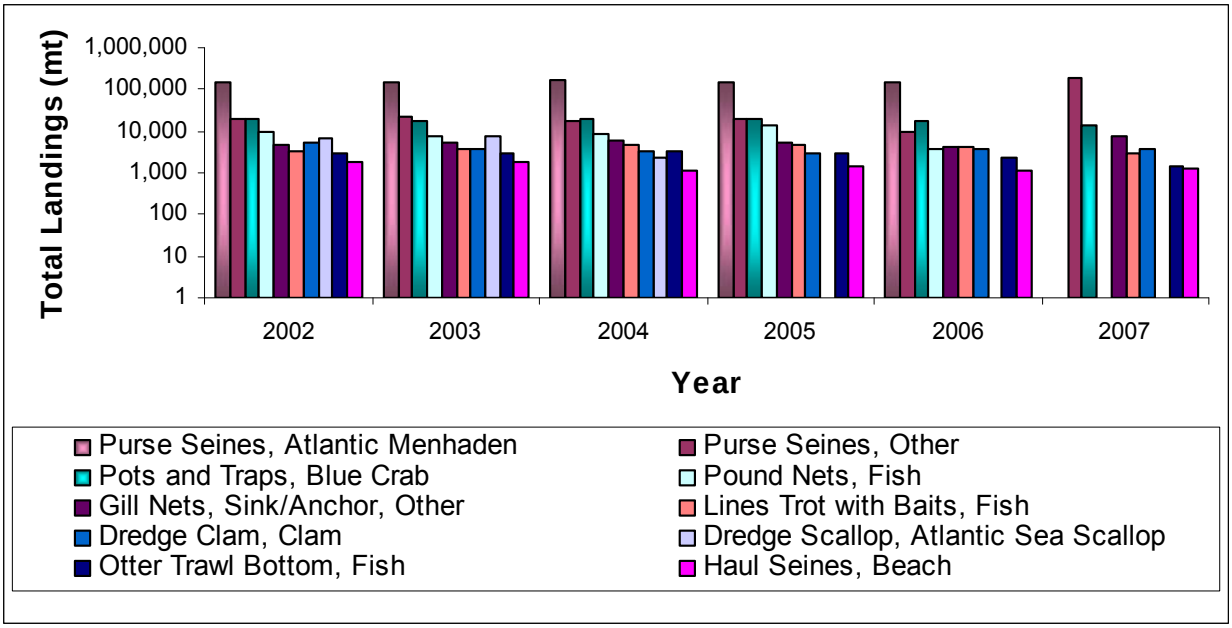

Figure 5-12. Commercial landing by gear type in the Chesapeake Bay from 2002 to 2007. [2]

Table 5-3. Major commercial fisheries by gear type, management jurisdiction/fishery management plans (FMPs), and stock status in the Chesapeake Bay (NOAA-CBFEAP 2006).[1]

Common Name (Species)	Major Gear Type	Management Jurisdiction (FMP/Date)	Stock Status
American eel (*Anguilla rostrata)*	Pots and Traps	ASMFC (Draft Addendum II) (2008)	Unknown
Atlantic croaker (*Micropogonias undulates)*	Gill Nets, Drift, Sink/Anchor, Pound Nets, Otter Trawl Midwater/Bottom, Haul Seines, Beach	ASMFC (Amendment 1) (2005)	Not overfished, overfishing not occurring
Atlantic menhaden (*Brevoortia tyrannus)*	Purse Seines, Pound Nets	ASMFC (Addendum III to Amendment 1) (2006)	Not overfished, overfishing not occurring
Atlantic striped bass (*Morone saxatilis)*	Gill Nets, Sink/Anchor, Pound Nets, Lines Hand	ASMFC (Addendum I to Amendment 6) (2007)	Not overfished, overfishing not occurring
Black drum (*Pogonias cromis)*	Gill Nets, Drift, Sink/Anchor, Lines Trot with Baits	Chesapeake Bay Fishery Management Plan (CBFMP) (2003)	Unknown
Black sea bass (*Centropristis striata)*	Otter Trawl Bottom, Lines Hand, Pots and Traps	ASMFC and MAFMC (Summer Flounder, Scup, Black Sea Bass Framework 7 (2007)	Overfished, Overfishing unknown

Table 5-3 (*continued*). Major commercial fisheries by gear type, management jurisdiction/fishery management plans (FMPs), and stock status in the Chesapeake Bay (NOAA-CBFEAP 2006).[1]

Common Name (Species)	Major Gear Type	Management Jurisdiction (FMP/Date)	Stock Status
Blue crab (*Callinectes sapidus)*	Pots and Traps, Dredge	Virginia and Maryland (1997)	Fishery recently declared as "collapsed"
Bluefish (*Pomatomus saltatrix*)	Gill Nets, Sink/Anchor, Pound Nets	ASMFC and MAFMC Framework 1 (2001)	Not overfished, overfishing not occurring
Horseshoe crab (*Limulus polyphemus)*	Otter Trawl Bottom	ASMFC (Addendum V (2008)	Unknown
Eastern oyster (*Crassostrea virginica)*	Dredge, Tongs and Grabs, Unspecified Gear	Virginia and Maryland Oyster Management Plan (OMP) (2005)	Major declines, NMFS is currently evaluating whether to protect populations under the ESA
King mackerel (*Scomberomorous cavalla)*	Gill Nets, Drift, Sink/Anchor	ASMFC and SAFMC (Amendment 15) (2004)	Not overfished, overfishing not occurring
Red drum (*Sciaenops ocellatus)*	Gill Nets, Sink/Anchor, Pound Nets, Haul Seines	ASMFC (2008)	Overfished, Overfishing unknown
Shad/River herring (*Alosa* spp.)	Gill Nets, Sink/Anchor, Pound Nets	ASMFC (Addendum I to Amendment 1 (2002)	Not overfished, overfishing not occurring
Spanish mackerel (*Scomberomorous maculates)*	Pound Nets, Gill Nets, Sink/Anchor	ASMFC and SAFMC (Amendment 15 (2004)	Not overfished, overfishing not occurring
Spot (*Leiostomus xanthurus)*	Gill Nets, Sink/Anchor, Haul Seines Beach, Pound Nets	ASMFC (1987)	Unknown
Spotted seatrout (*Cynoscion nebulosus)*	Haul Seines, Beach, Gill Nets, Sink/Anchor	ASMFC-Amended (1991)	Unknown
Summer flounder (*Paralichthys dentatus)*	Otter Trawl Bottom, Pound Nets	ASMFC and MAFMC (Summer Flounder, Scup, Black Sea Bass Framework 7) (2007)	Not overfished, overfishing not occurring
Tautog (*Tautoga onitis)*	Lines Hand, Pots and Traps	ASMFC (Addendum V) (2008)	Unknown, Unknown
Weakfish (*Cynoscion regalis)*	Gill Nets, Sink/Anchor, Pound Nets	ASMFC (Addendum III to Amendment 4) (2007)	Depleted, overfishing not occurring

Table 5-4. Commercial fishing activities for primary commercial species in the Chesapeake Bay (Virginia and Maryland waters) (Wang et al. 1994).[5,6]

Target Species	Gear Type	Season	Location
Atlantic menhaden	Purse Seine	May to July	Chesapeake Bay
Alewife, Bluefish, Summer flounder, Atlantic striped bass, Weakfish, Spotted sea trout	Pound Nets (30.5 to 35.6 cm [deep water: 6.10 to 10.67 m] and 15.2 to 20.3 cm [close to shore water depth: 4.57 m]); Pound Net: Stretched mesh (3.8 cm) hedging or lead (twine size of #12 or larger); Restricted to set within 1,372 m of another pound net in the Chesapeake Bay and within 457 m in a tributary of the Chesapeake Bay, measured at right angles to the line of stakes. A person may not set at any time a stake net within 366 m of another stake net or pound net, measured at right angles to the line of stakes. Clear and unobstructed intervals of at least 61 m shall be maintained between successive pound or stake nets in the same row.	Spring to Fall	Restricted to River Mouths (i.e., York River, Mobjack Bay)
	Weakfish: Gillnet	Closed May 14 through October 20 and December 31 through March 15	Virginia
	Weakfish: Pound Net	Closed May 1 through 22 and September 13 through March 31	Virginia
	Weakfish: Haul Seine	April 1 through 15, June 11 through August 20, and Sept. 25 through March 31	Virginia
	Weakfish: Trawl	September 26 through March 31	Virginia
Weakfish	Ocean: All gear except Trawl:	March 26, 2008 through April 25, 2008 and September 3, 2008 through November 14, 2008 Sunday Closed	Maryland
	Chesapeake Bay: All gear	August 5, 2008 through September 30, 2008	

Table 5-4 (*continued*). Commercial fishing activities for primary commercial species in the Chesapeake Bay (Virginia and Maryland waters) (Wang et al. 1994).[5,6]

Target Species	Gear Type	Season	Location
Weakfish	Trawl	October 17, 2008 through December 29, 2008 - Saturday and Sunday Closed	
Blue crab	Hard Crab Pots, Trotline, Dip Nets, Traps, Scrapes, Skimming	In general: April, September, October, and November (0600 to 1400 hours [hrs.]); May, June, July, and August (0500 to 1300 hrs.) *Emergency Regulations: Commercial harvest of female crabs will be prohibited beginning October 23, 2008 and individualized catch limits will be effective beginning September 1, based on recent annual mean reported landings. Recreational fishery prohibition of any female blue crab harvest, effective immediately. Virginia's winter dredge fishery closed and also shortened the state's fall crab season	Chesapeake Bay
	Trap/Pot	April 1 through December 15 Pots, Traps, Rings, Handline, or Dip Nets: 1/2 hr before sunrise – 71/2 hrs after sunrise Pots can be aboard boat until 81/2 hrs after sunrise Trotlines/Scrapes: April, October, November and December Sunrise - 10 hrs after sunrise May, June, July, August and September 1 hr before sunrise - 9 hrs after sunrise Sunday or Monday Off	Maryland

Table 5-4 (*continued*). Commercial fishing activities for primary commercial species in the Chesapeake Bay (Virginia and Maryland waters) (Wang et al. 1994).[5,6]

Target Species	Gear Type	Season	Location
Atlantic striped bass	Hook and Line	November 16 through December 7; Fishing will be restricted to Monday, Tuesday, Wednesday, and Thursday of each week. Days may be added or removed later in the season depending on remaining quota.	Chesapeake Bay
	Pound Net	June 2 through November 29 (including Saturday)	Maryland
	Haul Seine	June 9 through November 28 Monday through Friday	Maryland
	Hook and Line	June 16 through November 27 Monday through Thursday	Maryland
	Drift Gillnet	January 1 through February 29 and December 1 through December 31 3:00 a.m. to 6:00 p.m. Monday through Friday	Maryland
	Ocean Trawl Gillnet	January 1 through April 30 and November 3 through December 31	Maryland
	Chesapeake Drift Net	January 1 through February 29 and December 1 through December 31	Virginia
	Atlantic Trawl and Atlantic Drift Gill Net	January 1 through April 30 and November 3 through December 31	Virginia
*Emergency regulations recently implemented due to the blue crab fishery collapse			

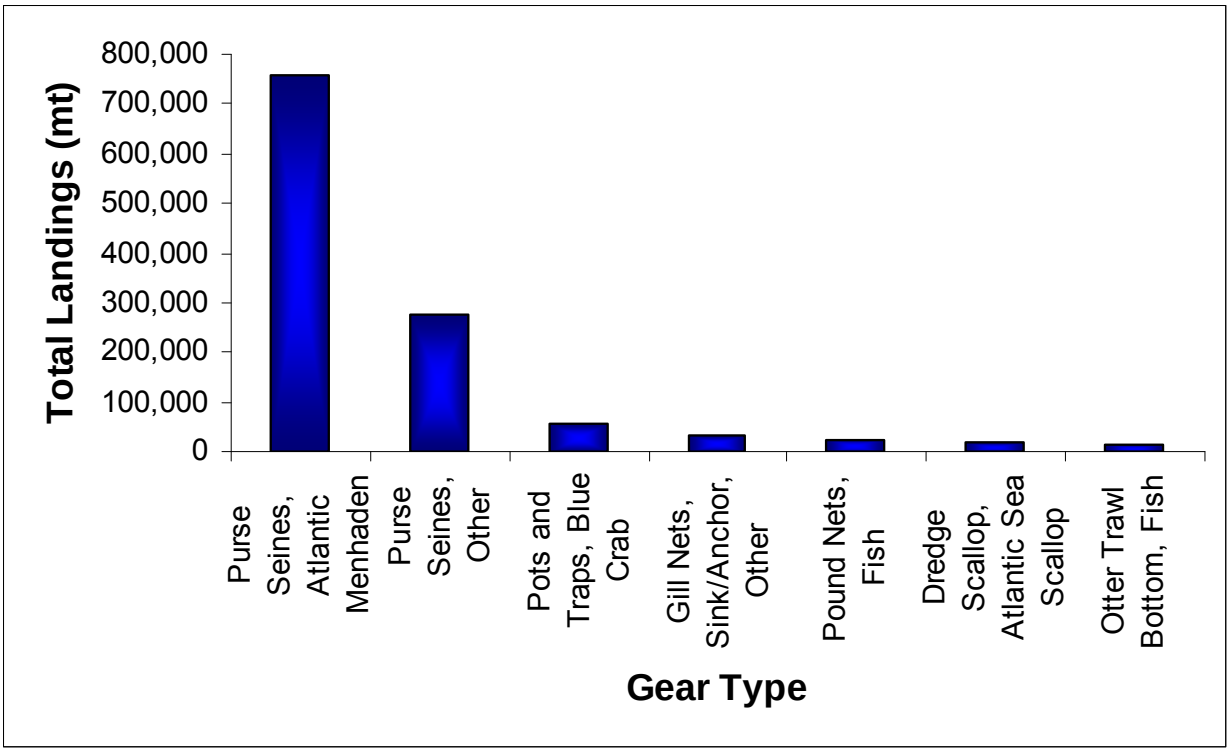

Figure 5-13. Commercial landing by gear type in Virginia from 2002 to 2007. [2]

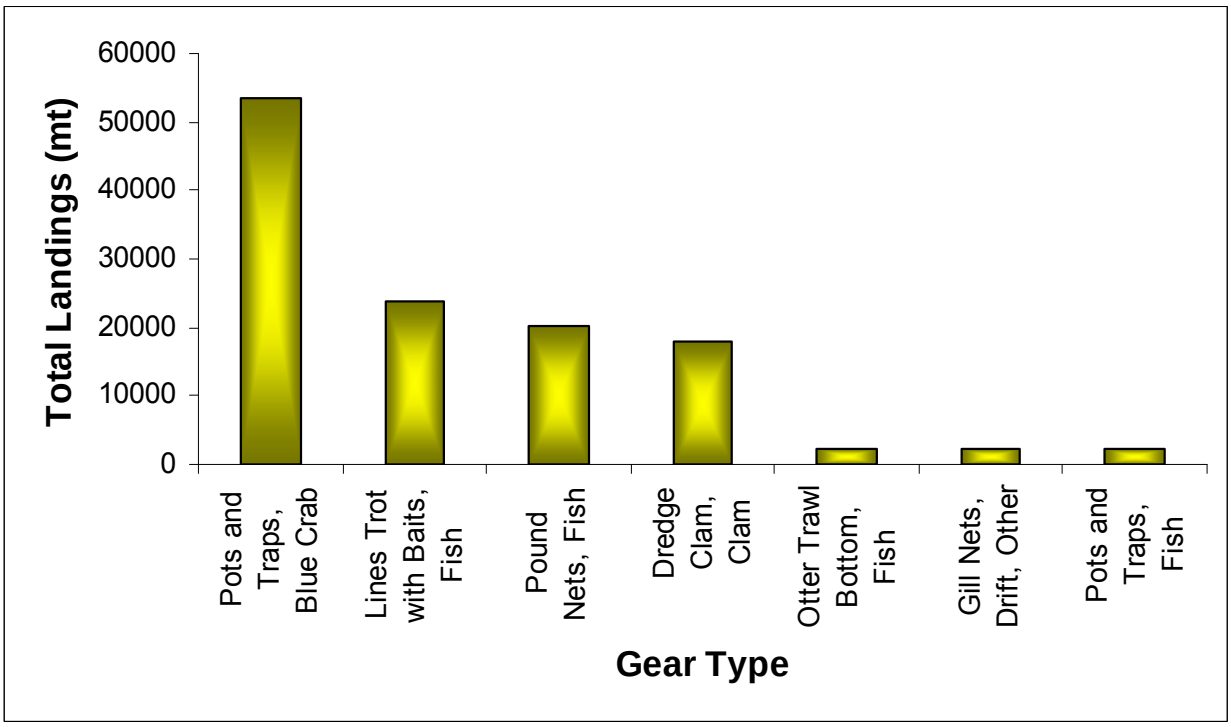

Figure 5-14. Commercial landing by gear type in Maryland from 2002 to 2007.[2]

In addition to the various regulations for the blue crab fishery, the Virginia Bay-wide Blue Crab Spawning Sanctuary and Lower Bay Crab Sanctuary Area is also closed to commercial and recreational crabbing from 1 May to 15 September.[5] In addition, it is unlawful to set crab gear in the Tangier Island Crab Scrape Sanctuary and Pretty Lake Area. The objective of the blue crab sanctuary is to protect females in and en route to the spawning grounds in the reproductive period with the overall goal of increasing spawning potential. Currently, the sanctuary expands from the mouth of the Chesapeake Bay to the Virginia/Maryland border, approximately at the 9.1 m depth contour; a size around 240,092 hectares (ha) (**Figure 5-15**) (Lambert et al. 2006).

It is estimated that this sanctuary protects 70% of the adult females (i.e., spawning stock) in the lower Chesapeake Bay during spawning season (Lambert et al. 2006). Both pound nets and gill nets also have stringent gear restrictions in the Virginia tidal waters. In order to reduce sea turtle entanglements and impingements, NMFS prohibited the use of all pound net leaders (set with the inland end of the leader >3 m from the mean low water line and > or = 30.5 cm stretched mesh and leaders with stringers) in the Virginia waters of the Chesapeake Bay and portions of the Virginia tributaries from May 6 to July 15 each year. The boundaries of the two regulated management areas defined in NMFS 2004 rule (FR 69:24997-25012) for the Virginia pound net fishery are illustrated in **Figure 5-16** (NMFS 2006a).

Similar to the commercial fishing regulations for Virginia waters, Maryland state commercial regulations include a mixture of seasonal closures (i.e., Atlantic striped bass and blue crab), size, permits, possession, catch limits, harvest quotas, and gear restrictions (e.g., gill nets, crabbing, and pound nets). Of the various individual (i.e., fish species) commercial fisheries in the Chesapeake Bay, the Atlantic striped bass and commercial crabbing fishery (blue crab) have the most stringent regulations. Gillnet restrictions in Maryland also consist of gear-marking, season and time, mesh size and tending, length and depth (gear depth), deployment method (straight line), distance to other associated nets, distance to other objects (e.g., bridges), within various artificial reefs, and depending on gear deployment location, gear must abide by various specific federal protected species regulations (Harbor Porpoise and Atlantic Large Whale Take Reduction Plans).[7,8]

5.2 RECREATIONAL FISHING

The Chesapeake Bay includes two state jurisdictions (Maryland and Virginia), encompassing 312 km (from north to south) and 8,960 km of shoreline making it as one of the largest recreational fishing areas in the U.S. As such, recreational saltwater fishing is highly valued in the Chesapeake Bay with recreational fishermen landing large catches of finfish and shellfish (NOAA-CBFEAP 2006). There are about 60 species or groups of species caught by Virginia anglers (Kirkley and Kerstetter 1997). Similar to commercial fisheries, recreational fisheries usually target the same species. In general, the majority of the targeted recreational fishes in the Chesapeake Bay are representative of the primary commercial species. In addition to these species, recreational fishermen harvest greater amberjack (*Seriola dumerili*), cobia (*Rachycentron canadum*), groupers, sharks, skates, and rays, sheepshead (*Archosargus probatocephalus*), Atlantic spadefish (*Chaetodipterus faber*), and shellfish (hard: *Mercenaria mercenaria*)/ soft: *Mya arenaria*) clams and conchs).

In Virginia's waters within the Chesapeake Bay, a recreational commercial gear license is required, which is an annual license that allows recreational anglers to use limited amounts of commercial gear to harvest species for their personal consumption. As part of the license requirement, each species or group of species are regulated by a minimum size and possession limit.[6] At this time, fishing from a licensed pier, licensed charter boat, or licensed private boat is exempt from possession of an individual license.

The five primary recreational species landed in Virginia from 2002 to 2007 were Atlantic croaker, spot, summer flounder, Atlantic striped bass, and black sea bass (**Figures 5-17 and 5-19**).[9] In 2007, most (63%) of the Atlantic croaker landed were between 254 and 330 millimeters (mm) FL (25.4 and 33.0 cm).

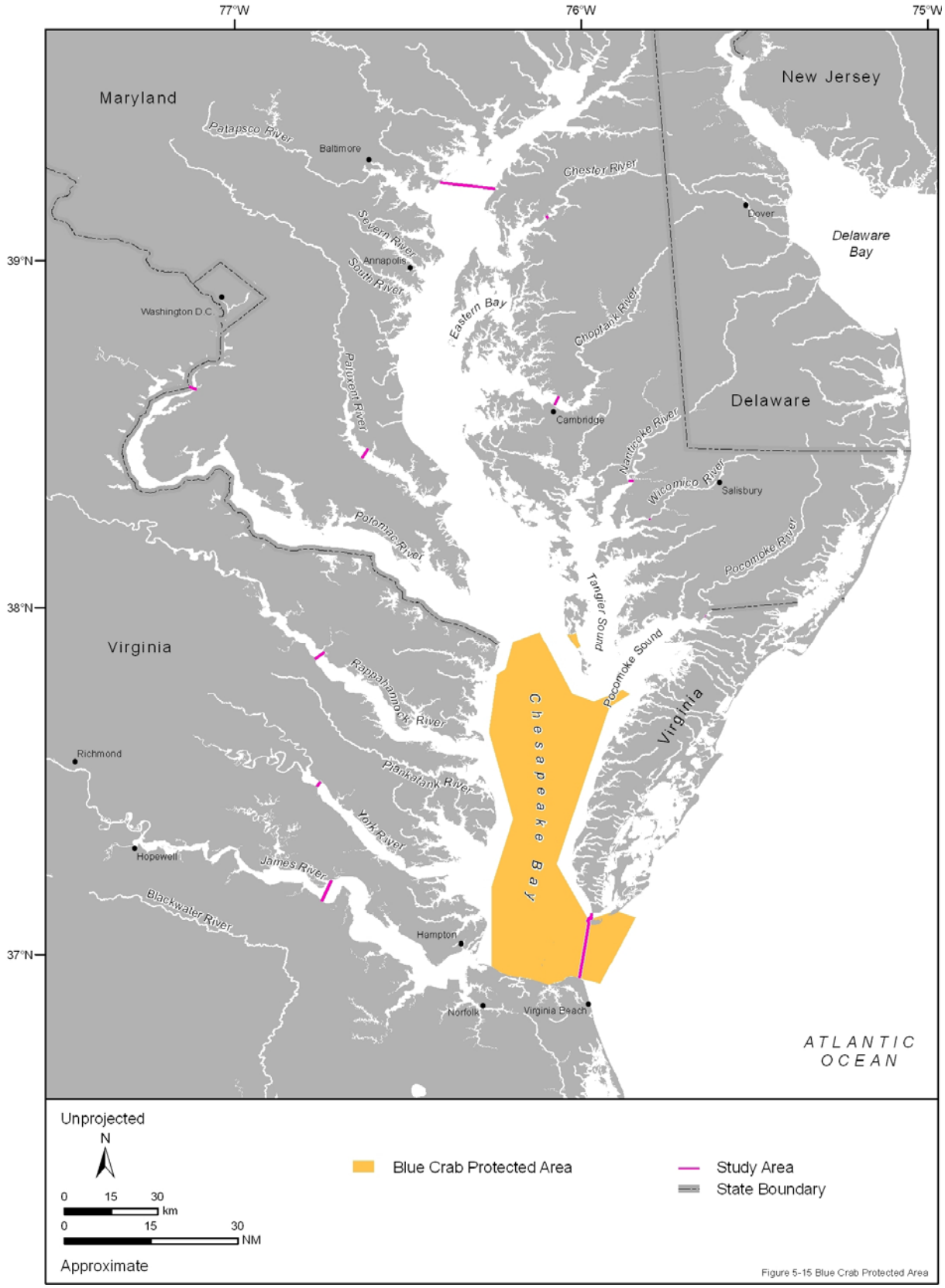

Figure 5-15. Blue crab spawning sanctuary in the Chesapeake Bay. Source data: Lambert et al. (2006).

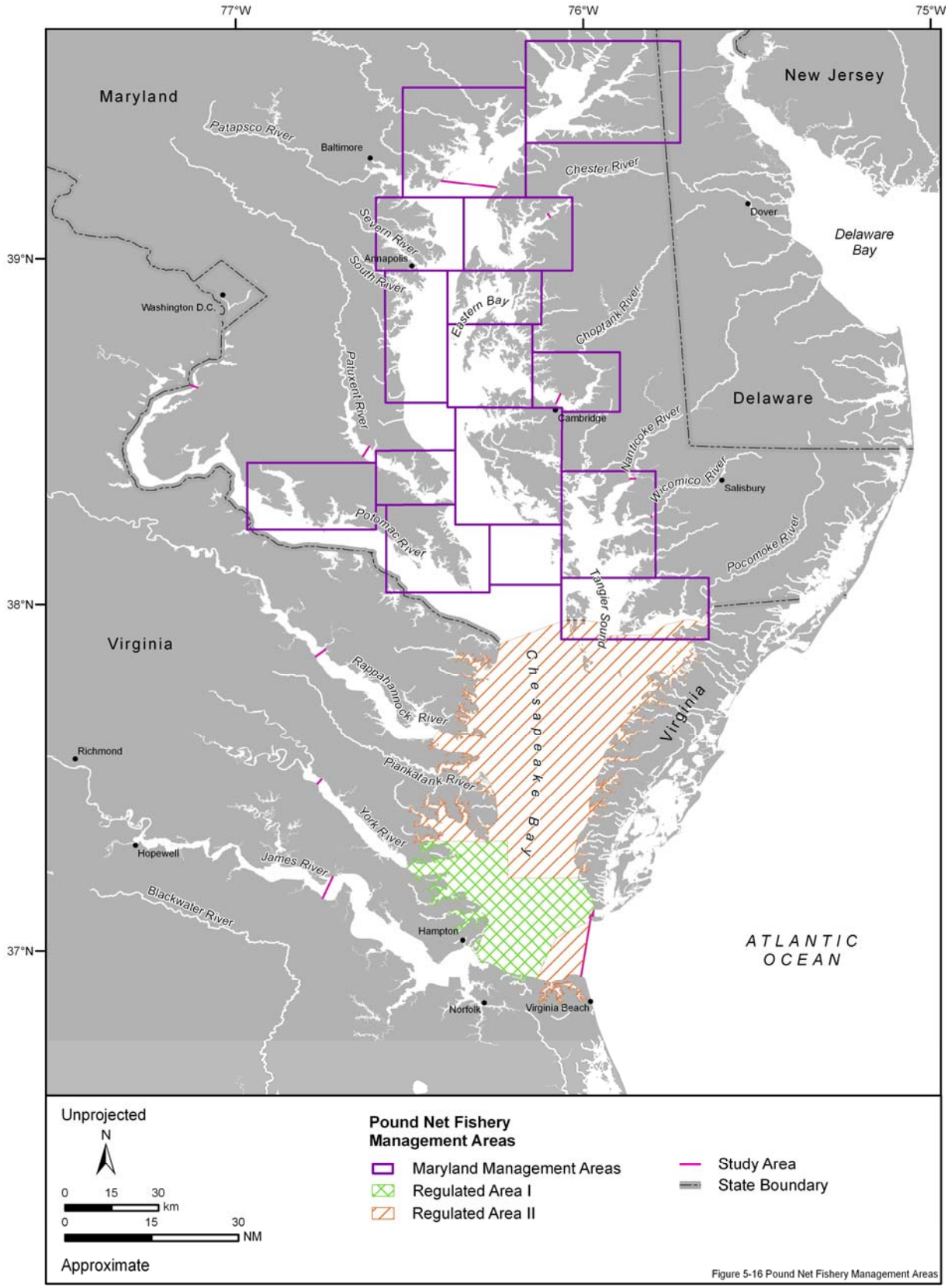

Figure 5-16. Pound net fishery management areas in the Chesapeake Bay. Source data: NMFS (2006a).

Evaluating the combined total numbers of fish landed by recreational fishermen in Virginia, it appears landings are stable (R^2 = 0.27; **Figure 5-17**).[9] In Maryland, the five primary species landed by recreational fishermen from 2002 to 2007 were white perch, Atlantic striped bass, Atlantic croaker, bluefish, and black sea bass (**Figures 5-18** and **5-20**).[9] White perch length frequency sizes were unavailable; however, the primary length frequency distribution for Atlantic striped bass landed by recreational fishermen from 2003 to 2007 was 431 to 482 mm FL (43.2 to 48.3 cm). In contrast to Virginia, total landings in Maryland appear to be increasing (R^2 = 0.66; **Figure 5-18**) even though the total number of fish landed is 16% less than in Virginia.[9]

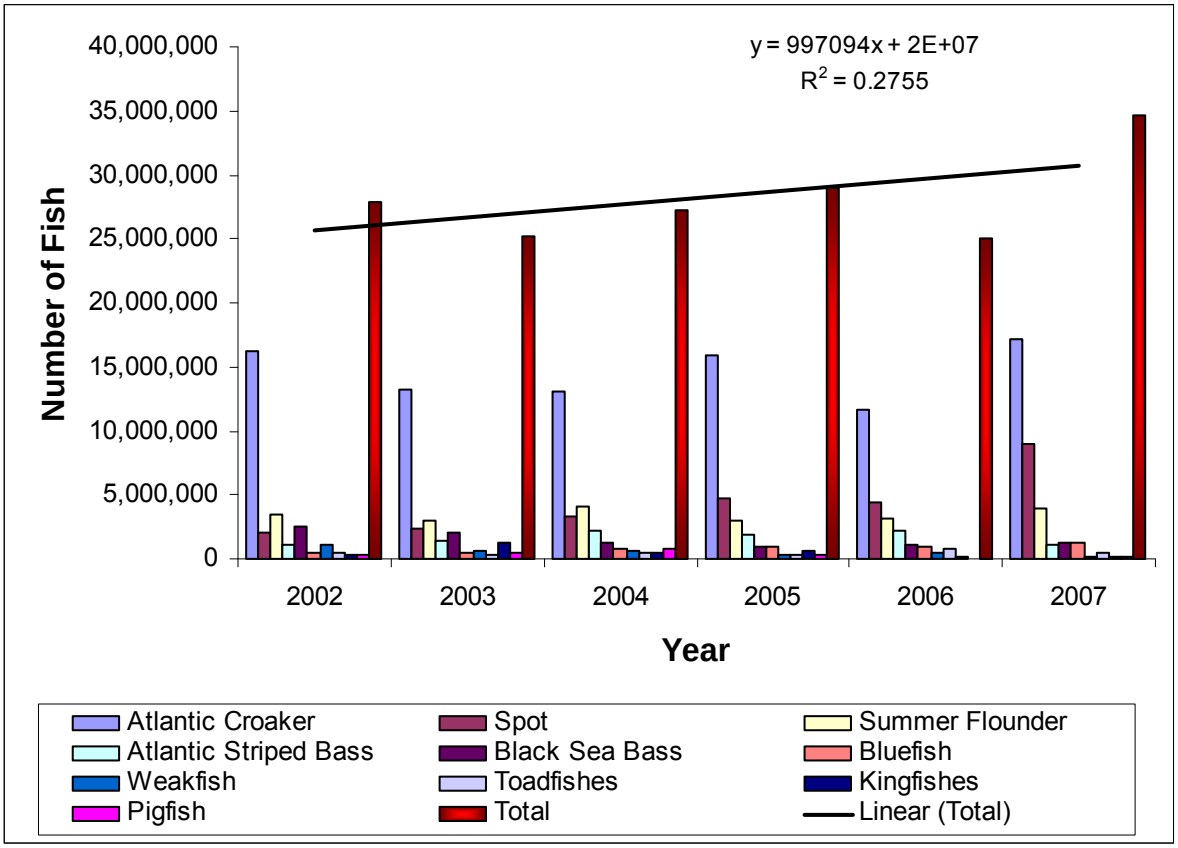

Figure 5-17. Total number of Virginia recreational fish from 2002 to 2007.[9]

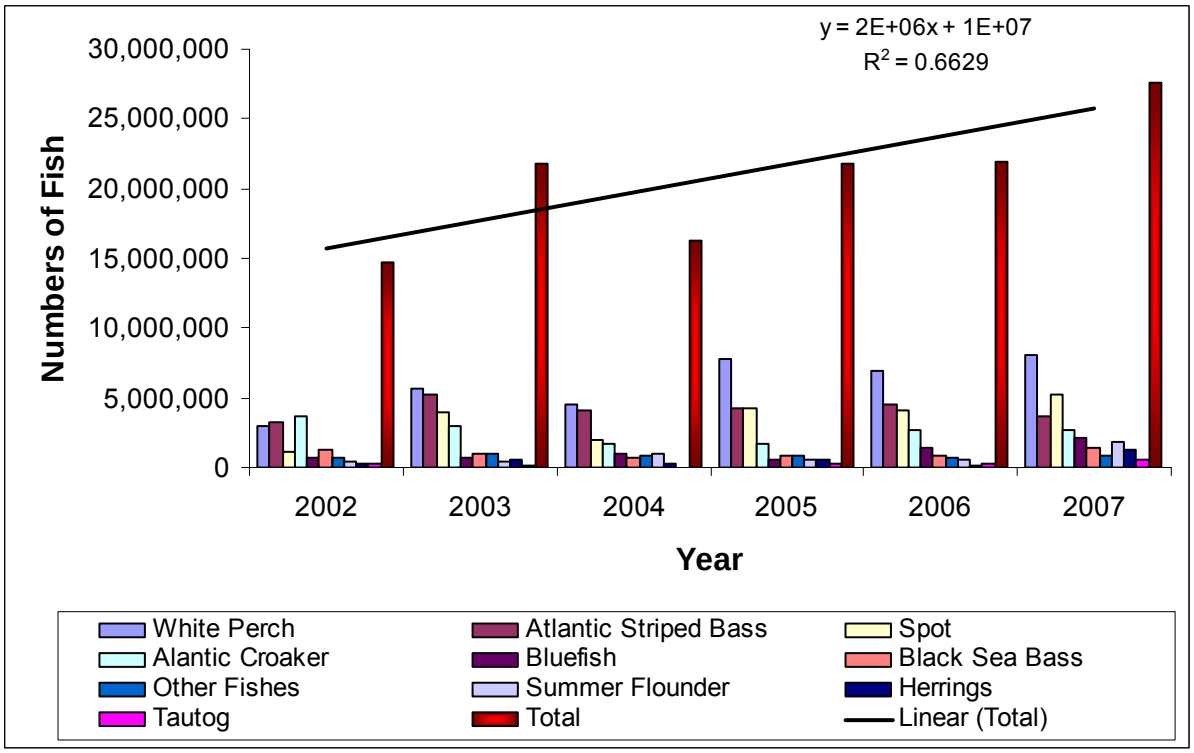

Figure 5-18. Total number of Maryland recreational fish from 2002 to 2007.[9]

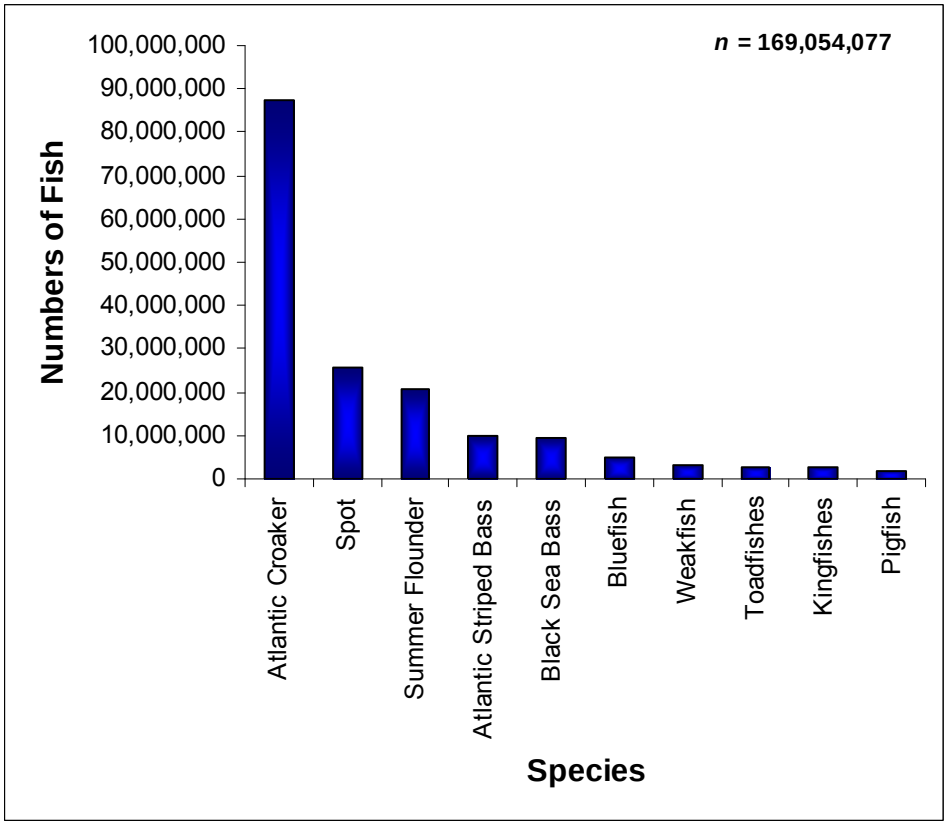

Figure 5-19. Primary species taken by Virginia recreational fishermen from 2002 to 2007.[9]

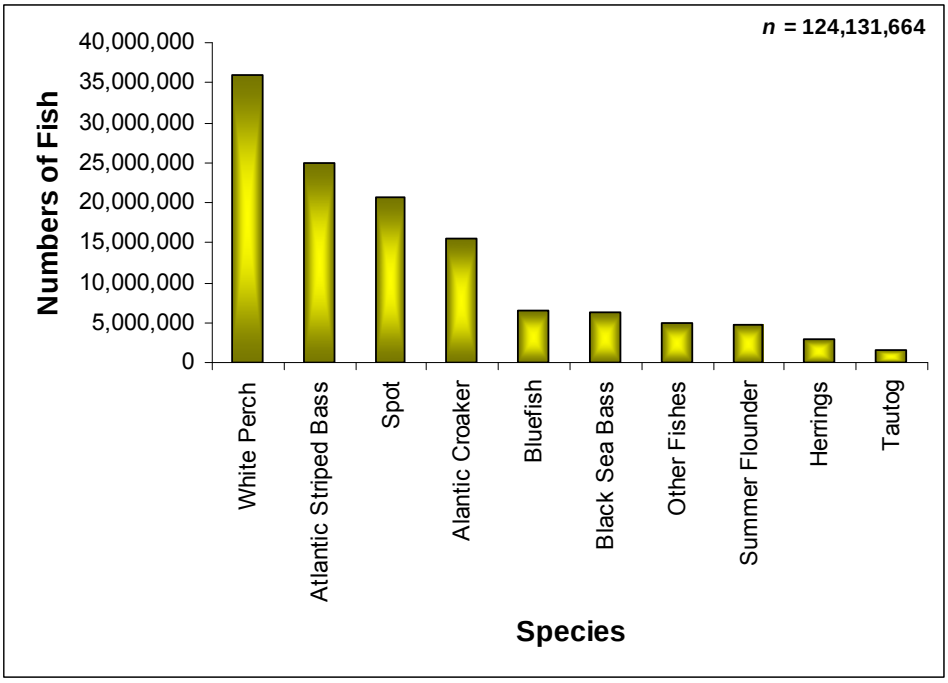

Figure 5-20. Primary species taken by Maryland recreational fishermen from 2002 to 2007.[9]

Recreational saltwater fishing is primarily either an onshore or offshore boat-based activity in the Chesapeake Bay. The three modes of fishing that exist in the Chesapeake Bay are 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.[9] Private and rental boat trips includes any fishing that takes place from either a personal and/or rented boat. From 2002 to 2007, the primary mode of recreational fishing in Virginia was private/rental. On average, this mode of fishing represented between 80% and 95% of the total landings. The second most popular mode of fishing was shore based followed by party and charter boat. The total number of recreational fishermen ranged from 724,398 in 2003 to 1,206,058 in 2005, and the mean was 937,119 fishermen.[9] Forty-one percent (382,357) of recreational fishermen were from other states. Of the total number of fishermen, about 82% were residents of coastal counties. Similarly, the primary mode used by recreational fishermen in Maryland from 2002 to 2007 was also private/rental (70 to 83%), followed by shore, charter, and party. In Maryland, the number of recreational fishermen ranged from 801,147 (in 2002) to 1,456,157 (in 2007), and the mean was 1,071,342.[9] On average, 413,622 (39%) recreational fishermen were from other states. Of the total number of fishermen, about 90% were residents of coastal counties. The number of angler trips was similar between Virginia and Maryland with the mean of 3.5 and 3.3 million trips (2002 to 2007), respectively (**Figure 5-21**).[9] Overall, the total number of angler trips is increasing significantly (R^2 = 0.90; **Figure 5-21**).[9]

Saltwater fishing techniques employed by recreational fishermen include rod and reel (i.e., hook and line), spear or gig, hand line, cast net, dip net or eel pots. Recreational fishing effort varies seasonally in the Chesapeake Bay in accordance to the availability of target species, which varies seasonally and annually. Biological and environmental factors such as habitat, nutrients, prey availability, currents, spawning behavior, fishing pressure, and population status of fishery stocks affect the timing and locations of fish (Freeman and Walford 1974; 1976). In general, recreational anglers focus their efforts in specific locations associated with subtle habitat features (e.g., shoals, middle grounds, banks, rock outcrops, artificial reefs, etc.) that concentrate fishes.

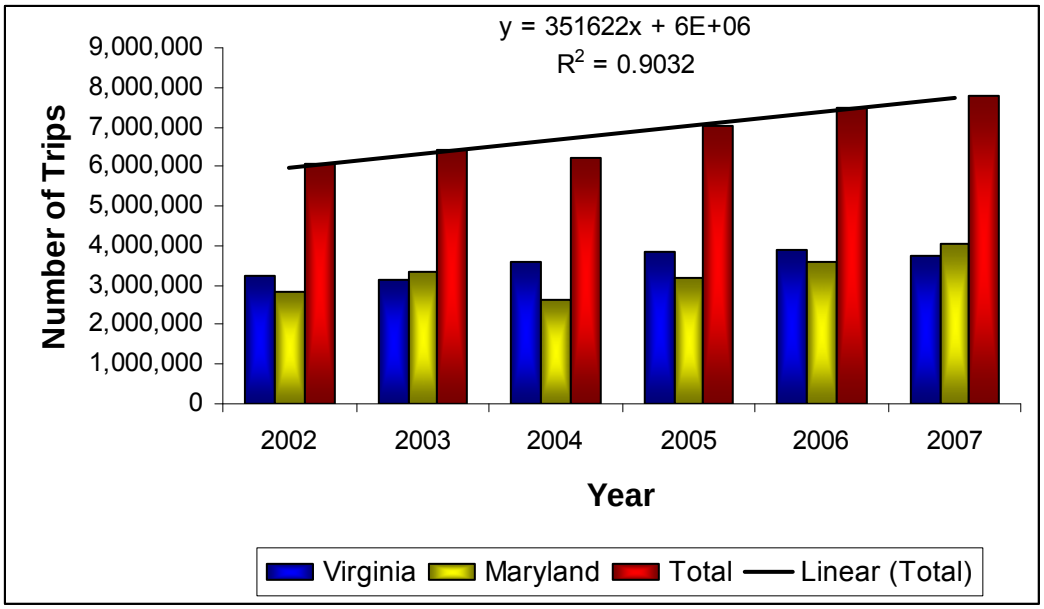

Figure 5-21. The number of recreational fishing trips in the Chesapeake Bay from 2002 to 2007.[9]

Numerous fishing hotspots are located throughout the Chesapeake Bay: (1) Cape Henry to Wolf Trap Light: along the eastern shore east, and west-southwest of Fishermen Inlet and along the western shore west of the Chesapeake Bay Bridge-Tunnel, and near the mouths of the James, York, Back, and Poquosan rivers and Mobjack Bay, and the James River proper; (2) Wolf Trap Light to Bloodsworth Island: Pocomoke and Tangier sounds and near the mouths of the Rappahannock, Great Wicomico, Potomac, Big Annereooex, and Manokin rivers and Morrie Bay; (3) Bloodsworth Island to Kent Island: bay mainstem, Poplar Island Narrows, and near the river mouths of the Nanticoke, Honga, and Patuxent rivers and Fishing Bay; and (4) Kent Island to Susquehanna River: bay mainstem, Eastern Bay, and near the mouths of the South, Severn, Patapsco, and Chester rivers (in the Study Area) and Elk, Northeast, and Susquehanna rivers (north of the Study Area; **Figure 5-22**) (Freeman and Walford 1976).[10,11] Other hotspots would include various artificial reef and shipwrecks locations. Favored fishing hotspots 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.

In addition to these offshore fishing hotspots, the following popular game fish are also caught at various angling locations throughout the Chesapeake Bay: spot and Atlantic croaker (piers, docks, boats, and shoreline), Atlantic striped bass (the Chesapeake Bay Bridge-Tunnel, various tributary rivers and bayside creeks), bluefish (the Chesapeake Bay and numerous inlets), summer flounder (the Chesapeake Bay Bridge-Tunnel, the lower Chesapeake Bay, and Rudlee Inlet), black sea bass (underwater structures: wrecks and reefs), black drum (near breakwaters, jetties, channels, and on oyster and clam beds), weakfish (boats and shore areas), cobia (wrecks and buoys), Spanish mackerel (piers, jetties, and bridges), and tautog (oyster reefs, shipwrecks, rock piles, artificial reefs, jetties, and bridge pilings) (Kirkley and Kerstetter 1997).

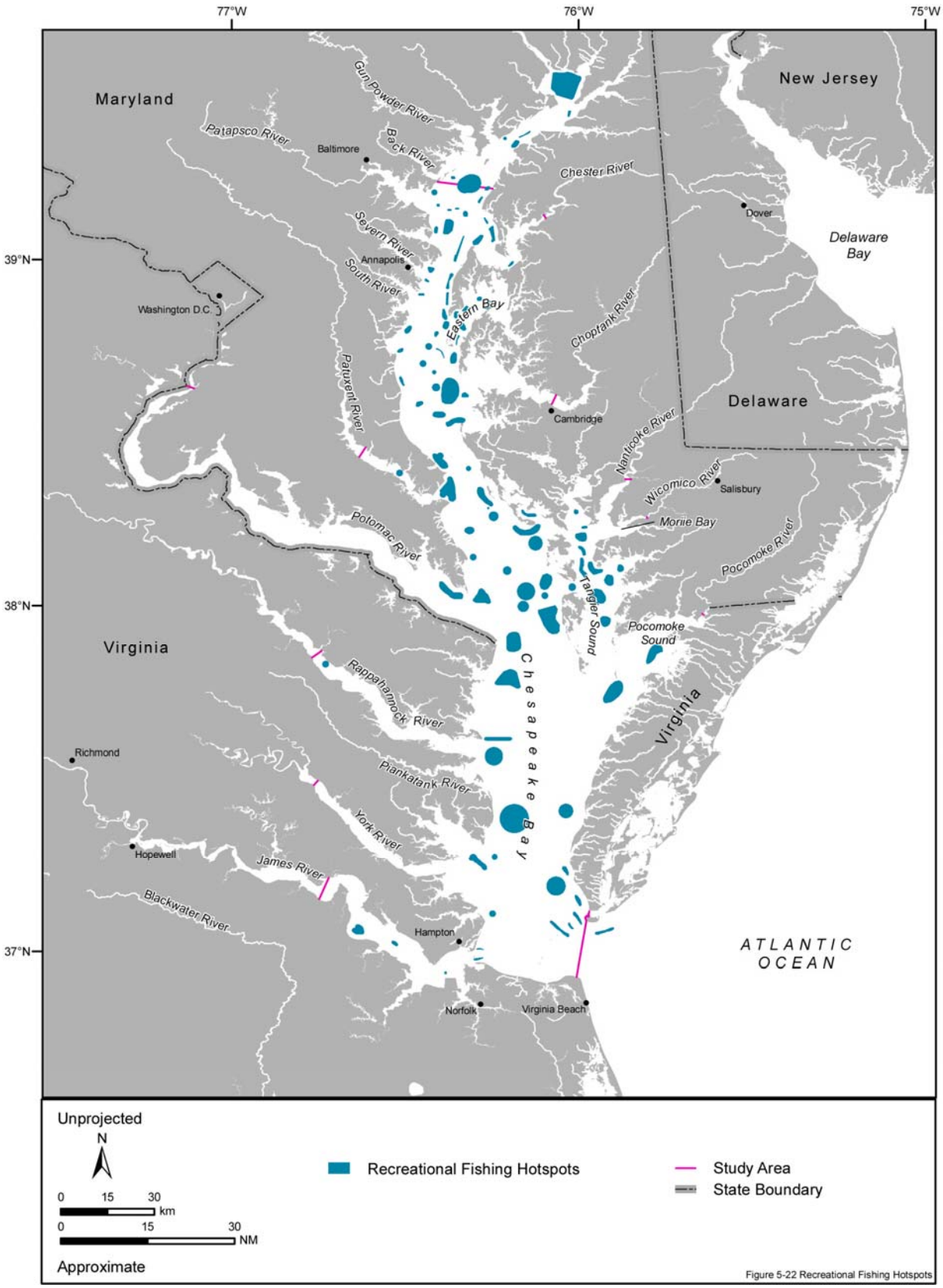

Figure 5-22. Recreational fishing hotspots in the Chesapeake Bay. Source data: Freeman and Walford (1976).[10,11]

Organized fishing tournaments in the Chesapeake Bay occur within the state boundaries of Virginia and Maryland. Some tournaments have weigh-in categories for specific species or a number of species. As expected, the greatest numbers of tournaments occur in the summer months (June through September) when the weather is better and species are more abundant. Organizations and companies usually sponsor tournaments and each tournament usually has its own set of specific rules, which include time limits and geographical boundaries; however, 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 and new tournaments may be organized. In addition, the exact dates of annual tournaments will vary slightly from year to year. An example of the types, locations, and dates of tournaments is shown in **Table 5-5**.

Table 5-5. Recreational fishing tournaments in the Chesapeake Bay.[12, 14]

Date	Weigh-in City	Tournament	Species
All year	Tidewater Region – various locations	50th Annual Virginia Saltwater Fishing Tournament	Multi-species
All year	Maryland Portion of Bay and it's tidal tributaries	Maryland Sport Fishing Tournament	Multi-species
7 to 9 June	Reedville, Virginia	Reedville Bluefish Tournament	Bluefish
8 to 10 June	Rock Hall, Maryland	Annual Rockfish Tournament	Rockfish
22 to 24 June	Crisfield, Maryland	18th Annual Scorchy Tawes Fishing Tournament	Trout, Bluefish, Flounder, and Croakers
16 to 18 August	Virginia Beach	2nd Annual Virginia Beach Sport Fishing Bluewater Classic	Flounder, Cobia, and Spanish mackerel
11 to 12 October	Capeville, Virginia	First Annual Hooked on Habitat Fishing Tournament	Red drum, Atlantic striped bass, Speckled trout, Flounder, Spot, Croaker
15 to 16 November	Sandy Point State Park, Calvert Marina in Solomons, Taylors Island Family Campground, Knapp's Narrows Marina on Tilghman Island, and Breezy Point Marina in Chesapeake Beach	16th Annual Chesapeake Bay Fall Tournament	Bluefish and Rockfish
1 November	Virginia Beach, Norfolk, Hampton, Newport News, Yorktown, and Suffolk	Striped Bass World Championship	Atlantic striped bass
29 November	Chesapeake Bay Bridge	Rock Around the Clock Pier Fishing Tournament	Multi-species

5.3 ESSENTIAL FISH HABITAT DISTRIBUTION AND SPECIES

As mentioned in **Section 1.3.1**, the MSFCMA contains an Essential Fish Habitat (EFH) and a HAPC provisions which were put forth to conserve fish habitat. Within the Chesapeake Bay, fish species are managed or co-managed by FMC, a federal agency, and a fisheries commission: 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), NMFS (jurisdiction over highly migratory species is in federal waters off the U.S. Atlantic coast and the Gulf of Mexico), and ASMFC (jurisdiction is state waters from Maine through eastern Florida). The FMC or NMFS may designate EFH and/or HAPC for federal management species outside their region of jurisdiction, whereas the Interstate Marine Fisheries Commission (IMFC) identifies all habitats and HAPC, but refrains from identifying EFH (Greene et al. 2009).

EFH has been designated for 19 fish species within the Chesapeake Bay; hereinafter these designated species will be referred to as managed species (**Tables 5-6** and **5-7**). In this report, these managed species are categorized as temperate, subtropical-tropical, and highly migratory species (HMS). Of the 19 managed species with EFH designation, 11 are classified as temperate, four are considered subtropical-tropical, and four are defined as HMS. Several of these species or management units (MU) are managed by more than one FMC. Due to NMFS' repeal of the red drum FMP, EFH and HAPC designations for the red drum were also repealed (NMFS 2008a). Therefore, the following red drum habitat descriptions are provided for completeness, but are not considered current EFH or HAPC designations.

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 1998; MAFMC and ASMFC 1998a; MAFMC and ASMFC 1998b; NEFMC 1998; SAFMC 1998; NEFMC 1999; NEFMC 2003a; NEFMC 2003b). Eggs are the product of those individuals that have spawned, but not hatched and are completely dependent on the egg's yolk for nutrition. 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. Adults are sexually mature individuals that are not necessarily in spawning condition and spawning adults are those individuals capable of spawning (Moyle and Cech 1988; MAFMC 1998; MAFMC and ASMFC 1998a; MAFMC and ASMFC 1998b; NEFMC 1998; SAFMC 1998; NEFMC 1999; NEFMC 2003a; NEFMC 2003b).

Although the individual lifestage terms and definitions are the same as those defined by the FMCs, NMFS uses a different lifestage classification system that bases the lifestage combinations on the general habitat shifts that accompany each developmental stage (NMFS 2006b). 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 2006b).

Both the FMCs and NMFS are also required to identify other important areas called HAPC. Criteria for HAPC should demonstrate one or more of the following considerations: (a) ecological function, (b) sensitivity to human-induced environmental degradation, (c) development activities stressing habitat type, or (d) rarity of habitat (NMFS 2002).

The EFH and HAPC for federally managed species that occurs within the Chesapeake Bay are broadly described as:

- *Estuarine waters and substrates*: include the sub-tidal and adjacent inter-tidal vegetation. Specific habitats include SAV (seagrasses), tidal and inter-tidal flats, estuarine bottom habitats, shellfish beds (aquatic [oyster] reefs), coastal wetlands, and the estuarine water. These benthic habitats are utilized by a variety of species for spawning/nesting, development, dispersal, and feeding (SAFMC 1998; NMFS 1999) and

Table 5-6. Fishes for which EFH has been designated in the Study Area for the Chesapeake Bay. Taxonomy follows Nelson et al. (2004) for fishes.

I. TEMPERATE SPECIES
- Atlantic herring
- Black sea bass
- Bluefish
- Butterfish
- Clearnose skate
- Little skate
- Red hake
- Scup
- Summer flounder
- Windowpane flounder
- Winter skate

II. SUBTROPICAL-TROPICAL SPECIES
- Cobia
- King mackerel
- Red drum*
- Spanish mackerel

III. HIGHLY MIGRATORY SPECIES
- Atlantic sharpnose shark
- Dusky shark
- Sand tiger shark
- Sandbar shark

*Previously designated for EFH

Table 5-7. Management units (MU) and managed species with EFH designated within the Chesapeake Bay by management agency. Taxonomy follows Nelson et al. (2004) for fishes.

NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Atlantic Herring MU
Atlantic herring (*Clupea harengus*)

Northeast Multispecies MU
Small Mesh MU
- Red hake (*Urophycis chuss*)

Large Mesh MU
- Windowpane flounder (*Scophthalmus aquosus*)

Northeast Skate Complex MU
Clearnose skate (*Raja eglanteria*)
Little skate (*Leucoraja erinacea*)
Winter skate (*Leucoraja ocellata*)

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Atlantic Mackerel, Squid, and Butterfish MU
Butterfish (*Peprilus triacanthus*)

Bluefish MU[1]
Bluefish (*Pomatomus saltatrix*)

Summer Flounder, Scup, & Black Sea Bass MU[1]
Black sea bass (*Centropristis striata*)
Scup (*Stenotomus chrysops*)
Summer flounder (*Paralichthys dentatus*)

SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

Coastal Migratory Pelagics MU[2]
Cobia (*Rachycentron canadum*)
King mackerel (*Scomberomorus cavalla*)
Spanish mackerel (*Scomberomorus maculatus*)

Red Drum MU[3]
Red drum (*Sciaenops ocellatus*)

NATIONAL MARINE FISHERIES SERVICE
(Highly Migratory Species Management Division)

Large Coastal Shark MU
Sandbar shark (*Carcharhinus plumbeus*)

Small Coastal Shark MU
Atlantic sharpnose shark (*Rhizopriondon terraenovae*)

Prohibited Species MU
Dusky shark (*Carcharhinus obscurus*)
Sand tiger shark (*Carcharius taurus*)

[1] Jointly managed by the MAFMC and the ASMFC
[2] Jointly managed by the SAFMC (lead) and the GMFMC
[3] Currently managed by the ASMFC

- *Habitat Areas of Particular Concern:* Three species have designated HAPC for some or all lifestages in the Chesapeake Bay and include the following habitat types:

  - All lifestages of the sandbar shark—shallow areas at the mouth of Great Bay, New Jersey, lower and middle Delaware Bay, the 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, are designated as HAPC. These areas within Virginia are located in the Chesapeake Bay.

  - 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; SAV 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. SAV beds are within the boundaries of the Chesapeake Bay and had been previously designated as EFH (NMFS 2008a).

  - Juvenile and adult lifestages of the summer flounder—all native marine and freshwater species of SAV 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 ASMFC 1998a). These habitats are located within the Chesapeake Bay.

Since descriptions of EFH are not currently included in the ASMFC's FMPs, the HAPC definition has been modified to include areas within the species' habitat that satisfy one or more of the aforementioned criteria. A HAPC is a subset of habitats the species is known to occupy, and could include spawning habitat, nursery habitat for larvae, juveniles, and sub-adults, and/or some amount of foraging habitat for mature adults. HAPC are geographical locations that are particularly critical to the survival of a species (Greene et al. 2009).

Information on the EFH and/or HAPC designations by life stage as well as the management, status, distribution, habitat associations (substrate, depth, temperature, and salinity), life history (migration, movements, and spawning), and common prey species of these 19 species is discussed below.

5.3.1 Temperate Water Species

- **Atlantic Herring (*Clupea harengus*)**

Management—The Atlantic herring is managed and has EFH 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 western North Atlantic Ocean (Overholtz 2000). The Atlantic herring is neither subject to overfishing nor does it have an overfished status (ASMFC 2008a; NMFS 2008).[15]

Distribution—The Atlantic herring inhabits both sides of the North Atlantic Ocean in temperate and boreal waters (Munroe 2002). In the western North Atlantic Ocean, this species ranges from the Labrador Province, Canada, to Cape Hatteras, North Carolina (Overholtz 2000).

- Information Specific to the Chesapeake Bay—Juveniles occur in the Chesapeake Bay year-round. The majority of juveniles are found in the tributaries extending as far north as the Susquehanna flats during late winter and throughout the lower Chesapeake Bay in early spring. Peak abundance occurs in April and May. In summer and fall, a few juveniles can be found at the mouth and in the mainstream of the Chesapeake Bay, respectively. Adults are found at the Chesapeake Bay mouth or along the Atlantic coast beaches only during the winter months (Murdy et al. 1997; Geer 2002).

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 5 to 90 m with strong tidal currents. 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 6° to 16°C, salinity of 32 psu, and depths of 50 to 90 m (Stevenson and Scott 2005). 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). In the Chesapeake Bay, juveniles are found at temperatures between 10°C and 16°C, salinities greater than 14 psu, and depths of less than 10 m; whereas adults occurred within the same salinity range but at greater depths and colder waters (Geer 2002).

Life History—Atlantic herring spawn over rocks, shells, pebbles, gravel, and clay substrates in well-mixed waters with 1.5- to 3.0-kt tidal currents, temperatures below 15°C, depths of 20 to 90 m, and a salinity range from 32 to 33 psu (Munroe 2002; Stevenson and Scott 2005). 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 (Stevenson and Scott 2005). Adult and juvenile herring undergo complex and extensive north-south and inshore-offshore migrations for the purpose of spawning, feeding, and overwintering; they also undertake diel vertical migrations in response to light intensity (Munroe 2002; Stevenson and Scott 2005).

Common Prey Species—Atlantic herring are opportunistic filter feeders, preying primarily on zooplankton (copepods, euphausiids, amphipods, chateognaths, pteropods, and mysids) with larger fish also preying on pandalid shrimp. This species feeds in the upper layers of the water with peak feeding activity occurring at dusk and dawn (Munroe 2002; Stevenson and Scott 2005).

EFH Designations (NEFMC 1998; NMFS 2001) (**Figure 5-23**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Larva—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Juvenile—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Adult—The seawater salinity zone of the Chesapeake Bay has been designated as EFH for adult Atlantic herring.
- Spawning Adult—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

HAPC Designations—No HAPC are identified for this species by the FMC. The ASMFC has identified HAPC to include estuaries and embayments as important nursery grounds for juveniles.[3]

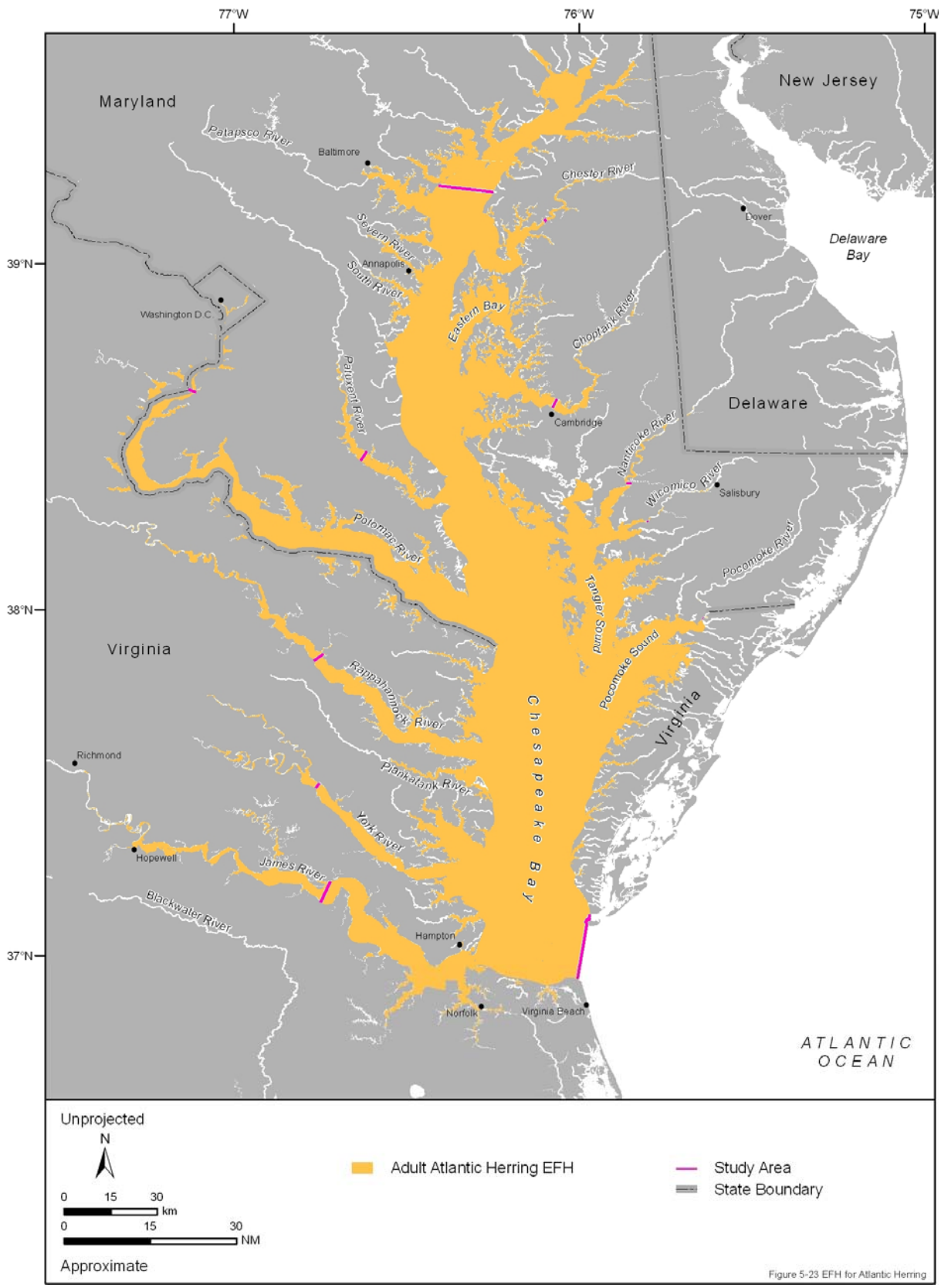

Figure 5-23. Essential fish habitat for adults of the Atlantic herring designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2001).

- **Black Sea Bass (*Centropristis striata*)**

Management—The Atlantic black sea bass are managed as three separate stocks: Mid-Atlantic, South Atlantic, and Gulf of Mexico (Drohan et al. 2007), The Mid-Atlantic and South Atlantic stocks are divided north and south of Cape Hatteras, North Carolina; whereas Gulf of Mexico stock ranges from Cape Canaveral, Florida, to Texas (Drohan et al. 2007). 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 Canaveral, Florida, is managed by the SAFMC (1998).

Status—The NMFS (2008) states that the Mid-Atlantic black sea bass stock is not overfished nor is overfishing occurring.[15]

Distribution—Black sea bass range from southern Nova Scotia and Bay of Fundy, Canada to Cape Canaveral, Florida, and into the Gulf of Mexico (Klein-MacPhee 2002c; Drohan et al. 2007).

- Information Specific to the Chesapeake Bay—Juveniles are common throughout the Chesapeake Bay and lower portions of the James and York rivers during spring and summer (April through July); whereas adults are more common during the later part of the summer and into the fall on the eastern side of the Chesapeake Bay as far as Maryland's Solomons Island (Murdy et al. 1997; Geer 2002).

Habitat Associations—This species is usually associated with structured and artificial habitats such as artificial reefs and shipwrecks located on the continental shelf (Klein-MacPhee 2002c; Drohan et al. 2007). 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 prefer hard bottom habitats associated with shipwrecks; while offshore, they prefer 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 2002c). Eggs are buoyant and found over the continental shelf from May through October, while larvae move to estuarine habitats, 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 (MAFMC and ASMFC 1998a). Juveniles and adults prefer waters warmer than 6°C (MAFMC and ASMFC 1998a). During the summer, adults share their complex habitats with a variety of other fishes (tautog, red hake, butterfish, windowpane flounder, pinfish [*Lagodon rhomboids*], etc.) and transients such as gray triggerfish (*Balistes capriscus*) in the MAB (Musick and Mercer 1977; Eklund and Targett 1991; Gabriel 1992). In the Chesapeake Bay, juveniles are found in deep, vegetated flats, whereas adults are most often found on rocky bottoms and near pilings, wrecks, and jetties (Murdy et al. 1997). Both juveniles and adults are found at salinities greater than 18 psu and depths greater than 8 m (Geer 2002).

Life History—Schools of black sea bass from the northern stock demonstrate inshore-offshore movements, which are dependent on water temperature (Klein-MacPhee 2002c). 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 (Klein-MacPhee 2002c; Drohan et al. 2007). The northern stock spawns on the continental shelf from April through October, peaking in June, at depths from 20 to 50 m, while the southern stock spawns earlier from January through June (Musick and Mercer 1977; Klein-MacPhee 2002c; Drohan et al. 2007). The lower portion of the Chesapeake Bay is an important nursery and feeding ground for young black sea bass.[1]

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 2002c). Feeding activities increase after periods of spawning (Drohan et al. 2007).

EFH Designations (MAFMC and ASMFC 1998a; NMFS 2001) (**Figure 5-24**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Larva—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Juvenile—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay, Tangier/Pocomoke sounds, and James River have been designated as EFH for juvenile black sea bass.
- Adult—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay, Tangier/Pocomoke sounds, and James River have been designated as EFH for adult black sea bass.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

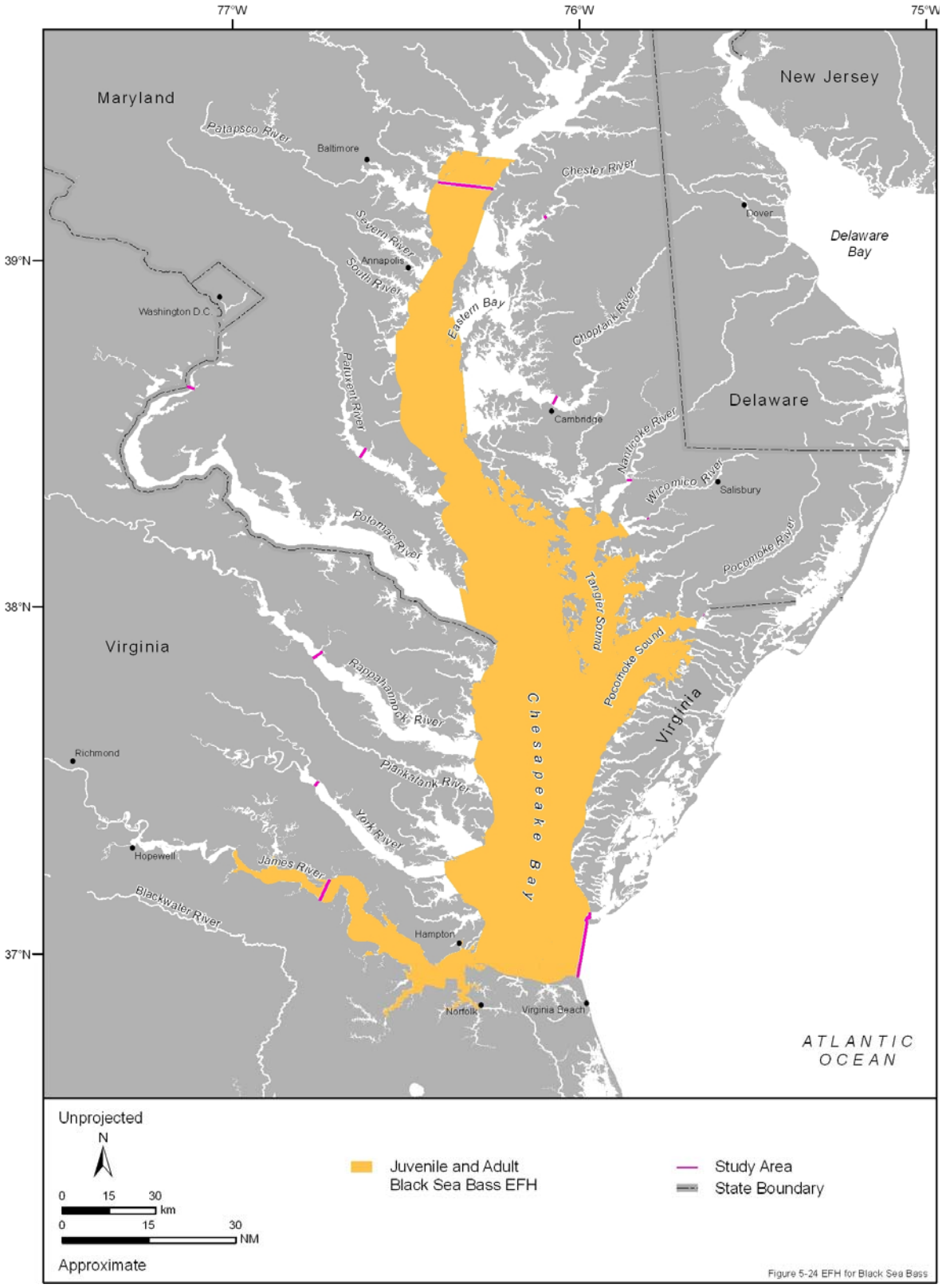

Figure 5-24. Essential fish habitat for juveniles and adults of the black sea bass designated in the Chesapeake Bay Study Area. Source maps (scanned): MAFMC and ASMFC (1998a) and NMFS (2001).

- **Bluefish (*Pomatomus saltatrix*)**

Management—The bluefish population along the east coast is managed as a single stock. EFH was designated under Amendment 1 to the Bluefish FMP, which was jointly 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 nor subjected to overfishing (ASMFC 2008a; NMFS 2008).[15]

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, Canada, and Bermuda to Argentina, South America; however, is considered uncommon between southern Florida and northern South America (Shepherd and Packer 2006).

- Information Specific to the Chesapeake Bay—Bluefish juveniles occur in the Chesapeake Bay and its tributaries throughout the warmer months (May through November) with June and September being the peak months. This species is abundant in the Chesapeake Bay mainstem, Tangier/Pocomoke sounds, and near the freshwater interface in the Potomac, Rappahannock, York, and James rivers, but is only common in the Chester, Choptank, and Patuxent rivers (Geer 2002; Shepherd and Packer 2006).

Habitat Associations—Bluefish is a warm-water coastal pelagic species that rarely occurs in temperatures below 14°C and utilizes both offshore and inshore habitats (Klein-MacPhee 2002d). 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 northeastern 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 (Shepherd and Packer 2006). 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). In the Chesapeake Bay, juveniles utilize oyster reefs, oyster bars, sandy bottoms, and shoal habitats at salinities greater than 16 psu, depths between 8 m and 10 m, and two water temperature peaks, one between 14°C and 18°C and the second between 22°C and 26°C (Geer 2002; Shepherd and Packer 2006).

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 2002d). 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 trigger seasonal migrations, but offshore and inshore migrations also parallel the movements of their prey (Klein-MacPhee 2002d). There are two discrete spawning cohorts for the western Atlantic bluefish: (1) a spring spawning cohort occurs near the edge of the continental shelf in the SAB during March through May, and (2) a summer spawning cohort occurs over the mid-continental shelf in the MAB between June and August in waters with temperatures between 18°C and 25°C and salinities from 25 to 31 psu (Klein-MacPhee 2002d; Shepherd and Packer 2006).

Common Prey Species—Bluefish are piscivorous and feed on a variety of species including Atlantic menhaden, herring, alewife, anchovy, eel, sculpin, killifish, silverside, Atlantic croaker, scup, goby, sand lance, butterfish, and Atlantic mackerel. This species also feeds on invertebrates (shrimp, squid, crabs, and worms) and is known for cutting and tearing prey in pieces (Klein-MacPhee 2002d).

EFH Designations (MAFMC and ASFMC 1998b; NMFS 2001) (**Figure 5-25**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

- Larva—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

- Juvenile—The mixing and seawater salinity zones of the Chesapeake Bay and its tributaries have been designated as EFH for juvenile bluefish.

- Adult—The mixing and seawater salinity zones of the Chesapeake Bay and its tributaries have been designated as EFH for adult bluefish.

HAPC Designations—No HAPC are identified for this species by the FMC. The ASMFC has identified HAPC to include inshore areas and estuaries as important habitats for larvae and juveniles.[3]

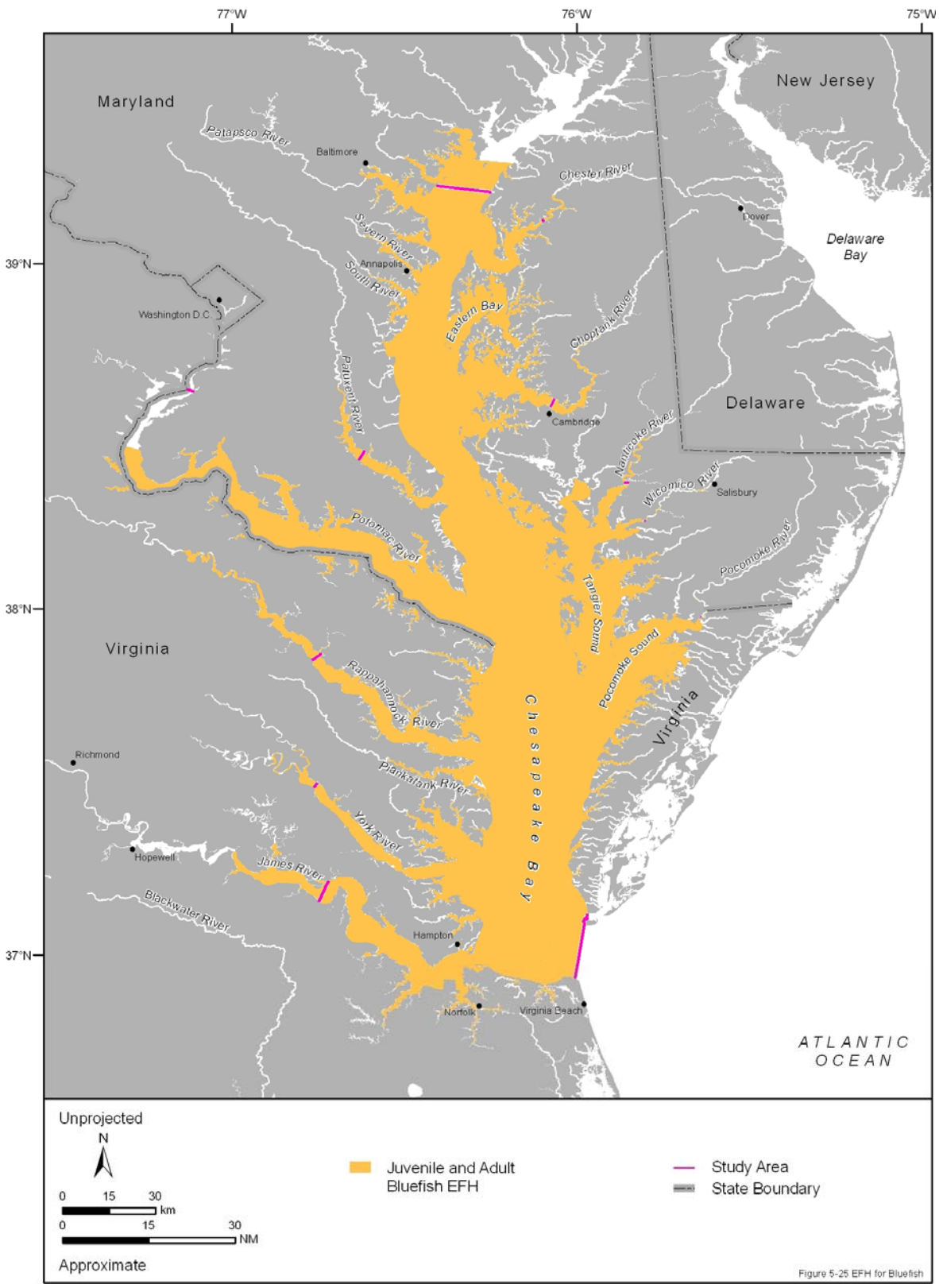

Figure 5-25. Essential fish habitat for juveniles and adults of the bluefish designated in the Chesapeake Bay Study Area. Source maps (scanned): MAFMC and ASMFC (1998b) and NMFS (2001).

- **Butterfish (*Peprilus triacanthus*)**

Management—Butterfish are managed and have EFH designated under Amendment 8 to the Atlantic Mackerel, Squid, and Butterfish FMP, which was developed by the MAFMC (MAFMC 1998). This species is considered a single unit; however, there may be two stocks south of Cape Hatteras, North Carolina, that are isolated by depth (Cross et al. 1999).

Status—The butterfish stock in the western North Atlantic Ocean is overfished, but is not subject to overfishing (NMFS 2008).[15]

Distribution—Butterfish range from the Gulf of St. Lawrence and the southern coast of Newfoundland, Canada to the deeper waters off Florida in the western North Atlantic Ocean, but are most common between Nova Scotia, Canada, and Cape Hatteras, North Carolina (Colton 1972; Klein-MacPhee 2002g).

- Information Specific to the Chesapeake Bay—Butterfish are common in the lower Chesapeake Bay from March through November (Murdy et al. 1997). All life stages (eggs through spawning adults) occur in the Chesapeake Bay mainstem, whereas juveniles/adults are common in the York and James rivers but rare in the Choptank, Patuxent, Potomac, and Rappahannock rivers and Tangier/Pocomoke sounds (Stone et al. 1994). Distribution of juveniles is restricted to the mainstem of the Chesapeake Bay in the spring, become well dispersed throughout the estuary by summer, and show signs of a seaward migration towards the Chesapeake Bay mouth by the fall months. Adults show a similar distribution pattern in the spring, but rarely migrate up the tributaries during the summer, becoming rare by fall (Geer 2002).

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, pelagic, and are most abundant between June and August (Waring and Murawski 1982; Klein-MacPhee 2002g). 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 <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 2002g). 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 <120 m) (Waring and Murawski 1982; Cross et al. 1999). As juveniles, butterfish depart their sheltered habitat and begin schooling; they occur anywhere in the water column over sand and mud substrates at temperatures between 4.4°C and 29.7°C, salinities between 3.0 psu and 37.4 psu, and depths ranging from 10 to 330 m (most often found in depths <120 m) (Cross et al. 1999; Klein-MacPhee 2002g). Schools of adults are found throughout the water column from the surface to depths of 420 m over areas with sand, sand-silt, and mud substrates. They are eurythermal and euryhaline, tolerating temperatures from 4.4° to 29.7°C and salinities from 3.8 to 33.0 psu (Cross et al. 1999; Klein-MacPhee 2002g). In the Chesapeake Bay, both juveniles and adults are found at salinities greater than 20 psu, water temperatures greater than 18°C, and depths between 10 m and 14 m (Geer 2002).

Life History—Butterfish are broadcast spawners (Klein-MacPhee 2002g) spawning primarily in the evening or at night (Kendall and Naplin 1981). Spawning occurs annually in nearshore waters of the MAB and SAB from late January through July in waters with temperatures greater than 15°C (Colton 1972; Rotunno and Cowen 1997). In the Chesapeake Bay, butterfish begin spawning in late May peaking in June and July (Cross et al. 1999). 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 2002g).

Common Prey Species—Butterfish feed on a variety of planktonic invertebrates (mollusks, crustaceans, polychaetes, small fishes, and ctenophores) but primarily feed on tunicates, sea squirts, salps, and sea angels (Cross et al. 1999; Klein-MacPhee 2002g).

EFH Designations (MAFMC 1998; NMFS 2001) (**Figure 5-26**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Larva—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay has been designated as EFH for larval butterfish.
- Juvenile—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay and the York and James rivers have been designated as EFH for juvenile butterfish.
- Adult—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay and the York and James rivers have been designated as EFH for adult butterfish.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

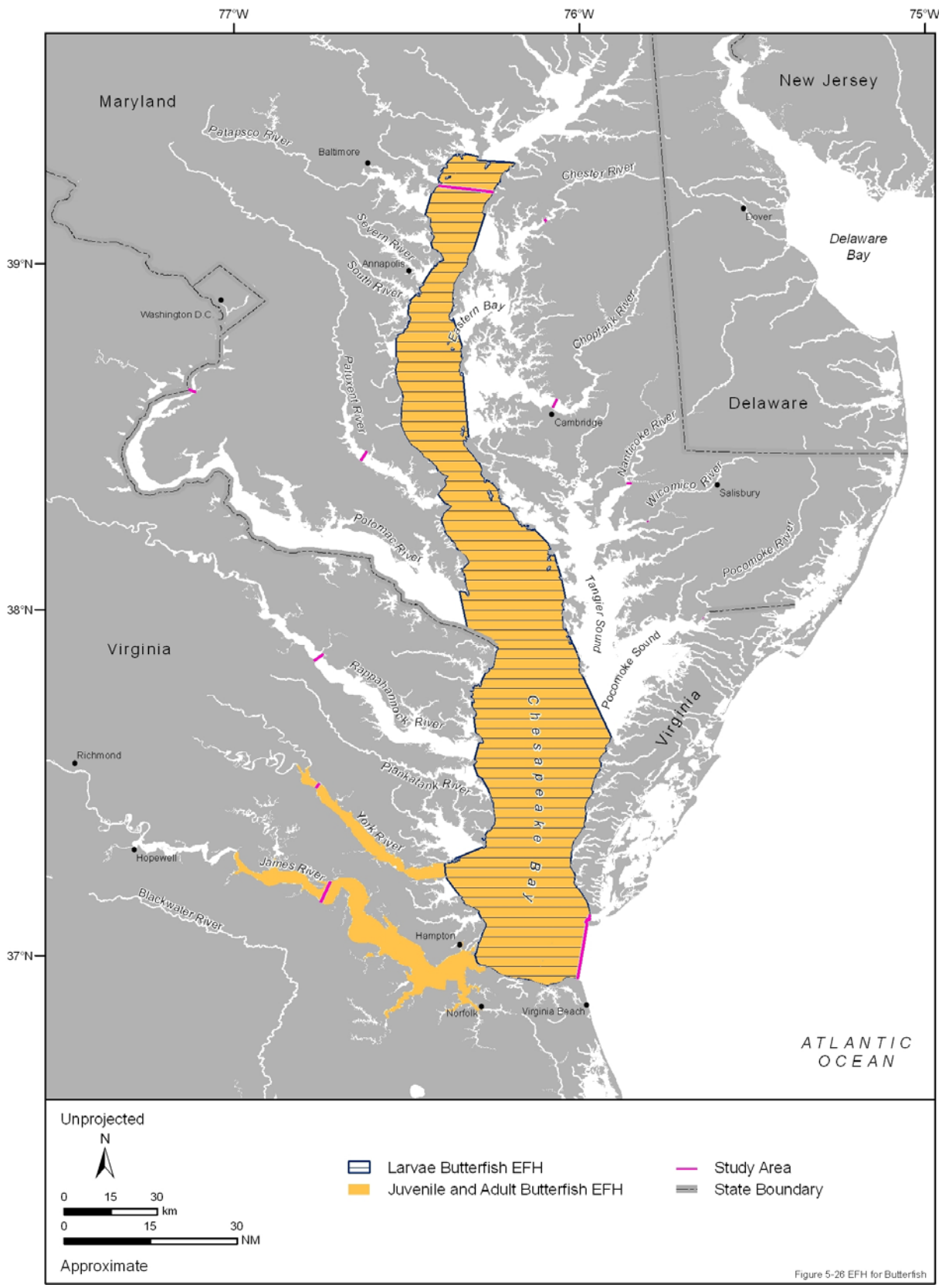

Figure 5-26. Essential fish habitat for larvae, juveniles, and adults of the butterfish designated in the Chesapeake Bay Study Area. Source maps (scanned): MAFMC (1998) and NMFS (2001).

- **Clearnose Skate (*Raja eglanteria*)**

Management—Clearnose skates are managed and have EFH designated under the NEFMC Final FMP for the Northeast (NE) Skate Complex (NEFMC 2003b).

Status—Currently, this skate species is neither overfished nor subject to overfishing (NMFS 2008).[15]

Distribution—The clearnose skate is found along the eastern U.S. coast from the Nova Scotia shelf, Canada to northeastern Florida, as well as in the northern Gulf of Mexico from western North 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 during the warmer months (McEachran and Musick 1975; McEachran 2002).

- Information Specific to the Chesapeake Bay—Both juvenile and adult clearnose skates have been found in the Chesapeake Bay from April to December with peak abundance occurring between May and August. They are most abundant near the Chesapeake Bay mouth in the spring and summer, but appear throughout the lower Chesapeake Bay during all four seasons. This species rarely is found in the adjacent riverine tributaries (Murdy et al. 1997; Geer 2002).

Habitat Associations—This species primarily is associated with mud and sand substrates along the continental shelf, but is also found associated with rock or gravel substrates (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). In the Chesapeake Bay, both juveniles and adults are found at salinities greater than 22 psu, water temperatures between 8°C and 24°C, and depths ranging from 1 to 33 m, but mostly between 7 m and 15 m (Geer 2002).

Life History—Limited spawning habitat information is available. Available information indicates that 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, migrate offshore and southward, while skates south of Cape Hatteras, North Carolina, do not seasonally migrate to deeper waters during the winter (McEachran and Musick 1975).

Common Prey Species—Clearnose skates feed on a variety of invertebrates (mysid shrimp, amphipods, mollusks, polychaetes, and squid) and small fishes (soles, scup, weakfish, and butterfish), with crabs being the primary component of their diet (McEachran 2002; Packer et al. 2003a).

EFH Designations (NMFS 2001; NEFMC 2003b) (**Figure 5-27**)

- Egg—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for clearnose skate eggs.

- Larva—No larval stage exists for this species. Upon hatching, they are fully developed juveniles.

- Juvenile—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for juvenile clearnose skates.

- Adult—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for adult clearnose skates.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

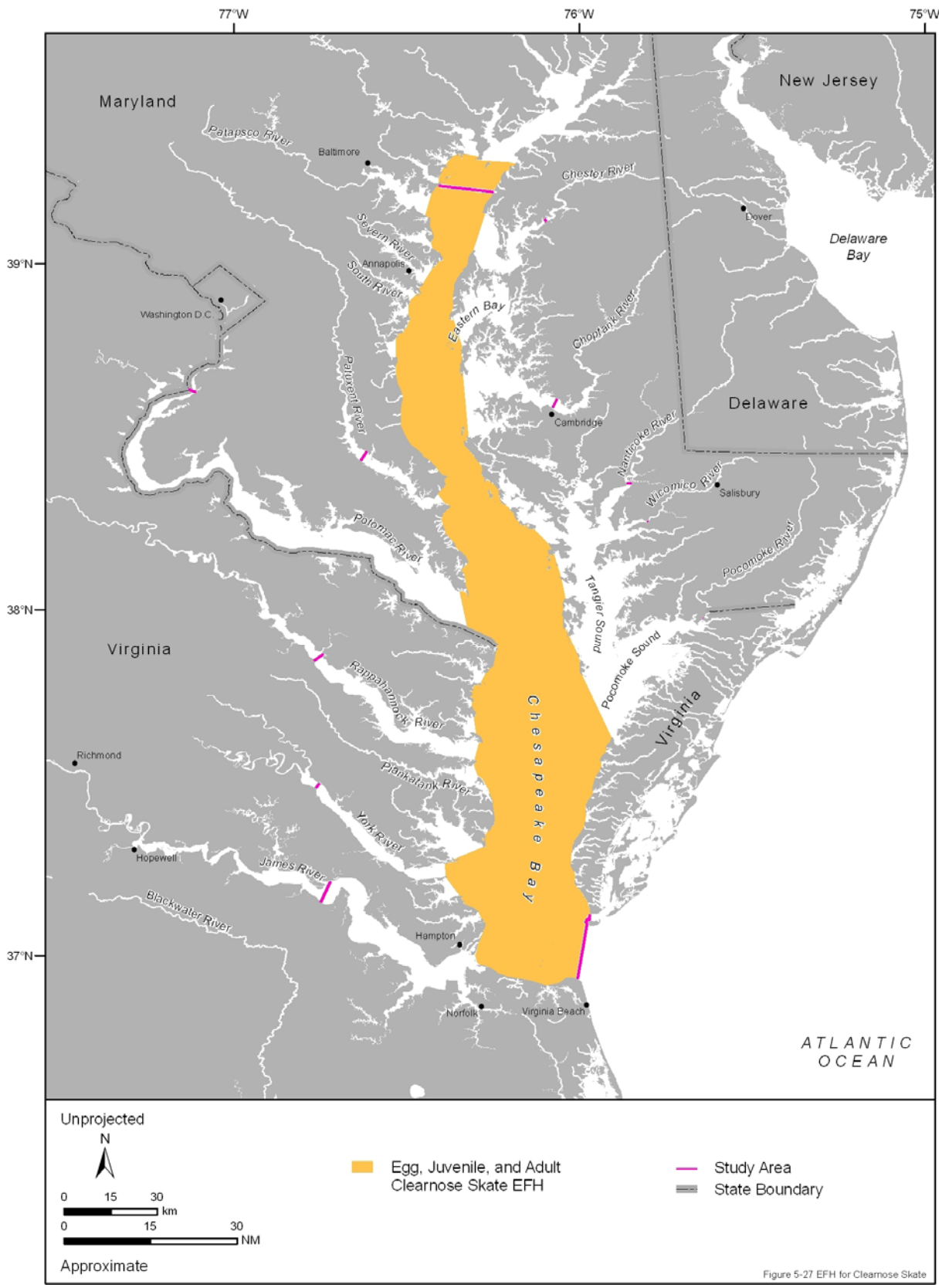

Figure 5-27. Essential fish habitat for juveniles and adults of the clearnose skate designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2001) and NEFMC (2003b).

- **Little Skate (*Leucoraja erinacea*)**

Management—Little skates are managed and have EFH designated under the NEFMC Final FMP for the NE Skate Complex (NEFMC 2003b).

Status—The little skate is not overfished and is not subject to overfishing (NMFS 2008).[15]

Distribution—The little skate ranges from Nova Scotia, Canada, to Cape Hatteras, North Carolina, with its center of abundance occurring on Georges Bank and in coastal waters south to the mouth of the Chesapeake Bay (McEachran 2002; Packer et al. 2003b).

- Information Specific to the Chesapeake Bay—The little skate is occasionally found in the lower Chesapeake Bay during the winter and spring. Juveniles and adults are primarily found in April and May with their distribution concentrated in the high salinity waters of the Chesapeake Bay mouth (Murdy et al. 1997; Geer 2002).

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 is found at depths 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 (NEFMC 2003b).

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 again 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 [*Microgadus tomcod*], silver hake [*Merluccius bilinearis*], sculpin, silverside, wolfish, sand lance, cunner [*Tautogolabrus adspersus*], winter flounder, and yellowtail flounder [*Limanda ferruginea]*) (McEachran 2002; Packer et al. 2003b).

EFH Designations (NMFS 2001; NEFMC 2003b) (**Figure 5-28**)

- Egg—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for little skate eggs.

- Larva—No larval stage exists for this species. Upon hatching, they are fully developed juveniles.

- Juvenile—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for juvenile little skates.

- Adult—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for adult little skates.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

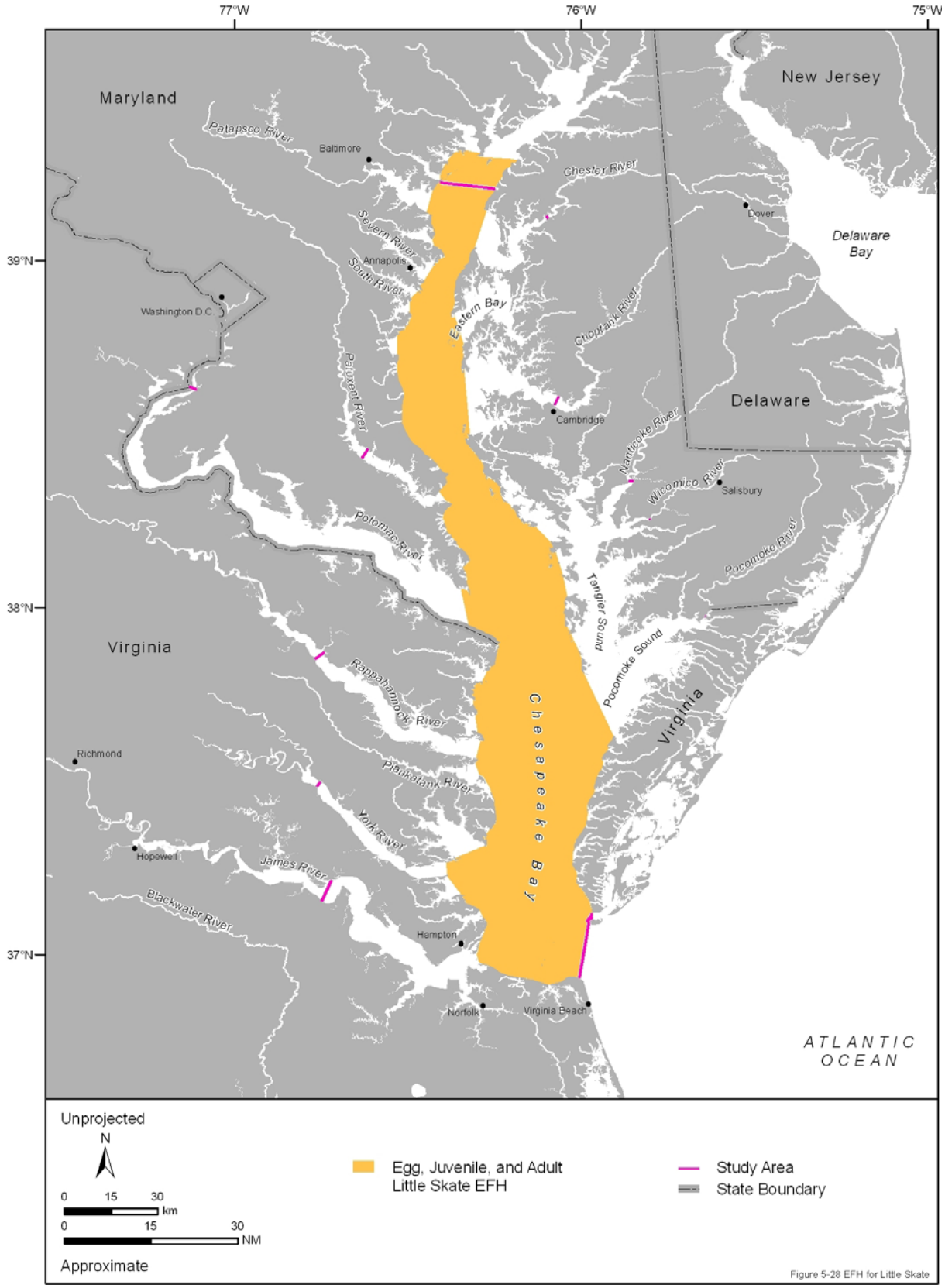

Figure 5-28. Essential fish habitat for eggs, juveniles, and adults of the little skate designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2001) and NEFMC (2003b).

- **Red Hake (*Urophycis chuss*)**

Management—The red hake is managed and has EFH designated by the NEFMC under Final Amendment 12 to the Northeast Multispecies FMP (NEFMC 1999). This species is divided into two separate stocks: northern stock (Gulf of Maine to northern Georges Bank) and southern stock (southern Georges Bank into the MAB), which is divided along the central east-west axis of Georges Bank in U.S. waters (NEFMC 1999).

Status—Currently, red hake is not currently overfished; however, it is unknown whether overfishing is occurring (NMFS 2008).[15]

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, Massachusetts, and in the northern MAB off Long Island, New York. All lifestages of the red hake are also found in estuaries from southern Maine to the Chesapeake Bay (Steimle et al. 1999a).

- Information Specific to the Chesapeake Bay—Juvenile and adult red hakes are seasonal visitors in the Chesapeake Bay that are common during the late winter and spring months. They occur in the deeper channels of the Chesapeake Bay mainstem as well as the deep channels of Hampton Roads Harbor. Occasionally they are found in the upper Chesapeake Bay, extending as far north as the Patuxent River (Murdy et al. 1997; Geer 2002).

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 2002e). 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 2002e). In the MAB, larvae occur in water ranging from 8° to 23°C and at depths between 10 m and 200 m (Steimle et al. 1999a). Both the eggs and larvae are known to drift with the prevailing currents to the southwest (Anderson 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 2002e). Juveniles display a preference for waters between 4.2°C and 7.5°C, depths from 40 to 50 m, and salinities from 31.0 to 32.8 psu. Adults prefer water temperatures ranging from 5° to 12°C in temperature with a salinity range around 33 or 34 psu. They inhabit soft sediments at depths of 35 to 980 m, being found less frequently over gravel, shell, or rocky bottoms. They also inhabit natural and artificial reefs (Steimle et al. 1999a; Klein-MacPhee 2002e). In the Chesapeake Bay, red hakes utilize soft mud and silt bottoms at salinities above 16 psu and water temperatures below 16°C (Murdy et al. 1997; Geer 2002).

Life History—The main spawning grounds for red hake include the southwest portion of Georges Bank and 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. 1999a). Spawning occurs from April through November at temperatures between 5°C and 10°C (Steimle et al. 1999a). Red hake undergo extensive seasonal, depth, and temperature-related migrations and are found in the coastal waters (<100 m) during the warmer months and migrate further offshore (>100 m) during colder months (Steimle et al. 1999a).

Common Prey Species—Red hake feed primarily on crustaceans (crab and shrimp) and other invertebrates (bivalves, squid, and worms) and secondarily on fishes (haddock [*Melanogrammus aeglefinus*], silver hake, sand lance, sea robin, and mackerel) (Klein-MacPhee 2002e).

EFH Designations (NEFMC 1999; NMFS 2001) (**Figure 5-29**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Larva—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Juvenile—The seawater salinity zone of the Chesapeake Bay has been designated as EFH for juvenile red hake.
- Adult—The seawater salinity zone of the Chesapeake Bay has been designated as EFH for adult red hake.
- Spawning Adult—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- ***HAPC Designations***—No HAPC are identified for this species by the FMC or the ASMFC.

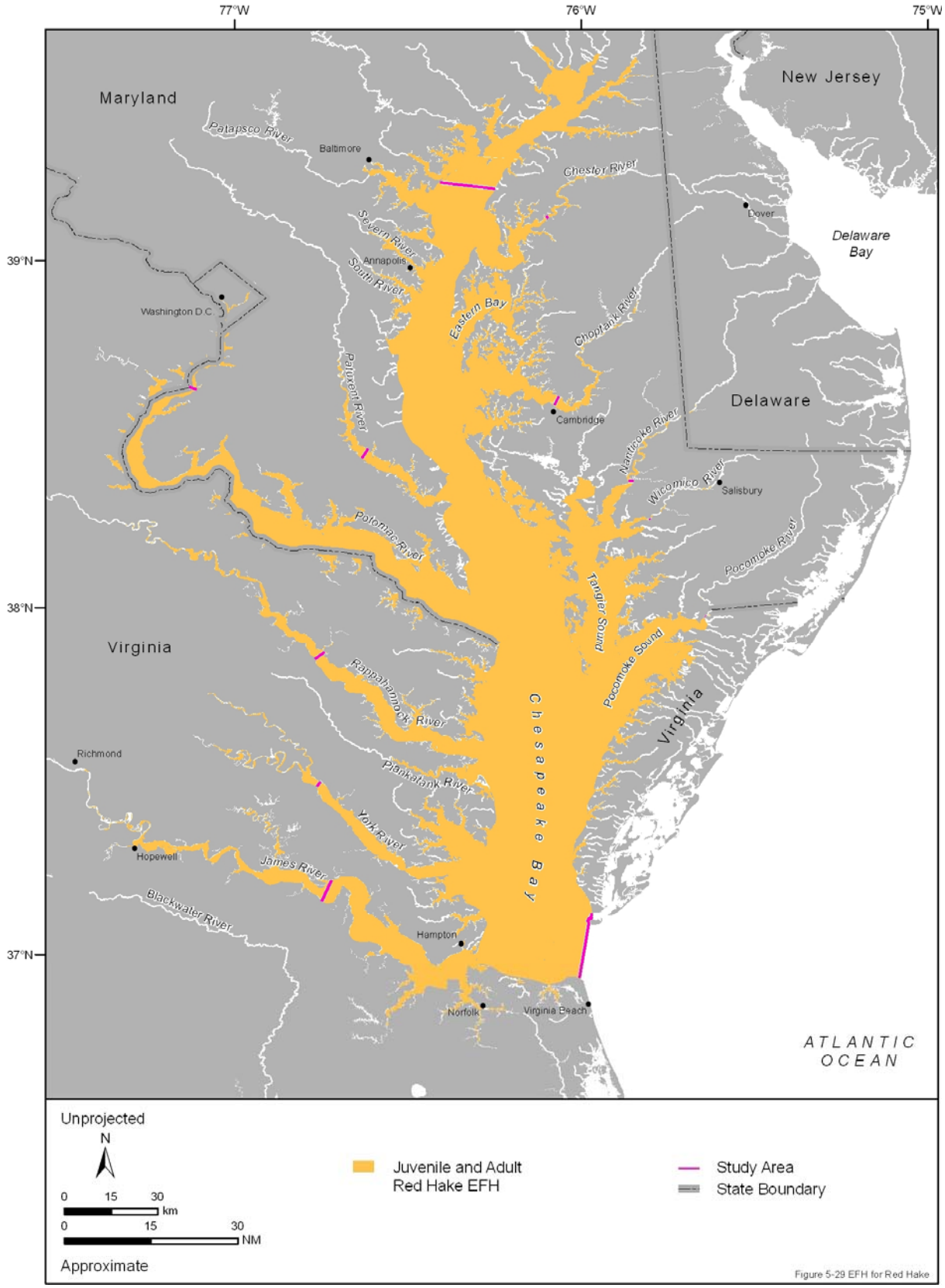

Figure 5-29. Essential fish habitat for juveniles and adults of the red hake designated in the Chesapeake Bay Study Area. Source maps (scanned): NEFMC (1999) and NMFS (2001).

- **Scup (*Stenotomus chrysops*)**

Management—The scup fishery is managed and 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 western North Atlantic Ocean is overfished and overfishing is currently occurring (NMFS 2008).[15]

Distribution—Scup are a continental shelf species found in the western North Atlantic Ocean. They occur primarily from Cape Cod, Massachusetts, 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. 1999b; Klein-MacPhee 2002f) and as far south as Florida (Manooch III 1988).

- Information Specific to the Chesapeake Bay—The scup is common to abundant in the Chesapeake Bay from spring to autumn with peak abundances occurring between June and September, peaking in July. Both juveniles and adults are distributed throughout the lower Chesapeake Bay extending as far north as the York River and the Eastern Shore seaside (Murdy et al. 1997; Geer 2002).

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. 1999b). Larval scup are also pelagic and occur from May through September in coastal waters at temperatures ranging from 14° to 22°C. Both the eggs and the larvae are typically found in waters less than 50 m in depth (Steimle et al. 1999b). During the transition of larvae into juveniles, the scup abandons its pelagic lifestyle in favor of bottom habitats (Morse 1982). Juvenile scup prefer 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 that have 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 5°C and 27°C (Steimle et al. 1999b). In the Chesapeake Bay, scups prefer hard-bottom areas and submerged structures at salinities greater than 16 psu and water temperatures ranging from 10° to 28°C (Murdy et al. 1997; Geer 2002).

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. 1999b; Klein-MacPhee 2002f). 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, New York, to North Carolina (Terceiro 2001; Klein-MacPhee 2002f). Scup return to the inshore waters once the temperatures begin to rise again in the spring (Steimle et al. 1999b). During the summer, scup are most common in most large estuaries and coastal areas (Klein-MacPhee 2002f). Scups are also members of an offshore-wintering guild of fishes (summer flounder, black sea bass, northern searobin [*Prionotus carolinus*], and smooth dogfish [*Mustelus canis*]) whose movements, habitats, and food habitats generally coincide (Colvocoresses and Musick 1984; Shepherd and Terceiro 1994; Brown et al. 1996).

Common Prey Species—Scup feed on benthic invertebrates (mollusks, crab, shrimp, squid, small crustaceans including zooplankton, and worms) and small fishes but rarely feed any higher in the water column (Steimle et al. 1999b; Klein-MacPhee 2002f).

EFH Designations (MAFMC and ASMFC 1998a; NMFS 2001) (**Figure 5-30**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Larva—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Juvenile—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay and Tangier/Pocomoke sounds have been designated as EFH for juvenile scup.
- Adult—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay and Tangier/Pocomoke sounds have been designated as EFH for adult scup.

HAPC Designations—No HAPC are identified for this species by the FMC. The ASMFC has identified HAPC to include sandy and weedy areas and structured habitats as important fishery nursery areas for juveniles.[3]

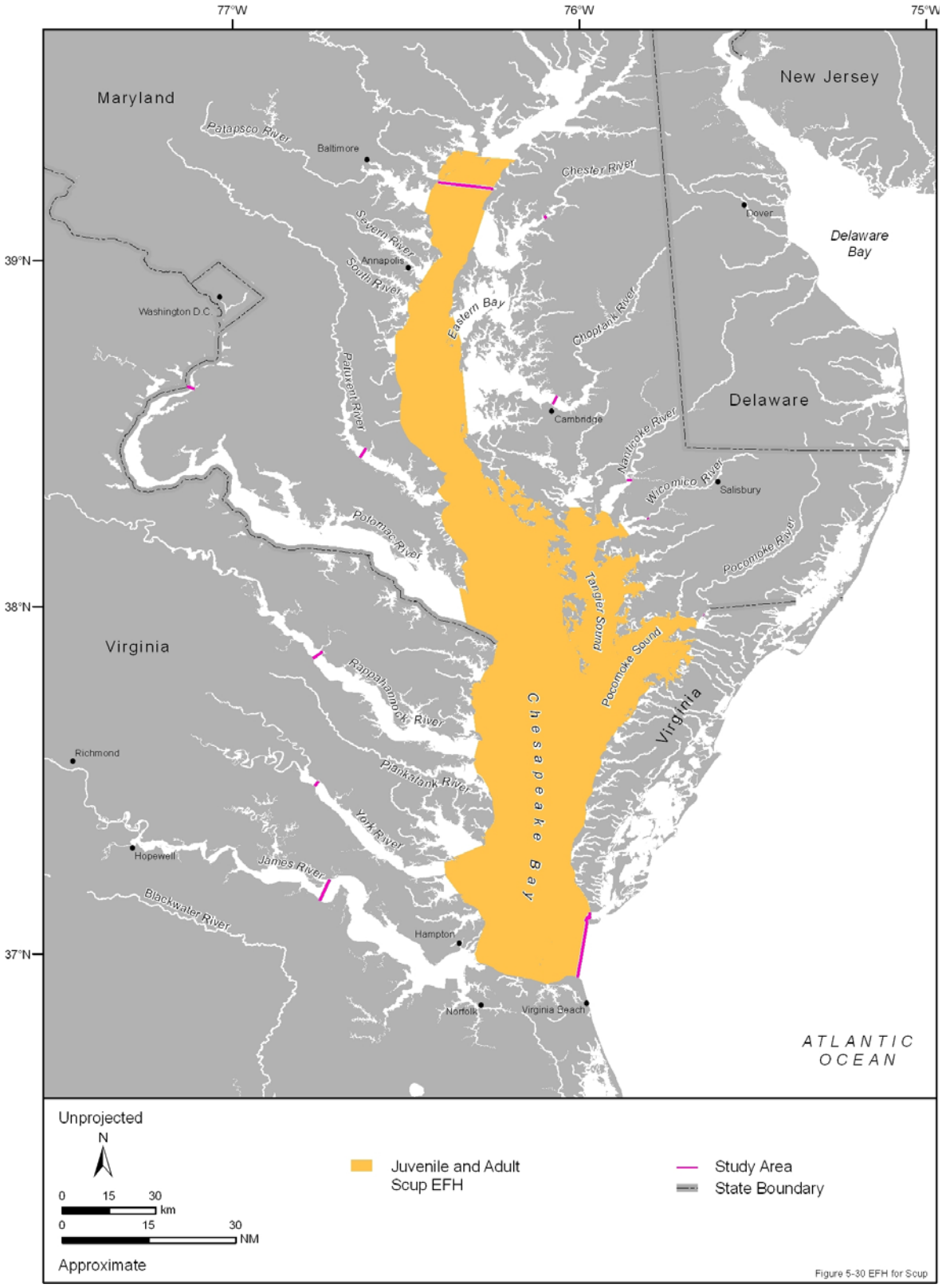

Figure 5-30. Essential fish habitat for juveniles and adults of the scup designated in the Chesapeake Bay Study Area. Source maps (scanned): MAFMC and ASMFC (1998a) and NMFS (2001).

- **Summer Flounder (*Paralichthys dentatus*)**

Management—The summer flounder is managed as a single stock and 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—The summer flounder stock is not overfished nor subjected to overfishing (NMFS 2008).[15]

Distribution—The range of summer flounder includes the continental shelf and estuaries from Nova Scotia to Florida, but their occurrence north of Cape Cod, Massachusetts, and south of Cape Hatteras, North Carolina, is rare (Byrne and Azarovitz 1982; Klein-MacPhee 2002a).

- Information Specific to the Chesapeake Bay—The summer flounder is well distributed throughout the Chesapeake Bay and the major Virginia tributaries (Rappahannock, York, and James rivers). This species is more common in the lower Chesapeake Bay than the upper Chesapeake Bay, extending as far north as Maryland's Gundpowder River. Both juveniles and adults commonly occur from May to November and larvae from October to May (Murdy et al. 1997; Wagner and Austin 1999; Geer 2002).

Habitat Associations—Summer flounder eggs are pelagic and occur over the continental shelf in waters with temperatures ranging from 9° to 23°C, although the majority of eggs have been observed at temperatures between 12°C and 19°C. Eggs are most common in the MAB between Long Island, New York, 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 0°C and 23°C but appear with the most frequency in waters between 9°C and 18°C. Following their metamorphosis into juveniles, the summer flounder seeks inshore demersal habitats (Byrne and Azarovitz 1982). They display a preference for portions of estuaries containing sandy substrates or where there is a transition from fine sand to silt and clay and water temperatures ranging between 3°C and 27°C (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). Virginia's artificial reefs also provide additional habitat for summer flounder (Packer et al. 1999). In the Chesapeake Bay, juveniles utilize a variety of habitats (shallow, mud bottomed marsh creeks, shallow sand substrates including eelgrass beds, and deep sand/deep fine-sand substrates); whereas adults typically occur in deep channels, ridges, or sandbars. Both juveniles/adults are found at salinities greater than 16 to 18 psu, water temperatures ranging from 10° to 20°C, and depths between 4 m and 14 m (Murdy et al. 1997; Packer et al. 1999) (Geer 2002).[1]

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 2002a). 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 2002a). Adult summer flounders use the Eastern Shore seaside lagoons and inlets and the shoal water flat areas of higher salinity (>18 psu) in the lower Chesapeake Bay as a summer feeding and nursery areas (Schwartz 1961; Packer et al. 1999).

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 2002a). Summer flounder feed on benthos as well as throughout the water column to the surface (Klein-MacPhee 2002a).

EFH Designations (MAFMC and ASMFC 1998a; NMFS 2001) (**Figure 5-31**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

- Larva—The mixing and seawater salinity zones of the mainstem of the Chesapeake Bay and the Rappahannock, York, and James rivers have been designated as EFH for larval summer flounder.

- Juvenile—The mixing and seawater salinity zones of the Chesapeake Bay and its tributaries have been designated as EFH for juvenile summer flounder.

- Adult—The mixing and seawater salinity zones of the Chesapeake Bay and its tributaries have been designated as EFH for adult summer flounder.

HAPC Designations—(MAFMC and ASMFC 1998a; VIMS 2006) (**Figure 5-31**)

- 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 (MAFMC and ASMFC 1998a). The ASMFC has identified HAPC as shoal waters of Cape Cod Bay, Massachusetts, and estuaries, bays, and harbors east and south of Cape Cod as important juvenile habitat. In addition, estuarine waters west and northwest of Cape Hatteras, North Carolina, and high salinity bays and tidal creeks of Core Sound, North Carolina, are important nursery grounds for juveniles.[3]

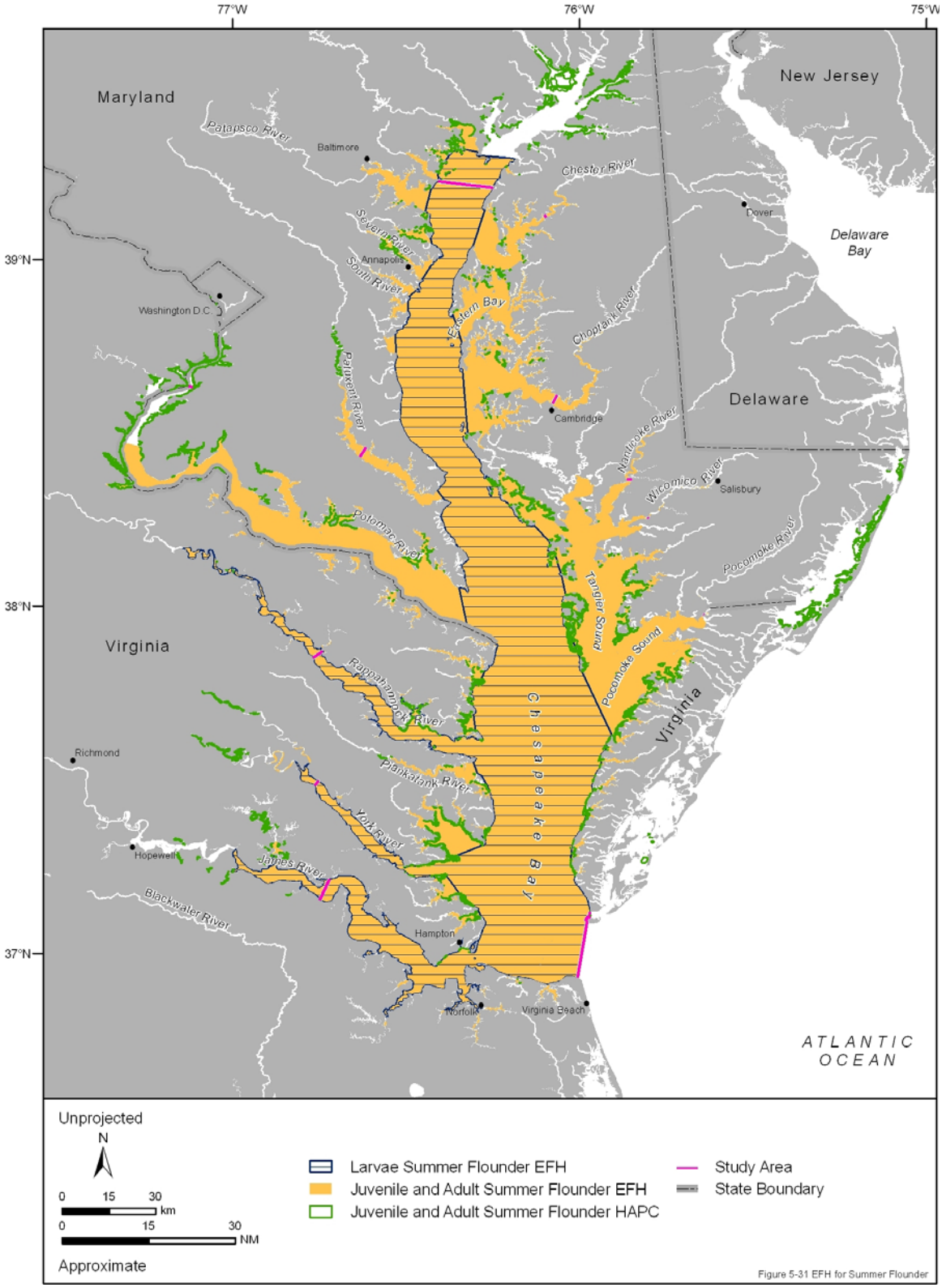

Figure 5-31. Essential fish habitat for larvae, juveniles, and adults and habitat areas of particular concern (HAPC) for juveniles and adults of the summer flounder designated in the Chesapeake Bay Study Area. Source maps (scanned): MAFMC and ASMFC (1998a), NMFS (2001), and VIMS (2006).

- **Windowpane Flounder (*Scophthalmus aquosus*)**

Management—Windowpane flounder is currently managed and has 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; NEFMC 2003a).

Status—Currently, the SNE/MA stock of the windowpane flounder is overfished; but, overfishing is no longer occurring (NMFS 2008).[15]

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).

- Information Specific to the Chesapeake Bay—Windowpane flounders are a year-round resident of the Chesapeake Bay extending as far north as the Choptank River. Juveniles and adults are abundant being concentrated in the Chesapeake Bay mouth and along the Eastern Shore. Juveniles peak in abundance from April to June, while adults peak in November (Murdy et al. 1997; Geer 2002).

Habitat Associations—Windowpane flounder eggs are primarily found throughout the high salinity areas of estuaries and the inner continental shelf in waters between 5°C and 20°C in temperature and less than 70 m in depth (Chang et al. 1999). Larval windowpane flounder start off as pelagic but settle to the bottom at approximately a size of 10 mm. They are found primarily in estuaries and on the nearshore continental shelf in waters with temperatures ranging from 3° to 19°C and at depths of less than 70 m (Morse and Able 1995; Chang et al. 1999). Juveniles and adults are found in estuaries and throughout much of the continental shelf between depths of 5 m and 207 m (most common in waters <50 m) and temperatures from 0° to 27°C (Morse and Able 1995; Chang et al. 1999; Klein-MacPhee 2002b). Adults are euryhaline and can tolerate salinity ranges between 5.5 psu and 36.0 psu (Chang et al. 1999; Klein-MacPhee 2002b). Adult windowpane flounder prefer 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). In the Chesapeake Bay, adults prefer higher (>22 psu) and lower water temperatures (<16°C) than juveniles (Geer 2002).

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 2002b) with spawning completed by January (Morse and Able 1995). Spawning typically occurs in waters with temperatures between 6°C and 17°C at night or in the evening (Klein-MacPhee 2002b). 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 [*Neomysis americana*], sand shrimp [*Crangon vulgaris*], and bony fishes (anchovy, snake eel, silver hake, tomcod, cusk-eel, killifish, silverside, pipefish, blackbelly rosefish [*Heliocolenus dactylopterus*], sculpin, Atlantic striped bass, sand lance, and flatfish species) as well as fish larvae (Klein-MacPhee 2002b). They have also been reported to feed on various other invertebrates, including squids, mollusks, worms, isopods, krill, and salps (Klein-MacPhee 2002b).

EFH Designations (NEFMC 1998; NMFS 2001) (**Figure 5-32**)

- Egg—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Larva—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.
- Juvenile—The mixing and seawater salinity zones of the Chesapeake Bay and its tributaries have been designated as EFH for juvenile windowpane flounder.
- Adult—The mixing and seawater salinity zones of the Chesapeake Bay and its tributaries have been designated as EFH for adult windowpane flounder.
- Spawning Adult—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

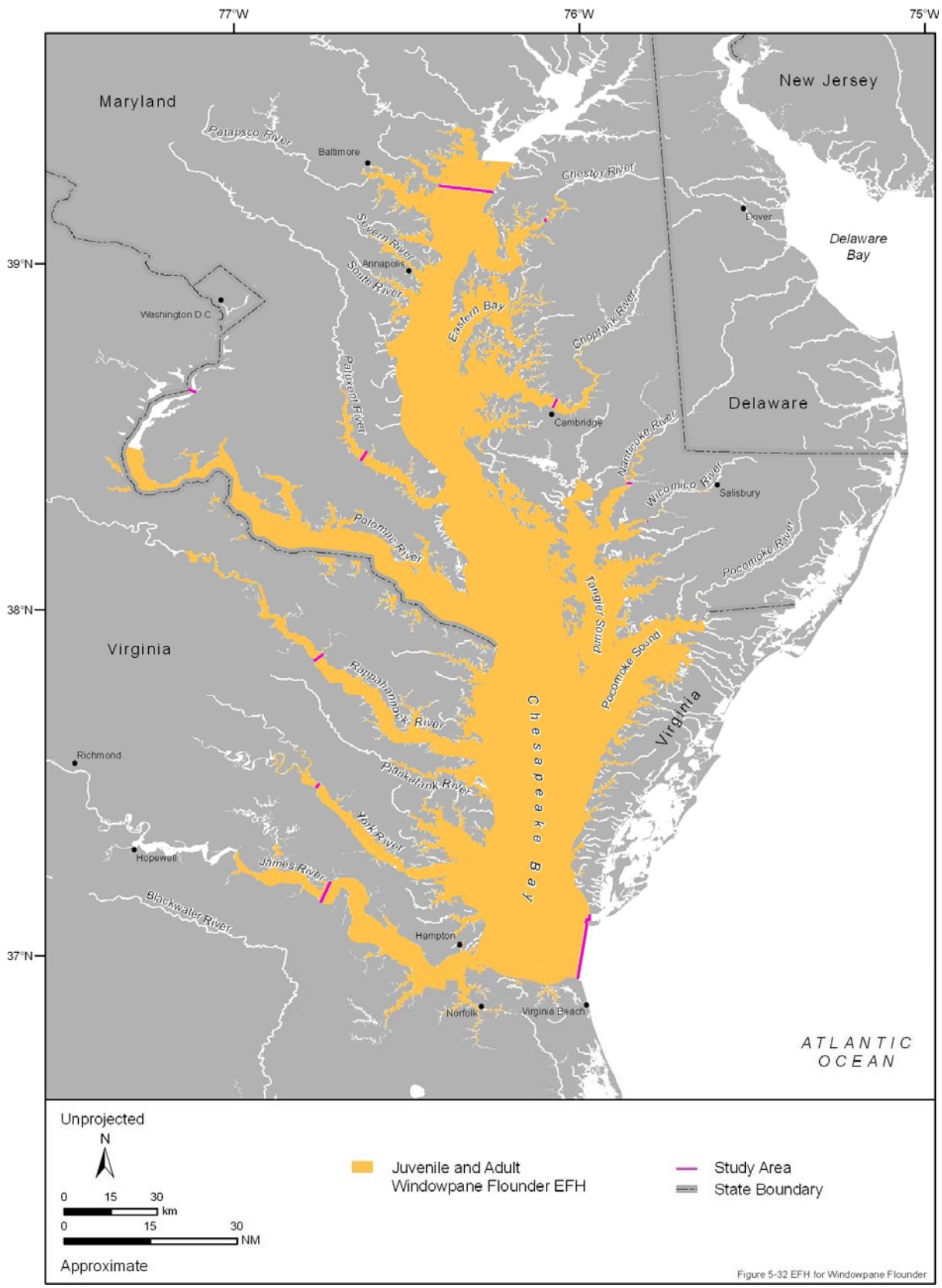

Figure 5-32. Essential fish habitat for juveniles and adults of the windowpane flounder designated in the Chesapeake Bay Study Area. Source maps (scanned): NEFMC (1998) and NMFS (2001).

- **Winter Skate (*Leucoraja ocellata*)**

Management—Winter skates are managed and have EFH designated by the NEFMC through the Final FMP for the NE Skate Complex (NEFMC 2003b).

Status—The winter skate is overfished but overfishing is not currently occurring (NMFS 2008).[15]

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. 2003c).

- Information Specific to the Chesapeake Bay—The winter skate is an occasional winter to springtime (December to April) visitor to the southern Chesapeake Bay inhabiting the Chesapeake Bay mouth (Murdy et al. 1997; Geer 2002).

Habitat Associations—The eggs of winter skates are laid on the bottom in capsules (McEachran 2002; Packer et al. 2003c). Upon hatching, the skates are already fully developed juveniles (NEFMC 2003b). During the spring, juvenile winter skates are most common in waters with temperatures of 4° to 5°C, salinities of 32 to 33 psu, and depths of 11 to 70 m. In the fall, juveniles are typically observed in waters with temperatures ranging from 7° to 16°C (peaks between 13°C and 15°C), salinities between 32 psu and 33 psu, and depths ranging from 21 to 80 m (Packer et al. 2003c). In spring, adult winter skates are most abundant in waters ranging from 4° to 6°C in temperature, salinities of 33 psu, and depths of 31 to 60 m. In the fall, adults are most common in waters with temperatures ranging from 11° to 15°C, salinities of 32 psu, and depths of 31 to 50 m (Packer et al. 2003d). Winter skates are mostly found in habitats that have sand or gravel bottoms (McEachran 2002). In the Chesapeake Bay, this species prefers colder waters less than 12°C (Geer 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 Bay. 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, Atlantic menhaden, silver hake, red hake, tomcod, cod, smelt, sculpins, redfish, sand lance, cunner, butterfish, Atlantic mackerel, summer flounder, and yellowtail flounder) (McEachran 2002; Packer et al. 2003c).

EFH Designations (NMFS 2001; NEFMC 2003b) (**Figure 5-33**)

- Egg—Bottom habitats in the mainstem of the Chesapeake Bay has been designated as EFH for winter skate eggs.

- Larva—No larval stage exists for this species. Upon hatching, they are fully developed juveniles.

- Juvenile—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for juvenile winter skates.

- Adult—Bottom habitats in the mainstem of the Chesapeake Bay have been designated as EFH for adult winter skates.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

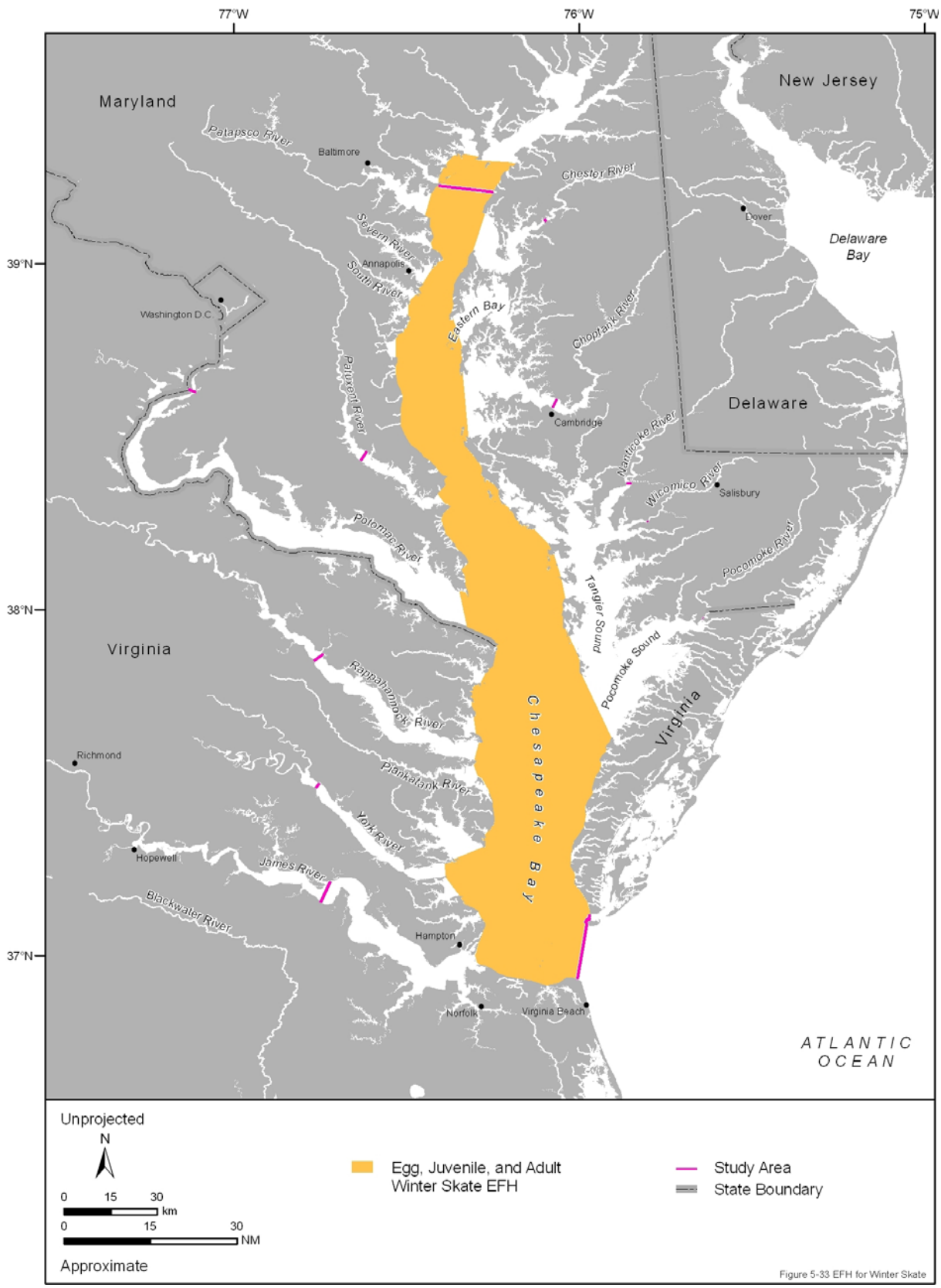

Figure 5-33. Essential fish habitat for eggs, juveniles, and adults of the winter skate designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2001) and NEFMC (2003b).

5.3.2 Subtropical-Tropical Water Species

- **Cobia (*Rachycentron canadum*)**

Management—Cobia off the southeast coast of the U.S. are managed jointly by the SAFMC and GMFMC through the Coastal Migratory Pelagic Resources FMP (GMFMC and SAFMC 1985), but EFH in the Chesapeake Bay is only designated by the SAFMC through the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—This species is not overfished nor is overfishing currently occurring (NMFS 2008).[15]

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 2003).

- Information Specific to the Chesapeake Bay—Cobia are an occasional to common summer visitor in the lower Chesapeake Bay. This species occurs along both the eastern and western shores of the mainstem Chesapeake Bay moving as far north as Tangier Sound and the mouth of the Potomac River (Murdy et al. 1997; Geer 2002).[1]

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 psu and 35 psu in salinity. Developing larvae occupy waters with temperatures from 24.2° to 32.0°C, salinities between 18.9 psu 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°C and 25.2°C and at salinities between 30.0 psu and 36.4 psu. Adults prefer temperatures between 19.6°C and 28.0°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). In the Chesapeake Bay, cobia are found in open shallower water (<12 m) around buoys, pilings or floating objects with a preference for higher salinity (>18 psu) and warm waters (>16°C), either solitary or in small groups (Murdy et al. 1997; Geer 2002).[1]

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 1999; 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). In the Chesapeake Bay, cobia enter the bay in late May or early June and move out of the Chesapeake Bay and migrate south by mid-October. Spawning occurs from mid-June to mid-August near the Chesapeake Bay mouth or just offshore, where they form aggregations (Murdy et al. 1997).

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, pilot fish [*Naucrates doctor*], turtles, and large rays as they feed, to scavenge food from the other animals (Williams 2001; CBP 2004).

EFH Designations (SAFMC 1998; VIMS 2006) (**Figure 5-34**)

- All Lifestages—EFH designated in the Chesapeake Bay for cobia include high salinity (>19 psu) portions of the Chesapeake Bay and its tributaries, the mouth of the Chesapeake Bay (coastal inlet), and all seagrass habitat.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

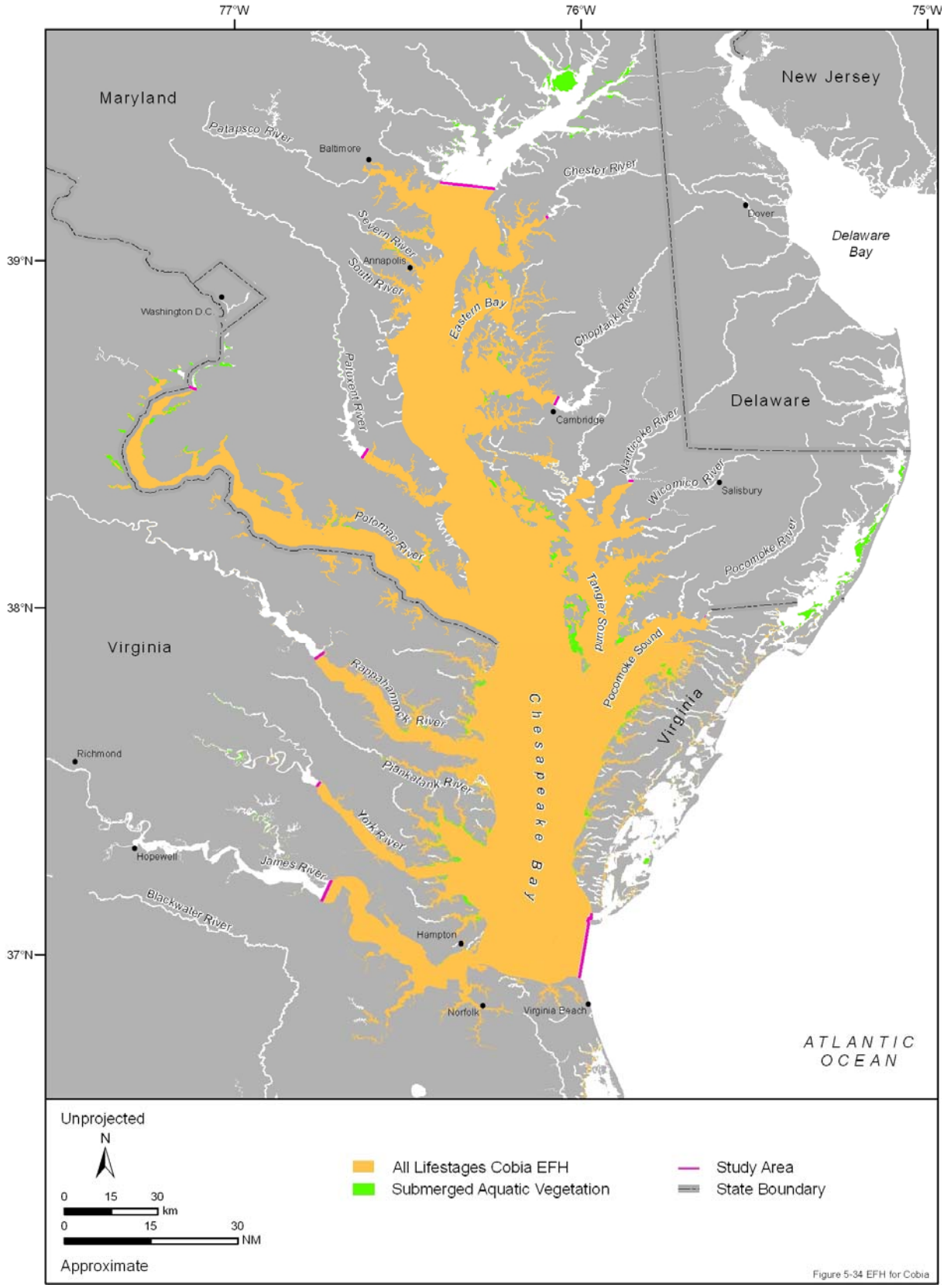

Figure 5-34. Essential fish habitat for all lifestages of the cobia designated in the Chesapeake Bay Study Area. Source maps (scanned): SAFMC (1998) and VIMS (2006).

- **King Mackerel (*Scomberomorous cavalla*)**

Management—This species is managed by the SAFMC and GMFMC through the Coastal Migratory Pelagic Resources FMP (GMFMC and SAFMC 1985), but EFH for this species in the Chesapeake Bay 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 2008).[15]

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 (Collette 2002; Gold et al. 2002). This species does not typically occur beyond the continental shelf break (GMFMC and SAFMC 1985).

- Information Specific to the Chesapeake Bay—King mackerel are occasional visitors to the lower Chesapeake Bay and rare to occasional visitors in the upper Chesapeake Bay. They occur during the warm months (June to October), with peak abundance in September (Murdy et al. 1997).

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°C to 28°C, salinities between 30 psu 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 psu and 36 psu. As adults, king mackerel rarely enter estuaries but feed upon estuarine-dependent species (GMFMC 1998). In the Chesapeake Bay, this surface-dwelling, nearshore species is found around wrecks, towers, reefs, and other hard structures (Murdy et al. 1997).

Life History—King mackerel are highly fecund serial spawners (Gledhill and Lyczdowski-Shultz 2000). They have a protracted spawning season, which occurs on the middle/outer continental shelf from May to October (Godcharles and Murphy 1986; Murdy et al. 1997) 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 [*Opisthonema oglinum*], 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 2002).

EFH Designations—(SAFMC 1998) (**Figure 5-35**)

- All Lifestages—EFH has been designated as the inlet to the Chesapeake Bay for all lifestages of king mackerel.

HAPC Designations—No HAPC are identified for this species by the FMC or the ASMFC.

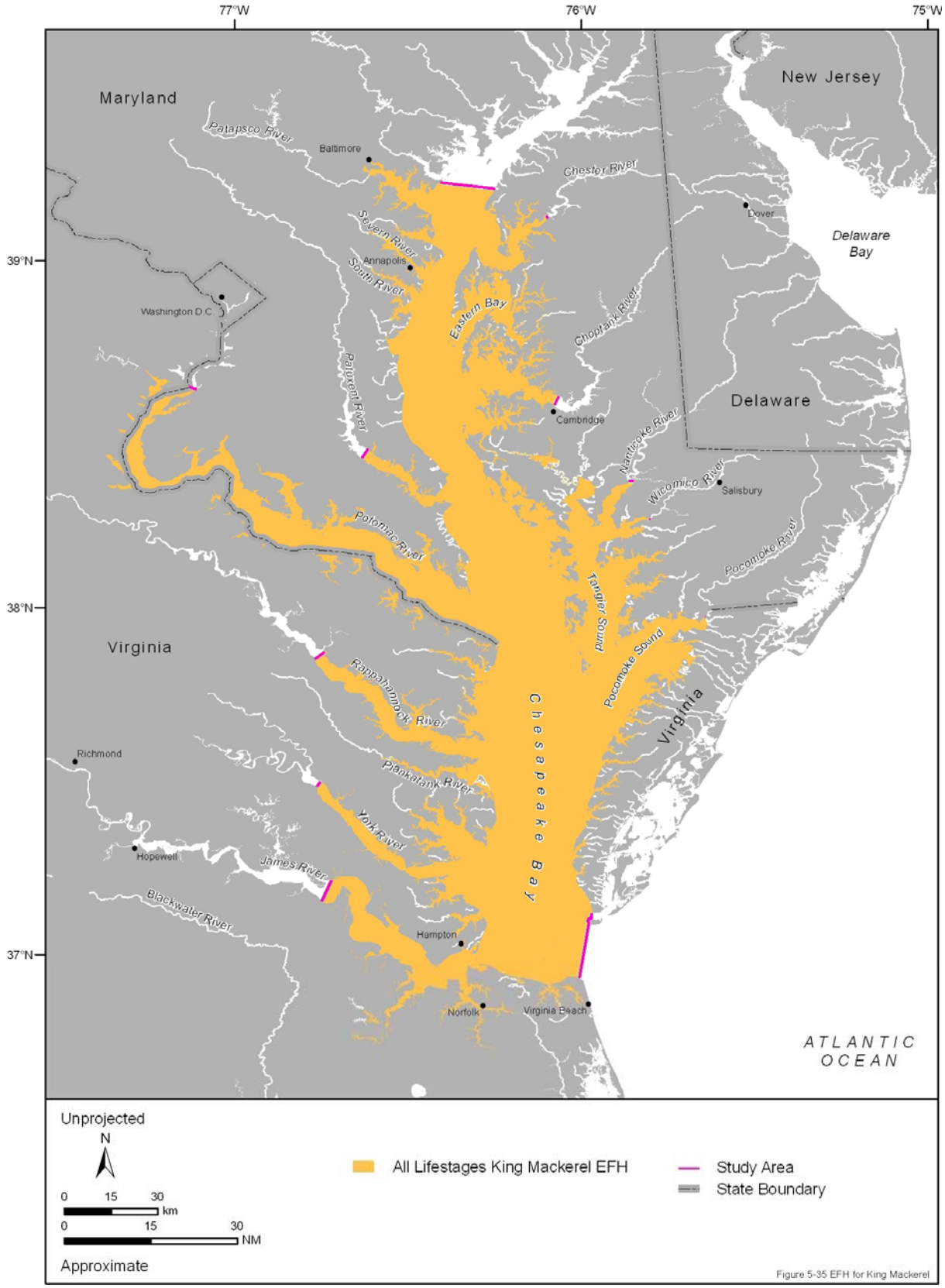

Figure 5-35. Essential fish habitat for all lifestages of the king mackerel designated in the Chesapeake Bay Study Area. Source maps (scanned): SAFMC (1998).

- **Red Drum (*Sciaenops ocellatus*)**

Management—Red drum is managed and has EFH designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998). On November 5, 2008, the red drum FMP was transferred from the SAFMC in cooperation with the MAFMC under the Magnuson-Stevens Act to the ASMFC under the Atlantic Coastal Act (NMFS 2008a).

Status—The red drum stock on the Atlantic coast of the U.S. is subjected to overfishing and it is unknown if it is subject to being overfished (NMFS 2008).[15]

Distribution—Red drum are found throughout estuarine and coastal waters of the U.S. Atlantic coast from Massachusetts to Florida. They are also found throughout the Gulf of Mexico from southwestern Florida to Tuxpan, Mexico (Reagan 1985; Manooch III 1988).

- Information Specific to the Chesapeake Bay—Red drum are a common from May through November in the Chesapeake Bay, extending as far north as the Patuxent River. Their distribution is concentrated in the lower portions of the riverine tributaries and the upper portion of Virginia side of the Chesapeake Bay. They are most abundant in the spring and fall near the Chesapeake Bay mouth (Murdy et al. 1997; Geer 2002).

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). Sub-adult red drum exit the shallow nursery habitats and begin utilizing a variety of habitats within the estuaries. Changes in temperature and food availability have been linked to the movement of sub-adults within the estuaries (ASMFC 2002). Little is known about the habitat preferences of adults. Adult red drum tend to spend more time in the coastal waters following sexual maturity but continue to frequent estuaries on a seasonal basis (ASMFC 2002). Adults can primarily be found in high salinity surf zones and around live/hard bottom and artificial reefs (SAFMC 1998). In the Chesapeake Bay, this species can be found in waters with temperatures less than 10°C and salinities greater than 10 psu (Geer 2002).

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 2002). Adult red drum tend to migrate offshore and south along the Atlantic coast in the fall and return north and move inshore during the spring of each year (ASMFC 2002).

Common Prey Species—Decapod crustaceans, primarily mud crabs and fiddler crabs, and fishes, mostly juvenile spot and mummichog [*Fundulus heteroclitus*], are the primary food items of adult red drum along the southeastern coast of the U.S. (ASMFC 2002).

***Previous* EFH Designations** (SAFMC 1998; VIMS 2006; NOAA 2008) (**Figure 5-36**)

- All Other Lifestages—Previous EFH had been designated for red drum in the Chesapeake Bay to include 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 unconsolidated bottom (soft sediments).

***Previous* HAPC Designations** (SAFMC 1998; VIMS 2006; NOAA 2008) (**Figure 5-36**)

- All Lifestages—Previous HAPC had been designated for the Chesapeake Bay as all seagrass beds and SAV. The ASMFC has identified HAPC to include tidal freshwater, estuarine emergent vegetated wetlands (flooded salt marshes, brackish marsh, and tidal creeks), estuarine scrub/shrub (mangrove fringe), submerged rooted vascular plants (seagrasses), oyster reefs and shell banks, unconsolidated bottom (soft sediments), ocean high salinity surf zones, and artificial reefs as important habitats.[3]

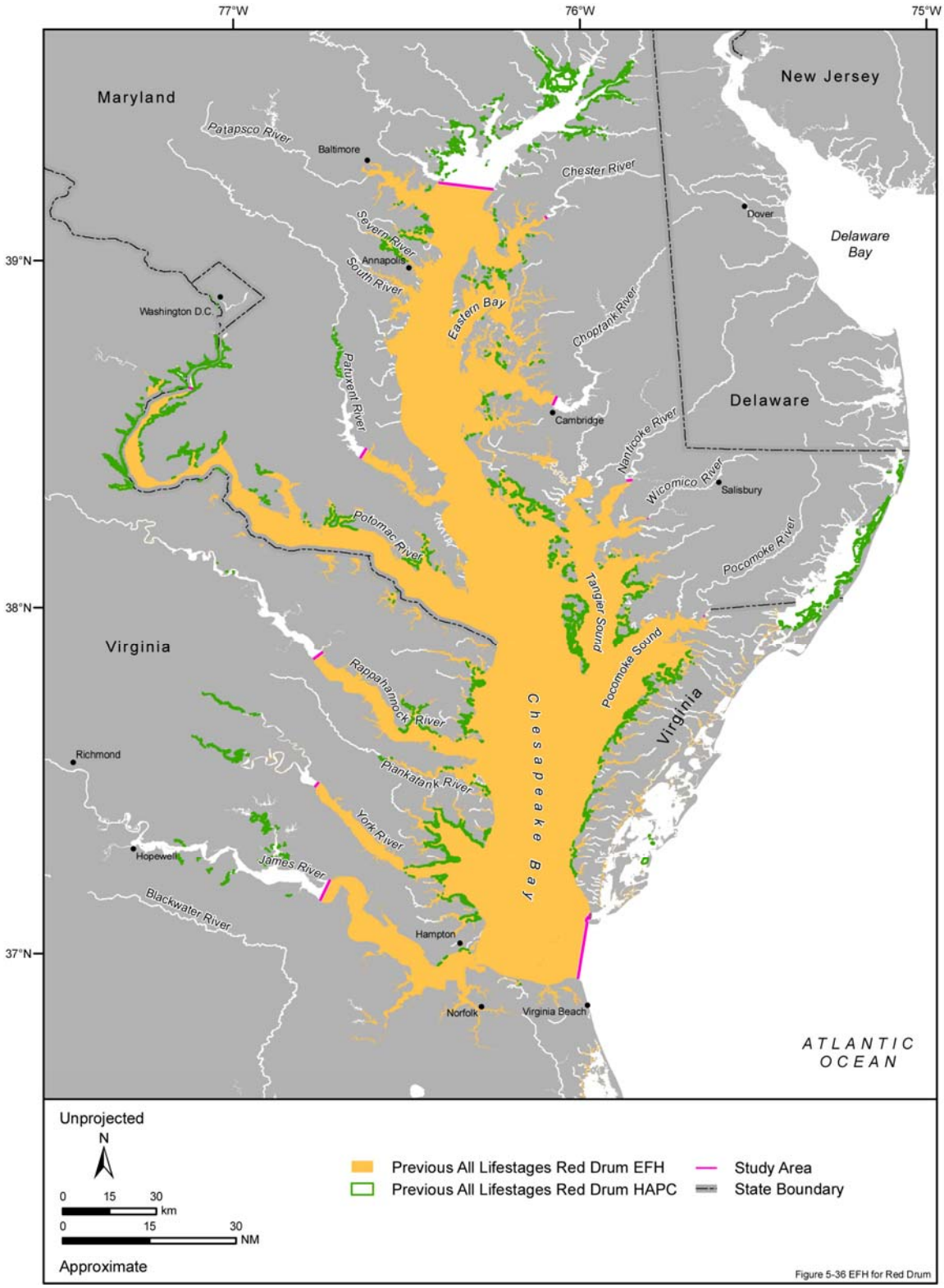

Figure 5-36. Previous essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the red drum designated in the Chesapeake Bay Study Area. For specific designated EFH habitats, please refer to Figure 4-1, Figure 4-3, Figure 4-4, and Figure 4-5. The habitat descriptions are mapped for completeness, but are not considered current EFH or HAPC designations. Source maps (scanned): SAFMC (1998), VIMS (2006), and NOAA (2008).

- **Spanish Mackerel (*Scomberomorous maculatus*)**

Management—Spanish mackerel are managed jointly by the SAFMC and the GMFMC through the Coastal Migratory Pelagic Resources FMP (GMFMC and SAFMC 1985), but EFH in the Chesapeake Bay is only designated by the SAFMC under the Final Habitat Plan for the South Atlantic Region (SAFMC 1998).

Status—The Spanish mackerel stock is not currently overexploited nor is it considered to be overfished (NMFS 2008).[15]

Distribution—Spanish mackerel are abundant from the Chesapeake Bay south through the Gulf of Mexico; however, they occasionally are found as far north as coastal southern New England (Collette 2002).

- Information Specific to the Chesapeake Bay—Spanish mackerel are common in the middle-lower Chesapeake Bay from spring (May) to autumn, extending at least as far north as the mouth of the Patuxent River. Their major concentrations are along the lower Western Shore and lower portion of Virginia's riverine tributaries (Murdy et al. 1997; Geer 2002).

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 psu and 37 psu, and depths from 9 to 84 m (most abundant in waters <50 m) (Godcharles and Murphy 1986; GMFMC 1998). Ichthyoplankton 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 depths less than 75 m (GMFMC 1998). In the Chesapeake Bay, this species occurs at depths between 6 m and 8 m, salinities above 24 psu, and water temperatures between 22°C and 32°C (Geer 2002).

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 begins 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 2002). Spanish mackerel make seasonal migrations along the Atlantic coast. They are found off Florida during the winter and migrate north as the waters warm in spring and summer. They arrive off the Carolinas in April, off Virginia by May, and as far north as Narragansett Bay, Rhode Island, 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 (*Etrumeus teres*), Atlantic menhaden, alewives, anchovies, pilchards, and mullets. This species also preys upon shrimp, crabs, and squid (GMFMC and SAFMC 1985; Collette 2002).

EFH Designations (SAFMC 1998) (**Figure 5-37**)

- All Lifestages—EFH has been designated as the inlet to the Chesapeake Bay for all lifestages of Spanish mackerel.

HAPC Designations—No HAPC are identified for this species by the FMC. The ASMFC has identified HAPC to include spawning grounds and areas where eggs and larvae develop, and estuaries as important habitat and nursery areas, respectively.[3]

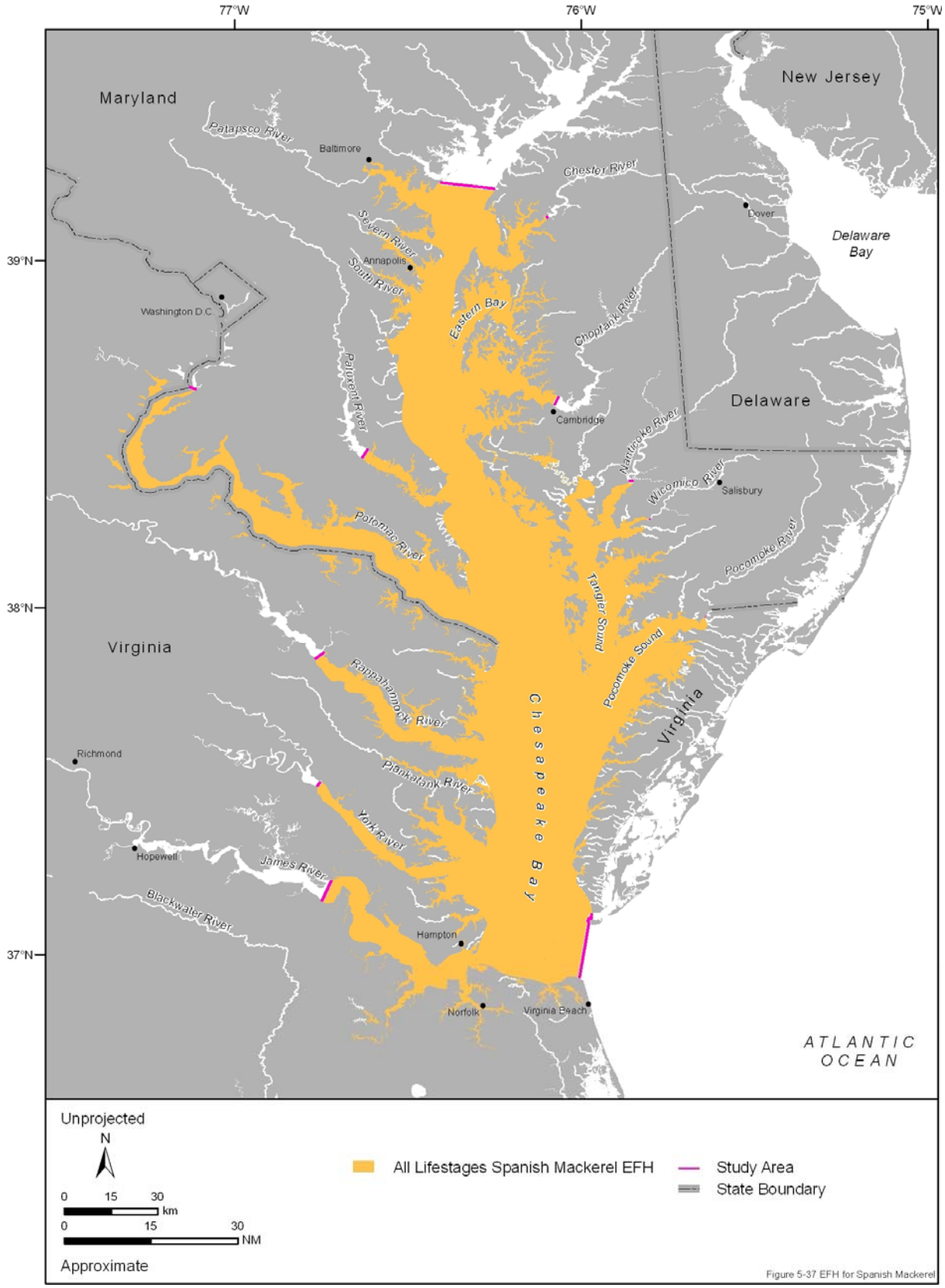

Figure 5-37. Essential fish habitat for all lifestages of the Spanish mackerel designated in the Chesapeake Bay Study Area. Source maps (scanned): SAFMC (1998).

5.3.3 Highly Migratory Species

- **Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*)**

Management—The Atlantic sharpnose shark is managed by NMFS under the Small Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006b; NMFS 2008b).

Status—This species is not overfished or subjected to overfishing (NMFS 2008). The International Union for the Conservation of Nature (IUCN) Red List designates this species as a lower risk but conservation dependent.[16]

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, Canada 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 1999; NMFS 2006b).

- Information Specific to the Chesapeake Bay—Atlantic sharpnose sharks are rare visitors in the lower Chesapeake Bay from their more common coastal habitats. Adults have been reported from the Chesapeake Bay Bridge Tunnel up to Cape Charles, Virginia (Murdy et al. 1997; NMFS 2001).

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 small demersal coastal carcharhinid has a broad salinity tolerance (22.8 to 37.2 psu) (NMFS 2008b) and has been found up rivers, such as the Pascagoula River in Mississippi (Allen 1999). This species and its nursery areas (i.e., Crooked Island Sound and Apalachicola Bay, northeastern Gulf of Mexico) can also be found in estuarine habitats (Castro 1993; NMFS 2008b). Habitats for young-of-the-year (YOY) included mud, sand, and seagrass, and for juveniles sand, seagrass, and mud in descending order of predominance (NMFS 2008b).

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 (Atlantic menhaden, eel, silverside, wrasse, jack, toadfish, filefish, smallmouth flounder [*Etropus microstomus*], herring, anchovy, pipefish, sea robin, stargazer, and puffer), worms, shrimp, crabs, and mollusks (Delius and Morgan 1999; Branstetter and Burgess 2002a).

EFH Designations (NMFS 2003b; NMFS 2006b) (**Figure 5-38**)

- Neonate (≤40 cm total length [TL])—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

- Juvenile (41 to 78 cm TL)—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

- Adult (≥79 cm TL)—EFH is designated as coastal waters to the 25-m isobath from Cape May, New Jersey, south to Cape Hatteras, North Carolina, for Atlantic sharpnose sharks.

HAPC Designations—No HAPC are identified for this species by the NMFS.

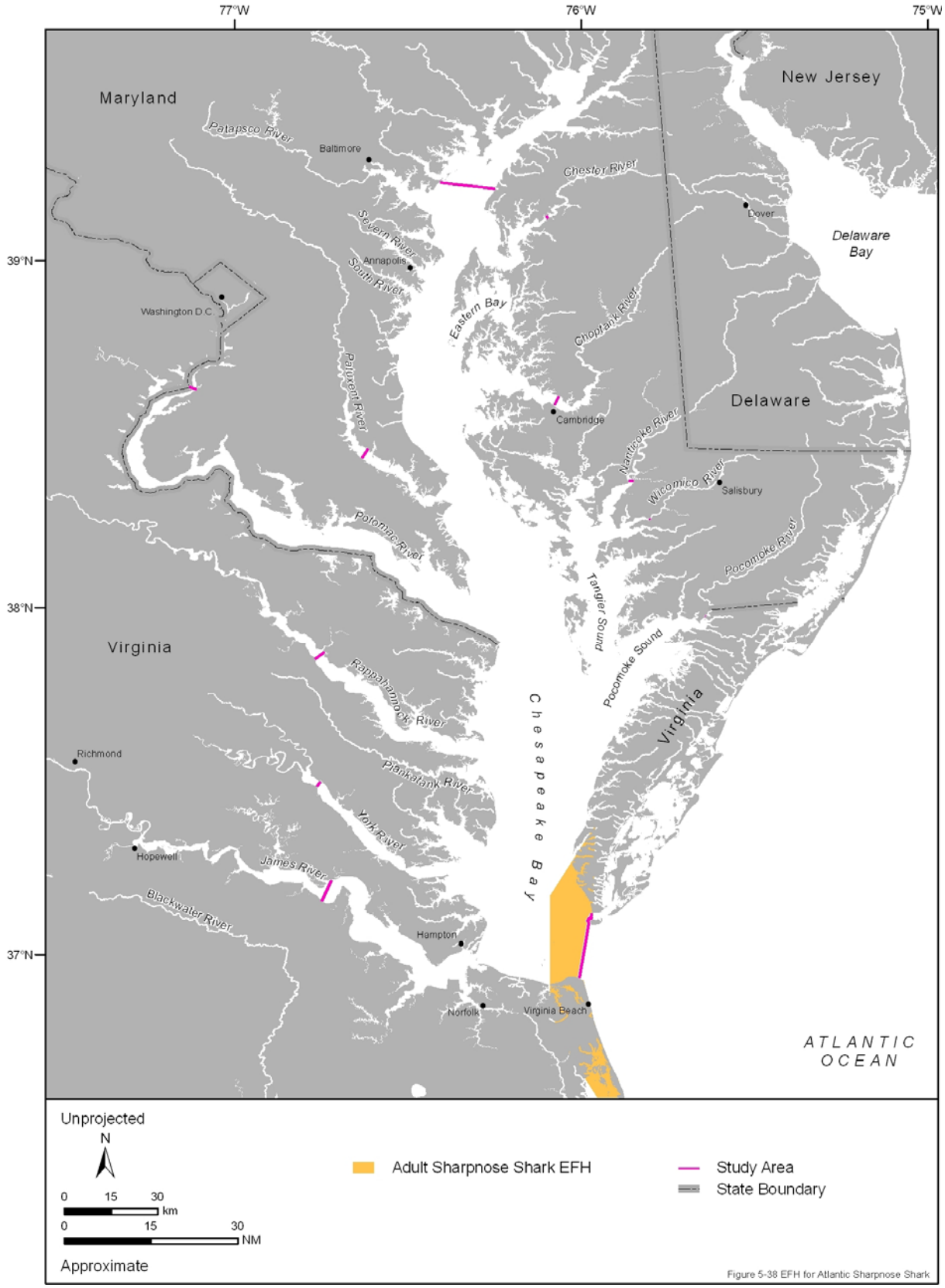

Figure 5-38. Essential fish habitat for adults of the Atlantic sharpnose shark designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2003b).

- **Dusky Shark (*Carcharhinus obscurus*)**

Management—The dusky shark is managed by NMFS under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006b; NMFS 2008b).

Status—Under this FMP, the dusky shark receives full protection as a prohibited species from harvest on the Atlantic coast (NMFS 2008). The dusky shark is currently identified as a species of concern (formerly a candidate species) by the NMFS (2006c) and is considered overfished, as well as subject to overfishing (NMFS 2008).[15] 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 2000a).[16]

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).

- Information Specific to the Chesapeake Bay—The dusky shark is an infrequent visitor to the lower Chesapeake Bay during the summer months. Neonates and juveniles have been reported from the Chesapeake Bay mouth up to Pocomoke Sound (Murdy et al. 1997; NMFS 2001).

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 and Burgess 2002a). Major nursery areas have been identified in coastal waters from Massachusetts to the South Carolina coast (Castro 1993; McCandless et al. 2002). The shoals on the seaside of the Virginia Barrier Islands serve as a pupping ground for this species (Murdy et al. 1997).

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, South Carolina, dusky sharks typically give birth from April to May, while in the Chesapeake Bay, this species gives birth 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; NMFS 2006b).

Common Prey Species—Bony fishes (eels, Atlantic menhaden, herring, anchovies, hakes, goosefish [*Lophius americanus*], 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 other sharks, crustaceans, and squid (Branstetter and Burgess 2002a).

EFH Designations (NMFS 2003a; NMFS 2003b; NMFS 2006b) (**Figure 5-39**)

- Neonate (≤110 cm TL)—EFH is designated in the Chesapeake Bay as coastal waters out to the 200-m isobath offshore for neonate dusky sharks.

- Juvenile (110 to 299 cm TL)—EFH is designated in the Chesapeake Bay as shallow coastal waters, inlets, and estuaries to the 200-m isobath offshore for juvenile dusky sharks.

- Adult (≥299 cm TL)—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

HAPC Designations—No HAPC are identified for this species by the NMFS.

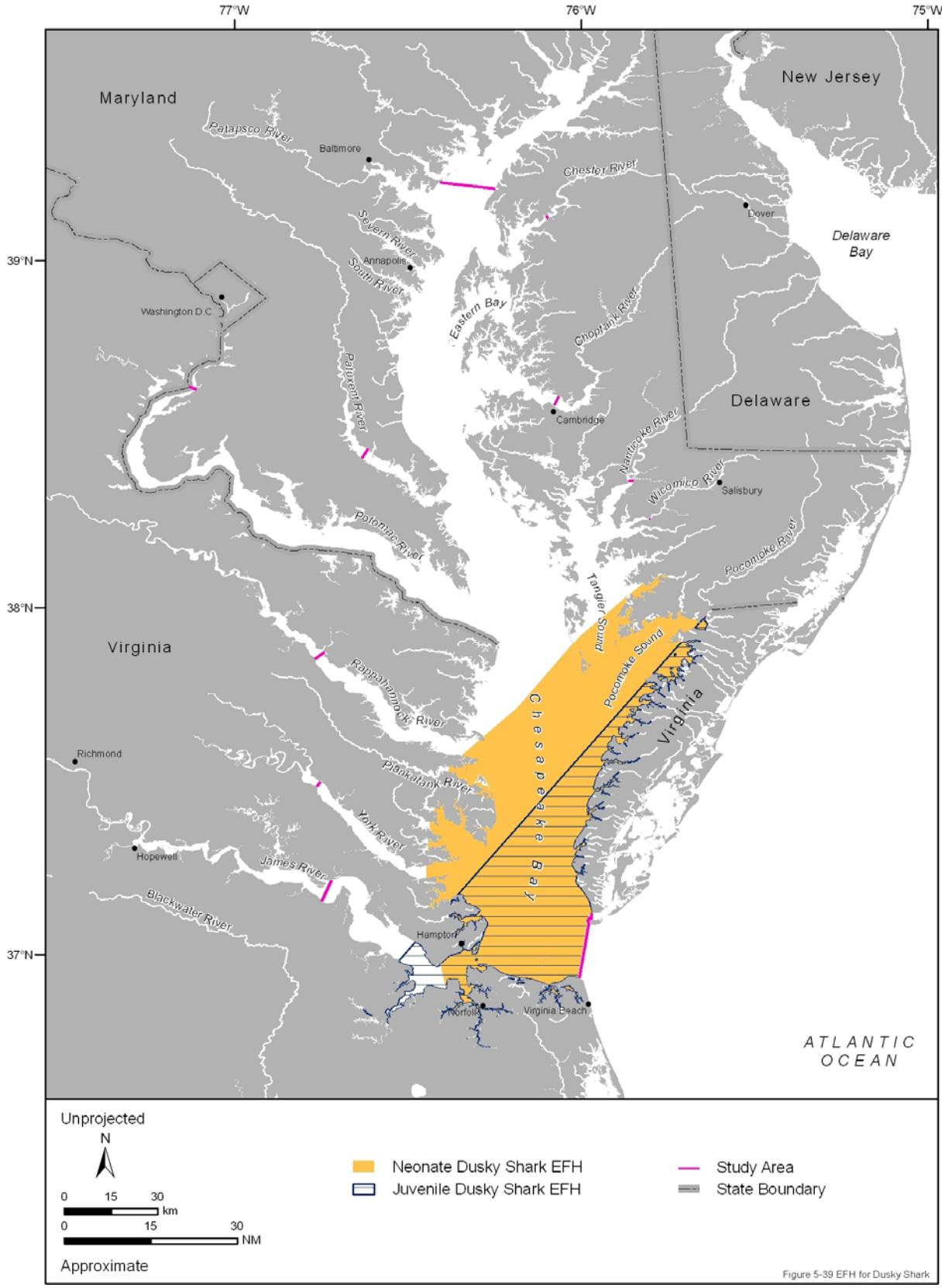

Figure 5-39. Essential fish habitat for neonates and juveniles of the dusky shark designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2003b).

- **Sand Tiger Shark (*Carcharias taurus*)**

Management—The sand tiger shark is managed by the NMFS under the Prohibited Species MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006b; NMFS 2008b).

Status—Under this FMP, the sand tiger shark receives full protection as a prohibited species from harvest on the Atlantic coast (NMFS 2008). 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 (2006c), but It is not currently overfished or subjected to overfishing (NMFS 2008). 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).[16]

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 and Burgess 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, Massachusetts, to Delaware Bay (Castro 1983).

- Information Specific to the Chesapeake Bay—The sand tiger shark is a common visitor in the summer and fall to the lower Chesapeake Bay, inhabiting shallow estuaries and coastal waters. Neonates and adults have been reported from the Chesapeake Bay Bridge Tunnel up to southwest and southeast of Tangier Island (Murdy et al. 1997; NMFS 2001).

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 1999; Branstetter and Burgess 2002b). Neonate and juvenile sand tiger sharks utilize estuarine waters (i.e., the Chesapeake Bay) and coastal sounds 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 1999; Branstetter and Burgess 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 and Burgess 2002b).

EFH Designations (NMFS 1999; NMFS 2003b; NMFS 2006b) (**Figure 5-40**)

- Neonate (≤117 cm TL)—EFH for the Chesapeake Bay is designated as the shallow coastal waters to 25 m for neonate sand tiger sharks.

- Juvenile (118 to 236 cm TL)—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

- Adult (≥237 cm TL)—EFH has not been designated in the inshore waters of Virginia or Maryland for this lifestage.

HAPC Designations—No HAPC are identified for this species by the NMFS.

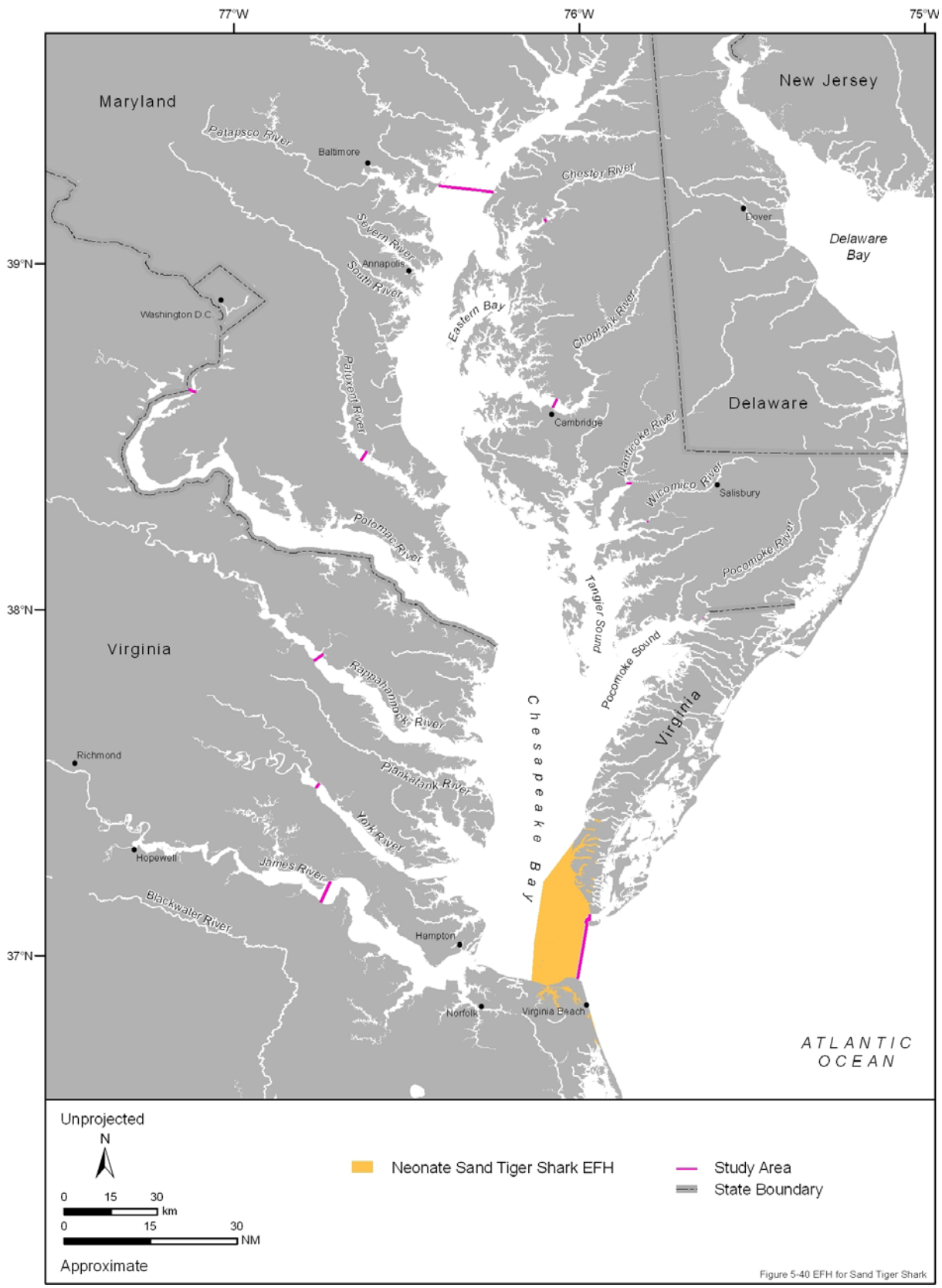

Figure 5-40. Essential fish habitat for neonates of the sand tiger shark designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2003b).

- **Sandbar Shark (*Carcharhinus plumbeus*)**

Management—The sandbar shark is managed by NMFS under the Large Coastal Shark MU through the Final Consolidated Atlantic HMS FMP (NMFS 2006b; NMFS 2008b).

Status—Sandbar shark has an overfished status and overfishing is occurring (NMFS 2008).[15] The IUCN Red List designates the northwest Atlantic stock as a lower risk but conservation dependent (Shark Specialist Group 2000b).[16]

Distribution—Sandbar sharks are cosmopolitan in distribution, found in shallow coastal waters from Cape Cod, Massachusetts, 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 and Burgess 2002a).

- Information Specific to the Chesapeake Bay—The sandbar shark is a seasonal visitor to the Chesapeake Bay in summer and fall (June to October) with juveniles common to abundant. All lifestages have been reported from Chesapeake Bay mouth up to Maryland's Pocomoke Sound and in all of the Virginia's major riverine systems. They are most common in Virginia's portion of the Chesapeake Bay (Murdy et al. 1997; NMFS 2001).

Habitat Associations—This bottom-dwelling species is found in temperate to tropical waters over the continental shelf and in deep water 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 55 m depths (Compagno 1984a; Knickle 1999). 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). In the Chesapeake Bay, this species prefers higher salinities (>16 psu) and is most often found over sand bars and in shallow grass beds (Geer 2002).[1]

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 1999). 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 1999; NMFS 1999; NMFS 2006b). 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 MAB (Branstetter and Burgess 2002a), especially the southeastern portion of the estuary, where salinity is greater than 20.5 psu and depth is greater than 5.5 m (NMFS 2008b).

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 1999; Ellis and Musick 2007).

EFH Designations—(NMFS 2003a; NMFS 2003b; NMFS 2006b) (**Figure 5-41**)

- Neonate (≤71 cm TL)—EFH for the Chesapeake Bay is designated as shallow coastal areas seaward offshore to 17 NM from shore for neonate sandbar sharks. Seasonally (summer), nursery areas within the shallow coastal waters of the Chesapeake Bay are also designated as EFH.

- Juvenile (71 to 147 cm TL)—EFH for the Chesapeake Bay is designated as shallow coastal areas out to the 25-m isobath offshore for juvenile sandbar sharks.

- Adult (≥147 cm TL)—EFH in the Chesapeake Bay is designated as the shallow coastal areas from the shore seaward offshore to 50 m for adult sandbar sharks.

HAPC Designations (NMFS 1999; NMFS 2003a; NMFS 2003b; NMFS 2006b) (**Figure 5-41**)

- All Lifestages—HAPC are designated in the shallow areas of the lower Chesapeake Bay since it represents important nursery and pupping grounds for sandbar sharks.

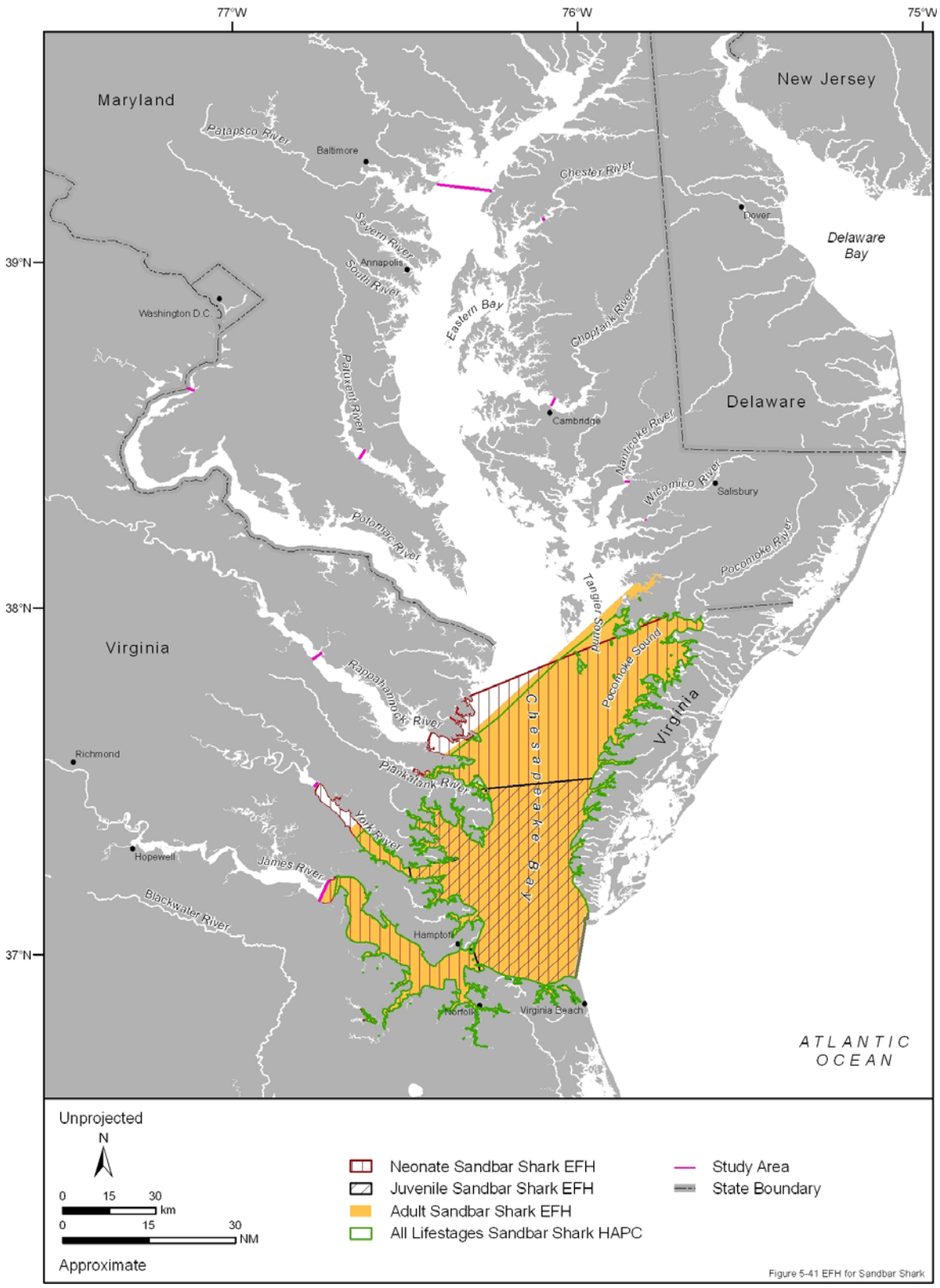

Figure 5-41. Essential fish habitat and habitat areas of particular concern (HAPC) for all lifestages of the sandbar shark designated in the Chesapeake Bay Study Area. Source maps (scanned): NMFS (2003b).

5.4 ASMFC MANAGED AND STATE PROTECTED SPECIES

The ASMFC consists of the 15 coastal states (Maine to Florida) that border the Atlantic Ocean. Similar to Regional Fishery Management Councils, the ASMFC serves as the primary marine resource management organization that coordinates the conservation and management of each state's shared nearshore fishery resources – marine, shell, and anadromous – for sustainable use. At this time, the ASMFC manages 22 Atlantic coastal fish species or species groups.[3] Seven of these species that are managed by ASMFC in the Chesapeake Bay have EFH and/or HAPC designation under the MSFCMA and are discussed in length in **Section 5.3**. Thirteen of the remaining species and the two species groups (coastal sharks and shad/river herring) that have HAPC designation by the ASMFC are listed in **Table 5-8**. Currently 40 species of coastal sharks are managed by ASMFC (**Table 5-9**). Fourteen of these sharks species occur seasonally in the Chesapeake Bay. Four shark species have EFH designation and have been discussed in detail in **Section 5.3**, while the remaining 10 species are presented in **Table 5-10**. Detail information about these 10 species can be found in NMFS (2008b). Information pertaining to the ASMFC 12 non-EFH species and the shad/river herring group consisting of their management, status, distribution (including location and seasonal occurrence in the Chesapeake Bay), habitat associations (substrate, depth, temperature, and salinity), life history (migration, movements, and spawning), common prey species, and HAPC are presented in **Tables 5-11** through **5-14**.

In addition, consistent with federal statutes and regulations, both Virginia and Maryland protect the shortnose and Atlantic sturgeons as endangered species (VDGIF 2006; MDNR 2007). Shortnose sturgeon are also listed as vulnerable on the IUCN Red List.[16] Detailed information on shortnose sturgeon is discussed in **Section 3.4**, whereas Atlantic sturgeon information is presented in **Table 5-12**.

Table 5-8. Atlantic coastal fishes managed under ASMFC Interstate Fishery Management Plans (ISFMPs). Taxonomy follows Nelson et al. (2004) for fishes.3

American eel (*Anguilla rsotrata*)	Shad and River herring
American lobster (*Homarus americanus*)[1]	American shad (*Alosa sapidissima*)
Atlantic croaker (*Micropogonias undulates*)	Hickory shad (*Alosa mediocris*)
Atlantic herring (*Clupea harengus*)[2]	Alewife (*Alosa pseudoharengus*)
Atlantic menhaden (*Breoortia tyrannus*)	Blueback herring (*Alosa aestivalis*)
Atlantic striped bass (*Morone saxatilis*)	Spanish mackerel (*Scomberomorus maculates*)[2]
Atlantic sturgeon (*Acipenser oxyrhynchus*)	Spiny dogfish (*Squalus acanthias*)/Coastal sharks[4]
Black sea bass (*Centropristis striata*)[2]	Spot (*Leiostomus xanthurus*)
Bluefish (*Pomatomus saltatrix*)[2]	Spotted seatrout (*Cynoscion nebulosus*)
Horseshoe crab (*Limulus polyphemus*)	Summer flounder (*Paralichthys denatus*)[2]
Northern shrimp *(Pandalus borealis*)[1]	Tautog (*Tautog onitis*)
Red drum (*Sciaenops ocellatus*)[3]	Weakfish (*Cynoscion regalis*)
Scup (*Stenotomus chrysops*)[2]	Winter flounder (*Pseudopleuronectes americanus*)

[1] Not found in the Chesapeake Bay
[2] EFH species
[3] Previous designated EFH species in the Chesapeake Bay
[4] See **Table 5-8** for list of managed ISFMP Atlantic shark species

Table 5-9. Atlantic coastal sharks managed under ASMFC Interstate Fishery Management Plan (ISFMP). Taxonomy follows Nelson et al. (2004) for fishes. (Murdy et al. 1997; ASMFC 2008b)

Atlantic angel (*Squatina dumeril*)[1]
Atlantic sharpnose (*Rhizoprionodon terraenovae*)[2]
Basking (*Cetorhinus maximus*)[1]
Bigeye sand tiger (*Odontaspis noronhai*)
Bigeye sixgill (*Hexanchus nakamuri*)
Bigeye thresher (*Alopias supercilious*)
Bignose (*Carcharhinus altimus*)
Blacknose (*Carcharhinus acronotus*)
Blacktip (*Carcharhinus limbatus*)[1]
Blue (*Prionace glauca*)
Bluntnose sixgill *(Hexanchus griseus*)
Bonnethead (*Sphyrna tiburo*)[1]
Bull (*Carcharhinus leucas*)[1]
Caribbean sharpnose (*Rhizoprionodon porosus*)
Common thresher (*Alopias vulpinus*)
Dusky (*Carcharhinus obscurus*)[2]
Galapagos (*Carcharhinus galapagensis*)
Great hammerhead (*Sphyrna mokarran*)
Finetooth (*Carcharhinus isodon*)
Lemon (*Negaprion brevirostris*)[1]
Longfin mako (*Isurus paucus*)
Narrowtooth (*Carcharhinus brachyurus*)
Night (*Carcharhinus signatus*)
Nurse (*Ginglymostoma cirratum*)
Oceanic whitetip (*Carcharhinus longimanus*)
Porbeagle (*Lamna nasus*)
Reef (*Carcarhinus perezii*)
Sand tiger (*Carcharias taurus*)[2]
Sandbar (*Carcarhinus plumbeus*)[2]
Scalloped hammerhead (*Shpyrna lewini*)[1]
Sharpnose sevengill (*Heptranchias perlo*)
Shortfin mako (*Isurus oxyrinchus*)
Silky (*Carcarhinus falciformis*)
Smalltail (*Carcharhinus porosus*)
Smooth dogfish (*Mustelus canis*)[1]
Smooth hammerhead (*Sphyrna zygaena*)[1]
Spinner (*Carcharhinus brevipinna*)
Tiger (*Galeocerdo cuvier*)[1]
Whale (*Rhincodon typus*)
White (*Carcharodon carcharias*)

[1] See **Table 5-9** for Atlantic coastal sharks that occur or have been reported in the Chesapeake Bay
[2] EFH species

Table 5-10. Atlantic coastal sharks managed under ASMFC Interstate Fishery Management Plan (ISFMP) that occur in the Chesapeake Bay. Taxonomy follows Nelson et al. (2004) for fishes. (Murdy et al. 1997; ASMFC 2008b) 17

Shark Species	Occurrence	Location in the Chesapeake Bay
Atlantic angel	Seasonal (summer through fall)	Occasionally found in the lower bay, but rare in the upper bay
Basking	Occasional (may enter bay in early spring)	Mainstem bay
Blacktip	Rare (summer)	Common along the Eastern Shore, occasionally moves into the bay
Bonnethead	Occasional (summer)	Found in the lower bay in 10 m to 25 m depths with sand/mud bottoms
Bull	Occasional (summer)	Found in the mainstem bay; extending as far north as the Patuxent and Susquehanna rivers
Lemon	Rare (summer)	Common along the Eastern Shore, occasionally moves into the bay
Scalloped hammerhead	Rare (summer)	Common along Virginia coast, near the bay mouth at Cape Charles
Smooth dogfish	Common to abundant (seasonal: summer and fall; juveniles abundant throughout summer)	Found in the lower bay extending as far north as the mouth of Patuxent River in waters <18 m with mud/sand bottoms
Smooth hammerhead	Rare to occasional (seasonal: summer or fall)	Found in the lower bay extending as far north as mouth of Choptank River
Tiger	Rare (summer)	Found in the lower bay at Smith Island shoal and bay mouth; common in coastal waters

Table 5-11. Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	American eel (*Anguilla rostrata*)	Atlantic croaker (*Micropogonias undulates)*	Atlantic menhaden (*Brevoortia tyrannus*)	Atlantic striped bass (*Morone saxatilis)*
Management	IFMP for American eel	Amendment 1 to the IFMP for Atlantic croaker	Amendment 1 to the IFMP for Atlantic menhaden	Amendment 6 to IFMP for Atlantic striped bass
Status	Unknown (if overfished), Unknown (whether overfishing is occurring)	Mid-Atlantic stock: not overfished; overfishing not occurring	Not overfished; overfishing not occurring	Not overfished; overfishing not occurring
Distribution	Southern tip of Greenland to northeastern South America (Atlantic coast of North America, Gulf of Mexico, Caribbean Sea, and Central America to Venezuela), St. Lawrence Seaway, and Great Lakes	Gulf of Maine to Argentina (U.S. Atlantic coastal waters: Massachusetts to Florida and Gulf of Mexico); uncommon north of New Jersey)	Nova Scotia, Canada to northern Florida	St. Lawrence River, Canada to St. John's River, Florida, and Gulf of Mexico (western Florida to Louisiana); most abundant from Maine to North Carolina
Chesapeake Bay	All tributaries of the Chesapeake Bay: at depths of 4 to 10 m, temperature between 13°C and 27°C, DO levels between 5 mg/L and 9 mg/L, and salinities from 2 to 27 psu, over detritus, hydroid, or shell bottoms	Found in the Chesapeake Bay as far north as Susquehanna Flats at salinities >5 psu during spring through summer	Found throughout the Chesapeake Bay during spring, summer, and fall in all salinities	Year-round resident in all tributaries from Havre de Grace, Maryland, to Cape Henry, Virginia; major spawning area
Habitat Associations	Small freshwater streams, lakes, and ponds, rivers, large coastal tributaries, estuaries, and open ocean; eggs/larvae – pelagic upper 250 m at temperature <18.2°C; juveniles (elver) – wide variety of benthic substrates/water temperatures at currents >25 cm/sec; adults – bottom substrate oriented, variable depths, salinity, and temperature, and high density with large velocity-depth regime	Freshwater creeks, tidal rivers/inlets, estuaries, and coastal waters: juveniles – shallow marsh habitats with mud bottoms containing large amounts of detritus; adults – seagrass beds, oyster, coral, and sponge reefs, and artificial structures on muddy/sandy substrates, temperatures from 5° to 36°C and salinities from 2 to 70 psu (most common 6 to 20 psu)	River shoals/small tidal creeks, estuaries, bays, and coastal waters: larvae/juveniles – pelagic, shallow, low-salinity (<10 psu) estuaries used as nursery areas over unconsolidated bottom substrate (mud/sand with various mixture of organic material and fresh tidal marshes/swamps; adults – pelagic, over unconsolidated bottom in waters of varying salinities (3.5 to 32.0 psu) and water temperatures around 18°C	Freshwater, estuarine, and inshore habitats: eggs (buoyant/semi-buoyant) - low salinities (2 to 10 psu) and DO (3 to 5 mg/L) at 18°C ; larvae (pelagic) and juveniles (demersal) - clean, sandy shallow bottoms, salinity ranging (0.2 to 16.0 psu), DO (6 to 12 mg/L), and temperature (larvae: 15° to 22°C, juveniles: 18° to 23°C); juveniles also found over gravel beaches with mud, sand, gravel, and rock; adults - wide variety of substrates (rock and boulders, gravel, sand, SAV, and mussel beds) and habitats (sandy beaches, rocky shores, surf zone, areas hollowed out by wave action, sand bars, and floating seaweed.

Table 5-11 (*continued*). Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	American eel (*Anguilla rostrata*)	Atlantic croaker (*Micropogonias undulates)*	Atlantic menhaden (*Brevoortia tyrannus*)	Atlantic striped bass (*Morone saxatilis)*
Life History	Catadromous: migrates to ocean to reproduce in water temperatures ranging from 18° to 19°C and at depths between 200 m and 300 m; spawning grounds (February to April) located in the Sargasso Sea, a large portion of the western Atlantic Ocean, east of the Bahamas and south of Bermuda; migrates in freshwater according to nightly tidal height, river water temperatures and discharges, and difference between bay and river temperatures	Migrates north and inshore during warmer months and south into the ocean during the winter; spawning: July to February in tidal inlets, estuaries, and continental shelf at temperatures (16° to 25°C) and depths (7 to 81 m)	Extensive seasonal migrations: north during the summer and south during the winter; spawning in shelf waters: March to May and September to October	Anadromous school species: Atlantic coastal rivers from Albemarle Sound (North Carolina) north, migratory, traveling annually from the ocean to riverine spawning grounds and back to ocean; spawning occurs in freshwater near the heads of Atlantic coast estuaries, or far inland up major tributaries in 40 km over sand/mud at temperatures (14.4° to 21.1°C peaking from 17.8° to 20.0°C) from April to early June; undertake northern summer and southward winter migrations
Common Prey Species	Omnivores: insects, mollusks, crustaceans, worms, and fish	Opportunistic feeder: polychaete worms, mollusks, small crustaceans, and small fish	Filter feeders: phytoplankton and zooplankton	Piscivorous: small fish, invertebrates, crabs, and squid
HAPC Designation	Oceanic waters of the Sargasso Sea, continental shelf, and estuarine/freshwater habitats	Estuaries - important nursery and spawning areas	Marine-subtidal [1]; Estuarine-subtidal [2]; River-tidal [3]	Spawning sites; nursery areas; inlets that allow passage between inland riverine spawning and estuarine nursery habitats; and offshore (6 to 8 km) wintering grounds: Long Island Sound south to at least Topsail Island, North Carolina

[1] Marine-subtidal: This habitat type is utilized by spawning adults (eggs), pre-estuarine immigrant larvae, post-estuarine emigrant juveniles, and sub-adults.[3]
[2] Estuarine-subtidal: In the Mid- and South Atlantic, estuarine habitat utilized for transformation and early development is one of the most critical and vulnerable habitats.[3]
[3] Riverine-tidal: The interface with this habitat type and estuarine areas represent the upstream extent of larval movement for transformation and early juvenile development.[3]

Table 5-12. Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	Atlantic sturgeon (*Acipenser oxyrhynchus*)	Horseshoe crab (*Limulus polyphemus*)	Spiny dogfish (*Squalus acanthias*)	Spot (*Leiostomus xanthurus*)
Management	Amendment 1 to the IFMP for Atlantic sturgeon	IFMP for horseshoe crab	IFMP for spiny dogfish	IFMP for spot
Status	Overfished; overfishing not occurring; 40+ year moratorium to be rebuilt by ~2038; candidate species	Unknown (if overfished), unknown (whether overfishing is occurring)	Not overfished; overfishing not occurring	Unknown, unknown whether overfishing is occurring
Distribution	Labrador, Canada (Churchill and George rivers, Ungava Bay) to Port Canaveral and Hutchinson Island, Florida	Northern Maine to the Yucatan Peninsula and Gulf of Mexico; most abundant from New Jersey to Virginia with center of abundance in Delaware Bay	Circumboreal; western Atlantic Ocean: Labrador, Canada to Florida; most abundant from Nova Scotia to Cape Hatteras, North Carolina	Gulf of Maine to Florida and Bay of Campeche off northern Mexico; most abundant from the Chesapeake Bay to South Carolina
Chesapeake Bay	Found in the Chesapeake Bay during April and May; limited spawning populations in James and York rivers	Found in the Chesapeake Bay near coastal beaches to mouth of Chester River, Maryland, but can occur farther north during years of above normal salinity levels; shoal water/shallow waters; important nursery area	Found in the lower Chesapeake Bay (south of the mouth of the Potomac River): early spring and late fall	Found throughout the Chesapeake Bay often penetrating tributaries to the lower reaches of freshwater
Habitat Associations	Freshwater rivers, coastal estuaries, and open ocean: eggs/larvae - hard substrate, deep channels (9.1 to 19.8 m), and temperatures (15.0° to 24.5°C); juveniles (estuarine)- sand, mud, or transitional, deep water and holes (2 to 37 m), salinity (>3 psu), and temperatures (0.5° to 27.0°C)/ (open ocean) – sand, gravel, silt, and clay from 7 to 43 m; adults (freshwater) – hard substrate from 3 to 27 m, current flow (0.46 to 0.76 m/s), and temperature (13.0° to 23.4°C)/ (estuarine) – fine mud, sand, pebbles, and shell substrate from 1.5 to 60 m, salinity (0 to 28.6 psu), and temperature high as 33°C	Estuaries, bays, and continental shelf: eggs – porous, well-oxygenated sediments (11.5 cm) Intertidal zone; larvae – nearshore shallow waters; juveniles – shallow, intertidal flats; adults – subtidal at depths <30 m	Continental shelf (North Carolina to the eastern edge of Georges Bank): juveniles – pelagic, depths (50 to 150 m) and bottom temperatures (8° to 13°C); adults – demersal, sand, silt, and mud, depths (10 to 49 m) and bottom temperatures (7° to 13°C)	Estuarine(low salinity bays and tidal marsh creeks) and coastal waters: mud and detrital bottoms;. juveniles - eelgrass beds, DO <5 mg/L; adults - wide-range salinities (1 to 60 psu) and temperatures (1° to 37°C)

Table 5-12 (*continued*). Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	Atlantic sturgeon (*Acipenser oxyrhynchus*)	Horseshoe crab (*Limulus polyphemus*)	Spiny dogfish (*Squalus acanthias*)	Spot (*Leiostomus xanthurus*)
Life History	Anadromous, migrating from the ocean into coastal estuaries and rivers to spawn; spawning occurs in tidal freshwater regions in April and May; fish spawn once every 2 to 6 years	Adults either remain in estuaries or migrate to overwinter on continental shelf; migrations resume in the spring to sandy beach areas within bays/coves to spawn; juveniles spend the first 2 years in nearshore areas: spawning usually coincides with the high tide during the full and new moon phase	Major migrations: north in spring/summer and south in fall/winter and inshore (estuaries) and offshore seasonally in response to water temperatures; undergo daily vertical migrations; ovoviviparous - mating and pupping occurs in the winter months: gestation (18 to 24 months) and litters (2 to 15)	Migrate seasonally between estuarine and coastal waters; enter bays and estuaries in spring, where they remain until late summer or fall, then move offshore to spawn; .undergo north (summer) to south (fall) migrations, spawn in late fall to early spring peaking in February
Common Prey Species	Omnivorous, opportunistic benthic feeders: mollusks, insects, crustaceans	Benthic organisms: mostly mollusks; vascular plants	Opportunistic predatory feeders: fishes, crustaceans, and squid	Opportunistic bottom feeders: polychaete worms, small crustaceans, and mollusks as well as organic material
HAPC Designation	Spawning sites/hatching grounds, nursery areas, estuarine inlets, and wintering grounds (Gulf of Maine to Cape Lookout, North Carolina	Nearshore, shallow water intertidal flats (juveniles) and sandy beaches (adults): Delaware Bay and Maryland's Chesapeake Bay	Ocean bottom habitat and estuarine areas for refuge, foraging, or both	Estuaries - important nursery grounds

Table 5-13. Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	Spotted seatrout (*Cynoscion nebulosus*	Tautog (*Tautoga onitis)*	Weakfish (*Cynoscion regalis*)	Winter flounder (*Pseudopleuronectes americanus*)
Management	IFMP for spotted seatrout	Amendment 3 to IFMP for tautog	Amendment 4, and its addenda, to the IFMP for weakfish	Amendment 1 to the IFMP for inshore stocks of winter flounder
Status	Unknown, unknown whether overfishing is occurring	Overfished; overfishing not occurring	Depleted; overfishing is not occurring	Overfished; overfishing is occurring in SNE/MA stock
Distribution	Cape Cod, Massachusetts, to the Florida Keys; most abundant from the Chesapeake Bay southward; year-round residents of estuaries along the South Atlantic coast	Nova Scotia, Canada to South Carolina; most abundant from Cape Cod, Massachusetts, to the Chesapeake Bay	Massachusetts to Cape Canaveral, FL, occasional to Nova Scotia, Canada and into the eastern Gulf of Mexico;, most common between Long Island, New York, and North Carolina; important wintering grounds located in offshore waters from the Chesapeake Bay to Cape Lookout, North Carolina	Labrador, Canada to Georgia; most common from New England to New Jersey with smaller populations extending to the Chesapeake Bay
Chesapeake Bay	Found in throughout the bay; most abundant in the lower Chesapeake Bay's shallow creeks and rivers adjacent to eelgrass and widgeon grass beds	Year-round resident near the Chesapeake Bay entrance, seasonally extending as far north as Chester River, Maryland, around wrecks and structures.	Found throughout the Chesapeake Bay: larvae/juveniles - summer/late-summer months; larger/older fish – the lower Chesapeake Bay April to May	Found throughout the Chesapeake Bay from the Susquehanna River to the mouth; less common during summer, more abundant during the winter
Habitat Associations	Estuarine and coastal waters; eggs – pelagic; juveniles - seagrass or oyster beds, tidal pools, small creeks, and surf zone; adults - most abundant in semi-landlocked lagoons and quiet estuaries; wide-ranging salinities (0.2 to 75.0 psu) and temperatures (15° to 27°C)	Estuarine and coastal waters: eggs – buoyant and pelagic; larvae – planktonic/benthic, estuary-ocean gradient; juveniles/adults - vegetation, rocks, natural and artificial reefs, jetties, groins, mussel and oyster beds, and man-made structured coastal habitats; depth (25 to 45 m) and temperatures (<10° to >11°C)	Estuarine and coastal waters: eggs – pelagic at salinities (>30 psu) and temperatures (20° to 21°C); larvae – pelagic, low-salinity; juveniles – demersal, sand or sand/seagrass bottoms; adults – demersal, shallow, sand bottom areas with salinities (>10 psu), along eelgrass and channel edges, rock, and oyster reefs	Estuaries, coastal waters, and offshore fishing banks: eggs, adhesive/demersal, sand, muddy sand, mud and gravel,, diatom mats/drifting macroalgae, depth (0.3 to 4.5 m), salinity (10 to 32 psu), DO (11.1 to 14.2 mg/L), and temperature (3° to 5°C); larvae – fine sand/gravel, depth (1.0 to 4.5 m), salinity (3.2 to 30.0 psu), DO (10.0 to 16.1 mg/L), and temperature (2° to 15°C); YOY – mud to sand with shell or leaf litter, sea lettuce (*Ulva*), eelgrass and unvegetated adjacent areas, depth (0.5 to 12.0 m), salinity 23 to 33 psu), DO (2.2 mg/L), and temperature (2.0° to 29.4°C); juveniles – mud or sand

Table 5-13 (*continued*). Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	Spotted seatrout (*Cynoscion nebulosus*	Tautog (*Tautoga onitis)*	Weakfish (*Cynoscion regalis*)	Winter flounder (*Pseudopleuronectes americanus*)
Habitat Associations				shell, depth (18 to 27 m inshore/<100 m), salinity (19 to 21 psu), and temperature (10° to 25°C); adults – mud, sand, cobble, rocks, boulders, depth (1 to 30 m inshore/<100 m), salinity (15 to 33 psu), and temperature (0.6° to 23.0°C); nursery habitat includes littoral/sublittoral saltwater coves, coastal salt ponds, estuaries, and protected embayments
Life History	Migrate offshore and south (deeper channels and holes, and occasionally along beaches) in fall, returning in spring to estuaries; spawning occurs at night in estuaries and nearshore coastal waters at temperatures (21° to 28°C) from mid-April to September, peaking in May and July	Seasonal inshore-offshore migrations triggered by changes in bottom water temperatures; spawn in or near the entrances of estuaries and offshore (wrecks/reefs) from late April to early August with peaks in June and July at temperatures (17° to 21°C)	Migrate spring-summer northward and inshore and fall-winter southward and offshore triggered by water temperatures; spawning occurs from April to August peaking from May through June	Migrations inshore-offshore related to spawning behavior/water temperature; seasonal movements consist of two phases: an autumn estuarine immigration prior to spawning, and a late spring/summer movement to either deeper, cooler portions of estuaries or to more offshore areas; in more southerly regions, remain in shallow waters; spawning occurs from November to April when water temperatures range from 0° to 6°C
Common Prey Species	Opportunistic carnivores: crustaceans and fish	Opportunistic feeders-invertebrates: mollusks (both univalves and bivalves), mussels, barnacles, crustaceans, amphipods, isopods, decapods, echinoderms; and occasionally small fishes	Opportunistic feeders-small fish, large zooplankton, shrimp, and crabs; become more piscivorous with age	Small crustaceans and worms
HAPC Designation	Seagrass beds	Bottom structured habitats (such as outcrops, reefs, and SAV) and inlets adjacent to estuaries: serve as important refuge and spawning sites	Spawning areas (coastal bays, sounds, and nearshore Atlantic Ocean): nursery areas (upper/lower portions of rivers and associated bays and estuaries	Spawning habitats (shallow areas (<5 m) in the upper estuary, suitable coves and river mouths; nursery habitats (in or near spawning and settlement areas; estuaries important foraging areas for adults

Table 5-14. Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	American shad (*Alosa sapidissima*)	Hickory shad (*Alosa mediocris*)	Alewife (*Alosa pseudoharengus*)	Blueback herring (*Alosa aestivalis*)
Management	Amendment 1, Technical Addendum 1 and Addendum I to the IFMP for American shad and river herring	Amendment 1, Technical Addendum 1 and Addendum I to the IFMP for American shad and river herring	Amendment 1, Technical Addendum 1 and Addendum I to the IFMP for American shad and river herring; species of concern.	Amendment 1, Technical Addendum 1 and Addendum I to the IFMP for American shad and river herring; species of concern.
Status	Depleted; overfishing is not occurring	Unknown (whether the stock is overfished); unknown (whether overfishing is occurring)	Unknown (whether the stock is overfished); unknown (whether overfishing is occurring)	Unknown (whether the stock is overfished); unknown (whether overfishing is occurring)
Distribution	St. Lawrence River, Canada to the St. Johns River, FL	Cape Cod, MA to the Tomoka River, Florida; most abundant from New York southward.	Newfoundland, Canada to North Carolina; most abundant in the Mid-Atlantic and Northeast states	Cape Breton, Nova Scotia and the Miramichi River, New Brunswick to the St. John's River, Florida; most numerous in waters from the Chesapeake Bay south
Chesapeake Bay	Found in the Chesapeake Bay rivers as far north as the Susquehanna River	Found in the Chesapeake Bay rivers (~ as far north as the Susquehanna River)	Found in the Chesapeake Bay rivers, streams, and ponds	Found in the Chesapeake Bay rivers and streams
Habitat Associations	Riverine, estuarine, and oceanic: semi-buoyant eggs – gravel, rubble, and sand in shallow water, current velocity (0.3 to 0.9 m/s), and temperature (8° to 30°C); larvae – pelagic, depth (0.46 to 15.24 m), current velocity (0.3 to 0.9 m/s), and temperature (10° to 30°C); early juvenile (riverine) – boulder, cobble, gravel, sand, and SAV, depth (0.46 to 15.24 m), current velocity (0.1 to 0.8 m/s), salinity (0 to 30 psu), and temperature (3° to 35°C); sub-adult/non-spawning adult	Available information is limited, but habitats are assumed to be similar to American shad; riverine, estuarine, and oceanic: eggs (adhesive)/larvae – depth (6.1 m), DO (between 5 mg/L and 10 mg/L), pH (6.4 to 6.6), and temperature (eggs: 9.5° to 22.0°C); early juvenile (riverine/estuarine) - DO (4.1 to 10,9 mg/L), salinity (10 to 20 psu), and temperature (16° to 31°C); sub-adult/non-spawning adult (estuarine/oceanic) – move offshore when temperatures reach 31°C; and spawning adult (riverine) -	Riverine, estuarine, and oceanic: eggs (demersal and pelagic)/larvae - substrates with 75% silt or other soft material containing detritus and vegetation, low flow, DO (>5 mg/L), and temperature (range 8° to 31°C); early juvenile (riverine) – SAV, current velocity (avoid >10 m/s), DO (>3.6 mg/L), and temperature (4° to 27°C); sub-adult/non-spawning adult – depth (46 to 192 m) and temperature (2° to 23°C); and spawning adult (riverine) - sand, gravel, cobble or coarse	Riverine, estuarine, and oceanic: eggs (demersal and semi-pelagic)/larvae - substrates with 75% silt or other soft material containing detritus and vegetation, DO (>5 mg/L), salinity (0 to 22 psu), and temperature (range 7° to 28°C); early juvenile (riverine) – SAV, current velocity (avoid >10 m/s), DO (>3.6 mg/L), salinity (0 to 28 psu), and temperature (11° to 32°C); sub-adult/non-spawning adult – depth (27 to 55 m) and temperature (2° to 20°C); and spawning adult (riverine) - sand, pebbles, or gravel, swift-flowing

Table 5-14 (*continued*). Life history characteristics of the ASMFC managed Chesapeake Bay fish species with Habitat Areas of Particular Concern (HAPC) designation (Murdy et al. 1997; Pereira et al. 1999; Arendt 2001; Stehlik 2007; ASMFC 2009; Greene et al. 2009).[3,15]

Categories	American shad (*Alosa sapidissima*)	Hickory shad (*Alosa mediocris*)	Alewife (*Alosa pseudoharengus*)	Blueback herring (*Alosa aestivalis*)
Habitat Associations	(estuarine/oceanic) – depth (0 to 340 m) and temperature (7° to 13°C); and spawning adult (riverine) – sand, silt, gravel, and boulder, depth (0.46 to 15.24 m), current velocity (0.3 to 0.9 m) and temperature (8° to 26°C)	cobble, gravel, or sand with ledges/fallen trees, DO (5.7 to 11.8 mg/L), current velocity (0.20 to 0.39 m/s), and temperatures (8° to 22°C); rivers, bays, and estuaries used a nursery areas for juveniles	stone substrate to SAV or organic detritus, slow-moving waters, depth (0.2 to 3.0 m), DO (>5 mg/L), and temperature (10.5° to 21.6°C).	waters, DO (>5 mg/L), salinity (0 to 6 psu), and temperature (13° to 27°C).
Life History	Anadromous coastal pelagic species, migrating inshore (natal rivers)-northward in the spring to spawn and offshore-southward in the fall to overwintering grounds (i.e., Maryland to North Carolina); spawning occurs from April to June over fresh to low-salinity flats in tributaries (Maryland and Virginia rivers)	Anadromous, ascend coastal rivers during spring migration, return to ocean by mid-summer; oceanic distribution and movements are unknown; spawning occurs in freshwaters reaches of coastal rivers, flooded swamps, and channels of tributary creeks from Maryland south	Anadromous, highly migratory, euryhaline, pelagic, schooling species; follow a south-north seasonal migration in response to water temperatures; undergo diel movements controlled by light intensity patterns; spawning occurs in late March or April within slow-moving shallow sections of rivers and streams and barrier beaches.	Anadromous, highly migratory, euryhaline, pelagic, schooling species; follow a north-south seasonal migration in response to water temperatures and light intensity; undergo diel vertical migrations in response to prey movement/availability; spawning occurs in early April (lower tributaries) and late April (upper reaches)
Common Prey Species	Plankton, fish eggs, and small crustaceans and fishes; do not feed while migrating upriver	Piscivorous: small fish, squid, small crabs, pelagic crustaceans, and fish eggs.	Planktivores: diatoms, copepods, ostracods, shrimps, amphipods, insects, small fish, squid, and fish eggs	Planktivores: diatoms, copepods, ostracods, shrimps, amphipods, insects, small fish, squid, and fish eggs
HAPC Designation	Spawning sites, nursery areas; inlets that provide access to coastal bays, estuaries, and riverine habitats upstream to spawning grounds, and sub-adult and adult nearshore ocean habitat	Spawning sites, nursery areas; inlets that provide access to coastal bays, estuaries, and riverine habitats upstream to spawning grounds, and sub-adult and adult nearshore ocean habitat	Spawning sites, nursery areas; inlets that provide access to coastal bays, estuaries, and riverine habitats upstream to spawning grounds, and sub-adult and adult nearshore ocean habitat	Spawning sites, nursery areas; inlets that provide access to coastal bays, estuaries, and riverine habitats upstream to spawning grounds, and sub-adult and adult nearshore ocean habitat

5.5 ADDITIONAL COMMERCIAL, RECREATIONAL, AND FORAGE FINFISH SPECIES

In addition to the EFH and ASMFC managed species, other low volume commercial and recreational finfishes along with various forage species provide an important resource to the seasonal dynamics of the Chesapeake Bay ecosystem. These low volume commercial and recreational finfishes are secondary components that add to the overall fisheries in the Chesapeake Bay. Forage fishes are small fishes that mature at a young age and although some are not of direct commercial and/or recreational importance, they are of considerable indirect value as a forage (prey) resource for other fishes and wading birds and as bait for fisherman (Houde 1993). Information pertaining to these species consisting of their fishing interest (direct or indirect), location, and habitat in the Chesapeake Bay, and references are presented in **Table 5-15**.

Table 5-15. Additional commercial, recreational, and forage finfish species that occur in the Chesapeake Bay (Murdy et al. 1997; MDNR 1999; Fabrizio and Montane 2007).

Species	Fishing Interest: Direct or Indirect	Chesapeake Bay Location and Habitat	References
Bay anchovy (*Anchoa mitchilli*)	Indirect: Forage	Main bay and lower reaches of tributaries	(Morton 1989)
Striped anchovy (*Anchoa hepsetus*)	Indirect: Forage	Entire bay	(Murdy et al. 1997)
White catfish (*Ameiurus catus*)	Direct: Commercial; and recreational	Tributaries	(Manooch III 1988)
Channel catfish (*Ictalurus punctatus*)	Direct: Commercial and recreational	Tributaries	(Manooch III 1988)
Blue catfish (*Ictalurus furcatus*)	Direct: Recreational	Brackish waters of tributaries	(Murdy et al. 1997)
Sheepshead minnow (*Cyprinodon variegates*)	Indirect: Bait and forage	Mainstem bay: shallow flats, marshes, and tidal ponds	(Murdy et al. 1997)
Striped killifish (*Fundulus majais*)	Indirect: Bait and forage	Entire bay: tidal creeks, sand flats, and grass beds	(Abraham 1985)
Mummichog (*Fundulus heteroclitus*)	Indirect: Bait and forage	Entire bay: muddy marshes, channels, and grass flats	(Abraham 1985)
Atlantic silversides (*Menidia menidia*)	Indirect: Bait and forage	Shore zone of entire bay, also tidal creeks and grass flats	(Fay et al. 1983)
Inland silversides (*Menidia beryllina*)	Indirect: Forage	Entire bay: tidal creeks and grass flats	(Martin and Drewry 1978)
Harvestfish (*Peprilus alepidotus*)	Direct: Minor Commercial and limited recreational	Lower bay: sand and mud bottoms, floating vegetation, and jellyfishes	(Martin and Drewry 1978)
Greater amberjack (*Seriola dumerili*)	Direct: Recreational	Lower bay: reefs, rocks, outcrops, and wrecks	(Johnson 1978)
Black drum (*Pogonias cromis*)	Direct: Commercial and recreational	Lower bay: west of Cape Charles, VA	(Manooch III 1988)
Kingfishes (*Menticirrhus* spp.)	Direct: Limited Commercial	Lower bay: firm bottoms	(Murdy et al. 1997)
Silver perch (*Bairdiella chrysoura*)	Direct: Limited Commercial	Mainstem bay: shallow seagrass beds	(Manooch III 1988)
Atlantic spadefish (*Chaetodipterus faber*)	Direct: Minor Commercial	Mid to lower part of bay: towers, buoys, and other structures	(Johnson 1978)
Seaboard goby (*Gobiosoma ginsburgi*)	Indirect: Forage	Mainstem bay: deeper flats and oyster reefs	(Fritzsche 1978)
Naked goby (*Gobiosoma bosc*)	Indirect: Forage	Mainstem bay: fresh to marine shallow waters, vegetated flats, oyster reefs, and firm substrates	(Fritzsche 1978)

Table 5-15 (*continued*). Additional commercial, recreational, and forage finfish species that occur in the Chesapeake Bay (Murdy et al. 1997; MDNR 1999; Fabrizio and Montane 2007).

Species	Fishing Interest: Direct or Indirect	Chesapeake Bay Location and Habitat	References
White perch (*Morone americana*)	Direct: Important commercial and recreational, especially in Maryland waters	All tributaries: level bottoms of compact silt, mud, sand, or clay	(Hardy 1978)
Sheepshead (*Archosargus probactocephalus*)	Direct: Recreational, where abundant	Mid to lower bay: jetties, wharves, pilings, shipwrecks, and other structures encrusted with oysters, barnacles, and mussels	(Johnson 1978)
Pigfish (*Orthopristis chrysoptera*)	Direct: Minor Commercial and recreational	Lower to upper bay: mud bottoms and sandy, vegetated areas	(Manooch III 1988)

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6.0 ADDITIONAL CONSIDERATIONS

6.1 INTRODUCTION

This chapter includes brief descriptions of additional topics that may be relevant to the Chesapeake Bay Study Area. These topics include commercially navigable waterways and shipping lanes, recreational dive sites, and current research that occur in the Chesapeake Bay and its major tributaries. Previous MRAs have included maritime boundaries as one of the topics in this chapter; however, because the entire Chesapeake Bay is located within the inshore state waters of Maryland and Virginia, a discussion on the U.S territorial sea, contiguous zone, and exclusive economic zone, is not relevant.

6.2 COMMERCIALLY NAVIGABLE WATERWAYS/ SHIPPING LANES

Navigable waters are defined as "…those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which 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 of commercially navigable waterways exists within the U.S. transportation system (BTS 2004).

The U.S. Atlantic coast supports a large volume of both domestic and international maritime traffic. Waterways and shipping lanes connect major ports along the coast with five major commodity exchange regions: the Caribbean, Northern Europe, the Mediterranean, West Africa, and the Persian Gulf (Gaines et al. 1987). Historically, the Chesapeake Bay has been used for centuries to move goods and people across the bay. Today, however, it is mostly used as a port for goods going to and from the Atlantic (CBAHHSFC 2007). Navigable waterways and shipping lanes connect the Chesapeake Bay to major ports in the north (New York and Boston) and the south (Savannah, Charleston, and Miami) (**Figure 6-1**).

The Chesapeake Bay houses two of the major U.S. Atlantic coast ports, Baltimore, Maryland and the Port of Virginia (**Figure 6-1**) (Reshetiloff 2004). Both ports are important for exporting coal from the Appalachia region (Reshetiloff 2004). Automobiles, petroleum, cement, sugar, liquefied gas, scrap material, and other commodities, are common types of cargo transported to and from these and other ports within the Chesapeake Bay (CBAHHSFC 2007).

In comparison to other harbors on the U.S. Atlantic coast, the Port of Virginia can better accommodate large commercial vessels with 16-m deep open channels.[1] The Port of Virginia ranks third in the nation for total exports by weight (Reshetiloff 2004). It is made up of four cargo terminals including: the Norfolk International Terminals, the marine ports of Portsmouth and Newport News, and the Virginia Inland Port at Front Royal.[1] The top three exports (in tons) 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.[2] 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.[2]

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.[3] It is ranked first on the U.S. Atlantic coast for truck cargo (CBAHHSFC 2007). 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.[3]

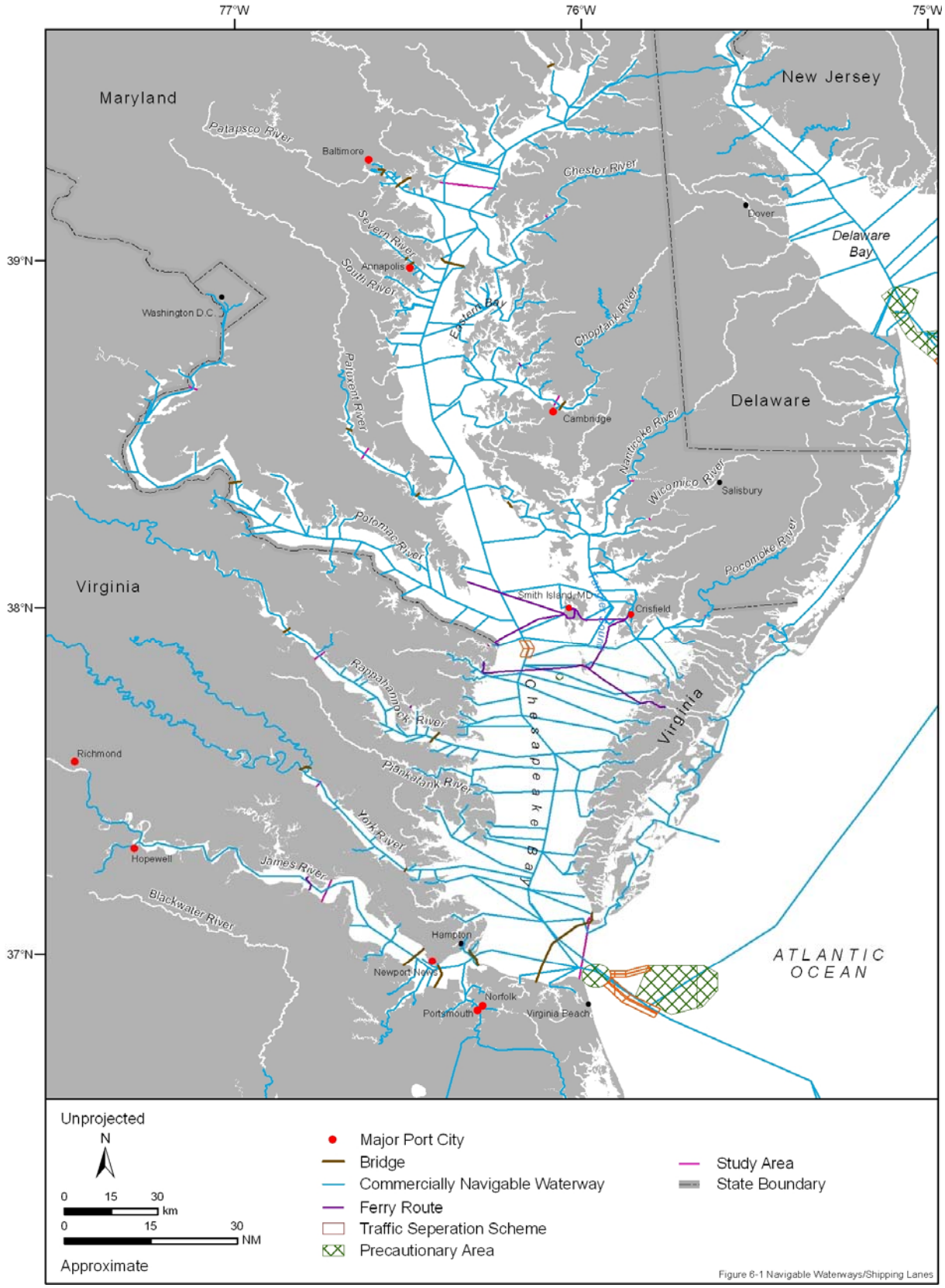

Figure 6-1. Navigable waterways and shipping lanes in the vicinity of the Chesapeake Bay Study Area. Source data: PHMSA (2002) and NOAA-OCS (2006).

Crisfield, Maryland is another important port in the Chesapeake Bay (**Figure 6-1**). It started off as a popular cove that offered sufficient protection from storms in the Chesapeake Bay waters.[4] In 1854 oyster beds were discovered in the area, and because of this the Eastern Shore Railroad was pushed from Salisbury to Crisfield.[4] The presence of the oyster industry and the railroad later led to the development of other industries in the area. Now it is a major exporter of seafood. At one time it was known as the "Seafood Capital of the World".[4]

To facilitate organized and safe transit into and out of the Chesapeake Bay, a traffic separation scheme has been defined at the mouth of the bay (**Figure 6-1**). 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 the 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 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 the very high frequency (VHF) FM Channel 16 (33 CFR 167.203).

There are currently two major bridges in the Chesapeake Bay. The Chesapeake Bay Bridge-Tunnel is located in Virginia waters and the Chesapeake Bay Bridge is located in Maryland waters (**Figure 6-1**). These two bridges were built during the last 60 years and have been the dominant method for moving people and goods across the Chesapeake Bay (CBAHHSFC 2007).

The Chesapeake Bay Bridge-Tunnel opened in 1964 and for over 43 years has been used for travel, and is also a major tourist attraction. It connects the Virginia Eastern Shore with Virginia Beach on the Virginia mainland.[5,6] It is a major convenience in that it reduces the journey by 153 km. The four-lane Bridge-Tunnel is 28 km long from shore to shore and is the largest bridge-tunnel in the world. It contains two 1.6-km tunnels, 19.3 km of low trestle, two bridges, 3.2 km of causeway, and four manmade islands that are each <0.1 km^2.[6,7] The two tunnels are beneath Thimble Shoals and Chesapeake navigation channels. The clearances for the tunnels are 7.3 m horizontally and 4.0 m vertically. The islands are each located at each end of the tunnels and are 9.1 m above the surface.[7] The two high level bridges are called North Channel Bridge and Fisherman Inlet Bridge, and they cross over other navigation channels. The northbound North Channel Bridge is 1.2 km in length with a 23-m vertical clearance and a 91-m horizontal clearance. The southbound North Channel Bridge is 0.9 km and has a 23-m vertical clearance as well as a 91-m horizontal clearance. The northbound Fisherman Inlet is 0.1 km long with a 12.2-m vertical clearance and a 34-m horizontal clearance. The southbound Fisherman Inlet is 0.1 km in length with a 12.2-m vertical clearance and a 34-m horizontal clearance. Between North Channel and Fisherman Inlet, the Bridge-Tunnel crosses over Fisherman Island which includes the Fisherman Island NWR.[7]

The Chesapeake Bay Bridge is also known as the William Preston Lane, Jr. Memorial Bridge, or just the Bay Bridge. It has dual spans that connect Maryland's Eastern Shore to the areas of Baltimore, Annapolis, and Washington, D.C. It has a shore-to-shore length of 7 km and is one of the longest in the world.[8] It has a westbound span that is three lanes and an eastbound span that is two lanes. There is a suspension span over the main shipping channel with a horizontal clearance of 0.5 km and a vertical clearance of 57 m.[8]

A third important bridge, the James River Bridge, was completed in 1928 and was the first bridge to go across Hampton Roads. It has a 1.3-km vertical clearance when the bridge is open, and then an 18-m vertical clearance when closed. It is currently 7 km long and 9.1 m wide (**Figure 6-1**).[9] The Monitor-Merrimac Memorial Bridge-Tunnel, which also crosses the James River, is 7 km long and is four lanes wide. It consists of a 1.5-km long tunnel, two portal islands, and 5.1 km of trestle (**Figure 6-1**).[10]

There is a growing interest to support a larger ferry system for the Chesapeake Bay area as opposed to building another bridge. A ferry system is more environmentally friendly and does not require the same maintenance needed to upkeep a bridge (CBAHHSFC 2007). Ferries in the Chesapeake Bay area are used primarily for tourism. There is currently a ferry system that takes passengers to Smith Island and Tangier Island from both sides of the Chesapeake Bay.[11] Another major ferry system in the Chesapeake Bay is the Jamestown-Scotland Ferry fleet that runs back and forth from Jamestown to Scotland across the James River. It is made up of four different boats; the Pocahontas, Surry, Williamsburg, and Virginia, and transports 936,000 vehicles across the James each year.[12] Ferry routes in the Chesapeake Bay area are shown in **Figure 6-1**.

6.3 SCUBA DIVING SITES

The Chesapeake Bay, due to its low visibility, has a very small number of popular dive sites. The most popular sites tend to be near the mouth of the Chesapeake Bay, including the areas around the Chesapeake Bay Bridge-Tunnel Islands, the Chesapeake Light Tower, and the William D. Sanner. The Chesapeake Bay Bridge-Tunnel Islands are a group of four islands that support the Chesapeake Bay Bridge-Tunnel. The Atlantic Ocean is within view of these islands and they attract a great variety of marine life (**Figure 6-1**).[13] The Chesapeake Light Tower is located just outside of the mouth of the Chesapeake Bay, just 19.3 km east of Rudee Inlet (**Figure 6-2**).[13] This structure attracts a great diversity of fish.[13] William D. Sanner is a submerged Maryland Pilot Boat located just inside the Chesapeake Bay entrance. Many artifacts have been recovered from this site (see **Figure 4-5** in **Chapter 4**).[13]

Even though the Chesapeake Bay itself offers little visibility, there is still a good amount of wreck diving that goes on during the summer months from the mouth of the Susquehanna to Virginia Beach (see **Figure 4-5**).[14] Sometimes dive trips are made on oyster reefs within the Chesapeake Bay and its lower tributaries (see **Figure 4-4** from **Chapter 4**).[14,15] The dive season starts in May and runs through October.[16]

6.4 RESEARCH ON THE CHESAPEAKE BAY

The major research institutes and organizations that conduct work in the vicinity of the Chesapeake Bay include VIMS and its Eastern Shore Lab (VIMS ESL), the University of Maryland Chesapeake Biological Lab (UMCBL), the University of Maryland Horn Point Lab (UMHPL), Old Dominion University (ODU), the Chesapeake Bay Program Office (CBPO), and CBOS (**Figure 6-2**). VIMS conducts research on coastal and estuarine science, and educates and advises students, policy makers, industry, and the general public.[17] In more detail, VIMS research includes the restoration of blue crab populations, oyster populations, SAV, climate change, aquaculture and fisheries, aquatic diseases and immunity, and coastal economics and restoration.[18] VIMS has a secondary campus, VIMS ESL, located on Virginia's Eastern Shore. VIMS ESL has a beneficial location for VIMS, having close access to the Atlantic Ocean.[19]

UMCBL is located on the western shore of the Chesapeake Bay at the mouth of the Patuxent River. Its areas of research include ecosystem studies and restoration science, fisheries science, and environmental chemistry and toxicology.[20] Its sister campus, UMHPL, is located on the Eastern Shore of Maryland on the Choptank River.[20,21] Its areas of research include oceanography, wetland ecology, plankton and nutrient dynamics, benthic invertebrate ecology, and aquaculture.[21]

The Center for Coastal Physical Oceanography (CCPO) is a department of ODU that specializes in physical oceanography.[22] This facility is located near the mouth of the Chesapeake Bay in Norfolk, and it is ideally located for its research on the physical oceanography of the coastal Atlantic and the Chesapeake Bay.[22] CBPO is located in Annapolis; it is known as "America's premier watershed partnership" and specializes in restoration of the Chesapeake Bay.[23]

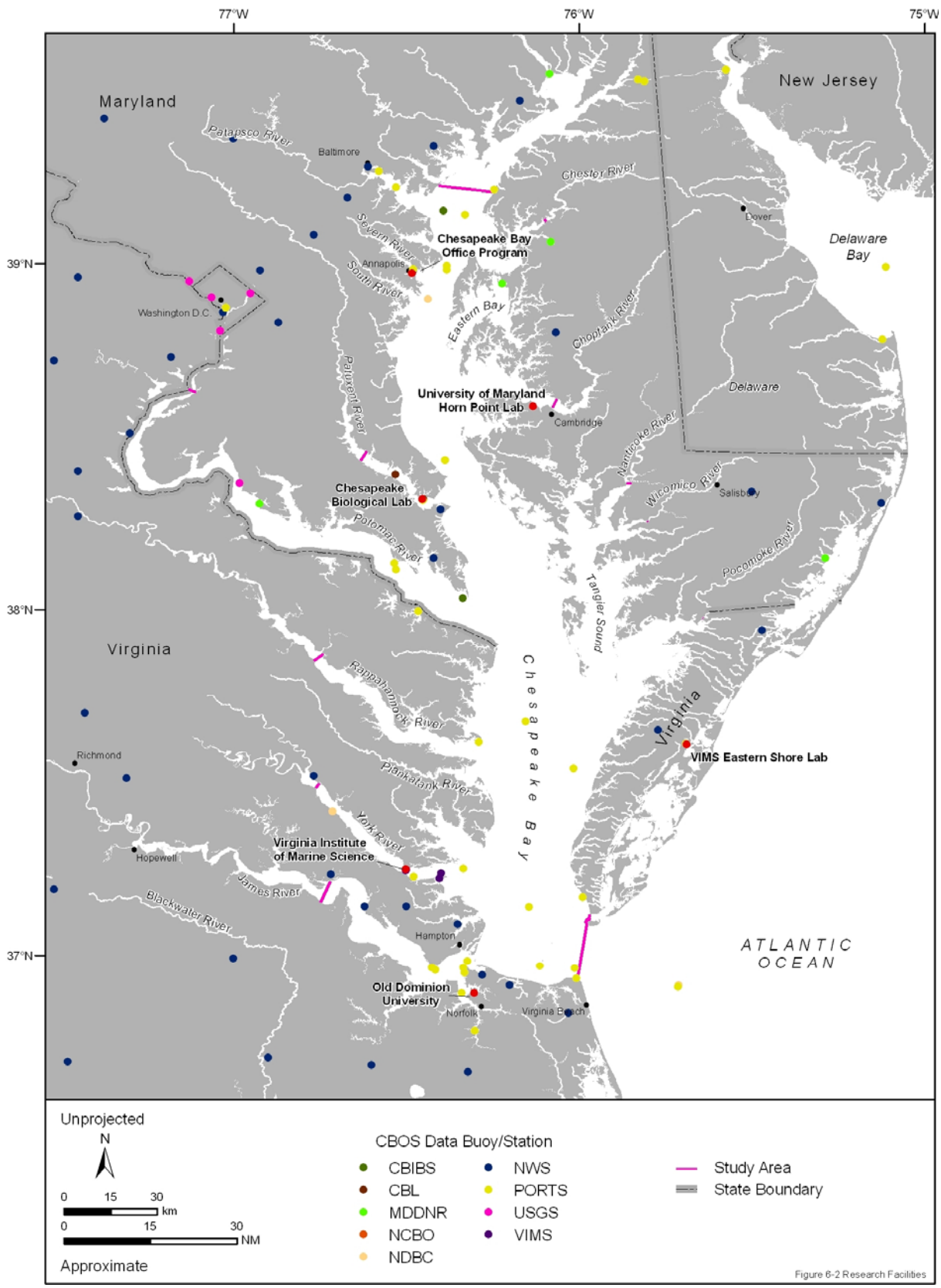

Figure 6-2. Research stations and buoys in the vicinity of the Chesapeake Bay Study Area. Source data: NOAA (2006a, 2006b) and CBOS (2008).

CBOS is an organization made up of data users and data providers that work together to observe, manage data, and create distribution systems in order to meet the commercial, recreational, educational, scientific, and restoration needs of the Chesapeake Bay.[24] The National Weather Service (NWS), USGS, VIMS, UMCBL, Maryland DNR, Chesapeake Bay Interpretive Buoy System (CBIBS), NCBO, NDBC, and Chesapeake Bay PORTS® (PORTS®) have buoys and stations in or near the Chesapeake Bay that act to collect atmospheric and oceanographic data for CBOS (**Figure 6-2**). PORTS® and NWS are both regulated by NOAA and have the most buoys and stations in the vicinity of the Chesapeake Bay (**Figure 6-2**).

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7.0 RECOMMENDATIONS

The Chesapeake Bay Study Area is located within the MAB and northern SAB. It is a dynamic region that has been studied and surveyed heavily by various academic institutions (i.e., ODU and VIMS) and research organizations (i.e., CBOS, NOAA, and USGS). Despite the wealth of scientific knowledge for the Chesapeake Bay Study Area 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 Chesapeake Bay 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 Chesapeake Bay MRA.

7.1 MARINE RESOURCES ASSESSMENTS

- Update EFH and HAPC identifications, species descriptions, and ecologically important commercial/recreational closure areas and status of overfished stock assessments as revised or additional amendments and/or FMPs that become available from the MAFMC, NEFMC, SAFMC, NMFS, and/or AFMFC (e.g., NEFMC EFH Omnibus Amendment 2, Amendment 1 Consolidated Atlantic Highly Migratory Species FMP EFH, SAFMC Fishery Ecosystem Plan, and individual species updates from peer-reviewed journals, reports, theses, etc.). **Cost**: Moderate. **Priority**: 1.

- Support the development of a database containing all the Chesapeake Bay Study Area EFH data and information, which would provide user-friendly access to all the EFH data and maps. **Cost**: Low to Moderate. **Priority**: 1.

- Update species of concern, candidate species, proposed threatened/endangered (T&E) species and critical habitats as they become designated by NMFS and/or USFWS (i.e., Atlantic sturgeon, alewife, blueback herring, sand tiger shark, etc.). **Cost**: Moderate. **Priority**: 1.

- Obtain marine mammal and sea turtle datasets for the Study Area that were not available for inclusion in this assessment.

  - Complete stranding dataset from Northeast Region National Stranding Network

  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.

- Obtain fisheries datasets for the Study Area that were not available for inclusion in this assessment. 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.

- Support the development of a custom GIS-based application designed to provide functionality to the use of EFH data and use the EFH database proposed in the above recommendation as its base. This custom, stand-alone application would not require the purchase of any additional software or hardware and would allow for easy use of the EFH data in many different environments. **Cost**: Moderate. **Priority**: 2.

Table 7-1. Suggested expert reviewers for the Chesapeake Bay Study Area MRA.

Name	Affiliation	Area of Expertise
Dr. Bill Boicourt	University of Maryland, Horn Point Lab	Oceanography
Dr. John Musick	Virginia Institute of Marine Science	Sharks, ray, and sea turtle conservation
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 aerial and shipboard surveys in the sections of the Chesapeake Bay area. Virtually no systematic surveys of the Chesapeake Bay for marine mammals have been conducted throughout the Chesapeake Bay region. Dedicated marine mammal surveys would provide a clearer picture of the occurrence and distribution of species in the Chesapeake Bay. **Cost**: High. **Priority**: 1.

- Support and/or fund the marine mammal passive acoustic surveys or with the deployment and monitoring of sonobuoys. Acoustic surveys have been conducted in conjunction with some sighting

surveys and provide a more comprehensive assessment of marine mammal presence. **Cost**: Moderate to High. **Priority**: 2.

- Support dedicated marine mammal and sea turtle aerial and/or shipboard surveys in the sections of the Chesapeake Bay Study Area not covered or inadequately covered by previous survey efforts. While it is essential to continue surveying in previously studied areas to account for seasonal and inter-annual variation in distribution and abundance of protected species stocks, it is critical to gather data for areas where survey effort has not taken place (or has occurred at lower levels). By focusing attention on these areas, a more complete concept of marine mammal and sea turtle distribution may emerge. Surveys are especially recommended in the upper Chesapeake Bay region during the spring, summer, and fall seasons as very little data beyond fisheries bycatch exist for this region. **Cost**: High. **Priority**: 2.

- 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 and tracking 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.

- Utilize satellite-tracking technology to monitor the movements of species of special interest. Several species of endangered cetaceans and sea turtles occur in the Chesapeake Bay, yet little is known about their seasonal movements in or through the Chesapeake Bay. 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. The cost of satellite-tracking sea turtles will be less expensive than the cost of tracking cetaceans as sea turtles are more easily captured and their shells provide easy attachment surfaces for the satellite tags. **Cost**: High. **Priority**: 3.

- Support efforts that allow experienced observers to collect marine mammal and sea turtle sighting data during NMFS ichthyoplankton, fish, or other dedicated non-NMFS 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, including the Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) and Fisheries Ecosystem Modeling and Assessment Project (FEMAP) surveys run out of VIMS, provide a valuable chance to collect data opportunistically that would otherwise only be collected during dedicated cruises, which are very expensive. **Cost**: Low. **Priority**: 3.

- Sponsor sea turtle telemetry studies for turtles captured within the Chesapeake Bay. 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.

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8.0 LIST OF PREPARERS

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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

Adhesive—sticky

Adult—developmental stage characterized by sexual or physical (full size and strength) maturity

Aggregation—is a group of animals that forms when individuals (usually similar, but can also be dissimilar) are attracted to an environmental resource to which each responds independently; the term does not imply any social organization

Aggression—is a set of social interactions ranging from threats to open fights, reflecting a conflict of interest over limited resources and having the potential to cause injuries and sometimes death to participants. Generally refers to conflict involving members of the same species by may refer to any interaction of this kind

Amphidromous—refers to fishes that regularly migrate between freshwater and the sea (in both directions), but not for the purpose of breeding, as in anadromous and catadromous species

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

Anchovy—a small herring-like schooling saltwater plankton-feeding marine fish of the family Engraulidae

Annelids—invertebrate animals of the phylum Annelida in which the body is typically made up of a series of rings or segments covered by a soft cuticle and lacking jointed appendages (e.g., marine worms)

Anomaly—refers to something irregular or abnormal

Anthropogenic—describing a phenomenon or condition created, directly or indirectly, as a result of effects, processes, objects, or materials that are derived from human activities, as opposed to those occurring in natural environments without human influences

Anticyclonic—clockwise circulation in the Northern Hemisphere and counterclockwise circulation in the Southern Hemisphere; in oceanography, synonymous with the warm-core ring

Aquatic—relating to water

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 habitat—a human-made, estuarine/marine habitat (sunken ships, artificial reefs: concrete igloos, rubble) created in the navigable waters of the U.S. to attract aquatic life

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

Atlantic Flyway—one of several distinct, traditional corridors that migrating birds follow in their annual travels between breeding and wintering areas; the Atlantic Flyway follows roughly the eastern coast of North America from far northern Canada (Nunavat) to Puerto Rico and the U.S. Virgin Islands in the Caribbean

Baleen—the interleaved, hard, fibrous plates made of keratin (protein in fingernails and hair) that hang side by side in rows from the roof of the mouth of mysticete whales; baleen takes the place of teeth and serves to filter the whale's food from the water

Bank—a submerged ridge, shoal, sandbar, or other unconsolidated material that rises from the seafloor to near the water's surface, sometimes creating a navigational hazard

Barnacles—a collective name for various marine crustaceans of the subclass Cirripedia; the adults form a hard outer shell and attach to hard substrates such as rocks and ships, as well as to certain whales

Baseline—the line from which maritime boundaries (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

Basking—describes an activity whereby an individual (e.g. pinnipeds and sea turtles) exposes itself to the sun, generally for the purpose of increasing its core temperature; may be done at the water's surface or on land

Batch spawner—a species that spawns repeatedly, releasing batches of eggs and sperm into the open-sea marine environment for external fertilization and development

Bathymetry—the topography of the ocean floor

Bay—a body of water partly enclosed by land but with a wide outlet to the sea

Beach seine—a short (typically 20 m or less) fine mesh catch net that can be pulled through shallow water on to beach areas by hand

Beaked Whales—are members of the family Ziphiidae, includes the genus *Ziphius*, *Mesoplodon*, *Indopacetus*, *Berardius*

Behavioral Audiogram—is 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

Benthos—organisms that live in, on, near, or are attached to the ocean bottom substrate

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)

Blackfish—is a colloquial term adopted from American whalers and sometimes applied to pilot whales and other superficially similar species, including false killer, pygmy killer, and melon-headed whales

Bloom—the 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

Boreal—comprising or found throughout far northern regions

Brackish—refers to waters having a salinity between that of fresh (0 psu) and sea water (37 psu)

Breakwater—a protective structure of stone or concrete; extends from shore into the water to prevent a beach from washing away

Broadcast spawner—a fish that releases its gametes into the water, where fertilization occurs; without parental care

Brooding—sitting on eggs to warm them and help them hatch (incubating).

Brumation—a state similar to hibernation in which a reptile dramatically reduces its food intake, although it may still drink. Both hibernation and brumation are a response to cold weather but in brumation the animal's response does not exhibit the extreme torpor of a hibernating animal

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 Netting—refers to a coordinated feeding technique of humpback whales, in which they use bubbles to corral and trap small fish or invertebrates

Buffer—polygon or area that is a specified, equal distance around a geospatial feature

Bull—is a male seal or whale, especially an adult male

Buoy—a bright-colored float attached by rope to the seabed to mark channels in a harbor or underwater hazards

Burst-pulse—an impulse sound in which peak amplitude is reached very quickly

Bycatch—are marine species incidentally caught in a fishery which intended to target another species, but which are not sold and usually not kept for personal use. Includes economic and regulatory discards; bycatch species can be either alive or dead

Calf—is a young animal that are dependent on its mother

Callosity—is a patch of thickened, keratinized tissue on the head of a right whale, inhabited by large numbers of whale lice

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

Carnivore—an animal that feeds exclusively on another animal's tissue

Cast net—a (usually weighted) fishing net that is thrown and then pulled back via an attached line

Catadromous—life history strategy of fishes, that includes migration between fresh- and saltwater, in which fish reproduce and spend their early life stages in saltwater, move into freshwater to rear as subadults, and return to saltwater to spawn as adults

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

Chaetognaths—known as arrow worms that are active elongated, transparent predators in marine plankton

Charter boat—a vessel typically less than 91 metric ton that carries six or fewer passengers for hire

Cheloniidae—the family of hard-shelled sea turtles that include the green, hawksbill, Kemp's ridley, and loggerhead turtles

Chevron—a V-shaped stripe

Circumglobal—ranging all the way around the world

Circumpolar—refers to animals that range around high northern or southern latitudes

Cladocern—order of microscopic crustaceans with trunk limbs enclosed in a carapace used for feeding and antennae used for swimming; called water fleas

Clam dredge—a shellfish dredge that includes a pair of longitudinally extending parallel and spaced apart runners having a collecting bag mounted adjacent the rear

Click—a broad-frequency sound used by toothed whales for echolocation and which may serve a communicative function; usually with peak energy between 10 kHz and 200 kHz

Closed season—a specified period during which the category of fish or marine plants may not be fished or harvested

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

Coda—a patterned series of 3 to 20 clicks lasting about 0.5 to 2.5 seconds, used by sperm whales for communication

Cohort—a group of animals of the same species, identified by a common characteristic, which are studied over a period of time as part of a scientific investigation; group of fish of the same age

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 state that turtles enter when they are suddenly exposed to very cold water (<10°C). They become lethargic and begin to float on the surface of the water. In this state, they are susceptible to predators, accidental boat strikes, and even death if water temperatures continue to drop

Commensal—eating the same food as another animal

Commercial fishing—fishing in which the fish is harvested, either in whole or part, are intended to enter commerce through sale, barter, or trade

Common—in the case of sea turtles, common means that sea turtles have been recorded in all, or nearly all, proper habitats, but some areas of the presumed habitat are occupied sparsely or not at all and/or the region regularly hosts large numbers of the species

Competitive exclusion—a concept that two or more resource-limited species having identical patterns of resource use cannot coexist in a stable environment

Conch—a marine mollusk with a large brightly colored spiral shell

Conspecific—member of the same species, and in many cases, the same age or even sex

Continental Margin—is the boundary or transition area between the continents and the ocean basins that consists of the physiographic provinces of the continental shelf, continental slope, and continental rise

Continental Rise—refers to an area; the province of the continental margin with a sloping seabed (1:100-1:700 gradient change) and a generally smooth surface; the area which lies between the abyssal plains and continental slope

Continental Shelf Break—is the area where the slope of the continental shelf rapidly changes from gently sloping to steeply sloping; where the continental shelf gives way to the continental slope

Continental Shelf—refers to an area; the province of the continental margin with a gently seaward-sloping seabed (1:1000 gradient change) extending from the low-tide line of the shoreline to 100- to 200-m water depth where there is a rapid gradient change

Continental Slope—refers to an area; the province of the continental margin with a relatively steeply sloping seabed (1:6 to 1:40 gradient change) that begins at the continental shelf break (about 100 to 200 m) and extends down to the continental rise; along many coasts of the world, the slope is furrowed by deep submarine canyons

Contour—a line of connected points of equal value on a surface

Coordinate system—set of numbers used to assign a location in a given reference system (x and y in a planar coordinate system and x, y, and z in a three-dimensional coordinate system); a pair of coordinates represents a location on the earth's surface relative to other locations

Copepods—very small planktonic crustaceans present in a wide variety and great abundance in marine habitats, forming an important basis of ecosystems; they are a major food of many marine animals and are the main link between phytoplankton and higher trophic levels

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

Countershading—is a form of camouflage exhibited by many fish and cetaceans, with dark upper body surfaces and lighter undersides. When viewed from above the darker dorsal surface blends in with the water; from below the lighter ventral surface matches the light coming from the sky, making the animal more difficult to detect

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

Critical Habitat—refers to the minimum portion of the habitat that is essential for the survival and recovery of protected (threatened and endangered) species, including but not limited to, areas for feeding or reproduction; designated through federal rule by NMFS or USFWS on a case-by-case basis under the authority of the Endangered Species Act of 1973

Crustaceans—arthropods that have two pairs of antennae and a hard exoskeleton, such as lobster, shrimp, and crabs

Ctenophores—a phylum of invertebrates, commonly ellipsoidal in shape, swimming by means of eight longitudinal rows of paddles; commonly called the *comb jellies*, because the separate paddles somewhat resemble combs

Curved Carapace Length—is a measurement used by sea turtle researches defined as the length of a sea turtle's carapace as measured by a flexible tape measure

Cusk-eel—elongate compressed somewhat eel-shaped fishes

Cyclonic—counterclockwise circulation in the Northern Hemisphere or clockwise in the Southern Hemisphere; in oceanography, synonymous with cold-core ring

Decapod—an order of freshwater, marine, and terrestrial crustaceans having five pairs of legs on the thorax and a carapace completely covering the throat (e.g., shrimps, crabs, lobsters)

Decibel (dB)—is the logarithmic measure of sound strength; it is a ratio of intensity (pressure) at reference range compared with a with a reference level; in air, the reference pressure is 20 µPa and the reference range is 1 m, while for underwater sound, the reference is 1 µPa and the reference range is also at 1 m

Decimal degrees—degrees of latitude and longitude in decimal format instead of degrees, minutes, and seconds

Deep Scattering Layer—is 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

Delayed Implantation—refers to mammals; it is the suspended development of an embryo between shortly after conception and subsequent attachment (implantation) to the uterine wall

Delphinus—it is the genus of oceanic dolphins consisting of short-beaked and long-beaked common dolphins, which are similar in appearance

Demersal—applied to fishes that live close to the seafloor, such as cod and hake

Density—it is the physical property measured by mass per unit volume. Often used in biology, as a unit of measurement defined as the number of organisms per unit of distance or volume; often used as measure of abundance

Dermochelyidae—the family of sea turtles that includes only one species, the leatherback turtle

Detritus—nonliving, organic material (dead leaves, etc)

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

Diatom—eukaryotic algae that are usually unicellular, bilateral, and contain a cell wall made of silica

Diel—refers to 24-hour activity cycle based on daily periods of light and dark

Dip net—a net or wire mesh bag attached to a handle, used especially to scoop fish from water

Dispersal—refers to those processes by which a species maintains or expands the distribution of a population. Can refer to the movement of individuals throughout suitable habitat within or outside the population range.

Display—is any behavior that conveys information, usually to members of the same species or to predators; often used during mating or territory defense

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

Dredge—an implement consisting of a net on a frame, used for gathering shellfish

Drift gillnet—gillnet attached to the stem of a fishing boat and allowed to drift below the surface

Drift net—a monofilament gillnet set at or near the surface that stretches up to 60 km or more in length; used passively (drifts) to entangle fish or invertebrates, which also catches a large number of non-target species, including marine mammals and sea turtles

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

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

Eelgrass—vascular flowering plant of the genus *Zostera* that are adapted to living under water while rooted in shallow sediments of bays and estuaries

Eggs—those individuals that have spawned but have not hatched and are completely dependent on yolk for nutrition

El Niño—the interannular climatic change that results in the warming of waters in the equatorial Pacific Ocean and the suppression of upwelling into the euphotic zone of nutrient rich waters off the coast of Peru; also referred to as the El Niño/Southern Oscillation (ENSO)

Elver—a young eel

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

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 very short time

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

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])

Estuarine—associated with estuaries

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

Euphausiids—known as krill, these are pelagic shrimp-like crustaceans

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)—refers to the waters from the low-tide line seaward to 200 NM in which the inner boundary is a line coterminous with the seaward boundary of each coastal state or territory; special circumstances exist for situations where EEZs of nations overlap

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—refers to outside the normal limits of an animal's distributional range; in the case of marine mammals, 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

Facultative resident species—resident species that occur in both wetlands and uplands (inland of wetlands)

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

Fecund—fertile; producing a large number of eggs

Finfish—fish with fins and a bony skeleton (trout, bass, carp etc.)

Fish—as defined by the Sustainable Fisheries Act, finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds

Fish haven—an off-shore artificial reef preservation site

Fishery—one or more stocks of fish that can be treated as a unit for the purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics, and any fishing for such stocks

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

Flatfish—members of the fish order Heterosomata which swims or lies on side of its body; sides are greatly flattened and compressed; mainly marine animals (e.g., flounders, soles)

Fledged—in birds, fully feathered and ready to fly

Flighted—having the ability to fly; fully feathered

Flipper—refers to the flattened forelimb of a marine mammal

Flora—plant species of a given area

Flotsam—refers to marine debris; can also refer to the wreckage or cargo left floating on the sea surface after a shipwreck

Flukes—the horizontally spread tail of a cetacean

Forage—is the act of searching for food (prey items) or provisions; can also refer to graze or consume

Forage fish—any fish eaten by larger predatory fish, seabirds, or marine mammals, usually swimming in large schools

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—is a spindle-shaped or torpedo-shaped and tapering at one or both ends

Gadids—are members of the family Gadidae which includes Pacific cod and hake

Galumph—to move with a clumsy heavy tread

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

Gestation—period of development in the uterus from conception until birth (pregnancy)

Gig—an arrangement of barbless hooks that is dragged through a school of fish to hook them in their bodies; a pronged spear for fishing

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

Goby—any of numerous usually small spiny-finned fishes of the family Gobiidae, having the pelvic fins united to form a suction disk

Gregarious—used to describe animals that form social groups

Groins—small jetties extending from a shore to protect a beach against erosion or to trap shifting sands

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

Guild—a group of species having similar ecological resource requirements and foraging strategies, and therefore having similar roles in the community

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

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 association—the choice by an organism of a particular habitat over other available habitats

Hake—any of various marine food fishes of the genus *Merluccius* and *Urophycis*, related to and resembling the cod

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

Harvest—fish killed as a result of encounters with fishing gear

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—refers to the process by which pinnipeds and sea turtles crawl or pull themselves out of the water onto land for the purpose of respite, basking, breeding, nesting and/or molting; can be intertidal rock outcrops, sandbars, shoals, mudflats, or sandy beaches; important area where marine mammals periodically and purposefully come ashore

Haul out site—refers to intertidal rock outcrops, sandbars, shoals, mudflats, or sandy beaches where marine animals, such as pinnipeds, periodically and purposefully come ashore

Haul seine—comprised of a long strip of netting with the top edge buoyed to keep it raised and the bottom edge weighted; one end of the net remains on land, and the other is drawn through the water encircling a school of fish, the net is then hauled in along with the fish

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

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

Immature—refers to bird; one hatched in the spring of the same year

Impingement—entrapment of any life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal

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

Inter-nesting interval—the amount of time between successive sea turtle nesting events during the nesting season

Intertidal—the area of shore exposed between high and low tide

Invertebrate—an animal that lacks a backbone

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

IUCN Red List—a list of animal species and subspecies established by the International Union for Conservation of Nature and Natural Resources which are thought to be threatened or endangered of extinction and those which are known to have already become extinct in the wild

Jetties—structure used at inlets to stabilize the position of the navigation channel, to shield vessels from wave forces, and to control the movement of sand along the adjacent beaches so as to minimize the movement of sand into the channel

Juvenal—plumage stage in bird ontogeny; refers to the first true covering of feathers following the downy stage

Juvenile—mostly similar in form to an adult but not yet sexually mature; a smaller replica of the adult

Killifish—any of various tiny, oviparous (egg-laying) cyprinodontiform fish (including families Cyprinodontidae and Poeciliidae)

Kogia—the genus comprised of the pygmy sperm whale (*Kogia breviceps)* and dwarf sperm whale (*Kogia sima*)

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

Larvae—individuals that have hatched and have the ability to capture food items

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

Loafing—behavior not connected with feeding or breeding; this includes preening and resting and does not imply that time is being wasted; some types of birds, such as wildfowl, have habitual 'loafing places'

Loafing habitat—preferred area or habitat type for loafing behavior

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

Lunge—a term for a thrusting of the forward part of an animal through the water surface, showing less than 40% of the body (often the result of feeding at the surface)

Macroalgae—true oceanic plants, large in size, including bubble algae, large varieties of kelp, and *Sargassum*

Macrophyte—an aquatic plant that grows in or near water and is either emergent, submergent, or floating

Mantis shrimp—marine crustacean characterized by a pair of enlarged appendages, called maxillipeds that form powerful claws for seizing prey; belong to the order Stomatopoda, one part of the class Malacostraca, the largest class of crustaceans

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 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

Masking—is the process of obscuring sounds of interest by interfering sounds, generally at similar frequencies

Mean—(arithmetic) average

Melon—a fatty cushion forming a bulbous "forehead" in toothed whales; may act to focus sound for echolocation

Mesohaline—water with salinity of 5 to 18 practical salinity units (psu)

Mesoplodon—a taxonomic classification; a genus of beaked whales, which includes the Blainville's beaked whale, True's beaked whale, Sowerby's beaked whale, and Gervais' beaked whale among others

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

Metamorphosis—the process of transforming from one body form to another form during development (e.g., tadpole changing to a frog)

Mid-Atlantic bight (MAB)—zoogeographic marine region of the Atlantic Ocean that includes the estuarine and the continental shelf between Cape Code, Massachusetts (including the southwestern flank of Georges Bank), and Cape Hatteras, North Carolina

Migrant—an animal that migrates

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

Molt—refers to the shedding of an external shell or skin; often used in growth. In pinnipeds, this refers to fur shedding; belugas are the only cetacean known to do this–the top layer of skin is shed all at one time of the year versus other cetaceans which continuously are sloughing skin. In crustaceans (e.g., crabs), this refers to shedding of the exoskeleton (external support) which is part of an important growth process that enables the animal's body to expand.

Morphology—the form and structure of an organism considered as a whole; appearance

Morphometric—the study of comparative morphological measurements

Mud flats—shallow areas composed of silt and other fine particles that are periodically exposed at relatively even elevations

Mysids—small shrimp-like crustaceans

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

Nektonic—used to describe aquatic organisms that swim independently of currents

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

Nest scrape—a small hollow excavated in soil, sand or shingle by a bird that does not make a 'proper' nest, although it may line the scrape with pieces of grass or similar material; examples of birds that nest in scrapes include some types of wader and the terns (family Sternidae)

Niche segregation—partitioning of resources by individuals, populations, or species to reduce competition

Nocturnal—applied to events that occur during nighttime hours

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

Nursery habitat—an environment crucial for the development of early-stage animals; for some sea turtles, this environment is often an open-ocean area characterized by the presence of *Sargassum* rafts and/or ocean current convergence fronts

Occurrence record—a marine mammal or sea turtle sighting (aerial or shipboard survey), stranding, incidental fisheries bycatch, nesting, or tagging data record for which location information is available. An occurrence record, especially sighting occurrence records, may represent the occurrence of one or multiple animals of a particular species; for instance, one occurrence record from a marine mammal sighting survey may indicate that 34 short-finned pilot whales were observed at a location but this information would be plotted on a MRA map figure as one occurrence record

Oceanic—of or pertaining to the ocean

Oceanography—the scientific study of the oceans, including the chemistry, biology, geology, and physics of the ocean environment

Octave band—is the frequency band whose upper limit in Hz is twice the lower limit

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

Omnivore—an animal that feeds on both plant and animal tissue

Opportunistic—used to describe organisms that take advantage of all feeding opportunities and do not prey on a few specific items

Ostracods—refers to crustacean-like crabs and lobsters that have thicker ornamented valves

Otter trawl—demersal (bottom) trawl operated by a single vessel in which the horizontal opening of the net is achieved and maintained by two angle-towed otter boards

Overexploited—abundance of the stock is too low or when biomass has been estimated to be below a limit biological reference point that is used as the threshold that defines overfished conditions

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

Overwinter—staying the winter in one area

Oyster (aquatic) reef—three-dimensional structure created by oysters growing on a firm substrate such as shell, while subsequent generations attach to the older oysters, often forming clusters

Pack Ice—refers to sea ice, especially that which is unattached to land; characterized by its dynamism and seasonal expansion/diminution

Pagophylic—associated with ice

Pandalid shrimp—refers to nearshore and offshore members of the infraorder Caridea; coldwater “true shrimp” are commercially important

Pantropical—distributed throughout tropical regions

Parturition—is the act of giving birth

Peak sensitivity—the frequency at which hearing is most sensitive and amplitude is lowest for a perceived sound

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)

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

Phocids—refers to all of the “true” seals (i.e., “earless” species); from the family Phocidae. Generally used to refer to all recent pinnipeds that are more closely related to Phoca than to otariids or the walrus

Photic zone—the uppermost zone in the water where sunlight 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

Pier—a platform built out from the shore into the water and supported by piles; provides access to ships and boats

Pilchard—a small edible sea fish of the herring family, with a rounded body covered with large scales [origin unknown]

Pinnipeds—refers to seals, sea lions, fur seals, and walruses

Pipefish—fish with long tubular snout and slim body covered with bony plates

Piscivorous—a carnivorous animal that eats fish

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

Planktonic—of or relating to plankton

Plastron—bony shield composing the ventral side of a turtle's shell

Platform—offshore structure from which development wells are drilled

Playa—type of shallow wetland in prairie, semiarid, or arid environment

Plumage—the covering of feathers over a bird's body; plumage may vary with age or season of the year, and accordingly it may be described as breeding (alternate) plumage, non-breeding (basic) plumage, or juvenile, immature or adult plumage

Plume—a column of water

Point—single x, y coordinate pair that represents a single geographic feature (e.g., sea turtle sighting)

Polar—refers to the latitudes near one of the poles (North or South), typified by cold and ice-infested waters

Polychaetes—a class of soft-bodied, metamerically segmented coelomate worms that bear bristles and fleshy appendages on most segments; marine; may be free-swimming, errant, burrowing or tube dwelling

Polygon—area represented by a two-dimensional feature

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)

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

Pound net—trap consisting of an arrangement of nets directing fish into an enclosure

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

Prey—animal hunted or caught for food

Primary producer—an autotroph or organism able to utilize inorganic sources of carbon and nitrogen as starting materials for biosynthesis; uses either solar or chemical energy

Projection—mathematical formula that transforms the three-dimensional real world features and their locations on 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

Protected species—is a species that is afforded special consideration as (by law) a result of being listed, or being considered for listing, under state or federal resource law such as the Endangered Species Act or the Marine Mammal Protection Act; a protected species often has a depleted or imperiled population and is in some form of extinction danger

Pteropods—refers to small, free-swimming, shelled mollusks which swims near the surface by means of a modified foot with wing-lie appendages; related distantly to oysters and mussels

Pup—refers to a young animal of various species; (e.g., pinnipeds, sharks)

Pupping—is the process of giving birth (e.g. pinnipeds, sharks)

Pyrosomas—blue-green bioluminescent, pelagic, tunicates that form thimble-shaped colonies of the genus *Pyrosoma*

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"

Range—refers to the maximum extent of geographic area occupied or used by a species

Rare—is terminology used in population status; reference to a plant or animal that is restricted in distribution or number; in the case of sea turtles, rare means that a species is found, or probably is found, regularly within the region but in very small numbers; in the case of marine mammals, rare means a species that only is found in the area sporadically

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

Recruitment—when juvenile fish become large enough to be susceptible to fishing

Refractive index—The ratio of the speed of light in air or in a vacuum to the speed of light in another medium

Refuge—a device by which an individual can avoid predation

Relief—the inequalities (elevations and depressions) of the sea bottom

Remigration interval—the amount of time between successive sea turtle nesting seasons

Resident species—a species that doesn't migrate

Riverine—associated with rivers

Robust—powerfully built

Rookery—an animal's breeding ground; for sea turtles, it is the specific beach on which they nest

Roost—a place where birds sleep, as opposed to a mere loafing ground; roosting is the behavior associated with finding or going to a roost

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)

Salp—barrel-shaped tunicate without an exoskeleton that forms asexual polymorphic colonies that are found in the upper levels of most oceans

Salt marsh—low areas covered by salt-tolerant vegetation (bushes and grasses) near the sea that are periodically flooded by seawater but not exposed to daily tides; plants in this ecosystem have special adaptations to survive in the presence of high salinities

Salt pond—a shallow marine embayment that receives freshwater inflow from groundwater entering the head of the pond, and saltwater inflow through an inlet from the sea with the inlet periodically opening and closing by the shifting of barrier sands

Sand bar—a ridge or shoal of sand formed in a river or along a shore by the action of currents or tides

Sand lances—refers to sand eels, a common forage of the family Ammodytidae that has a narrow, elongate, subcyclinrical body with a pointed snout and long dorsal and anal fins

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

Satellite telemetry—transmission of data over long distance communication links (i.e. satellites) from a transmitter attached to a sea turtle in order to monitor its movements and/or behavior

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

Sciaenid—widely distributed family of carnivorous percoid fishes having a large air bladder used to produce sound

Scutes—long, thickened scales that cover underlying bony plates of carapace and plastron of sea turtles that are used for protection

Sea angels—a group of small swimming sea slugs

Seagrass—are rhizome angiosperm grasses (e.g., Zostera, Posidonia) adapted to live underwater in shallow estuaries and sheltered lagoons; important for nutrient productivity and provide protective habitat for juvenile fish to develop

Seahorse—a small marine fish of the genus *Hippocampus,* characteristically swimming in an upright position and having a prehensile tail, a horselike head, and a body covered with bony plates

Seamount—refers to an undersea mountain rising more than 914 m from the sea floor, but having a summit at least 305 m below sea level (in contrast to an island)

Sea squirts—sedentary tunicates of the class Ascidiacea, having a transparent sac-shaped body with two siphons; also called *ascidian*.

Sea urchins—one of the class (Echinoidea) of echinoderms in which the body is covered by hard shell (test) composed of fitted immovable plates with often large and sharp spines that are articulated at bases; may be of various sizes - spherical, depressed spherical, discoid, or round

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)—refers to the region where the slope of the seabed rapidly changes from gently sloping on the continental shelf to steeply sloping on the continental slope; the world-wide average water depth at the shelf break is 155 m, and on average, the shelf break usually occurs between 100 to 200 m

Shelf break region—refers to the geographic area surrounding the continental shelf break and including both the outer continental shelf and upper continental slope

Shellfish—an aquatic animal, as a mollusk, having a shell of shell-like exoskeleton

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

Silverside—any of various chiefly marine fishes of the family Atherinidae, characteristically having a broad silvery band along each side

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, Florida

Spawn—the release of eggs and sperm during mating

Spear—an implement with a shaft and barbed point used for catching fish

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

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

Stenella—the genus of oceanic dolphins consisting of striped, Atlantic spotted, pantropical spotted, Clymene, and spinner dolphins, which are similar in appearance

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

Sublittoral—benthic region extending from mean low waters to a depth of about 200 m

Submerged aquatic vegetation (SAV)—rooted plants and algae that live in submerged saline water during their entire life cycle (including reproduction); occur in fresh, brackish, and marine waters; in marine waters they are found in the low intertidal and subtidal zones

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

Subtidal—estuarine or marine environment that lies below mean low-water; always submerged in a tidally-influenced area

Subtropical—the regions lying between the tropical and temperate latitudes

Suction feeding—refers to the capture of prey using suction method, generally with the tongue employed as a piston to create a vacuum pressure

Surface-active—behaviors of whale groups performed at the surface

Surf zone—area of the water from the surf line to the beach

Target species—species of fish or invertebrate specifically sought by a fishery

Taxa (taxon)—a defined unit (e.g., species, genus, or family) in the classification of living organisms

Taxonomy—the study of the rules, principles, and practice of classification, especially of living organisms

Temperate—the region of the Earth at the mid-latitudes that is characterized by a mild, seasonally changing climate

Temporary threshold shift—refers to a temporary impairment in hearing ability caused by exposure to strong sounds

Terrestrial—relating to land

Thermocline—the depth in the ocean (water column) in which there is an abrupt temperature change

Thermoregulatory—an organism's ability to maintain a specific body temperature regardless of the environmental temperature

Threatened species—any plant or animal species likely to become endangered within the foreseeable future throughout all or a part of its range; the authority to designate a species as threatened is shared by the USFWS (terrestrial species, sea turtles on land, manatees) and National Marine Fisheries Service (most marine species) under provisions of the ESA

Tidal flat—a nearly flat coastal area, alternately covered and exposed by the tides, and consisting of unconsolidated sediments

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

Tongs—a two-pronged device used for lifting objects, and comes in all sizes depending on the task

Topography—physical features of the ocean floor, such as mounds or ridges

Transient species—species that are likely to move away from an area

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 net with a cod-end or bag for collecting the fish or other target species; they can be towed at any depth of the water column

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

Trotline—a method of fishing that involves a horizontal set mainline that has small floats attached to suspend it off the seabed to avoid snagging. Short, weighted lines, sometimes called snoods or trots, are attached at intervals along the length of the mainland. These are set vertically in the water and act like a series of short droplines

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—refers to the movement of dense, cold, nutrient-rich water up from ocean depths to the surface

Vagrant—refers to a wanderer, in the same sense of an animal moving outside the usual limits of distribution for its species or population

Ventral—relating to the underside (or belly side) of an animal

Vertebrates—animals with a backbone

Visual acuity—sharpness of vision; the visual ability to resolve fine detail

Warm-core ring—is an eddy or circular current of warm water; in the North Atlantic Ocean, the water in warm-core rings circulates anticyclonically (clockwise) and the rings are formed when meanders pinch off the northern side of the warm Gulf Stream

Water column—a vertical column of seawater extending from the surface to the sea bottom

Water mass—a body of water that can be identified by a specific temperature or salinity

Waterfowl—the members of the family Anatidae, which contains the swans, geese and ducks; may be used to refer specifically to this family, particularly in North America, but can include birds other than wildfowl living on or beside water, such as the divers (family Gaviidae) and the grebes (family Podicipedidae)

Watershed—a wetland, river, lake, or estuary, and all the areas around it that drains into it

Weaning—age at which offspring first ingest a food source other than mother’s milk

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 or marine mammal less than one year old

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

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-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.

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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 km versus 0 km at the poles. Using a map projection mitigates this difference or seeming distortion when using geographic coordinates; however, when multiple data sources with multiple projection systems are used, the most flexible system to standardize the disparate data is to keep all data unprojected. Thus, the maps in this MRA are untransformed, meaning they are shown unprojected on the map figures and their associated geographic data are delivered unprojected.

Since the measurement units for unprojected, geographic coordinates are not associated with a standard length, they cannot be used as an accurate measure of distance. Since the maps in 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.

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Appendix A-3. Overview of all known research efforts that provide occurrence information for marine mammals and sea turtles in the Chesapeake Bay.

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 Chesapeake Bay. For a variety of reasons, it was not possible to obtain data from every known source; all sighting, stranding, incidental fisheries bycatch, and nesting data available were included in this MRA report (**Table A-1**).

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.

Table A-1. Data sources for marine mammal and sea turtle occurrence records that are included in the Chesapeake Bay MRA.

Data	Year(s)
Shipboard Sighting Surveys	
North Atlantic Right Whale Consortium (NARWC) Database	1762-2001
CETAP Shipboard Survey	1978-1982
Aerial Sighting Surveys	
NMFS-SEFSC Mid-Atlantic *Tursiops* Surveys (MATS)	2002
North Atlantic Right Whale Consortium (NARWC) Database	1762-2001
CETAP Aerial Survey	1978-1982
University of North Carolina at Wilmington (UNCW)—Marine Mammal Aerial Surveys	2006-2007
Strandings	
NMFS-NEFSC Marine Mammal Stranding Data	1995-2000
Sea Turtle Stranding and Salvage Network	1998-2005
Mixed/Miscellaneous	
NMFS-NEFSC Sea Turtle Mapping and Information System	1980-1997
Virginia Department of Game and Inland Fisheries Nesting Database	1970-2007
Florida Marine Research Institute	2002
Sirenia Project	2002, 2007
North Atlantic Right Whale Consortium (NARWC) Database	1762-2001
New England Aquarium (NEA) Sightings (Historical)	1876
NMFS Large Whale Ship Strike Database	1992, 1994
Berquist Personal Observation	2008
Dittmar Personal Observation	2008
Olds Personal Observation	2008

Table A-1. Data sources for marine mammal and sea turtle occurrence records that are included in the Chesapeake Bay MRA.

Data	Year(s)
Published Literature and Reports	
Bailey	1948
Blaylock	1984
Blaylock et al.	1985
Dunn et al.	2002
Goodwin	1954
Huang	1993
Keinath and Musick	1990
Keinath et al.	1991
McAlear Baker	2000
Miller	1927
Morgan et al.	2002
Potter	1991
Rathbun et al.	1982
Schwartz	1962
Swingle et al.	1993
Swingle et al.	2007
Westgate	2005
Wiley et al.	1995
Williams	1995
Wilson et al.	1987

Aerial Surveys

- 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, New Jersey and Vero Beach, Florida (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 (Hoggard 2002; Garrison et al. 2003). Another purpose was to update the MATS 1995 abundance estimates based upon the stock structure of seasonal management units (Garrison et al. 2003). Bottlenose dolphin and loggerhead sightings recorded in the mouth of the Chesapeake Bay in 2002 are the only records from the MATS database that occur in the Study Area.

- The **University of North Carolina at Wilmington (UNCW)** conducted aerial surveys from **December 2006 through May 2007.** These aerial surveys spanned from the South Carolina/North Carolina border to the southern end of Assateague Island, Virginia. The survey targeted right whales; however, all observations of marine mammals, sea turtles, and large fish were recorded. 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 06 February to 02 March 2001 and 22 January to 19 March 2002 (McLellan et al. 2001; McLellan et al. 2002) and from February to June 2008; however, only sightings from the 2007 survey occur in the Study Area and are included in this report.

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 Florida and Nova Scotia. 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 data sources within the NARWC database that provide data for the Chesapeake Bay Study Area. Dedicated or directed aerial surveys for right whales have only been conducted since the early 1980s (DoN 1996).

- The **Cetacean and Turtle Assessment Program (CETAP)** was initiated by the University of Rhode Island, with support from the Bureau of Land Management (Scott and 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, North Carolina, and Nova Scotia. The Study Area ran from the shore out to 5 nm 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 and Gilbert 1982). Data from CETAP included in this report come from both aerial and shipboard platforms and included marine mammal and turtle sightings in the mouth of the Chesapeake Bay. Opportunistic sightings and historical data from Chesapeake Bay between 1976 and 1980 also collected by CETAP are included in this report.

- The **New England Aquarium (NEA)** collects historical records for incorporation into the NARWC database. An **1876** sighting of a North Atlantic right whale in the lower Chesapeake Bay is 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 and 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 Chesapeake Bay. Stranding data for **1995-2000** were received from the NMFS-NER marine mammal stranding network.

- The **Sea Turtle Stranding and Salvage Network (STSSN)** is a network of private citizens and 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 and 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. Sea turtle strandings recorded throughout the Chesapeake Bay **between 2001 and 2005** are included in this report.

- **Virginia Institute of Marine Science (VIMS)** runs the Sea Turtle Stranding and Salvage Network in Virginia. VIMS is responsible for covering the area from the James River north to the Maryland border/Potomac River. VIMS works in cooperation with other state agencies (Virginia Aquarium Stranding and the Department of Game and Inland Fisheries) and volunteers to respond to strandings throughout the rest of the state. Sea turtle stranding data from the Chesapeake Bay are included in this report for **1998 through 2007**.

- **Maryland Department of Natural Resources (DNR)** responds to sea turtle strandings in Maryland through a coalition between the Cooperative Oxford Lab (COL) and the National Aquarium in Baltimore (NAIB). Sea turtle stranding data that occur within the Chesapeake Bay for the state of Maryland between **1998 and 2007** are included in this report.

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, North Carolina. Stranding data recorded **between 1990 and 1997** occur in the Study Area.

Other Data Sources

- **Virginia Department of Game and Inland Fisheries** (Ruth Boettcher) provided sea turtle nesting data for the state of Virginia since 1970. The data were compiled from a public sighting program (voluntary reporting by the public) as well as state funded beach surveys that occur along the Atlantic facing beaches (Chincoteague National Wildlife Refuge and Back Bay National Wildlife Refuge). Nesting data were collected from June 1970 through August 2007. Only nesting data from **1998 through 2007** is included in this report.

- **Florida Marine Research Institute** (Thomas Pitchford) provided manatee stranding records for manatees in Virginia and North Carolina. These reports came from a variety of sources including NMFS, USFWS, North Carolina Division of Marine Fisheries, and private citizens from the period of 2002.

- **Sirenia Project** (Cathy Beck) provided sighting data for manatees in the Chesapeake Bay area in **2002 and 2007**.

- **NMFS** summarized records of large whale ship strike records from 1975 through 2002 to compile the **Large Whale Ship Strike Database** (Jensen and Silber 2003). Only records from **1992 and 1994** occur in the Study Area and 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 included.

  - **Berquist 2008** is a personal observation of a pod of dolphins (most likely bottlenose dolphins) observed in the York River at the mouth of Queen's Creek May 2008.
  - **Dittmar 2008** discusses a sighting of two manatees in the northern portion of Chesapeake Bay in September 2008.
  - **Olds 2008** is a personal observation of four dolphins in Hampton Roads Bay in October 2008.

Published Literature

- There are several published papers that contain data on strandings or opportunistic sightings within the Chesapeake Bay. Papers from which data were taken for this report are summarized below.

  - Bailey (1948) described two records; one a stranding and one unknown, of the fin whale in Chesapeake Bay.

  - Blaylock et al. (1985) described the natural history and occurrences of marine mammals in Virginia waters. The authors summarized both published and unpublished records and included information for Chesapeake Bay up to 1984

  - Dunn et al. (2002) reviewed strandings of bottlenose dolphin calves believed to be the victims of infanticide. These stranded individuals were collected by the Virginia Marine Science Museum Stranding Program during 1996 and 1997.

  - Goodwin (1954) reported a record of a harp seal caught in a fisherman's net and subsequently escaped.

  - Huang (1993) discussed several sightings of the same manatee within the Chesapeake Bay area.

  - Keinath and Musick (1990) reviewed an incidence of bycatch and summarized general occurrence of leatherback turtles in Chesapeake Bay.

  - Keinath et al. (1991) detailed the capture of a hawksbill by a commercial clammer in Chesapeake Bay.

  - McAlear Baker (2000) described a study of bottlenose dolphins in the Eastern Bay and Choptank River areas of Chesapeake Bay.

  - Miller (1927) described a stranding of a sei whale in March 1923.

  - Morgan et al. (2002) reviewed records of cetacean strandings and manatee sightings in Virginia waters during the period of January 1983 through December 1989. It specifically focused on strandings that showed signs of human interaction.

  - Potter (1979) summarized occurrences of marine mammals in Virginia waters.

  - Rathbun et al. (1982) summarized reports collected from 1974 for sightings of manatees north of Florida. The authors also discussed the results of a 27-month long survey for manatees starting in April 1979 near a power plant in Brunswick, Georgia.

  - Schwartz (1962) discussed the occurrence of a juvenile minke whale stranded in July 1959.

  - Swingle et al. (1993) described sightings of juvenile humpbacks at the mouth of the Chesapeake Bay during January through March 1991 and 1992. The record of these whales feeding is the first report of humpbacks feeding in the Virginia area.

  - Swingle et al. (2007) discussed marine mammal and sea turtle strandings recorded in Virginia in 2006.

  - Westgate (2005) analyzed the population structure of common dolphins in the North Atlantic and collected samples from live and stranded animals.

- Wiley et al. (1995) reviewed strandings of humpback whales in the mid-Atlantic from 1985-1992. Records in Chesapeake Bay are from 1986 and 1990.

- Williams (1995) discussed a leatherback turtle that was caught by a fisherman and subsequently released.

- Wilson et al. (1987) summarized sightings and strandings of striped dolphins from all over the world.

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