MARINE RESOURCE ASSESSMENT FOR THE CHERRY POINT AND SOUTHERN VIRGINIA CAPES (VACAPES) INSHORE AND ESTUARINE AREAS

FINAL REPORT

JUNE 2003

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

CONTRACT NUMBER:
N62470-95-D-1160
TASK ORDER NUMBER: 0030

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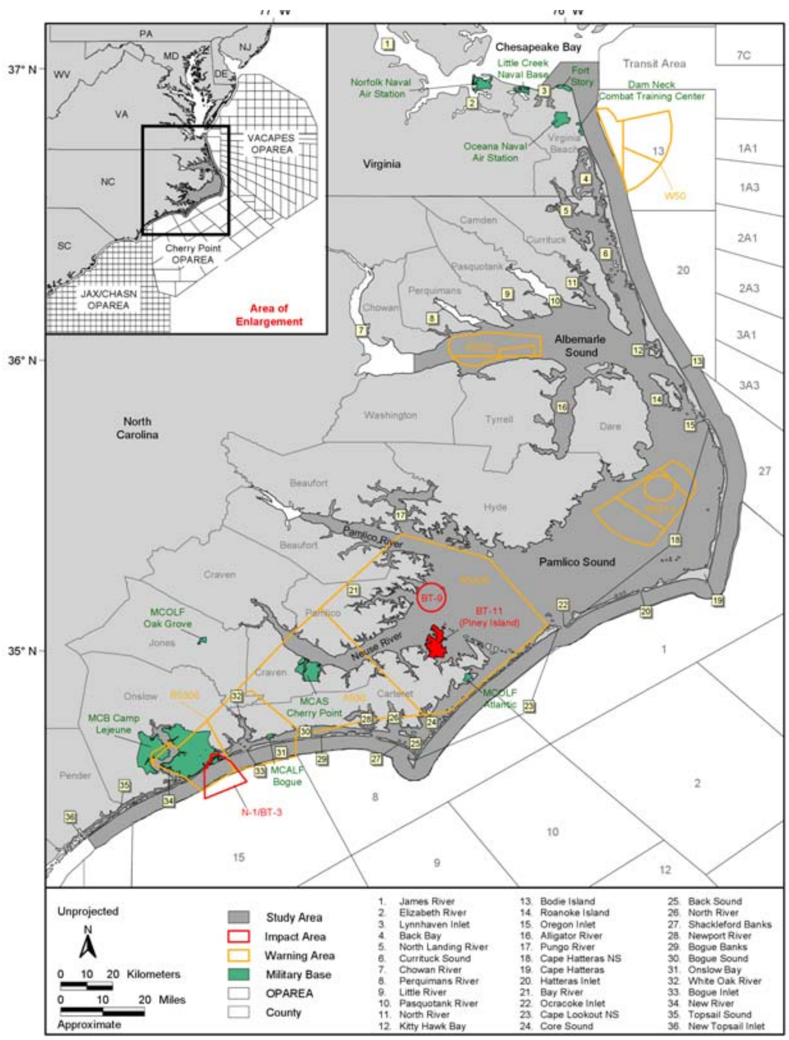
EXECUTIVE SUMMARY

The Department of the Navy is committed to demonstrating environmental stewardship while executing its national defense mission. The Navy is responsible for compliance with a suite of federal environmental and natural resources laws and regulations that apply to the marine environment, including the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as amended by the Sustainable Fisheries Act (SFA). The Navy Commander, U.S. Atlantic Fleet (COMLANTFLT) implemented the marine resource assessments (MRAs) to develop a comprehensive compilation of data and literature concerning the protected and managed marine resources found in its various operating areas (OPAREAs) and adjacent regions. The information in this MRA is vital for planning purposes and for various types of environmental documentation such as biological assessments (e.g., essential fish habitat) and environmental assessments (e.g., environmental impact statements) that must be prepared in accordance with the NEPA, MMPA, ESA, and SFA.



This MRA documents and describes the diversity of marine resources in the Cherry Point and southern Virginia Capes (VACAPES) inshore and estuarine areas, especially those that are protected or managed. Detailed information is included on the characteristics of protected species relevant to the evaluation of potential impacts of Navy operations. Protected species represent such taxonomic groups as plants, fishes, reptiles, birds, and mammals. Seasonal variations in occurrence patterns have been identified, mapped, and described along with the associated factors (behavioral, climatic, or oceanographic). The section on the physical environment reflects the habitat complexity of the study area, with a discussion of several habitat types. Human activities, including commercial and recreational fishing, commercial shipping, diving, and recreational boating, are mapped (when appropriate) and discussed. One chapter is devoted to information about marine protected areas.

Thorough and systematic literature and data searches were conducted, providing as much relevant information as possible for this assessment. All available sighting, stranding, incidental fisheries bycatch, satellite-tracking, and nesting data for marine mammals and sea turtles were compiled and interpreted to predict the occurrence patterns (concentrated, expected, low/unknown, and not expected in the study area) of these protected and managed species. Predictions of the seasonal occurrence patterns of marine mammals and sea turtles are based on the interpretation of all available data as well as scientific literature and expert opinion.

The geographical representation of the marine resource occurrences in the study area and vicinity was a major constituent of this MRA. A geographic information system (GIS) was used to enter, store, manipulate, and visualize the spatial data and information accumulated for the study area. The GIS contains over 150 layers of data and information, including bathymetry, sea surface temperature, protected and managed species' occurrences, fishing grounds, military facilities and ranges, and marine protected areas. This summary of the marine resources occurring in the study area and vicinity is provided in both paper and electronic form.

REPORT ORGANIZATION

This report consists of eight major chapters and associated appendices:

- **Chapter 1 Introduction**—provides background information on this project, an explanation of its purpose and need, a review of relevant environmental legislation, and a description of the methodology used in the assessment;
- **Chapter 2 Habitat Types and the Physical Environment**—describes the physical environment and ecological considerations of the various habitats within the study area, including the geology (physiography, bathymetry, and bottom sediments), physical oceanography (circulation and currents), hydrography (temperature and salinity), biological oceanography (chlorophyll concentrations and plankton), and associated species assemblages;
- **Chapter 3 Biodiversity and Species of Concern**—covers the federally protected species found in the study area (plants, fishes, reptiles, birds, and marine mammals) with detailed narratives of their morphology, status, habitat preferences, distribution, behavior, and life history;
- **Chapter 4 Human Activities**—discusses commercial and recreational fisheries, commercial shipping, scuba diving, and recreational boating in the study area and vicinity;
- **Chapter 5 Marine Protected Areas**—describes regions of the marine environment that are federally protected;
- **Chapter 6 Recommendations**—suggests future avenues of research that are necessary to fill the data gaps identified in this project and prioritizes research needs from a cost/benefit approach;
- **Chapter 7 List of Preparers**—lists all individuals who prepared this MRA report;
- **Chapter 8 Glossary**—includes definitions of the terms used in the MRA report; and
- **Appendices—**provide supplemental and supportive information to the chapters.

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LIST OF ACRONYMS AND ABBREVIATIONS

AOU	American Ornithologists Union
APES	Albemarle-Pamlico Estuary System
ASMFC	Atlantic States Marine Fisheries Commission
°C	Degrees Celsius
CAN	Canada
CBC	Christmas Bird Count
CBRA	Coastal Barrier Resources Act
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
COMLANTFLT	Commander, U.S. Atlantic Fleet
cm	Centimeter
CT	Connecticut
CWA	Clean Water Act
CZCS	Coastal Zone Color Scanner
CZMA	Coastal Zone Management Act
dB	Decibel
dB re 1µPa-m	Decibels at the Reference Level of One Micropascal at One Meter Reference Distance
DE	Delaware
DoD	Department of Defense
DoN	Department of the Navy
DPS	Distinct Population Segments
DU	Duke University
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
e.g.	Exempli Gratia (Latin: For Example)
EIS	Environment Impact Statement
ENSO	El Niño/Southern Oscillation
ESA	Endangered Species Act
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization
FL	Florida
FMC	Fishery Management Council
FMP	Fishery Management Plan
FWPCA	Federal Water Pollution Control Act
FZ	Fishery Management Zone
GA	Georgia
GIS	Geographic Information System
GMI	Geo-Marine, Inc.
GPS	Global Positioning System
GSMFC	Gulf States Marine Fisheries Commission
ha	Hectare
HAB	Harmful Algal Bloom
HAPC	Habitat Area of Particular Concern
HSI	Habitat Suitability Index
Hz	Hertz
IBA	Important Bird Area
i.e.	Id Est (Latin: That Is)
Is.	Island
IWC	International Whaling Commission
JAX/CHASN	Jacksonville-Charleston
kg	Kilogram
kHz	Kilohertz

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

km	Kilometer
km^2	Square kilometer
LSIW	Labrador Sea Intermediate Water
μPa	Micropascal
m	Meter
MA	Massachusetts
MAB	Mid-Atlantic Bight
MARAD	Maritime Administration
MATS	Mid-Atlantic *Tursiops* Survey
MBTA	Migratory Bird Treaty Act
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
ME	Maine
mi	Mile
min	Minute
mm	Millimeter
MMC	Marine Mammal Commission
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 Resource Assessment
m/sec	Meters per second
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
N	North
NARP	National Artificial Reef Plan
NARWC	North Atlantic Right Whale Consortium
NASA	National Aeronautics and Space Administration
NAVO	Naval Oceanographic Office
Navy	United States Navy
NC	North Carolina
NCDENR	North Carolina Department of Environment and Natural Resources
NCDENR/WRC	North Carolina DENR/Wildlife Resources Commission
NCDMF	North Carolina Division of Marine Fisheries
NCNHP	North Carolina Natural Heritage Program
NCWRC	North Carolina Wildlife Resources Commission
n.d.	No date
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NERRS	National Estuarine Research Reserve System
NFEA	National Fishing Enhancement Act
NJ	New Jersey
NM	Nautical Mile
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NP	National Park
NPS	National Park Service

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

NRC	National Research Council
NRDC	Natural Resources Defense Council
NRFCC	National Recreational Fisheries Coordination Council
NS	National Seashore
NSGL	National Sea Grant Library
NTIS	National Technical Information Service
NUWCDIVNPT	Naval Undersea Warfare Center, Division Newport, Environmental Division
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
NY	New York
ODU	Old Dominion University
OPAREA	Operating Area
ORV	Off Road Vehicles
PBR	Potential Biological Removal
PDF	Portable Document Format
PI	Principal Investigator
PL	Public Law
psu	Practical Salinity Unit
PR	Puerto Rico
RFRCP	Recreational Fishery Resources Conservation Plan
SAB	South Atlantic Bight
SAFMC	South Atlantic Fisheries Management Council
SAV	Submerged Aquatic Vegetation
SC	South Carolina
SCDMF	South Carolina Department of Marine Fisheries
SCDNR	South Carolina Department of Natural Resources
scuba	Self-Contained Underwater Breathing Apparatus
S.D.	Standard Deviation
SEAMAP	Southeast Area Monitoring and Assessment Program
sec	Second
SECAS	Southeast Cetacean Aerial Survey
SEFSC	Southeast Fisheries Science Center
SETS	Southeast Turtle Survey
SFA	Sustainable Fisheries Act
spp.	Species
SST	Sea Surface Temperature
Stat.	Statute
study area	Cherry Point and Southern Virginia Capes Inshore and Estuarine Areas
TAMU	Texas A&M University (main campus at College Station)
TEWG	Turtle Expert Working Group
TIRN	Turtle Island Restoration Network
TTS	Temporary Threshold Shift
TX	Texas
U.N.	United Nations
UNCW	University of North Carolina at Wilmington
U.S.	United States
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USGS	United States Geological Survey
USMC	U.S. Marine Corps
USFWS	U.S. Fish and Wildlife Service
USVI	U.S. Virgin Islands
VA	Virginia

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

VACAPES	Virginia Capes
VDGIF	Virginia Department of Game and Inland Fisheries
VIMS	Virginia Institute of Marine Sciences
VMRC	Virginia Marine Resources Commission
W	West
WM	College of William and Mary

1.0 INTRODUCTION

This marine resource assessment (MRA) was contracted by the United States (U.S.) Navy's (Navy) Commander, U.S. Atlantic Fleet (COMLANTFLT) to initiate collection of data and information concerning the protected and commercial marine resources found in the Cherry Point and southern Virginia Capes (VACAPES) inshore and estuarine areas, which lay inshore of the Virginia Capes and Cherry Point U.S. Atlantic Fleet (Fleet) Operating Areas (OPAREAs). For the purposes of this MRA, this region will be considered as one unit and is hereinafter referred to as the "study area."

1.1 PURPOSE AND NEED

The goal of this MRA is to describe and document the marine resources in the study area and vicinity, including both protected and commercial marine species. This MRA report provides a compilation of the most recent data and information on the occurrence of these resources in the study area. A synopsis of environmental data for the study area and in-depth discussions of the species of concern and habitat types found in the region are included. The locations of commercial and recreational fishing grounds, as well as other areas of interest (such as marine protected areas, artificial habitats, and scuba diving sites), are also addressed in this assessment.

The assembled information in this MRA will serve as a baseline from which the Navy may evaluate future actions and consider adjustments to training exercises or operations in order to mitigate potential impacts to protected and commercial marine resources. This assessment will contribute to the Fleet's Integrated Long-Range Planning Process and represents an important component in the Fleet's ongoing compliance with U.S. federal mandates that aim to protect and manage resources in the marine environment. All species and habitats 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.

A search and review of relevant literature and data were conducted to summarize the relevant features of the marine and inshore environment, the occurrence patterns of protected species, and the distribution of important habitats and human activities occurring in the study area. To describe the physical environment of the study area, physiographic, bathymetric, geologic, hydrographic, and oceanographic data for the study region are presented. All available sighting, stranding, incidental fisheries bycatch, tagging, satellite tracking, and nesting data for marine mammals and sea turtles were compiled and interpreted to predict the occurrence patterns of the protected species in the study area. Seasonal variations in occurrence patterns have been identified, mapped, and described along with the likely causative factors (behavioral, climatic, or oceanographic). Characteristics of these species, such as their behavior and life history, relevant to the evaluation of potential impacts of Navy operations are included. Other protected species (plants, fishes, and birds) are treated in a similar fashion. Also reviewed are fishing activities (commercial and recreational), commercial shipping lanes, marine protected areas, and recreational diving sites.

1.2 LOCATION OF STUDY AREA

The study area is located within eastern North Carolina and southeastern Virginia and includes coastal waters out to the 3 nautical mile (NM) state limit, intracoastal estuarine waters, and the barrier beaches between them (Figure 1-1). Two OPAREAs are contiguous to the study area, the VACAPES OPAREA off Virginia and North Carolina and the Cherry Point OPAREA off North Carolina. A third OPAREA, the Jacksonville/Charleston (JAX/CHASN) OPAREA, borders the southernmost edge of the study area. Marine resource assessments have been prepared for all three OPAREAs (DoN 2001, 2002a, 2002b).

The study area covers 10,885 square kilometers (km^2) of coastal waters, barrier beaches, and intracoastal estuarine waters. The eastern boundary of the study area is the 3 NM limit off the coast of North Carolina and Virginia. The western boundary of the study area is the intracoastal shoreline of eastern North Carolina and southeastern Virginia. The northernmost limit of the study area is the mid-mouth of Chesapeake Bay (37.01°N) but only extending into the bay as far west as the mouth of Lynnhaven Inlet (36.91°N, 76.09°W). The southernmost limit of the study area is New Topsail Inlet (34.35°N, 77.66°W).

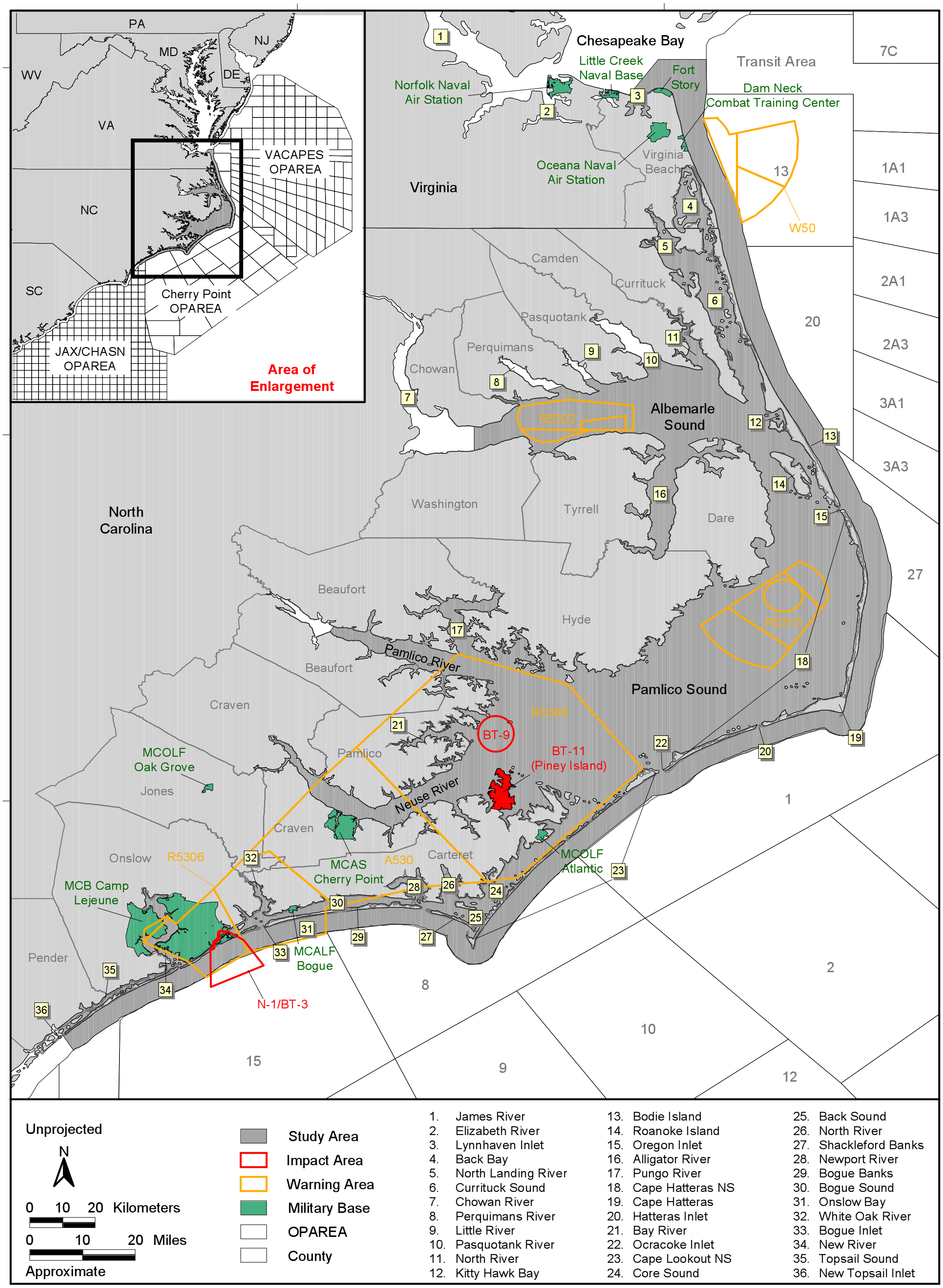

Figure 1-1. The Cherry Point and southern VACAPES inshore and estuarine areas are located along the U.S. Atlantic coast within the states of North Carolina and Virginia. Source data: USMC (2001a, 2001b, 2001c) and NIMA (2002).

1.3 APPLICABLE LEGISLATION

1.3.1 Federal Resource Laws

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

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

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

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

The **Marine Mammal Protection Act (MMPA)** of 1972 established a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The MMPA defines taking as "harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill any marine mammal" (16 U.S. Code [U.S.C.] 1312[13]). It also prohibits the importation into the U.S. of any marine mammal or parts or products thereof, unless it is for the purpose of scientific research or public display, as permitted by the Secretary of the Interior or the Secretary of Commerce. In the 1994 amendments to the MMPA, two levels of "harassment" were defined. Harassment is defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A), or any act that has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to migration, breathing, nursing, breeding, feeding, or sheltering (Level B).

Section 101(a)(5)(A) of the MMPA directs the Secretary of Commerce, upon request, to authorize the unintentional taking of small numbers of marine mammals incidental to activities (other than commercial fishing) when, after notice and opportunity for public comment, the Secretary: (1) determines that total takes during a five-year (or less) period have a negligible impact on the affected species or stock, and (2) prescribes necessary regulations that detail methods of taking and monitoring and requirements for reporting. The MMPA provides that the moratorium on takes may be waived when the affected species or population stock is at its optimum sustainable population and will not be disadvantaged by the authorized takes (i.e., be reduced below its maximum net productivity level). Section 101(a)(5)(A) also specifies that the Secretary has the right to deny 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 **Marine Protection, Research, and Sanctuaries Act (MPRSA)**, often referred to as the "Ocean Dumping Act," was enacted in 1972, two days after passage of the MMPA. The MPRSA regulates the dumping of toxic materials beyond U.S. territorial waters and provides guidelines for the designation and regulation of marine sanctuaries. MPRSA Titles I and II prohibit persons or vessels subject to U.S. jurisdiction from transporting any material out of the U.S. for the purpose of dumping it into ocean waters without a permit. The term “dumping,” however, does not include the intentional placement of devices in ocean waters or on the sea bottom when the placement occurs pursuant to an authorized federal or state program.

The **Coastal Zone Management Act (CZMA)** of 1972 established a voluntary national program through which states can develop and implement coastal zone management plans (USFWS 2000). The National Oceanic and Atmospheric Administration (NOAA), under the Secretary of Commerce, administers this act. States use coastal zone management plans “to manage and balance competing uses of and impacts to any coastal use or resource” (NOAA 2000). A coastal zone management plan must be given federal approval before the state can implement the plan (USFWS 2000). The plan must include, among other things, defined boundaries of the coastal zone, identified uses of the area that the state will regulate, a list of mechanisms that will be employed to control the regulated uses, and guidelines for prioritizing the regulated uses. The CZMA also authorizes the implementation of a National Estuarine Research Reserve (NERR) system.

In addition, the act provides federal agencies with restrictions concerning their behavior in relation to managed zones. Federal agency actions that affect the zone must be “consistent to the maximum extent practicable” with the applicable plan regulations (Coastal Zone Reauthorization Amendments of 1990). Indirect federal actions, such as activities accomplished with a federal permit, must strictly comply with the applicable plan regulations.

The **Endangered Species Act (ESA)** of 1973 established 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. The U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) 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 species may be a candidate for listing as a threatened or endangered species due to any of the following five factors: (1) current/imminent destruction, modification, or curtailment of its habitat or range; (2) overuse of the species for commercial, recreational, scientific, or educational purposes; (3) high levels of disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or human-induced factors affecting its continued existence.

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

Many species of plants, fishes, reptiles, birds, and marine mammals occur in the study area. Of these, one plant, one fish, six reptiles (including five sea turtles), two birds, and three marine mammals are listed as threatened or endangered (Table 1-1). Of the marine mammal species, the NMFS has jurisdiction over the whales while the USFWS has jurisdiction over the manatee. The NMFS has jurisdiction over sea turtles while they are in the water, and the USFWS has jurisdiction over sea turtles on land (including eggs, hatchlings that are on the beach, and nesting females).

Table 1-1. The threatened and endangered species found in the Cherry Point and southern VACAPES inshore and estuarine areas. Marine mammal taxonomy follows Rice (1998) for the West Indian manatee and the IWC (2001) for cetaceans except for the North Atlantic right whale, which was revised by Rosenbaum et al. (2000). Sea turtle taxonomy follows Pritchard (1997).

Plants		
Seabeach amaranth	*Amaranthus pumilus*	Threatened
Fishes		
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Reptiles		
American alligator	*Alligator mississippiensis*	Threatened[1]
Green sea turtle	*Chelonia mydas*	Threatened[2]
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Birds		
Piping plover	*Charadrius melodus*	Threatened[3]
Roseate tern	*Sterna dougallii*	Endangered
Marine Mammals		
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
West Indian manatee	*Trichechus manatus*	Endangered

[1] The American alligator is listed as threatened throughout its range due to its similarity in appearance to the American crocodile. Since the American crocodile is endangered, the government does not want hunters to confuse the two different types of animals.
[2] As a species, the green sea turtle is listed as threatened. However, the Florida and Mexican Pacific coast nesting populations are listed as endangered. It should be noted that not all greens found in the study area come from the Florida population.
[3] Critical habitat in the study area.

The Fishery Conservation and Management Act of 1976, 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, including the USFWS, which 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. Since a substantial portion of fishery resources in offshore waters was allocated for foreign harvest, these foreign allocations were eventually reduced as domestic fish harvesting and processing industries expanded under the domestic preference authorized by the MSFCMA. At that time, exclusive federal management authority over U.S. domestic fisheries resources was vested in the NMFS.

The authority to place observers on commercial fishing and processing vessels operating in specific geographic areas is also provided by the MSFCMA. The data collected by the **National Observer Program**, which is overseen by the 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.

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

The CWA took the first step towards establishing a comprehensive solution to the country's serious water pollution problems (EPA 1997). 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 act sets water quality standards for all pollutants, requires a permit for the discharge of pollutants from a point source, and funds sewage treatment plant construction (EPA 2002). Section 403 of the CWA sets out permit guidelines specific to the discharge of contaminants into the territorial sea, the contiguous zone, and waters further offshore (USFWS 2000). The Chief of Engineers and the Secretary of the Army must approve discharges of dredged or fill material into all waters of the United States, including wetlands. In addition to regulating pollution in offshore waters, the CWA, under the amendment known as the **Water Quality Act** of 1987, also requires state and federal agencies to devise programs and management plans that aim to maintain the biological and chemical integrity of estuarine waters. In estuaries of national significance, NOAA is permitted to conduct water quality research in order to evaluate state and federal management efforts.

Another law regulating the discharge of contaminants into the ocean is the **Marine Plastic Pollution Research and Control Act (MPPRCA)** of 1987. 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, lining, 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. They may only do so, however, when they are beyond a distance from shore as prescribed by the MPPRCA. An additional component of this act is the requirement that all manned, 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 (NOAA 1998).

During the reauthorization of the MPRSA in 1992, Title III of the MPRSA was designated the **National Marine Sanctuaries Act**. Title III authorizes the Secretary of Commerce to designate and manage areas of the marine environment with nationally significant aesthetic, ecological, historical, or recreational value as national marine sanctuaries. The primary objective of this law is to protect marine resources, such as coral reefs, sunken historical vessels, or unique habitats while facilitating all compatible public and private uses of these resources. National marine sanctuaries, similar to underwater parks, are managed according to management plans, prepared by the NOAA on a site-by-site basis. NOAA is the agency responsible for administering the National Marine Sanctuary Program.

In 1996, the MSFCMA was reauthorized and amended by the **Sustainable Fisheries Act (SFA)**. The SFA provides a new habitat conservation tool in the form of the **Essential Fish Habitat (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 clarify that "waters" include all aquatic areas and their biological, chemical, and physical properties, and "substrate" includes the associated biological communities that make these areas suitable fish habitats; the description and identification of the EFH includes habitats used at any time during a species' life in all its life history stages (NMFS 2002).

The Secretary of Commerce implements the SFA through the NMFS. The SFA requires that the EFH be identified and described for each federally managed species. The identification must include descriptive information on the geographic range of the EFH for all life stages, along with maps of the EFH for life stages over appropriate time and space scales. Habitat requirements must also be identified, described, and mapped for all life stages of each species. The NMFS and regional FMCs determine the species distributions by life stage and characterize associated habitats, including habitat areas of particular concern (HAPC). The SFA requires federal agencies to consult with the 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, the EFH Final Rule was authorized, simplifying EFH regulations (NMFS 2002). Significant changes delineated in the EFH Final Rule are: (1) clearer standards for identifying and describing EFH, including 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 clear 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 described in NMFS (2002).

Passage of the **Oil Pollution Act** of 1990 increased the protection of our nation's oceans. The act details new policies' relating to oil spill prevention and cleanup methods as well as amends the CWA. 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 (USFWS 2000). Federal, state, Indian tribe, and foreign trustees must assess the natural resource damages that occur from oil spills in their trusteeships and develop plans to restore the damaged natural resources. The act also establishes the Interagency Coordinating Committee on Oil Pollution Research, whose purpose is to research and develop plans for natural resource restoration and oil spill prevention.

The federal government furthered its estuary protection efforts by passing the **Estuary Restoration Act** of 2000. This act establishes the Estuary Habitat Restoration Council, a federal interagency council that must develop a national estuary habitat restoration strategy. Private entities propose projects to the council that must meet certain criteria and fulfill the council's strategy. The council chooses projects to recommend to the U.S. Army Corps of Engineers (USACE). Projects recommended to the USACE are selected for implementation based on another set of criteria. The federal government pays up to 65% of the project costs, excluding operation and maintenance costs. The ultimate goal of the act is to restore 405,000 hectares (ha) of estuary habitat by 2010.

To protect undeveloped coastal barriers, Congress passed the **Coastal Barrier Resources Act** (CBRA) in 1982. The statute created the John H. Chafee Coastal Barrier Resources System, which consists of various undeveloped coastal barriers. Any development on these 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. The act adds additional undeveloped coastal barriers to the system, alters the definition of "coastal barrier" to include more areas, such as the Florida Keys, and provides additional exemptions from the funding prohibitions (USFWS 2000). Local and state governments and nonprofit conservation organizations can now voluntarily add lands in their possession to the system. The system now includes 515,000 ha of coastal barriers that cover 1,940 kilometers (km) of shoreline (USFWS 2000).

In response to the growing harmful algal bloom and hypoxia problems, Congress passed the **Harmful Algal Bloom and Hypoxia Research and Control Act** of 1998. This statute formed an Inter-Agency Task Force on Harmful Algal Blooms and Hypoxia. The task force must compose a national assessment on the ecological and economic impacts of harmful algal blooms, the same type of assessment for hypoxia, and a separate assessment for hypoxia in the Gulf of Mexico. All three assessments must also include plans on how to reverse these growing problems 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 (CENR 2000).

Congress passed the **Rivers and Harbors Appropriation Act** of 1899 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 Engineers 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 structures and excavation in navigable waters.

The **Migratory Bird Treaty Act (MBTA)** of 1918 prohibited the taking, transporting, and harming of migratory birds and their parts, eggs, nests, and young unless permitted by federal regulations. This act implemented provisions from the 1916 convention between the U.S. and Great Britain that addressed the protection of migratory birds. Provisions from later conventions with Mexico, Japan, and the Soviet Union were implemented as amendments to the MBTA. The Department of the Interior has the authority to enforce the act’s provisions, which includes determining periodically when the taking of migratory birds may occur. 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.

Congress furthered the protection of migratory birds by passing the **Neotropical Migratory Bird Conservation Act** in 2000. The 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 uses a set of criteria to determine which projects will receive federal funding. Not more than 25% of the project’s funds can come from the federal government. At least 75% of the funds allocated for this act, which is $5 million a year until 2005, must be used on projects outside the U.S.

1.3.2 Executive Orders

Executive Order 12962 on Recreational Fisheries was enacted in 1995 to ensure that federal agencies strive to improve the “quantity, function, sustainable productivity, and distribution of U.S. aquatic resources” so that recreational fishing opportunities nationwide can increase. The overarching goal of this order is to promote the conservation, restoration, and enhancement of aquatic systems and fish populations by increasing fishing access, education and outreach, and multi-agency partnerships. The National Recreational Fisheries Coordination Council (NRFCC), co-chaired by the Secretaries of the Interior and Commerce, is charged with overseeing federal actions and programs that are mandated by this order. The specific duties of the NRFCC include: (1) ensuring that the social and economic values of healthy aquatic systems, which support recreational fisheries, are fully considered by federal agencies; (2) reducing duplicative and cost-inefficient efforts among federal agencies; and (3) disseminating the latest information and technologies to assist in the conservation and management of recreational fisheries. In June 1996, the NRFCC developed a comprehensive Recreational Fishery Resources Conservation Plan (RFRCP) specifying what member agencies would do to achieve the order’s goals

(NMFS 1999). In addition to defining federal agency actions, the plan also ensures agency accountability and provides a comprehensive mechanism to evaluate achievements (Panek 1998). A major outcome of the RFRCP has been the increased utilization of artificial reefs to better manage recreational fishing stocks in U.S. waters.

Executive Order 13158, Marine Protected Areas, of 2000 is a furtherance of Executive Order 13089. It created the framework for a national system of marine protected areas (MPAs). MPAs are defined in Executive Order 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." This executive order 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 activity (Agardy 2000).

Executive Order 13186 on the Responsibilities of Federal Agencies to Protect Migratory Birds was enacted 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 the 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 that affect 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.

1.4 METHODOLOGY

1.4.1 Literature and Data Search

A thorough and systematic search for relevant scientific literature and data was conducted. Once identified, information vital to the production of the report was then obtained, reviewed, and catalogued. Of the available scientific literature (both published and unpublished), the following types of documents were utilized in this assessment: journals, periodicals, bulletins, monographs of scientific and professional societies, theses, dissertations, project reports, endangered species recovery plans, stock assessment reports, environmental impact statements (EISs), fishery management plans (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 study area.

To investigate the habitat types and physical environment of the study area and to determine the occurrence of species of concern, recreational and commercial fishing grounds, and other areas of interest, information was collected from the following sources:

- Academic and educational/research institutions (Coastal Carolina University, College of William and Mary [WM], Cumberland Island Museum, Duke University [DU], Florida Marine Research Institute [FMRI], North Carolina Maritime Museum, Old Dominion University [ODU], Smithsonian Institution, Texas A&M University [TAMU], Texas A&M University at Galveston [TAMUG], University of North Carolina at Wilmington [UNCW], University of Rhode Island [URI], University of Texas at Dallas [UTD], and Virginia Institute of Marine Science [VIMS]) were contacted regarding data source information and literature collection.

- On-line computer databases accessible through DU, ODU, TAMU, UTD, VIMS, and WM were used to search the following databases: DIALOG (Oceanic Abstracts, Enviroline, Pollution Abstracts, Aquatic Sciences and Fisheries Abstracts, Life Science Collection, Zoological Record Online, Water Resources Abstracts, National Technical Information Service [NTIS], Federal Register, Dissertation

Abstracts, and BIOSIS Previews) and First Search (e.g., BIODigest, BiolAgrindex, GenSciIndex, and the Government Printing Office).

- The World Wide Web was accessed to search various data- or literature-related databases and related links such as: NOAA, NMFS, USFWS, International Council for the Exploration of the Seas, Elsevier, Inter Research, Allen Press, Blackwell-Science, Natural Resources Defense Council, Food and Agriculture Organization (FAO), Marine Turtle Newsletter, Proceedings of the Annual Sea Turtle Symposium, University of Florida Sea Turtle Bibliography, U.S. Geological Survey (USGS) Loggerhead Sea Turtle Bibliography, National Sea Grant Library (NSGL), Naval Oceanographic Department (NAVO), National Atmospheric and Space Administration (NASA), Minerals Management Service (MMS), and USACE Coastal Ecology Group Waterways Experiment Station.

- Marine resource experts/specialists, state agencies (North Carolina Department of Environment and Natural Resources/Wildlife Resources Commission [NCDENR/WRC], North Carolina Natural Hertiage Program [NCNHP], North Carolina Center for Graphical Analysis and Information [NCCGIA], North Carolina Division of Marine Fisheries [NCDMF], South Carolina Department of Natural Resources [SCDNR], Florida Fish and Wildlife Conservation Commission [FFWCC]), and federal agencies (NOAA: NMFS [Beaufort Laboratory, Office of Protected Resources, Office of Habitat Protection, Northeast Fisheries Science Center {NEFSC}, Southeast Fisheries Science Center {SEFSC}], National Ocean Service [NOS]; National Estuarine Research Reserve {NERR}, Southeast Area Monitoring and Assessment Program [SEAMAP]; NAVO; MMS; NASA; National Marine Mammal Laboratory; Marine Mammal Commission [MMC]; South Atlantic Fishery Management Council [SAFMC]; USFWS; USGS) were also contacted for information regarding species and habitats of concern.

1.4.2 Spatial Data Representation—Geographic Information System

The geographical representation of marine resource occurrences in the study area and vicinity was a major constituent of this MRA report. The marine resources data and information accumulated for this project were accessed from a wide variety of sources, were in disparate formats, covered a broad range of time periods, and represented differing levels of accuracy as well as quality assurance. The spatial or geographical component that was common to all datasets allowed the widely dissimilar data to be 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.

A geographic information system (GIS) was used to store, manipulate, analyze, and visualize the spatial data and information accumulated for the study area. For this project, Environmental Systems Research Institute, Inc.'s (ESRI) ArcView® version 3.2 GIS software was used to create the majority of map figures and ArcView® version 8.2 was used to create the metadata. ArcView® was chosen for this project due to its widespread use, its ease of operation, and its ability to create multiple views and layouts within the same project file.

1.4.2.1 Geographic Data

Problems were encountered when datasets were combined during the development of the map figures. 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 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 to match dataset records with a set of standard field names. In some cases, the latitude and longitude had to be converted to decimal degrees with accuracy to the fourth decimal place. Species' common names were added to the database to replace the multiple species codes that accompanied the original data. The different types of codes used for species names in the original datasets were not always consistent from one dataset to the next. Compiling a comprehensive list of species names increased the chances of plotting all sightings for a given species on the map figures. To maintain integrity of the original data, all fields and records were kept without alteration. When necessary, fields were created to store supplemental information or data that was altered from the original source. No original data fields were deleted and all added fields are signified by the "GMI_" prefix. For example, source fields were added to the main dataset to indicate the origin of the data and are shown in the field as "GMI_source."

The geographic locations of important marine resources in the study and vicinity were derived from four types of sources (in order of reliability): source data, scanned source maps, source information, and information adapted from published maps and literature. The "source data," which include geographic coordinates and GIS shapefiles, were first scrutinized for data quality. If the data were in coordinate form, they were then converted to decimal degrees if necessary and text fields were renamed or added for ease of manipulation. Once standardized, the source data were imported into the GIS software. Some of the data were only available as graphical representations or "source maps." These data were scanned, imported into ArcView®, and geo-referenced using the Image Analysis extension, with significant information being digitized into a shapefile format. Materials acquired as Adobe® Portable Document Format (PDF) files were also treated as scanned source maps (i.e., they were geo-referenced and pertinent information was digitized), since they were already in a digital form. A third type of source, "source information," encompasses information that was neither taken from a scanned map nor was available in coordinate form. For example, maps displaying non-coordinate data, information given via personal communication, or information extracted from a literature description are referenced as source information. In certain cases, source maps and/or information had to be interpreted to be usable in the GIS environment. Maps displaying geographic information that was interpreted or altered from the original source map/information are noted in the figure caption as being "adapted from" that source. The source type and associated reference citations for all marine resource data presented in the map figures are listed in each figure's caption. These four source types have differing levels of associated data reliability or confidence. The level of data confidence is dependent upon three factors: precision, accuracy, and currency. Each of these three factors are in turn affected by all the variables involved in obtaining data and putting the data into a GIS in order to display the data on a map. Following is a brief description of the three main factors and some of the subsequent variables that figure into overall level of confidence.

- ***Precision***—Refers to whether or not the description of the data is specific or non-specific. It is possible to have data recorded very precisely but with very low accuracy. For example, we may say that 2 + 2 = 5.12546732, where the sum is given very precisely but inaccurately. GPS (global positioning systems) offers the highest level of precision for recording locations.

- ***Accuracy***—Refers to how well the data reflect reality. There may be 10 sightings of harbor porpoises in an area, but they may actually have been common dolphins. Even if the locations were precisely recorded, the data are still not accurate. Some variables that affect accuracy are who originally recorded the data (source reliability), how many people have processed/altered the data since it originated (number of iterations), and the method used to record the data.

- ***Currency***—Refers to how recently the data were obtained. Because recent developments in equipment and methods have improved precision and accuracy, confidence is higher for data that have been recorded more recently.

1.4.2.2 Geographic Data Representation

GIS data are displayed as layers or "themes" 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. Since understanding the role map projections play in the creation of valid and usable maps is so critical, further explanation of this issue is provided. A geographic reference system (such as latitude and longitude) is based on the angles measured from the earth's center. A planar coordinate system, on the other hand, is based on measurements on the surface of the earth. To meaningfully transfer real world coordinates (in three dimensions) to planar coordinate (two dimensions), a transformation process has to be applied. This transformation process is called a projection. Such a transformation involves the distortion of one or more of the following elements: shape, area, distance, and/or direction. The user typically dictates the choice of a projection type to ensure the least distortion to one or more of the four elements. Choice of a particular projection is dictated by issues such as the location of the place on earth, purpose of the project, user constraints, and others.

Map Examples	Description of Map Data	Confidence Level
Physical Environment maps, Species of Concern maps, SAV, Salt Marshes, and Tidal Flats	Data from original/reliable sources. Provided in a digital format with geographic coordinates given. Identified as "*source data*" in map captions.	**HIGH** 33 maps (69% of total number of maps)
Recreational Fishing, Artificial Reefs, and Coral and Live/Hard Bottom	First- or second-hand data sources. Locations obtained through scanning geo-referenced* maps. Identified as "*source map(s) scanned*" in map captions.	**MEDIUM** 4 maps (8% of total number of maps)
Commercial Fisheries maps and *Sargassum*	First- or second-hand data sources. Locations obtained by digitizing from written descriptions with no coordinate data or by altering and/or interpreting raw data. Identified respectively as "*source information*" or "*map adapted from*" in map captions.	**LOW** 11 maps (23% of total number of maps)

* Geo-referenced–Refers to data, maps, and images with points that can be matched to real world coordinates so that the data can be accurately positioned in a GIS.

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 spatial data format is the unprojected geographic coordinate system, which uses decimal-degree latitude and longitude coordinates. The decimal-degree format is the only format that allows unlimited, temporary, custom projection and re-projection in ArcView® and is therefore the least restrictive spatial data format. Thus, the maps in this MRA are untransformed, meaning they are shown unprojected on the map figures and their associated geographic data are delivered unprojected.

Since the measurement units for unprojected, geographic coordinates are not associated with a standard length, they cannot be used as an accurate measure of distance. Since the maps in the assessment report are in geographic coordinates, the map figures should not be used for measurement and the scale information only provides approximate distances. The map scales and reference datum used on all maps in this MRA are presented in statute miles, not nautical miles. It is not currently possible to use nautical miles for the scale in ESRI's ArcView® GIS software.

The majority of maps in this report are presented in two forms: a display that includes four seasonal maps per page and a display that includes one full-page map. Maps of each display type are presented at the same approximate scale; the full-page maps are at the approximate scale of 1:1,750,000 while each of the seasonal maps (one of four per page) is shown at the approximate scale of 1:3,500,000. The maps in this MRA report are presented in kilometers and statute miles.

1.4.2.3 Physical Environment Maps

The bathymetry and sea surface temperature (SST) maps represent gridded raster data that were converted to the raster ArcGrid™ format. Selected isobaths from the resulting two-dimensional contours are shown on the bathymetry figures and on various maps throughout the MRA report.

The SST derived from the Advanced Very High-Resolution Radiometer (AVHRR) were downloaded from NASA and processed by the NAVO's Meteorology and Ocean Measurement Division. The resulting gridded raster data were manipulated in the same manner as the bathymetric data, resulting in contour lines of the respective data. The gridded SST satellite data were sampled at a 5-min resolution and contoured at 1°C intervals.

1.4.2.4 Habitat Type Maps

Multiple sources of data and information were used in the creation of maps of habitat types in the study area and vicinity. Maps displaying live/hard bottom communities, as well as artificial reefs and shipwrecks, were created using scanned images and geographic coordinate data available from published and unpublished scientific literature. The map of live/hard bottom substrate was created not only from a source map but also from source data in the form of GIS shapefiles.

Several of the map figures in the habitat types chapter are composites of multiple data and information sources. The artificial reefs and shipwrecks map is another good example of a map created from multiple sources, as it incorporates information from scanned maps as well as data available from both federal and state government websites. Artificial reefs often consist of multiple types of material placed on the seafloor. To accurately depict this on a map, artificial reefs that were located within 500 m of one another were denoted as an artificial reef complex. Artificial reef complexes consist of at least two groups of artificial reef material but may contain as many as four or five groups of reef substrate. Since geographic locations for each artificial reef were available in coordinate form, ArcView® GIS was used to create a buffer polygon (radius 500 m) around each individual reef. If the resulting buffer polygons overlapped, the artificial reefs were then grouped together and reclassified as an artificial reef complex. Artificial reefs that lie more than 500 m from any other reefs are labeled solely as artificial reefs.

Geographic data utilized for the creation of maps for submerged aquatic vegetation (SAV), salt marshes, and tidal flats were obtained from the North Carolina Environmental Sensitivity Index report. Geographic data provided in this report were compiled and/or created by the NOS. All data from this source were provided in ArcView® GIS shapefile format and therefore represent a high level of data confidence.

1.4.2.5 Biological Resource Maps—Species of Concern

Marine mammal and sea turtle occurrence data were accumulated from every available source for the study area. Available marine mammal and sea turtle data included in this MRA are listed in Appendix A. Occurrence data from aerial and shipboard (sighting) surveys, stranding records, incidental fisheries bycatch records, and radio- or satellite-tagging programs are included. Data incorporated into the marine mammal and sea turtle maps were vital to the determination of seasonal occurrence patterns for protected species known to inhabit the waters of the study area. Seasons throughout the report are defined as winter (January through March), spring (April through June), summer (July through September), and fall (October through December).

Sighting data from aerial and shipboard sighting surveys were obtained from the NMFS, the DoN, and other sources. In addition to sea turtle and marine mammal data from agencies and institutions, miscellaneous sighting data from the scientific literature were also used in this MRA.

Much of the marine mammal stranding data used in this report were acquired from the Smithsonian Institution. The Smithsonian is the final repository for marine mammal stranding data. The Smithsonian marine mammal stranding dataset includes historical records prior to the formal creation of the marine mammal stranding networks and is thus the most comprehensive stranding dataset available for the U.S. Atlantic coast, especially for beaked whale species.

Incidental fisheries bycatch data for marine mammals and sea turtles were obtained from the NMFS, as fisheries observer programs fall under its jurisdiction. The NMFS and SCDNR provided sea turtle tagging data. Sea turtle sightings are categorized into two distinct groups, survey sightings and public sightings, to help facilitate accurate interpretation of the data.

While working with the marine mammal and sea turtle data, several assumptions were made. First, it was assumed that the species identifications given in the original datasets were correct. Since the reliability of species identifications from one dataset to the next was not always known, it was necessary to work under this assumption. A species reliability index was included in the dataset. For the sake of consistency, reliability of species identification was not considered in the plotting of any marine mammal or sea turtle data. The reliability of marine mammal and sea turtle species identification is of greater importance when calculating densities or estimating a species' abundance in a particular area.

Although it was assumed that the species identifications were correct, it could not always be assumed that the geographic coordinates given in the dataset were correct. Problems were often encountered when the original data coordinates were plotted and animals were shown to occur in unexpected locations. This was especially true of the marine mammal stranding data. For example, the geographic coordinates of several strandings often indicated that they occurred well out to sea or far inland. In such cases, the stranding record was moved as close to the original geographic description as possible. If no geographic description was available, the stranding was moved to the nearest shoreline at an accuracy scale of 1:250,000. If the stranding record was too far offshore or inland to estimate an accurate shore position, the record was deleted.

For the purposes of this project, most categories of unidentified species were merged into one category called unidentified cetaceans. There were some exceptions to this process. Unidentified rorquals (the family of baleen whales which includes the blue, fin, sei, minke, Bryde's, and humpback whales) were left as a separate group to conservatively determine endangered whale distribution for the study area. Although the category of unidentified rorquals includes the non-endangered/non-threatened minke and Bryde's whales, it seemed appropriate to use the group of unidentified whales when determining the distribution of endangered whales in the study area, since most rorquals are endangered species.

The data for individual and groups of species were used to develop polygons of seasonal occurrence for marine mammal and sea turtle species. Four types of occurrence information may be displayed on each turtle or mammal map: areas of **expected occurrence** (areas encompassing the expected distribution of a species based on what is known of its habitat preferences, life history, and the available sighting, stranding, incidental fisheries bycatch, and, when applicable, tagging data), areas of **concentrated occurrence** (subareas of a species' expected occurrence where there is the highest likelihood of encountering that species; this designation is based primarily on areas of concentrated sightings and preferred habitat), areas of **low/unknown occurrence** (areas where a species is believed to be rare or the likelihood of encountering that species is not known), and areas labeled **occurrence not expected** (areas within the study area where a species is not expected to be encountered). A high number of sightings indicates nothing about the number of individuals associated with each sighting; a sighting for some species, particularly some dolphin species, may involve a very large group with thousands of individuals.

Geographic data utilized for the creation of maps for the shortnose sturgeon, sea beach amaranth, piping plover, and roseate tern were obtained from the North Carolina Environmental Sensitivity Index report. Geographic data provided in this report was compiled and/or created by the NOS. Some maps also include data sets from the North Carolina Natural Heritage Program (see metadata for specific sources). Data from both sources were provided in ArcView® GIS shapefile format and therefore represent a high level of data confidence.

1.4.2.6 Human Activity Maps

The maps of commercial fishing grounds are composites of multiple data sources and types. Commercial fishing ground maps and descriptions available from the literature and government websites were adapted so that fishing ground polygons could be drawn for relevant fishery types in the study area and vicinity. Multiple sources were also used in the creation of the recreational fishing maps. Recreational fishing sites include sites from artificial reefs and live/hard bottom communities. Fishing tournament polygons were created using a 75 NM buffer from weigh-in locations for offshore tournaments and literature descriptions for coverage of surf and inshore tournaments. Maps for dive sites, recreational boating, and shipping lanes utilized data created from a combination of scanned maps and source data.

1.4.2.7 Marine Protected Areas

Information regarding the locations of MPAs was collected from available multiple data sources. Much of the data utilized for the creation of the MPA map were obtained from the North Carolina Environmental Sensitivity Index report. Geographic data provided in this report were compiled and/or created by the NOS. Data from this source were provided in ArcView® GIS shapefile format and therefore represent a high level of data confidence. Data for other protected areas were obtained from NOAA as both digital data and map images.

1.4.3 Inherent Problems with Marine Survey Data

When attempting to use aerial and shipboard survey data as a major indicator of a species' occurrence, it is necessary to first recognize the inherent problems associated with each survey type. One of the main drawbacks of surveys in the marine environment is that shipboard and aerial surveys count the number of animals at the water's surface, where species such as cetaceans and sea turtles spend relatively little time. Since sea turtles spend over 90% of the time under water, 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 seen at the surface, the diving behavior of one individual may be different from that of other members of the same species. Even though marine mammals and sea turtles are obligated to come to the surface to breathe, many individuals will not surface within an observer's field of view. This is of particular concern when attempting to sight species that dive for extended periods of time, do not possess a dorsal fin, and are known to exhibit cryptic behavior, such as beaked whales, *Kogia* spp., and sperm whales (Würsig et al. 1998; Barlow 1999). Beaked whales are often solitary individuals, which makes their sightability much different from a species that regularly occurs in large groups, such as dolphins in the genus *Stenella* (Scott and Gilbert 1982).

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

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

In addition, marine surveys are unable to assist scientists in accurately describing the seasonal occurrence of marine mammals and sea turtles in extremely large areas such as the Atlantic Ocean or in spatially complex areas such as the study area. The occurrence of marine mammals and sea turtles in an area often changes on a seasonal basis in response to changes in water temperature, the movement and availability of prey, or an individual's life history requirements, such as reproduction. Therefore, the number of sightings on a specific date over a specific survey 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.

Data on incidental fisheries bycatch of marine mammals and sea turtles in fisheries were used as supplemental information to determine occurrence patterns of these protected species in the study area. Aerial and shipboard surveys are most successful in determining occurrence patterns of marine mammals and sea turtles when the sighting conditions are optimal, which is usually during the summer. Fisheries, however, operate year-round, even in inclement weather. Therefore, including bycatch records to supplement the survey data for seasons in which sub-optimal sighting conditions persist (as in winter) is a useful tool. The fisheries bycatch data also proved to be an adequate resource for determining the locations of commercial fishing activity.

1.4.4 Inherent Problems with Stranding Data

How closely the distribution of marine mammal and sea turtle stranding records mirrors the actual occurrence of a species in a given region is often not known. Sick animals may strand well beyond their normal range and carcasses may travel long distances before being noticed by observers. Stranding frequency in a given area is as much a function of nearshore and offshore current regimes and coastal zone patrol efforts as it is a function of the stranded species' actual pattern of occurrence. Since coastal species will strand more frequently than oceanic species, due to their closer proximity to shore, stranding frequencies should not be used when attempting to compare the occurrence of a coastal versus an oceanic stock in a certain area. Comparisons cannot be made between species of differing sizes and social structures, as strandings of large-bodied species and groups of individuals are much more likely to be reported than strandings of small-bodied species or single individuals. An additional problem with the use of stranding data involves the inability of reporters to identify carcasses as a certain species. For example, only the most experienced marine mammal scientists are likely able to differentiate between the several species of beaked whale in the genus *Mesoplodon*.

1.5 REPORT ORGANIZATION

This report consists of eight chapters and associated appendices. Chapter 1—Introduction provides background information on this project, an explanation of its purpose and need, a review of relevant environmental legislation, and a description of the methodology used in the assessment. Chapter 2—Habitat Types and the Physical Environment describes the physical environment and ecological considerations of the various habitats within the study area, including the marine geology (physiography, bathymetry, and bottom sediments), physical oceanography (circulation and currents), hydrography (surface temperature and salinity), biological oceanography (chlorophyll concentrations and plankton), and associated species assemblages. Chapter 3—Biodiversity and Species of Concern covers the federally protected species found in the study area (plants, fishes, reptiles, birds, and marine mammals) with detailed narratives of their morphology, status, habitat preferences, distribution, behavior, and life history. Chapter 4—Human Activities discusses commercial and recreational fisheries, commercial shipping, scuba diving, and recreational boating in the study area and vicinity. Chapter 5—Marine Protected Areas describes regions of the marine environment that are federally protected. Chapter 6—Recommendations suggests future avenues of research that are necessary to fill the data gaps identified in this project and prioritizes research needs from a cost/benefit approach. Chapter 7 is the List of Preparers and Chapter 8 is the Glossary. The Appendices (A, B, C, and D) provide supplemental information of marine mammal and sea turtle data sources, species of fishes with essential fish habitat designated, piping plover critical habitat units, and a mylar map of the Gulf stream, respectively.

This report follows a closely adapted Chicago Manual of Style format and reference style. Depending on the chapter, cited literature appears at the end of the chapter, or at the end of each significant section within a chapter.

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2.0 PHYSICAL ENVIRONMENT AND HABITAT TYPES

The Cherry Point and southern Virginia Capes (VACAPES) inshore and estuarine areas are characterized by a wide diversity of habitat types and ecological complexity. The study area includes the coastal zone, encompassing the state waters beginning at the shoreline seaward to the 3 NM limit. The coastal zone is similar environmentally, ecologically, and biologically to the oceanic environment typical of the Navy's offshore operating areas. The coastal zone of the study area is separated from the intracoastal, estuarine waters of eastern North Carolina and Virginia by a long chain of barrier islands. Barrier islands, although technically terrestrial, are considered in this marine resource assessment because of their definitive role in separating the wholly marine coastal waters from the protected estuarine waters and in providing habitat for species of concern, such as the sea beach amaranth. The study area's extensive barrier island system ranges along the shore from southeastern Virginia to southern North Carolina and is generally known as the Outer Banks. A network of rivers and sounds comprises the study area inside the barrier island system. The Pamlico and Neuse Rivers flow into the largest body of water, Pamlico Sound, where they discharge freshwater and sediments from interior North Carolina. Pamlico Sound is connected to the study area's second largest water body, Albemarle Sound, via the small Croatan and Roanoke Sounds, which are located on either side of Roanoke Island. To the south, Pamlico Sound is connected to the very narrow Core Sound. Bogue Sound, also a very narrow body of water, lies furthest south and is connected to Core Sound. Currituck Sound crosses the North Carolina-Virginia border and is oriented roughly parallel to the barrier island chain separating it from the Atlantic Ocean.

2.1 CLIMATE/WEATHER

The climate of the study area is moderated by the Atlantic Ocean, resulting in a maritime climate that is mild and moist. Rainfall averages from 119 to 130 centimeters per year (cm/yr) throughout the study area but is highly variable both temporally and spatially (Copeland et al. 1983; Copeland and Riggs 1984). Precipitation is fairly uniformly distributed throughout the year but is highest in summer, usually associated with tropical storms or thunderstorms, and lowest in fall.

Air temperatures vary widely throughout the year, from 6° to 8°C in January to 28° to 32°C in August (Copeland et al. 1983; Copeland and Riggs 1984). Winters are mild and summers hot and humid. Prevailing winds are typically from the south-southwest and average 15 to 16 kilometers per hour (km/hr) (Copeland et al. 1983; Copeland and Riggs 1984). Lowest wind velocities generally occur in summer while cold fronts moving in from the north or northwest cause the highest velocity winds to occur in winter.

Exceptions occur from late spring through early fall (May through October) when tropical storms or hurricanes develop in the equatorial Atlantic Ocean and, steered by the Gulf Stream, often travel north along the southeastern coast of the U.S. Although hurricanes occur infrequently in the study area, they cause not only high winds but higher than normal tides and storm surge bring a greater volume of seawater into the coastal lagoons (sounds) shoreward of the barrier islands. More than nine hurricanes affected the North Carolina coast in the 1950s and one major hurricane struck the Outer Banks in the 1960s (USFWS 1980). Six major hurricanes of magnitude 2 or greater struck the North Carolina coast from 1996 through 1999 (Paerl et al. 2001). Another type of extreme weather event, extratropical storms or "northeasters," can also present a significant problem for parts of the study area in the winter, notably the Outer Banks due to the extreme eastward projection of the barrier island chain at Cape Hatteras. Northeasters develop as strong low-pressure (clockwise flowing) systems, moving slowly offshore into the Atlantic Ocean. Winds from these storms can reach hurricane force and blow onshore from a northern or eastern direction for sustained periods. Damage and floods from northeasters have equaled or exceeded that caused by hurricanes in North Carolina (USFWS 1980).

2.2 GEOLOGICAL SETTING

The east coast of the U.S. is a passive continental margin and its geology and physiography typify that setting. At a passive margin, the continent and adjacent ocean floor are on the same crustal plate. Passive continental margins such as the east coast of the U.S. are characterized by subsidence, erosion, and thick sediment accumulations that have led to the development of the classic continental margin sequence: continental shelf, slope, and rise (Kennett 1982).

The study area lies at the transition between continent and ocean. The portion of the study area inside the barrier island system lies on the edge of an extensive, flat coastal plain called the Pamlico Terrace, which transitions into the continental shelf that underlies the portion of the study area outside the barrier islands. A relict shoreline, the Suffolk Scarp, separates the terrace in the west from the higher elevation interior areas. Covered largely by sand and clay, the coastal plain of the study area is no higher than 1 m elevation, except for sand ridges and hills that parallel the shoreline from Cape Henry, Virginia south to Albemarle Sound.

The study area's dominant physiographic feature is the long barrier island chain that separates the coastal ocean waters from the estuarine waters of the coastal lagoons. Seaward of the barrier islands, the continental shelf is the seaward extension of the continent, almost like a submarine platform. A gentle incline or gradient (<1:1,000), low relief (< 20m), widths of about 100 km, and water depths of 130 m on average worldwide distinguish the continental shelf (Kennett 1982; Eisma 1988). Along the eastern U.S. coast, the continental shelf ranges in width from less than 5 km off southern Florida to nearly 400 km in the Gulf of Maine. At Cape Hatteras, the continental shelf narrows to 45 km. Cape Hatteras is an area of geologic transition between the carbonate province found to the south and the carbonate-depleted, primarily terrigenous (from land) province to the north (Johnson 1989).

2.3 HABITAT TYPES

A variety of marine, coastal, and aquatic habitats occur within the study area. There are many ways of classifying these habitats, from their ecological associations to their formation mechanisms. We have chosen to take a holistic environmental approach in describing the habitat types found in the study area. This approach begins with an explanation of how the habitats were formed, followed by a description of the each habitat's environment and its ecological associations. This approach is key to understanding the diverse habitats found in the study area. The habitat areas in the study area belong in two broad categories: those that are part of the barrier island complex and those that are characteristic of the nearshore, oceanic waters.

2.3.1 Nearshore/Coastal Oceanic Waters

The habitat of the study area seaward of the barrier island chain (up to 3 NM from shore) is homogeneous and differs little from the oceanic environment typical of waters overlying the continental shelf of the mid-Atlantic U.S. coast. This area near shore is dominated by the southward moving longshore current and subsequent sand transport dynamics as well as its proximity to the western boundary of the Gulf Stream Current. A longshore current is a current that moves parallel to shore near the surf zone and is caused when waves approach the beach or shore at an angle, resulting in incomplete wave energy refraction (Figure 2-1). Longshore currents transport sediments, usually sand, suspended in the water along the shore in a process called longshore transport or littoral drift. The direction of net sediment transport is the same as the current movement. Sand or sediment flow along the U.S. east coast is southward, as waves that drive the longshore current and transport approach shore from the north, where they are usually generated by storms in the North Atlantic (Garrison 1995).

The nearshore waters are shallow, with depths only reaching 20 m east of Duck Island (Figure 2-2). The average water depth is about 7 m. Typical of the east coast's inner continental shelf, the sea floor of the nearshore or coastal waters is covered primarily by sand, and some silt (Figure 2-3).

The salinity of the nearshore waters is 28 to 32 practical salinity units (psu) (Figure 2-4). These salinities are lower than the average salinity for ocean water (~35 psu) as they are modified by mixing of lower salinity water moving seaward through the inlets of the Outer Banks. The salinity of the water in the vicinity of Cape Hatteras is higher due to the presence of deeper water very near shore in this area. A salty wedge of water intrudes onto the shelf near Cape Hatteras during every season but is especially apparent in the winter when the average salinity reaches 36 psu (Cook 1988). This high salinity intrusion

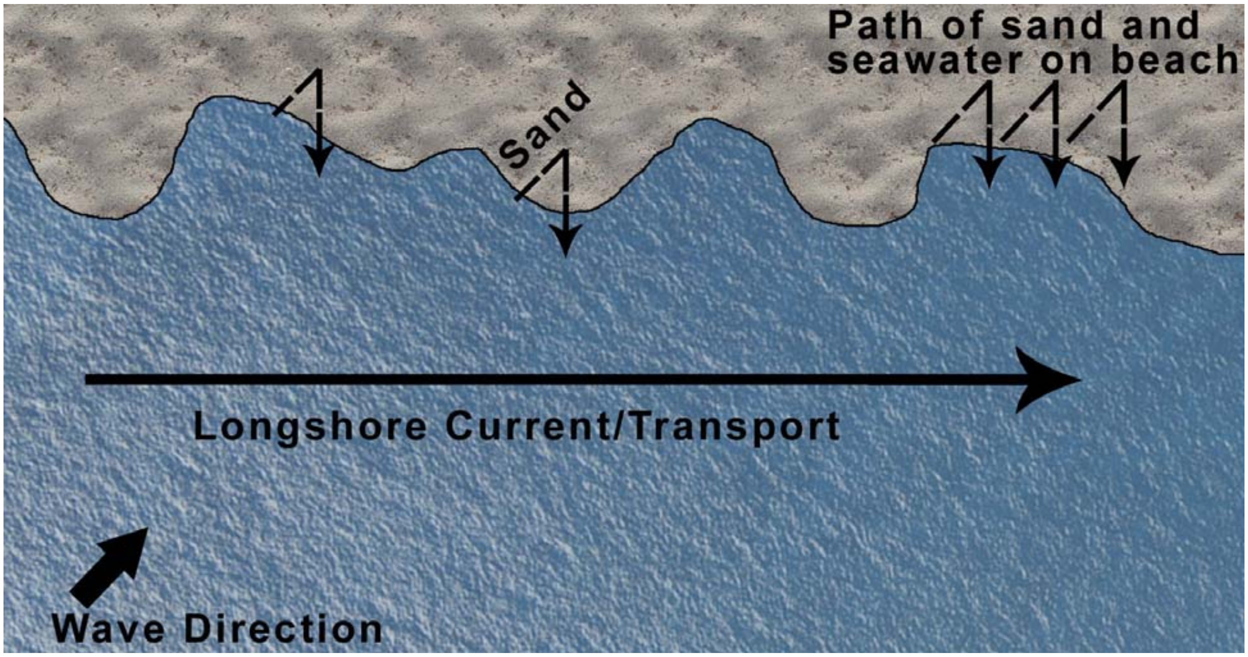

Figure 2-1. Longshore currents are nearshore currents that move parallel to the shoreline and transport sediments (sand) along the coast. These currents are one of the mechanisms that build barrier islands along the coast.

on the inner shelf appears to be coincident with the average path of the Gulf Stream through the area, although the higher salinities do occur farther north than the mean axis.

The nearshore, coastal waters exhibit more than a 20°C temperature flux throughout the year. During most of the year, there is a clear north-south gradient of increasing sea surface temperatures, although this trend is less apparent in summer when the surface temperatures are more homogeneous (Figure 2-5). Minimum water temperatures occur in fall and winter with a marked thermal convergence at Cape Hatteras (area just north of the cape [winter, Figure 2-5] where the isotherms lie very close together).

The warm year-round temperature of the nearshore waters provides a suitable environment for many coastal species, allowing both temperate and tropical species to exist in this transition zone. Temperature certainly affects the abundance of plankton, especially phytoplankton. Phytoplankton are single-celled organisms that are similar to plants because they use sunlight and chlorophyll to photosynthesize. At the base of the marine food chain, phytoplankton are essential to the overall productivity of any aquatic environment. Their growth and distribution are influenced by several factors, the most important of which are temperature (Eppley 1972), light (Yentsch and Lee 1966), and nutrient concentration (Goldman et al. 1979). Phytoplankton distribution is patchy, occurring in environments that have optimal light, temperature, and nutrient conditions. In general, the abundance of phytoplankton in the ocean is higher in nearshore waters due to the input of nutrients from land sources. The diversity of phytoplankton is also highest in nearshore waters closest to the coast. The concentration of chlorophyll *a*, often used as a proxy for primary productivity, varies little seasonally in the nearshore waters of the study area, indicating that nutrient concentrations are probably plentiful year round and that water temperatures do not limit phytoplankton growth. Phytoplankton populations in continental shelf waters consist primarily of diatoms (Marshall 1971, 1991). While these diatom populations could extend deeper than the continental shelf, they have not been observed past the western wall of the Gulf Stream (Marshall 1971).

Aggregations or mats of *Sargassum natans* and *S. fluitans,* planktonic brown algae, form an integral habitat for a variety of marine flora and fauna (Settle 1993). Pelagic *Sargassum* is an important temporary habitat for larval and juvenile fishes, many of which are commercially and recreationally fished (SAFMC

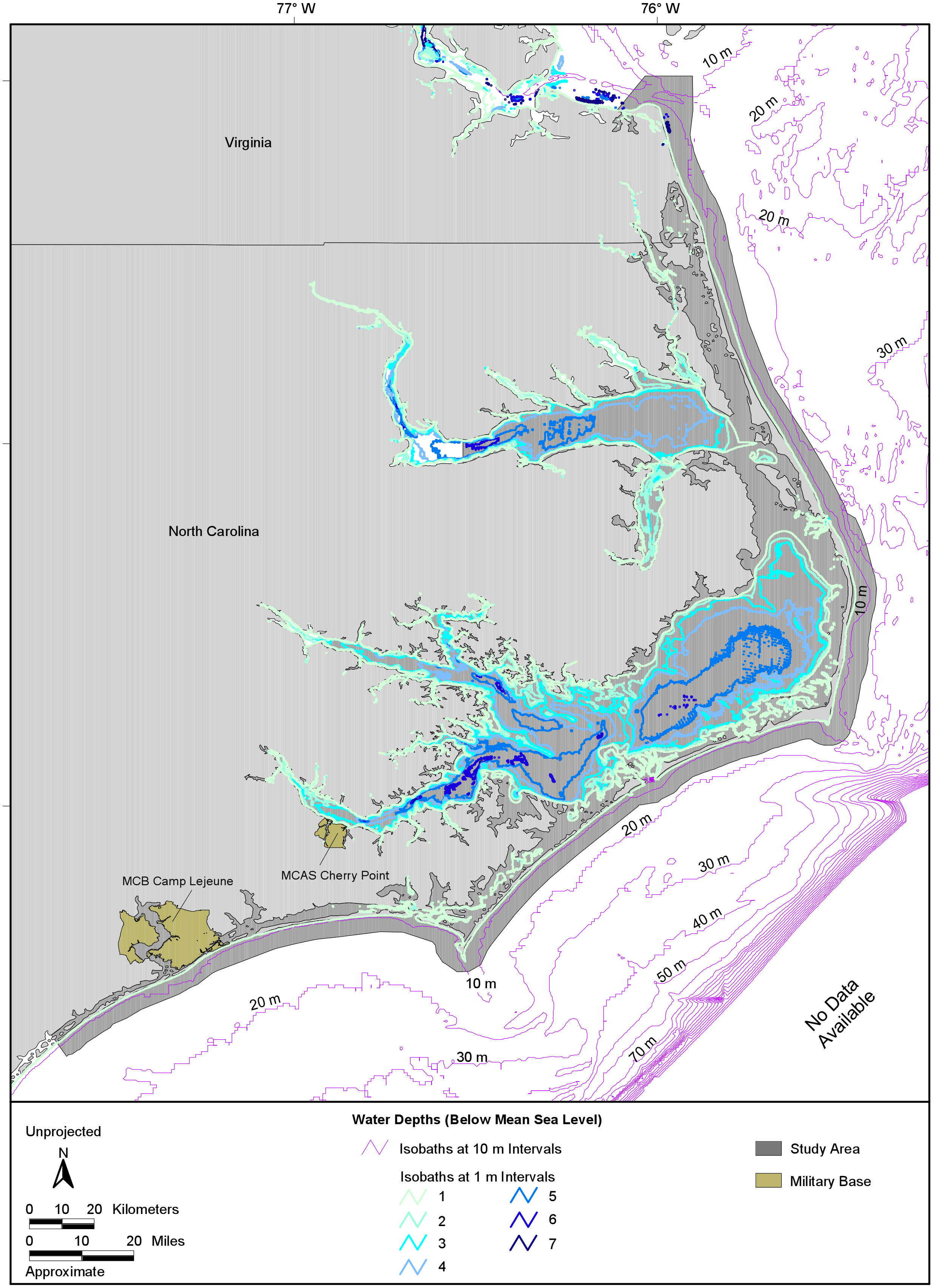

Figure 2-2. Bathymetry of the Cherry Point and southern VACAPES inshore and estuarine areas. Isobaths connect points of equal depth. Source data: NOAA (1999).

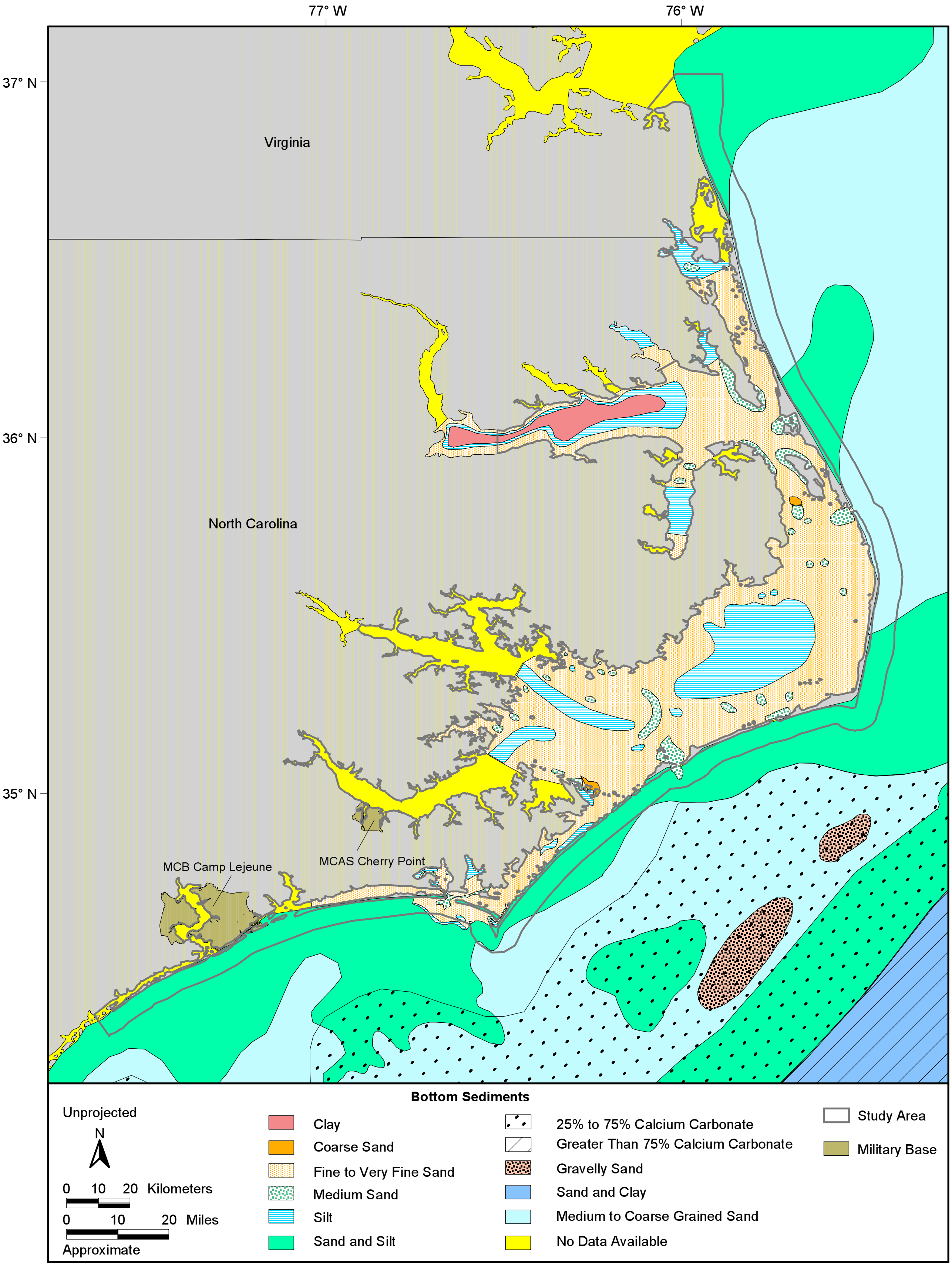

Figure 2-3. Types of bottom sediments found in the Cherry Point and southern VACAPES inshore and estuarine areas. Source maps (scanned): Wells (1989) and Amato (1994).

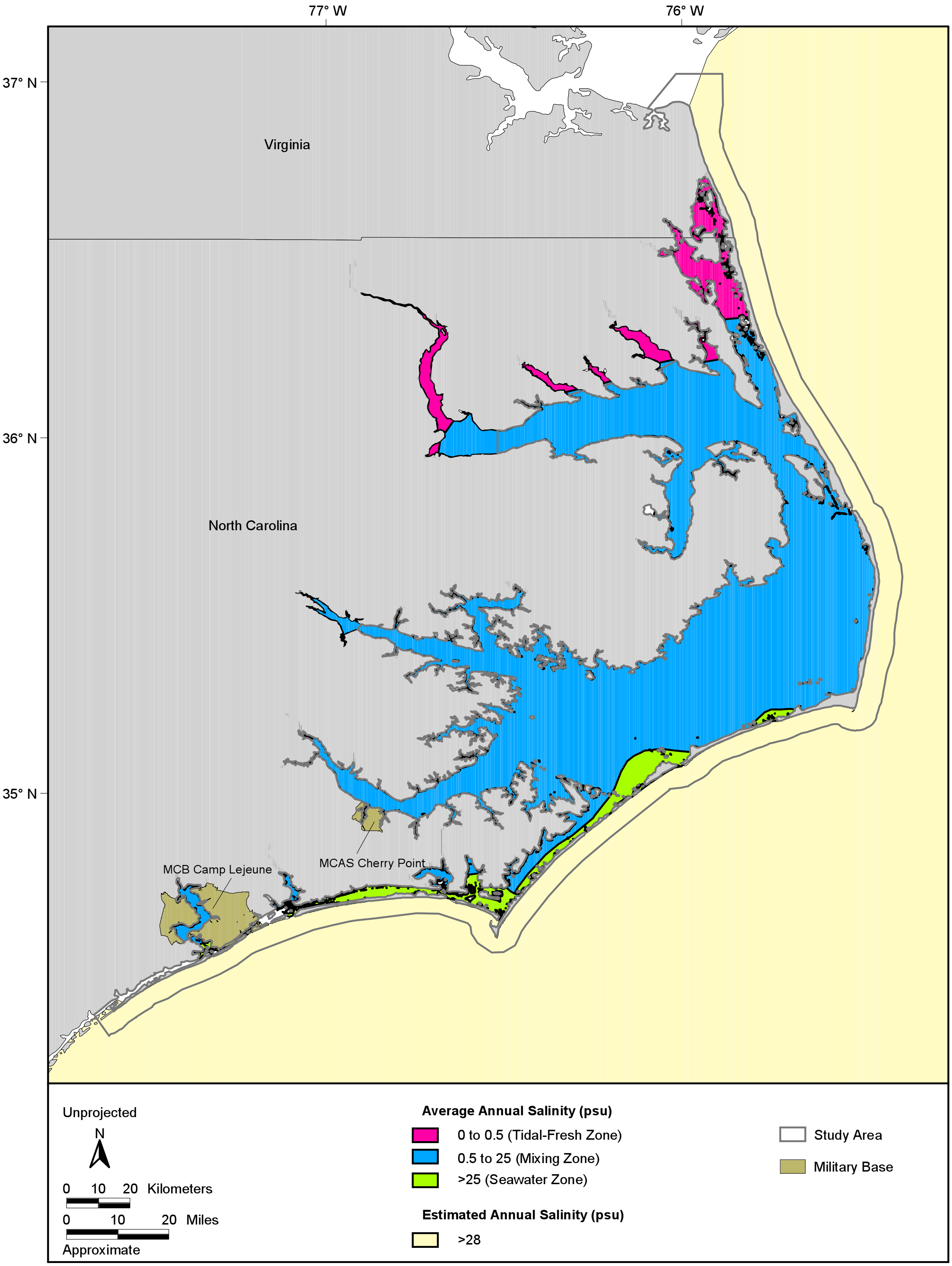

Figure 2-4. Average annual surface salinity in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NOAA (1998a).

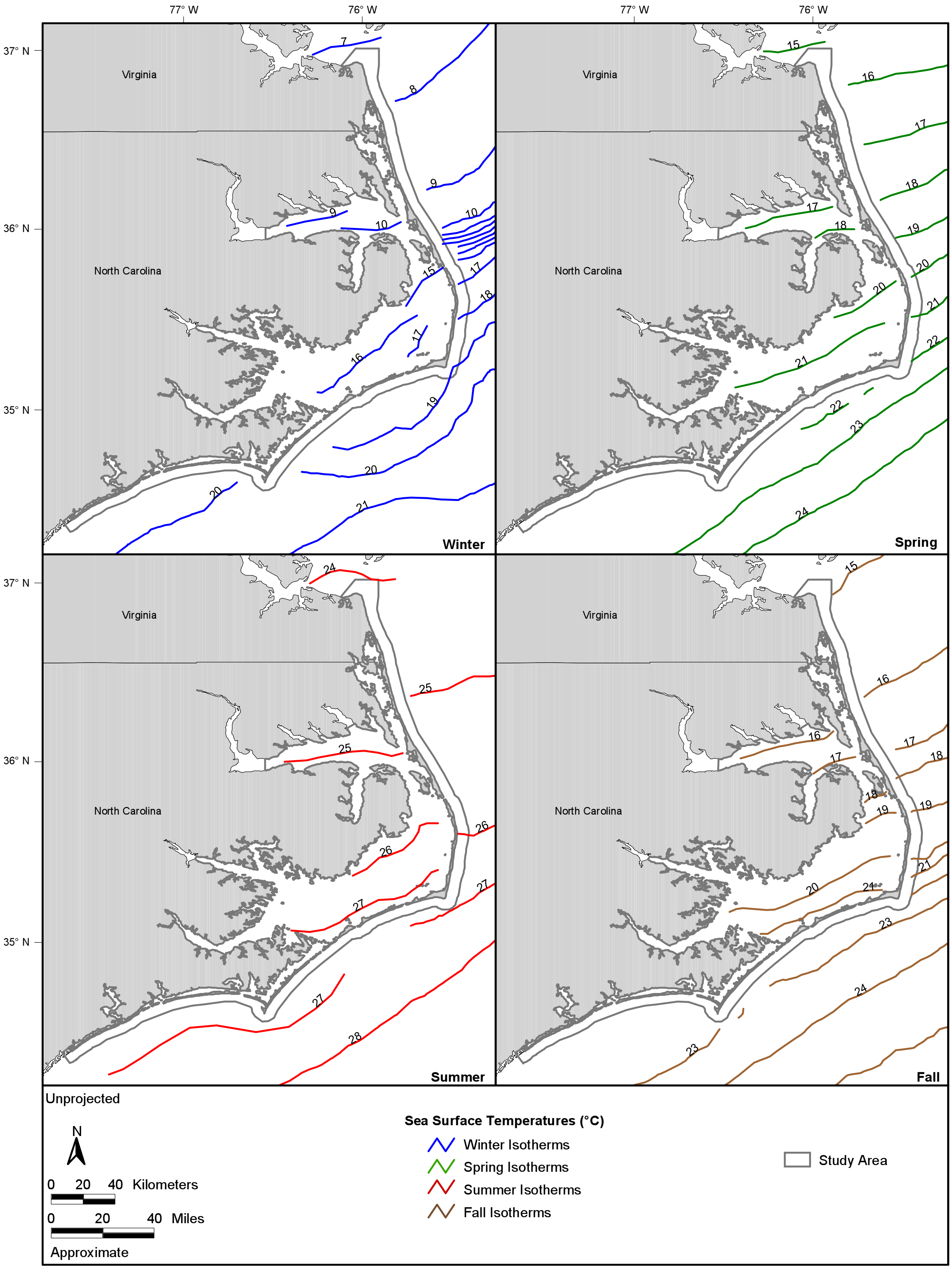

Figure 2-5. Mean seasonal sea surface temperatures in the Cherry Point and southern VACAPES inshore and estuarine areas from 1985 through 1997. Isotherms connect points of equal temperature and are contoured at 1°C intervals. Source data: NASA Jet Propulsion Laboratory (1998).

1998). Sometimes sea turtles and marine birds utilize the drifting algal mats. Pelagic *Sargassum* has been found to be an important early developmental habitat for sea turtle hatchlings during their "lost year," when they passively drift along with the floating algal mats. The largest known aggregation of loggerhead hatchlings was found off North Carolina during a commercial *Sargassum* harvest (Schwartz 1988). *Sargassum* is also a permanent habitat for other fish and invertebrate species. The distribution of pelagic *Sargassum* is not well defined but it is frequently entrained in the Gulf Stream Current. Drifting *Sargassum* can travel over the continental shelf for extended periods of time, remain in the Gulf Stream, or wash ashore (SAFMC 1998). Thus, *Sargassum* can be found commonly in nearshore North Carolina waters.

A wide variety of fish species occur in the nearshore waters of the study area. This diversity is the result of the interaction of zoogeographic factors, environmental variables such as currents and temperature, and habitat features such as artificial reefs. Many fish and invertebrate species move through the nearshore waters and through the barrier island inlets to gain access to the protected estuarine waters of the study area's coastal lagoons. Many of the fish species found in the nearshore environment are important to both commercial and recreational fisheries. The nearshore waters of North Carolina are the predominant fishing grounds of the shrimp fishery.

The nearshore waters of the study area are also home to protected species such as sea turtles and marine mammals. Bottlenose dolphins are observed frequently, often feeding, in nearshore waters. Sea turtles, especially the loggerhead, have been observed in waters close to shore, either feeding or traveling to their nesting beaches.

2.3.2 Barrier Island Complex

A barrier island complex consists of barrier islands as well as the coastal lagoons landward of the islands (Figure 2-6). A barrier island includes the sandy beach, dunes, and salt marshes or tidal flat. Coastal lagoons (called sounds in North Carolina and Virginia) are formed at the same time barrier islands are formed. Barrier islands form parallel to the coast and are long, relatively straight sand ridges often separated from one another by inlets, which allow ocean water to flow into the lagoons located landward of the barrier islands. The formation of barrier islands or beaches typically occurs along low-lying coasts such as the U.S. east coast.

Many hypotheses exist to explain how barrier islands were formed but the exact mechanism (s) is not yet clearly understood, undoubtedly because barrier islands have formed in several different ways at different geographic locations. It is likely, however, that the "multiple causality" theory, proposing a combination of factors, is the most valid theory proposed thus far (USFWS 1980). Proposed mechanisms include the longshore transport of sand, spit formation downstream of eroding headlands, buildup of submarine sand bars, and submergence of coastal beach ridges (USFWS 1980; Kennett 1982). The barrier islands found along the southeastern coast of the U.S. evolved about 4,000 to 6,000 years ago during a period of rising sea level, when coastal processes began creating the extensive barrier island complexes that now typify the coastline (Kennett 1982). As sea level began rising after the last glacial period, 15,000 years ago, the sea increasingly flooded the coastal plain. The large volumes of sediments, available as the continental glaciers melted, were transported along shore forming elevated ridges or beaches, which left shallow lagoons isolated behind them. These elevated shoreline ridges or beaches migrated with the rising sea level until sea level stabilized about 5,000 years ago. Regardless of the specific evolutionary mechanism, the formation of barrier islands is closely associated with sediment (sand) supply, sea level, and subsidence or uplift (Kennett 1982).

Barrier islands are dynamic or ever-changing shoreline features; they are not stable environments. The beach and the dunes are composed of sand that is either being moved onto the beach (deposition) during calm weather or removed from the beach by storms (erosion). This can happen any time of the year but because more storms happen in the winter, most beach erosion occurs in that season. When sand is deposited, the barrier beach grows in size and when sand is eroded from the beach, the beach gets smaller. The barrier beach and dune system protect the continental mainland from storms and hurricanes and are considered land's first and second lines of defense, respectively, against the sea.

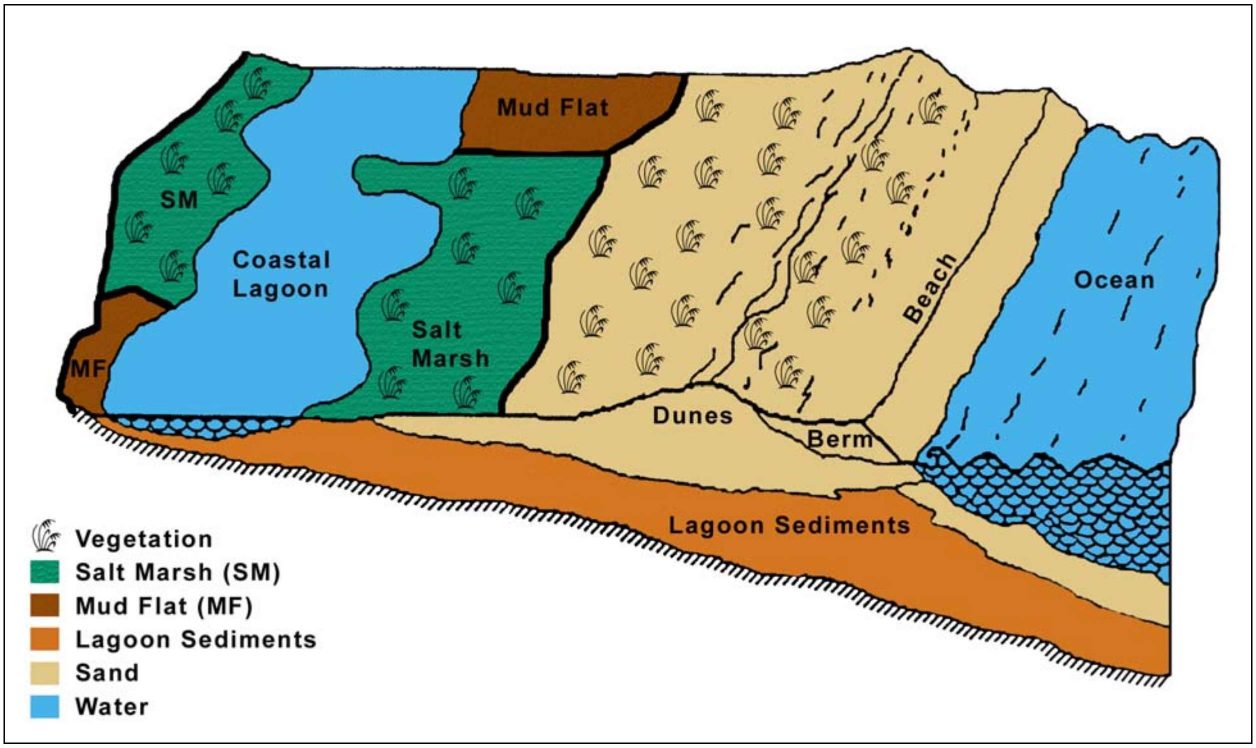

Figure 2-6. Cross-section of a barrier island complex, including the associated coastal lagoon. A barrier island consists of a sand beach, dunes, salt marsh, and/or mud flat. On the barrier island, vegetation grows from the foredune landward to the salt marsh or coastal lagoon edge.

When waves from a severe storm such as a hurricane hit a barrier beach, the wave energy is so strong and the storm surge so high that waves breach or flow over the barrier island beach and dunes into the lagoon. As these strong waves move over the beach and dunes, the water entrains sand in the water, eroding the beach and dunes. If this erosion is severe enough, an inlet is cut through the barrier island, allowing direct flow of seawater from the ocean into the lagoon. Inlets are not permanent features. Over time, sand and sediments fill the inlets, so that the barrier island is once again intact. Humans often make inlets permanent by dredging a channel and reinforcing the sides with concrete or boulders. Along the Outer Banks, the largest permanent inlets between the barrier islands of the Outer Banks are Oregon, Hatteras, Ocracoke, and Beaufort inlets.

Wind moves grains of sand from the beach to the dunes. Dunes are formed when the wind picks up and entrains particles of sand from the barrier beach. A dune begins to form when an obstacle, such as a stone or stick, lies in the wind's path. The obstacle causes the wind to decrease in velocity and the sand particles fall out of suspension. As the number of sand particles increases, a dune or hill of sand is formed, sometimes rising to 25 m in height. Usually a series of dunes, called a dune field, form. The first dune closest to the beach, the primary dune, is always the largest. The windward side of the primary dune is steep and is called the foredune. Secondary dunes are landward of the primary dunes. These dunes are smaller in size and their sides are not as steep.

Sand beaches and dunes are harsh, arid environments, where survival demands specialized adaptations to the widely ranging air temperatures, salt spray, shifting sands, periodic inundation of seawater, and sustained winds. Plants, such as beach grass and sea oats, have extensive root systems that form a network that anchors the sand, stabilizing the dune. An endangered plant species, the seabeach amaranth, colonizes the lower foredune or upper beach of the barrier islands in the study area. Despite the harsh conditions, the beach and dune environment also host numerous bird populations, including colonial waterbirds and shorebirds. Two species of these bird groups, the piping plover and the roseate tern, are endangered and may be found in the dunes or upper sandy beaches of the study area.

2.3.3 Coastal Lagoons and Estuaries

Even though coastal lagoons are part of the barrier island complex, the lagoons are described separately as they encompass such a diverse group of water bodies with distinctive characteristics and habitats. In the study area, seven sounds form a network of coastal lagoons landward of the Outer Banks; from north to south these include the Currituck, Albemarle, Croatan, Roanoke, Pamlico, Core, and Bogue sounds. Additionally, two rivers, the Neuse and Pamlico, empty into Pamlico Sound (Figure 1-1). These rivers and sounds are irregularly shaped, providing evidence of their origin as drowned river valleys. Since Croatan and Roanoke sounds are such minor water bodies whose waters are virtually indistinguishable from those of Pamlico Sound, they are included in the description of Pamlico Sound so that only Pamlico is described in detail.

The protected waters of these rivers and sounds create a rich estuarine environment with high productivity and rich species diversity. An estuary is defined as a semi-enclosed coastal body of water, which has an open connection to the sea and within which freshwater mixes with salt water (Stickney 1984). By this definition, all seven sounds and the Neuse and Pamlico Rivers can be considered estuaries. The open connection to the sea is via barrier island inlets. Freshwater sources include the Neuse and Pamlico Rivers and all other tributaries and streams that discharge into the sounds.

Estuaries are a prized ecological resource, serving many functions: protected nursery area for larvae and juveniles of many fish and invertebrate species; sediment, nutrient, and pollutant filters or sinks; shelter and food source for migratory species; as well as recreation areas for boating and fishing.

The water in many of the estuarine sounds and rivers in the study area is brackish or has a very low salinity. Water temperatures in the North Carolina estuaries are high during the summer, reaching nearly 30°C. Warm, brackish water with a high nutrient concentration in an estuary that is poorly flushed (water remains in it for a long time) are the prime factors triggering outbreaks of harmful algal blooms, such as the toxic blooms of the dinoflagellate, *Pfiesteria*, that occurred in North Carolina estuaries in the 1990s (EPA 2002). In the presence of fish, *Pfiesteria* emits a toxin that ultimately kills the fish and is toxic to humans as well.

2.3.3.1 Pamlico Sound

Pamlico Sound is the largest coastal lagoon estuary in the U.S.; it is 100 to 140 km long, 35 to 50 km wide, with a surface area of 5,300 km^2 and volume of 26 billion square meters (m^3) (Pietrafesa et al. 1986; Paerl et al. 2001). Pamlico Sound is a shallow estuary with a mean and maximum water depth of 4.5 and 6 to 7 m, respectively (Figure 2-2) (Paerl et al. 2001). The sound is bounded in the north by the lesser Roanoke and Croatan sounds, by the Core Sound to the south, by the Neuse and Pamlico rivers to the west, and by the Outer Banks to the east. The tidal range is low (1 m) near the inlets and is reduced to approximately 10 cm in the sound (Eisma et al. 1997). Wind dominates the circulation and freshwater input into the sound is low, resulting in long residence times for sound waters. Paerl et al. (2001) estimated that the time to replace freshwater in Pamlico Sound is 11 months, far in excess of the replacement time for most temperate estuaries. The realistic residence time is probably much longer due to restricted flow in sheltered areas and the location of inlets relative to freshwater input (Paerl et al. 2001).

Fine sand and silt cover the bottom of Pamlico Sound while medium sands typify the bottom near the inlets to the ocean (Figure 2-3; Wells 1989; Eisma et al. 1997). Salinities in Pamlico Sound range from 10 to 31 psu with highest salinities found closest to the inlets (Figures 2-4 and 2-7; Wells 1989). Salinities are highly variable and fluctuate with seasons, with highest salinities found in the fall (15 to 31 psu) and lowest salinities found in spring (10 to 19 psu) (Figure 2-7; Wells 1989; NOS 2001). Vertical stratification is weak, with only 1 psu difference in the water column (Wells 1989). Salinity fluctuations are likely linked to the timing of high freshwater input and precipitation. Surface water temperatures vary seasonally but have a small range between highs and lows in each season. Lowest temperatures (15 to 17° C) are found in winter (January through March) while the highest (26° to 27°C) occur in summer (Figure 2-5). The temperature gradient is oriented in a generally northeast to southwest direction regardless of season.

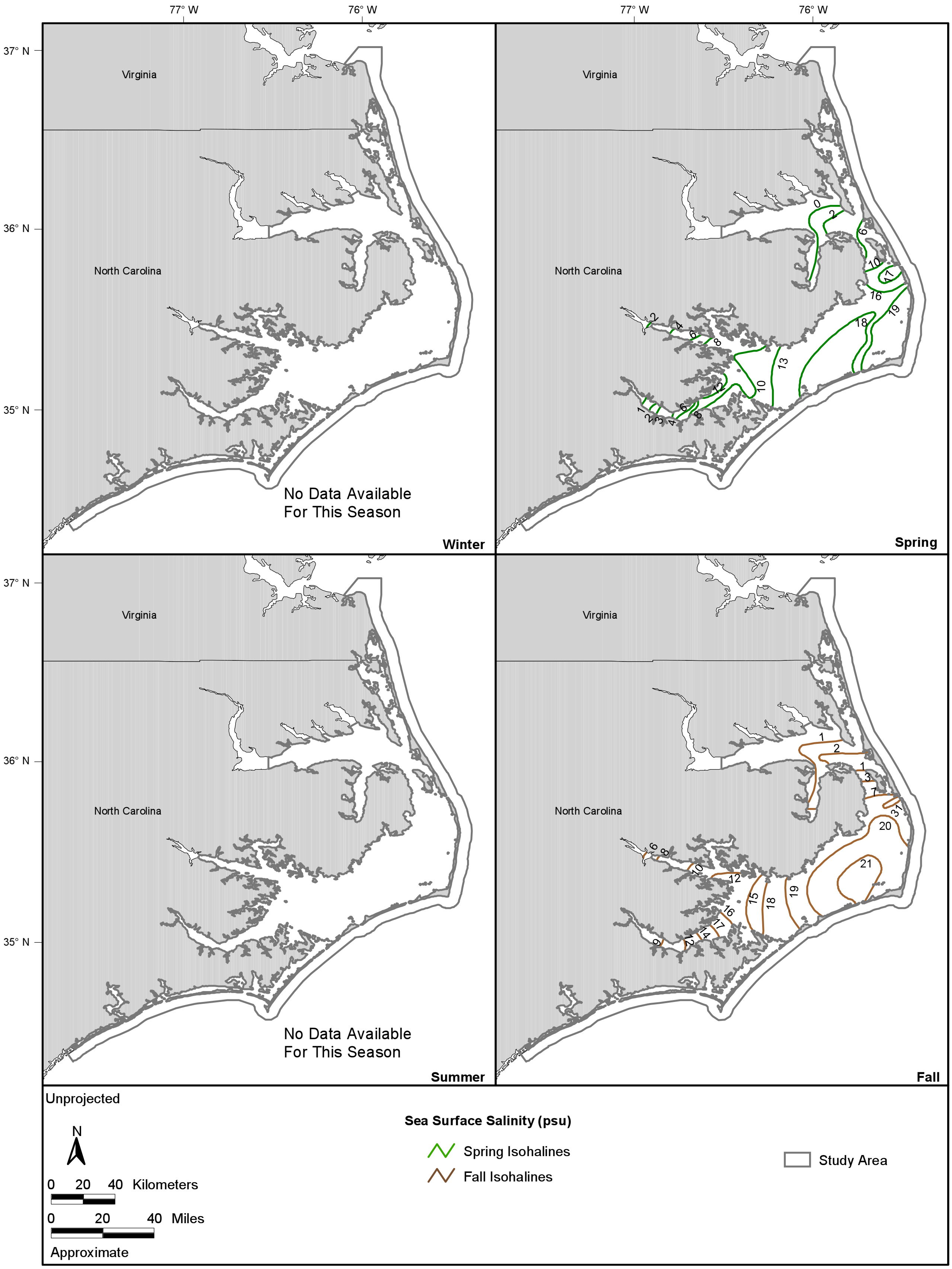

Figure 2-7. Spring and fall surface salinities in the Cherry Point and southern VACAPES inshore and estuarine areas. Source map (scanned): Wells (1989).

2.3.3.2 Albemarle Sound

Albemarle Sound, the drowned river valley of the Roanoke River, is oriented roughly east to west and is a shallow, irregularly shaped body of water, with as many as seven small embayed, lateral estuaries radiating outward from the central axis of the sound. The shape and lateral estuarine extensions result in an estuarine shoreline exceeding 800 km (Copeland et al. 1983). The sound is 90 km long, varies in width from 5 to 20 km, has a surface area of 1,240 km^2, and a volume of 6.6 million m^3 (Copeland et al. 1983; Wells 1989). Albemarle Sound opens into Roanoke, Croatan, and Currituck Sounds to the east. While the average depth of Albemarle Sound is about 3.5 m, water depths gradually increase with distance from shore to the flat central axis of the sound where the depth is 6 m (Figure 2-2; Copeland et al. 1983; Wells 1989). The tidal range in Albemarle Sound is negligible (~10 cm) and lunar tides are of little importance. Wind is the dominating factor driving circulation and water levels in the sound and its embayed estuaries. Due to the shallowness and long fetch of the sound, wind and wave action effectively eliminate vertical stratification (Copeland et al. 1983).

Fine sediments such as clay, silt, and sand cover the flat bottom of Albemarle Sound and its lateral extensions (Figure 2-3). Albemarle Sound is typically oligohaline (i.e., surface salinities ranging from 0.5 to 5 psu) with the average salinity never exceeding 5 psu (Figures 2-4 and 2-7; Copeland et al. 1983). Salinities are most influenced by seasonal freshwater input from either the Roanoke or Chowan rivers. Highest salinities occur in fall and lowest salinities are observed in spring (Figure 2-7; NOS 2001). The surface water temperature varies throughout the year by as much as 16°C (Figure 2-5). In summer, surface water temperatures are nearly homogeneous (25°C) throughout Albemarle Sound but in winter the surface water temperature ranges from 9° to 10°C.

2.3.3.3 Currituck Sound

The very narrow (2.4 to 3 km wide), brackish water estuary of Currituck Sound is oriented north to south and is roughly 64 km long with a surface area of 396 km^2 (USFWS 1980; Caldwell 2001). Currituck Sound lies parallel to the barrier island shore and spans the North Carolina-Virginia border. The average depth of the sound is 1.5 m or less (Figure 2-2; Caldwell 2001). Fine-grained sediments cover the bottom of the sound and range from fine sand to silt (Figure 2-3). Currituck Sound flows into Albemarle Sound to the south and is bordered on land on all remaining sides. The oligohaline (0 to 15 psu) waters of the sound have freshwater input from Northwest and North Landing rivers (Figure 2-4; USFWS 1980). Only the southernmost portion of the sound exhibits salinities higher than 5 psu; highest salinities (0.5 to 15 psu) in the sound are found in the fall while the lowest (0 to 5 psu) are found in spring (Caldwell 2001; NOS 2001). Salinity in the sound is controlled by the amount of freshwater input, the amount of evaporation, and the amount of seawater that washes over Currituck Banks into the sound. The tidal range is negligible with wind influencing the circulation and water level in the sound. The waters of Currituck Sound are turbid and contain large concentrations of nutrients and organic matter (USFWS 1980).

2.3.3.4 Core and Bogue Sounds

These extremely shallow, narrow lagoonal estuaries are located behind a band of very narrow, nearly linear barrier islands of the lower Outer Banks. Core Sound is approximately 48 km long and 6 km wide while Bogue Sound is 56 km long and 4 km wide. Core Sound flows into lower Pamlico Sound and is connected to Bogue Sound to the southwest while Bogue Sound terminates at Bogue Inlet in the west.

Two inlets bisect the barrier island adjacent to Bogue Sound, allowing direct seawater flow into the sound. Both bodies of water are extremely shallow with a maximum depth of 1 m (Figure 2-2). Fine sand covers the bottom of both sounds (Figure 2-3). Freshwater discharge into both sounds is limited but is sufficient to produce strong salinity gradients in the three rivers flowing into the sounds in the late winter and spring (NOS 2001). The salinity structure of Core Sound is controlled primarily by precipitation and evaporation while Bogue Sound is more influenced by the seawater input via the inlets in addition to precipitation and evaporation. The water column is homogeneous with no stratification (NOS 2001). Salinities are usually fairly high in both sounds (Figure 2-4) with the highest salinities (>25 psu) occurring in June through August and the lowest (15 to 25 psu) occurring from January through March.

2.3.3.5 Neuse River

One of the major contributors of freshwater and sediments to Pamlico Sound is the Neuse River. The Neuse River drains a watershed of about 16,000 km^2 and receives substantial nutrient input from agricultural, industrial, and wastewater sources upstream (Eby and Crowder 2002). The Neuse River is an estuary that is 3.5 m deep on average with maximum depths reaching 6 m (Figure 2-2). Salinity is highly variable and the estuary is often stratified (Paerl et al. 2002). Salinities typify a mixed estuary with the range from 0.5 to 25 psu (Figure 2-4); high salinities (9 to 17 psu) are found in fall while salinities are lowest (0.5 to 10 psu) in spring (Figure 2-7; NOS 2001). Temperature follows a seasonal cycle with a mean water temperature of 20°C in May, the peak temperature of 28° to 30°C in July through August, with decreasing temperatures to about 18° to 20°C by October (Paerl et al. 2002).

Ordinarily, phytoplankton, particularly in the upper part of the estuary, assimilates the nutrients carried into the Neuse River from the uplands. During times of high river flow, however, phytoplankton can't utilize all the nutrients in the water. Freshwater with a high nutrient concentration enters the entire estuarine system and phytoplankton blooms occur. This high flow typically occurs in January through February, which understandably coincides with the time of year when lowest salinity values are found (Paerl et al. 1990). High primary productivity often leads to eutrophication of bottom waters, characterized by low oxygen concentrations. When the estuary becomes stratified and there is a high oxygen demand in bottom waters (due to decomposition of phytoplankton), hypoxia (<2 milligrams oxygen per liter [mg O_2/l]) is the result. Hypoxia often forms in the deeper up-river portion of the estuary but sometimes extends throughout the entire estuary and occurs intermittently from spring to fall (Paerl et al. 2002). Fish avoid hypoxic areas, leading to a decrease in the amount of usable habitat. This loss of habitat and alteration of habitat usage results in decreased growth and health of the fish community (Paerl et al. 2002).

2.3.3.6 Pamlico River

The Pamlico River is an important estuary in North Carolina and is one of the tributaries that empty into Pamlico Sound. It is characterized by low to mid-salinity, high turbidity, and shallow water (Copeland and Riggs 1984). The estuary is roughly 65 km long and ranges in width from 0.5 to 8 km for a volume of 2,000,000,000 m^3 (Copeland and Riggs 1984). This drowned river has the associated irregular shape that usually defines this estuarine type. The Pamlico River drains about 14,000 km^2 of watershed and great volumes of freshwater flow into it from the Tar River (Copeland and Riggs 1984). The Pamlico River estuary is nearly dominated by freshwater flow and thus tides have little influence, with an average tidal range of less than 15 cm (Copeland and Riggs 1984). Circulation is dominated by freshwater inflow and wind. This shallow estuary has an average depth of 3.3 m but deepens to a maximum depth of nearly 6 m in mid-river (Figure 2-2).

Fine sediments cover the bottom of the Pamlico River, mostly clayey mud in the central portions with fine sands near the perimeter (Copeland and Riggs 1984). The deepest central portion of the river is frequently hypoxic during the summer (Copeland and Riggs 1984). Salinities are variable, ranging from <2 to 12 psu (Figure 2-4). Highest salinities (6 to 12 psu) are found during fall with lowest salinities (<2 to 8 psu) are found in spring (Figure 2-7; NOS 2001). Mean monthly water temperatures in the estuary range from 5°C during January to about 27°C in July through August but temperatures are highly variable and can range in extremes from 0° to 30°C (Copeland and Riggs 1984).

2.3.3.7 Estuarine Shoreline Environments

Although the coastal lagoons or estuaries found in the study area differ in size and in their physical parameters, similar habitats are found in each estuary. The physical parameters and size may limit the number of animals or plants and the species found in each estuary, but each estuary has the same characteristic shoreline habitats. The important factor determining where these habitats are found along the shore is the amount of time they are covered by water. Since tides, or in the case of some of North Carolina's estuaries, wind-tides, regulate the water height, the parts of the shore where each habitat type is found is called a tidal zone (Figure 2-8). Salt marshes are found at the highest elevations on the

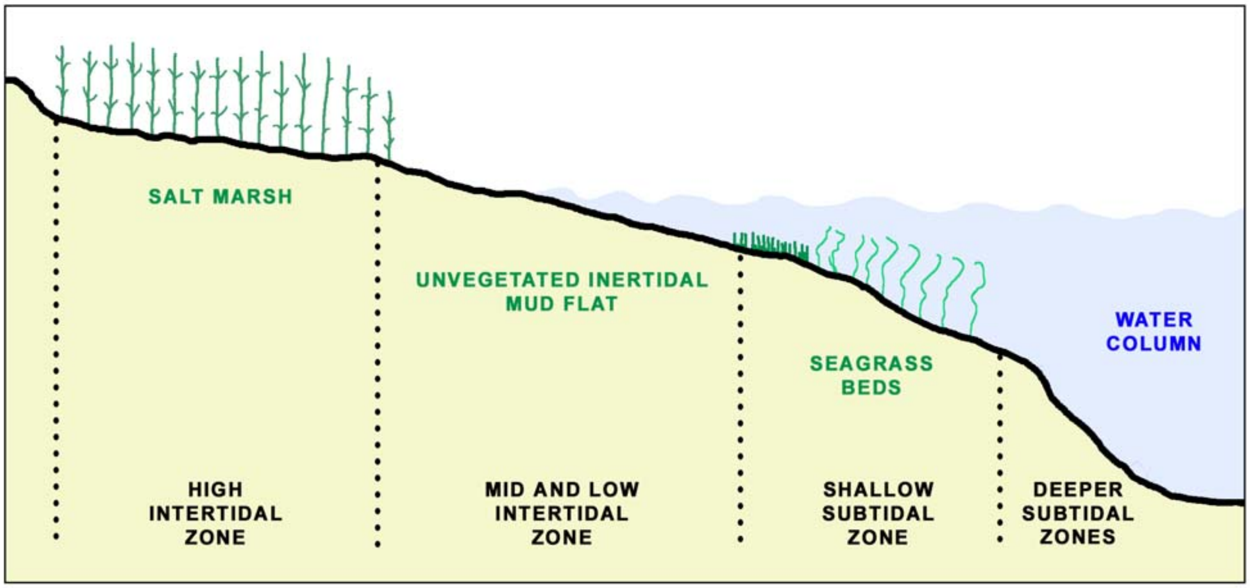

Figure 2-8. Intertidal and subtidal shore/coastal habitat environments or zones found in the estuarine areas of the study area.

shoreline and are only partially inundated by seawater each day. Likewise, mud or tidal flats are exposed to the atmosphere only part of the day. Seagrass beds, however, are continuously submerged

- Salt Marshes

Salt marshes are a type of temperate coastal wetland that is inundated by seawater at high tide. They are the most common type of coastal wetland throughout the southeastern U.S. (Tiner 1993). These intertidal ecosystems represent a transition between the land and the sea; they are bordered by the land on one side and by an estuary or sea on the other and thus contain elements of both terrestrial and marine communities. Salt marshes form in protected, low energy environments, usually in a coastal lagoon behind a barrier island or in an estuary, and are dominated by plant species.

Most salt marshes are dominated by a single species (Wiegert et al. 1981). Mid-Atlantic salt marshes are characterized by the dominance of smooth cordgrass (*Spartina alterniflora*) (Schafale and Weakley 1990). Three vegetation zones are commonly recognized: low marsh, high marsh, and the upland border. The low marsh produces the foundation of the estuarine food web and is the most productive, self-sustaining habitat (Ursin 1972; Patrick 1994; Coker et al. 2000). Unlike the high marsh, the low marsh is flooded by seawater twice daily, resulting in different floral and faunal inhabitants (Tiner 1993; Bertness 1999). Terrestrial grasses and plants such as shrubs characterize the upland border. It is in the upland border where land mammals such as raccoons and foxes venture into the marsh to feed.

Smooth cordgrass occurs in both the low and high marsh zones, but is densest in the low marsh. Although smooth cordgrass dominates the lower zone, perennial glasswort and sea lavenders may also be found (Tiner 1993). In the high zone, the second most common species is black needlerush. Other dominant species expected in the high zone are salt meadow cordgrass, salt grass, coastal dropseed, salt marsh bulrush, big cordgrass, and key grass (Schafale and Weakley 1990; Tiner 1993; SAFMC 1998, Coker et al. 2000).

In the coastal marshes of the study area, sediment from continental erosion has accumulated for over 150 million years (Bertness 1999). Salt marshes are formed by fine silt and clay settling in slow-moving waters (Bertness 1999; Coker et al. 2000). These particles accumulate and are stabilized by seagrasses, such as smooth cordgrass, making an extensive root network underground that hardens the substrate (Bertness 1999). Each fall smooth cordgrass dies back and becomes a primary food source for many animals (Coker et al. 2000).

The Albemarle-Pamlico estuarine system has the greatest extent of marsh habitat for an estuarine drainage area in all the South Atlantic states (i.e., North Carolina, South Carolina, Georgia and Florida) (SAFMC 1998). North Carolina alone has 86,100 hectares (ha) of salt marsh (SAFMC 1998). The coastal lagoons in the study area are typically lined with salt marshes usually referred to as fringing marshes (Figure 2-9). No salt marshes are found on the seaward side of the barrier islands as the wave energy is too high. Salt marshes are found all along the west side of the barrier islands and along the coast of the mainland but especially in the areas where the effect of lunar amplitude is maximized (Schafale and Weakley 1990).

The greatest density of salt marshes occurs in Pamlico Sound at Long Bay and Swanquarter Wildlife Refuge. Currituck Sound is lined by salt marshes on the east, west, and north sides. Albemarle Sound, including Alligator River, lacks extensive salt marsh coverage except along the eastern side of the North River. Pamlico Sound is lined by salt marshes along the coast of the mainland and the west side of the barrier islands. The mouth of the Pamlico River is heavily lined with salt marshes on the north (including Pungo River) and thinly lined on the south. At Pamlico Point, at the mouth of the river, are drained salt marshes. The Neuse River is sparsely lined with salt marshes; however, at the mouth of the Neuse at Long Bay salt marshes dominate the habitat. From Cape Lookout south to the boundary of the study area almost the entire estuarine coastline is lined with salt marsh habitat. Bogue Sound is sparsely lined with salt marshes as well as the New River.

Coastal wetland areas have been declining sharply over the last 80 years. Mitsch and Gosselink (1993) reported the losses of 8,000 ha a year from 1920 to 1950, 19,000 hectares a year from 1950 to 1970, and 3,000 hectares a year from 1970 to 1990.

Marshes are known for their value as nursery grounds. Species with both commercial and ecological value utilize this area as juveniles (Bertness 1999). Specifically, red drum and shrimp use this habitat (SAFMC 1998; NCDMF 2001). Salt marshes are considered essential fish habitat (EFH) in North Carolina (NCDMF 2001). Salt marshes are involved in the cycling of nitrogen and sulfur (Mendelssohn 1979; Bertness 1999) and excess carbon from burning fossil fuels is collected in marshes (Bertness 1999). Coastal marshes also assist in filtering terrestrial inputs by slowing the movement of runoff and assisting in the removal of particulates, the effect of which is improved water quality and natural waste treatment (Bertness 1999). Reductions in salt marshes could have serious effects on nutrient cycling and the reproduction of its inhabitants (Schafale and Weakley 1990).

- Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) refers to benthic macroalgae and seagrasses that grow in or attach to soft sediments in coastal, estuarine, and freshwater habitats. Macroalgae (sometimes called seaweed) are multicellular, eukaryotic algae held to the substrate by holdfasts (root-like structures). Seagrasses are vascular, rooted flowering plants that are adapted to the saline environment and grow fully submerged, i.e., subtidal (Dennison et al. 1993). Seagrasses are unique in the marine environment as they are the only land plants to return to the sea and their entire life cycle occurs completely in seawater. Both seagrasses and macroalgae grow in often dense aggregations called beds. During the last 20 years, the importance of SAV to coastal and estuarine ecosystems has been acknowledged; SAV beds are highly productive and rich in faunal diversity. Beds of SAV provide food, protective habitat, nutrient sinks, substrate for epiphytes, and sediment/shoreline stabilization (Thayer et al. 1978; CSC 2001). 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 protecting from erosion. Detritus and sediments collect around the base of seagrasses and macroalgae, providing the important function of ridding the water column of excessive sediments at the same time enabling nutrients from detritral decomposition to be recycled back into the water column (SAFMC 1998; CSC 2001).

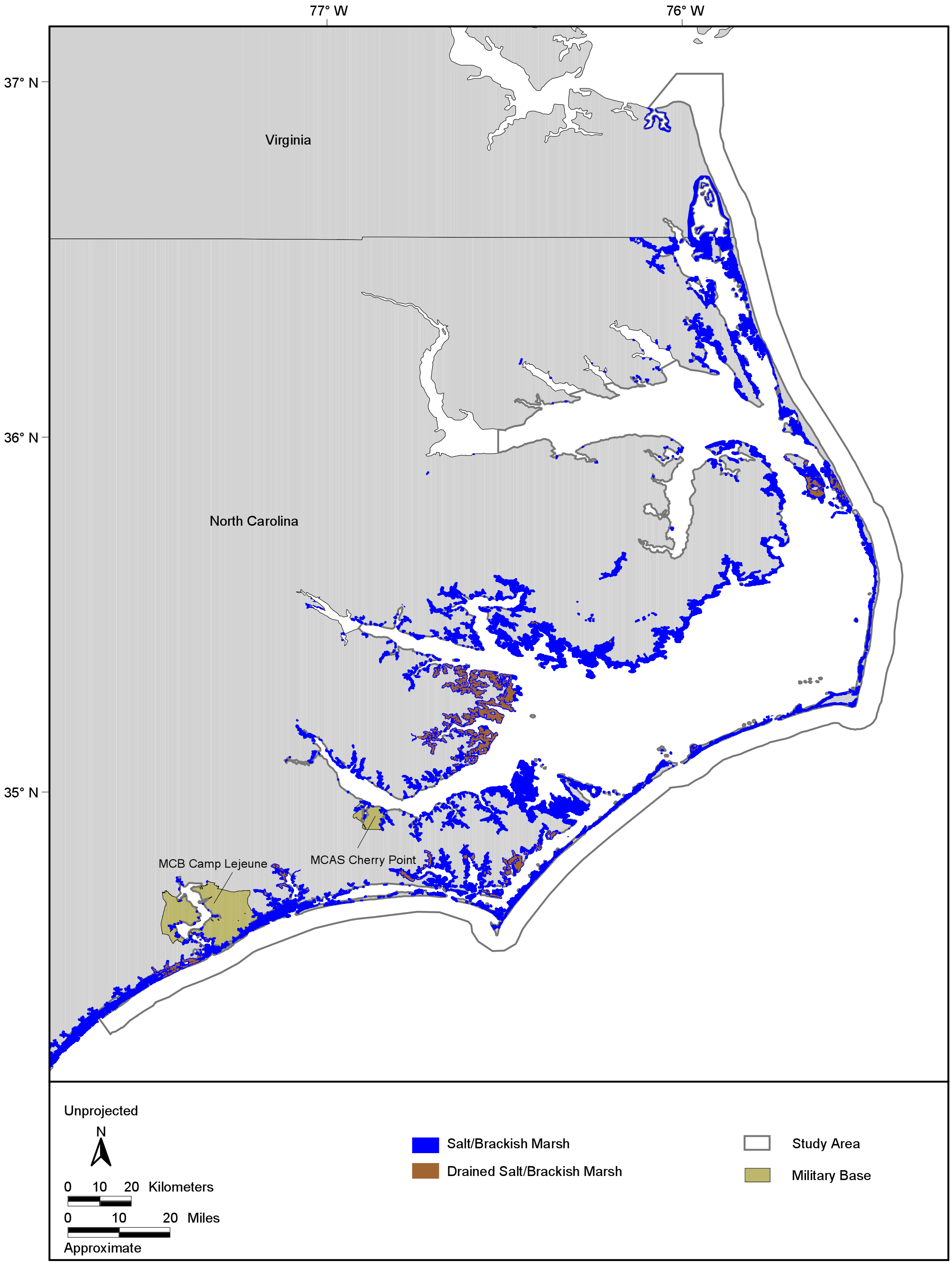

Figure 2-9. Distribution of salt marshes in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NCDCM (1999) and NOS (2001). Map adapted from: USFWS (1980).

Like their land counterparts, SAV use sunlight for photosynthesis and release dissolved oxygen. However, in this case the oxygen is released into the water column to be used by aquatic species for respiration and decomposition (CSC 2001). Seagrasses also provide an important food source for waterfowl, sea turtles, sea urchins, and fish. SAV beds also provide important shelter for juvenile and larval stages of many invertebrates and fishes. Ecologically and commercially important species utilize SAV beds at some point in their life cycle. Bay scallops, hard clams, blue crabs, pink and brown shrimp, and lobster use seagrass beds for attachment and protection (SAFMC 1998). The cownose ray forages in the seagrass beds in North Carolina's sounds and in Chesapeake Bay (Peterson and Peterson 1979), damaging beds while digging for shellfish. Animals such as gray trout, red drum, spotted seatrout, mullet, pinfish, pigfish, gag grouper, silver perch, summer and southern flounder, pink and brown shrimp, blue crabs, hard shell clams, and bay scallops use SAV for nurseries (Murphey and Fonseca 1995; CSC 2001). Adults of many species utilize the area (Ferguson and Woods 1994). Egrets, herons, sandpipers, terns, gulls, swans, geese, ducks, and osprey are some avian species that feed in SAV beds (Ferguson and Woods 1994). Other species feed directly on SAV (e.g., echinoderms, birds, fishes, turtles, and manatees) (SAFMC 1998). Seasonal reproduction in several fish species has been linked to seasonal abundance in SAV (SAFMC 1998).

These plants (and their associated epiphytes) depend on sunlight for growth, so their growth is limited to clear water areas where sunlight can penetrate (photic zone). Disturbances in the substrate (e.g., results of storms or human activities) increase turbidity, reducing the plant and algae's access to sunlight. During summer, the Gulf Stream waters bring in water with greater clarity to this area of North Carolina (Searles 1984). Water clarity in the sounds of North Carolina is typical of southeastern U.S. coastal estuaries (i.e., the sounds are typically more turbid than freshwater or oceanic environments). In the study area, turbidity limits growth of macroalgae to depths of 1 to 2 m and of seagrasses to depths up to 2.4 m (Schneider 1976; Searles 1984; Ferguson and Wood 1994).

North Carolina has an interesting mix of macroalgal species, with some temperate and some subtropical to tropical (Humm 1969; Schneider 1976; Searles 1984). Temperature is considered the limiting factor for macroalgae distribution (Schneider 1976). According to Ferguson and Wood (1994), macroalgae beds are less abundant than seagrass beds in the Albemarle-Pamlico estuarine system. The main macroalgae species found in the study area are red algae (e.g., *Callithamion byssoides*, *Champia parvula*, *Hypoglossum tenuifolium*, and *Rhodymenia pseudopalmata*) and brown algae (*Giffordia intermedia*) (Kapraun and Zechman 1982). Searles and Schneider (1980) found 289 species of macroalgae in North Carolina; 190 species of green, brown, and red algae were found in the shallow water adjacent to the Outer Banks (Searles and Schneider 1980).

Growth of SAV, primarily seagrasses, is most prominent along the western side of the Outer Banks barrier island chain, with the greatest density of seagrasses located north of Hatteras Inlet (Figure 2-10). A recent look at macrofaunal distribution in Core and Back Sounds found higher densities on the western sides of the Sounds than on the east side (Hovel et al. 2002). Ferguson and Wood (1994) found that the distribution of seagrasses in Albemarle and Pamlico sounds to be similar to that found within Chesapeake Bay, with growth restricted to shallow water usually less than 2 m. Besides water clarity, salinity is a prime factor limiting the growth and distribution of seagrasses. Each species of seagrass has a specific range of salinities that it can tolerate. Species such as eelgrass (*Zostera marina*), widgeon grass (*Ruppia maritima*), and shoalgrass (*Halodule wrightii*) require higher salinity (5 to 40 psu) water than other species and are found growing in the higher salinity areas of the study area (Ferguson and Wood 1994; SAFMC 1998; Hovel et al. 2002). Eelgrass is considered the most important of these seagrasses (Patrick 1994) and makes its greatest contribution to primary production by carbon fixation and oxygenation (Patrick 1994). Widgeon grass can tolerate lower salinities and dominates growth in lower salinity waters (Ferguson and Wood 1994). Low-salinity (<5 psu) species of seagrasses such as wild celery, Eurasian water milfoil, bushy pondweed, redhead grass, sago pondweed, leafy pondweed, horned pondweed, alligatorweed, spatterdock, and bladderwort grow within the study area (Ferguson and Wood 1994).

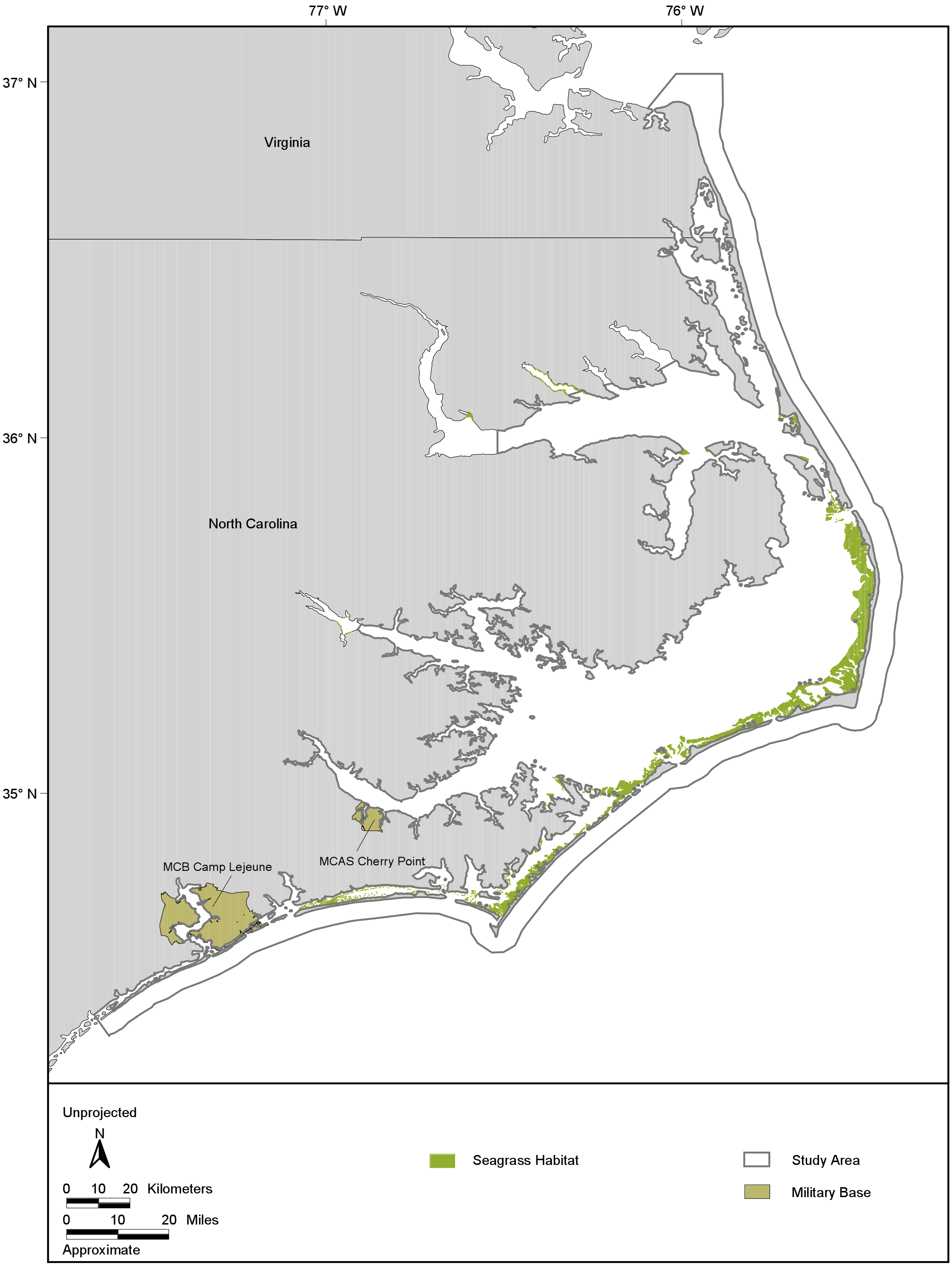

Figure 2-10. Distribution of seagrass communities in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: USFWS (1980) and NOS (2001).

In 1972, a tropical storm in the Chesapeake Bay reduced the salinity for a month, drastically reducing the SAV population (Orth and Moore 1983). Many areas were left completely unvegetated, even ten years later (Orth and Moore 1983). Ferguson and Wood (1994) felt the loss of seagrass beds could lead to a collapse in estuarine fisheries in North Carolina. Dense SAV in the study area is used as primary habitat for red drum (NCDMF 2001). Decreases in SAV abundance have been linked to decreases in populations for animal species feeding on seagrasses (Orth and Moore 1983; Thayer et al. 1984). Eelgrass comprises 80% of the diet of the American brant (*Branta bernicla*). In the Chesapeake Bay, when eelgrass was severely reduced, brant populations also declined (Cottam 1934). There were also long-term declines of widgeon, pintails, and redheads correlated with declines in SAV (Orth and Moore 1983). Fortunately, there are some species that can alter their diets. Canvasbacks shifted to a carnivorous diet and the whistling swan and Canada goose shifted their diets to agricultural crops (Thayer et al. 1984). Damage to SAV is not always easy to estimate. The results of damage to SAV beds may cascade through the food web when the habitat, food, and shelter of lower trophic species are destroyed (CSC 2001).

- Tidal Flats

Tidal flats, also called intertidal soft-sediment habitats, lie between the low and high tide lines and are unvegetated (no macroalgae or seagrasses) substrates, usually mud or fine sand. Tidal flats usually border the lower edge of salt marshes, estuaries, and river mouths (Figure 2-11; Peterson and Peterson 1979; Bertness 1999; Coker et al. 2000). Tidal flats depend upon the surrounding seagrasses and salt marshes for primary production (Bertness 1999). The occurrence of tidal flats can be due to several factors. Lunar tides are the most recognized influence. However, the tidal range in the study area is small. Other factors such as water depth, prolonged wind direction, and configuration of the water body can lead to the presence of tidal flats.

Tidal flats serve important functions as nurseries, feeding grounds, and refuge from predation and adverse physical conditions (SAFMC 1998). Predators, such as shorebirds, visit the flats to forage at low tide; at high tide fishes and crabs forage, often taking the same prey as shorebirds (Bertness 1999). The most characteristic predators of a tidal flat are flatfishes (e.g., flounder, sole, and tonguefish), important in both commercial and recreational fisheries (Peterson and Peterson 1979). Tidal flats are the areas where the primary production from salt marshes and seagrass beds is consumed and turned into animal biomass (Peterson and Peterson 1979).

Tidal flats are utilized by a wide range of organisms including bacteria, fungi, microflora, macrophytes, phytoplankton, burrowing worms, crabs, fishes, and wading birds (Bertness 1999). Three categories of animals inhabit tidal flats: infauna, epifauna, and mobile epibenthos. Infauna are invertebrate species, such as mollusks, gastrotriches, turbellarians (flat worms), and gnathostomulids (jaw worms), amphipods, and copepods, which burrow in the substrate (Peterson and Peterson 1979). Epifauna, such as bivalves and cnidarians, are sessile animals that subsist on the surface of the tidal flats. Mobile epibenthos, such as fiddler crabs, insect larvae, and nematodes, move on top of the substrate (Peterson and Peterson 1979; Lippson and Lippson 1997).

Microalgae (e.g., benthic diatoms, benthic dinoflagellates, filamentous greens, and blue-green algae) inhabit tidal flats (Peterson and Peterson 1979). Macrophytes that attach to hard substrates can also be found in the intertidal flats. North Carolinian macrophytes include several species of filamentous brown algae (e.g., *Ectocarpus*), filamentous green algae (e.g., *Enteromorpha* and *Cladophora*), leafy green algae (e.g., *Ulva*), and other green filamentous green algae (Peterson and Peterson 1979).

Several protected and important species utilize tidal flats. 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 baitfish (Peterson and Peterson 1979). The red drum, for instance, uses tidal flats as nursery habitat (NCDMF 2001). Brown shrimp, the most common shrimp in North Carolina, are considered to use seagrasses as their primary feeding ground, but some will forage on the tidal flats at high tide (Peterson and Peterson 1979). Birds utilizing the area can be broken down by their foraging strategy:

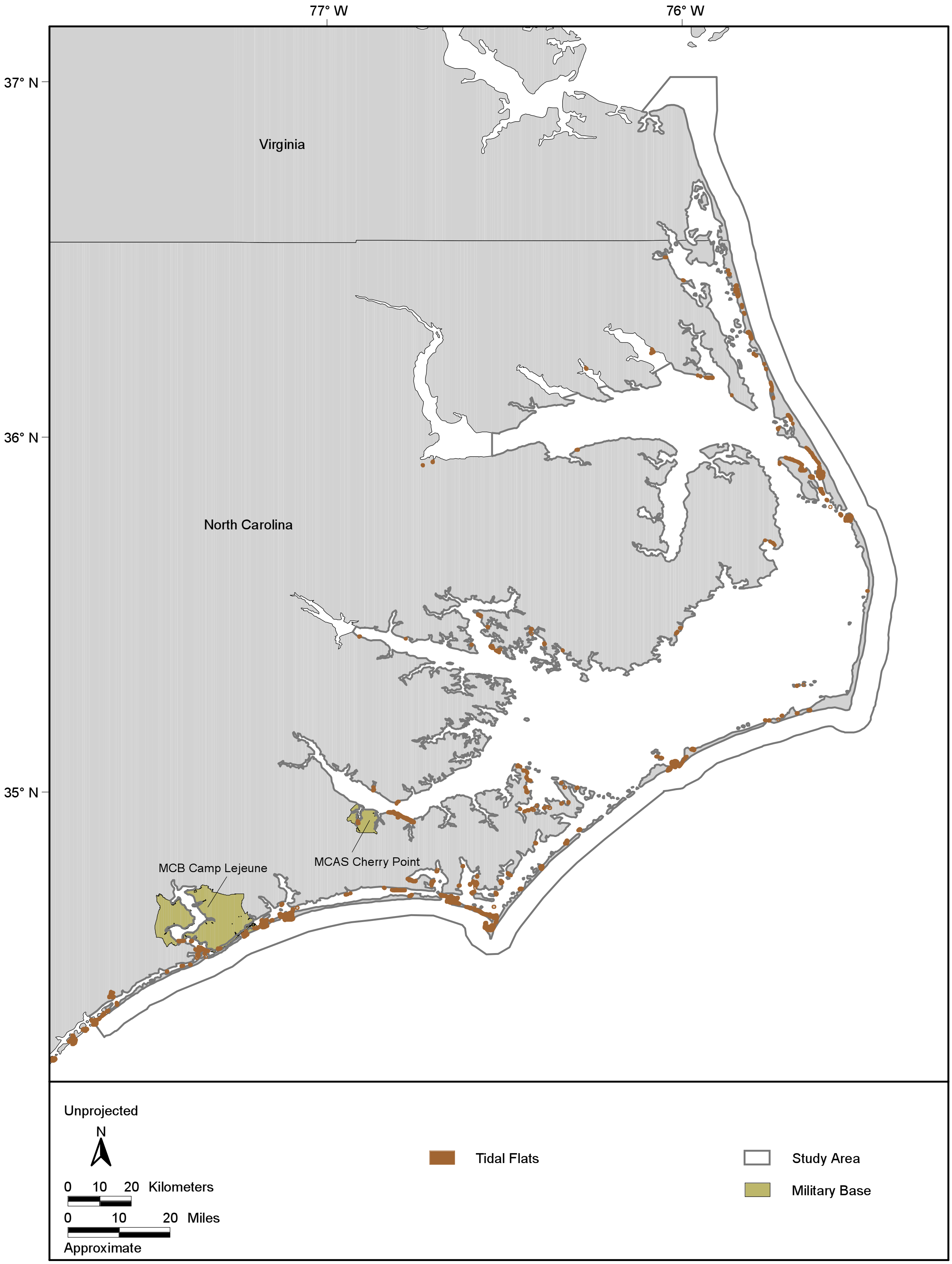

Figure 2-11. Distribution of tidal flats in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: USFWS (1980) and NOS (2001).

wading birds, shallow- and deep-probing birds, aerial searching birds, floating or diving water birds, and birds of prey (Peterson and Peterson 1979). Wading birds and shorebirds are totally dependent on tidal flats as their main food source. Endangered bird species such as the piping plover and even the bald eagle (though rarely) seasonally forage on tidal flats (Peterson and Peterson 1979). The American oyster grows on tidal flats in North Carolina while blue crabs and whelks are common foragers on the tidal flats in the study area (Peterson and Peterson 1979).

Areas of tidal flat concentration in the study area are the eastern side of Currituck Sound, both sides of Roanoke Sound, Long Bay, Cape Lookout and Shackleford Banks, Bear to Brown's Inlet, and the Neuse Inlet and River (Figure 2-11). The heaviest concentration of tidal flats is in the southern part of the study area from Cape Lookout south. Between Oregon Inlet and Roanoke Island there are several tidal flats not associated with a shoreline. Several more tidal flats not associated with shorelines occur near other inlets (e.g., near Hatteras Inlet and Ocracoke Inlet). From Currituck Sound to the Neuse River, tidal flats are mostly absent along the mainland.

2.3.4 Live/Hard Bottom Communities, Reef/Reef-Like Habitats, and Coral Patches

The Cherry Point and southern VACAPES inshore and estuarine area (i.e., study area) contains live/hard bottom communities, reef/reef-like habitats, and coral patches; however, it does not contain true coral reefs (Macintyre and Pilkey 1969; Macintyre 1970; McCloskey 1970; Huntsman and Macintyre 1971; Steimle and Zetlin 2000).

Coral reefs refer to marine ecosystems in which "a prominent ecological functional role is played by scleractinian corals" (McManus 2001). "Normal" coral reefs refer to biogenic "production-dominated reefs" (Kleypas et al. 2001). Coral reef communities are tropical, mostly shallow water ecosystems, largely restricted to the area between 30°N and 30°S. The Florida reef tract from Miami to the Dry Tortugas represents the northernmost extent of true coral reefs along the eastern U.S. coast. Coral diversity and abundance abruptly declines north of Miami, although live/hard bottom communities containing hermatypic corals and gorgonians (represented as solitary corals or deepwater banks) can be found as far north as Cape Lookout, NC (Jaap 1984; Jaap and Hallock 1991). Northward from Miami/Palm Beach, FL tropical coral reef biota become increasingly less important in a south-to-north gradient and no true coral reefs are found. The "patch" and "outer bank reef-building" coral reef habitats as defined by SAFMC (1998) do not occur in the temperate region from southeast Florida to North Carolina. Because there are no coral reefs within the study area, Executive Order 13089 (Coral Reef Protection) does not apply. Nevertheless, corals of the study area remain sensitive to man-induced impacts including high nutrient runoff, sedimentation, and physical impacts (e.g., Wilkinson 2000).

Live/hard bottom communities are small, isolated areas of low, rough, or broken relief consisting of naturally occurring hard or rocky outcroppings (Figure 2-12). The geological and biological architecture of these three-dimensional substrates provide shelter and substrate for live communities composed of benthic and demersal organisms (Cahoon et al. 1990).

Reef/reef-like habitats in the study area include natural structures and man-made structures found in estuarine and coastal environments (Steimle and Zetlin 2000; Figure 2-12). Natural reefs in the study area include biogenic reefs (hard substrates formed by organisms) and nonbiogenic reefs (hard substrates formed by rock or rocky reef areas). Natural reefs can be temporary as in the case of water-logged tree trunks that sink to the bottom. Coral patches refer to rocky outcrops such as those occurring on the inner continental shelf in Onslow Bay, NC that are colonized by sessile organisms including hard corals, soft corals, hydroids, algae, and sponges (Macintyre and Pilkey 1969; Figure 2-12).

2.3.4.1 Live/Hard Bottom Communities

Live/hard bottom communities in general can sometimes contain rich sessile biological assemblages (sea fans, sea whips, ascidians, bryozoans, hard/soft corals, hydroids, anemones, and sponges) and favor relatively dense aggregations of turtles, commercial/recreational fishes, and other fauna (Thompson et al. 1999). It is important to note that not all hard bottom habitats support a live bottom community (Kirby-

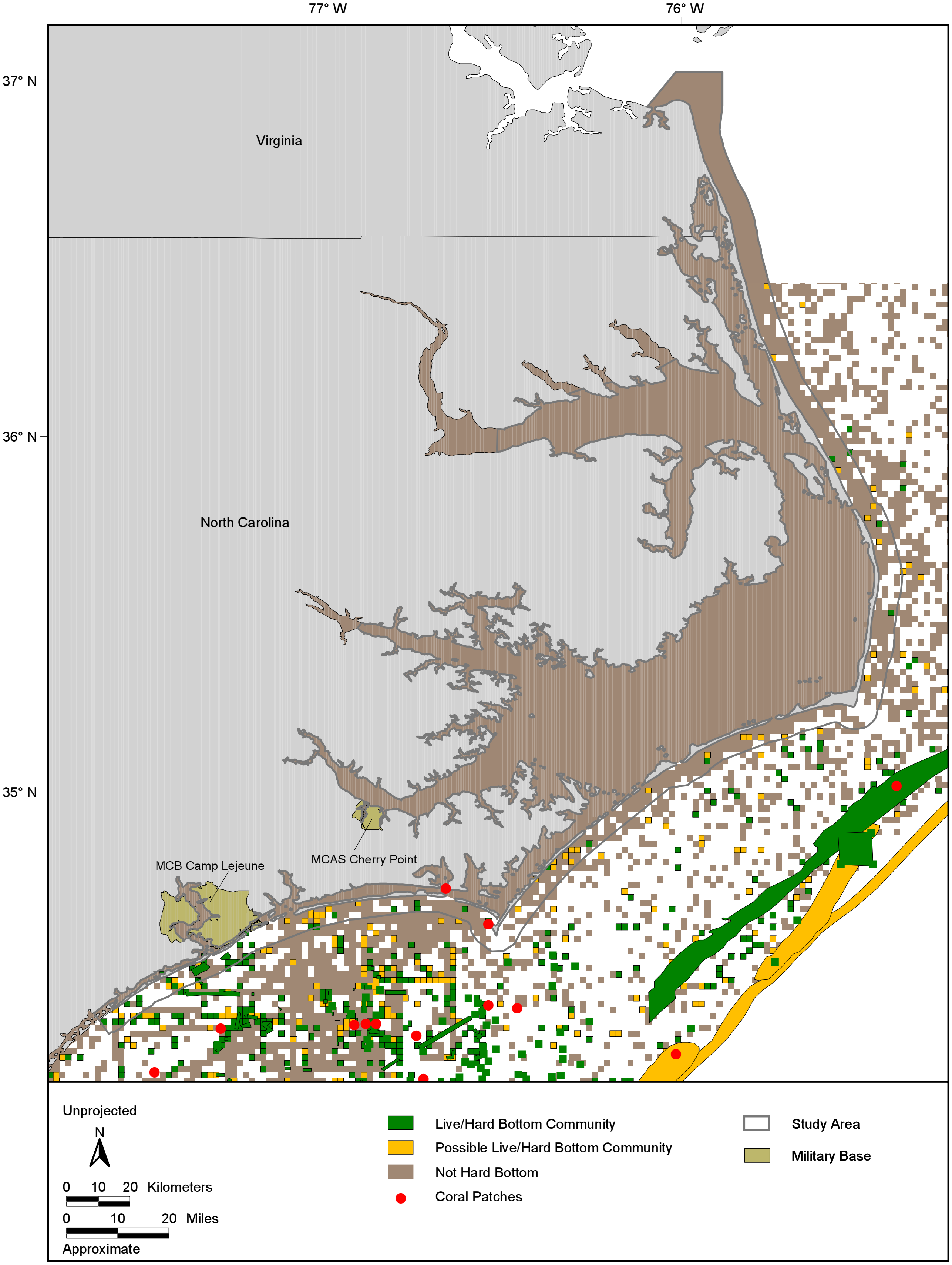

Figure 2-12. Locations of coral, live/hard bottom communities, and possible live/hard bottom communities in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: Reed (1980) and SEAMAP (2001). Source maps (scanned): McCloskey (1970), Huntsman and Macintyre (1971), BLM (1976), and Riggs et al. (1986). Map adapted from: Amato (1994).

Smith and Ustach 1986; SAFMC 1998). The seafloor substrate off the Carolinas varies from smooth mud to outcrops encrusted with corals, sponges, and other predominantly tropical invertebrate fauna. These constitute nearshore live/hard bottom communities (Figure 2-12). Some of these outcrops (such as those found in Onslow Bay) are remnants of shallow reefs developed following the Wisconsin glaciation (10,000 years before present) (Kennett 1982; Veron 1995; SAFMC 1998). Known live/hard bottom communities of this region, however, occur seaward and south of the study area, on the mid and outer continental shelf (SAFMC 1998).

2.3.4.2 Reef/Reef-Like Habitats

Steimle and Zetlin (2000) present in great detail the reef/reef-like habitats and associated biological communities of the study area. The following is an overview of Steimle and Zetlin's (2000) characterization of natural reefs in estuarine and coastal areas (less than 19.3 km from the coastline) that are potentially found within the study area.

Natural reef habitats in the study area consist of submerged rocks, hard materials, and other solid structures produced by living organisms (Figure 2-12; Steimle and Zetlin 2000). In estuarine environments, natural reef habitats formed by organisms include beds of eastern oyster, blue mussel, the cup coral *Astrangia poculata*, polychaete worms, and sponges. Other reef substrates in estuarine environments include exposed clay, peat, and rock outcrops; waterlogged trees; fields of boulders or cobbles; and former deltaic deposits of rocks, cobbles, and gravel (Steimle and Zetlin 2000).

In coastal environments in and adjacent to the study area, mussel and coral beds produce biogenic reefs much like in the estuarine environment. In fact, blue mussel beds are more likely found in the cooler coastal marine waters. These mussel beds change with time as a given bed may have a lifespan limited to ten years and are continually exposed to predation and harvesting. Other natural reef habitats of the coastal environment include rocky outcrops, accumulations of glacial erratic boulders or cobbles, relict shell fields, and exposed stiff clay and peat deposits (Steimle and Zetlin 2000).

The presence of certain species found in reef habitats in the study area probably shifts as a function of their life cycle and season. Some organisms associated with the reefs exist as larvae in the water column, then on estuarine reefs as juveniles, and then in deeper and more marine habitats at the end of their first season. High relief reefs are usually habitats for bluefish, mackerel, tuna, jack, and bottom-dwelling species such as summer flounder. These reefs and their fishes are targeted more by recreational than commercial fishermen simply because commercial trawl fishing gear cannot be towed through high relief reefs without being seriously damaged (Steimle and Zetlin 2000). However, commercial handlining and pot/trap fishing are common.

Reefs in estuaries of the study area support epibenthic and epibiotic organisms. Epibenthic organisms are those that attach to rock, wood, metal, stiff clay, or peat. Oyster beds and blue mussel beds are typically found on rock, wood, or metal. Epibiotic organisms attach themselves to other organisms that have settled on abiotic substrates. Reefs made of oysters or blue mussels can support a multitude of epibiotic organisms such as barnacles, ribbed mussels, blue mussels, algae, sponges, tubeworms, anemones, hydroids, and bryozoans. Silt accumulations between the oyster shells can support benthic invertebrates. Polychaetes and amphipods can also be found between mussel shells and within byssal threads (Steimle and Zetlin 2000).

Hard surfaces in estuarine environments of the study area predictably support algae, barnacles, sponges, tube worms, hydroids, anemones, encrusting bryozoans, oysters, blue mussels, jingle shells, the coral *Astrangia poculata*, tunicates, and amphipods. Wooden structures (even after antiborer treatment) are frequently bored by shipworms (*Toredo*) and gribbles (*Limnoria*). Softer surfaces such as semi-hard clay and *Spartina* peat "reefs" can support burrowing mollusks and epibenthic algae (Steimle and Zetlin 2000).

The more-motile species of estuarine reef communities include both invertebrates and fishes, such as American lobster, American eel, mud crabs, blue crabs, rock crabs, spider crabs, sea stars, gobies, spot, striped bass, black sea bass, white perch, toadfish, scup, drums, croaker, sheepshead, pinfish, tautog, and northern puffer (Steimle and Zetlin 2000).

2.3.4.3 Coral Patches

Hunstman and Macintyre (1971) documented 20 coral patches located 11 to 48 nautical miles (NM) from the Onslow Bay coastline (Figure 2-12), well beyond the boundaries of the study area. These coral patches contained scattered individual reef-building coral heads (e.g., lobe star coral and starlet coral), non-reef building corals (e.g., ivory bush coral, cup coral, hidden cup coral, and porous cup coral), sea fans, Spanish lobster, spiny lobster, mollusks (including calico scallops), algae, and sponges (Macintyre and Pilkey 1969; Huntsman and Macintyre 1971). The largest coral patch found in Onslow Bay is about 6.4 km long and 2.4 km wide. The coral patches are located in 19 to 40 m of water. Other coral patches may be present in shallower areas of Onslow Bay and possibly within the study area (Huntsman and Macintyre 1971). However, higher turbidity and colder water temperatures shoreward of the 18 m isobath probably limit the occurrence of coral assemblages in the study area (Macintyre 1970).

In the early 70s, primarily fishermen knew of the coral patches located in Onslow Bay as they supported aggregations of tropical and subtropical fishes. Reef fishes popular with fishermen in Onslow Bay include red snapper, groupers, and sea basses (Huntsman and Macintyre 1971). Two of the coral species making up much of the coral patches are knobby star coral and massive starlet coral. Some of the colonies of knobby star coral in Onslow Bay are comparable to the largest heads found in tropical waters (e.g., Florida, Bahamas, and the Caribbean; Smith 1971). The largest knobby star coral specimen found by Macintyre and Pilkey (1969) in Onslow Bay was 30 cm high and 30 cm wide. Massive starlet coral is far less abundant in Onslow Bay than knobby star coral, and its colonies are only 10 cm in diameter. This is in contrast with massive starlet coral colonies in the tropics that can be 2 m in diameter. Both knobby star coral and massive starlet coral tolerate a water temperature range of 10.6 to 24.7°C, including exposure for three months of the year to temperatures well below the accepted 16°C minimum tolerance temperature. A low sedimentation rate and numerous rock outcroppings in Onslow Bay appear to provide adequate conditions (despite seasonal low temperatures) for knobby star coral and massive starlet coral to be present (Macintyre and Pilkey 1969).

McCloskey (1970) found patches of ivory bush coral (*Oculina arbuscula*), a branching nonreef-building species, both in estuarine and coastal environments of the study area, including Shark Shoal Jetty in the Beaufort estuary and beyond the surf zone on Cape Lookout Jetty (which extends 830 m into Onslow Bay) (Figure 2-12). Ivory bush coral was also present seaward of the study area on a rock outcrop off Lookout Shoals (40 km offshore) (Figure 2-12). Colonies of ivory bush coral were spherical, measured up to 1 m in diameter, and grew in 3 to 25 m of water (McCloskey 1970).

Ivory bush coral sampled at Shark Shoal Jetty and Cape Lookout Jetty had live tissue only along the periphery of the colonies (McCloskey 1970). The base and core of these coral samples were heavily bored and dead, with the centers (between branches) filled with shell fragments, sediment, and various animals (e.g., anemones, flat worms, ribbon worms, mollusks, polychaete worms, crustaceans, echinoderms, tunicates, and fishes). The deeper sampling location in Onslow Bay yielded specimens of ivory bush coral that were completely alive and had well-developed branches that were spaced apart. Sedimentation is probably the main cause for the differences in growth forms and amount of living tissue observed between the estuarine, nearshore, and offshore locations.

The existence of corals in Onslow Bay probably depends on continual supplies of propagules from upstream reefs (including those in the Caribbean) transported by the Gulf Stream and coastal currents (Macintyre and Pilkey 1969; Veron 1995; Powell et al. 2000). Physical-environmental parameters explain the absence of true coral reefs within the study area (Veron 1995). Latitude-correlated physical-environmental parameters include temperature, light, substrate, and currents. Light availability, not temperature, is the most ecologically significant latitude-correlated physical-environmental parameter. Lack of light will prevent the coral-zooxanthellae symbiosis that positively influences coral growth and reef accretion. Low temperatures (<11°C) will generally kill zooxanthellae and high temperatures (30 to 34°C) will cause coral bleaching (disruption of coral-zooxanthellae symbiosis due to expulsion of zooxanthellae).

In the case of the temperate-tolerant ivory bush coral found in Onslow Bay, biotic factors (mainly competition for space with algae) restrict its growth and abundance in shallow water, even though its colonial growth is physiologically best suited to shallow water conditions, particularly summer conditions (high light levels, temperatures, and chlorophyll *a* concentrations) (Miller 1995).

Non-latitude-correlated or regional physical-environmental factors that affect coral growth include surface water circulation, substrate availability, sedimentary regimes, tidal regimes, and nutrients (Veron 1995). The most limiting of all regional physical-environmental parameters to reef coral distribution is substrate availability. Sedimentary regimes, associations of substrate type, sedimentation, turbidity, and light availability also affect coral diversity and distribution at local, macroenvironmental (e.g., continental shelf), and biogeographic (e.g., entire coral province) scales (Veron 1995).

2.3.5 Artificial Habitats

Artificial habitats (shipwrecks, artificial reefs, and other man-made structures) represent physical alterations to the seafloor. Under the right conditions, these types of artificial habitats can benefit benthic communities and onshore economies. When man-made objects with numerous and varied surfaces are introduced to areas of the seafloor that are predominantly made up of soft sediments, these objects provide the appropriate substrates necessary for the settlement and colonization of epibenthic organisms such as algae, sponges, barnacles, soft corals, anemones, and hydroids, among others (Bohnsack et al. 1991). As more sessile organisms colonize a site, a complex biological community develops, ultimately attracting large predatory game fishes. In turn, the establishment of the artificial reef will attract recreational and commercial fishermen. The process of reef colonization and community building ultimately extends the potential range of some commercially and recreationally important fishes and invertebrates by providing more habitat area. The preservation of a successful reef habitat can have a bearing on the biological productivity and economic value of offshore areas.

Although artificial in their origin and design, established shipwrecks and artificial reefs behave like natural hard bottom communities (Bohnsack et al. 1991). Fishermen commonly target sharks, mackerels, jacks, barracuda, cobia, and bluefish at productive artificial habitat sites (Myatt 1978). Other targeted fishes such as black sea bass, scup, monkfish, and summer flounder seasonally seek out artificial reef habitats for shelter and food. This is also generally true of members of the snapper and grouper families that aggregate around man-made structures in the ocean (SCWMRD and GADNR 1981). Despite being located in temperate latitudes, the shipwrecks and artificial reefs off the North Carolina coast also host tropical and subtropical species. The Gulf Stream Current transports eggs and larvae of southern fishes and invertebrates to the waters of the study area. This provides the numerous shipwrecks and artificial reefs located in the clear waters off North Carolina with a tropical reef fish community (McGovern et al. 1998).

In addition to fishes and invertebrates, sea turtles are attracted to these artificial habitats for food and shelter. Sea turtles forage around artificial reefs for organisms such as algae, anemones, sponges, and crustaceans (Bjorndal 1997). Seasonally migrating loggerhead sea turtles often use artificial reefs along the continental shelf edge on the western side of the Gulf Stream as foraging grounds (Musick and Limpus 1997). Some top ocean predators (e.g., hammerhead, blue, and mako sharks) are also attracted to shipwrecks, artificial reefs, and other man-made structures to feed on dense aggregations of prey items (VMRC 2002).

Unlike artificial reefs and shipwrecks that rest on the seafloor, other man-made structures (e.g., fish aggregating devices [FADs]) are deployed between the bottom and the surface. FADs consist of objects suspended in the water column (usually anchored to the bottom) or floated at the surface to attract fishes (Bohnsack et al. 1991). Although FADs have had varying levels of success in nearshore and offshore applications, they are effective in attracting pelagic fish species like yellowfin tuna, blackfin tuna, skipjack tuna, wahoo, mackerel, marlin, and dolphinfish in North Carolina and Virginia waters (Beets 1989). Artificial habitats, including FADs, enhance fish aggregation and production (Seaman and Sprague 1991).

A wide variety of man-made structures and materials have been constructed and/or deposited underwater or nearshore in the study area. Structures include shoreline bulkheads, bridge abutments, piers, docks, groins, lighthouses, pipelines (natural gas, storm water, sewage), communication cables, and shipwrecks. Artificial reef materials vary dramatically in size and include beverage containers, ballast rocks, and old vehicles. Materials used for nearshore and offshore reefs can sometimes be significantly larger (e.g., larger shipwrecks) than materials used for estuarine habitats. Artificial reefs, especially those that are planned, can enhance shellfish and finfish fisheries. Colonization of reef materials by attached organisms paves the way for subsequent communities of organisms (Steimle and Zetlin 2000; NOAA 2002).

2.3.5.1 Shipwrecks

The numerous shipwrecks in the study area and vicinity are the result of powerful currents (notably the Labrador Current and Gulf Stream), winds (such as from cold fronts), rough seas (from storms, including many hurricanes), coastal topography (e.g., Cape Hatteras, Cape Lookout, and Cape Fear), shallow water and sandbars (Cape Lookout Shoal and Diamond Shoals), and wars (Revolutionary War, Civil War, and World War II) (Gentile n.d.; Newton et al. 1971). Approximately 158 shipwreck sites are located in the study area, 13 in the estuarine system and 145 in coastal waters (Figure 2-13).

Many shipwrecks occur off the Virginia coast. For example, more than 1,100 shipwrecks have been reported sunk off Virginia during the period from 1874 to 1915 (Outer Banks Posters 2002). Within the Virginia portion of the study area, some of the well-known wrecks include the *Chilore*, *William D. Sanner*, and *Cape Henry Lightship* at the mouth of Chesapeake Bay; the *Kingston Ceylonite*, *Santore*, and *Tiger* sunk by German submarines in World War II; and the *Edward Luchenbach* and *Clythia* along the southern Virginia coast south of Virginia Beach (Gentile n.d.; The Associates of Underwater Explorers 2002).

Some of the shipwrecks along the North Carolina coast date to colonial times, including the first recorded shipwreck, the *Tyger* at Ocracoke Inlet, in 1585. Over 1,000 ships have been lost along the North Carolina coast in the past four centuries, earning those treacherous waters the nickname, "The Graveyard of the Atlantic." The highest concentrations of shipwrecks are in the vicinity of Cape Hatteras, where the clash of cold northern currents and the northbound Gulf Stream forms the shallows of the Diamond Shoals (Newton et al. 1971). Extending seaward over submerged, shallow shifting sandbars for 17 NM, the Diamond Shoals create hazardous sea conditions for mariners. The famous Civil War Union battleship, the U.S.S. *Monitor*, sank in heavy seas near the Diamond Shoals while being towed. The frequency of hurricanes and cold fronts in the area also accounts for a large number of the wrecks northeast of Cape Hatteras (Hause 2002). Additionally, wars have claimed their share of ships along the North Carolina coast. German submarines sank a number of Allied ships off the North Carolina coast during World War II, such as the SS *Liberator*, *Australia*, and *Kassandra Louloudis* near the Diamond Shoals and the *Ashkahabad* and *Caribsea* near Cape Lookout. The U.S. Coast Guard and Navy sank German submarines in turn, including the U-85 off Oregon Inlet and the U-352 off Cape Lookout Shoals (BFDC 2000). This area is referred to as the infamous "Torpedo Junction" (Gentile 1992, 1993). The North Carolina Artificial Reef Program has designated several of the shipwrecks as artificial reef sites (NCDMF 2001).

2.3.5.2 Artificial Reefs

An artificial reef is defined as one or more submerged structures of natural or human origin deployed purposefully onto the seabed to influence physical, biological, or socioeconomic processes related to living marine resources (Baine 2001). Artificial reefs are defined physically by the design and arrangement of materials used in construction and functionally according to their purpose (Seaman and Jensen 2000). A large number of items can and have been used in the creation of artificial reefs. Materials can include natural objects such as wood (e.g., weighted tree trunks), shells, and rock, and man-made objects such as vehicles (e.g., automobile bodies, railroad cars, and Sherman tanks), aircraft, boats (e.g., Liberty ships, landing craft, barges, and tugboats), home appliances, discarded construction materials (e.g., concrete culverts), scrap vehicle tires, oil/gas platforms, ash byproducts (from solid municipal incineration and coal/oil combustion), and prefabricated concrete structures (e.g., "reef balls")

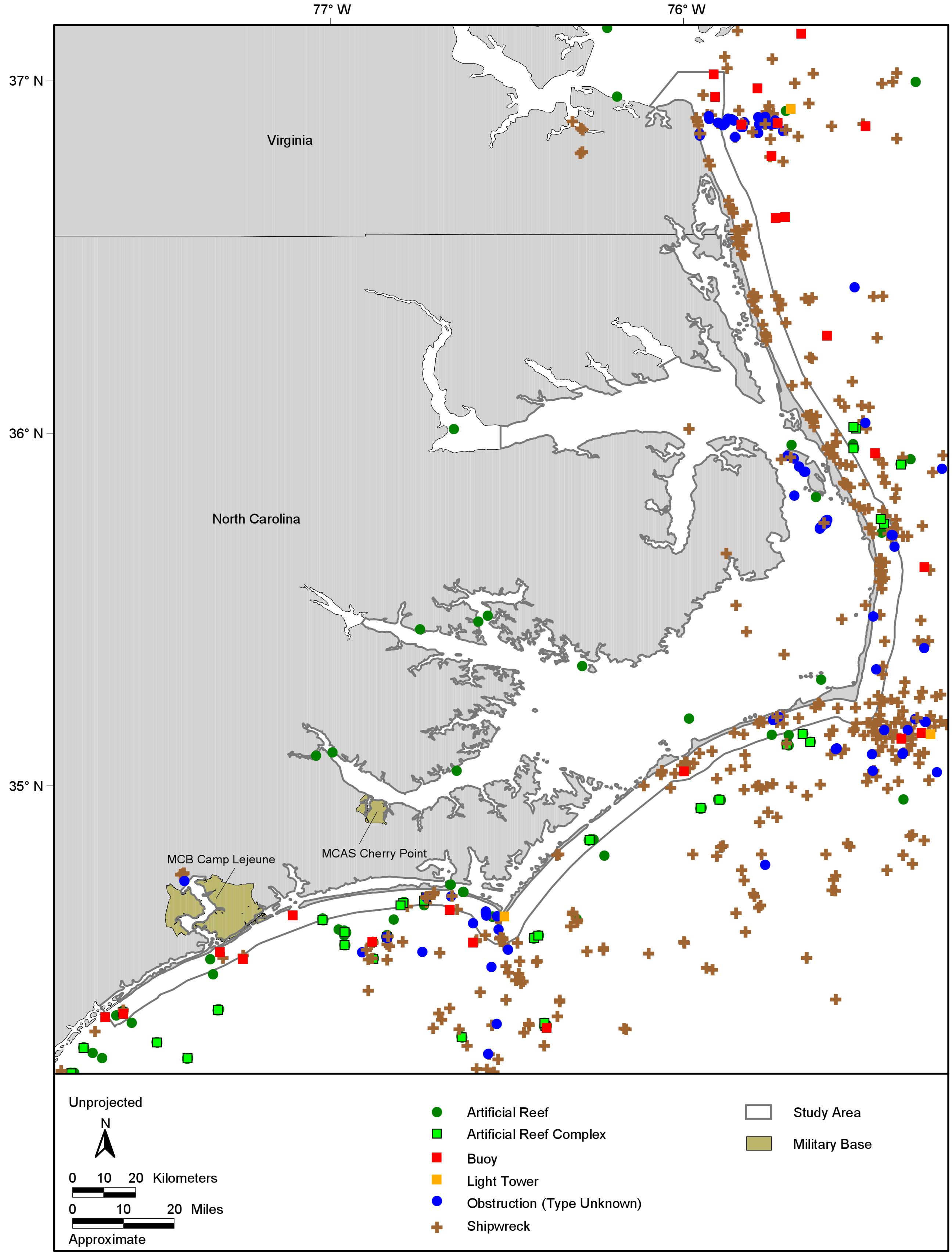

Figure 2-13. Distribution of artificial reefs, artificial reef complexes, shipwrecks, and other man-made structures in the Cherry Point and southern VACAPES inshore and estuarine areas. An artificial reef complex consists of multiple artificial reefs that are located within 500 m of one another. Source data: NOAA (1998a, 2002), NCDMF (2001), SEAMAP (2001), and VMRC (2002). Source maps (scanned): BLM (1976), Freeman and Walford (1976), and BFDC (2000).

(Artificial Reef Subcommittee 1997). The purposes of deploying artificial reefs into the marine environment are to enhance commercial fishery production/harvest, to enhance recreational activities (e.g., fishing, scuba diving, and tourism), to restore/enhance water and habitat quality, to provide habitat protection and aquaculture production sites, and to control fish mortality (Seaman and Jensen 2000).

McGurrin et al. (1989) provide an excellent summary of the history of artificial reef development in the U.S. In 1984, the U.S. Congress, recognizing the social and economic value of artificial reefs, passed the National Fishing Enhancement Act (NFEA) (Title II of Public Law [PL] 98-623). One of the primary directives of the NFEA was the preparation of a long-term National Artificial Reef Plan (NARP). Section 202 of the act recognizes the harmful effects of overfishing on fishery resources and proposes that properly designed, constructed, and located artificial reefs could enhance the habitat and diversity of fishery resources. The NARP, which is currently undergoing revision (NMFS 2002), was implemented in November 1985 to provide guidance and/or criteria on various aspects of artificial reef use, including types of construction materials and planning, siting, designing, permitting, installing, maintaining, and managing artificial reefs (Gordon 1993).

One of the most significant recommendations in the NARP was the development of state-specific artificial reef plans. The Atlantic and Gulf States Marine Fisheries Commissions (ASMFC and GSMFC, respectively) began to coordinate state artificial reef program activities for states along the Atlantic seaboard and the Gulf of Mexico coast. States bordering the Atlantic Ocean and the Gulf of Mexico have taken the lead in developing and managing artificial reefs. Each state involved in the NARP has developed state-specific plans that have established protocols for siting, deployment, and evaluation of materials for artificial reefs (Joint Artificial Reef Technical Committee 1998).

Currently, most of the southern coastal states have developed their own non-profit artificial reef programs. North Carolina has an active artificial reef program and a few states, such as Florida, encourage private creation of artificial reefs and have designated zones to avoid conflicts with other maritime activities. In 1972, the Maritime Programs Appropriations/Authorization Act of 1972 (PL 98-402) provided for the transfer of obsolete Liberty ships from the U.S. Maritime Administration (MARAD) to coastal states for use as artificial reefs. This resulted in the passage of the Liberty Ship Act (PL 92-402) in 1974 (Gordon 1993). The MARAD Artificial Fish Reef Program authorized the Secretary of Commerce to transfer scrap Liberty ships to any state filing an application. Many of the southern U.S. coastal states have taken advantage of this program. The majority of Liberty ships transferred under this act were sunk between 1974 and 1978. Six vessels were sunk in offshore waters to form the popular Triangle Reef off Virginia Beach and the Parramore Reef off Wachapreague (Virginia Marine Resources Commission 2002). Eight ships were used as reef material off the coast of North Carolina (Artificial Reef Subcommittee 1997). Three of these vessels were sunk on reef sites off the Oregon Inlet (2 ships: *Dionysus* and *Zane Grey*) and Beaufort Inlet (*Theodore Parker*) (SAFMC 1998; BFDC 2000).

Using Liberty ships as artificial reefs is somewhat prohibitive because it requires the applicants to provide any funds necessary for the transport and preparation of the ships before sinking (Naval Vessel Register 2001). In 1984, the Liberty Ship Act was amended by PL 98-623 to include reserve ships other than Liberty class ships for artificial reef construction. Most of the 650 World War II-era merchant vessels still available in the early 1970s were Victory class ships. However, relatively few Victory class merchant vessels were ever secured for use as artificial reefs. No vessels were obtained under this law from 1979 through 1987, and only 15% of all Liberty ship vessels were deployed from 1988 through 1992 (Gregg and Murphey 1994; Artificial Reef Subcommittee 1997). Construction of artificial reefs using other vessels (mainly barges and landing craft) has occurred primarily off the Atlantic coast states and western Florida (Gregg and Murphey 1994).

By mid-1979, 89 artificial reefs had been established along the south Atlantic coast from Oregon Inlet, NC, to Key West, FL (Gusey 1981). Artificial reef development off the coasts of south Atlantic states (as measured by the number of permitted construction sites) has increased nearly five-fold since 1980, with approximately 250 sites now permitted in the coastal and offshore waters from North Carolina to Florida (SAFMC 1998). Roughly half of these sites are in waters off the east coast of Florida (SAFMC 1998). State marine resource management agencies of the Atlantic coast states are actively involved in various aspects of artificial reef site planning, development, and management, both in their own waters as well as in contiguous federal waters. The Marine Resources Commission manages Virginia's current Artificial Reef Program. Most of Virginia's artificial reefs are deployed in Chesapeake Bay or off the eastern shore of Virginia (VMRC 2002). The North Carolina Department of Environmental and Natural Resources (NCDENR), Division of Marine Resources, currently maintains numerous artificial reef sites. These sites are located from 0.86 to 33 NM from shore and are strategically located near every maintained inlet along the coast (SAFMC 1998).

Nine artificial reef complexes consisting of 48 artificial reefs have been established within the bounds of the study area, primarily within the 3 NM coastal waters (Figure 2-13; NCDMF 2001). Reef complexes can be composed of more than one type of reef material. A reef complex is an aggregation of artificial reefs that are located within 500 m of one another. Most of the artificial reef complexes in the North Carolina artificial reef system are numbered and marked on location with a permanent buoy (SAFMC 1998). In addition to artificial reef complexes, there are approximately 28 individual artificial reefs within the study area: 19 in the estuarine system and 9 in the coastal waters (Figure 2-13; NCDMF 2001).

2.3.5.3 Fish Aggregating Devices

FADs consist of single or multiple floating structures (Seaman and Sprague 1991) that are connected to the ocean floor by ballast or anchors. These devices are designed to provide surface area at a designated height above the ocean's floor or below the ocean's surface (depending upon ocean depth at the location where the FADs are deployed). Usually prefabricated, FADs are designed to attract pelagic species (Klima and Wickham 1971). Deployment can be in pre-arranged alleys (rows) or in random patterns (Beets 1989; Rountree 1989). Two fundamentally different oceanic and coastal FADs have been established in the U.S. since the 1970s: large, floating FADs and small, mid-water FADs. Large, floating FADs have been successfully deployed in water depths up to 1,829 m for ocean pelagic commercial and recreational fisheries. Small, mid-water FADs have been used for coastal (5 km offshore) recreational fisheries in waters ranging in depths from 14 to 30 m (Roundtree 1990). Incorporation of FADs in the vicinity of artificial reefs and the attachment of FADs to artificial reefs have been reported to improve catches of pelagic sportfishes (Stephan and Lindquist 1989) and demersal finfishes (Kellison and Sedberry 1998). FADs have been placed in Onslow Bay, NC (Stephan and Lindquist 1989).

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3.0 BIODIVERSITY AND SPECIES OF CONCERN

This chapter provides information on the plant and animal species occurring in the Cherry Point and southern VACAPES inshore and estuarine areas. In particular, detailed information is presented for species of special interest to the Navy due to their protected status and the potential of Navy activities to impact these animals. The five groups of organisms (plants, fishes, reptiles, birds, and marine mammals) are arranged phylogenetically.

Ecologically, the study area represents two transition zones. First, the marine environment near Cape Hatteras is a transition zone where temperate waters meet subtropical to tropical waters. The boundary between these two regions is the northern wall of the Gulf Stream. Because the study area spans both temperate and subtropical/tropical waters, both cold-water and warm-water marine species may be found in the region. Second, the study area spans several habitat types (Chapter 2), from the low-salinity westernmost estuarine waters, to the terrestrial barrier islands, to the coastal waters that are part of the open ocean. Organisms tolerant of different salinity regimes can be found in various parts of the study area.

Unlike the OPAREA MRAs, in which sea turtles and marine mammals are the only threatened or endangered species, the habitat complexity of the study area results in additional taxa being included among the species of concern. The inclusion of the barrier island habitat necessitates the discussion of one plant species (seabeach amaranth) and two bird species (piping plover and roseate tern). The inclusion of estuarine waters necessitates the discussion of a reptile other than a sea turtle (American alligator) and an inshore fish (shortnose sturgeon). Nevertheless, sea turtles and marine mammals comprise the bulk of the discussion of species of concern.

Each of the five taxon sections initially provides a general overview of the diversity of that taxon within the study area, as well as some associated ecological and/or behavioral information. For example, the marine mammal and sea turtle sections include a discussion of underwater bioacoustics and hearing, which is useful in consideration of any potential anthropogenic impacts to these animals.

Following the overview of each group, those species that are protected by the MMPA and/or ESA are singled out for further discussion. Each species has a detailed narrative, which provides a description of the species and its status, habitat preferences, distribution (including a focus on the study area), behavior, and life history, as well as an account of its vocalizations and hearing capabilities (when appropriate). Maps depicting the distribution of each species in the study area and vicinity can be found within each taxonomic section. In the case of sea turtles and marine mammals, distribution maps are provided for each season. The maps are imbedded within the sections to facilitate easy cross-referencing to the text.

3.1 PLANTS

3.1.1 General Overview

The plant communities of the Cherry Point and southern VACAPES inshore and estuarine areas include microscopic and macroscopic algae, submerged and emergent aquatic plants, and terrestrial vegetation. Both coastal and estuarine plant resources may vary widely in species diversity and abundance (Milliman and Wright 1987). Factors that affect diversity and abundance include salinity, turbidity, light penetration, nutrient loading, mixing characteristics, and seasonal variations (Dame et al. 2000).

3.1.1.1 Microscopic Algae

Microscopic algae communities consisting of phytoplankton and benthic microalgal forms (periphyton and edaphic algae) occur in the coastal and adjacent estuarine systems within the study area.

3.1.1.1.1 Coastal waters

Of the eight major types of marine phytoplankton, the most abundant are diatoms, dinoflagellates, and coccolithophores (Garrison 1995). The remaining five types, silicoflagellates, cryptomonads, chrysomonads, green algae, and cyanobacteria (blue-green algae), are present but less numerous (Duxbury and Duxbury 1997). Over 900 species of phytoplankton have been identified along the U.S. east coast, over half of which are diatoms and dinoflagellates (Milliman and Wright 1987). Minor taxa of U.S. east coast phytoplankton include coccolithophores, silicoflagellates, cyanophyceans, green algae, euglenoids, cryptomonads, and yellow-green algae (Milliman and Wright 1987).

Seasonal patterns of succession occur, with areas of high cell concentrations dominated by small-sized centric diatoms (e.g., *Skeletonema costatum*, *Leptocylindrus danicus,* and *Thalassionema nitzschiodies*) and several ultraplankton components (e.g., *Synechococcus* and *Cryptomonas*; Marshall and Ranasinghe 1989). These temperate and boreal neritic species dominate in the cold months (winter and early spring), eventually yielding in abundance to the summer warm-water dominants. Characteristic for waters north of Cape Hatteras during the summer period are the aforementioned centric diatom species, along with several species of *Rhizosolenia* and a variety of dinoflagellates (e.g., *Ceratium*; Marshall 1976, 1978). In coastal waters south of Cape Hatteras, the typical tropical-subtropical species are found and consist of a rather diverse group of neritic and pelagic species (Marshall 1977). Displaying a larger number of dominants and greater species diversity than the more-northern group, the phytoplankton community south of Cape Hatteras includes centric diatoms such as *Coscinodiscus*, *Hemiaulus*, and *Rhizosolenia*). Dominant ultraplanktonic organisms such as *Ceratium*, *Exuviaella*, *Oxytoxum*, and *Podolampas* are common throughout the year, and coocolithophores have a greater diversity in these warmer waters than further north. Common plankton representatives in the coastal areas adjacent to the estuarine systems included the centric diatoms *Melosira distans* and *M. islandica*, along with several other species commonly found in freshwater habitats. There appears to be a close relationship between the appearance of these species north of Cape Hatteras, the meanderings of the Gulf Stream, and the summer increase in water temperatures (Marshall 1971).

In terms of relative abundance, the concentration of diatoms, which dominate nutrient-rich shallower coastal waters, decrease seaward, while coccolithophores increase significantly in nutrient-poor oceanic waters offshore (Marshall 1976). Concentration levels of dinoflagellates are less than diatoms, although isolated blooms of dinoflagellates (e.g., bloom of *Gymnodium breve* in North Carolina coastal waters in 1987-1988; Warlen et al. 1998) may occur depending upon nutrient levels, wind speed, water circulation, and temperature (Garrison 1996). In general, the highest concentrations of phytoplankton occur in the coastal areas adjacent to major estuarine systems at temperatures ranging between 11° and 23°C and salinities between 29 and 33 psu (Marshall and Ranasinghe 1989).

Benthic microalgal forms (periphyton and edaphic algae) can be found growing on or anchored to sand and mud bottoms in shallow coastal waters. Unicellular or filamentous green algae (e.g., *Cladophora* and *Ectocarpus*) may be very abundant on the surface of sediments, on hard substrates such as rocks, and on fronds and leaves of macroalgae. Pennate diatoms (e.g., *Navicula*, *Amphipleura*, and *Nitzchia*) are often dominant in algal mats found in shallow-water environments, occurring as single cells or in colonial arrangements (Valiela 1995). Blue-green species (e.g., *Lyngbya* and *Spirulina*) occur as epiphytes on various macroalgal species and invertebrates or on various abiotic substrates (e.g., stone jetties and exposed peat deposits) (Halvorson and Dawson 1973).

3.1.1.1.2 Estuarine waters

The flora composition at the mouth of Chesapeake Bay is similar to the phytoplankton reported in the neritic waters of the Mid-Atlantic Bight (Marshall and Cohn 1982). The phytoplankton community experiences seasonal successional changes in composition and abundance, with a bimodal pattern of population peaks occurring in spring and fall (Marshall 1988). Contributing to the species composition of Chesapeake Bay are forms indigenous to the bay, as well as species transported by water masses entering the bay from over the continental shelf or farther offshore (Marshall 1980).

Ubiquitous in this region are several species of diatoms which are responsible for the major periods of spring and fall growth. Summer dominants included dinoflagellates, the chrysophyte *Calycomonas ovalis*, and several *Cryptomonas* species (Marshall 1991). Many of these species are cold-water types preferring the cooler temperatures associated with the local fall pulse and accompanying the spring bloom (Marshall 1980). Winter concentrations are low and characterized by centric and pennate diatoms (Marshall 1991). A second assemblage of species, characterized by phytoflagellates and microflagellates, is more common in estuaries and their tributaries (Marshall 1991). Harmful algal bloom (HAB) species (e.g., *Pfiesteria piscicida*, *P. minimum*, and *Aureococcus anophagefferens*) have been reported as occurring during the summer in Chesapeake Bay and are affected by nutrient pulses (Gilbert et al. 2001).

In the coastal estuaries of North Carolina, the various sounds (e.g., Pamlico and Albemarle) are dominated by diatoms, as are the most saline portions of riverine estuaries in spring and fall. Cryptomonads are present during most of the year, while flagellates dominate under mesohaline conditions. Cryptomonads can be very abundant, especially during periods of freshwater influence during spring and fall (Mallin 1994). The most abundant dinoflagellates are the bloom-formers *Heterocapsa triquetra*, *P. minimum*, *Katodinium rotundatum*, and *Gymnodinium* spp. These species form a distinct winter-spring group encountered in several North Carolina estuaries (e.g., Pamlico, Neuse, and Newport rivers, and Gales Creek), primarily in mesohaline areas (Mallin 1994; Litaker et al. 2002). The chrysophyte *C. ovalis* formed summer and fall blooms in the Pamlico estuary and Gales Creek (Campbell 1973). Formation of summer cyanobacteria blooms in the lower reaches of the Chowan and Neuse rivers was influenced by watershed rainfall levels and subsequent runoff. Green algae are encountered more frequently upstream in the fresh-to-oligohaline areas (Mallin 1994).

Phytoplankton production and abundance typically exhibit peaks in the March-to-May and July-to-September periods (Carpenter 1971; Thayer 1971; Mallin 1994). Periodic winter blooms of estuarine dinoflagellates (e.g., *Pfiesteria* spp.) and cryptomonads, linked to nitrate-loading pulses, occur in some estuaries (e.g., Pamlico, Neuse, and New rivers) in North Carolina (Dame et al. 2000; Burkholder and Glasgow 2001; Glasgow et al. 2001). Diatoms generally dominate the spring bloom phytoplankton communities in North Carolina estuaries, but dinoflagellates and cryptomonads can also be prevalent during all seasons and can dominate during the summer months along with cyanobacteria (Moore 1992; Mallin 1994).

Benthic microalgal forms (periphyton and edaphic algae) are found on the surface of salt marshes, subtidal areas, and tidal flats within the study area (Dame et al. 2000). Diatoms and cyanobacteria form a nearly continuous cover on the surface, with lower salinity marshes having a greater diversity than higher salinity marshes. Several hundred species of pennate diatoms have been identified in salt marshes, forming a continuous benthic marsh cover in areas with and without a vascular plant canopy (Hustedt 1955; Sullivan 1977). This association apparently represents a single, basic edaphic community indigenous to Atlantic and Gulf coast salt marshes. The most abundant taxa include *Navicula*, *Nitzschia*, *Cylindrotheca*, and *Gyrosigma*. Many of these same taxa are also reported from open waters, suggesting that suspension of periphytic and edaphic diatoms plays an important role in maintaining the planktonic diatom community structure (Dardeau et al. 1992). Ralph (1977) described a single nearly homogeneous community of cyanobacteria throughout the Atlantic and Gulf of Mexico marsh zones. Dominant taxa included *Schizothrix arenaria*, *S. calcicola*, *Anacystis* spp., *A. oscillaroides*, and *Entophysalis conferta*. Otte and Bellis (1985) noted that the North Carolina edaphic diatom flora differed appreciably from those of the mid-Atlantic and Gulf coasts, which were more similar in composition to each other. The plant community associated with tidal flats consists of a benthic microalgae habitat formed by benthic diatoms, predominantly *Naviclua* and *Nitzschia*, cyanobacteria (e.g., *Lyngbya*, *Microcoleus*, and *Phormidium*), benthic dinoflagellates, and filamentous green algae (e.g., *Rhizoclonium* and *Enteromorpha*) (Peterson and Peterson 1979; Patrick 1994).

3.1.1.2 Macroscopic Algae

Macroscopic algae communities consisting of benthic and planktonic seaweeds occur in the coastal and adjacent estuarine systems within the study area.

3.1.1.2.1 Coastal waters

The benthic macroscopic algae (seaweeds) along the continental shelf of the eastern U.S. represent elements of two floras and centers of distribution, a cold-water flora along the coasts of New England and the Canadian maritime provinces, and a warm-water flora centered in the Caribbean Sea around the islands of the West Indies and along the coast of northern South America (Humm 1977). Within the study area, the distribution of benthic macroscopic algae in inshore waters is a response to the pattern of major currents (Labrador Current and Gulf Stream) and their influence on water temperature. Cape Hatteras (more specifically, Beaufort, NC) is a transitional zone in the north-south distribution of many species of marine benthic macroalgae (Humm 1977). The species of marine benthic marcoscopic algae that occur in the shallow coastal waters are the more eurythermal species of the two major floras; as such, there are no truly endemic species in this area (Humm 1977). Approximately 150 seaweed species have been reported between Long Island Sound, NY and Cape Hatteras, NC and 320 species between Cape Hatteras and Cape Canaveral, FL (Searles 1984). Of the 320 species, 303 species are known from North Carolina, where approximately two-thirds occur in shallow coastal habitats and are potential residents of rubble structures (e.g., jetties, weir jetties, groins, breakwaters, seawalls, bulkheads, and revetments) (Searles and Schneider 1980; Hay and Sutherland 1988). For shallow-water species, 21 species reach their northern limit and 27 species reach their southern limit of distribution in North Carolina. The Cape Lookout jetty appears to be the northernmost limit in the intertidal zone for tropical and subtropical seaweeds (Schneider 1976). In the study area, Kapraun and Zechman (1982) noted that red algae (eurythermal tropical element) were most diverse in summer, brown algae (eurythermal cool-temperate element) were most diverse in winter, and green algae (warm-temperate element) were relatively aseasonal. Schneider (1976) reported that the number of species and total biomass decreased in fall, reached a yearly low in winter, and then increased spring through summer with a maximal development occurring in mid-summer.

Most of the study area is an inhospitable habitat for seaweeds because of large expanses of unconsolidated sands, silts, and muds to which most seaweeds cannot attach. Since natural hard substrates (e.g., intertidal rocks) are rare in the study area, most seaweeds attach themselves to shell fragments, to other macroalgae, or to introduced substrates such as rubble structure (e.g., jetties [Cape Lookout, Beaufort Inlet], seawalls, and docks) (Hay and Sutherland 1998). Rubble structures present a fairly clean intertidal rocky environment that would support a typical marine intertidal population. Seaweeds growing in the higher intertidal zone of the rubble structures are usually cyanobacteria, followed immediately below by green macroalgae (e.g., *Ulva*, *Enteromorpha*, and *Cladophora*) and, at times, the red alga *Porphyra*. The lower intertidal zone of the rubble structures is usually occupied by a mixed species group of red seaweeds (e.g., *Polysiphonia*, *Herosiphonia*, *Audouinella*, and *Erythrotrichia*) and species of the green alga *Codium* (Halvorson and Dawson 1973; Hay and Sutherland 1988). Virtually all of the above-mentioned genera also occur in the shallow subtidal zone during some times of the year or in some locations. The most abundant subtidal seaweed along much of the coast is the brown benthic alga *Sargassum* (Kapraun and Zechman 1982).

Hard substrates (reef patches) that are available for attachment occur most abundantly off the North Carolina coast (Onslow Beach). Offshore coastal submerged reef patches in 3.6 to 19.8 m of water would be colonized by *Pockockiella variegata*, *Spatoglossum schroederi*, *Sargassum filipendula*, *Dictyopteris serrata*, *Cladophora pellucida*, and *Caulerpa prolifera*. Buoys also provide a substrate for several genera and species of macroalgal forms with tropical or subtropical affinities between New River and Cape Lookout, NC (Halvorson and Dawson 1973).

In addition to the benthic macroscopic algae, one large, multicellular planktonic brown macroscopic alga, *Sargassum,* forms a dynamic structural habitat within the warm waters of the western Atlantic. Consisting of two species, *Sargassum natans* and *S. fluitans*, it circulates between 20°N and 40°N and between 30°W and the western edge of the Gulf Stream. The greatest concentrations of *Sargassum* are found within the North Atlantic Central Gyre in the Sargasso Sea. Depending on prevailing surface currents, this material may remain on the shelf for extended periods, be entrained into the Gulf Stream, or be cast ashore. Large quantities of *Sargassum* frequently occur on the continental shelf off the southeastern U.S. (SAFMC 1998). Halvorson and Dawson (1973) reported *S. natans* occurring as vegetative plants floating or washed ashore above and below Cape Hatteras, NC. Both pelagic species of *Sargassum* have essential fish habitat (EFH) designation. The EFH for pelagic *Sargassum* includes the areas overlying the continental slope within the exclusive economic zone (EEZ) and state waters (3 NM from shore). EFH habitat areas of particular concern (HAPC) for pelagic *Sargassum* in the study area includes the EEZ and state waters adjacent to the North Carolina coast (SAFMC 1998).

3.1.1.2.2 Estuarine waters

In Chesapeake Bay and its estuaries, substrates for benthic macroscopic algae are limited to calcareous matter (e.g., oyster reefs), artificial habitat (e.g., pilings, docks, bulkheads, cement blocks, and shipwrecks), fleshy sessile organisms (e.g., sponges), aquatic angiosperms, and various salt marsh plants (Wulff and Webb 1969). Twenty-nine species of benthic macroscopic algae have been reported from the lower Chesapeake Bay consisting of 8 species of green algae, 3 species of brown algae, and 18 species of red algae (Zaneveld and Barnes 1965).

The low salinity and variable temperature combine to produce a reduced number of marine algal species that inhabit Chesapeake Bay when compared with more northern and southern regions of the east coast of North America (Wulff and Webb 1969). Zaneveld and Barnes (1965) reported that most of the coastline of the mouth of Chesapeake Bay consists of sand beaches barren of benthic macroscopic algae. Moving between the Virginia Capes (Cape Charles and Cape Henry) westward toward Hampton Roads and river entrances, the beaches are replaced by mudflats, which are also unsuitable for the growth and development of macroscopic algae. The occurrence of algae is seasonal, reaching maximum density in the summer months of June, July, and August (Halvorson and Dawson 1973). The planktonic macroscopic algae *Sargassum natans* has been reported as floating or washed ashore in Chesapeake Bay and within the estuarine system of North Carolina in June, July, and November (Zaneveld 1962).

The estuarine systems along the southeastern Atlantic coast of the U.S. (e.g., the Albemarle-Pamlico Estuarine System) have been characterized as inhospitable to macroscopic algae (benthic and planktonic) (Humm 1969). This is due to the high turbidity (low light) accompanying rapid sedimentation, and the desiccation and extreme temperatures (Dardeau et al. 1992). However, several species of benthic macroscopic algae may become abundant within salt marsh tidal creeks, salt marshes, and tidal mudflats (SAFMC 1998). Small macroscopic red algae (e.g., *Caloglossa* and *Bostrychia)* may be found on standing dead cordgrass culms in summer months, while *Ectocarpus confervoides* may develop on the stems of streamside cordgrass in the winter months. Benthic macroscopic algae are also, during certain times of the year, very abundant in the extensive tidal mudflats. *Enteromorpha* and *Cladophora* are abundant from February through June, *Ectocarpus* from November through March, and *Ulva* in the summer (April through July) (Peterson and Peterson 1979). In North Inlet, SC, the highest numbers of macroalgal species were found in winter, with peak production occurring during the spring (Dame et al. 2000).

3.1.1.3 Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV), which includes both true seagrasses in saline regions and freshwater angiosperms that have colonized lower salinity regions of estuaries, is found in the shallow coastal areas of all Atlantic coastal states (NOAA 2001). Of the 13 seagrass species common in U.S. waters, three species (eelgrass [*Zostera marina*], Cuban shoalgrass [*Halodule wrightii*], and widgeon grass [*Ruppia maritima*]) are found within the study area. In addition, approximately 20 to 30 species of freshwater macrophytes may be found in the tidal freshwater and low salinity areas of the estuaries of the eastern U.S. The lower salinity communities can be quite diverse with as many as 10 species of freshwater macrophytes co-occurring at a single location (SAFMC 1998).

Fourteen SAV species are commonly found in Chesapeake Bay and its tributaries. Eelgrass is dominant, with widgeon grass as a minor component of the polyhaline SAV beds in the lower reaches of the bay, except in the shallowest areas. Widgeon grass, which is tolerant of a wide range of salinities, has been found throughout the mid-bay as well as in the Patuxent, Potomac, and Rappahannock rivers. Both pondweed (*Potamogeton*) and freshwater-mixed communities dominate the middle and upper portions of the bay (Moore et al. 2000). Of the 25,669 ha of SAV communities reported from Chesapeake Bay, approximately 20,685 ha (80.6%) of the SAV habitat consists of eelgrass (13,385 ha) and widgeon grass (7,300 ha) (Moore et al. 2000). Within the study area, eelgrass and widgeon grass have been found in Broad Bay adjacent to Cape Henry (Orth et al. 1994).

The three seagrass species (eelgrass, Cuban shoalgrass, and widgeon grass) growing in North Carolina are all found within coastal lagoons, protected inland waterways, and river mouths protected by barrier islands. There are no known open-ocean seagrass meadows in North Carolina. Two of these species are at their southern (eelgrass) and northern (Cuban shoalgrass) range limits, and when one species is limited by seasonal thermal extremes, the other species may be abundant (SAFMC 1998). Thirteen SAV species have been reported for the Albemarle-Pamlico Estuarine System; the remaining 10 species consist of low salinity-tolerant freshwater macrophytes (Ferguson et al. 1989; Davis and Brinson 1990). In the relatively clear high-salinity waters of the Core, Back, and Bogue sounds and the eastern periphery of Pamlico Sound, the temperate eelgrass species, the tropical Cuban shoalgrass species, and the panlatitudinal widgeon grass species are abundant and widespread. Aquatic beds of SAV are neither diverse in species nor widespread in the predominantly mesohaline waters of the Neuse River estuary, the Pamlico River estuary, western Pamlico Sound, and Roanoke/Croatan sounds. The shallow portions of the Neuse and Pamlico rivers and the Roanoke/Croatan sounds are largely devoid of aquatic bed habitat due to physiological stress from variable salinity, chronic turbidity, and darkly colored water from coastal swamp drainage (SAFMC 1998). Within the oligohaline and freshwater portions of the Albemarle-Pamlico Estuarine System, the euryhaline widgeon grass and low salinity-tolerant freshwater aquatic plants occur in varying distributions (Ferguson and Wood 1994; SAFMC 1998). The total amount of SAV habitat in the Albemarle-Pamlico Estuarine System is 47,716.1 ha: 36,423 ha in eastern Pamlico Sound, 8,068.9 ha in Core Sound, 2,448.4 ha in Currituck Sound, 1,796.5 ha in Albemarle Sound, 374.8 ha in Croatan/Roanoke sounds, 36 ha in the Neuse River estuary, 152.9 ha in the Pamlico River estuary, and 33.6 ha in western Pamlico Sound (Ferguson and Wood 1994).

3.1.1.4 Emergent Aquatic Vegetation

Emergent aquatic vegetation communities within the study area consist of tidal salt marshes. Salt marshes occur along the U.S. Atlantic coast from New England south to northern Florida. The majority of salt marshes in the southeastern U.S. are lagoonal or deltaic types, i.e., they have formed in the shallow, sedimentary area between a barrier island and the mainland, or in the protected delta areas of a large river (Wiegert and Freeman 1990). North Carolina has two major types of salt marshes. Regularly flooded marshes, like those in Georgia and South Carolina, occur along the southern coast up to Morehead City, NC and near inlets along the outer banks. Irregularly flooded marshes (not flooded on every tide) are most extensively developed along the Outer Banks from Beaufort to Currituck County, NC and on the inner fringes of sounds. Flooding in these marshes is primarily due to the effects of wind and storms (Dardeau et al. 1992). The dominant macrophyte in tidal marshes from northern Florida to Maine is smooth cordgrass (*Spartina alterniflora*), but this species reaches its greatest development from North

Carolina southward. Within the study area, the total area of salt marshes is 73,979.2 ha: 63,780.7 ha in Albemarle and Pamlico sounds, 8,539.2 ha in Bogue Sound, and 1,659.3 ha along the New River (SAFMC 1998).

The vegetative communities of salt marshes can be characterized into five or more less distinct categories: (1) creek bank, which has very little vegetation and is muddy or sandy; (2) streamside marsh, which is 1 to 3 m wide, dominated by smooth cordgrass, and is adjacent to the creek bank; (3) levee marsh, in which smooth cordgrass is of intermediate height on the natural levees that border the creek; (4) a wide, flat area behind the levee, which supports the short smooth cordgrass; (5) salt pan or barren area, which is notable for high interstitial salinities and the absence of vascular plants and has thin films of cyanobacteria; (6) salt flat marsh, which comprises sandy areas near the upland border where the succulents (e.g., perennial glasswort, saltwort, sea oxeye, and salt grass) occur; and (7) higher elevations, which include dense monospecific stands of black needlerush (Patrick 1994). In the more brackish areas of the estuary, smooth cordgrass and black needlerush are replaced by big cordgrass (*Spartina cynosuroides*) (Wiegert and Freeman 1990).

3.1.1.5 Terrestrial Vegetation

On sandy shorelines of the barrier islands from the North Carolina/Virginia border to just south of Cape Lookout, NC, sand dune plant communities are characterized by terrestrial vascular plants in soft-sediment habitats (Bertness 1999). In areas consisting of sandy beaches, with or without lagoons behind them, the general community pattern is upper beach, dune grasses, dune grasses and shrubs (maritime dry grassland), and maritime shrubs, which are then bounded by a lagoon with its associated tidal marsh or by an upland forest. Some barrier islands exist in a natural state, while others have been modified (sometimes through stabilization projects) by man. Natural barrier islands are characterized by having a wide (100 to 200 m) beach on the ocean side, behind which is a zone of low irregular dunes. These dunes are fragmented by overwash breaches (Halvorson and Dawson 1973). The upper beach community lies above the mean high tide, but is inundated by high spring tides and storm tides. Vegetation is sparse, characterized by a small number of species, many of them succulents. Annuals are most prevalent, including sea rocket (a winter annual) and the threatened seabeach amaranth (*Amaranthus pumilus*). If protected from disturbance, this community will quickly succeed to perennial-dominated dune grass communities. At inlets on accreting ends of islands, upper beach may intergrade with dune grass through a rather long transition zone of low, semi-stabilized zones (Schafale and Weakley 1990; Weakley et al. 1998).

The dune grass community is exposed to nearly continuous salt spray, which, along with excessive drainage and shifting sand, maintains this habitat dominated by perennial rather than annual plants. Sea oats is dominant in most of North Carolina, with beach grass becoming the dominant grass in the northern part of the state around Nags Head (Schafale and Weakley 1990). Rare plant species found in this community include the threatened seabeach amaranth. Cover ranges from sparse on foredunes and on actively moving sand to fairly dense on more stable dunes. Godfrey and Godfrey (1976) note that dunes on islands perpendicular to prevailing winds tend to be larger and better developed than those on islands parallel to the winds. The natural dune form on most islands is one of relatively low, discontinuous dunes with overwash passes between them (Godfrey and Godfrey 1976). These dunes also control the amount of overwash and salt spray on the rear parts of the barrier islands, which determines the location of maritime dry grassland, maritime shrub, and maritime forest (Schafale and Weakley 1990).

The remaining vegetation communities comprising the unmodified dune areas include the maritime dry grassland, maritime shrub, and maritime forest. Low stable dunes and overwash terraces behind or between low dunes with occasional to frequent seawater overwash and sand burial form the maritime dry grassland. This community is dominated by saltmeadow cordgrass (*Spartina patens*) with generally moderate to dense herbaceous cover, except in recently overwashed areas (Weakley et al. 1998). Some species more typical of the upper beach, such as beach grass and the threatened seabeach amaranth, occur rarely in this community type when seed has been transported by overwash (Schafale and Weakley 1990). The maritime shrub community occurs on sand dunes, dune swales, and sand flats protected from saltwater flooding and the most extreme salt spray. This vegetative habitat consists of dense shrubs, such as wax-myrtle, yaupon, mulletbush, Virginia red-cedar, and stunted live oak (Schafale and Weakley 1990). Occurring in the sheltered parts of the unmodified barrier islands is the maritime forest which has a low to moderately high tree canopy, often stunted and pruned by salt spray into streamlined shapes. This habitat is dominated by combinations of live oak, loblolly pine, and sand laura loak (Halvorson and Dawson 1973; Schafale and Weakley 1990).

Barrier islands that have been stabilized through human intervention have undergone changes resulting in the reduction of the beach area to less than 50 m; in some areas the beach has all but disappeared. Man-made dunes are often much higher in profile than dunes on unmodified barrier islands. This has led to a loss of some upper beach species and a reduction in the amount of overwash to the backside of the islands. The majority of these stabilized dunes are dominated by beach grass along with smaller communities of sea oats. High-profile man-made dunes provide greater protection from oceanic storms than natural dunes, but allow the shrub community to produce large, impenetrable thickets (Halvorson and Dawson 1973).

3.1.2 Threatened and Endangered Species

- Seabeach Amaranth (*Amaranthus pumilus)*

  Description—The seabeach amaranth is a member of the family Amaranthaceae (amaranths) (Small 1933; Duncan and Duncan 1987). This annual herbaceous plant, upon germination, forms a small unbranched sprig. The central sprig begins to branch profusely into a clump, often reaching a foot in diameter and consisting of 5 to 20 branches. Occasionally a clump may get as large as a yard or more across, with 100 or more branches. The stems are fleshy and pink-red or reddish, with small ovate to ovate-spatulate thick leaves that are 1.3 to 2.5 cm in diameter. Clustered toward the tip of the stem, the leaves are normally a spinach-green color and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous, borne in clusters along the stem (Radford et al. 1968; Beacham 1994).

  Status—On April 7, 1993, the seabeach amaranth was federally listed as threatened throughout its entire current range (New York, New Jersey, Maryland, Virginia, North Carolina, and South Carolina) (USFWS 1993). Seabeach amaranth has been eliminated from two-thirds of its historic range (Massachusetts to South Carolina). The most serious threats to its continued existence are the destruction or adverse alteration of its habitat. It is extremely vulnerable to habitat fragmentation and associated consequences (e.g., isolation of small populations) (Pardue 2002). Construction of soft beach stabilization structures (e.g., sand fencing and planting of beach grasses), beach erosion and tidal inundation, beach grooming, fungi (e.g., white wit), herbivory by insects (e.g., webworms), feral animals (e.g., horses), off-road vehicles, and storm-related erosion are the natural and man-induced factors that currently threaten this species (USFWS 1992; Pardue 2002). Man-related activities far inland can also impact this plant and its habitat. Damming of major rivers reduces the sediment load that is carried to the coast. This sediment load helps to maintain barrier islands. Without the sediment load, many barrier islands are eroding away along with the seabeach amaranth habitat (Beacham 1994). The seabeach amaranth is afforded legal protection in North Carolina by the General Statutes of North Carolina, Sections 106-202.15 and 106-202.19 (North Carolina General Statutes Section 106 [Supplement 1991]), which provide for protection from intrastate trade (without a permit) and for monitoring and management of state-listed species and which prohibit taking of plants without written permission of landowners (USFWS 1993).

  Habitat Preferences—Seabeach amaranth is an endemic species that is found only along the Atlantic coastal plain where it inhabits barrier island beaches (Beacham 1994). Overwash flats at the accreting ends of the islands, lower foredunes, and upper strands of noneroding beaches (at the wrackline) are its primary habitat. Occasionally, this species establishes small temporary populations in other habitats such as sound-side beaches, blowouts in foredunes, and sand/shell material placed as beach replenishment or dredge spoil (USFWS 2002). Seabeach amaranth usually is found on a nearly pure silica sand substrate that is sparsely vegetated with annual herbs (forbs) and, less commonly, perennial herbs (mostly grasses) and scattered shrubs (Weakley et al. 1996). This natural community or vegetation type is classified by Schafale and Weakley (1990) as Upper Beach, although seabeach amaranth can be found on sand spits 50 m or more from the base of the nearest foredune (Weakley et al. 1996).

Preferring only disturbed or unvegetated sites, the seabeach amaranth is a pioneer species. It is intolerant of competition. This plant's root system acts as an effective sand binder or stabilizer, building dunes where it grows. A single large plant can create a dune up to 6 decimeters high that contain 2 to 3 cubic meters of sand, although most are smaller (USFWS 1993). The species appears to need extensive areas of barrier islands and inlets, functioning in a relatively natural and dynamic manner. These characteristics allow it to move around the landscape as a fugitive species, occupying suitable habitat as it becomes available (USFWS 1992).

Distribution**—**Historically, the range of the seabeach amaranth included 31 counties in nine states from Nantucket, MA to Charleston, SC (USFWS 1992). Fifteen populations from six states (Massachusetts, Rhode Island, New Jersey, Delaware, Maryland, and Virginia) are now extinct. Currently, extant populations are known to occur in New York (13), North Carolina (34), and South Carolina (8). Of the 55 populations remaining in these states, 50% are located on federal/state/municipal lands and 50% on private lands (Beacham 1994). The only remaining large populations of *Amaranthus pumilus* are in North Carolina, with populations distributed in Currituck (1), Dare (3), Hyde (2), Carteret (10), Onslow (3), Pender (4), New Hanover (6), and Brunswick (11) counties (USFWS 1992; Amoroso 2002; Pardue 2002). At least 68%, or 23 of the 34 populations, potentially occur in the study area (Figure 3-1). Most of the largest remaining North Carolina populations are located on publicly owned land, including Cape Hatteras and Cape Lookout National Seashores and Pea Island National Wildlife Refuge (Weakley et al. 1996; Cape Lookout National Seashore 2001). The continued presence of seabeach amaranth in North Carolina and in part of South Carolina is due to the lack of seawalls. Widespread use of seawalls and hard stabilization structures were apparently associated with the extirpation of this species in the other states (USFWS 1993).

Life History**—**Flowering of the seabeach amaranth begins as soon as the plants have reached sufficient size, sometimes as early as June in North Carolina, but more typically commencing in July and continuing until the death of the plant in late fall or early winter (Beacham 1994). Seed production begins in July or August, reaching a peak in September during most years, but usually continues until the plant dies (Weakley et al. 1996). Weather and other natural events, such as rainfall, hurricanes (e.g., Hugo in 1989, Bertha/Fran in 1996, Bonnie in 1998, and Dennis/Floyd in 1999), temperature extremes (e.g., severe northeasters in the winter of 1989-1990), and predation by webworms (e.g., moderate to severe in 1987 and 1988) had strong effects on the length of the seabeach amaranth's reproductive season (USFWS 1993). Due to Hurricane Hugo, a 74% reduction in amaranth numbers occurred in North Carolina from 1988 to 1990 (41,851 plants to 10,898 plants, respectively; Pardue 2002). As a result of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July. Under favorable conditions, the reproductive season may extend until January or sometimes later in the south (USFWS 2002). Based on the morphology of the flower and inflorescence, seabeach amaranth is probably wind-pollinated (Weakley et al. 1996). Seeds may survive many years buried in the sand, germinating only when brought near the surface by severe storms and dispersed many miles by ocean currents. This may be the explanation for the reappearance of this species in areas (e.g., tiny stands in Delaware and Maryland) where it was seemingly absent in the recent past (NatureServe 2001).

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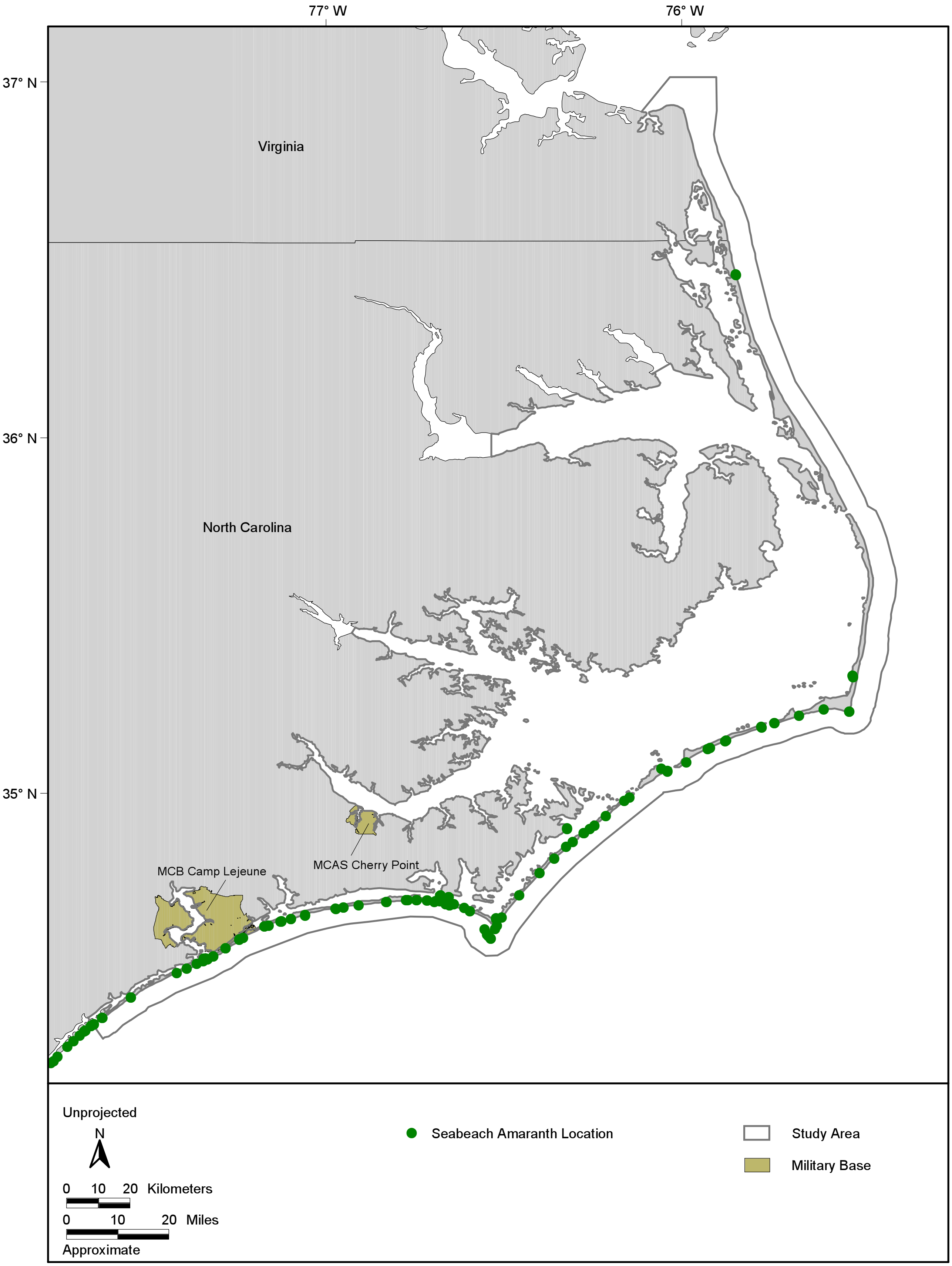

Figure 3-1. Distribution of the seabeach amaranth in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NOS (2001) and NCNHP (2002).

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3.2 FISHES/INVERTEBRATES

Numerous fishes and invertebrates of ecological and economical value inhabit the Cherry Point and southern VACAPES inshore and estuarine areas. The fishes include both pelagic and demersal species, while the invertebrates are represented by crustaceans (e.g., shrimp) and mollusks (e.g., squids, clams, oysters, mussels, and scallops). At some point in their development, these organisms utilize the various habitats found within the study area for all or only one of their life history stages (e.g., egg, larvae, juvenile, and/or adult). Most of the fish species migrate seasonally, with cold-temperate species present in winter and warm-temperate/subtropical species present in summer (Musick et al. 1985).

3.2.1 General Overview

The fish fauna in the study area is diverse, with more than 685 fish species representing 149 families (Schwartz 1989). In addition, there are at least 13 invertebrate species of commercial and/or recreational importance found in the shallow coastal waters and adjoining estuarine systems (Nelson et al. 1991; Stone et al. 1994). Of all the fishes and invertebrates in the study area, only one species, the shortnose sturgeon (*Acipenser brevirostrum*), is listed as endangered under the Endangered Species Act (ESA), while 74 fish and invertebrate species have essential fish habitat (EFH) designations under the Sustainable Fisheries Act (SFA). These species are federally managed by the New England Fishery Management Council/Mid-Atlantic Fishery Management Council (16 temperate water/northeast species), South Atlantic Fishery Management Council (47 subtropical-tropical water/southeast species), and National Marine Fisheries Service (NMFS) (11 highly migratory species: tunas, billfishes, and sharks). Within the study area, EFH-habitat area of particular concern (HAPC) has been identified for more than half (67%) of the EFH species/complexes, including the summer flounder, sandbar shark, red drum, penaeid shrimp (3 species), coastal migratory pelagic complex (6 species), and snapper-grouper complex (38 species) (Appendix B) (SAFMC 1998; NMFS 1999).

3.2.1.1 Ichthyofaunal Ecology

The study area is situated in an area that is composed of two distinct faunas, temperate (northern) and subtropical/tropical (southern), with Cape Hatteras as the transition point. Distribution of the ichthyofaunal community along the east coast of the U.S. is highly variable and dynamic due to seasonal/climatic changes, varying life history strategies, hydrographic phenomena, fishing pressure, and natural cycles of abundance (Briggs 1974). Although a species of fish may be representative of a particular faunal group that is considered typical, individuals of that species may be found within another faunal group range as well. As might be expected, most fish species in the study area are associated with the subtropical/tropical (southern) fauna (attributable to the effects of the Gulf Stream), while fish species associated with the temperate (northern) fauna make a lesser contribution (attributable to their southern range limits) (Table 3-1; Vernberg and Vernberg 1970; Schwartz 1989). The high concentration of migratory species (75%) in this area is due to the extensive migrations of both faunas as they follow temperature gradients (Olney and Bilkovic 1998).

The dynamic interplay of cold currents from the north and the warm Gulf Stream current from the south also has profound effects on the fish fauna of the study area. Population structure, local movements, and regional migrations of many species are the result of seasonal variations in water temperature and current patterns (Schwartz 1989). Fish species move in and out of the study area during the year based on their thermal tolerances and other environmental variables.

Wind and buoyancy are the principle agents driving the transport of ichthyoplankton and invertebrates utilizing the nearshore, mid-shelf, and Gulf Stream fronts on the continental shelf in the Middle Atlantic and South Atlantic bights (Epifanio and Garvine 2001). Because many marine fish species spawn in the coastal zone of the Chesapeake Bay region, year-class success often depends on critical wind direction and the influence of an oceanic water mass (slope water) on the shelf edge adjacent to the bay which transports larval invertebrates and fish into the bay (Murdy et al. 1997). In the vicinity of Cape Hatteras, larval distributions are affected by interactions between the Gulf Stream and other shelf water masses

Table 3-1. Groupings of fishes found in the Cherry Point and southern VACAPES inshore and estuarine areas.

	Number of Species	Percentage
Faunal Component		
Temperate (Northern)	127	18.5
Subtropical/Tropical (Southern)	559	81.5
Depth Distribution		
Estuaries	44	6.4
Continental Shelf	518	75.5
Deep Ocean	124	18.1
Habitat Preference		
Pelagic	173	25.2
Benthic	513	74.8
Mud	151	29.4
Sand	242	47.2
Reef	119	23.2
Sponge	1	0.2
Residency Type		
Resident	100	14.6
Migrant	518	75.6
Unknown	67	9.8
Estuarine Dependent	216	NA
Migration Strategy		
North / South	419	61.1
Onshore / Offshore	72	10.5
Vertical	14	2.0
Local Short Distance	45	6.6
Freshwater Intruder	38	5.5
Unknown	98	14.3

NA = Not Available
Source: adapted from Schwartz 1989

(Grothues et al. 2002). Lower recruitment of fish spawned in the southern Middle Atlantic Bight may result from the loss of shelf water in the vicinity of Cape Hatteras (Hare et al. 2001). The intrusion of larvae from the warm Gulf Stream onto the continental shelf is evident in various studies conducted in Onslow Bay, where it was reported that coastal water stations had low ichthyoplankton densities/diversity compared to the open shelf stations. The coastal water stations were dominated by estuarine-dependent species (e.g., Atlantic menhaden and spot), while the open shelf stations were dominated by reef-associated species (e.g., wrasses, gobies, grunts, triggerfish, and jacks) (Powell and Robbins 1994, 1998). It has also been reported that the effect of tides on the transport of larvae may be important in the immediate vicinity of estuaries and inlets (Epifanio and Garvine 2001).

3.2.1.2 Biodiversity/Species Composition

Of the 149 fish families occurring in the study area, the ten most dominant are the sea basses (Serranidae), jacks (Carangidae), gobies (Gobiidae), left-eyed flounders (Bothidae), drums and croakers (Sciaenidae), sea robins (Triglidae), wrasses (Labridae), requiem sharks (Carcharhinidae), herrings (Clupeidae), and snappers (Lutjanidae) (Schwartz 1989). These and the other families can be divided into ecological groups using parameters such as depth distribution and habitat preference (Table 3-1).

Both the demersal and pelagic fish communities have their highest diversity in September and lowest diversity in late winter (February/March) (Colvocoresses and Musick 1984; Musick et al. 1985; Phoel 1985). The study area is an important foraging and spawning ground for a wide variety of fishes. In winter, the fauna is dominated by boreal species (e.g, hakes, monkfish, and spiny dogfish) and in the summer by warm temperate/sub-tropical species (e.g., summer flounder, croakers, drums, sea basses, Atlantic menhaden, and large coastal sharks). In spring and fall, this area is an important migration corridor for striped bass and bluefish (Musick 1998).

3.2.1.3 Habitats

Coastal areas provide various environments (e.g., surf zone, rubble structures, coral patches, live/hard bottoms, shipwrecks, and artificial reefs) for a wide variety of demersal and pelagic fishes that occur adjacent to the southern Virginia mainland beach from Cape Henry south to beyond the barrier islands (Outer Banks) and along the entire length of the North Carolina coast (Newton et al. 1971; Steimle and Zetlin 2000).

Shallow surf zone habitats, which are characterized by low species diversity, serve as nursery areas (or, in certain cases, a year-round habitat) and are numerically dominated by a few species, either planktivores (e.g., rough silversides and striped anchovy), benthic invertivores (e.g., Florida pompano and gulf kingfish), or benthic omnivores/detritivores (e.g., white mullet) (Layman 2000; Ross and Lancaster 2002). The surf zone fish community above Cape Hatteras is strongly influenced by the proximity of Chesapeake Bay, while below Cape Hatteras the community is influenced by the Gulf Stream (Monteiro-Neto 1990).

The species composition of fishes found on shallow rubble structures is similar to the community composition on natural (coral patches and live/hard bottoms) and artificial (shipwrecks and artificial reefs) habitats that occur offshore and on inshore oyster beds (Lindquist at el. 1985). Inshore rubble structures have lower species diversity and often harbor high densities of young fishes that typically live on offshore reefs as adults (Hay and Sutherland 1988). Fishes colonizing these areas include year-round residents (e.g., blennies and gobies), dominants (e.g., pinfish, spottail pinfish, black sea bass, and pigfish), large predatory species (e.g., bluefish, Spanish mackerel, and smooth dogfish), and various tropical fishes (e.g., butterflyfishes and surgeonfishes) (Hay and Sutherland 1988).

Although true coral reefs do not exist off North Carolina, fishes that are typically associated with coral reefs ("reef fishes") are well represented in the study area (Huntsman and Manooch 1978; Grimes et al. 1982; Chester et al. 1984; Huntsman and Willis 1989; Lindquist 1989). Most of the continental shelf off North Carolina is relatively featureless (Newton et al. 1971), yet occasional patches of structural complexity exist that attract reef fishes (Menzies et al. 1966; Parker and Ross 1986). Some of these sections of habitat relief are natural, such as coral patches, rocks, or clusters of invertebrates. More significantly, however, is the tremendous number of artificial habitats, most notably shipwrecks, on the ocean floor off North Carolina (Steimle and Zetlin 2000). The combination of habitat complexity, warm water from the Gulf Stream and pelagic larvae of coral-associated fishes (Leis 1991) results in significant assemblages of reef fishes (e.g., gray triggerfish, black grouper, and amberjack) in the study area (Struhsaker 1969; Miller and Richards 1980; Parker et al. 1983; Parker 1990; Parker and Mays 1998). The reef fish fauna of the North Carolina shelf is becoming more tropical (Parker and Dixon 1998), suggesting ecosystem changes may be more favorable to the dispersal of invasive species from more tropical populations (e.g., Indo-Pacific lionfish; Whitfield et al. 2002).

Both the inshore waters of Chesapeake Bay and North Carolina shallow estuaries and sounds (Albemarle, Currituck, Croatan, Pamlico, Core, Back, and Bogue) function as nursery areas, feeding grounds, and havens from predation for many species of fishes (Schwartz 1989; Murdy et al. 1997). Although most of Chesapeake Bay is not in the study area, it plays an important role in fish composition and habitat utilization.

The fish fauna of Chesapeake Bay, consisting of freshwater, estuarine, marine, anadromous (e.g., clupeids and striped bass), and catadromous (e.g., American eel) species, is dynamic due to the extreme seasonal temperature changes and the diversity of habitats. Fish diversity reaches a maximum in late summer and early autumn (August to September) with rare tropical species joining warm-temperate and subtropical summer residents (Murdy et al. 1997). From late fall through winter, the fish community in the lower bay undergoes a seasonal transformation, being replaced by boreal demersal (e.g., hakes) and pelagic (e.g., Atlantic mackerel, Atlantic herring, and spiny dogfish) species. Anadromous species enter the lower bay to begin their upstream spawning migrations from late winter to early spring (February through March), with sciaenids and summer flounder following in late spring before the return of the summer warm-temperate/subtropical species (Freeman and Walford 1974, 1976; Murdy et al. 1997).

The nekton of the North Carolina sounds and adjacent estuarine rivers includes anadromous, catadromous, migratory, and indigenous species. Dominating the anadromous fish population are river herrings (e.g., blueback herring and alewife in the Pamlico/Albemarle sounds and Neuse River) and striped bass (in Albemarle Sound). Catadromous species are represented by the American eel in the Pamlico/Albemarle sounds and Pamlico/Neuse rivers (Hester and Copeland 1975; Copeland et al. 1983, 1984; Nelson et al. 1991). Migratory species that occur in the inshore/offshore areas utilize these large semi-enclosed estuarine systems during only a portion of their life cycle. After spawning, larvae of migratory species enter the sounds through inlets in the barrier islands where they selectively occupy shallow, productive nursery areas (tidal flats, salt marshes, oyster beds, and submerged aquatic vegetation [SAV]). The young remain in the estuarine nursery zone through most of the summer before they migrate in the fall to offshore areas to winter or spawn (Schwartz 1989). Dominant migratory species found in the Albemarle/Pamlico/Bogue sounds and Pamlico/Neuse/New rivers include spot, Atlantic croaker, Atlantic menhaden, southern flounder, brown shrimp (except in Albemarle Sound), and blue crab. The most prominent indigenous species in all the above-listed sounds/rivers is the bay anchovy (*Anchoa mitchilli*) along with the abundant grass shrimp (*Palaemonetes pugio,* except in the Albemarle Sound) (Hester and Copeland 1975; Copeland et al. 1983, 1984; Nelson et al. 1991). Most of the dominant migratory and indigenous species found in the Albemarle/Pamlico estuarine system have been reported as occurring in the lagoonal areas behind the Virginia barrier islands north of the study area (Richards and Castagna 1970; Norcross and Hata 1990).

Of the different nekton inhabiting these large, shallow, estuarine systems, migratory species are the most numerous fish fauna occurring as young-of-the-year, reaching maximum abundance in spring through early summer (April through June), in contrast to a secondary peak during the winter which is made up primarily of freshwater and anadromous species (Ross and Epperly 1985). Both marine and freshwater species are abundant in North Carolina estuaries, but their densities are low (Schwartz 1998). A total of 118 marine species within 45 families, mostly juveniles or adults, occurring within these estuaries is carried upstream by late summer or fall marine intrusions (e.g., strong wind currents and tides). Similarly, 51 freshwater species within 14 families, many as larval or juvenile stages, are swept suddenly by freshwater inflows into nursery or marine habitats of the Carolinas (Schwartz 1998).

Tidal flats, salt marshes, oyster beds, and SAV are critical primary and secondary nursery areas within the large, shallow, estuarine systems of North Carolina for nekton species (SAFMC 1998). A total of 52,156.9 ha of coastal waters has been designated as either primary or secondary nursery areas. Within the study area, approximately 25,369.8 ha fall into these categories (primary: 7,081.8 ha and secondary: 18,267.3 ha) (Noble and Monroe 1991). Different studies have clearly demonstrated that these habitats serve as important nursery areas for larval/juvenile life stages of finfish, crustaceans, invertebrates of the dominant/abundant nekton community (paralichthid flounders, drums and croakers, mullets, penaeid shrimp, blue crab, bay scallops [SAV only], and gray snapper) associated with estuarine systems (Peterson and Peterson 1979; Olney and Boehlert 1988; Wiegert and Freeman 1990; Noble and Monroe 1991; SAFMC 1998; Harding and Mann 2001).

3.2.2 Threatened and Endangered Species

- Shortnose Sturgeon (*Acipenser brevirostrum)*

Description—The anadromous shortnose sturgeon, also known as the salmon sturgeon in the Carolinas, is a member of the family Acipenseridae (sturgeons) (NMFS 1998). This species 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; NatureServe 2001). 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 42 kg (Gilbert 1992; Rohde et al. 1994). The shortnose sturgeon is also easily confused with a related species, the Atlantic sturgeon (*Acipenser 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 in 1973. Under a 1974 government reorganization plan (38 Federal Register 41370), jurisdiction for the shortnose sturgeon was assumed by the NMFS (NMFS 1998).

Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication (Appendix II, issued by the U.S. Department of the Interior stated that shortnose sturgeons were "in peril…gone in most of the rivers of its former range [but] probably not as yet extinct" (NMFS 1998). Pollution, overharvesting in commercial fisheries (including bycatch in the shad fishery), and its closely related appearance to the commercially valuable Atlantic sturgeon, were listed as principal reasons for the species decline (NMFS 1998). Other risk factors include poaching (northern rivers), accidental introduction of exotic species, very low productivity, freshwater spawning and nursery areas destroyed or degraded due to human-caused dissolved oxygen reductions, contaminants (e.g., heavy metals, pesticides, and organochlorine compounds), siltation from dredging and bridge construction/demolition, and impingement on power plant cooling water intake screens, impoundment operations, and hydraulic dredging machines (NMFS 1998; Collins et al. 2000; Musick et al. 2000; NatureServe 2001).

Habitat Preferences—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 prefer 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).

Distribution—Historically, the range of the shortnose sturgeon extended along the Atlantic coast from Saint John River, New Brunswick, Canada to Indian River, FL (Gruchy and Parker 1980). Currently, the NMFS recognizes 19 distinct population segments (DPS) with one population occurring in each of the following riverine/estuarine areas: Saint John River, New Brunswick, Canada; Merrimack River, MA; Connecticut River, CT; Hudson River, NY; Delaware River, NY/DE; Chesapeake Bay/Potomac River, MD/VA; and Cape Fear River, NC; two populations in both the Penobscot River/Kennebec system, ME and the St. Marys/St. Johns rivers, FL; and four populations each in the Winah Bay/Santee and Cooper rivers/Ashepoo, Combahee, and Edisto Basin, SC and the Savannah/Ogeechee/Altamaha/Satilla rivers, GA (NMFS 1998; Musick et al. 2000). All populations from the Chesapeake Bay north are considered "northeast" while those south of Chesapeake Bay are considered "southeast" population segments (NMFS 1998).

- <u>Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas</u>—Within the study area, the first published account of the shortnose sturgeon in the Chesapeake system was an 1876 record from the Potomac River. Based on its occurrence north and south of

Chesapeake Bay, it was likely a resident of Chesapeake Bay and occupied all four major riverine estuaries of Virginia (Burkhead and Jenkins 1991). Other historical records support this observation by the reporting of this species 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). Currently, the shortnose sturgeon has been reported in the Maryland waters of upper Chesapeake Bay by commercial fisherman between January 1996 and January 2000. It has been determined that this species probably traverses the Chesapeake and Delaware Canal and may be a transient from the Delaware River where a well-documented population currently exists (Murdy et al. 1997; Welsh et al. 2002).

Besides the self-sustaining population in the Cape Fear River drainage, the status and distribution of the shortnose sturgeon in North Carolina has never been well known, although some populations have probably been recently extirpated (Collins et al. 2000). No data on population dynamics currently exist for the Albemarle Sound/Roanoke and Chowan rivers and the Pamlico Sound/Pamlico and Neuse rivers. Some of the historical information from the North, New, Neuse, and lower Chowan rivers, Beaufort, and nearshore ocean (Oregon Inlet) cannot be validated and may be misidentifications of Atlantic sturgeon (Ross et al. 1988; NMFS 1998). Counties within the study area where the shortnose sturgeon has been reported within the past 23 years include Currituck, Camden, Pasquotank, Dare, Hyde, Pamlico, Carteret, and Onslow counties (Figure 3-2) (LeGrand et al. 2001; NOS 2001; USFWS 2002).

Behavior and Life History—Migrational patterns of the shortnose sturgeon varies 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). 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).

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: 2 to 5 years, females: 6 years) growing faster than those in northern rivers (males: 10 to 11 years, females: 7 to 18 years) (Burkhead and Jenkins 1991). Channels with moderate flow (0.8 m/sec) are important for spawning in many rivers. The preferred spawning substrate mixture consists of gravel, rubble, and large boulders with little sand or silt (NMFS 1998). 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 (2-year intervals) than females (3 to 5-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 with feeding varying 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 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 has also been found that feeding activity of the shortnose sturgeon is greatly reduced with reduction in water temperature (Gilbert 1992).

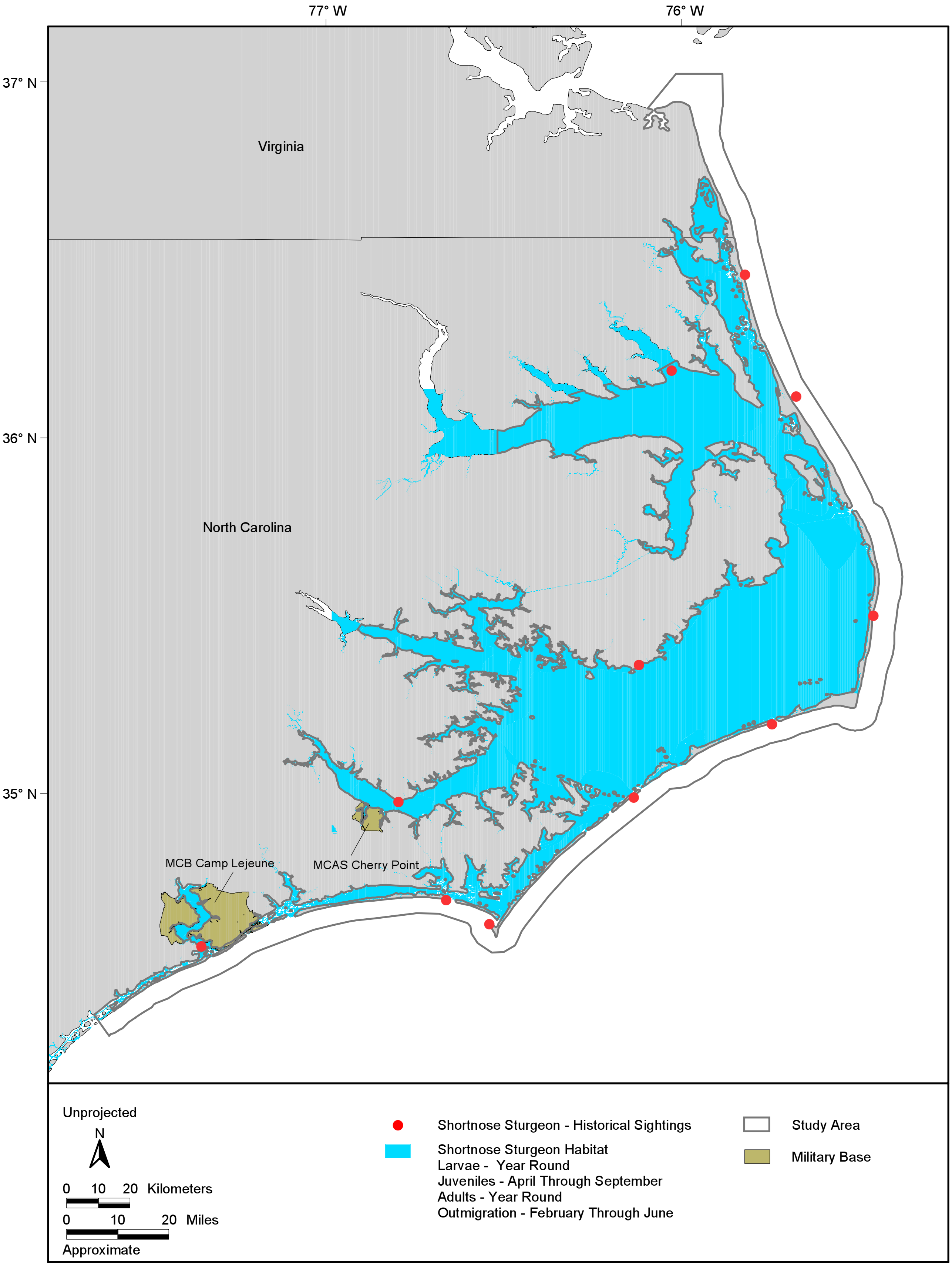

Figure 3-2. Distribution of the shortnose sturgeon in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NOS (2001) and NCNHP (2002). Map adapted from: NMFS (1998).

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). 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).

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3.3 REPTILES

3.3.1 Introduction

Reptiles are a highly diverse and abundant group of organisms, with over 8,000 extant species worldwide (EMBL 2002). Included in this class of animals are turtles, lizards, snakes, alligators, crocodiles, and the tuatara. Reptiles are ectothermic (cold-blooded) organisms, meaning that they regulate their body temperature behaviorally by exchanging heat with their surroundings. Additional distinguishing characteristics of these animals include external armoring (possession of horny epidermal scales or bony dermal plates), powerful jaws, internal egg fertilization, land-based egg laying and incubation, and respiration by lungs (Hickman and Roberts 1994). Several reptile species (including most turtles, some lizards, and all alligators, crocodiles, and tuataras) undergo a phenomenon known as temperature-dependent sex determination, where the animal's sex is determined thermally (i.e., by its incubation temperature) rather than genetically (Mrosovsky 1988; Hickman and Roberts 1994; Girondot 2000).

There are approximately 350 species of reptiles found in the terrestrial, freshwater, and marine ecosystems of the Unites States (U.S.) and Canada (Uetz 2000). Of that, 37 are listed as either threatened or endangered under the Endangered Species Act (ESA). There are six threatened and endangered reptiles, five sea turtle species and one alligator species, with potential occurrence in the Cherry Point and southern VACAPES inshore and estuarine areas (study area) (Table 3-2).

Table 3-2. Threatened and endangered reptiles found in the Cherry Point and southern VACAPES inshore and estuarine areas. Sea turtle taxonomy follows Pritchard (1997).

	Scientific Name	Status
Class Reptilia (reptiles)		
Order Testudines (turtles)		
Suborder Cryptodira (hidden-necked turtles)		
Family Dermochelyidae (leatherback turtles)		
Leatherback turtle	*Dermochelys coriacea*	Endangered
Family Cheloniidae (hard-shelled sea turtles)		
Loggerhead turtle	*Caretta caretta*	Threatened
Green turtle	*Chelonia mydas*	Threatened[a]
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered
Hawksbill turtle	*Eretmochelys imbricata*	Endangered
Order Crocodilia (alligators and crocodiles)		
Family Alligatoridae		
American alligator	*Alligator mississippiensis*	Threatened[b]

[a] As a species, the green turtle is listed as threatened. However, the Florida and Mexican Pacific coast nesting populations are listed as endangered. It should be noted that not all greens found in the study area come from the Florida population.

[b] The American alligator is listed as threatened throughout its range due to its similarity in appearance to the American crocodile. Since the American crocodile is endangered, the government does not want hunters to confuse the two different types of animals.

3.3.2 Sea Turtles

Sea turtles are long-lived, air-breathing reptiles found throughout the world's tropical, subtropical, and temperate seas (CCC 1996). There are seven living species of sea turtles from two distinct families, the Cheloniidae (hard-shelled sea turtles) and the Dermochelyidae (leatherback sea turtle). Sea turtles in these families are distinguished from one another on the basis of their carapace (upper shell) structure. An important marine resource, sea turtles are of nutritional, economic, and existence (non-use) value to humans (Witherington and Frazer 2003). However, over the last few centuries, sea turtle populations throughout the world have declined dramatically as a result of anthropogenic activities such as coastal development, oil exploration, commercial fishing, marine-based recreation, pollution, and over-harvesting (NRC 1990; Eckert 1995).

Sea turtles are highly adapted for life in the marine environment. They are unlike terrestrial and freshwater turtles in that they possess powerful, modified forelimbs (flippers) that enable them to swim continuously for extended periods of time (Wyneken 1997). Sea turtles have also developed a compact and streamlined body plan that helps to reduce drag while underwater. Additionally, sea turtles have evolved physiological traits and behavioral patterns that allow them to spend as little as 3% to 6% of their time at the water's surface, permitting highly efficient foraging and traveling (Lutcavage and Lutz 1997). Sea turtles often travel thousands of miles between their nesting beaches, mating areas, nursery habitats, developmental habitats, and adult feeding grounds, migratory activities which would not be possible without the aforementioned suite of adaptations (Ernst et al. 1994; Meylan 1995). The traits and behaviors of sea turtles also help to protect them from predation. Sea turtles armor themselves physically by developing a tough outer shell and growing to a large size as adults (Ernst et al. 1994). Mature leatherback turtles can weigh up to 450 kilograms (kg). Growing to a large size as adults is important because sea turtles cannot withdraw their head or limbs into their shell. As young individuals (i.e., post-hatchlings and juveniles), sea turtles will evade predation behaviorally by residing in habitats that are either structurally complex or moderately shallow, where predators such as sharks, marine crocodiles, and large fishes do not have easy access (Musick and Limpus 1997).

Although they are specialized for life at sea, sea turtles begin their lives on land. Aside from this brief terrestrial period, which lasts approximately three months as an egg and an additional few minutes to a few hours as a hatchling scrambling to the surf, sea turtles are rarely encountered out of the water. Sea turtles return to land primarily to nest, although certain species in Hawaii return in order to bask while others throughout the world return if injured (Spotila et al. 1997). These activities are infrequent yet often vital to the continued existence of a sea turtle (Musick and Limpus 1997). Sea turtles observed on land are most often females since males are not involved in the nesting process and likely gain fewer benefits from basking on land than females (Spotila et al. 1997). Scientists have determined that females bask not only to thermoregulate and elude predators, but also to avoid harmful mating encounters with male turtles and possibly to accelerate the development of their eggs (Spotila et al. 1997).

Female sea turtles nest in tropical, subtropical, and warm-temperate latitudes, often in the same region where they were born (Miller 1997). Upon selecting a suitable nesting beach, female sea turtles tend to re-nest in relatively close proximity during subsequent nesting attempts. Some sea turtles, however, fail to nest when emerging from the ocean. Non-nesting emergences, also known as false crawls, occur when sea turtles are either obstructed from laying their eggs (by debris, rocks, or roots) or distracted by conditions on the nesting beach (such as noise, lighting, or human presence). Female sea turtles that are successful at nesting usually lay several clutches of eggs during a nesting season, with each clutch containing between 50 and 200 eggs depending upon the species (Witzell 1983; Dodd 1988; Hirth 1997). Most females, with the possible exception of Kemp's ridleys, do not nest in consecutive years; instead they will often skip two or three years before returning (Márquez-M. 1994; Ehrhart 1995). Nesting success is vital to the long-term existence of sea turtles, as roughly only one in every 1,000 sea turtle hatchlings survives long enough to reproduce (Frazer 1986).

During the nesting season, daytime temperatures on tropical, subtropical, and warm-temperate beaches can be lethal. As a result, adult sea turtles often nest and hatchlings often emerge from their nest at night (Miller 1997). After emerging from the nest, sea turtle hatchlings use visual cues (e.g., light intensity or certain wavelengths of light) to orient themselves towards the sea (Lohmann et al. 1997). Hatchlings have a strong tendency to crawl in the direction of the brightest light, which on most beaches is towards the ocean/sky horizon (Ernst et al. 1994). Some hatchlings, however, never make it into the water. On the beach, sea turtle hatchlings are easy prey for seabirds during the day, and scavenging crabs and mammals at night (Ehrhart 1995; Miller 1997). Hatchlings can also suffer the effects of disorientation if artificial beachfront lighting appears brighter than the seaward horizon (Lutcavage et al. 1997).

Those hatchlings that do make it into the water will spend the first few years of their lives in oceanic waters, drifting in convergence zones and *Sargassum* rafts where they find refuge and food (mostly pelagic invertebrates) in items that accumulate in surface circulation features (Carr 1987). Originally labeled the "lost year," this stage in a sea turtle's life history is now known to be much longer in duration, possibly lasting 10 years or more (Chaloupka and Musick 1997; Bjorndal et al. 2000). Post-hatchling sea turtles spend nearly a decade growing in the pelagic "early juvenile nursery habitat" before migrating to distant feeding grounds, which are known as the "later juvenile developmental habitat" (Musick and Limpus 1997; Eckert and Abreu-Grobois 2001). Shallow nearshore and inshore waters represent the later juvenile developmental habitat most often utilized by hard-shelled sea turtles (Eckert and Abreu-Grobois 2001). For leatherback turtles, however, the later developmental habitat can be either a coastal feeding area in temperate waters or an offshore feeding area in tropical waters depending upon the season (Eckert and Abreu-Grobois 2001).

Once in the later juvenile developmental habitat, most sea turtles modify their foraging behavior from surface to benthic feeding, and will begin to feed upon larger items such as crustaceans, mollusks, sponges, coelenterates, fishes, and seagrasses (depending upon the species) (Bjorndal 1997). An exception is the leatherback turtle, which will feed on pelagic soft-bodied invertebrates at both the surface and at great depths (S. Eckert et al. 1989). Sea turtles do not have teeth, but their jaws have modified "beaks" suited to their particular diet (Mortimer 1995). The diet exhibited by a sea turtle varies according to the habitat in which it feeds and its preferred prey. Sea turtles undergo complex seasonal movements, which are influenced by changes in ocean currents, turbidity, salinity, and food availability (Musick and Limpus 1997). Sea turtles possess a specialized digestive system so that a diverse array of food items can be consumed (Mortimer 1995).

In addition to the above factors, the distribution of many sea turtle species is dependent upon (and often restricted by) water temperature (Lutcavage and Musick 1985; Epperly et al. 1995a; Coles and Musick 2000). Most sea turtles become lethargic at temperatures below 10°C and above 40°C (Spotila et al. 1997). Coles and Musick (2000) observed that the range of each species' preferred water temperature regulates sea turtle distribution. The normal range of sea surface temperatures (SST) that sea turtles prefer is from 13.3° to 28°C (Coles and Musick 2000). Sea turtles' preferred temperature ranges vary across age classes and species as well as seasons. As a species, leatherback turtles have a much wider range of preferred temperatures than other species because they can maintain warm body temperatures in temperate waters and can avoid overheating in tropical waters (Spotila et al. 1997).

Although sea turtles are nearsighted out of water, their vision underwater is very good. Their sense of smell is also very keen (Ernst et al. 1994); a sea turtle likely uses olfaction in conjunction with sight during foraging. Sea turtle hearing sensitivity is not well studied. Reception of sound through bone conduction, with the skull and shell acting as receiving structures, is hypothesized to occur in some sea turtle species (Lenhardt et al. 1983). A few preliminary investigations using adult green, loggerhead, and Kemp's ridley turtles suggest that they are most sensitive to low-frequency sounds (Ridgway et al. 1969; Lenhardt et al. 1983; Bartol et al. 1999). An anecdotal observation of a leatherback's response to the sound of a boat motor suggests that leatherbacks may be sensitive to low-frequency sounds, but the response could have been to mid- or high-frequency components of the sound (ARPA 1995).

The range of maximum sensitivity for sea turtles is 100 to 800 Hertz (Hz), with an upper limit of about 2,000 Hz (Lenhardt 1994). Hearing below 80 Hz is less sensitive but still potentially usable to the animal (Lenhardt 1994). Green turtles are most sensitive to sounds between 200 and 700 Hz, with peak sensitivity at 300 to 400 Hz. They possess an overall hearing range of approximately 100 to 1,000 Hz (Ridgway et al. 1969). Bartol et al. (1999) reported that juvenile loggerhead turtles hear sounds between 250 and 1,000 Hz; however, O'Hara and Wilcox (1990) found that they would often avoid sources of low-frequency sound. Finally, sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 decibels with a reference pressure of one micropascal at one meter (dB re 1 µPa-m) (Lenhardt 1994). In terms of sound emission, nesting leatherback turtles produce sounds in the 300 to 500 Hz range (Mrosovksy 1972).

For more information on the biology, life history, and conservation of sea turtles, the following organizations' websites are extremely useful: the Archie Carr Center for Sea Turtle Research (http://accstr.ufl.edu/index.html), the Caribbean Conservation Corporation (http://www.cccturtle.org), and seaturtle.org (http://www.seaturtle.org). Other important resources include Proceedings from the Annual Symposium on Sea Turtle Biology and Conservation, Bjorndal (1995), Lutz and Musick (1997), and Lutz et al. (2003).

3.3.2.1 Sea Turtles of the Cherry Point and Southern VACAPES Inshore and Estuarine Areas

Of the seven living species of sea turtle, five have been documented to occur in the study area. These include the leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and hawksbill (*Eretmochelys imbricata*) turtles (Table 3-2). All five species are protected under the ESA. The Kemp's ridley, hawksbill, and leatherback turtles are listed as endangered, while the loggerhead turtle is listed as threatened. As a species, the green turtle is also listed as threatened although specific nesting populations are currently listed as endangered. Green turtles found along the east coast of the U.S. are likely a mix of offspring from both threatened and endangered nesting populations in the western North Atlantic Ocean (Bass and Witzell 2000).

The temperate inshore and nearshore waters of North Carolina and southern Virginia host a large number of sea turtles throughout much of the year, most of which are immature individuals (Lee and Palmer 1981; Lutcavage and Musick 1985; Keinath et al. 1987, 1996; Byles 1988; Barnard et al. 1989; Schwartz 1989; Epperly et al. 1995a, 1995b, 1995c). However, as a result of commercial harvesting, incidental fisheries bycatch, and countless other factors, sea turtles inhabiting the waters of these two states are much less abundant today than they were hundreds of years ago (Epperly et al. 1995b).

Due to the narrowness of North Carolina's continental shelf near Cape Hatteras (and its close association with the western wall of the Gulf Stream), sea turtles are often concentrated in the shallow, nearshore waters of the study area (Epperly et al. 1995c; Keinath et al. 1996). The inshore and estuarine waters of the study area are an extremely important developmental habitat for juvenile loggerhead, green, and Kemp's ridley turtles (Epperly et al. 1995a). Juveniles frequent the inshore and coastal waters of North Carolina and southern Virginia throughout much of the year, as both states possess vast systems of sounds, bays, and estuaries that boast extensive beds of submerged aquatic vegetation (SAV) and a rich diversity of bottom-dwelling fauna (Keinath et al. 1996; Boettcher 1998). Habitats such as these provide growing juveniles with sufficient cover and forage needed for survival. The waters of the study area are also utilized on a seasonal basis (during spring and fall) by non-resident sea turtles that are in transit to and from more northerly foraging habitats such as Long Island Sound and Cape Cod Bay (Keinath et al. 1996). In addition to serving as an important developmental and transitional habitat, the waters of the study area also provide a suitable long-term habitat for adult sea turtles that take up residency during the spring and summer months (Keinath et al. 1996). During these months, adults will gather en masse in the nearshore waters off North Carolina and southern Virginia in order to breed and prepare to nest (Schwartz 1989). After nesting on the study area's ocean-facing beaches, adult females will often forage in the region's protected sounds and bays before either nesting again or returning to more tropical waters (Mansfield 2000).

Along the U.S. Atlantic coast, nesting has been known to occur as early as February and as late as October, although the official nesting season (the time of year when the vast majority of nesting activity occurs) begins in May and ends in August (Meylan et al. 1995; Webster and Cook 2001). Adult sea turtles (primarily loggerheads, as well as a few greens and infrequent leatherbacks) most often visit the study area's ocean-facing beaches to nest in June and July, although North Carolina and southern Virginia are recognized as the northern limit of nesting activity for all three species (Schwartz 1989; Godfrey 2002). Although nesting is known to occur along the entire North Carolina coast (Figure 3-3), the highest levels of sea turtle nesting activity in the study area occur along Cape Lookout National Seashore and Onslow

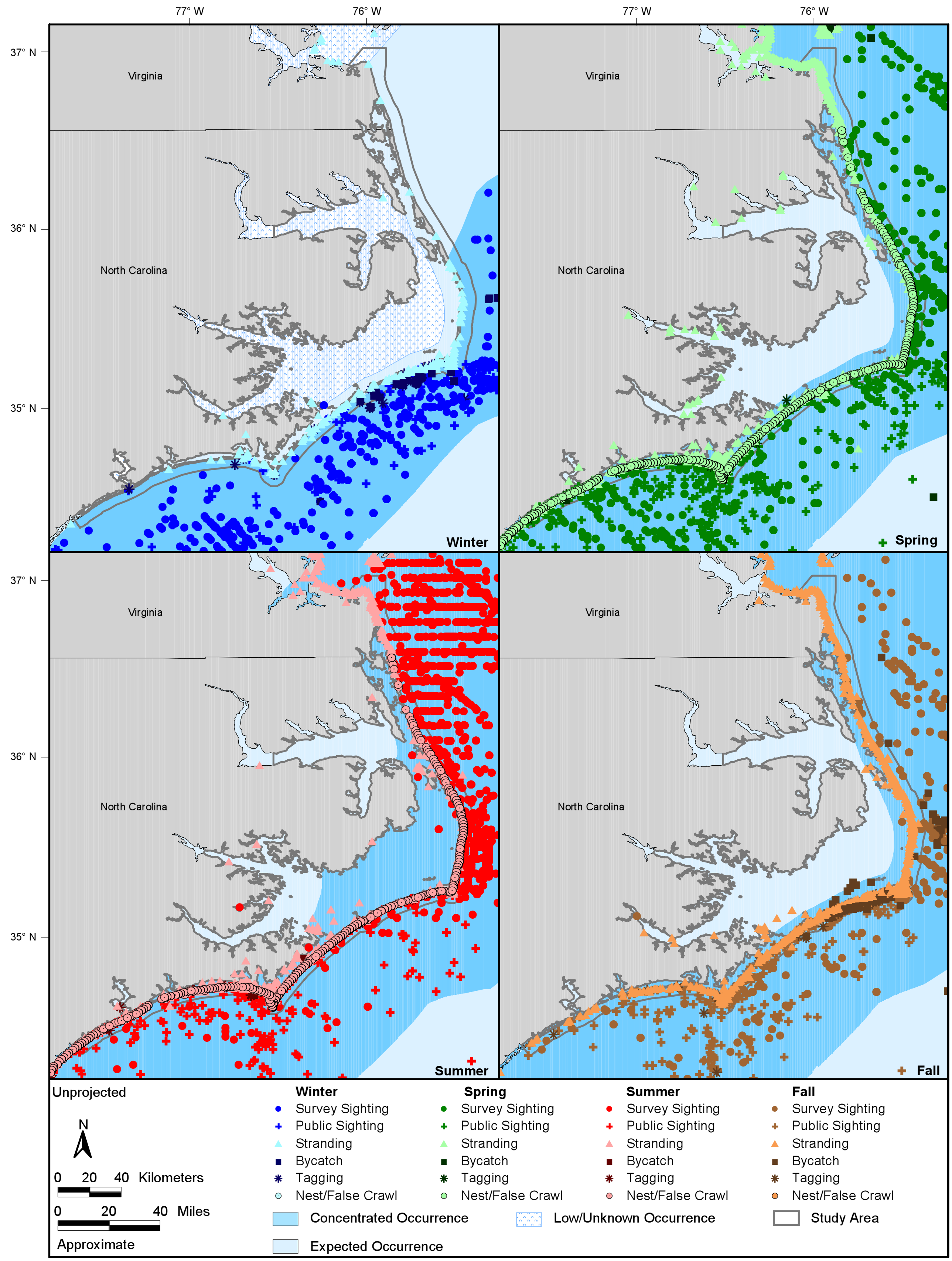

Figure 3-3. Occurrence of all sea turtles in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, incidental fisheries bycatch, tagging, and nesting records are represented by season. Source data: refer to Appendix A.

Beach (Hopkins and Richardson 1984; Schwartz 1989). In the late spring and summer of 2000, sea turtles produced a total of 190 nests and 13,471 viable hatchlings along the 90-km stretch of beaches at Cape Lookout National Seashore (NPS 2001). During that same year, an 11.3-km stretch of military-controlled land at Onslow Beach was home to 45 nests, from which 2,050 viable hatchlings emerged (USMC 2000). During the 2000 nesting season, most nesting events and false crawls on Onslow Beach took place on the northeast end of the beach, in very close proximity to MCB Camp Lejeune's N-1/BT-3 Impact Area (USMC 2000). As a result of the high level of nesting activity on Onslow Beach during the spring and summer months, military personnel have implemented an intensive sea turtle monitoring, nest relocation and protection program so that amphibious landings and other training activities can be conducted without impacting protected species (USMC 2002). Just offshore of Onslow Beach, adult sea turtles receive further protection as a result of the existence of a sea turtle sanctuary (Figure 3-4). Running from New River Inlet to Bogue Inlet, this sanctuary was established by North Carolina Fishery Laws in 1980 after researchers discovered that intense shrimp trawling coincided with high nesting activity along Onslow and Hammocks Beaches (Schwartz 1989). Under this law, shrimp trawling within the sanctuary was prohibited between June 1 and August 31 unless permitted by the North Carolina Fisheries Director, who was given the right to modify the sanctuary within the described area and vary implementation between specified dates depending upon the existing environmental conditions (Godfrey 2003). Benthic-feeding sea turtles are extremely susceptible to bycatch in bottom trawl fisheries, and as such, the state government took steps to ensure that sea turtles inhabiting the waters of the sanctuary will have an opportunity to forage, mate, and reproduce with little to no bottom trawl fishery interaction.

In North Carolina, sea turtles are found in inshore waters primarily from April through December, while in Chesapeake Bay they most often occur between May and November (Epperly et al 1995b). As inshore waters begin to cool in the fall, sea turtles will often move offshore towards the Gulf Stream or migrate to waters south of Cape Hatteras, where water temperatures are much warmer (Schwartz 1989). Sea turtles that fail to vacate temperate inshore waters become susceptible to cold stunning, a type of hypothermia that occurs when water temperatures drop quickly (Spotila et al. 1997). Only when waters warm again in the spring do sea turtles begin to migrate back north and inshore. Aerial surveys for sea turtles over Core and Pamlico Sounds have indicated a pattern of spring immigration into the sounds of the study area, a summertime dispersal throughout the sounds, and an emigration out of the sounds in the late fall and early winter (Epperly et al. 1995a). The coastal area immediately adjacent to Cape Hatteras has long been recognized as a migratory pathway for leatherbacks, loggerheads, and Kemp's ridleys (Lee and Palmer 1981; NRDC 2000). Spring and fall migration activities tend to increase North Carolina coastal sea turtle abundance to levels that exceed summer "resident" populations (Keinath et al. 1996).

The distribution of available sea turtle occurrence records by season (winter=January through March; spring=April through June; summer=July through September; fall=October through December) is presented in Figure 3-3. Occurrence records include survey sightings, public sightings, strandings, taggings, nesting attempts (including false crawls), and bycatch records within the study area and vicinity. It should be noted that the number of sea turtle records in a given season or portion of the study area is often as much a function of the source or type of data (bycatch data versus data collected by aerial or shipboard surveys), level of effort, and sighting conditions (such as calm seas) as the actual abundance of sea turtles at that time or in that area.

Unidentified sea turtles (individuals that could not be identified to species) account for a large number of occurrence records, particularly sightings. The hard-shelled sea turtles (loggerhead, green, Kemp's ridley, and hawksbill) are often difficult to distinguish to species, particularly when they are young (i.e., small size classes) and especially during aerial surveys. Sea turtles may respond to aircraft overflights and vessel approaches by making a quick dive, even before being sighted by observers, which makes not only sighting a sea turtle difficult but also confirming its identity to species (Kenney 2001). Of all sea turtle sightings recorded during an aerial survey program over North Carolina waters between 1991 and 1992, only identifications of leatherback turtles were assumed to be 100% reliable (McNeill 2002). Species identification is less reliable when the general public sights sea turtles. The reliability of species recognition may also be in question when sea turtles are recorded stranding or nesting, especially if qualified individuals are not present to make an accurate identification (Lund 1985; Godfrey 2002).

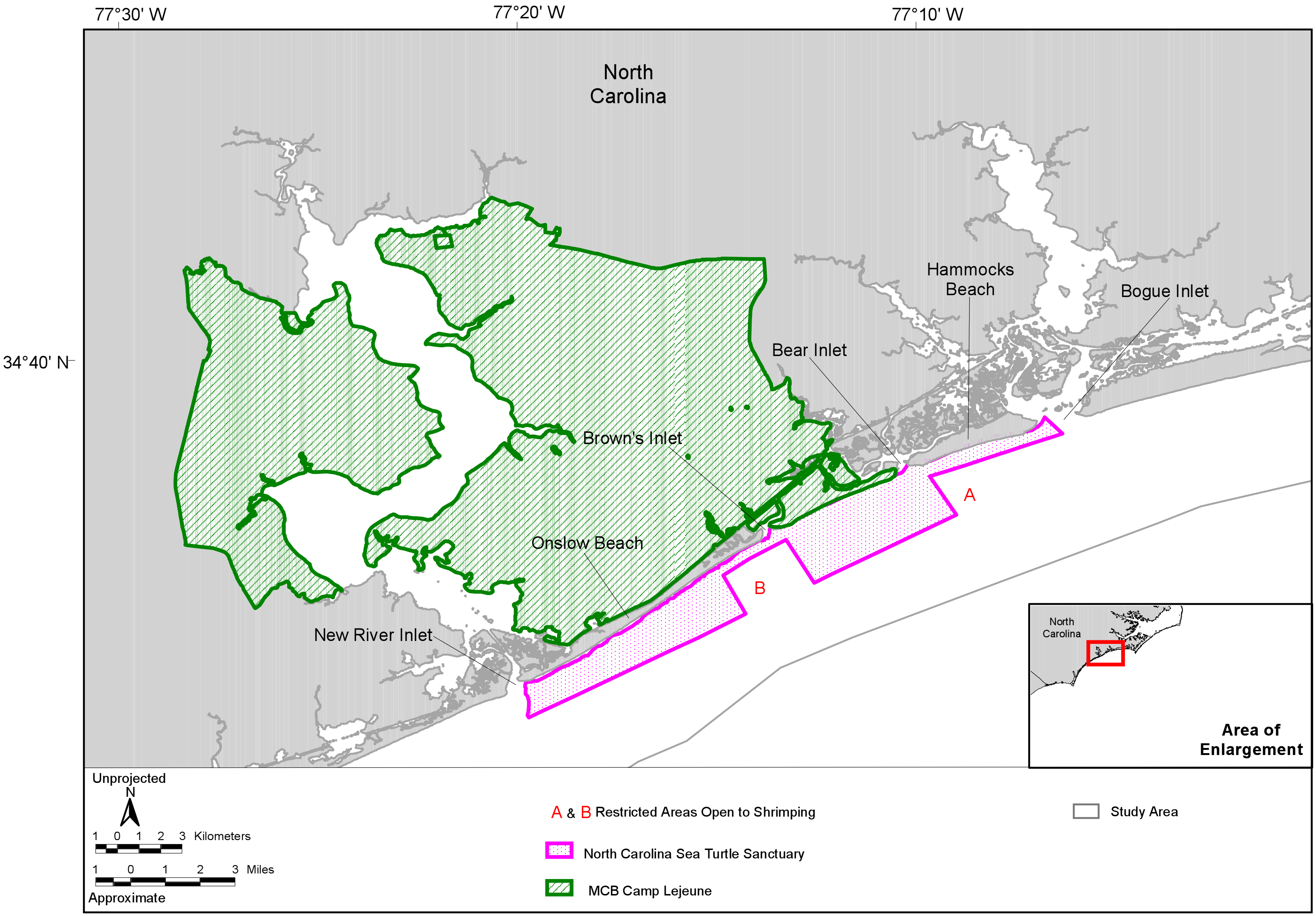

Figure 3-4. Location of a North Carolina sea turtle sanctuary within the Cherry Point and southern VACAPES inshore and estuarine areas. Map adapted from: Schwartz (1989).

During winter, sea turtle occurrence is concentrated in nearshore waters of the study area as far north as Oregon Inlet (Figure 3-3). Further north, ocean-side sightings, strandings, and bycatches become less and less prevalent. Sea turtle occurrence is concentrated in these waters due to the existence of favorable temperature and depth regimes along North Carolina's narrow shelf in winter, as the presence of the Gulf Stream helps to warm nearshore waters in the vicinity of Cape Hatteras (Epperly et al. 1995c). The narrowness of the continental shelf near Cape Hatteras and the potential influence of the Gulf Stream on these nearshore regions serve to concentrate sea turtles emigrating from the Mid-Atlantic Bight (MAB) and Pamlico and Core Sounds (Epperly et al. 1995c). It follows that the nearshore waters of Raleigh Bay, which are affected by the warm, fast-moving Gulf Stream more than any other waters in the South Atlantic Bight (SAB), house the highest concentrations of sea turtles during winter (Epperly et al. 1995c). Aside from the nearshore clustering of sea turtle sightings between Capes Hatteras and Lookout, sightings elsewhere on the continental shelf occurred much closer to the western edge of the Gulf Stream than to the coast. Sea turtles are known to prefer offshore waters in winter, since inshore and nearshore waters independent of the Gulf Stream can be cold enough to be lethal (Schwartz 1989; Epperly et al. 1995c). For this reason, sea turtle occurrence in inshore waters of the study area is only expected in those waters nearest to the ocean and is low/unknown in estuarine waters that are a good distance away from the Outer Banks. Winter occurrence is also low/unknown in all waters of Chesapeake Bay and in the nearshore waters north of the bay's eastern edge. It is hypothesized that sea turtles in nearshore and inshore waters can bruminate (bury themselves in the sediment to avoid cold temperatures) throughout the winter, although this phenomenon has only been seen in waters south of Cape Hatteras (Epperly et al. 1995a). The overall pattern of winter occurrence in the study area demonstrates the emigration of sea turtles from inshore waters between January and March, as water temperatures and prey availability are at their lowest during those months of the year (Epperly et al. 1995a, 1995c).

During spring, sea turtles are expected to occur in all waters of the study area, as evidenced by several strandings that occur as far inshore as the Neuse, Pamlico, Chowan, and James Rivers (Figure 3-3). The area of concentrated occurrence for sea turtles extends further north and inshore in the spring, encompassing all nearshore waters of the study area, North Carolina's inshore waters that were labeled as areas of expected occurrence in winter, and waters in the southern portion of Chesapeake Bay. It should be noted that spring sightings, taggings, and bycatches along the U.S. Atlantic coast are highly prevalent in continental shelf waters as far north as Delaware Bay (Kenney 2001). Sea turtles known to inhabit the nearshore waters of the study area in spring are loggerheads, greens, Kemp's ridleys, and leatherbacks, since nearshore waters are known to be acceptable habitats for both juveniles and adults of these species. As inshore and nearshore water temperatures increase from winter to spring, sea turtles begin to repopulate North Carolina and southern Virginia's shallow bays and estuaries from waters further offshore, although in early spring, sea turtles north of Cape Hatteras will still likely inhabit waters closer to the Gulf Stream, as water temperatures along the northern Outer Banks remain cool (Schwartz 1989). In late spring, sea turtles that annually spend their summers in feeding habitats north of the study area will begin to migrate along a 19-kilometer (km) wide corridor spanning the mid-Atlantic coast of the U.S. from Cape Hatteras to Cape May (NRDC 2000). The observation that sea turtle occurrences are extremely numerous in spring agrees with findings from past aerial survey and public sighting programs, in which a seasonal peak in density and abundance for western Atlantic sea turtles occurred between May and June (Epperly et al. 1995b; Keinath et al. 1996). The increase in sea turtle records during this season is a reflection of surface water temperatures and migration activity around Cape Hatteras beginning to increase (Keinath et al. 1996), but may also be due to survey and fishing effort beginning to increase due to better weather and calmer seas. The overall pattern of spring occurrence in the study area reflects the immigration of immature sea turtles into North Carolina and southern Virginia's sounds and bays and the gathering of mature sea turtles in these states' nearshore waters prior to and during the early part of the nesting season, which begins on the first of May (Epperly et al. 1995a; Webster and Cook 2001).

In the summer, sea turtle occurrence is concentrated in all nearshore ocean waters of the MAB and SAB (Kenney 2001), as water temperatures in these regions remain within the preferred range of sea turtles throughout this season. In the inshore waters of the study area, sea turtles are concentrated as far west as the areas where North Carolina and southern Virginia's major rivers feed into Pamlico and Albemarle Sounds and the Chesapeake Bay (Figure 3-3). The area of expected occurrence encompasses the downstream portions of those rivers due to several strandings that occur in those locations. The high number of very nearshore records for summer when compared to the other seasons demonstrates that most sea turtles prefer to inhabit feeding areas close to shore (such as Chesapeake Bay, Raleigh and Onslow Bays, and Pamlico and Core Sounds) at this time of year (Epperly et al. 1995a, 1995b; Keinath et al. 1996). The overall pattern of summer occurrence in the study area shows the dispersing of sea turtles throughout North Carolina and southern Virginia's warm inshore waters from July to September and the concurrent peak in adult female nesting activity that occurs during those months (Epperly et al. 1995a).

In the fall, the area of concentrated occurrence contracts southward and moves back towards the ocean, although it still encompasses all nearshore waters of the study area in addition to the same inshore waters labeled as areas of concentrated occurrence in spring (Figure 3-3). This is due not only to the numerous sightings that occur along the U.S. Atlantic coast as far north as Massachusetts, but also to the knowledge that sea turtles are following migration routes south along the coast during this time of year (Shoop and Kenney 1992; NRDC 2000). Keinath et al. (1996) note that loggerheads and Kemp's ridleys will often round Cape Hatteras on their way south in October and November. As in the early spring, late fall aggregations of sea turtles north of Cape Hatteras are most often found in offshore waters, while those south of Cape Hatteras are most often found in inshore and nearshore waters (again due to the thermal preferences of sea turtles). As in the spring and summer, all waters in the study area are designated as areas of expected occurrence. Although survey and fishing effort decreases from October to December, North Carolina's recreational fishermen have documented more sea turtle sightings in nearshore waters in the fall than in any other season (Epperly et al. 1995b). The overall pattern of fall occurrence in the study area indicates the onset of sea turtle emigration activity from North Carolina and southern Virginia's inshore waters as described in Epperly at al. (1995a) and Keinath et al. (1996).

A listing of data sources used to determine each species' occurrence in the study area is found in Appendix A, while the process used to create the map figures is described in Section 1.4.2.5. On the map figures, various types of shading and terminology designate the occurrence of sea turtles in the Cherry Point and southern VACAPES inshore and estuarine areas. "Expected occurrence" (area shaded in light blue) is defined as the area encompassing the expected distribution of a species based on what is known of its habitat preferences, life history, and the available sighting, stranding, incidental fisheries bycatch, and tagging data. "Concentrated occurrence" (area shaded in dark blue) is the subarea of a species' expected occurrence where there is the highest likelihood of encountering that species; the designation is based primarily on areas of concentrated sightings and preferred habitat. "Low/unknown occurrence" (pattern-filled area) is the area where the likelihood of encountering a species is rare or not known. "Occurrence not expected in study area" (white, unmarked area) is the area where a species encounter is not expected to occur.

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

- Leatherback Turtle (*Dermochelys coriacea*)

  Description—The leatherback is the largest living sea turtle. These sea turtles are placed in the family Dermochelyidae, a separate family from all other sea turtles, in part because of their unique carapace structure. A leatherback turtle's carapace lacks the outer layer of horny scutes possessed by all other sea turtles; it is instead composed of a flexible layer of dermal bones underlying tough, oily connective tissue and smooth skin. The body of a leatherback is barrel-shaped and tapered to the rear, with seven longitudinal dorsal ridges, and is almost completely black with variable spotting. All adults possess a unique spot on the dorsal surface of their head, a marking that can be used by scientists to identify specific individuals (McDonald and Dutton 1996). Adult carapace lengths range from 130 to 180 centimeters (cm) (NMFS and USFWS 1992), with a maximum of 256.5 cm (Ernst et al. 1994). Adult leatherbacks weigh between 200 and 700 kg (NMFS and USFWS 1992).

  Status—Leatherback turtles are classified as endangered under the ESA. There are an estimated 20,000 to 30,000 leatherbacks in the North Atlantic Ocean (Coren 2000). Nesting populations in southern Florida, Culebra, and the U.S. Virgin Islands are believed to be increasing due to heightened protection and monitoring of the nesting habitat over the past twenty years (Hillis-Starr et al. 1998; Fleming 2001; Thompson et al. 2001; FMRI 2002).

***Habitat Preferences*—**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). What is known is that these life stages are restricted to waters greater than 26°C and that they likely do not involve an association with *Sargassum*, as is the case for the other four sea turtle species found in continental U.S. waters (NMFS and USFWS 1992; Eckert 2002).

Late juvenile and adult leatherback turtles are known to range from mid-ocean to the continental shelf and nearshore waters (Schroeder and Thompson 1987; Shoop and Kenney 1992; Grant and Ferrell 1993; Epperly et al. 1995a, 1995b). Juvenile and adult foraging habitats include both coastal feeding areas in temperate waters and offshore feeding areas in tropical waters (Eckert and Abreu-Grobois 2001). The movements of adult leatherbacks appear to be linked to the seasonal availability of their prey and the requirements of their reproductive cycle (Collard 1990a; Davenport and Balazs 1991).

***Distribution*—**The leatherback turtle is distributed circumglobally in tropical and warm-temperate waters throughout the year and into cooler temperate waters during warmer months (Ernst et al. 1994). Leatherbacks in the North Atlantic Ocean are broadly distributed from the Caribbean region to as far north as Nova Scotia, Newfoundland, Labrador, Iceland, the British Isles, and Norway (Ernst et al. 1994). This species migrates further and moves into cold waters more than any other sea turtle species (Bleakney 1965; Lazell 1980; Shoop and Kenney 1992). This species is also the most oceanic and most wide-ranging of sea turtles, undertaking extensive migrations following depth contours for hundreds, even thousands, of kilometers (Morreale et al. 1996; Hughes et al. 1998). Using satellite telemetry, it has been determined that migrating leatherback turtles often use similar, and in some cases virtually identical, pathways or ocean corridors through which to travel (Morreale et al. 1996).

In the western North Atlantic, leatherbacks show strong seasonal distribution patterns and extensive migrations. Tag returns from individuals tagged at tropical nesting beaches have documented some of the longest migrations of any reptile (Meylan 1995). Female leatherbacks tagged in the U.S. Virgin Islands, Colombia, French Guiana, and Costa Rica have been found stranded along the Atlantic and Gulf coasts of the U.S. (Thompson et al. 2001). One leatherback caught in the Chesapeake Bay was tagged, released, and then caught again over a year later off southern Cuba, a minimum distance of 2,168 km (Keinath and Musick 1990). Tagging studies also indicate many variations in overwintering and onshore-offshore occurrence patterns (Lee and Palmer 1981). For example, a leatherback satellite-tagged on a Florida nesting beach traveled directly to the coast of Virginia after her last nest of the season; while there, she remained within 100 km of shore during her entire four-month stay (CCC 2002).

The seasonal occurrence of large subadult and adult leatherbacks off the east coasts of the U.S. and Canada appears to vary with latitude. Aerial surveys along the Atlantic coast of North America have allowed scientists to document the seasonal movements of these age classes. The survey data indicate that leatherback migration starts with the 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. However, by April and May leatherbacks begin to occur in large numbers off the coasts of Georgia and the Carolinas (NMFS 1995, 2000; Murphy 2002). In late spring/early summer, leatherbacks begin to appear off the mid-Atlantic and New England coasts, while by late summer/early fall, many will have traveled as far north as the waters off eastern Canada (CETAP 1982; Shoop and Kenney 1992; Thompson et al. 2001). Throughout the year, leatherbacks are the most abundant sea turtle species in western Atlantic waters north of Cape Cod (Shoop and Kenney 1992). The distribution and frequency of leatherback strandings along the U.S. Atlantic coast are highly correlated with the seasonal occurrence patterns of this species (Thompson et al. 2001; Wyneken and Epperly 2001). In North Carolina and southern Virginia, the leatherback turtle is abundant from mid-April through mid-October in relatively shallow waters (Lee and Palmer 1981; Keinath et al. 1996). The coastal area immediately adjacent to Cape Hatteras has long been recognized as a migratory pathway for leatherbacks (Lee and Palmer 1981).

As a result of the leatherback's wide-ranging occurrence in waters off the southeast U.S. coast during winter and spring, and the fact that this species is often incidentally captured by shallow- and deepwater commercial trawl fisheries, all inshore and offshore waters adjacent to the U.S. Atlantic coast between Cape Canaveral, FL and the North Carolina/Virginia border (within the U.S. EEZ) are designated as a Leatherback Conservation Zone (NMFS 1995). When leatherback sightings during aerial surveys exceed 10 individuals per 50 NM, as they often do between January and June, nearshore regions of the Leatherback Conservation Zone are closed to fishing activities (most notably shrimp trawling) for extended periods of time.

Leatherback nesting in the western North Atlantic is restricted to coarse-grained beaches in subtropical and tropical latitudes (NMFS and USFWS 1992). Nesting occurs along the coasts of South, Central, and North America from Brazil to Mexico and throughout the West Indies, with significant populations in French Guiana, Suriname, and Costa Rica (Ernst et al. 1994). Along the Atlantic coast of the U.S., leatherback turtles nest annually on beaches from southern Florida to Georgia (Ernst et al. 1994), with occasional records from the Carolinas (Murphy 2002). Once the nesting season is over, leatherbacks leave the waters adjacent to their nesting grounds for feeding grounds further north.

- Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas—Although the leatherback is the most oceanic sea turtle occurring in the study area, the occurrence data show that this species is often found in close proximity to the North Carolina and Virginia shores during spring and summer (Figure 3-5). However, throughout the year leatherbacks are rarely encountered in the inshore waters of the study area. Although the available sighting, stranding, bycatch, tagging, and nesting data demonstrate the pattern of north-to-south nearshore migration from winter to summer, they don't at all depict the pattern of east-to-west (offshore-to-inshore) migration which is typical of loggerhead, green, and Kemp's ridley turtles in this region. The highly variable occurrence patterns of leatherbacks from season to season distinguish them from the four other species with potential occurrence in the study area.

  During the winter, leatherback turtles are expected to occur in nearshore waters of the study area only as far north as the Gulf Stream boundary off the Outer Banks (Figure 3-5). North of this boundary is the area of low/unknown occurrence, where water temperatures are much cooler and prey availability is much less. Although the leatherback is physiologically capable of occurring in colder ocean waters north of Cape Hatteras, the majority of winter occurrences take place off the coast of Florida (Musick and Limpus 1997). The few sightings in winter compared to other seasons may also reflect survey conditions that are not favorable for sighting sea turtles. Since Chesapeake Bay and the Albemarle-Pamlico Estuarine Complex are very cold during winter (mean SST <17°C), and likely house very few jellyfish at that time, leatherbacks are not at expected to occur in the inshore waters of the study area from January to March.

  In the spring, leatherbacks expand their range north and begin to concentrate in nearshore waters along the entire southeast coast of the U.S. (Figure 3-5). The leatherback becomes abundant in waters off North Carolina beginning in April (Lee and Palmer 1981). Between April and June, a limited amount of nesting activity may occur on the beaches of Cape Hatteras and Cape Lookout National Seashores. Non-nesting leatherback turtles also remain in close proximity to North Carolina's shore during their spring migration (Lee and Palmer 1981), which is likely the reason for the numerous public sightings within Raleigh and Onslow Bays. Recreational and commercial fishermen have observed large numbers of leatherbacks moving northward along the barrier islands enclosing Core and Pamlico Sounds in early May (Epperly et al. 1995b). The area of concentrated occurrence extends into slope waters in the vicinity of Cape Hatteras during the spring because aggregations of sightings also occurred in association with the Gulf Stream. The area of concentrated occurrence does not continue up the continental shelf above Cape Hatteras

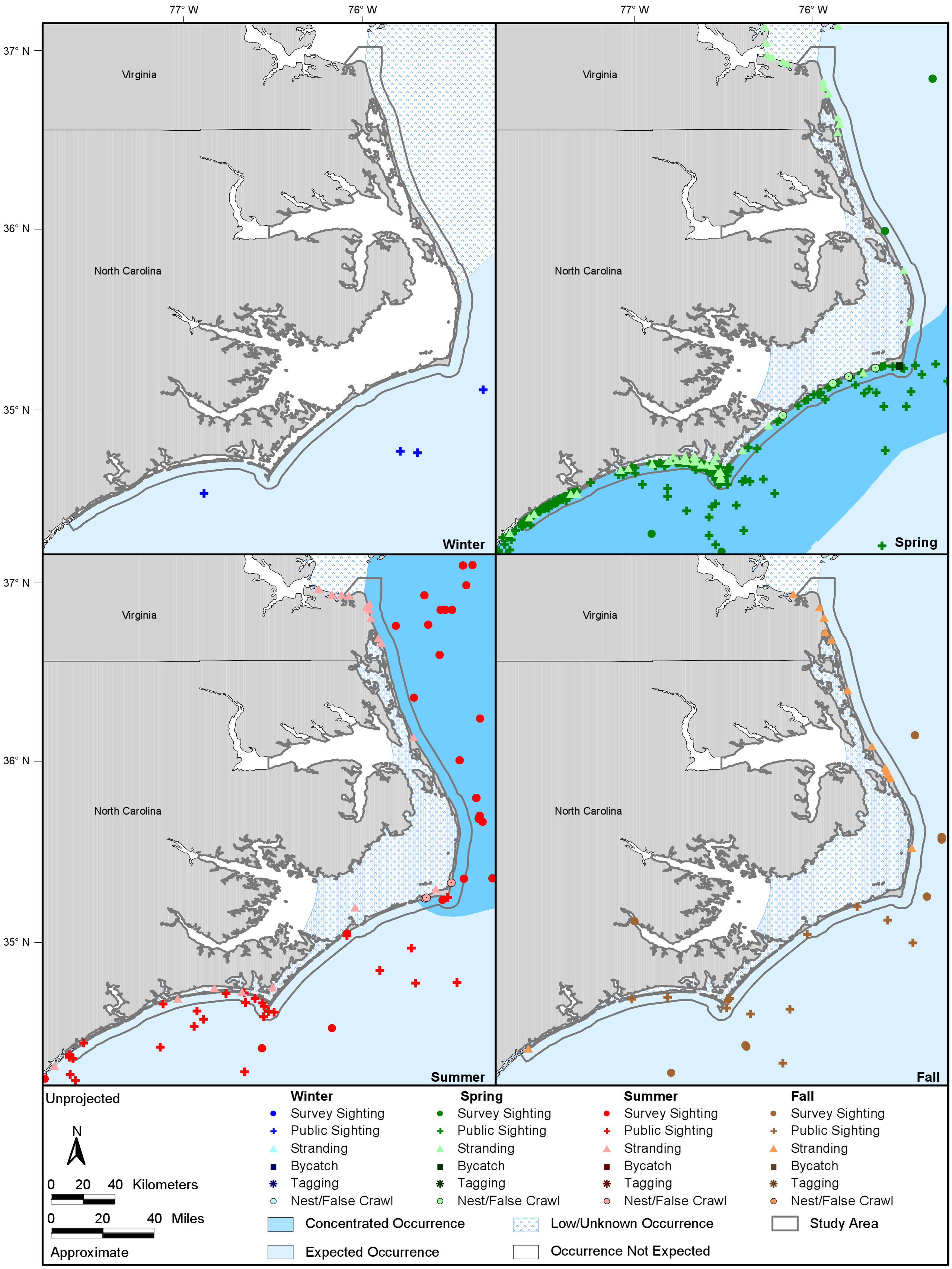

Figure 3-5. Occurrence of the leatherback turtle in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, incidental fisheries bycatch, tagging, and nesting records are represented by season. Source data: refer to Appendix A.

because to the north nearshore waters are still relatively cool and nesting activity has not been documented there. In addition, the cannonball jellyfish (*Stomolophus meleagris*), a major nearshore prey item of the leatherback during May and June, only occurs south of Cape Hatteras (Grant and Ferrell 1993). Therefore, these nearshore waters are only labeled as areas of expected occurrence. Since leatherbacks infrequently enter inshore waters, their occurrence is low/unknown in Virginia's Chesapeake and Back Bays and in North Carolina's Currituck, Pamlico, Core, Back, Bogue, and Topsail Sounds (Figure 3-5). Leatherback occurrence is not expected in much of Albemarle Sound (as access to this sound from offshore waters is extremely restricted), nor is it expected in the downstream portions and mouths of the major rivers of the study area (Epperly et al. 1995b).

In the summer, leatherback turtles are known to make extensive northward excursions, as indicated by the area of concentrated occurrence, which encompasses only the northern nearshore waters of the study area (Figure 3-5). At this time of the year, leatherbacks aggregate in both nearshore and offshore waters north of Cape Hatteras, taking advantage of food resources located in the vicinity of the coastline and along the deep canyons of the MAB (Shoop and Kenney 1992). During summer, leatherback turtles are very abundant off the coasts of the mid-Atlantic states and New England, most notably around the mouth of the Chesapeake Bay, where they often feed on dense aggregations of jellyfish that breed in the bay (CETAP 1982; Barnard et al. 1989). Leatherbacks not found feeding in or migrating through the shallow waters off the mid-Atlantic states are most likely to be found traversing the steep topography of the continental slope, where they are either summer residents of those waters or long-distance migrants on their way to subpolar foraging grounds off eastern Canada (Lee and Palmer 1981). To the south of Cape Hatteras, nearshore leatherback abundance is not as great and nesting activity on North Carolina's southern beaches is virtually zero during the summer months. As it is in spring, summer occurrence of leatherback turtles is low/unknown in most of North Carolina and southern Virginia's major sounds and is not expected in much of Albemarle Sound and in the vicinity of the states' major rivers (Figure 3-5). Summer occurrence is also low/unknown throughout the lower Chesapeake Bay since leatherbacks moving north along the Atlantic coast likely only enter these waters by chance and do not remain there for extended periods of time (Hardy 1969).

During fall, leatherback turtle occurrence is not concentrated anywhere in the study area. However, occurrence is concentrated in a zone further offshore, between the 200 and 2,000 m isobaths north of Cape Hatteras (DoN 2002). As water temperatures drop in the fall, leatherbacks begin to follow migration routes south, and may prefer to avoid cooler nearshore waters along the way. As their prey moves along offshore thermal fronts during cooler months, so will these turtles (Thompson 1984). Only leatherbacks spending their summers in habitats south of Cape May will likely use the nearshore migratory corridor described by NRDC (2000). As a result of these individuals, all nearshore waters along the North Carolina and southern Virginia coasts are labeled as areas of expected occurrence (Figure 3-5). For inshore waters, the pattern of fall occurrence mimics that of spring and summer due to the rarity of leatherbacks in these waters.

Behavior and Life History—The wider range of leatherbacks when compared to other sea turtles is likely due to their highly evolved thermoregulatory capabilities. Leatherbacks can maintain body core temperatures well above the ambient water temperature. For example, a leatherback caught off Nova Scotia had a body temperature of 25.5°C in water that was 7.5°C (Frair et al. 1972). 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).

Leatherback turtles predominantly feed upon gelatinous zooplankton such as jellyfish and salps (Bjorndal 1997); however, a wide variety of other prey items are known (NMFS and USFWS 1992). In the North Atlantic Ocean, the primary prey appears to be the lion's-mane or arctic jellyfish (Lazell 1980). Leatherbacks feed throughout the water column from the surface to depths as far as 1,200 m (Eisenberg and Frazier 1983; Davenport 1988). Studies of leatherback turtle diving patterns off St.

Croix suggested that nocturnal foraging on the deep-scattering layer was taking place (S. Eckert et al. 1989).

Mating is thought to occur prior to or during the migration from temperate to tropical waters (Eckert and Eckert 1988). Typical clutches range in size from 50 to over 150 eggs, with the incubation period lasting around 65 days. Females lay an average of five to seven clutches in a single season (with a maximum of 11) at 8- to 10-day intervals or longer (NMFS and USFWS 1992). Females remain in the general vicinity of the nesting habitat during inter-nesting intervals, with total residence in the nesting/inter-nesting habitats lasting up to four months (K. Eckert et al. 1989; Keinath and Musick 1993). Most adult females return to nest on their natal beach every two years; however, remigration intervals (the number of years between successive nesting seasons) between one and five years have been recorded (Boulon et al. 1996). The nesting season of the western North Atlantic leatherback stock is mainly from March to July (NMFS and USFWS 1992).

The leatherback is the deepest diving sea turtle. Dive depth likely depends on the reason for the dive and the proximity to shore; leatherbacks closer to shore probably make shallower dives than those in the open ocean (Ernst et al. 1994). Average dive depths from tagging studies off the continental shelf of St. Croix are 35 to 122 m, with estimated maximum depths of over 1,000 m (S. Eckert et al. 1989). Typical dive durations average 6.9 to 14.5 min per dive, with a maximum of 42 min (Eckert et al. 1986; S. Eckert et al. 1989). Routine dive lengths for leatherbacks around St. Croix can range from 4 to 14.5 min. Day dives around St. Croix were deeper and longer than those at night. Eckert et al. (1996) described leatherback turtle diving off Malaysia, where the bottom depth barely reaches 60 m. Bottom times were greater than 3 min in 47% of all dives in this shallow water habitat. Standora et al. (1984) measured a maximum dive length of 7.7 min for a subadult leatherback.

- Loggerhead Turtle (*Caretta caretta*)

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

***Status*—**Loggerhead turtles are classified as threatened under the ESA. There is no estimate of the size of the loggerhead population in the western North Atlantic Ocean (Frazer 1998). The South Florida nesting subpopulation is the largest loggerhead rookery in the Atlantic Ocean (approximately 83,400 nests in 1998) and is the second largest in the world (TEWG 2000). Nesting trends indicate that the number of nesting females associated with the South Florida subpopulation is increasing (Epperly et al. 2001). However, environmental groups have recently petitioned that both the Northern (North Carolina to northeast Florida) and Florida Panhandle nesting subpopulations be uplisted to endangered due to continually decreasing numbers of nesting females over the past several decades (NMFS 2002). Their petition states that both subpopulations are in imminent danger of extirpation due to threats such as commercial fishing, coastal development, and pollution and that if either subpopulation is extirpated, re-establishment is unlikely and the loss of genetic contribution to the species would be permanent (NMFS 2002).

***Habitat Preferences*—**The loggerhead turtle occurs worldwide in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd 1988). Loggerheads are primarily oceanic as post-hatchlings and early juveniles, often occurring in *Sargassum* drift lines where they are transported throughout the ocean by dominant currents (Carr 1987; Witherington 1994a; Bolten and Balazs 1995). In the North Atlantic Ocean, it is hypothesized that during the "lost year," early juvenile loggerheads inhabit the pelagic zone of the North Atlantic Gyre system (Carr 1987). As pelagic immatures, loggerheads apparently then shift to a different mid-water feeding habitat; in the eastern North Atlantic Ocean it is believed to be the waters surrounding the Azores and Madeira (Brongersma 1972; Bolten et al. 1994, 1998). Genetic evidence has shown that pelagic-feeding loggerheads found off the Azores are often derived from the southeast U.S. nesting population (Bolten et al. 1994, 1998).

After reaching a certain size, early juvenile loggerheads will then make a trans-oceanic crossing back towards the western Atlantic Ocean (Musick and Limpus 1997). As adults and later juveniles, loggerheads most often occur on the continental shelf and shelf-edge of the U.S. Atlantic and Gulf coasts; they are also known to inhabit coastal estuaries and bays along both coasts (CETAP 1982; Shoop and Kenney 1992).

Immature benthic-feeding loggerheads are the predominant age class found along the Atlantic and Gulf coasts of the U.S. (TEWG 1998). Based on the sighting records, the entire continental shelf south of southern New England should be considered as loggerhead turtle feeding habitat. Later developmental habitat for loggerheads includes lagoons, estuaries, bays, river mouths, and coastal waters typically less than 100 m deep (TEWG 1998). The shallow bays, sounds, and coastal waters of the northeast U.S. (e.g., Cape Cod Bay, Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds) serve as important summer developmental habitats for late juvenile loggerheads (Lutcavage and Musick 1985; Byles 1988; Burke et al. 1992; Epperly et al. 1995a, 1995b; Keinath et al. 1996). Based on growth models, immature loggerheads may occupy coastal feeding grounds for 20 years before their first reproductive migration (Bjorndal et al. 2001). Juvenile loggerheads are also known to inhabit offshore waters in the North Atlantic Ocean where they are often associated with natural and/or artificial reefs (Fritts et al. 1983a). These offshore habitats provide juveniles with an abundance of prey as well as sheltered locations where they can rest (Rosman et al. 1987). Adult loggerhead turtles reside in similar habitats, although their feeding behavior is more benthic-oriented; thus, they are more likely to be found in nearshore rather than offshore waters.

Distribution**—**Loggerhead turtles are found in subtropical and temperate waters throughout the world (NMFS and USFWS 1991a). The loggerhead is the most abundant sea turtle occurring in U.S. waters, numbering in the thousands throughout inner continental shelf waters of the Atlantic coast from Cape Cod, Massachusetts (MA), to southern Florida and the Gulf coast from southern Florida to southern Texas. Loggerheads are outnumbered by other species in only a few distinct areas of the western North Atlantic Ocean under U.S. jurisdiction: they are outnumbered by leatherbacks north of Cape Cod (Shoop and Kenney 1992) and by greens and hawksbills around Puerto Rico and the U.S. Virgin Islands (Hillis-Starr et al. 1998). Based on aerial survey results, it is estimated that 73% of all western North Atlantic loggerheads reside along the U.S. Atlantic coast (TEWG 1998).

Off the northeast U.S., loggerheads are commonly sighted from the shore to the shelf break as far north as Long Island Sound, although further north and east sightings are sparse (CETAP 1982; Shoop and Kenney 1992). Loggerheads seem generally restricted to waters of the North Atlantic Ocean south of 38°N, with mean surface temperatures around 22.2°C (Shoop and Kenney 1992). North of Cape Hatteras, loggerhead sea turtle occurrence is highly seasonal, primarily from May to October with a peak in June, though sightings have occurred in all months of the year (CETAP 1982; Lutcavage and Musick 1985; Shoop and Kenney 1992). Lutcavage and Musick (1985) determined that loggerheads enter Chesapeake Bay in late May or early June when water temperatures rise to 16° to 18°C and depart between late September and early November. In the fall, when water temperatures drop, loggerheads leave inshore waters north of Cape Hatteras (Epperly et al. 1995a, 1995b, 1995c). Once south of Cape Hatteras, Keinath et al. (1996) found that tagged loggerheads released off North Carolina either moved offshore to deeper waters, traveled nearshore to Florida, or overwintered off North Carolina on the west side of the Gulf Stream. These findings are supported by aerial surveys as well (Epperly et al. 1995a; Keinath et al. 1996). Aerial surveys over North Carolina's Core and Pamlico Sounds demonstrate that loggerheads move into these waters in the spring, disperse throughout the sounds in the summer, and vacate inshore waters in the late fall and early winter (Epperly et al. 1995a, 1995b).

South of Cape Hatteras, loggerhead sea turtles are year-round residents. In warmer months (April through October), loggerheads tend to reside in coastal nearshore and inshore waters, within a mile or two of the shore (Lee and Palmer 1981); only on rare occasions are individuals other than hatchlings found far offshore, such as in the Gulf Stream. However, Keinath et al. (1996) have documented the movements of two satellite-tagged loggerheads within the Gulf Stream off North Carolina. The Gulf Stream has considerable influence on the distribution of certain loggerhead life stages (Hoffman and Fritts 1982; Thompson 1984; Chester et al. 1994; Epperly et al. 1995c). Late juveniles of this species appear to actively avoid the Gulf Stream in fall to prevent being transported northward, but do seek areas to the west where warm waters are associated with the Gulf Stream boundary (Hoffman and Fritts 1982; Thompson 1984; Chester et al. 1994; Epperly et al. 1995c).

Low water temperatures affect loggerhead turtle activity. Cold-stunned loggerheads have been found in various locales, including Long Island Sound, NY; Indian River Lagoon, FL; and at sites in Texas (Burke et al. 1991; Morreale et al. 1992; Ernst et al. 1994). Loggerheads become lethargic at about 13° to 15°C and adopt a stunned floating posture in water around 10°C (Mrosovsky 1980). Some loggerheads are believed to escape cold conditions by burying themselves in the bottom sediment; the reason for this is unknown. This behavior appears to only occur south of North Carolina (Epperly et al. 1995a), although it has only been documented in Florida's Cape Canaveral Ship Channel (Carr et al. 1980). An age difference exists in the loggerhead's cold tolerance, with younger turtles more resistant (Schwartz 1978). Coles and Musick (2000) identified an upper and lower thermal limit (28°C and 13.3°C, respectively) as preferred sea surface water temperatures for loggerhead turtles off North Carolina.

Loggerhead turtles nest almost exclusively in warm-temperate regions. Throughout the world nesting on warm temperate beaches is much more common than nesting in the tropics (TEWG 2000). Females typically nest on continental coastlines adjacent to warm-temperate currents (Dodd 1988). In the western North Atlantic Ocean there are at least five demographically independent loggerhead nesting groups or subpopulations: (1) Northern: North Carolina, South Carolina, Georgia, and northeast Florida (approximately 7,500 nests in 1998); (2) South Florida: occurring from 29°N on the east coast to Sarasota on the west coast (approximately 83,400 nests in 1998); (3) Florida Panhandle: Eglin Air Force Base and the beaches near Panama City, FL (approximately 1,200 nests in 1998); (4) Yucatán: the eastern shore of the Yucatán Peninsula, Mexico (approximately 1,000 nests in 1998); and (5) Dry Tortugas: near Key West, FL (approximately 200 nests per year) (Encalada et al. 1998; TEWG 2000; Epperly et al. 2001). Small but significant nesting aggregations are also known from the Bahamas and Cuba (Dodd 1988; Eckert et al. 1992).

Genetic evidence has shown that assemblages of benthic-feeding immature loggerheads on foraging grounds comprise a mix of subpopulations (Sears et al. 1995; TEWG 1998; Epperly et al. 2001). At least two of the subpopulations intermingle on the foraging grounds of the U.S. Atlantic coast. Norrgard (1995) found that loggerheads hatched from the Northern subpopulation rookeries selectively use more northerly developmental habitats (such as Chesapeake Bay) than loggerheads from the South Florida rookery. Epperly et al. (2001) reported that the Northern subpopulation accounts for 46% of the loggerheads in Virginia and 25% to 28% of the loggerheads off the Carolinas (Epperly et al. 2001). Genetic data collected from loggerheads in North Carolina's Albemarle-Pamlico Estuarine Complex revealed that the South Florida subpopulation dominates there (Epperly et al. 2001).

- <u>Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas</u>—The loggerhead turtle is by far the most abundant sea turtle occurring in the study area, as evidenced by the large number of sighting, stranding, bycatch, tagging, and nest/false crawl records for the waters and beaches of North Carolina and southern Virginia (Figure 3-6). No matter what time of year it is, no matter if it's in inshore or nearshore waters, loggerheads will outnumber all other species of sea turtle found in the study area. In Pamlico and Core Sounds loggerheads accounted for 80% of all sea turtles incidentally captured by commercial fisherman between 1988 and 1992 (Epperly et al. 1995b), while in Chesapeake Bay 84% of all sea turtles encountered from 1979 to 1981 were loggerheads (Lutcavage and Musick 1985).

  In the winter, loggerhead turtles are concentrated in nearshore waters of the study area as far north as Oregon Inlet (Epperly et al. 1995c; Figure 3-6). This occurrence pattern is supported due to a particularly concentrated area of winter sightings, strandings, and bycatches near Cape Hatteras at the point where the Gulf Stream deflects from the shore seaward. Epperly et al.

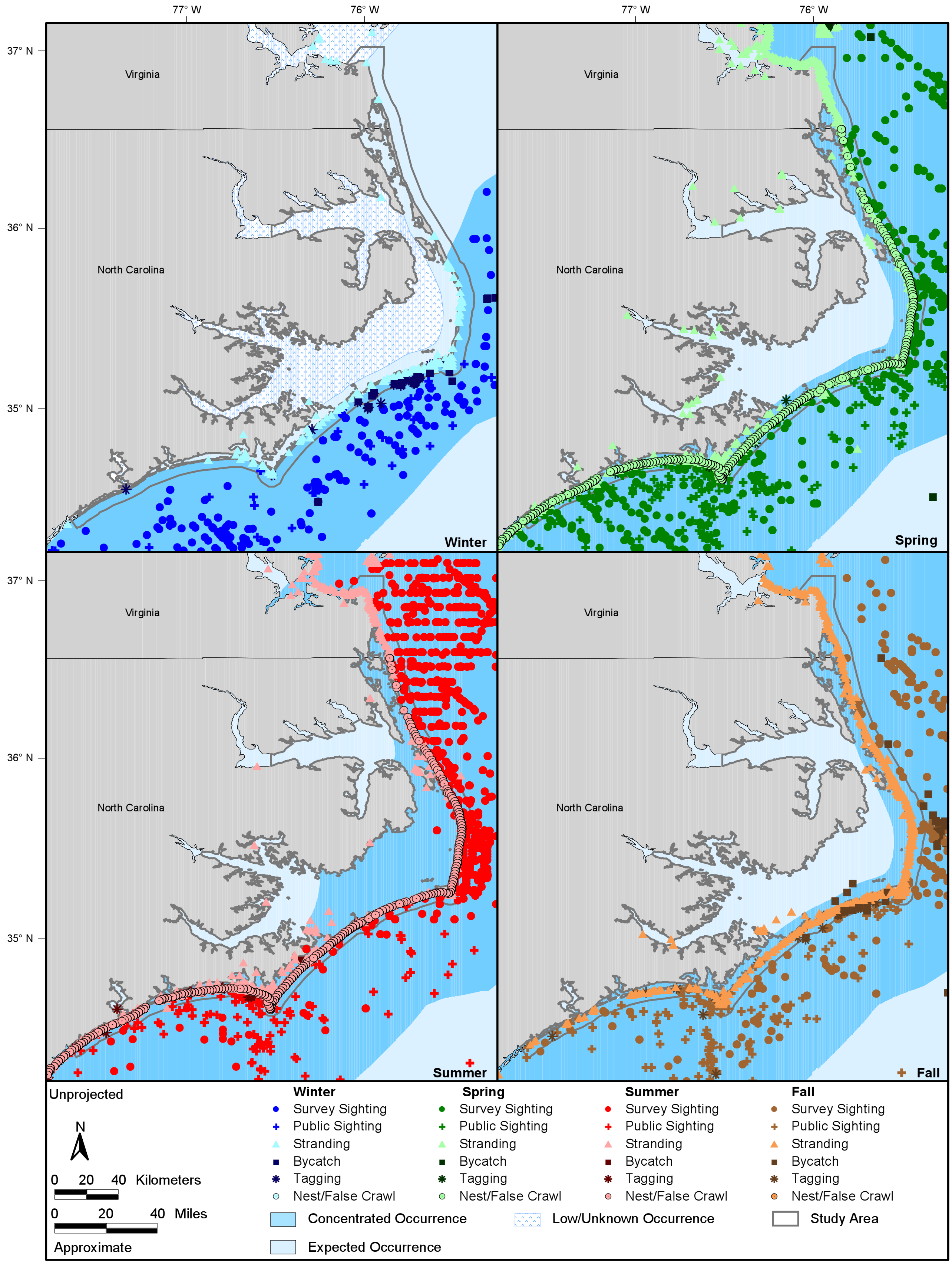

Figure 3-6. Occurrence of the loggerhead turtle in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, incidental fisheries bycatch, tagging, and nesting records are represented by season. Source data: refer to Appendix A.

(1995c) noted that during winter favorable temperature and depth regimes for loggerheads occur along the western edge of the Gulf Stream from the vicinity of Cape Hatteras southward. North of the Gulf Stream's influence winter water temperatures are somewhat cooler (often <10°C). Since low water temperatures often cause cold stunning (Schwartz 1978; Coles and Musick 2000), fewer individuals are expected to occur in waters along the Northern Outer Banks from January to March. Instead, most loggerheads leave the nearshore waters off the mid-Atlantic coast to overwinter in waters that are further south or near the Gulf Stream (Epperly et al. 1995c). However, since loggerheads are one of the more cold-tolerant sea turtle species (Ernst et al. 1994), they can be expected to occur in waters at least as far north as the mouth of the Chesapeake Bay and as far inshore as the waters immediately behind North Carolina and southern Virginia's barrier islands (where late emigrants and early immigrants are likely to be found). Winter occurrence is low/unknown in the rest of North Carolina's inshore waters as well as in all parts of Chesapeake Bay and in ocean waters to the bay's north, as overwintering in those areas is unlikely (Lutcavage and Musick 1985; Figure 3-6).

With spring comes an expansion of the areas of concentrated and expected occurrence to the north and west as thousands of immature loggerheads begin migrating toward and into developmental habitats along the mid-Atlantic and New England coasts (Keinath et al. 1996). Nesting activity along the entire North Carolina coast also commences in the spring, peaking in the month of June (Godfrey 2002; Figure 3-6). The high number of nearshore records for spring is most likely due to a combination of warm water temperatures, the onset of juvenile migration activity around Cape Hatteras, and the use of North Carolina's coastal waters as a transitional habitat by breeding adults. Since average sea surface temperatures throughout the MAB fall within the species' preferred range during the spring (refer to Figure 2-4), loggerheads will likely concentrate in all ocean waters adjacent to the study area out to 200 m in depth. Loggerhead sightings during spring have been recorded throughout the offshore area of concentrated occurrence, probably as a result of the high suitability of habitat along the entire continental shelf and the variability in migration timing exhibited by different individuals during these months. Loggerheads immigrate into North Carolina's sounds and Virginia's Chesapeake Bay beginning in April and May respectively, as exemplified by the inshore area of concentrated occurrence. This area includes the waters immediately behind North Carolina's barrier islands and those in southern portion of Chesapeake Bay, where the majority of loggerheads in inshore waters will likely be found during the spring months (Lutcavage and Musick 1985; Epperly et al. 1995a, 1995b). Loggerhead occurrence is expected (although not concentrated) in the remaining waters of the study area since the channels, river mouths, and estuaries of the mid- and south Atlantic coasts are also acceptable habitats for this species (Figure 3-6). However, in the spring most loggerheads will not have migrated that far inshore.

In the summer, large aggregations of loggerheads occur along the entire mid-Atlantic coast north of Cape Hatteras and in the vicinity of Cape Lookout (Figure 3-6). At this time of year juvenile loggerheads also disperse throughout much of Pamlico Sound and up into the mouth of the James River (Lutcavage and Musick 1985; Epperly et al. 1995a, 1995b). Loggerhead nesting on North Carolina and southern Virginia beaches continues throughout the summer, remaining at its peak in July and concluding in September (Godfrey 2002). Schwartz (1989) noted that between 200 and 500 loggerhead nests are laid on North Carolina beaches each year. Adult and juvenile loggerhead turtles often coexist in the inshore waters of the study area during the summer, as adult females are also known to utilize North Carolina and Virginia's shallow sounds and bays for foraging and protection during their inter-nesting and post-nesting periods (Mansfield 2000).

As summer turns to fall loggerhead nesting along the U.S. Atlantic coast comes to an end. Nevertheless, this species is still likely to be encountered on the beaches of the study area up until late October/early November, as hatchling loggerheads do not emerge until roughly two months after a nest is laid. Both hatchling and juvenile loggerheads begin to move east at this time of year; hatchlings on their way to offshore habitats associated with the Gulf Stream and juveniles on their way out of inshore waters of the mid-Atlantic. The fall areas of expected and concentrated occurrence revert to their spring forms because of this emigration activity from the inshore waters of the study area (Figure 3-6).

Behavior and Life History**—**The diet of a loggerhead turtle changes with age and size of the turtle. The gut contents of post-hatchlings found in masses of *Sargassum* contained parts of *Sargassum,* zooplankton, jellyfish, larval shrimp and crabs, and gastropods (Carr and Meylan 1980; Richardson and McGillivary 1991; Witherington 1994b). Juvenile and subadult loggerhead turtles are omnivorous, foraging on pelagic crabs, mollusks, jellyfish, and vegetation captured at or near the surface (Dodd 1988). Adult loggerheads are generalized carnivores that forage on nearshore benthic invertebrates (Dodd 1988).

Estimates of the age at sexual maturity for western Atlantic loggerheads range from 12 to 30 years (Zug et al. 1986; Klinger and Musick 1992). Females typically nest three to five times per season, at about two-week intervals (Dodd 1988; Frazer 1998). Loggerhead clutches contain between 95 and 150 eggs and often take 60 days to incubate. The most common inter-nesting interval is two years (Dodd 1988; Frazer 1998). Most nesting in the U.S. occurs between April and September (NMFS and USFWS 1991a).

On average, loggerhead turtles spend over 90% of their time underwater (Byles 1988; Renaud and Carpenter 1994). Routine dive depths of 9 to 22 m have been recorded (e.g., Byles 1988; Sakamoto et al. 1990). Dives of up to 233 m were recorded for a post-nesting female loggerhead (Sakamoto et al. 1990). Routine dives typically can last from 4 to 172 min (Byles 1988; Sakamoto et al. 1990; Renaud and Carpenter 1994).

- Green Turtle (*Chelonia mydas*)

Description**—**The green turtle is the largest hard-shelled sea turtle; adults commonly reach 100 cm in carapace length and 150 kg in weight (NMFS and USFWS 1991b). As hatchlings, however, green turtles are only about 50 millimeters (mm) long and weigh approximately 25 grams (g) at birth. Adult carapaces range in color from solid black to gray, yellow, green, and brown in muted to conspicuous patterns; the plastron is a much lighter yellow to white. Hatchlings are distinctively black on the dorsal surface and white on the ventral.

Status—Green turtles worldwide are classified as threatened, with the Florida and Mexican Pacific coast nesting populations listed as endangered under the ESA (NMFS and USFWS 1991b). There is no estimate of the total number of green turtles in the North Atlantic Ocean.

Habitat Preferences**—**"Lost year" green turtles are believed to reside in oceanic waters for a period of three to seven years (Balazs 1999). Once they reach a carapace length of 20 to 25 cm, greens then migrate to shallow nearshore areas where they spend the majority of their lives as late juveniles and adults (NMFS and USFWS 1991b; Ernst et al. 1994; Bjorndal and Bolten 1998). 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. They concluded that the "lost year" habitat of the green turtle has yet to be determined, although Carr and Meylan (1980) present direct evidence of hatchlings taking refuge in and around *Sargassum* rafts.

The optimal habitats for benthic-stage juveniles and adults are warm waters that (1) are quiet and shallow (3 to 5 m), (2) possess an abundance of SAV (seagrasses and/or algae), and (3) are located in close proximity to nearshore reefs or rocky areas that are used for resting (Ernst et al. 1994). Green turtles will feed as deep as their primary food source will grow (Bjorndal 2002). In Hawaii, green turtles have been found foraging in waters as deep as 20 to 50 m (Brill et al. 1995).

Important feeding areas for green turtles in the continental U.S. include waters in Florida and southern Texas such as the Indian River Lagoon, Florida Keys, Florida Bay, Homosassa Springs, Crystal River, Cedar Keys, and Laguna Madre Complex (NMFS and USFWS 1991b; Landry and Costa 1999). Further north, the inshore waters of North Carolina are an important developmental habitat for juveniles of this species (Epperly et al. 1995b, 1995c). Schwartz (1989) acknowledged that greens were the second most abundant sea turtle species in North Carolina waters, while Epperly et al. (1995b) indicated that, from 1988 to 1992, greens were the second most numerous species incidentally captured by commercial fishermen in Core and Pamlico Sounds.

***Distribution*—**Green turtles are distributed worldwide in tropical and subtropical waters (Ernst et al. 1994). In U.S. Atlantic waters, greens are found around the U.S. Virgin Islands, Puerto Rico, and the continental U.S. from Texas to Massachusetts (NMFS and USFWS 1991b). Adults are predominantly tropical and are only occasionally found north of southern Florida. Most sightings of individuals north of Florida occur during the warmest parts of the year, between late spring and early fall (CETAP 1982; Epperly et al. 1995b), and are juveniles (Lazell 1980; Burke et al. 1992; Epperly et al. 1995b). Small numbers of juveniles regularly occur as far north as Long Island Sound (Morreale et al. 1992). Long Island Sound's waters are warm enough to support green turtles from June through October (Morreale et al. 1992). From Long Island Sound south to Indian River Lagoon, green turtles generally comprise between 14% and 18% of the inshore sea turtle fauna present at any given time, although they are virtually absent from the waters of Chesapeake Bay (Keinath et al. 1987; Epperly et al. 1995b). This may be due to the tremendous decline in SAV that has been occurring in Chesapeake Bay since the 1960's (Orth and Moore 1983).

The temperature of inshore and nearshore waters is a major factor that often determines the distribution and abundance of green turtles along the U.S. Atlantic coast. Individuals occurring in temperate waters avoid becoming cold-stunned (induced into a motionless state of hypothermia) by either moving offshore or toward more southerly latitudes prior to the onset of winter. Cold-stunned greens have been found in various locales, including Long Island Sound, NY; Pamlico Sound, NC; Indian River Lagoon, FL; and at sites in Texas (Ernst et al. 1994). Cold-stunning usually happens when water temperatures drop to 10°C or below and can result in death if the cold period is extended and/or the temperature drops below 6.5°C. Green turtles lose the ability to dive at 9°C and remain floating horizontally until they either warm up or die (Schwartz 1978).

As they grow, most greens move through a series of developmental feeding habitats, which are often separated by thousands of miles (Hirth 1997). Adult green turtles are also known to undertake long migrations, the longest of which are between their foraging habitats and nesting beaches. 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). Most nesting in North America occurs in southern Florida and Mexico (Meylan et al. 1995), with scattered records in the Florida Panhandle, Alabama, Georgia, and the Carolinas (Peterson et al. 1985; Schwartz 1989; NMFS and USFWS 1991b; USAF 1996). Green turtles rank second behind loggerheads in the number of nests laid on U.S. beaches per year (Dodd 1995; Meylan et al. 1995).

Mixed-stock analyses on foraging populations of juveniles have revealed that developmental feeding habitats likely contain green turtles from multiple stocks. Green turtles occurring on foraging grounds off the U.S. Atlantic and Gulf coasts include representatives born on Costa Rican, U.S., Mexican, Aves Island, Suriname, Ascension Island, and Guinea Bissau (west Africa) nesting beaches (Lahanas et al. 1998).

- <u>Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas</u>—During warm months, the waters of North Carolina and southern Virginia are a suitable developmental habitat for juveniles while the states' ocean-facing beaches provide a suitable nesting habitat for adults. As a result, green turtles are expected to occur in the study area, although how far north and inshore they occur changes on a seasonal basis (Figure 3-7). Since the green turtle is primarily a tropical species, whose preferred habitats aren't as common in the study area as they are further south, year-round occurrence of this species is only expected in a small section of the study area.

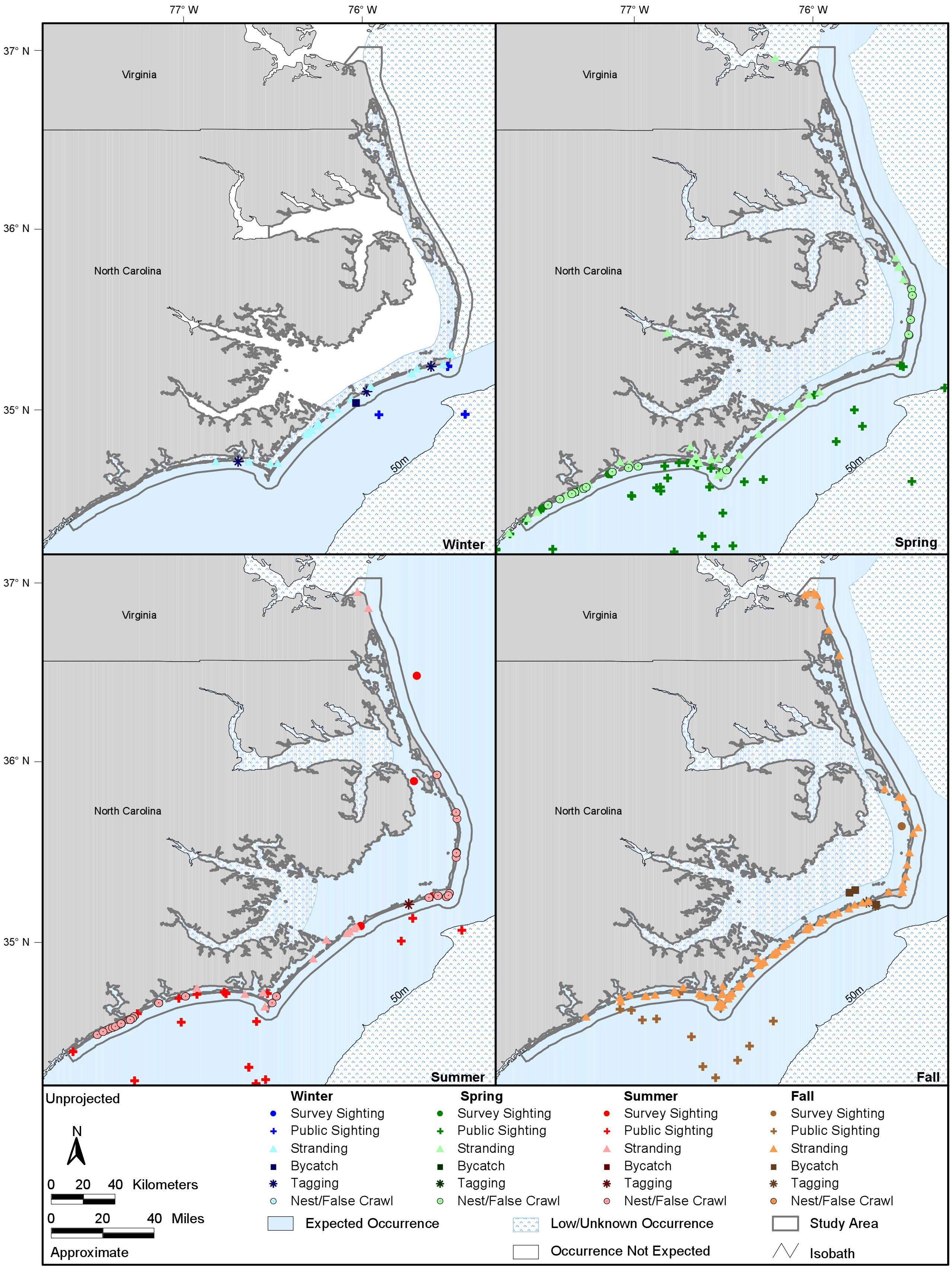

Figure 3-7. Occurrence of the green turtle in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, incidental fisheries bycatch, tagging, and nesting records are represented by season. Source data: refer to Appendix A.

Only nearshore waters south of Cape Hatteras, which are continually warmed by the Gulf Stream, are likely suitable for green turtles during winter months (Epperly et al. 1995c). Nearshore waters north of Cape Hatteras and inshore waters immediately behind North Carolina and southern Virginia's barrier islands are areas where winter occurrence is low/unknown (Figure 3-7). This is due to the fact that green turtles have stranded in the winter as far north as Cape Cod, MA and that waters along the western side of the barrier islands house some of the densest seagrass meadows in North Carolina and southern Virginia (refer to Figure 2-10). Thus, even though these temperate waters (which are independent of the Gulf Stream) are cold enough to be lethal from January to March, they still may be inhabited by greens that fail to migrate south and offshore for the winter (Schwartz 1978, 1989). Winter occurrence is not expected in Chesapeake Bay or in the rest of North Carolina's inshore waters, as these are areas where green turtles are known to be absent during winter due to poor habitat suitability and greater distance from the ocean (Epperly et al. 1995a, 1995b; Figure 3-7).

As waters of the MAB begin to warm in the spring, greens are expected to expand their range as far north as the nearshore waters off Delaware Bay (Kenney 2001). Away from the Gulf Stream's presence, however, offshore water temperatures in spring likely remain outside the species' preferred range. Thus, green turtles occurring north of the study area during the spring are probably following the 19-km wide coastal migratory corridor described in NRDC (2000). Schwartz (1989) determined that greens, like loggerheads, Kemp's ridleys, and leatherbacks, migrate north along North Carolina's coastline when water temperatures increase. Green turtles also begin to immigrate into North Carolina's and southern Virginia's sounds from April to June (Epperly et al. 1995a, 1995b). During these months, green turtles are expected to move into waters just behind the study area's barrier islands, where SAV habitat is most abundant (Figure 3-7). The near absence of individuals from Chesapeake Bay during the warmest months of the year indicates that this species rarely moves into the bay from waters offshore (Epperly et al. 1995b). Nevertheless, spring occurrence in Chesapeake Bay is low/unknown rather than not expected since water temperatures in the bay are warm enough to support green turtles at this time of year and SAV habitats, although greatly reduced, still exist in certain portions of the bay (Lutcavage and Musick 1985). Occurrence is also low/unknown in North Carolina's inshore waters that are a good distance away from the state's barrier islands and inlets, as these waters are virtually devoid of SAV and likely not yet suitable for green turtles until the summer months (Schwartz 1989; Epperly et al. 1995a, 1995b; Figure 3-7). Green turtles begin to nest on North Carolina's beaches starting in May, with nesting reaching its peak in June and July.

In the summer, when water temperatures along the mid-Atlantic coast are at their peak, green turtles are expected to occur in nearshore waters less the 50 m deep as far north as New York, due to summer sightings of individuals as far north as Hudson Canyon. Green turtles also venture further up the estuaries of the study area, although summer occurrence is still low/unknown in Chesapeake Bay and in portions of Pamlico and Albemarle Sounds where there is a greater riverine influence (Figure 3-7). Unlike loggerheads, green turtles are rarely found in the vicinity of river mouths and channels unless there are reef-like habitats or jetties in the area that can support the growth of macroalgal communities (Renaud et al. 1995; Bresette et al. 1998). Habitats such as these are not very abundant in the western portion of the Albemarle-Pamlico Estuarine Complex (refer to Figure 2-13). In late August, green turtle nesting on the study area's beaches comes to an end.

When waters of the MAB begin to cool in the fall, green turtles will start migrating back south and offshore, as exemplified by the contraction in the area of expected occurrence (Figure 3-7). On their journey to warmer waters south of Cape Hatteras, juveniles of this species will likely again use the 19-km wide migratory pathway along the mid-Atlantic coast. As a result, the fall occurrence patterns for green turtles in both inshore and nearshore waters of the study area mimic the patterns in spring, with individuals simply moving in the opposite direction.

Behavior and Life History—Late juvenile and adult green turtles feed primarily on seagrasses (e.g., turtle grass, manatee grass, shoal grass, and eelgrass), macroalgae, and reef-associated organisms

(Burke et al. 1992; Ernst et al. 1994; Bjorndal 1997). Post-hatchlings and early juveniles are more omnivorous, feeding on a variety of algae, invertebrates, and small fishes (Ernst et al. 1994). Observations of foraging adult green turtles in Hawaiian waters suggest that when benthic age classes feed, they generally lie down on the sea bottom and then crawl or move to a nearby site when food is no longer within easy reach (Hochscheid et al. 1999).

Green turtles are estimated to take 27 to 50 years to reach sexual maturity, the longest age to maturity for any sea turtle species (Frazer and Ehrhart 1985). Mature females nest from one to seven times in a season (two to three is typical) at approximately two-week intervals, and reproduce every two to four years (NMFS and USFWS 1991b). Within a nesting season, females remain in close proximity to their nesting beaches during inter-nesting intervals (Meylan 1995). Between 110 and 145 eggs are laid at a time, and the incubation period is 50 to 60 days. Greens that nest along the U.S. Atlantic coast do so between June and August (Coston-Clements and Hoss 1983).

Green turtles typically make dives shallower than 30 m (Hochscheid et al. 1999; Hays et al. 2000); however, a maximum dive depth of 110 m has been recorded in the Pacific Ocean (Berkson 1967). The maximum dive time recorded for a subadult green turtle is 66 min, with routine dives ranging from 9 to 23 min (Brill et al. 1995).

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

Description—The Kemp's ridley is the smallest living sea turtle. The straight carapace length of an adult is around 65 cm; adult Kemp's ridley shells are almost as wide as they are long (USFWS and NMFS 1992). The carapace is round to somewhat heart-shaped and distinctly light gray. Adult Kemp's ridleys typically weigh les than 45 kg (USFWS and NMFS 1992).

Status—Kemp's ridley turtles are classified as endangered under the ESA; they are considered the most imperiled of the world's sea turtles (USFWS and NMFS 1992). The worldwide Kemp's ridley population declined in numbers from tens of thousands of nesting females in the late 1940s to approximately 300 nesting females in 1985 (TEWG 2000). From 1985 to 1999, the number of nests at Rancho Nuevo, Tamaulipas on the eastern coast of Mexico (the primary and most important Kemp's ridley nesting beach) and nearby beaches has increased at a mean rate of 11.3% per year (TEWG 2000). Current totals at these beaches exceed 3,000 nests per year (TEWG 2000). There are currently no population estimates for Kemp's ridleys in the North Atlantic Ocean (Weber 1995).

Habitat Preferences—Kemp's ridley turtles occur in open-ocean and *Sargassum* habitats of the North Atlantic Ocean as post-hatchlings and small juveniles; they then move to benthic, nearshore feeding grounds along the U.S. Atlantic and Gulf coasts as large juveniles and adults. Habitats frequently utilized by Kemp's ridleys in the continental U.S. include warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where its preferred food, the blue crab (*Callinectes sapidus*), is known to exist (Lutcavage and Musick 1985; Landry and Costa 1999). Henwood (1987) and Gitschlag (1996) have documented sightings and movements of juveniles within and among preferred habitats along both the Atlantic and Gulf coasts. Along the Atlantic coast, known feeding areas include Cape Cod Bay, Long Island Sound, Chesapeake Bay, and the bays and sounds from North Carolina south (Lazell 1980; Lee and Palmer 1981; Lutcavage and Musick 1985; Barnard et al. 1989; Weber 1995). In the Gulf of Mexico, the western coast of Florida (particularly the Cedar Keys area), the eastern coast of Alabama, the mouth of the Mississippi River, and the coastal waters off western Louisiana and eastern Texas have all been identified as important developmental regions for the Kemp's ridley (Márquez-M. 1990, 1994; USFWS and NMFS 1992; Schmid et al. 2000). Renaud (1995) indicated that adult Kemp's ridley turtles may travel along the entire Gulf coast of the U.S. when looking for an optimal foraging habitat.

Scientists have developed a habitat suitability index (HSI) model for the Kemp's ridley based on what is known of its habitat preferences. In addition to water temperature, habitat factors of critical importance to this species include water depth and prey abundance. Using what is known about the Kemp's ridley's affinity for shallow coastal waters and aversion to cold temperatures, scientists have made estimates regarding the suitability of various parts of the northwestern Atlantic Ocean and Gulf of Mexico for the species (Coyne et al. 1998). In this theoretical, quantitative model, the most optimal habitats for Kemp's ridleys are those with a bottom depth of less than 10 m and a SST between 22° and 32°C. A cycling of HSI model outputs by month for the Atlantic and Gulf coasts can be viewed at http://www.seaturtle.org/research/hsi.html.

***Distribution*—**Kemp's ridleys are the only sea turtles that are restricted to the North Atlantic Ocean (Márquez-M. 1994). They occur primarily in the Gulf of Mexico, but occur in moderate numbers along the northeast U.S. coast up to Nova Scotia (Lazell 1980; Morreale et al. 1992). It is mostly juveniles that occupy the northern part of the range. Kemp's ridleys are reported eastward as far as the British Isles, Netherlands, France, and the Azores (Brongersma 1995).

Oceanic transport of neonate Kemp's ridleys is primarily controlled by hydrography in the Gulf of Mexico (Collard 1990b). Some juveniles are probably retained in the northern Gulf of Mexico, until they migrate inshore and become demersal. Others may be swept out of the Gulf of Mexico by the Loop and Florida Currents and then carried north along the U.S. Atlantic coast by the Gulf Stream (Collard and Ogren 1990). Juveniles are carried north along the east coast of the U.S. by the Gulf Stream, until they reach a size of approximately 20 to 30 cm, at which point they actively migrate to neritic developmental habitats. Adults appear to remain in the Gulf of Mexico, with an occasional occurrence in the Atlantic Ocean. Satellite-tracked adult females have been shown to move very little and maintain relatively small ranges, while nothing is known of the ranging patterns of adult males (Weber 1995).

Offshore water temperatures play a major role in determining the number of Kemp's ridleys present in the North Atlantic Ocean. Temperature is a limiting factor in their distribution; in temperatures less than 13°C they tend to float, make awkward movements (Márquez-M. 1994), and may even die of cold-stunning (Burke et al. 1991). There is some speculation concerning the mechanism for survival during the winter. One view is that they migrate to warmer waters and then return to their former habitat; another hypothesis is that they bury themselves in mud bottoms to avoid low temperatures (Márquez-M. 1994). Kemp's ridleys are likely only to be found along the mid-Atlantic coast from spring to fall (Lazell 1980; Lutcavage and Musick 1985; Weber 1995), but may be found throughout the SAB and Gulf of Mexico year-round.

Nesting occurs primarily on a single nesting beach at Rancho Nuevo, Tamaulipas, Mexico (USFWS and NMFS 1992), with a few additional nests in Texas, Florida, South Carolina, and North Carolina (Meylan et al. 1990; Weber 1995; Foote and Mueller 2002). Kemp's ridleys that nest in south Texas today are likely a mixture of returnees from the experimental imprinting and head-starting project and others from the wild stock (Shaver and Caillouet 1998). No nests have been documented as far north as the study area.

- Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas—Since the Kemp's ridley turtle is often restricted to waters less than 50 m deep (Byles 1988), it is a species that is prone to occur in the inshore and estuarine waters of the study area during warm months. The low/unknown occurrence of Kemp's ridleys in waters beyond 50 m during all seasons reflects the possibility that hatchlings or juveniles may be entrained in the Gulf Stream or North Atlantic Gyre (Figure 3-8). It is also possible that Kemp's ridleys in offshore waters may be missed or not identified to species during surveys due to their small size and diving behavior.

  Recent evidence indicates that North Carolina ocean waters just south of Cape Hatteras are an important source of winter habitat for the Kemp's ridley (Epperly et al. 1995c). During winter months, the Kemp's ridley turtle is expected to occur in nearshore waters of the study area as far north as the easternmost point of North Carolina, due to the temperature preferences of this species and the knowledge that above this boundary, winter sightings, taggings, and bycatches of live individuals likely do not occur (Figure 3-8). From January to March, waters north and inshore of the area of expected occurrence are unsuitable for Kemp's ridleys (Coyne et al. 1998). As a

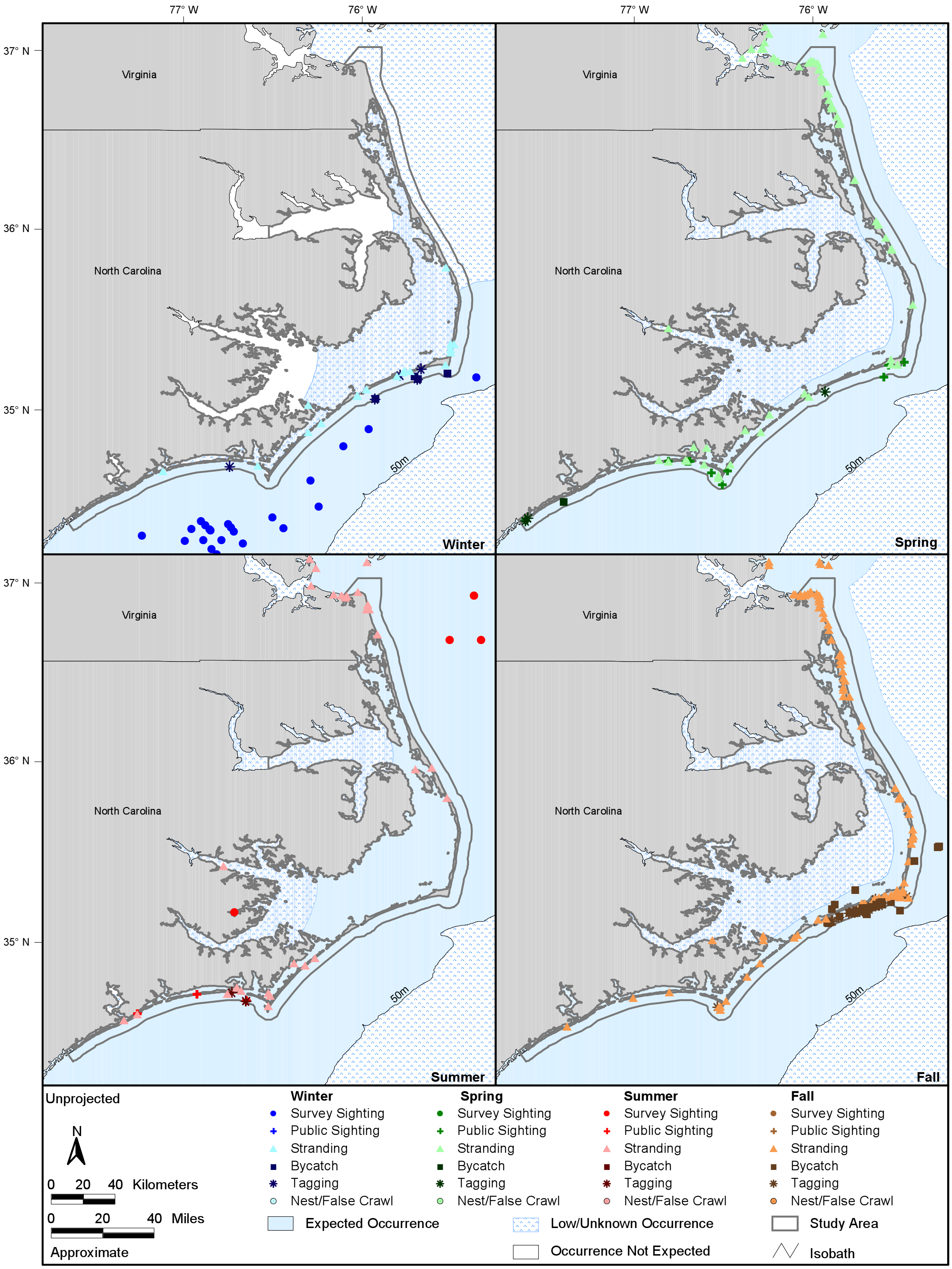

Figure 3-8. Occurrence of the Kemp's ridley turtle in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, incidental fisheries bycatch, tagging, and nesting records are represented by season. Source data: refer to Appendix A.

result, winter occurrence is low/unknown in Virginia's Chesapeake and Back Bays and in North Carolina's Currituck, Pamlico, Core, Back, Bogue, and Topsail Sounds, while it is not expected in much of Albemarle Sound nor in and around the major river mouths of the study area (Figure 3-8). Even within the area of expected occurrence, the habitat suitability of ocean waters off North Carolina during winter months is primarily low (Coyne et al. 1998).

In the spring, Kemp's ridleys expand their range north and inshore in a manner similar to that demonstrated by the green turtle. The suitability of shallow water habitats in the southern portion of the MAB changes tremendously during the spring months, from largely unsuitable in April to highly suitable in June (Coyne et al. 1998). From April to June, immature Kemp's ridleys are expected to use the 19-km wide coastal migratory corridor from Cape Hatteras to Cape May as they make their way to developmental habitats along the mid-Atlantic coast (NRDC 2000). Spring is the season when Kemp's ridleys begin to immigrate into North Carolina's sounds, as depicted by the area of expected occurrence, which encompasses the state's inshore waters that are nearest to the ocean (Figure 3-8). Along the coast of Virginia, Kemp's ridley abundance peaks in June, as large aggregations of blue crab (*Callinectes sapidus*), its preferred food, begin to appear in and around eelgrass habitats within Chesapeake Bay (Lutcavage and Musick 1985). Therefore, this species is expected to occur throughout the southern portion of the bay during this season. In all other waters of the study area that are further inshore Kemp's ridley occurrence is low/unknown, as they are only just beginning to enter inshore waters at this time of year (Figure 3-8).

As spring turns to summer the area of expected occurrence continues to extend further north and inshore. From July to September, suitable habitat for Kemp's ridleys exists in shallow (<50 m), nearshore and inshore waters along the U.S. Atlantic coast as far north as Long Island Sound (Coyne et al. 1998). Summer sightings in the study area and vicinity are few because many individuals of this species prefer to inhabit more northerly foraging grounds, such as the upper Chesapeake Bay, Long Island Sound, and Cape Cod Bay, during this season. In general, Kemp's ridleys account for only 5% of all sea turtle occurrences in Pamlico and Core Sounds; in Chesapeake Bay and Long Island Sound, Kemp's ridleys account for a greater proportion of total encounters, 15% and 24% respectively (Epperly et al. 1995b). As a result, summer occurrence is expected throughout Chesapeake Bay but not throughout North Carolina's major sounds. Instead, a low/unknown occurrence has been designated for portions of Pamlico and Albemarle Sounds where there is a greater riverine influence (Figure 3-8). As in spring, all rivers of the study area are designated as areas of low/unknown occurrence due to the low likelihood of sighting a Kemp's ridley in waters upstream of a river's mouth.

As water temperatures drop during the fall, the overall pattern of Kemp's ridley occurrence reverts back to its spring form (Figure 3-8). Kemp's ridleys that summer in northerly developmental habitats begin to migrate south along the mid-Atlantic coast between October and December (NRDC 2000). At this time of year, individuals inhabiting North Carolina's sounds also begin to move back towards the ocean. In the fall, the suitability of nearshore habitats off North Carolina and southern Virginia begins to lessen, going from highly suitable in October to unsuitable in December (Coyne et al. 1998). Kemp's ridleys occurring in inshore and estuarine waters outside the area of expected occurrence are prone to stranding. Repeated fall stranding events on Long Island, NY and at Cape Cod, MA over the past few years indicate that although Kemp's ridleys may be found along the northeast U.S. coast during colder months, those found north of Cape May in the late fall are more often than not either cold-stunned or already dead (Burke et al. 1991; Morreale et al. 1992).

Behavior and Life History—Kemp's ridley turtles feed primarily on portunids and other types of crabs, but are also known to eat mollusks, shrimp, fish, and plant material (Ernst et al. 1994; Márquez-M. 1994). This species may possibly feed on shrimp fishery bycatch (Landry and Costa 1999).

The Kemp's ridley is unique in that it is a daytime nester (Márquez-M. 1990). Females are estimated to become sexually mature at 11 to 12 years of age. Females nest approximately every two years, usually doing so between April and mid-August. A typical female produces about three clutches averaging 110 eggs at 20- to 28-day intervals (Miller 1997). Incubation time from deposition to emergence is 48 to 65 days.

Few data are available on the maximum duration of dives. Satellite-tagged juvenile Kemp's ridley turtles show different mean surface intervals and dive depths depending on whether they are located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). Dive times have been documented to range from a few seconds to a maximum of 167 min with routine dives lasting between 16.7 and 33.7 min (Mendonca and Pritchard 1986; Renaud 1995). Over a 12-hour period, Kemp's ridleys will spend between 89% and 96% of that time submerged (Byles 1989; Gitschlag 1996).

- Hawksbill Turtle (*Eretmochelys imbricata*)

Description—The hawksbill turtle is a small to medium-sized sea turtle. Adults range between 65 and 90 cm in carapace length and typically weigh around 80 kg (Witzell 1983; NMFS and USFWS 1993). Hawksbills are distinguished from other sea turtles on the basis of their hawk-like beaks, posteriorly overlapping carapace scutes, and two pairs of claws on their flippers (NMFS and USFWS 1993). The carapace of this species is often brown or amber with irregularly radiating streaks of yellow, orange, black, and reddish-brown.

Status—Hawksbill turtles are classified as endangered under the ESA and are second only to the Kemp's ridley in terms of endangerment (NMFS and USFWS 1993; Bass 1994). Hawksbill populations in the western Atlantic-Caribbean region are considered as greatly depleted and only remnants of much larger aggregations in the past. The most recent estimate of hawksbill abundance in the wider Caribbean was 4,975 nesting females calculated by Meylan in 1989 (Meylan and Donnelly 1999). In U.S. waters, hawksbill populations are noted as neither declining nor showing indications of recovery (Plotkin 1995). Only five regional populations worldwide remain with more than 1,000 females nesting annually (Seychelles, Mexico, Indonesia, and two in Australia) (Meylan and Donnelly 1999). Little is known about the status or abundance of this species along the U.S. Atlantic coast (Dodd 1995).

Habitat Preferences—Hawksbill turtles inhabit oceanic waters as post-hatchlings and small juveniles, where they are sometimes associated with floating patches of *Sargassum* (Parker 1995). Hawksbills recruit to benthic foraging grounds at 20 to 25 cm (Meylan 1988). The primary feeding habitats of benthic-stage juveniles and adults are tropical, nearshore waters that are associated with coral reefs or mangroves. Adults may occupy somewhat deeper waters (to 24 m) than juveniles (to 12 m). Major foraging populations in U.S. waters occur in the vicinity of the coral reefs surrounding Mona Island, PR and Buck Island, St, Croix, USVI (van Dam and Diez 1996; Starbird et al. 1999). Smaller populations of hawksbills reside in the hard bottom habitats that surround the Florida Keys and other small islands in Puerto Rico and the U.S. Virgin Islands (Witzell 1983; NMFS and USFWS 1993).

Distribution—Juvenile and adult hawksbills are found in the Gulf of Mexico, the Caribbean Sea, and along the Atlantic coast of southern Florida (Witzell 1983; NMFS and USFWS 1993). Accidental occurrences have been documented as far north as New England (Lazell 1980). Morreale et al. (1992) recorded hawksbill turtles regularly in Long Island Sound, while Parker (1995) reviewed sightings of juveniles and "lost year" hatchlings off the coasts of Massachusetts, Virginia, North Carolina, and Georgia. There are four other published records of hawksbills in North Carolina waters, including one 20 miles east of Oregon Inlet (Lee and Palmer 1981). In 1990, a hawksbill was incidentally captured in Virginia at the mouth of the St. James River (Keinath et al. 1991).

Originally thought to be a non-migratory species, due to the close proximity of suitable nesting beaches to coral reef feeding habitats and high rates of local recapture, hawksbills are now known to travel long distances over the course of their lives (Meylan 1999). Tag return, genetic, and telemetry studies have all indicated that Caribbean hawksbill turtles utilize multiple developmental habitats as they progress from age class to age class. However, within a given life stage, such as the later juvenile stage, some hawksbills choose to be sedentary within a specific developmental habitat for a long period of time (Meylan 1999).

Hawksbills tend to nest in multiple, small, scattered colonies, with the most significant nesting in the western North Atlantic Ocean occurring along the Yucatán Peninsula, Mexico. An estimated 1,900 to 4,300 adult females comprise the Mexican Atlantic nesting population (Garduño et al. 1999). Hawksbill nesting within the continental U.S. is restricted to beaches in southern Florida and the Florida Keys, although even there it is extremely rare (Dodd 1995). However, hawksbill nesting in these areas may be underestimated due to the masking effects of thousands of loggerheads that nest along the same stretches of beach (Lund 1985).

- Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas—Hawksbill turtle sighting, stranding, and tagging data as well as the endangered status of this species were considered for a conservative determination of its occurrence in the study area. The occurrence of hawksbill turtles in the nearshore waters of the study area is low/unknown for all seasons, although north of the mouth of Chesapeake Bay, winter occurrence is not expected due to very low temperatures in those waters (Figure 3-9). Due to the tropical nature of this species, occurrences north of Florida are extremely rare. However, individual hawksbills may be present off North Carolina and southern Virginia, as evidenced by the occurrence data as well as records from 1981 to 1994 in Parker (1995). There are no nesting records for hawksbills in the study area; therefore, individuals inhabiting the nearshore waters off North Carolina and southern Virginia are likely to be post-hatchlings or juveniles. Aside from the few documentations of hatchlings associated with *Sargassum* mats, scientists know relatively little about the distribution of this species in the western North Atlantic Ocean.

  Hawksbills are very difficult to identify during shipboard, beach, and aerial surveys (Shoop and Kenney 1992), especially when qualified observers are not present (Lund 1985). Hawksbills are also under-sampled during surveys because of size bias (Shoop and Kenney 1992). Thus, even though expert opinion states that they are rare (McNeill 2002), there may be more hawksbills in the waters off North Carolina and southern Virginia than the occurrence data imply. However, since the vast majority of records for spring, summer, and fall were from a public sighting program (where identifications are likely not 100% reliable [McNeill 2002]), a low/unknown occurrence designation for nearshore waters south of Chesapeake Bay is warranted for all seasons.

  Hawksbill turtles are not expected to occur in the inshore waters of North Carolina and southern Virginia during any season (Figure 3-9), as their preferred habitats (coral reefs and mangroves) are not at all present in these areas (Keinath et al. 1991; Steimle and Zetlin 2000). In addition, habitats such as artificial reefs and shipwrecks, that support the growth of sponges (their preferred prey), are much less abundant in the inshore waters of the study area than they are in offshore waters (refer to Figure 2-13). The only inshore occurrence record near the study area deemed an extralimital occurrence was a fall incidental bycatch at the mouth of the James River (Keinath et al. 1991).

Behavior and Life History**—**Hatchlings and small juveniles are believed to utilize *Sargassum* habitat but little is known about their diets during this stage. Hawksbill turtles recruit to benthic feeding habitats, such as coral reefs and other hard bottom habitats, at 20 to 25 cm (Meylan 1988). Scientists believe that hawksbills are omnivorous at that stage, feeding on encrusting organisms such as sponges, tunicates, bryozoans, algae, mollusks, and a variety of other items such as crustaceans and jellyfish (Bjorndal 1997). Larger juveniles and adults are more specialized, feeding primarily on sponges, which comprise as much as 95% of their diet in some locations (Witzell 1983; Meylan 1988).

The nesting season of hawksbills is the longest of all sea turtles; nesting may occur year-round. In the western North Atlantic, nesting occurs primarily between spring and late fall, with a peak in nesting

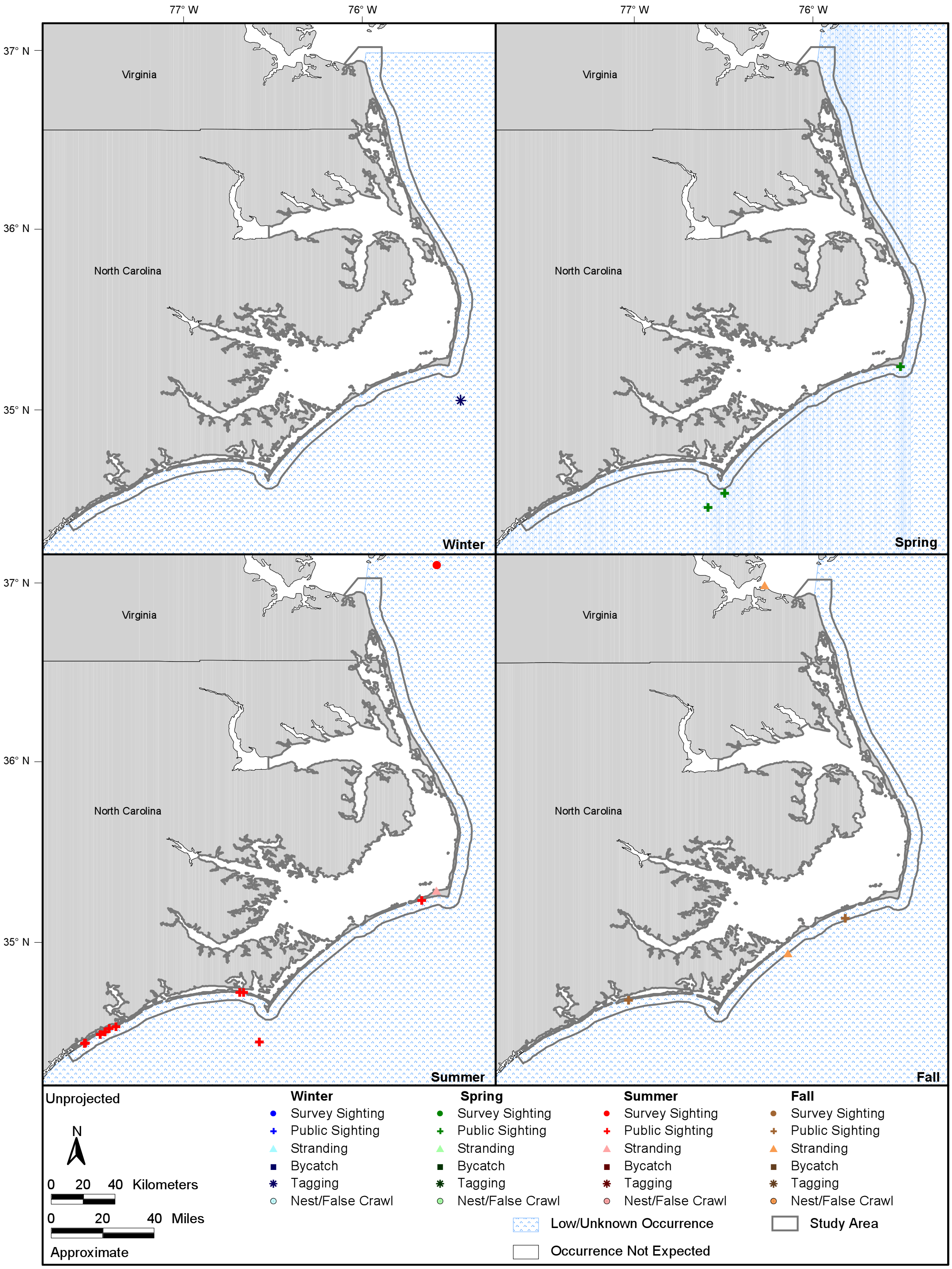

Figure 3-9. Occurrence of the hawksbill turtle in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, incidental fisheries bycatch, tagging, and nesting records are represented by season. Source data: refer to Appendix A.

activity between July and October (Witzell 1983). Mating is believed to take place in the waters adjacent to the nesting beach. Nesting occurs on both low- and high-energy beaches in tropical latitudes. Adult female nesting is often nocturnal and usually occurs on beaches with sufficient vegetative cover. An individual female nests two to five times per season with an inter-nesting interval of about 14 to 16 days. The typical remigration interval is two to three years. Clutch sizes are relatively large at 140 to 180 eggs, and incubation time is 50 to 61 days.

Hawksbills may have one of the longest routine dive times of all the sea turtles. Starbird et al. (1999) reported that inter-nesting females at Buck Island averaged 56.1 min dives with a maximum dive time of 73.5 min. Mean surface time was about 2 min. Average dives during the day ranged from 34 to 65 min, while those at night were between 42 and 74 min. The movements of all the turtles studied were confined to an area less than 1.5 square kilometers (km^2). Data from time-depth recorders have indicated that foraging dives of immature hawksbills in Puerto Rico range from 8.6 to 14 min in duration and have a mean depth of 4.7 m (van Dam and Diez 1996). These individuals were found to be most active during the day and mostly inactive at night.

3.3.3 Other Reptiles

♦ American Alligator (*Alligator mississippiensis*)

Description**—**The American alligator is the largest reptile in North America. Adult alligators can reach up to 5.5 m in length, although the average length is around 2.5 to 4 meters (m). An alligator's tail accounts for almost half of its body length. Male alligators, or bulls, are generally larger than females, weighing on average between 200 and 275 kg. The American alligator is distinguished from the American crocodile by its short, rounded snout and black color (NPCA 2002).

Status**—**First listed as an endangered species in 1967, the American alligator was downlisted in 1987 after the U.S. Fish and Wildlife Service pronounced a complete recovery of the species (NPCA 2002). However, the American alligator is still listed as threatened by the federal government because it is very similar in appearance to the American crocodile, which is an endangered species. American alligator harvesting is still allowed in some U.S. states, although it is heavily regulated.

Habitat Preferences**—**American alligators are semi-aquatic animals, typically occurring in slow-moving rivers, large shallow lakes, swamps, marshes, bogs, ponds, creeks, canals, and bayous. They can only tolerate salt water for brief periods because they do not have specialized salt glands. Alligators, however, are tolerant of poor water quality and occasionally inhabit brackish marshes along the coast. Females of this species often build their nests in marshy areas and along coastlines.

Distribution**—**The American alligator is found in waters of the southeastern U.S. from the Virginia-North Carolina border to the Rio Grande in Texas. This species is most widespread in the inshore waters of Florida, although large populations also exist in the coastal areas of Georgia and Louisiana.

➢ Information Specific to Cherry Point and Southern VACAPES Inshore and Estuarine Areas—Since the northern limit of the American alligator's range lies at the Virginia-North Carolina border, it is likely that this species is not an abundant reptile in the study area. The available sighting and habitat suitability data, however, indicate that there are certain inshore areas in North Carolina where alligators may potentially aggregate (Figure 3-10). Areas of clustered occurrences include the tidal creeks, tributaries, and brackish water marshes adjacent to the New and Neuse Rivers, along the Intracoastal Waterway west of Bogue Banks, and inside the Swanquarter and Alligator River National Wildlife Refuges (refer to Figure 5-1). Although few sightings have been recorded on the west banks of the Alligator River, suitable habitat for alligators exists there (Figure 3-10). Alligators are not likely to be found in the ocean waters of the study area, nor out in the middle of the large sounds and bays.

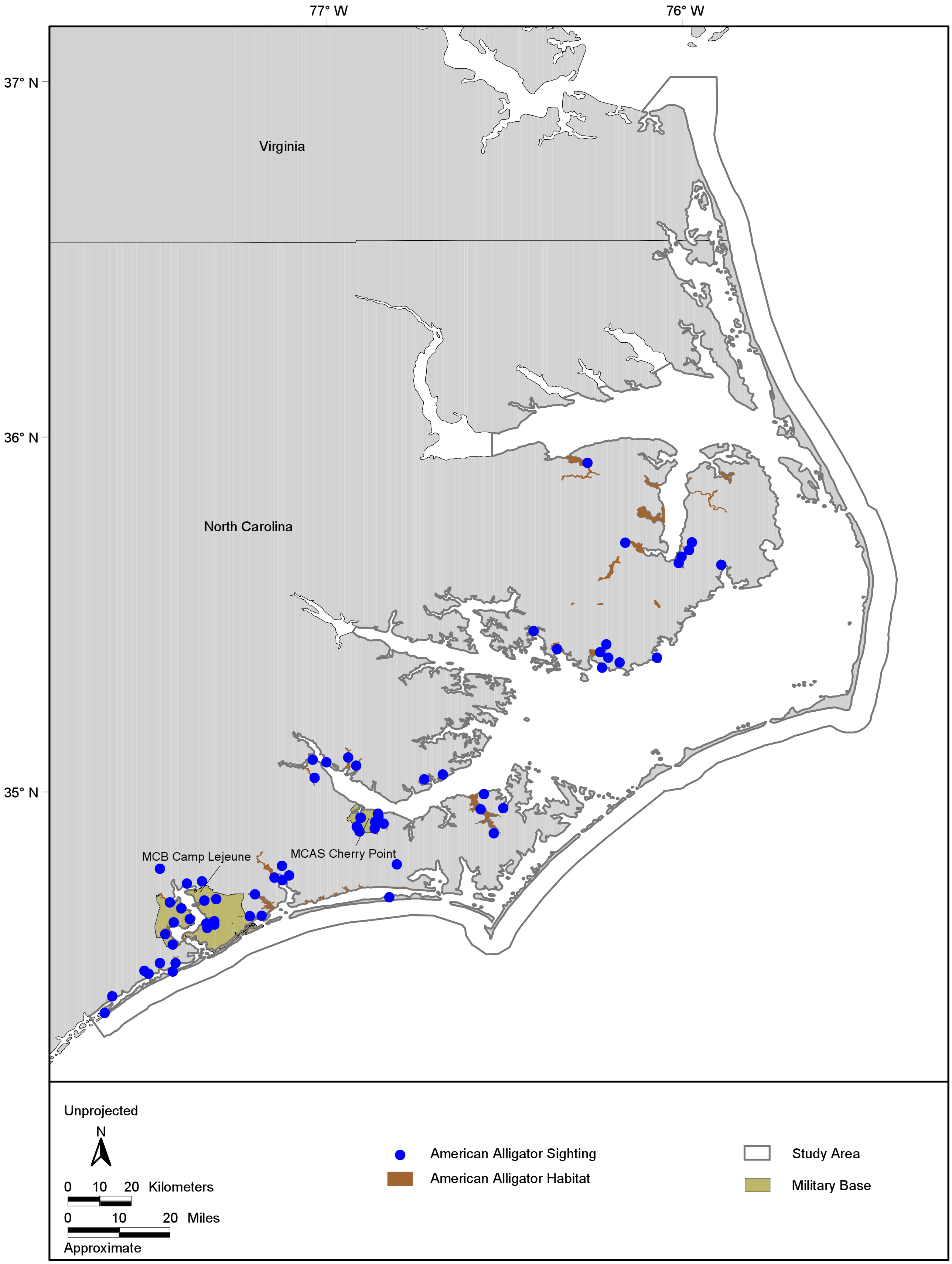

Figure 3-10. Distribution of American alligator sightings and suitable habitat within the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NOS (2001) and NCNHP (2002).

Even though they do not hibernate, alligators undergo periods of dormancy inside excavated caves and mud pits when the weather becomes cold. Thus, alligators inhabiting waters of the study area will be least active during the winter.

***Behavior and Life History*—**American alligators are primarily carnivorous animals that will eat just about anything they can catch, including snails, lizards, fish, snakes, turtles, small mammals, birds, crustaceans, and even small alligators (TPWD 2002). Alligators often swallow their prey whole, although large prey are often dragged underwater, drowned, and then devoured in pieces (NPCA 2002). Like sea turtles, alligators also have the potential to ingest anthropogenic debris (such as fishing lures and aluminum cans) during their foraging activities.

Males and females reach sexual maturity between the ages of 10 and 12 years. Breeding begins in April, as alligators emerge from their period of winter dormancy. Mating takes place during the night in shallow water. When ready to lay her eggs, the female will build a nest of leaves and vegetation up to 2 m across and a few meters high. She lays and buries her eggs in the center of this mound, allowing the warmth of the pile to incubate the eggs (high incubation temperatures will produce more males, low incubation temperatures will produce more females). Females typically lay over 50 eggs, with an incubation period of about 9 weeks. Unlike sea turtles, female alligators watch and defend their nest aggressively throughout the incubation period. As the young hatch, the female will assist them by digging them out of the nest. Newborn alligators will stay near the female for up to a year, as she will continue to protect them throughout this early juvenile period.

Female alligators usually remain in a small area. The males occupy areas greater than 10 km^2. Both males and females extend their ranges during the courting and breeding season. Young alligators remain in the area where they are hatched and are often found alongside their mothers. After two to three years, they leave their natal area in search of food, or are instead driven out by larger alligators.

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3.4 BIRDS

The Cherry Point and southern VACAPES inshore and estuarine areas and vicinity have been identified by ornithologists and wildlife managers as important areas for birds (Parnell and Soots 1979; Potter et al. 1980; Parnell and McCrimmon 1984; American Bird Conservancy 2002). Coastal aquatic habitats are used extensively by colonial waterbirds, waterfowl, and shorebirds. Terrestrial habitat along the coast is used for nesting by some species of colonial waterbirds and by a wide variety of neotropical songbird migrants (e.g., vireos and warblers) as a stopover site for feeding, resting, and roosting during migration (Fussell 1994). The Outer Banks of North Carolina has recently been designated as a globally Important Bird Area (IBA) because of the wide variety and abundance of nesting, migratory, and wintering birds (American Bird Conservancy 2002).

Colonial waterbirds, waterfowl, and shorebirds are protected by the Migratory Bird Treaty Act of 1918 (16 United States Code [USC] 703 et seq.). Unless permitted by regulations, this Act makes it unlawful to pursue, hunt, take, capture, or kill; attempt to take, capture or kill; possess, offer to sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product, manufactured or not. Most bird species are protected under the Act, with the exception of several species (e.g., house sparrows). Two bird species that occur in the study area are listed under the authority of the Endangered Species Act (ESA).

This section of the MRA provides information on the biodiversity, seasonal occurrence status and abundance, and habitat associations of birds that utilize aquatic habitats, as Navy training actions occur primarily in aquatic areas. Separate subsections are presented for colonial waterbirds, waterfowl, shorebirds, and the two federally-protected bird species that occur in the study area.

3.4.1 General Overview

Colonial waterbirds, waterfowl, and shorebirds are the dominant groups of birds that utilize aquatic habitats for feeding within the study area. A colonial waterbird is any bird that feeds predominantly in water and tends to nest in a group of closely associated nests (Speich 1986). Colonial waterbirds nest in terrestrial habitats (e.g., on natural and spoil islands, coastal habitats, and wetlands). Many colonial waterbird nest sites are known to occur in the study area (NCWRC 2002a). Waterfowl feed in aquatic and terrestrial habitats and nest in wetlands, in margins of aquatic habitats, and on Arctic tundra. Most waterfowl known from the study area are migrants and/or winter residents (Fussell 1994). A shorebird is a bird that uses the shallow water of open bays, ponds, lakes, reservoirs, coastal beaches, tidal flats, and grasslands for feeding. Shorebirds nest in coastal habitats (e.g., beaches, marshes, and tidal flats above the high tide mark) and in a variety of inland aquatic/terrestrial habitats. Most shorebird species (e.g., American golden plover) use the study area as a feeding area during migration on their way to nest on Arctic tundra or grasslands north of the study area, or on their return trip to wintering areas south of the study area.

3.4.1.1 Colonial Waterbirds

Colonial waterbirds of the study area include grebes, pelicans, cormorants, herons and egrets, ibises and storks, gulls, and terns. Fifty-eight species of colonial waterbirds are known to occur in the study area (Table 3-3). Colonial waterbird biodiversity is considered high in the study area because 62 % (58 of 93) of the colonial waterbird species with documented occurrences in North America north of Mexico occur or have occurred in or near the study area (Fussell 1994; Johnston 1997; AOU 1998).

Thirty-two of the 58 species are permanent residents or summer (June-July) residents that potentially nest or are known to nest in the study area (Fussell 1994). Common permanent residents include the great blue heron, great egret, snowy egret, laughing gull, ring-billed gull, and herring gull. Many colonial waterbird nesting sites occur in the study area, as these birds nest over a wide geographic area and within a variety of habitat types. Common colonial waterbirds in the study area include the brown pelican, great blue heron, great egret, snowy egret, little blue heron, tricolored heron, cattle egret, white ibis, glossy ibis, laughing gull, herring gull, gull-billed tern, royal tern, sandwich tern, Foster’s tern, common

Table 3-3. Colonial waterbirds found in the Cherry Point and southern VACAPES inshore and estuarine areas.

Class Aves[1]	Scientific Name[1]	Status[2]
Order Podicipediformes		
Family Podicipedidae		
Horned Grebe	*Podiceps auritus*	M, WR
Red-necked Grebe	*Podiceps grisegena*	M, WR
Eared Grebe	*Podiceps nigricollis*	M, WR
Order Pelecaniformes		
Family Sulidae		
Northern Gannet	*Morus bassanus*	M, WR
Family Pelecanidae		
American White Pelican	*Pelecanus erythrorhynchos*	R
Brown Pelican	*Pelecanus occidentalis*	R
Family Phalacorcrocorax		
Double-crested Cormorant	*Phalacrocorax auritus*	R
Great Cormorant	*Phalacrocorax carbo*	M, WR
Family Anhingidae		
Anhinga	*Anhinga anhinga*	R
Order Ciconiformis		
Family Ardeidae		
American Bittern	*Botarus lentiginosus*	R
Least Bittern	*Ixobrychus exilis*	M, SR
Great Blue Heron	*Ardea herodias*	R
Great Egret	*Ardea alba*	R
Snowy Egret	*Egretta thula*	R
Little Blue Heron	*Egretta caerulea*	R
Tricolored Heron	*Egretta tricolor*	R
Reddish Egret	*Egretta rufescens*	M, SR
Cattle Egret	*Bubulcus ibis*	M, SR
Green Heron	*Butoroides virescens*	M, SR
Black-crowned Night-Heron	*Nycticorax nycticorax*	R
Yellow-crowned Night-Heron	*Nyctanassa violacea*	M, SR
Family Threskiornithidae		
White Ibis	*Eudocimus albus*	R
Glossy Ibis	*Plegadis falcinellus*	M, SR
Family Plataleinae		
Roseate Spoonbill	*Ajaia ajaja*	SR
Family Ciconidae		
Wood Stork	*Mycteria americana*	V, S
Order Charadriiformes		
Family Laridae		
Pomarine Jaeger	*Stercorarius pomarinus*	M
Parasitic Jaeger	*Stercorarius parasiticus*	M, WR
Laughing Gull	*Larus atricilla*	R
Franklin's Gull	*Larus pipixcan*	M
Little Gull	*Larus minutus*	M, WR
Black-headed Gull	*Larus ribibunduss*	M, WR
Bonaparte's Gull	*Larus philadephia*	M, WR
Black-tailed Gull	*Larus crassirostris*	V
Mew Gull	*Larus canus*	V
Ring-billed Gull	*Larus delawarensis*	R

Table 3-3. Continued.

Class Aves[1]	Scientific Name[1]	Status[2]
California Gull	*Larus californicus*	V
Herring Gull	*Larus argentatus*	R
Yellow-legged Gull	*Larus cachinnans*	V
Thayer's Gull	*Larus thayeri*	V
Iceland Gull	*Larus glaucoides*	V, WR
Lesser Black-backed Gull	*Larus fuscus*	WR
Glaucous Gull	*Larus hyperboreus*	WR
Great Black-backed Gull	*Larus marinus*	R
Order Charadriidae[1]		
Family Laridae		
Sabine's Gull	*Xema sabini*	M
Black-legged Kittawake	*Rissa tridactyla*	M, WR
Gull-billed Tern	*Sterna nilotica*	M, SR
Caspian Tern	*Sterna caspia*	R
Royal Tern	*Sterna maxima*	R
Elegant Tern	*Sterna elegans*	V
Sandwich Tern	*Sterna sandvicensis*	M, SR
Roseate Tern	*Sterna dougallii*	M, SR
Common Tern	*Sterna hirundo*	R
Arctic Tern	*Sterna paradisaea*	M
Foster's Tern	*Sterna fosteri*	R
Least Tern	*Sterna antillarum*	M, SR
White-winged Tern	*Childonias leucopterus*	V
Black Tern	*Childonias niger*	M
Black Skimmer	*Rynchops niger*	R

[1] AOU 1998.
[2] Interpolated from Fussell 1994 and Johnston 1997

M = migrant R = resident S = summer
SR = summer resident V = vagrant WR = winter resident

tern, least tern, and black skimmer (Fussell 1994; NCWRC 2002a). Common spring (March-May) and fall (August-November) migrants include the northern gannet, double-crested cormorant, green heron, glossy ibis, ring-billed gull, herring gull, royal tern, common tern, least tern, and Foster's tern (Fussell 1994).

Many colonial waterbirds in the study area are opportunistic and use more than one of the habitat types found in the study area for feeding and nesting (see Chapter 2 for a discussion and maps of habitat types). Common to fairly common birds in coastal waters and open bay habitats include the brown pelican, double-crested cormorant, laughing gull, ring-billed gull, herring gull, least tern, royal tern, sandwich tern, Foster's tern, and common tern. Herons (e.g., little blue heron and tricolored heron) and egrets (e.g., great egret and snowy egret) feed in shallow water and use the margins of open bays and estuaries, salt marshes, and tidal flats. Coral patches, live/hard bottom areas, artificial reefs, and shipwrecks provide habitat for prey (e.g., fishes) that are important to many colonial waterbirds (e.g., cormorants, gulls, and terns). Spoil and barrier islands are the primary nesting and roosting habitat for many colonial waterbirds. Sandy beaches, tidal flats above the tide line, and islands are used by colonial waterbirds for resting and roosting especially during spring, fall, and winter.

3.4.1.2 Waterfowl

Geese, ducks, and swans are the primary groups of waterfowl that use the study area. Thirty-seven waterfowl species are known to occur in the study area (Table 3-4). Waterfowl biodiversity is considered high in the study area because 66% (37 of 56) of the waterfowl species with documented occurrences in North America north of Mexico occur or have occurred in or near the study area (Fussell 1994; Johnston 1997; AOU 1998).

Table 3-4. Waterfowl found in the Cherry Point and southern VACAPES inshore and estuarine areas.

Order Anseriformes[1]	Scientific Name[1]	Status[2]
Family Anatidae		
Fulvous Whistling-Duck	*Dendrocygna bicolor*	I
Greater White-fronted Goose	*Anser albifrons*	M, WR
Snow Goose	*Chen caerulescens*	M, WR
Ross's Goose	*Chen rossii*	M, WR
Canada Goose	*Branta canadensis*	M, WR
Brant	*Branta bernicla*	M, WR
Tundra Swan	*Cygnus columbianus*	M, WR
Wood Duck	*Aix sponsa*	FC, R
Gadwall	*Anas strepera*	M, WR
Eurasian Widgeon	*Anas penelope*	M, WV
American Widgeon	*Anas americana*	M, WR
American Black Duck	*Anas rubripes*	R
Mallard	*Anas platyrhynchos*	R
Blue-winged Teal	*Anas discors*	M
Cinnamon Teal	*Anas cyanoptera*	M, V
Northern Shoveler	*Anas clypeata*	M, WR
Northern Pintail	*Anas acuta*	M, WR
Green-winged Teal	*Anas carolinensis*	M, WR
Common Teal	*Anas crecca*	M, V
Canvasback	*Arthya valisiners*	M, WR
Redhead	*Aythya americana*	M, WR
Ring-necked Duck	*Aythya collaris*	M, WR
Greater Scaup	*Aythya marila*	M, WR
Lesser Scaup	*Aythya affinis*	M, WR
King Eider	*Somateria spectabilis*	M, V
Common Eider	*Somateria mollissima*	M, WR
Harlequin Duck	*Histrioncus histrioncus*	M, WR
Surf Scoter	*Melanitta perspicillata*	M, WR
White-winged Scoter	*Melanitta fusca*	M, WR
Black Scoter	*Melanitta nigra*	M, WR
Long-tailed Duck	*Clangula hyemalis*	M, WR
Bufflehead	*Bucephala albeola*	M, WR
Common Goldeneye	*Bucephala clangula*	M, WR
Hooded Merganser	*Lophodytes cucullatus*	M, WR
Common Merganser	*Mergus merganser*	M, WR
Red-breasted Merganser	*Mergus serrator*	M, WR
Ruddy Duck	*Oxyura jamaicensis*	M, WR

[1] AOU 1998.
[2] Interpolated from Fussell 1994 and Johnston 1997

FC = Fairly common	I = irruptive	M = migrant
R = resident	V = vagrant	WR = winter resident

Of the 37 waterfowl species, three (wood duck, American black duck, and mallard) nest or potentially nest in the study area (Fussell 1994). Most waterfowl in the study area are migrants and/or winter residents. Common to fairly common migrants and winter (December-February) residents include brant, snow goose, Canada goose, tundra swan, mallard, northern pintail, northern shoveler, gadwall, American widgeon, canvasback, redhead, ring-necked duck, lesser scaup, black scoter, surf scoter, bufflehead, hooded and red-breasted mergansers, and ruddy duck. Blue-winged teal is a common migrant but is not present in the study area during the winter (Fussell 1994; Johnston 1997).

Common to fairly common waterfowl of coastal waters, primarily during winter, are brant, lesser scaup, black scoter, and red-breasted merganser. These open water species dive for food, feeding on algae, crustaceans, mollusks, and fishes. Sounds and bays provide suitable wintering habitat for common species such as canvasback, redhead, and surf scoter. Estuarine habitats are used by most of the migrant and wintering waterfowl in the study area. Common waterfowl species of estuaries may include American black duck, mallard, northern pintail, gadwall, American widgeon, canvasback, ring-necked duck, bufflehead, and ruddy duck. Blue-winged teal favors salt marsh habitat. Most geese, with the exception of brant, use terrestrial habitats, and a wide variety of ducks that use estuarine habitats is also found on terrestrial impoundments (e.g., ponds) (Fussell 1994; Johnston 1997).

3.4.1.3 Shorebirds

Shorebirds include plovers, oystercatchers, avocets, stilts, and sandpipers. Forty-nine species of shorebirds have documented occurrences in the study area (Table 3-5). Shorebird biodiversity is considered high in the study area because 58% (49 of 84) of the shorebird species with documented occurrences in North America are known to occur in or near the study area (Fussell 1994; Johnston 1997; AOU 1998).

Summer shorebird species that nest in the study area include Wilson's plover, piping plover, American oystercatcher, black-necked stilt, and willet (Fussell 1994; Johnston 1997). Most shorebirds that occur in the region are spring and/or fall migrants. Common spring migrants are black-bellied plover, semipalmated plover, greater yellowlegs, lesser yellowlegs, whimbrel, ruddy turnstone, red knot, sanderling, semipalmated sandpiper, least sandpiper, dunlin, and short-billed dowitcher. Common fall migrants include black-bellied plover, semipalmated plover, greater yellowlegs, lesser yellowlegs, whimbrel, ruddy turnstone, red knot, sanderling, semipalmated sandpiper, western sandpiper, least sandpiper, dunlin, and short-billed dowitcher (Fussell 1994). Common shorebird species in winter include black-bellied plover, greater yellowlegs, sanderling, western sandpiper, and dunlin (Fussell 1994; Johnston 1997).

Migrant red-necked phalaropes and red phalaropes are the only shorebird species that may use open water coastal habitats in the study area. Many shorebird species are capable of using multiple habitats for feeding. American avocets often wade or swim to feed in open waters of bays and in tidal flats. Black-bellied plover and willet feed along margins of open bays with other migrant shorebirds. Typical shorebirds of sandy beaches are black-bellied plover, piping plover, Wilson's plover, sanderling, and red knot. Willets and whimbrels use salt marshes as feeding areas. Tidal flats are used extensively by a wide variety of resident and migrant shorebirds because of the rich and abundant food supply (e.g., crustaceans, polychaetes, and mollusks). Common tidal mudflat shorebird species are semipalmated plover, willet, whimbrel, marbled godwit, western sandpiper, dunlin, and short-billed dowitcher (Fussell 1994; Johnston 1997).

3.4.2 Threatened and Endangered Species

Two listed species of birds occur in the study area. One of the listed species, piping plover (*Charadrius melodus*), is a shorebird and a member of the family Charadriidae (sandpipers). The other, roseate tern (*Sterna dougallii*) is a colonial waterbird and a member of the family Laridae (gulls and terns).

Table 3-5. Shorebirds found in the Cherry Point and southern VACAPES inshore and estuarine areas.

Order Charadriiformes[1]	Scientific Name[1]	Status[2]
Family Charadriidae		
Black-bellied Plover	*Pluvialis squatarola*	M, R
American Golden Plover	*Pluvialis dominica*	M
Snowy Plover	*Charadrius alexandrius*	V
Wilson's Plover	*Charadrius wilsonia*	SR
Semipalmated Plover	*Charadrius semipalmatus*	R
Piping Plover	*Charadrius melodus*	R
Killdeer	*Charadrius vociferus*	R
Family Haematopodidae		
American Oystercatcher	*Haematopus palliatus*	R
Family Recurvirostridae		
Black-necked Stilt	*Himantopus mexicanus*	M, SR
American Avocet	*Recurvirostra americana*	R
Family Scolpacidae		
Greater Yellowlegs	*Tringa melanoleuca*	M, WR
Lesser Yellowlegs	*Tringa flavipes*	M, WR
Spotted Redshank	*Tringa eryerythropus*	V
Solitary Sandpiper	*Tringa solitaria*	M
Willet	*Catoptrophorus semipalmatus*	R
Wandering Tattler	*Heteroscelus incanus*	M, WR
Spotted Sandpiper	*Actitis macularia*	M
Upland Sandpiper	*Bartramia longicauda*	M
Whimbrel	*Numenius phaeopus*	M
Long-billed Curlew	*Numenius americana*	M, WR
Black-tailed Godwit	*Limosa limosa*	V
Hudsonian Godwit	*Limosa haemastica*	M
Bar-tailed Godwit	*Limosa lappronica*	V
Marbled Godwit	*Limosa fedoa*	M, WR
Ruddy Turnstone	*Arenaria interpres*	M, WR
Red Knot	*Caldris canutus*	M, WR
Sanderling	*Caldris alba*	M, WR
Semiplamated Sandpiper	*Caldris pusilla*	M
Western Sandpiper	*Caldris mauri*	M, WR
Red-necked Stint	*Caldris ruficollis*	M, WR
Little Stint	*Caldris minuta*	V
Least Sandpiper	*Caldris minutilla*	M
White-rumped Sandpiper	*Caldris fusicollis*	M
Baird's Sandpiper	*Caldris bairdii*	M
Pectoral Sandpiper	*Caldris melanotos*	M
Sharp-tailed Sandpiper	*Caldris acuminata*	V
Purple Sandpiper	*Caldris maritima*	M, WR
Dunlin	*Caldris alipina*	M, WR
Curlew Sandpiper	*Caldris ferruginea*	M
Stilt Sandpiper	*Caldris himantopus*	M
Buff-breasted Sandpiper	*Tryngites subruficollis*	M
Ruff	*Philomachus pugnax*	M
Short-billed Dowitcher	*Limnodromus griseus*	R, M
Long-billed Dowitcher	*Limnodromus scolopaceus*	M
Common Snipe	*Gallinago gallinago*	M, WR
American Woodcock	*Scolopax minor*	M, WR

Table 3-5. Continued

Order Charadriiformes[1]	Scientific Name[1]	Status[2]
Wilson's Phalarope	*Phalaropus tricolor*	M
Red-necked Phalarope	*Phalaropus lobatus*	M
Red Phalarope	*Phalaropus fulicaria*	M

[1] AOU 1998.
[2] Interpolated from Fussell 1994 and Johnston 1997

M = migrant R = resident V = vagrant
WR = winter resident SR = summer resident

♦ Piping Plover (*Charadrius melodus*)

Description—The piping plover is a small (152-198 millimeters [mm]) light-colored shorebird named for its melodious peep-peep song. Adults have pale grayish brown upperparts and white underparts. This coloration allows the piping plover to blend into the background of the sandy habitat it uses for nesting, foraging, and roosting (Terwilliger 1991).

On adult males, a black frontal bar extends from eye to eye across the front of the head. The forehead and lores are white. A black breast band, that may also at times be incomplete, is present across the chest. The bill is stubby and bicolored. The proximal half of the bill is orange while the distal half is black. Females differ only in the intensity of coloration on the frontal bar and breast band. These features are blackish-brown in breeding females and black in males. A bold white wing bar is visible in flight, and upon landing the dark distal center on the white tail is visible. In winter, the breast band is reduced to lateral patches and the bill is black. Juveniles look like winter adults (Terwilliger 1991).

Status—The piping plover was initially listed as a Category 2 candidate species on December 30, 1982 (USFWS 1982 in USFWS 2001). At the time of the listing, the USFWS defined a Category 2 candidate species as a species that might warrant listing as a threatened or endangered species in the future but that currently lacked sufficient data to support the listing. In November 1984, a proposal to list the species as threatened and endangered was published in the Federal Register (USFWS 1984 in USFWS 2001).

The piping plover was listed as endangered in the Great Lakes watershed (Illinois, Indiana, Michigan, northeastern Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario) and as threatened elsewhere within its range on December 11, 1985 (USFWS 1985 in USFWS 2001). The ruling classified all migratory piping plovers outside of the Great Lakes watershed and on their wintering grounds as threatened. No critical habitat was designated.

In 1996 and 1997, lawsuits were filed for failing to designate critical habitat for the Great Lakes and northern Great Plains populations of piping plover. The USFWS proposed critical habitat for all U.S. wintering piping plovers on July 6, 2000, because the Great Lakes, Great Plains, and Atlantic piping plover populations cannot be separated on their wintering grounds (USFWS 2000).

Critical habitat was defined in the ESA (Section 3[5][A]) as: "(I) The specific areas within the geographic area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (i) that are essential to the conservation of the species and (ii) that may require specific considerations or protection; and (II) special areas outside the geographic area occupied by the species at the time it is listed, upon determination that such areas are essential for the conservation of the species." "Conservation" means the use of all methods and procedures that are necessary to bring an endangered or threatened species to the point at which listing under the Act is no longer necessary. Thus, critical habitat areas should provide sufficient habitat to support the species at the population level and geographic distribution that are necessary for recovery. Proposed critical habitat for the wintering population of piping plover includes areas that are currently supporting the species, and also areas for which census data may be lacking but which contain habitat essential for the conservation of the species (USFWS 2000).

The final determinations of critical habitat for wintering piping plovers were made on July 10, 2001 (USFWS 2001). No critical habitat for wintering piping plovers was identified for Virginia. Critical wintering habitat was designated in North Carolina at various sites (units) along the Outer Banks (Appendix C).

The estimated number of breeding pairs of piping plovers in the U.S. Atlantic coast piping plover population, after a decline of 3% from 1997 through 1999, increased 4% from 1999 through 2000 and 6% from 2000 through 2001. In Virginia, the 2001 breeding population was 119 pairs. Based on data collected since 1986, the breeding population appears to be stable. In contrast, North Carolina's breeding population was only 23 pairs in 2001 and appears to be declining (USFWS 2002a).

***Habitat Preferences*—**The piping plover prefers sandy beaches from the dunes to the high tide line, or sandy alkaline shores of salty shallow lakes, for breeding. During migration, it uses a variety of coastal habitats and shorelines around lakes and ponds. In winter, it is found primarily on sandy beaches and tidal mudflats (AOU 1998).

***Distribution*—**Three piping plover populations, the Atlantic coast, Great Lakes, and northern Great Plains, are recognized by USFWS (2002a). The Atlantic coast population breeds in all Canadian Atlantic maritime provinces and along the eastern coast of the U.S. from Maine to South Carolina (Terwilliger 1991; AOU 1998). Piping plovers normally winter from coastal North Carolina south to the Gulf coast and Caribbean islands and along the eastern coast of Central America. The highest concentrations of wintering piping plovers are found in Florida, Louisiana, and Texas. However, only 63% of the breeding population were located during the 1991 winter census; other important wintering areas are unknown (USFWS 2002a).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Areas— In Virginia, the piping plover was historically classified as an uncommon transient and summer resident and a rare winter resident on the immediate coast and in lower Chesapeake Bay. An uncommon species was defined as a species that occurs in small numbers or in limited habitat. A rare species was defined as a species for which there are six or more occurrence records in the last 50 years. Species classified as rare cannot be expected with any certainty or they occur in very specific habitat and/or limited habitat (Virginia Society of Ornithology 1987). The distribution and abundance status of the species (Figure 3-11) is currently reported to be identical to that reported for the species historically (Johnston 1997).

  Extreme occurrence dates for migrants and summer resident piping plovers in Virginia range between March 15 and October 15. The breeding season ranges from April to early August. Most piping plovers breed north of the study area along Virginia's eastern shore. Seasonal peak counts were 65 at Chinoteague in spring 1969, 129 on the eastern shore barrier islands in summer 1982, 60 at Chinoteague in fall 1968, and 15 at Cape Charles in winter 1973 (Virginia Society of Ornithology 1987).

  No current occurrences for piping plover have been documented in the coastal areas of Virginia Beach (USFWS 2002b). Although uncommon, piping plovers have been located on beaches between Fort Story and False Cape State Park (Johnston 1997). The nearest recent breeding sites to the study area are at Craney Island and Grandview Beach in the Chesapeake Bay area (Figure 3-12). At Craney Island, one to five pairs of breeding piping plovers were present from 1989 through 1997; three to five pairs of breeding piping plovers were present at Grandview Beach from 1986 through 1991 (Table 3-6).

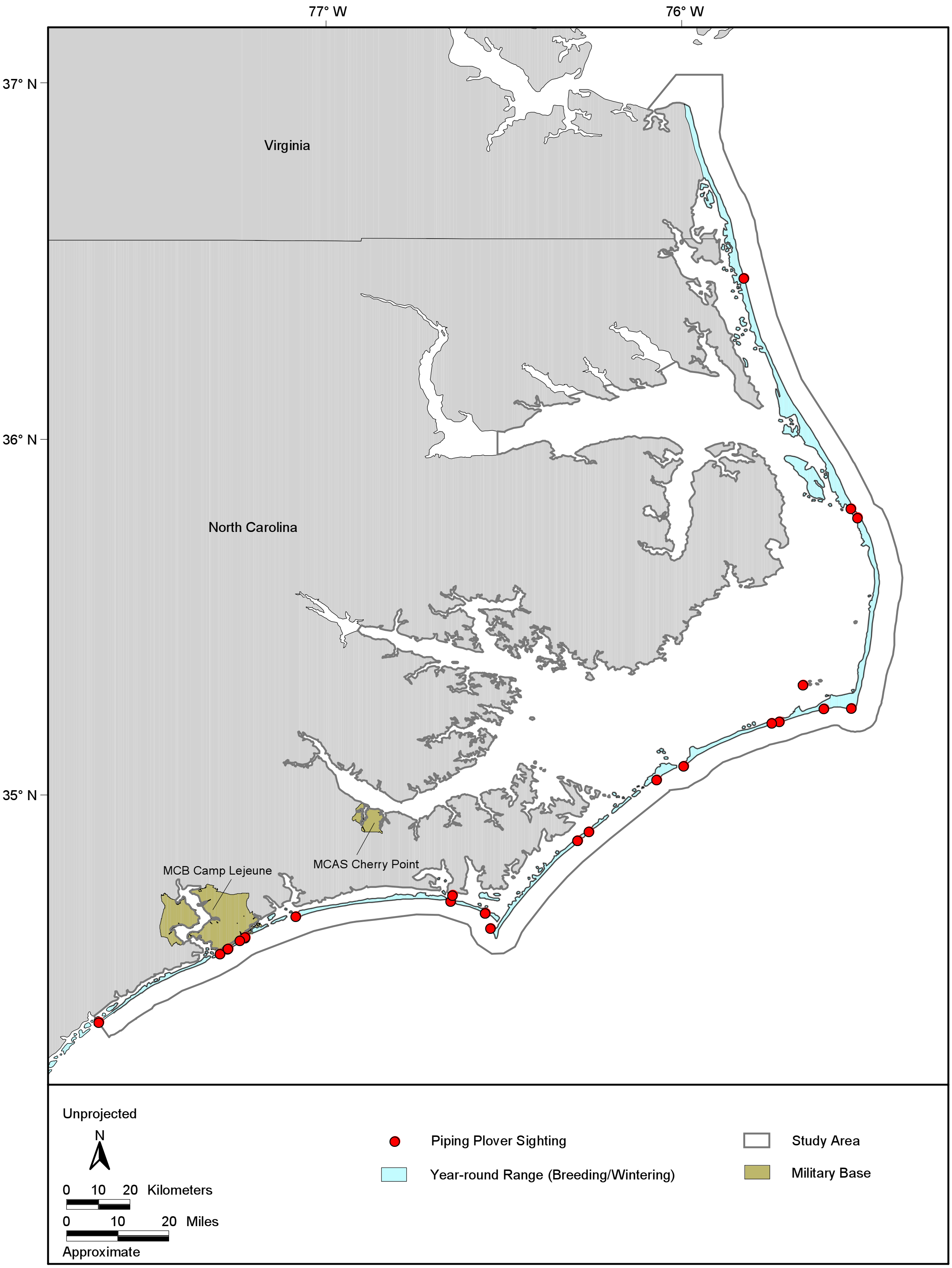

Figure 3-11. Distribution and sightings of piping plovers in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NOS (2001) and NCNHP (2002). Map adapted from: USFWS (1996).

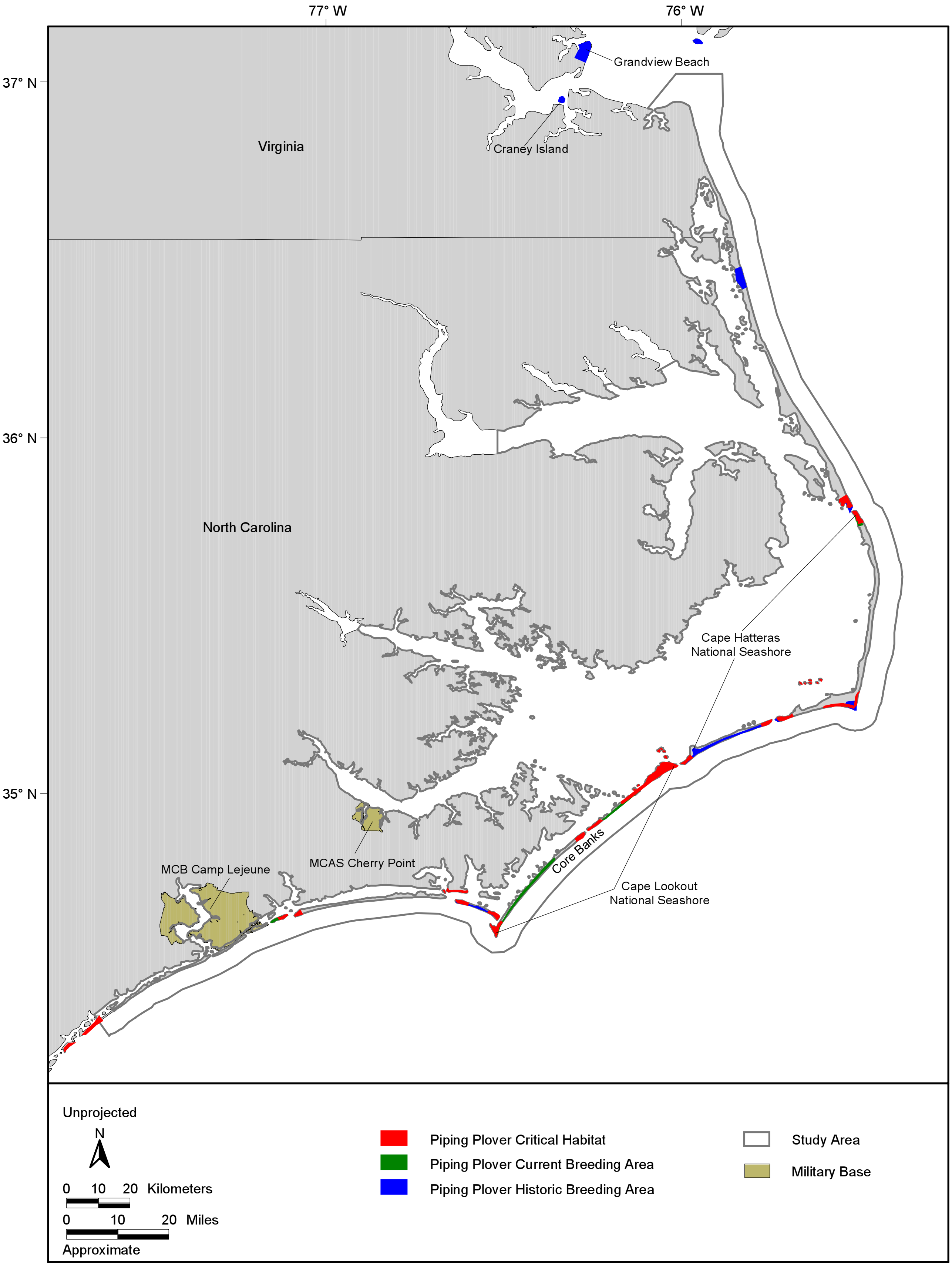

Figure 3-12. Piping plover habitat and breeding areas in the Cherry Point and southern VACAPES inshore and estuarine areas. Source map (scanned): USFWS (2001). Source information: USFWS (1996).

Table 3-6. Observations of piping plovers in the southeastern Virginia section of the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity (1986-2001).

General Location	Date	No.	Reference
Grandview (Hampton), VA	May 31,1986	8	Armistead 1986; VDGIF 2002
Grandview (Hampton), VA	Spring 1988	8	Armistead 1988; VDGIF 2002
Craney Island, VA	Spring-Summer 1988	2	VDGIF 2002
Grandview (Hampton), VA	May 19, 1990	8	Armistead 1990a; VDGIF 2002
Craney Island, VA	Spring-Summer 1990	8	VDGIF 2002
Grandview (Hampton), VA	Spring-Summer 1991	6	VDGIF 2002
Craney Island, VA	Spring-Summer 1991	6	VDGIF 2002
Grandview (Hampton), VA	Spring-Summer 1992	1	VDGIF 2002
Craney Island, VA	Spring-Summer 1992	6	VDGIF 2002
Craney Island, VA	Spring-Summer 1993	10	VDGIF 2002
Craney Island, VA	Spring-Summer 1994	10	VDGIF 2002
Craney Island, VA	Spring-Summer 1995	8	VDGIF 2002
Craney Island, VA	Spring-Summer 1996	6	VDGIF 2002
Craney Island, VA	Spring-Summer 1997	1	VDGIF 2002

Piping plovers rarely winter in the Virginia section of the study area. Two piping plovers were found during the Cape Charles Christmas Bird Count (CBC), just north of the study area, in late December 1990 and 1994 (National Audubon Society 1990, 1994).

In North Carolina, piping plovers historically occurred along coastal beaches from the Virginia border to Shackleford Banks near Morehead City and were classified as a fairly common winter resident along the Carolina coast from late August to early May (Potter et al. 1980). Fussell (1994) recently classified the piping plover as an uncommon year-round resident in coastal North Carolina. Breeding has been documented from the Virginia/North Carolina border south to Bird Isle on the border of North Carolina and South Carolina (Table 3-7). Major breeding areas include Cape Lookout National Seashore, Cape Hatteras National Seashore, and Core Banks (Table 3-7; Table 3-8; Figure 3-12). During fall migration, piping plovers are fairly common (Table 3-8). Piping plovers winter on the North Carolina Outer Banks (Table 3-9). Additional winter observations of piping plovers include 18 in Beaufort during the winter of 1988-1989 (LeGrand 1989b), 34 on Portsmouth Island on December 4, 1993 (Davis 1994b), 29 on Portsmouth Island on December 29, 2000 (Davis 2001), and 20 on Shackleford Banks on February 8, 2001 (Davis 2001). The abundance of wintering piping plovers generally increases from north to south on the Outer Banks during most winters (Table 3-9).

Behavior and Life History—Piping plovers breed only in North America and winter primarily from North Carolina to Florida and the Gulf coast in North America, south into the Caribbean (including the Bahamas and Greater Antilles), and south to the Yucatan Peninsula (AOU 1998). Nesting sites include coastal beaches, sandflats at the end of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, washover areas cut into or between dunes, and sites where suitable dredge material has been deposited. All nest sites are located above the high tide line (USFWS 1996). Arrival time on the breeding/nesting sites ranges from mid-March to mid-May. The nesting season is three to four months long. Three to four eggs are laid in a shallow scrape on a sand substrate that may be lined with pebbles and shell fragments. The eggs, which are incubated by both parents, hatch in 30 days. Fledging requires another 30 days (USFWS 2002c).

Table 3-7. Breeding pairs of piping plovers in the North Carolina section of the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity.

Number of Piping Plover Breeding Pairs in North Carolina

Location	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
South Topsail			1	1	0	1	1	0	--	0	0.5	0	1	0.5	1	1
North Topsail			0		0		--	0	--	0	0	0	--	0	0	0
Onslow Beach			0		0		--	0	--	0	0	0	--	0	0	0
Bear Island			0		0		--	0	--	0	0	0	--	0	0	0
Bald Head Island			0		0		0	0	--	0	0	0	0	0	0	0
Emerald Isle			0		0		--	0	--	0	0	0	0	0	0	0
Fort Macon			0		0		--	0	--	0	0	0	--	--	0	0
Bird Shoals			0		0		--	0	--	0	0	0	0	0	0	--
Cape Lookout Shackleford			1		--	--	--	--	--	0	--	0		0	0	0
Cape Lookout South Core Banks			6		9	6	7	7	6	5	4	6			4	2
Cape Lookout Middle Core Banks															2	0
Cape Lookout North Core Banks			28		15	28	28	32	29	13	32	26	21	16	10	11
Cape Hatteras National Seashore			15	14	4	12	12	11	14	13	11	9	4	4	3	2
Pea Island National Wildlife Refuge	1		0		0		--	0		1	2	1	2	2	1	2
Corolla and North to Virginia	3		3		0	2	2	2		0	--	0	0	0	0	0
Total	**4**		**44**	**15**	**28**	**49**	**50**	**52**	**49**	**32**	**49**	**42**	**28**	**22**	**21**	**18**

Blank space = Site specific data unavailable
Dashes = Location not surveyed
Zero = No plovers observed
0.5 = unpaired piping plover

Source: NCWRC 2002b

Table 3-8. Summer and fall observations of piping plovers in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity (1986-2001).

General location by season	Date	No.	Reference
Summer (June-July)			
Cape Lookout NS, NC	June 28-29, 1986	50	LeGrand 1986
Luark Hill to Currituck NWR, NC	Summer 1987	10	LeGrand 1987
North Core Banks, NC	Summer 1992	56	LeGrand 1993
North Core Banks, NC	Summer 1993	54	Davis 1993a
Cape Hatteras NS, NC	Summer 1993	24	Davis 1993a
Fall (August-November)			
Portsmouth Island, NC	October 4, 1991	91	LeGrand 1992
New Drum Inlet, NC	August 20, 1993	26	Davis 1994b
Portsmouth Island, NC	August 20, 1993	110	Davis 1994b
Portsmouth Island, NC	August 1, 1995	63	Davis 1996
Oracoke, NC	September 11, 2000	22	Davis 2001

Feeding habitats of breeding piping plovers include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, shorelines of coastal ponds, lagoons, and salt marshes (USFWS 1996). Piping plovers glean (pick) and probe the substrate for a variety of small invertebrates (marine worms, crustaceans, mollusks, insects, and the eggs and larvae of many marine invertebrates) (Terwilliger 1991).

Piping plovers generally depart for wintering grounds from mid-July through mid-October (USFWS 2002c). In winter, Atlantic coast piping plovers are found along sandy peninsulas, at accreting ends of barrier islands, and near coastal inlets.

♦ Roseate Tern (*Sterna dougallii*)

Description—The roseate tern is a medium-sized (40.64 centimeters [cm] long) tern with pale upperparts and light underparts. Breeding adults have a black head cap that extends over the dorsal surface of the head onto the neck (nape). The bill is long and slender. Early in the breeding season, the basal half of the black bill becomes red. The upperparts are a very pale gray and the underparts are white. The white breast is washed variably with pink. The wings are as pale as the back. In flight, the first three to four primaries show a dorsal black and white pattern. The white forked tail is very long. The legs and feet are red. In winter, the black feathers on the forehead are white and the bill is all black. Juvenile roseate terns have a gray forehead and a black cap that extends from above the eye to the nape. The juvenile's back is similar to or darker gray than the adult's back. At close range, the prominent black "V" marking on the back of the juveniles separates roseate terns from other juvenile medium-sized terns (Nisbet 1992).

Status—The roseate tern was initially listed as a Category 2 candidate species on December 30, 1982 (USFWS 1982 in USFWS 2002d). The USFWS defined a Category 2 candidate species as a species that might warrant listing as threatened or endangered but that the USFWS had insufficient data to support the listing at that time. On November 4, 1986, a proposal to list the northeastern (North Atlantic) population of the species as endangered was published in the Federal Register (USFWS 1986 in USFWS 2002d). The northeastern population of the roseate tern was listed as endangered on November 2, 1987 (USFWS 2002c). In the U.S., this designation includes the entire Atlantic coast from Maine to and including North Carolina.

Table 3-9. Winter observations of piping plovers in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity during National Audubon Society Christmas Bird Counts (1986-1999).

General Location	Date	No.	Reference
Morehead City, NC	December 21, 1986	1	National Audubon Society 1986
Bodie-Pea Island, NC	December 29, 1986	10	National Audubon Society 1986
Southpark/Bald Head/Oak Is., NC	January 1, 1987	1	National Audubon Society 1986
Ocracoke Island, NC	January 1, 1987	1	National Audubon Society 1986
Morehead City, NC	December 20, 1987	25	National Audubon Society 1987
Cape Hatteras, NC	December 30, 1987	1	National Audubon Society 1987
Southpark/Bald Head/Oak Is., NC	January 2, 1988	1	National Audubon Society 1987
Ocracoke Island, NC	January 2, 1988	1	National Audubon Society 1987
Morehead City, NC	December 28, 1988	17	National Audubon Society 1988
Bodie-Pea Island, NC	December 29, 1988	1	National Audubon Society 1988
Ocracoke Island, NC	December 31, 1988	4	National Audubon Society 1988
Portsmouth Island, NC	January 2, 1989	5	National Audubon Society 1988
Morehead City, NC	December 17, 1989	9	National Audubon Society 1989
Cape Hatteras Island, NC	December 27, 1989	1	National Audubon Society 1989
Bodie-Pea Island, NC	December 28, 1989	1	National Audubon Society 1989
Morehead City, NC	December 16, 1990	7	National Audubon Society 1990
Portsmouth Island, NC	December 30, 1990	1	National Audubon Society 1990
Southpark/Bald Head/Oak Is., NC	January 1, 1991	4	National Audubon Society 1990
Morehead City, NC	December 15, 1991	8	National Audubon Society 1991
Cape Hatteras, NC	December 17, 1991	2	National Audubon Society 1991
Morehead City, NC	December 20, 1992	6	National Audubon Society 2002
Cape Hatteras, NC	December 30, 1992	8	National Audubon Society 2002
Portsmouth Island, NC	January 2, 1993	21	National Audubon Society 2002
Southpark/Bald Head/Oak Is., NC	January 3, 1993	1	National Audubon Society 2002
Cape Hatteras, NC	December 25, 1993	11	National Audubon Society 2002
Morehead City, NC	December 25, 1993	7	National Audubon Society 2002
Southpark/Bald Head/Oak Is., NC	December 25, 1993	1	National Audubon Society 2002
Morehead City, NC	December 14, 1994	13	National Audubon Society 1994
Bodie-Pea Island, NC	December 29, 1994	5	National Audubon Society 1994
Cape Hatteras, NC	December 30, 1994	2	National Audubon Society 1994
Ocracoke Island, NC	January 1, 1995	3	National Audubon Society 1994
Southpark/Bald Head/Oak Is., NC	January 1, 1995	1	National Audubon Society 1994
Morehead City, NC	December 16, 1995	12	National Audubon Society 1995
Cape Hatteras, NC	December 27, 1995	3	National Audubon Society 1995
Southpark/Bald Head/Oak Is., NC	December 31, 1995	3	National Audubon Society 1995
Morehead City, NC	December 22, 1996	9	National Audubon Society 1996
Bodie-Pea Island, NC	December 28, 1996	1	National Audubon Society 1996
Morehead City, NC	December 21, 1997	18	National Audubon Society 1997
Bodie-Pea Island, NC	December 29, 1997	5	National Audubon Society 1997
Cape Hatteras, NC	December 30, 1997	9	National Audubon Society 1997
Ocracoke Island, NC	January 2, 1998	6	National Audubon Society 1997
Cape Hatteras, NC	December 30, 1998	10	National Audubon Society 2002
Morehead City, NC	December 20, 1998	16	National Audubon Society 2002
Portsmouth Island, NC	December 31, 1998	4	National Audubon Society 2002
Ocracoke Island, NC	January 1, 1999	4	National Audubon Society 2002

The roseate tern nesting population has been decimated in the northeastern U.S. by hunting for the millinery trade. The population recovered with the enactment of the Migratory Bird Treaty Act of 1918. By the 1930s, the roseate tern population had recovered to 8,500 pairs. By 1952, the population had declined to 4,800 pairs, and by 1977, the population had reached a low of 2,500 pairs. As of 1990, the population was fluctuating between 2,500 and 3,300 individuals (World Wildlife Fund 1990).

Currently, roseate terns are not known to nest south of Long Island, NY in the U.S. In 2001, the nesting population in the northeastern U.S. (i.e., coastal New England) was 3,717, a decrease of 593 from 2000 (Amaral 2002).

Habitat Preferences—The roseate tern prefers coastal waters, bays, and estuaries with islands during the breeding season. Primary nesting sites are on islands where it uses sandy beaches and open bare ground with nearby grassy areas. The species usually nests exclusively in colonies of common terns. During migration, the species is pelagic (open ocean) and winters in the open ocean off South America (Nisbet 1992; AOU 1998). No critical habitat has been designated for the species in the study area.

Distribution**—**The roseate tern was historically found along the eastern coast of Canada and the U.S. and throughout the islands of the Atlantic and Caribbean (World Wildlife Fund 1990). The roseate tern's breeding range is now restricted to a few islands off Nova Scotia, New England, New York, and Florida. The species is a pelagic migrant and summer (nonbreeding) visitor along the east coast of the U.S. (i.e., south of known breeding areas).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Areas**—** In Virginia, the roseate tern was historically classified as a rare transient and summer visitor along the coast. A rare species was defined as a species for which there are six or more occurrence records in the last 50 years. Species classified as rare cannot be expected with any certainty or they occur in very specific habitat and/or limited habitat (Virginia Society of Ornithology 1987).

  Extreme occurrence dates in Virginia ranged between April 6 and September 20. The species formerly nested irregularly north of the study area along the east shore of Virginia. The last documented breeding record was in 1927. The peak count for the species was 10 at Fisherman Island in 1927 (Virginia Society of Ornithology 1987). The species is currently classified as a rare migrant and summer resident in Chesapeake Bay and along the Virginia coast (Johnston 1997) (Figure 3-13).

  In North Carolina, the roseate tern was historically classified as a rare coastal migrant. At that time, a rare species was a species that would be expected no more than once per year. The roseate tern nested near the Core Banks in Carteret County during the summer of 1973 (Potter et al. 1980), which apparently was the last known nesting record for roseate tern in North Carolina. Currently, the roseate tern is a rare to uncommon migrant and nonbreeding summer resident. The species normally occurs from the third week of May through the second week in September (Fussell 1994).

  Observation records from 1986 through 2001 indicate that small numbers of roseate terns were present almost year round in the study area (Figure 3-14). More observations were made in North Carolina than in Virginia (Table 3-10).

  Most observations were made in spring and summer. The earliest observation date was May 6, 2000; the latest observation date was September 24, 1989. Most observations involved one to three individuals. Some of these roseate terns were spring/fall migrants while others lingered through the summer. Nesting was not reported for any individuals that spent the summer in the study area.

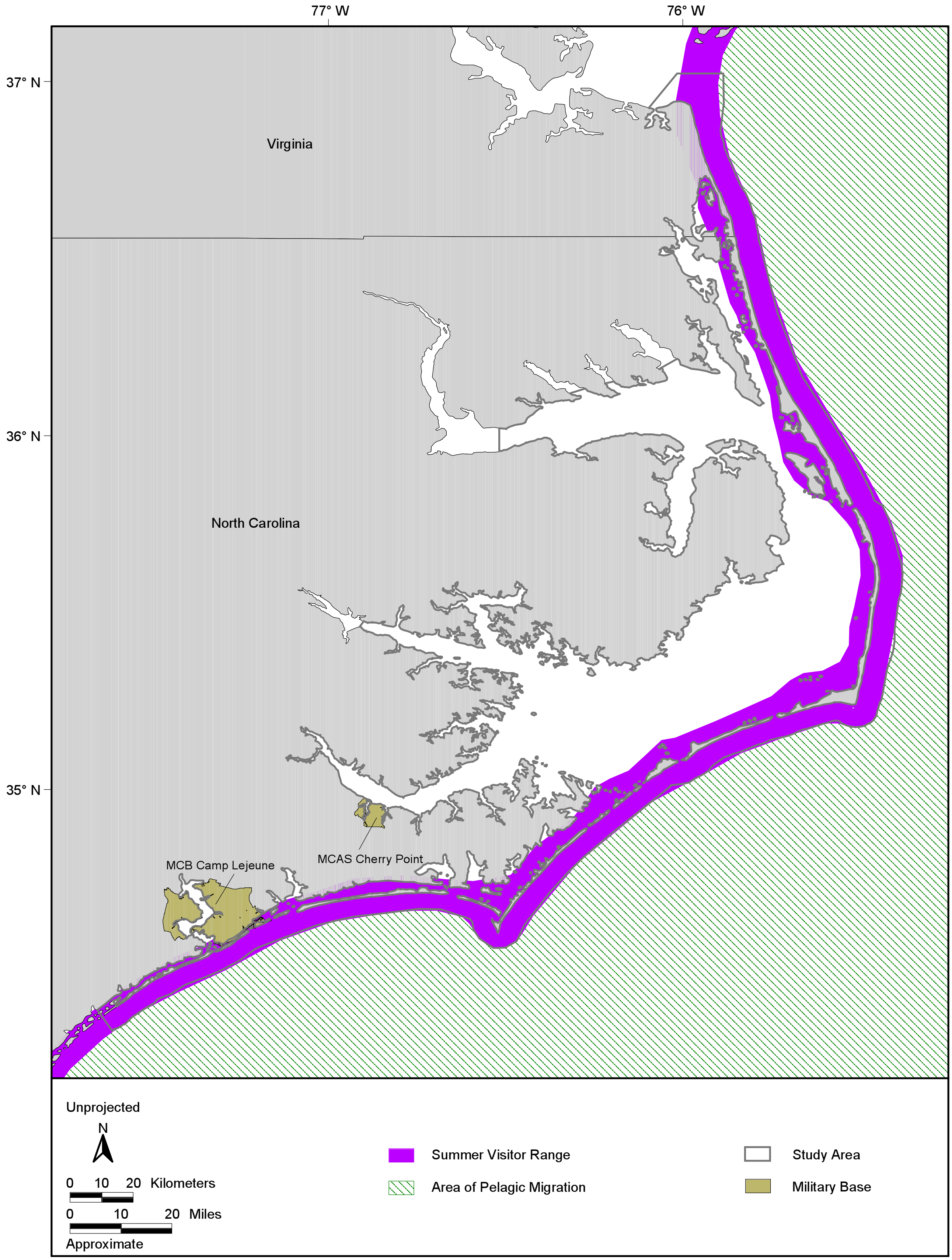

Figure 3-13. Range of the roseate tern in the Cherry Point and southern VACAPES inshore and estuarine areas. Map adapted from: National Geographic Society (1999).

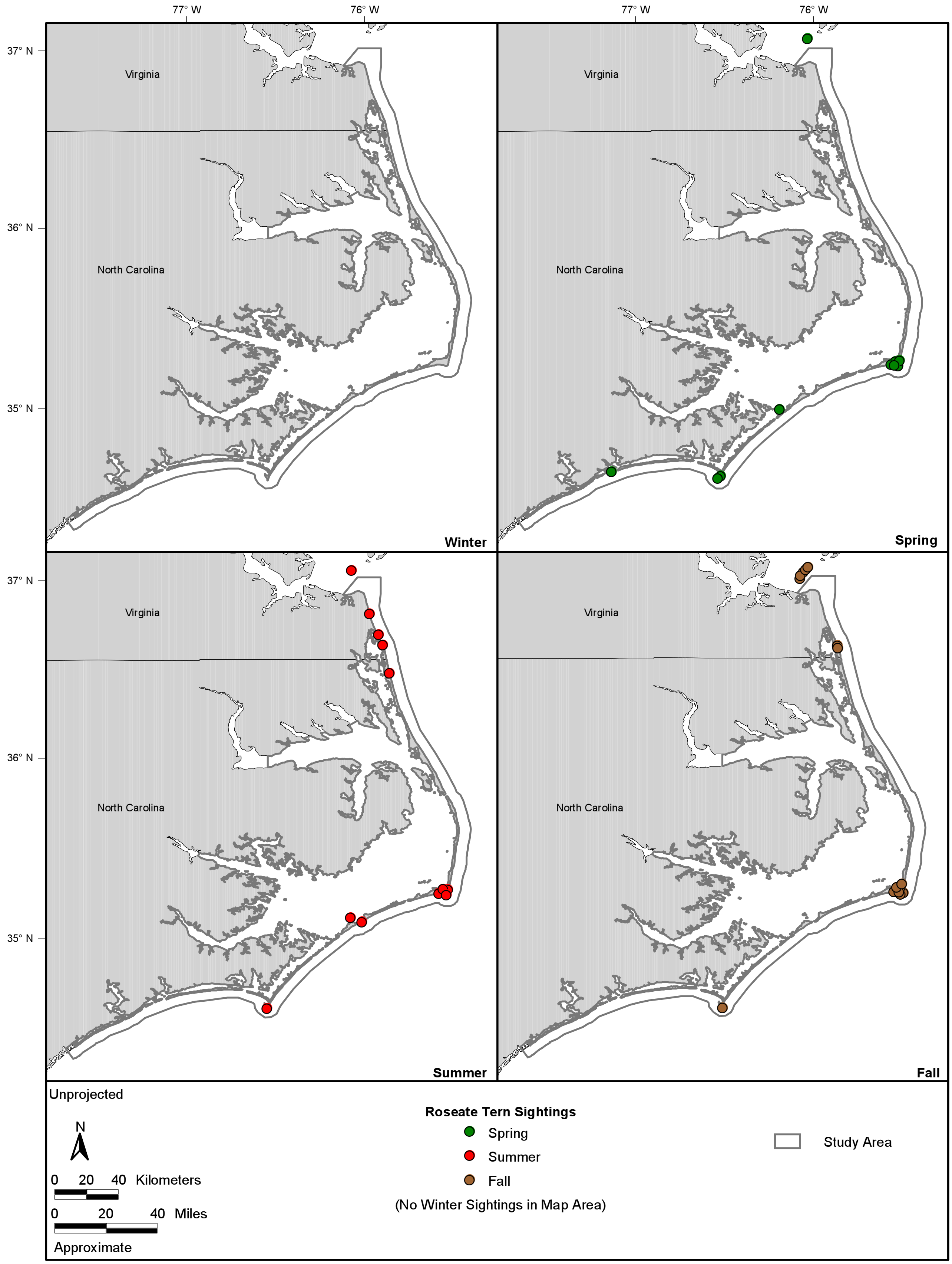

Figure 3-14. Sightings of roseate terns in the Cherry Point and southern VACAPES inshore and estuarine areas. Source information: refer to Table 3-10.

Table 3-10. Observations of roseate terns in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity (1986-2001).

General location by season	Date	No.	Reference
Spring (March-May)			
Chesapeake Bay Bridge Tunnel, VA	May 18-24, 1992	1	Armistead 1992a
North Core Banks, NC	May 29, 1992	1	Armistead 1992a
Cape Hatteras Point, NC	Spring 1993	NR	Davis 1993b
Core Banks, NC	Spring 1993	NR	Davis 1993b
Cape Hatteras Point, NC	May 10, 1994	4	Davis 1994c
Cape Lookout, NC	May 24, 1994	2	Davis 1994c
Cape Hatteras Point, NC	May 21-28, 1995	2-5	Davis 1995b
Cape Hatteras Point, NC	May 13-31, 1997	1-3	Davis 1997a
Cape Lookout, NC	May 16, 1998	2	Davis 1998
Bear Island (Onslow), NC	May 23, 1998	2	Davis 1998
Cape Hatteras Point, NC	May 26-31, 1998	1	Davis 1998
Summer (June, July)			
Cape Hatteras National Seashore, NC	June 27-July 27, 1987	2-3	LeGrand 1987
Corolla, NC	July 24, 1987	1-2	LeGrand 1987
Cape Hatteras Point, NC	July 3-4, 1988	1-2	LeGrand 1987
Back Bay NWR, VA	June 17, 1989	1	Armistead 1989
Ocracoke Inlet, NC	July 13, 1989	1	LeGrand 1990a
Cape Hatteras Point, NC	July 22-29, 1989	1	LeGrand 1990a
Cape Lookout, NC	June 11, 1990	1	LeGrand 1991a
Cape Hatteras Point, NC	June 26, 1990	1	LeGrand 1991a
Bodie Island, NC	July 24, 1991	2	LeGrand 1987
Cape Hatteras Point, NC	June 1, 1992	2	LeGrand 1993
North Core Banks, NC	June 1, 1992	2	LeGrand 1993
Portsmouth Island, NC	June 2-July 30, 1993	1	LeGrand 1993
Sandbridge, VA	July 13, 1996	2	Illiff 1996
Chesapeake Bay Bridge Tunnel, VA	July 14, 1996	1	Illiff 1996
Fall (August-October)			
Back Bay NWR, VA	August 17, 1986	2	Armistead 1987
Chesapeake Bay Bridge Tunnel, VA	August 17, 1986	1	Armistead 1987
Back Bay NWR, VA	August 30, 1986	1	Armistead 1987
Cape Hatteras Point, NC	August 19, 1987	1	LeGrand 1988
Cape Hatteras Point, NC	August 20-29, 1988	1	LeGrand 1989b
Cape Hatteras Point, NC	August 19, 1989	1	LeGrand 1990b
Chesapeake Bay Bridge Tunnel, VA	September 24, 1989	1	Armistead 1990b
Cape Hatteras Point, NC	September 3, 1990	1	LeGrand 1991b
Cape Hatteras Point, NC	August 25, 1991	2	LeGrand 1992
Cape Lookout, NC	September 20, 1991	1	LeGrand 1992
Back Bay NWR, VA	August 5, 1992	3	Armistead 1992b
Chesapeake Bay Bridge Tunnel, VA	September 6, 1992	1	Armistead 1992b
Cape Hatteras Point, NC	September 2-3, 1994	7	Davis 1995b
Cape Hatteras Point, NC	August 2, 1996	3	Davis 1997b
Chesapeake Bay Bridge Tunnel, VA	August 27, 1998	1	Illiff 1999
Cape Hatteras Point, NC	September 6, 2000	7	Davis 2001
Chesapeake Bay Bridge Tunnel, VA	September 6, 2000	1	Illiff 2001

NR = Not Reported NWR = National Wildlife Refuge

Behavior and Life History—The roseate tern is a long distance pelagic migrant that breeds during the summer in northeastern North America and the Caribbean and winters off South America. Breeding does not begin until it is three or four years old. Nesting occurs primarily on small offshore islands, barrier islands, rocks, cays, and islets with other colonial nesting birds. Nests are occasionally found on sandy beaches. The nest is located near vegetation or jagged rock, on narrow ledges of emerging rock near the waterline, and among coral rubble. The nest sites are usually concealed under vegetation, boulders, or driftwood rubble (World Wildlife Fund 1990; USFWS 2002e). The eggs are laid among rocks or on sand at a chosen nest site; nests are occasionally lined with beach grass, seaweed, or rubbish. Eggs are incubated for 21 to 26 days; fledging occurs in 27 to 30 days after hatching (Ehrlich et al. 1988). Roseate terns catch fish, their primary prey, by plunge diving (World Wildlife Fund 1990).

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3.5 MARINE MAMMALS

3.5.1 Introduction

The majority of the marine mammal species found in the Cherry Point and southern VACAPES inshore and estuarine areas (study area) belong to the order Cetacea (whales, dolphins, and porpoises). Cetaceans are divided into two major suborders: Mysticeti and Odontoceti (baleen and toothed whales, respectively). Odontocetes (toothed whales) use teeth to capture prey, whereas mysticetes (baleen whales) use baleen plates to filter their food from the water. Beyond contrasts in feeding methods, there are also life history and social organization differences (Tyack 1986). The West Indian manatee is the only sirenian species occurring along the U.S. Atlantic coast. The suborder Pinnipedia (part of the order Carnivora) is represented in this area by extralimital occurrences of hooded, gray, harp, and harbor seals.

3.5.1.1 Adaptations to the Marine Environment: Sound Production and Reception

Cetaceans display a number of anatomical and physiological adaptations to an aquatic environment that are discussed in detail by Pabst et al. (1999). Sensory changes from the basic mammalian scheme have also taken place in response to the different challenges an aquatic environment imposes. Sound travels further in water than in air and is, therefore, an important sense, although taste, touch, and sight are also well developed in whales and dolphins (Wartzok and Ketten 1999). Marine mammal vocalizations often extend both above and below the range of human hearing; vocalizations with frequencies lower than 18 hertz (Hz) are labeled as infrasonic and those higher than 20 kilohertz (kHz) as ultrasonic. Baleen whales primarily use the lower frequencies, producing tonal sounds in the frequency range of 20 to 3,000 Hz, depending on the species. The toothed whales produce a wide variety of sounds, which include species-specific broadband “clicks” with peak energy between 10 and 200 kHz, individually variable burst pulse click trains, and constant frequency or frequency-modulated whistles ranging from 4 to 16 kHz (Wartzok and Ketten 1999). Many toothed whales produce both tonal vocalizations (whistles) used for communication, and broadband clicks used during echolocation (Wartzok and Ketten 1999). Sperm whales, however, are known to produce only clicks, which may be used for communication and echolocation. Data on the hearing abilities of cetaceans are sparse, particularly for the larger cetaceans such as baleen whales. The auditory thresholds of some of the smaller odontocetes have been determined in captivity. It is generally believed that cetaceans should at least be sensitive to the frequencies of their own vocalizations. Comparisons of the anatomy of cetacean inner ears and models of the structural properties and the response to vibrations of the ear’s components in different species provide an indication of likely sensitivity to various sound frequencies. The ears of small toothed whales are optimized for receiving high frequency sound, while baleen whale inner ears are best in low to infrasonic frequencies (Ketten 1992, 1997). General reviews of cetacean sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), and Au et al. (2000). 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.

3.5.1.2 Marine Mammal Distribution and Habitat Associations

Cetaceans inhabit most marine environments, from deep ocean canyons to shallow estuarine waters. They are not, however, randomly distributed. Cetacean distribution is affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Bjørge 2002; Forcada 2002; Stevick et al. 2002).

Whale and dolphin movements are often related to feeding or breeding activity (Stevick et al. 2002). Some baleen whale species, such as humpback and North Atlantic right 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). These 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). Not all baleen whales, however, migrate. Some individual fin, Bryde’s, minke, and blue whales may stay year-round in a specific area. 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). Since most toothed whales do not have the fasting capability of the baleen whales, toothed whales probably follow seasonal shifts in preferred prey or are opportunistic feeders, taking advantage of whatever prey happens to be in the area. 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 making migratory movements in response to increasing or decreasing water temperatures. Water temperature may either directly affect migration by acting as a thermal barrier to dolphin movement or indirectly by affecting prey movements (Barco et al. 1999).

As already noted, cetacean movements are often a reflection of the distribution and abundance of prey (CETAP 1982; Gaskin 1982; Payne et al. 1986; Kenney et al. 1996). Small-scale hydrographic fronts may act as convergence zones. Bottlenose dolphins have demonstrated a spatial association with the area near the surface features of tidal intrusion fronts, which could be related to increased foraging efficiency resulting from the accumulation of prey in the frontal region (Mendes et al. 2002). Cetacean movements have also been linked to indirect indicators of prey, such as temperature variations, sea-surface chlorophyll *a* concentrations, and features such as bottom depth (Fiedler 2002).

Occurrence of cetaceans outside the area with which they are usually associated may reflect fluctuations in food availability. In some areas, these changes have been correlated with large-scale climatic events (El Niño and La Niña) that affect the normal distribution of prey. For example, during La Niña events cold-water currents may flow closer to shore, bringing prey commonly associated with deeper waters into coastal areas. During these times, oceanic marine mammal species may be seen closer to shore (Bryant et al. 1981; Whitehead and Carscadden 1985; Payne et al. 1986; Selzer and Payne 1988; Kenney et al. 1996). El Niño, which is associated with increased water temperatures and decreased upwelling, may cause influxes of warm-water species closer to shore (Benson et al. 2002). Additionally, a dramatic reduction in zooplankton biomass offshore during El Niño 1997 through 1998 off California led to a concentration of rorquals in the remaining productive coastal upwelling areas (Benson et al. 2002). A strong El Niño event in 1982 through 1983 affected the distribution of pilot whales (*Globicephala* spp.) off southern California when the influx of warm water caused squid not to spawn as usual in the area (Shane 1994). Short-finned pilot whales (*Globicephala macrorhynchus*) were virtually absent from the region during that time and did not reappear for another nine years. During the same El Niño event, coastal bottlenose dolphins expanded their range from southern to central California and remained in the new northern range even after the warming event subsided (Wells et al. 1990). Sperm whales (*Physeter macrocephalus*) in the eastern tropical Pacific had reduced calf survival during and after an El Niño event in the late 1980s (Whitehead 1997). High pinniped mortalities have been reported during El Niño events; many pups died of starvation because their mothers spent longer times at sea foraging (Domingo et al. 2002).

Climatic fluctuations have produced a growing concern about the effects of climate change on cetacean populations (MacGarvin and Simmonds 1996; IWC 1997; Evans 2002; Würsig et al. 2002). Long-term temperature trends may play a role in the distribution and abundance of cetacean species, either affecting them directly or indirectly, through alterations of habitat characteristics and distribution, and prey availability (Kenney et al. 1996; IWC 1997; Harwood 2001).

3.5.2 Marine Mammals of the Cherry Point and Southern VACAPES Inshore and Estuarine Areas

There are 40 marine mammal species that occur in the nearshore and offshore waters off Virginia and North Carolina: 35 cetacean species, four seal species, and one sirenian species. The marine mammal fauna of the continental shelf in the mid-Atlantic U.S. (Virginia and North Carolina) ordinarily consists of only six species: the bottlenose dolphin, harbor porpoise, North Atlantic right whale, humpback whale, and occasional sightings of the West Indian manatee and the killer whale (Table 3-11). Extralimital sightings of seals (harp, gray, harbor, and hooded seals), whales (minke and fin whales), and dolphins (common dolphin) have been recorded within the study area (Table 3-12). The vast majority of the marine mammal species occurring in the waters off Virginia and North Carolina are oceanic in distribution, occurring further offshore than the study area (DoN 2001, 2002).

Table 3-11. Marine mammal species found in the Cherry Point and southern VACAPES inshore and estuarine areas. Taxonomy follows Rice (1998) for sirenians and IWC (2001a) for cetaceans, except for the North Atlantic right whale, which was revised by Rosenbaum et al. (2000).

	Scientific Name	Status
Order Cetacea		
Suborder Mysticeti (baleen whales)		
Family Balaenidae (right whales)		
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Family Balaenopteridae (rorquals)		
Humpback whale	*Megaptera novaeangliae*	Endangered
Suborder Odontoceti (toothed whales)		
Family Delphinidae (dolphins)		
Common bottlenose dolphin	*Tursiops truncatus*	
Killer whale	*Orcinus orca*	
Family Phocoenidae (porpoises)		
Harbor porpoise	*Phocoena phocoena*	
Order Sirenia		
Family Trichechidae (manatees)		
West Indian manatee	*Trichechus manatus*	Endangered

Table 3-12. Marine mammal species with extralimital sightings in the Cherry Point and southern VACAPES inshore and estuarine areas. Taxonomy follows Rice (1998) for pinnipeds and IWC (2001a) for cetaceans.

	Scientific Name	Status
Order Cetacea		
Suborder Mysticeti (baleen whales)		
Family Balaenopteridae (rorquals)		
Fin whale	*Balaenoptera physalus*	Endangered
Minke whale	*Balaenoptera acutorostrata*	
Suborder Odontoceti (toothed whales)		
Family Delphinidae (dolphins)		
Common dolphin	*Delphinus* spp.	
Order Carnivora		
Suborder Pinnipedia (seals, sea lions, walruses)		
Family Phocidae (true seals)		
Harbor seal	*Phoca vitulina*	
Harp seal	*Pagophilus groenlandicus*	
Gray seal	*Halichoerus grypus*	
Hooded seal	*Cystophora cristata*	

The distribution of marine mammal records is presented for each season (winter=January through March; spring=April through June; summer=July through September; fall=October through December) in Figures 3-15 and 3-17 through 3-22. It should be noted that the number of cetacean observations in a given area is often as much a function of the source or type of data (bycatch data versus data collected by aerial or shipboard surveys), level of effort, and sighting conditions (such as calm seas) as the actual marine mammal abundance in that area.

A listing of data sources used to determine each species' occurrence in the study area is found in Appendix A, while the process used to create the map figures is described in Section 1.4.2.5. On the map figures, various types of shading and terminology designate the occurrence of marine mammals in the study area. "Expected occurrence" (area shaded in light blue) is defined as the area encompassing the expected distribution of a species based on what is known of its habitat preferences, life history, and the available sighting, stranding, incidental fisheries bycatch, and tagging data. "Concentrated occurrence" (area shaded in dark blue) is the subarea of a species' expected occurrence where there is the highest likelihood of encountering that species; the designation is based primarily on areas of concentrated sightings and preferred habitat. "Low/unknown occurrence" (pattern-filled area) is the area where the likelihood of encountering a species is rare or not known. "Occurrence not expected in study area" (white, unmarked area) is the area where a species encounter is not expected to occur.

Each marine mammal species is listed below with its description, status, habitat preference, distribution (including location and seasonal occurrence in the study area), behavior and life history, and information on its acoustics and hearing ability. Threatened and endangered marine mammals appear first.

3.5.2.1 Threatened and Endangered Species

There are six endangered marine mammal species with occurrence records in or near the study area: North Atlantic right whale, humpback whale, sei whale, fin whale, sperm whale, and the West Indian manatee. Four of these marine mammal species have sighting records in the study area: three baleen whale species (fin, humpback, and North Atlantic right whales) and the West Indian manatee. Of these before-mentioned species, only the humpback whale and the North Atlantic right whale are expected to occur in the study area. There are occasional, yet rare, sightings of the West Indian manatee in this area. The distribution of all sightings, strandings, and bycatch records of all endangered marine mammals available for the study area is shown in Figure 3-15.

Overlain on these data are polygons predicting the area used by these species during each season. Distributional polygons were developed from the before-mentioned data as well as the known distribution, habitat preference, and seasonal occurrence from literature on endangered whale species. Unidentified rorquals (the family of baleen whales which includes the blue, fin, sei, and humpback whales) were included to conservatively determine endangered whale occurrence for the study area. Considering unidentified rorquals, though this category includes the non-endangered/non-threatened minke and Bryde's whales, is appropriate in determining endangered whale occurrence in the study area since most of the rorquals are endangered species. Endangered marine mammals are expected to occur from the shore to seaward of the study area (the nearshore waters) year-round (Figure 3-15). This is primarily based on the occurrence patterns of the humpback whale and the North Atlantic right whale. There is a low or unknown occurrence of endangered marine mammals during spring, summer, and fall in the bays and sounds of the study area, which is a reflection of possible sightings of the West Indian manatee. The West Indian manatee is temperature-sensitive, avoiding cold waters, and individuals of this species are not expected anywhere in the study area during the winter months.

- 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 show that these two populations represent separate species: the North Atlantic right whale (*Eubalaena glacialis*) and the North Pacific right whale *(E. japonica*) (Rosenbaum et al. 2000).

  North Atlantic right whales are 9 to 17 meters (m) long, with a robust body shape, and are usually black (Jefferson et al. 1993). There is no dorsal fin on the broad back. The head is nearly one-third of its length. The jawline is arched and the upper jaw is very narrow in dorsal view. The head is covered with irregular whitish patches called "callosities."

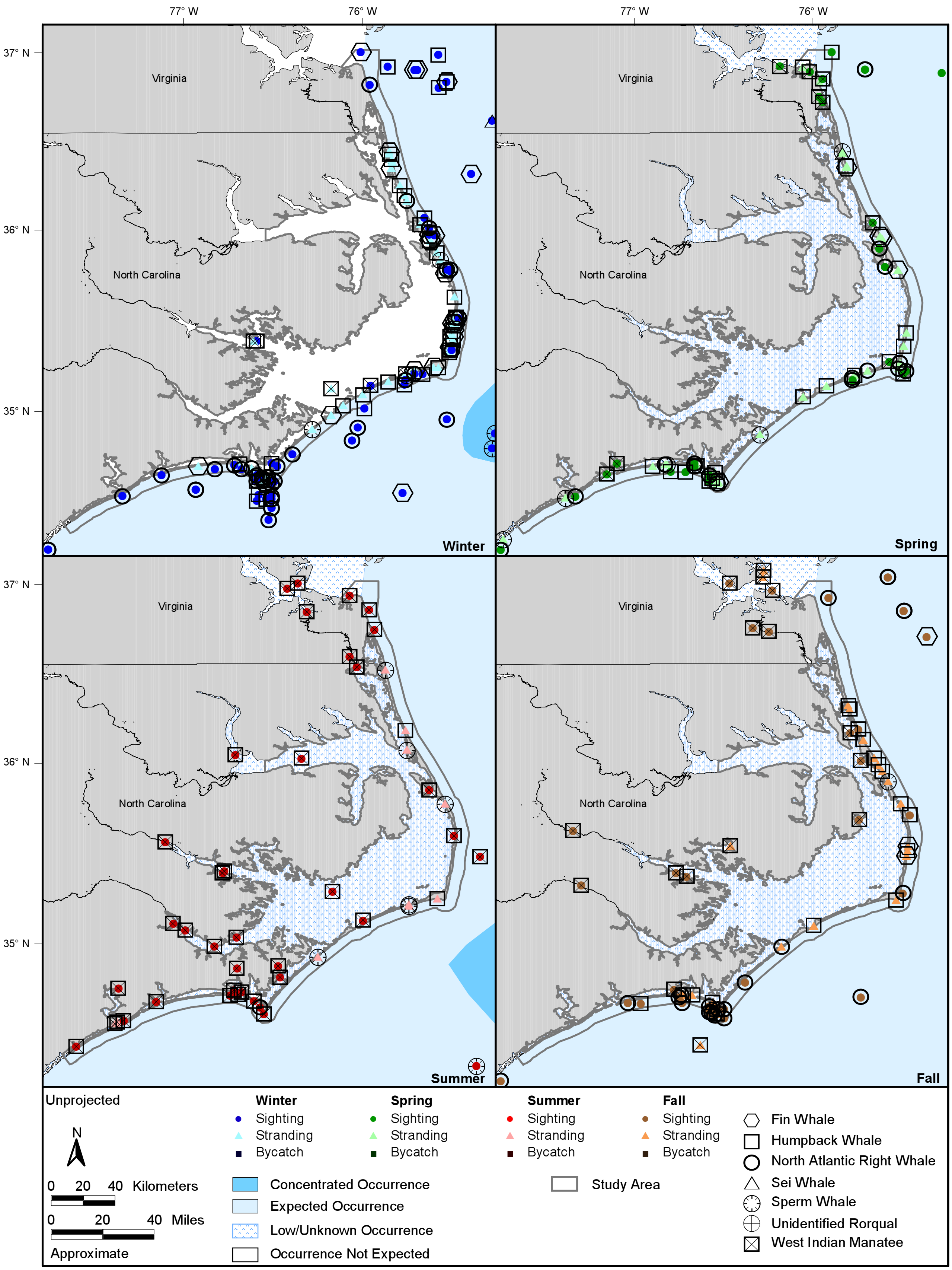

Figure 3-15. Occurrence of endangered marine mammals and unidentified rorquals in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

Status**—**The North Atlantic and North Pacific right whales are the world's most endangered large whale species (Clapham et al. 1999; Perry et al. 1999; IWC 2001b, 2001c; Silber and Clapham 2001). North Atlantic right whales are classified as endangered under the Endangered Species Act (ESA). There are approximately 300 individuals in the western North Atlantic (IWC 2001c) and they are presently declining in number (Caswell et al. 1999). Fujiwara and Caswell (2001) reported that the population decline could be halted only if less than two females died each year.

The calving grounds and two feeding areas in U.S waters are designated as critical habitat for North Atlantic right whales under the ESA (NMFS 1994; Figure 3-16). Critical habitat designations affect federal agency actions or federally funded or permitted activities. In 1999, a Mandatory Ship Reporting System was implemented by the U.S. Coast Guard (USCG 1999, 2001), which requires specified vessels (the Navy is exempt) to report their location. At the same time, ships receive information on locations of right whale sightings, in order to avoid collisions with the animals. Geographical boundaries of the area include coastal waters within about 25 nautical miles (NM) along a 90 NM stretch of the Atlantic coast in Florida and Georgia (Figure 3-16).

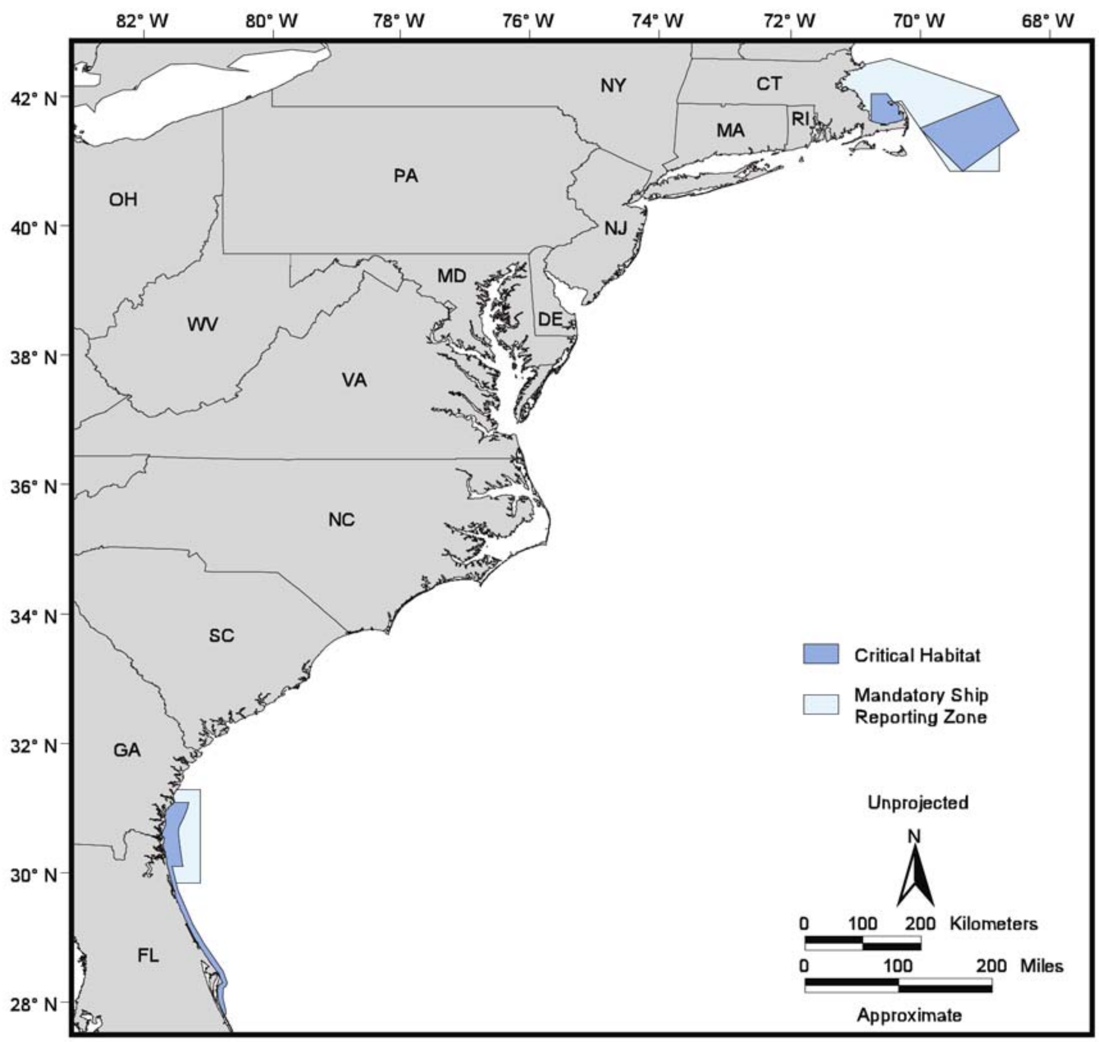

Figure 3-16. Designated critical habitats and mandatory ship reporting zones for North Atlantic right whales. Source information: NMFS (1994) and USCG (1999).

Habitat Preferences**—**North Atlantic right whales are most often sighted in nearshore and continental shelf waters between Florida and Nova Scotia. The feeding grounds are areas where bottom topography, water column structure, currents, and tides 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). Right whales on their feeding grounds tend to occur consistently in specific locations, often areas of low bathymetric relief near higher relief edges, with distinct frontal zones. There has been some research at attempting to use remotely sensed oceanographic data to predict right whale occurrence (Brown and Winn 1989; Clapham 1999; Ward 1999), but that work is in a very early stage. 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 extended periods in areas where upwelling occurs (Mate et al. 1997). Right whales on the winter calving grounds are most often found in very shallow nearshore waters, in cooler temperatures inshore of a mid-shelf front (Kraus et al. 1993; Ward 1999).

Distribution**—**Right whales occur in sub-polar to temperate waters. North Atlantic right whales are found primarily in continental shelf waters between Florida and Nova Scotia (Winn et al. 1986). Most sightings are concentrated within five high-use areas: coastal waters of the southeastern U.S. (Georgia and Florida), the 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). Radio-tagged animals have made extensive movements, sometimes moving from the Gulf of Maine into deeper waters off the continental shelf (Mate et al. 1997). Long-distance movements as far north as Newfoundland, the Labrador Basin, southeast of Greenland, Iceland, and Arctic Norway have been documented (Knowlton et al. 1992; IWC 2001c).

Most North Atlantic right whale sightings follow a well-defined seasonal migratory pattern through several consistently utilized habitats (Winn et al. 1986). It should be noted, however, that some individuals may be sighted in these habitats outside the typical time of year and that migration routes are poorly known (there may be a regular offshore component).

During the spring through early summer, North Atlantic right whales are found on feeding grounds off the coast of Massachusetts. Individuals may be found in Cape Cod Bay in February through April (Winn et al. 1986; Hamilton and Mayo 1990) and in the Great South Channel east of Cape Cod in April through June (Winn et al. 1986; Kenney et al. 1995). Right whales are found throughout the remainder of summer and into fall (June through November) on two feeding grounds in Canadian waters (Gaskin 1987, 1991). The peak abundance is in August, September, and early October. The majority of summer/fall sightings of mother/calf pairs occur east of Grand Manan Island, though some pairs might move to other unknown locations (Schaeff et al. 1993). 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, 1991; Stone et al. 1988). The Cape Cod Bay and Great South Channel feeding grounds are formally designated under the ESA as Critical Habitats (Silber and Clapham 2001) (Figure 3-16).

During the winter (as early as November and through March), right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida (Winn et al. 1986; Knowlton et al. 1994; Kenney personal communication). The waters off Georgia and northern Florida are the only known calving ground for western North Atlantic right whales; it is formally designated under the ESA as a Critical Habitat (Figure 3-16). Calving occurs December through March (Silber and Clapham 2001). 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 have been suggested to be a migratory corridor for the right whale (Winn et al. 1986). The Southeast U.S. Coast Ground, consisting of coastal waters between North Carolina and northern Florida, was mainly a winter and early spring (January-March) right whaling ground during the late 1800s (Reeves and Mitchell 1986). The whaling ground was centered along the coasts of South Carolina and Georgia (Reeves and Mitchell 1986). In North Carolina, whaling occurred as far north as Cape Hatteras, yet centered on the outer coasts of Core, Shackleford, and Bogue banks, particularly near Cape Lookout (Reeves and Mitchell 1988). An examination of sighting records from all sources between 1950 and 1992 found that wintering right whales were observed widely along the coast from Cape Hatteras, North Carolina (NC), to Miami, Florida (FL) (Kraus et al. 1993). Sightings off the Carolinas were comprised of single individuals that appeared to be transients (Kraus et al. 1993). These observations are consistent with the hypothesis that the coastal waters of the Carolinas are part of a migratory corridor for the right whale (Winn et al. 1986). Until better information is available on the width of the right whale's migratory corridor, it has been recommended that management considerations are needed for the coastal areas along the mid-Atlantic migratory corridor within 65 km from shore (Knowlton 1997).

- <u>Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Areas</u>—North Atlantic right whale sighting data and the endangered status of this species were considered for a conservative determination of right whale occurrence in the study area. Right whales are expected to occur from the shore to the shoreward boundary of the VACAPES and Cherry Point Operating Areas (OPAREAs) year-round (Figure 3-17). Right whales are not expected to make their way into inshore waters (for example, within Chesapeake Bay or inside of the barrier islands of North Carolina). Sighting records suggest that there is some overwintering along the North Carolina coast (Reeves and Mitchell 1988; Kraus et al. 1993). McLellan et al. (2003) conducted aerial surveys for right whales during 2001 and 2002 and noted that all sightings were south of Cape Fear. Knowlton (1997) estimated that 84% of the right whales sighted in the mid-Atlantic are seen between November and April, with peaks in December, March, and April. Sighting data shown in Figure 3-17 support this observation, with many right whales sighted during the fall, winter, and spring, when these whales transit the area on their migrations to and from breeding grounds further south or feeding grounds further north. During the summer months, right whales should occur further north on their feeding grounds; however, there is one reported sighting at Cape Lookout, NC and a few sightings further south off Florida. As noted by Gaskin (1982), right whales might be seen anywhere off the Atlantic U.S. throughout the year. It is only in average terms that the seasonal north-south migration of the entire population can be described. Whether or not a large baleen whale follows the "typical" migratory pattern can depend on a number of factors such as its previous reproductive history, its nutritional state, its state of health, its age and social status, and/or the ocean environmental conditions existing in the season in question.

Behavior and Life History—Right whales are most often seen as individuals or pairs (Jefferson et al. 1993). Right whales often occur in "surface active" groups, which appear to involve courtship and mating activity (Payne 1995). These groups have been observed year-round in all five high-use habitats; however, during the winter they do not appear to involve adults.

Calves are born during December through March after 12 to 13 months of gestation (Best 1994). Weaning occurs at 8 to 17 months (Hamilton et al. 1995). There is usually a three-year cycle (calving interval) between calves (Kraus et al. 2001).

North Atlantic right whales feed on zooplankton, particularly large calanoid copepods such as *Calanus* (Kenney et al. 1986; Beardsley et al. 1996). When feeding, a right whale skims prey from the water (Pivorunas 1979; Mayo and Marx 1990). Feeding can occur throughout the water column (Watkins and Schevill 1976, 1979; Mayo and Marx 1990; Goodyear 1993; Winn et al. 1995). Feeding behavior has been observed in all of the northern high-use areas (Mate et al. 1997), but has not been observed on the calving grounds or during migration (Slay personal communication).

Dives of 5 to 15 min or longer have been reported (CETAP 1982; Winn et al. 1995; Mate et al. 1997). Foraging dives in the known feeding high-use areas are frequently down to very near the bottom of the water column (Goodyear 1993; Mate et al. 1997).

Acoustics and Hearing—Right whale vocalizations include moans, low frequency calls, and broadband and impulsive sounds (Matthews et al. 2001). Frequencies of these vocalizations are

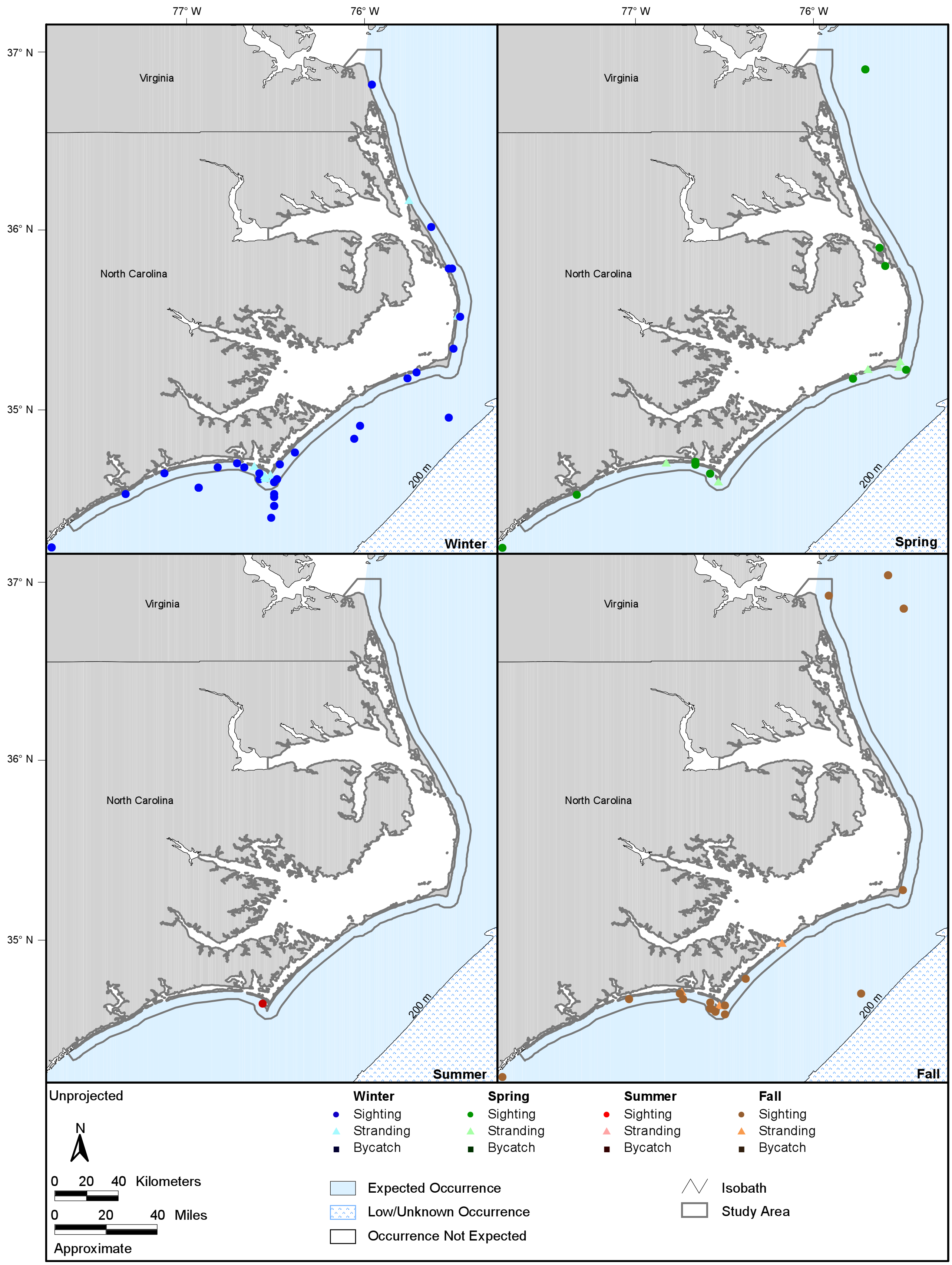

Figure 3-17. Occurrence of the North Atlantic right whale in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

between 50 and 500 Hz (Matthews et al. 2001). Moans are generally produced at or near the water's surface (Matthews et al. 2001). Vocalization rates of North Atlantic right whales are highly variable, and individuals have been known to remain silent for hours (Gillespie and Leaper 2001). Moans by an individual usually occur in clusters (Matthews et al. 2001). Results from the Bay of Fundy indicate high moan rates at night (Matthews et al. 2001). Source levels have been estimated only for pulsive calls, which are 172 to 187 decibels with a reference pressure of 1 micropascal at 1 meter (dB re 1 µPa-m) (Thomson and Richardson 1995). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

♦ Humpback Whale (*Megaptera novaeangliae*)

Description—Humpback whale adults 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 a third of the body length), usually white flippers (Jefferson et al. 1993; Clapham and Mead 1999). The flukes have a concave, serrated trailing edge; the ventral side is patterned in black and white. Individual humpback whales may be identified using these patterns (Katona et al. 1979).

Status—Humpback whales are classified as endangered under the ESA. There are an estimated 10,600 humpback whales in the entire North Atlantic (Smith et al. 1999). There are an estimated 902 humpback whales comprising the Gulf of Maine stock (Waring et al. 2002).

Habitat Preferences—The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving. Optimal calving conditions are warm water (24° to 28°C) and relatively shallow, low-relief ocean bottom in protected areas (behind reefs) to take advantage of calm seas, minimize the possibility of predation by sharks, or avoid harassment by males (Clapham 2000). In the northern feeding grounds, favored habitat is typically shallow banks and shoals or areas with high seafloor relief (CETAP 1982; Payne et al. 1990). The most important feeding habitat is the shallow southwestern Gulf of Maine from Jeffreys Ledge south to the Great South Channel.

Distribution—Humpback whales are found in all of the world's oceans (Jefferson et al. 1993). They generally are found during the summer on high-latitude feeding grounds and during the winter in the tropics around islands, over shallow banks, and along continental coasts, where calving occurs. In the North Atlantic, humpbacks are found in the Caribbean and Cape Verde islands in the south to Greenland, Iceland, and northern Norway in the north (Rice 1998). Most humpback whale sightings are in nearshore and in continental shelf waters; however, humpback whales frequently travel through deep water during migration (Clapham and Mattila 1990).

In the North Atlantic, humpbacks are found from spring through fall on feeding grounds that are located from south of New England to northern Norway (NMFS 1991). The largest numbers of humpback whales are from mid-April to mid-November. 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 Nova Scotian Shelf, the Gulf of St. Lawrence, and the Newfoundland Grand Banks (CETAP 1982; Whitehead 1982; Kenney and Winn 1986; Weinrich et al. 1997). Humpbacks return to the same feeding areas each year. There appears to be very little exchange between the six separate "feeding stocks": Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and Norway (Katona and Beard 1990; Clapham 1996).

Humpback feeding grounds are likely to be less consistent over the long term since their prey are much more mobile and their diet is more flexible. The distribution and abundance of sand lance are important factors underlying the distribution patterns of the humpback whale (Kenney and Winn 1986). Changes in diets and feeding preferences are likely caused by changes in prey distribution and/or in the relative abundance of different prey species (sand lance and herring) (Payne et al. 1986, 1990; Kenney et al. 1996; Weinrich et al. 1997). Feeding most often occurs in relatively shallow water over the inner continental shelf, 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). The calving peak is January through March, with some animals arriving as early as December and a few not leaving until June. 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; Swingle et al. 1993; Clapham et al. 1993). There has been an increasing occurrence of humpbacks during the winter along the U.S. Atlantic coast, from Florida north to Virginia, which appear to be primarily juveniles (Swingle et al. 1993; Clapham 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). These occurrences are not fully understood. They might be due to shifts in distribution, increases in sighting effort, or habitat that is becoming increasingly important for juveniles (Waring et al. 2002). Sighting histories of mature humpback whales suggest that the mid-Atlantic area contains a greater percentage of mature animals than is represented by strandings (Barco et al. 2002). It has recently been proposed that the mid-Atlantic region primarily represents a supplemental winter-feeding ground, which is also an area of mixing of humpback whales from different feeding stocks (Barco et al. 2002).

The migratory routes taken during the southbound and northbound migrations are not known. Since large numbers of humpback whales are not observed close to shore during this time, it is presumed that whales travel the more direct routes in deeper, offshore waters (Smith et al. 1999). 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). 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 Cherry Point and Southern VACAPES Inshore and Estuarine Areas—The endangered status of the humpback whale and the increasing occurrence of humpback whale sightings and strandings during the winter in the mid-Atlantic area (Swingle et al. 1993; Wiley et al. 1995; Laerm et al. 1997; Barco et al. 2002) were considered in determining the occurrence of humpbacks in the study area. Based on sighting data for the study area (as well as the near vicinity), humpback whales are expected to occur from the shore to the shoreward boundary of the VACAPES and Cherry Point OPAREAs during fall, winter, and spring (Figure 3-18). Humpback whales are not expected to make their way into inshore waters (for example, within Chesapeake Bay or inside of the barrier islands of North Carolina) (Kenney personal communication). Humpback whales migrate to calving grounds in the Caribbean during the fall and make return migrations to the feeding grounds much further north during the spring. During summer, humpback whales should occur further north on their feeding grounds; however, there are sightings in offshore waters in the vicinity of the study area (outside the areal extent of this map) (DoN 2001), as well as a few reported strandings (Barco et al. 2002; Figure 3-18). Therefore, there is a low or unknown occurrence of humpbacks during this season north of Cape Hatteras. Strandings are reported year-round, with the least occurring during the summer (Figure 3-18).

  The reports of humpbacks during the winter in the study area have been sporadic, in small numbers, and never consistent from year-to-year, so an area of concentrated occurrence was not designated (Kenney personal communication). It is possible that in the future, with continued survey efforts and more data, this area could be designated as an area of concentrated occurrence.

***Behavior and Life History*—**Single individuals are observed most commonly. On the feeding grounds, relatively large numbers of humpbacks may be observed within a limited area to feed on a

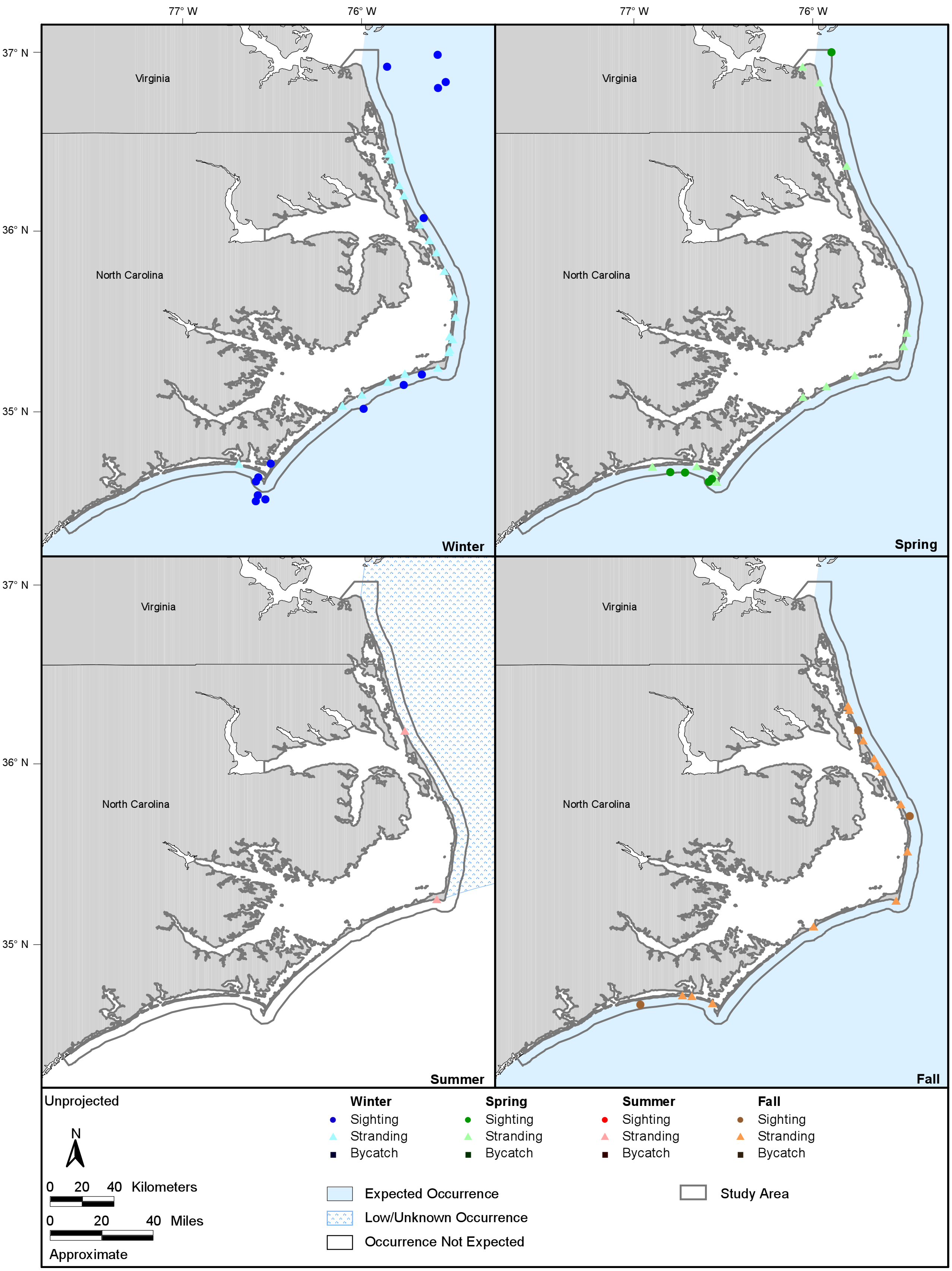

Figure 3-18. Occurrence of the humpback whale in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

rich food source (CETAP 1982). On the breeding grounds, small groups of males may occur, competing for access to females.

Humpback whales feed like most other rorquals by "gulping" (Pivorunas 1979). Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Jurasz and Jurasz 1979; Hain et al. 1982, 1995; Weinrich et al. 1992). The principal fish prey species in the western North Atlantic are sand lance (*Ammodytes americanus*), herring (Family Clupidae), and capelin (*Millotus villoses*) (Kenney et al. 1985).

Female humpbacks become sexually mature at 4 to 9 years of age (Clapham 1996). Gestation is approximately one year. Calves are weaned before one year of age. Calving intervals are usually 2 to 3 years although, occasionally, females 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).

Humpback whale diving behavior depends on the time of year (Clapham and Mead 1999). In summer, most dives last less than 5 minutes (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).

***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) sounds made on the feeding grounds (Thomson and Richardson 1995). "Feeding" calls are 20 Hz to 2 kHz, less than 1 second (sec) in duration, and have source levels of 175 to 192 dB re 1 µPa-m. Social calls are from 50 Hz to over 10 kHz with dominant energy below 3 kHz. Components of the song range from under 20 Hz to 4 kHz and occasionally 8 kHz, with source levels of 144 to 174 dB re 1 µPa-m, with a mean of 155 dB re 1 µPa-m. Houser et al. (2001) recently produced the first predicted humpback audiogram (using a mathematical model). The predicted audiogram indicates sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Au et al. (2001) recorded high-frequency harmonics (out to 13.5 kHz) and source level (between 171 and 189 dB re 1 µPa-m) of humpback whale songs.

- Fin Whale (*Balaenoptera physalus*)

***Description*—**Fin whales are the second-largest whale species, with adults reaching 24 m in length (Jefferson et al. 1993). Fin whales have a very sleek body with a pale, V-shaped chevron on the back, just behind the head. The dorsal fin is prominent and set two-thirds of the way back on the body. The head color is asymmetrical, with a white lower jaw on the right and dark on the left. Fin and sei whales are very similar in appearance, which has resulted in confusion about the distribution of either species (NMFS 1998).

***Status*—**Fin whales are classified as endangered under the ESA. The NOAA stock assessment report states that there are an estimated 2,814 individual fin whales in western North Atlantic stock (Waring et al. 2002), but it is underestimated because the data are not corrected for animals missed while diving (Kenney personal communication). Incorporating a dive correction (CETAP 1982), it is more likely that 5,000 to 6,000 fin whales occur off the eastern U.S. (CETAP 1982; Kenney et al. 1997). The entire North Atlantic population may number as many as 50,000 to 60,000 animals (Perry et al. 1999).

***Habitat Preferences*—**Fin whales in the U.S. Atlantic occur in continental shelf and shelf-edge waters, from the Gulf of Maine south to Cape Hatteras, NC (CETAP 1982; Hain et al. 1992; Waring et al. 2002). The fin whale appears to be scarce in offshore slope and Gulf Stream waters (CETAP 1982). This species tends to aggregate in locations where populations of prey are most plentiful, though those locations may shift seasonally or annually (Payne et al. 1986, 1990; Kenney et al. 1997). Relatively consistent locations for fin whales include the same habitats noted previously for humpbacks (with some additional areas) including Stellwagen Bank, Jeffreys Ledge, the Great South

Channel, Georges Bank, the banks on the Nova Scotian shelf, off Block Island and Long Island, and along the shelf break (CETAP 1982; Hain et al. 1992; Waring et al. 2002). Hain et al. (1992) reported the single most important habitat in their study was a region of the western Gulf of Maine, in approximately 90 m of water, from the Great South Channel past Cape Cod to Stellwagen Bank, Cape Ann, and Jeffreys Ledge. This was an area of high sand lance density during the 1970s and early 1980s (Kenney and Winn 1986). Secondary areas of important fin whale habitat included the shelf break from the Northeast Peak of Georges Bank to the mid-Atlantic and the mid-shelf from south of New England to the mid-Atlantic Bight. Waring and Finn (1995) found a significant relationship in co-distributions between 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 interfaces between mixed and stratified waters, which concentrate krill and herring (Woodley and Gaskin 1996).

Distribution—Fin whales are broadly distributed throughout the world's oceans, in both continental shelf and deep waters (Rice 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 (NMFS 1998). In general, fin whales are more common north of about 30ºN (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; Waring et al. 2002). The fin whale is the most common whale species acoustically detected via Navy deepwater hydrophone arrays in the North Atlantic (Clark 1995). Fin whales are the dominant large cetacean species in all seasons in this area; they have the largest standing stock and food requirements (Hain et al. 1992; Kenney et al. 1997).

Fin whales are believed to follow the typical baleen whale migratory pattern. However, the location and extent of the wintering grounds are poorly known (Aguilar 2002). Fin whales were acoustically detected in winter throughout the deep water of the North Atlantic, supporting the widely held hypothesis about their migration (Clark 1995). Acoustic detections of fin whales in offshore waters peaked in winter. The study showed a definite southward movement of fin whales in the fall and northward in spring; in the western North Atlantic the end points of most of the migration were Newfoundland/Labrador and south of Bermuda into the West Indies. Migration routes are otherwise unknown. Fin whales are not completely absent from U.S. Atlantic continental shelf waters 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). There have been scattered fin whale strandings and sightings in NC, mainly from late fall through mid-spring coinciding with this species' migratory pattern (Lee 1986; Webster et al. 1995).

- <u>Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Areas</u>—The fin whale is not expected to occur in the study area; any sightings would be extralimital (Kenney personal communication). Fin whales are not expected to occur in waters as shallow as those in the study area. There are only two sighting records for fin whales within the study area: one in February 1976 at the mouth of Chesapeake Bay and one made during March 1997 during NMFS-NEFSC cetacean surveys outside the barrier island off Roanoke Sound.

Behavior and Life History—Fin whales feed by "gulping" (Pivorunas 1979) and prey upon a wide variety of small, schooling prey (especially herring, capelin, and sand lance), including squid, krill, and copepods (Kenney et al. 1985; NMFS 1998). Single fin whales are most common. Fin whales are frequently observed in large multi-species feeding aggregations with humpback whales, minke whales, and 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 winter (Hain et al. 1992) after a gestation period of approximately 11 months; weaning may occur at 6 months (Boyd et al. 1999).

Fin whale dives are typically 5 to 15 min, separated by sequences of 4 to 5 blows at 10 to 20 sec intervals (CETAP 1982; Stone et al. 1992). 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) found that fin whales dived to 97.9 (±S.D. 32.59) m with a duration of 6.3 (±S.D. 1.53) min when foraging and to 59.3 (±S.D. 29.67) m with duration of 4.2 (±S.D. 1.67) min when not foraging. Fin whale dives of over 150 m were recently reported (Panigada et al. 1999). The diving bouts coincided with the diel migration of krill.

Acoustics and Hearing—Fin whales produce a variety of sounds with a frequency range up to 750 Hz. Infrasonic signals have been documented for fin whales (Watkins et al. 1987). The most typical fin whale sound is a 20 Hz infrasonic pulse (actually a frequency-modulated sweep from about 23 to 18 Hz) with a duration of about 1 sec and a typical source level of 160 to 186 dB re 1 µPa (maximum to 200) (Thomson and Richardson 1995; Charif et al. 2002). 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 manatee is a rotund, slow-moving animal reaching a maximum length of 3.9 m (Jefferson et al. 1993). The manatee has a small head with a squarish snout, fleshy mobile lips, and two semi-circular nostrils at the front. The tail is horizontal and paddle-shaped. The body is gray or gray-brown and covered with fine hairs that are sparsely distributed. The back is often covered with distinctive scars from boat propeller cuts (Moore 1956).

Status—The West Indian manatee is classified as endangered under the ESA. Florida manatee numbers are assessed by aerial surveys during the winter when manatees are concentrated in warm-water refuges. Aerial surveys conducted in January 2001 produced a total estimate of 3,276 manatees (Ackerman personal communication). Aerial surveys conducted in 2002 produced a total estimate of 1,796 manatees; however, the decrease was due to poor visibility during foul weather (Ackerman personal communication). Aerial surveys conducted in 2003 produced a total estimate of 3,113 manatees with 1,814 manatees occurring on the Atlantic coast of Florida (Ackerman personal communication).

The Florida population of the West Indian manatee is divided into four relatively discrete management units or subpopulations, with each representing a significant portion of the species' range (USFWS 2001). Manatees along the Atlantic Coast, including contiguous with the study area, represent the Atlantic Region (USFWS 2001).

In 1976, critical habitat was designated for the manatee in Florida (USFWS 1976). The designated area included all of the manatee's known range at that time (Laist personal communication). This designation of critical habitat is rarely used or referenced because it has a broad description, treats all waterways the same, and does not highlight any particular areas (Laist personal communication). There are two types of manatee protection areas in the state of Florida: manatee refuges and manatee sanctuaries (USFWS 2001, 2002a, 2002b). All water-related recreational activities are prohibited in manatee sanctuaries, whereas manatee refuges allow some regulated activities. In Florida, there are manatee sanctuaries in Kings Bay (Citrus County), Hillsborough County, and Pinellas County and manatee refuges in Brevard, Charlotte, De Soto, Hillsborough, Lee, and Sarasota counties (USFWS 2001, 2002a, 2002b).

Habitat Preferences—Sightings of manatees are restricted to warm freshwater, estuarine, and coastal waters. Shallow grass beds with ready access to deep channels are preferred feeding areas in coastal and riverine habitats (USFWS 2001). Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, mating, and calving (USFWS 2001). Estuarine and brackish waters as well as natural and artificial freshwater sources are sought out by manatees (USFWS 2001). When ambient water temperatures drop below about 20°C in fall and winter, manatees migrate to natural or anthropogenic warm-water sources (Irvine 1983).

Distribution—West Indian manatees occur in warm, subtropical, and tropical waters of the western North Atlantic from the southeastern U.S. to Central America, northern South America, and the West Indies, primarily in freshwater systems, estuaries, and shallow, nearshore, coastal waters (Lefebvre et al. 2001). Along the U.S. Atlantic coast, historically, manatees were probably restricted to the southernmost areas of Florida during the winter, expanding northward in the summer. However, the winter range is expanding northward as a result of the creation of warm-water refuges (i.e., power plant effluent plumes) by industrial development and the introduction of several exotic aquatic plant species that expanded the available food supply (USFWS 2001). Manatees are frequently reported in the coastal rivers of Georgia and South Carolina during warmer months (Zoodsma 1991; Lefebvre et al. 2001). Sightings on the Atlantic coast drop off markedly north of South Carolina (Lefebvre et al. 2001). Deutsch et al. (2001) found that manatees are highly consistent in their seasonal movement patterns over time and showed strong fidelity to warm season and winter ranges both within and across years.

Manatees along the Atlantic coast exhibit several different patterns of seasonal movement, ranging from year-round residents to long-distance migrants (Deutsch et al. 2001). Wide-ranging movements have been documented for some individuals. One manatee, "Chessie," gained fame in the summer of 1995 by making a 4,828 km, round-trip journey between Florida and Rhode Island (USGS 2002a). He made the trip north between January and August at a pace of 16 to 32 km per day. After returning to Florida for the winter, he wandered north again as far as Virginia. There were no sightings between 1996 and 2001. In early September 2001, "Chessie" was once again sighted in Virginia (USGS 2002a). In Virginia, "Chessie" has been sighted in Great Bridge, Portsmouth, and Williamsburg as well as Morehead City, North Carolina.

Although manatees are expected to inhabit the nearshore area, some have been sighted offshore. A manatee photographed in January 2000 in the Bahamas was matched to a manatee that had been seen in 1994 as a juvenile on the west coast of Florida, indicating the potential for offshore movements (Reid 2000). A manatee was also repeatedly sighted in the northern Gulf of Mexico south of the Florida Panhandle, well over 100 NM offshore in waters with a bottom depth of 914 m (Anonymous 2001).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Areas—Manatee sightings on the Atlantic coast drop off markedly north of South Carolina (Lefebvre et al. 2001). There are some sighting and stranding records for vagrant manatees reported between 1934 and 2002 (Figure 3-19). Additionally, McAtee (1950) relays an account from June 1676 of a possible manatee sighting. Fishermen captured a manatee in Masonboro Sound (North Carolina) during September 1919 (Brimley 1931a).

  Sighting and stranding data, the known habitat preferences, and the endangered status of this species were considered for a conservative determination of manatee occurrence in the study area. Most reported sightings occur during the spring, summer, and fall; the vast majority of sightings are during the summer months (Figure 3-19). The manatee is very sensitive to cold temperatures (under 20°C), so it is not surprising that there are very few records for this species during the winter months in the study area (Figure 3-19). Taking this information into consideration, there is a low or unknown occurrence of the West Indian manatee during the spring (probably late spring as water temperatures increase), summer, and fall in the study area (Figure 3-19).

  There has been an increase in sightings in recent years, most probably attributed to an increase in public awareness of manatees and the novelty of sighting this species in the study area. It is safe to assume that many of the sightings depicted in Figure 3-19 are multiple sightings of the same individual(s), especially if they occur within only a few days of each other and are in close proximity. This is certainly the case for spring, where half of the sightings are in close physical proximity and dates to one another.

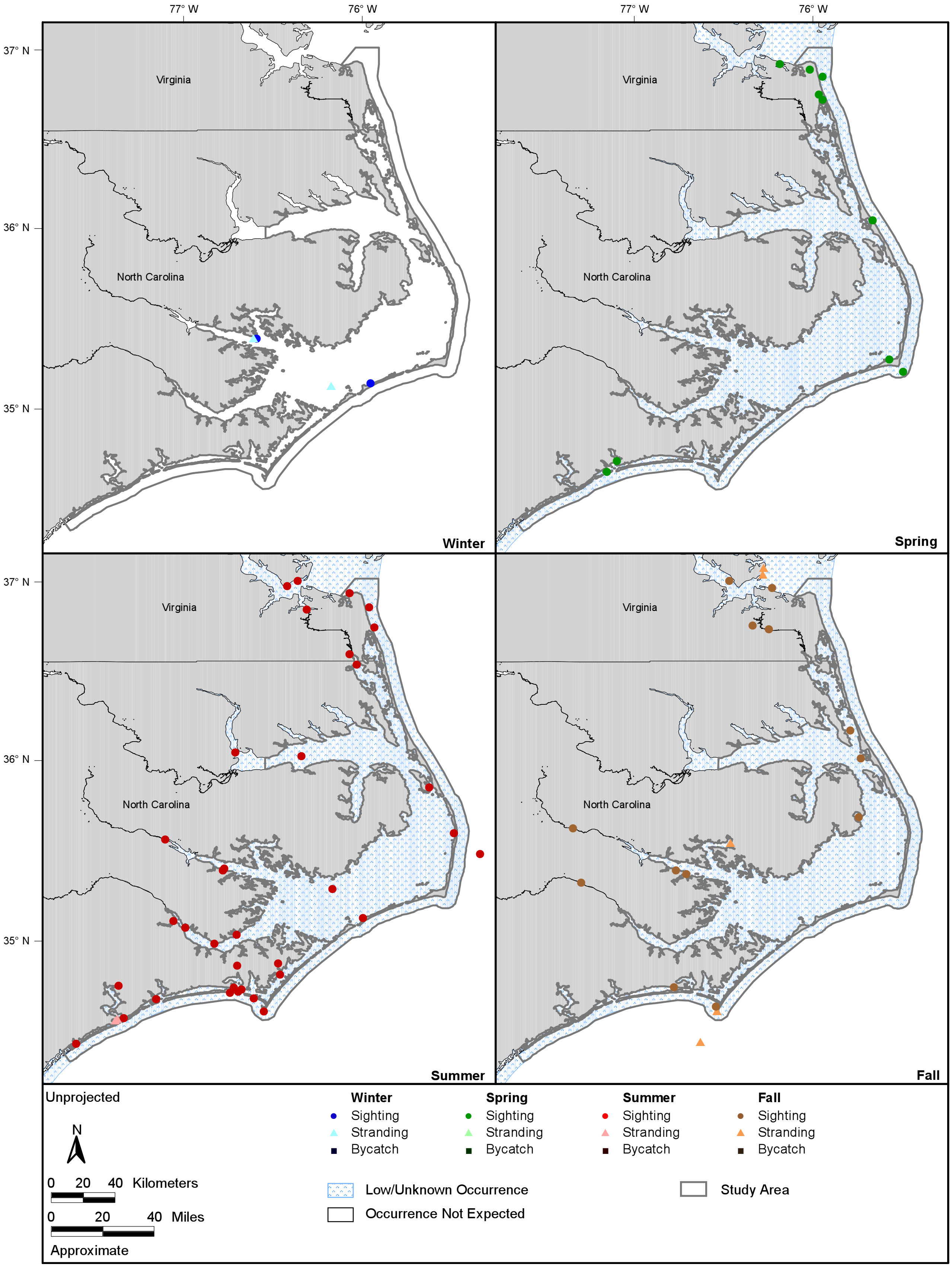

Figure 3-19. Occurrence of the West Indian manatee in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

Schwartz (1995) noted that subadult manatees were recorded in the vast majority of sightings in North Carolina. Occasionally cow-calf pairs are sighted; for example, in September 1994, a cow-calf pair was sighted in the Neuse River. There have been a few individual manatees in recent years that seem to be "regular" visitors. The most famous of these visitors is "Chessie" (mentioned earlier under distribution of this species). Individual manatees most likely transit through the area following the Atlantic Intracoastal Waterway that passes between the mainland and the barrier islands of North Carolina and leads into the mouths of the James River and Chesapeake Bay in Virginia (Schwartz 1995). Manatees are occasionally seen in the James River and other river mouths, as well as Chesapeake Bay (Figure 3-19). "Chessie" was even spotted in the Great Bridge Locks and the Deep Creek Locks (Virginia), waiting for the gates to open (USGS 2002b). Another individual ("Jimmy") was sighted as far up the James River as Richmond, VA (McAllister 2002).

Behavior and Life History**—**Two important aspects of the manatee's physiology influence behavior: nutrition and metabolism. Manatees have an unusually low metabolic rate and a high thermal conductance leading to energetic stress in winter, ameliorated by migration and aggregation in warm-water refugia (Hartman 1979). Manatees are herbivorous, feeding opportunistically on a wide variety of submerged, floating, and emergent vegetation (USFWS 2001).

Manatees are not gregarious and are most often observed alone (Hartman 1979). Manatees in Florida do, however, aggregate in large, unorganized groups around warm-water sources (Hartman 1979). The only significant social bonds are between mother and calf during the first 1 to 2 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).

Acoustics and Hearing**—**Manatees produce pulsed 200 to 500 millisecond (msec) species-specific calls (Gerstein et al. 1999, 2001). The average frequency range of their calls is between 1 and 12 kHz (Steel and Morris 1982). Ketten et al. (1992) described the anatomy of the manatee ear. Their hearing is sensitive to high frequencies with narrow critical bands (Gerstein et al. 1999). Audiogram work suggests manatees may hear better than originally suggested (Gerstein 1999; Gerstein et al. 1999). Current behavioral data for the West Indian manatee indicate a hearing range of approximately 0.4 to 46 kHz, with best sensitivities between 16 and 18 kHz (50 dB re 1 μ Pa-m). The range of best hearing is 6 to 20 kHz, with poor hearing in the low frequency ranges (USFWS 2001). The dominant sounds produced by watercraft are below 1 kHz, which is outside the lower fringe of their hearing range. Even in quiet conditions, manatees have difficulty detecting these sounds even at 90 or 100 dB (Gerstein et al. 1999).

3.5.2.2 Non-Threatened and Non-Endangered Marine Mammal Species of the Cherry Point and Southern VACAPES Inshore and Estuarine Areas

There are nine non-endangered/non-threatened marine mammal species recorded in the study area: one baleen whale species (minke), four toothed whale species (bottlenose dolphin, harbor porpoise, killer whale, and common dolphin), and four seal species (gray, harbor, harp, and hooded seals). Any sightings of common dolphin, minke whale, or the four seal species are considered to be extralimital.

- Minke Whale (*Balaenoptera acutorostrata)*

Description**—**The minke whale is the smallest balaenopterid species in the western North Atlantic, with adults reaching lengths of just over 9 m (Jefferson et al. 1993). The head is extremely pointed, and the median head ridge is prominent. The dorsal fin is tall, recurved, and located about two-thirds of the way back from the snout tip (Jefferson et al. 1993). The minke's coloration is distinct: dark gray dorsally, white beneath, and streaks of intermediate shades on the sides (Stewart and Leatherwood 1985). The most distinctive light marking is a brilliant white band across each flipper of northern hemisphere minke whales (Stewart and Leatherwood 1985).

Status—In the North Atlantic, there are four recognized populations–Canadian east coast, west Greenland, central North Atlantic, and northeastern North Atlantic (Waring et al. 2002). Minke whales off the eastern U.S. are considered to be part of the Canadian east coast stock, which inhabits the area from the eastern half of the Davis Strait out to 45ºW and south to the Gulf of Mexico (Waring et al. 2002). The best available current abundance estimate for the Canadian east coast stock of minke whales is 4,018 individuals (Waring et al. 2002).

Habitat Preferences—Off eastern North America, the minke whale generally occupies waters over the continental shelf, including inshore bays and estuaries (Waring and Palka 2002; Waring et al. 2002). However, based on whaling catches and surveys worldwide, there is a deep-ocean component to the minke whale's distribution (Slijper et al. 1964; CETAP 1982; Horwood 1990; Mitchell 1991; Mellinger et al. 2000; Waring et al. 2002).

Distribution—Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993). There appears to be a strong seasonal component to minke whale distribution. Spring and summer are times of relatively widespread and common occurrence, and during this time, they are most abundant in New England waters (Waring et al. 2002). During fall in New England waters, there are fewer minke whales; during winter the species appears to be largely absent. Minke whales are known to occur during the winter months (November through March) in the southwestern region of the North Atlantic, including the area from Bermuda to the West Indies (Mitchell 1991).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Areas—The minke whale is only occasionally found, and on a widely scattered basis, in the mid-Atlantic area (CETAP 1982; Waring et al. 2002). There is a more common occurrence further north. There is only one sighting of a minke whale reported for the study area that occurred in April 1980 (CETAP 1982) outside the barrier island off Currituck Sound. Any sightings of the minke whale in the study area would be considered extralimital (Kenney personal communication).

Behavior and Life History—Minke whales are sighted in small groups. Mating is thought to occur in winter or early spring, but has never been observed (Stewart and Leatherwood 1985). Stern (1992) described a general surfacing pattern of minke whales consisting of about four surfacings, interspersed by short-duration dives averaging 38 sec. After the fourth surfacing, there was a longer duration dive ranging from approximately 2 to 6 min. Minke whales are "gulpers," like the other rorquals (Pivorunas 1979). Hoelzel et al. (1989) reported on different feeding strategies used by minke whales. In the western North Atlantic, minke whales feed primarily on schooling fish such as sand lance, capelin, herring, and mackerel (Kenney et al. 1985).

Acoustics and Hearing—Recordings in the presence of minkes have included both high- and low-frequency sounds (Beamish and Mitchell 1973; Winn and Perkins 1976; Mellinger et al. 2000). Mellinger et al. (2000) described two basic forms of pulse trains that were attributed to minke whales: a "speed up" pulse train with energy in the 200 to 400 Hz band, with individual pulses lasting 40 to 60 msec, and a less-common "slow-down" pulse train characterized by a decelerating series of pulses with energy in the 250 to 350 Hz band. Recorded vocalizations from minke whales have dominant frequencies of 60 to greater than 12,000 Hz, depending on vocalization type (Thomson and Richardson 1995). Recorded source levels, depending on vocalization type, range from 151 to 175 dB re 1 µPa-m (Ketten 1998). Gedamke et al. (2001) recorded a complex and stereotyped sound sequence that spanned a frequency range of 50 Hz to 9.4 kHz. Broadband source levels between 150 and 165 dB re 1 µPa-m were calculated. While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- Common Bottlenose Dolphin (*Tursiops truncatus*)

Description—Bottlenose dolphins (genus *Tursiops*) are large, relatively robust dolphins that vary in color from light gray to charcoal. *Tursiops* is named for its short, stocky snout that is distinctively set off from the melon by a crease (Jefferson et al. 1993). There is striking regional variation in body size; adult body length ranges from 1.9 to 3.8 m (Jefferson et al. 1993).

The taxonomy of *Tursiops* continues to be in flux. Two species of *Tursiops* are currently recognized, the common bottlenose dolphin and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998; IWC 2001a), with more likely to be recognized with more genetic analyses. The Indo-Pacific bottlenose dolphin is found in the tropical Indo-Pacific, while all other bottlenose dolphins including those found in the western North Atlantic are considered to be the common bottlenose dolphin. Hereafter, the bottlenose dolphin refers to the common bottlenose dolphin. Scientists currently recognize a nearshore (coastal) and an offshore form of the bottlenose dolphin, which may be distinguished by external morphology, hematology, cranial morphology, diet, and parasite load (Duffield et al. 1983; Hersh and Duffield 1990; Mead and Potter 1995). There is a clear genetic distinction between the nearshore and offshore form of the bottlenose dolphin in the western North Atlantic (Curry and Smith 1997; Hoelzel et al. 1998; Rosel and Bero 2001). Only the nearshore form is expected in and around the vicinity of the study area, since the offshore form of bottlenose dolphins is found in waters with a bottom depth greater than 25 m (Kenney 1990; NMFS-SEFSC 2001; Waring et al. 2002).

***Status*—**Estimated overall abundance for the western North Atlantic coastal stock of bottlenose dolphins is 9,206 dolphins from summer surveys and 19,459 dolphins from winter surveys (Waring et al. 2002). Seven management units for the coastal bottlenose dolphin along the Atlantic U.S. have been defined (NMFS-SEFSC 2001; Waring et al. 2002). Three of these units (Northern Migratory Unit, Northern North Carolina Unit, and Southern North Carolina Unit) could spatially overlap in and around the vicinity of the study area. Abundance estimates for each management unit may be found in the most recent NOAA marine mammal stock assessment report (Waring et al. 2002).

During 1987 and 1988, the annual number of stranded bottlenose dolphins along the East Coast of the U.S. increased tenfold relative to previously observed stranding levels (MMC 2002). The die-off started in the mid-Atlantic region, moved northward and then southward to encompass essentially the entire coastline from New Jersey to central Florida (MMC 2002). The pattern of stranded animals was considered evidence for a single coastal migratory stock along the eastern coast, and an analysis of the event suggested that more than half of this coastal stock might have died (MMC 2002). The coastal stock is considered depleted under the MMPA (based on estimates that this stock might have declined by over 50% as a result of the 1987 to 1988 die-off) and is therefore a strategic stock (NMFS 2002). In July 2002, NMFS announced its intention to prepare an environmental impact statement (EIS) in conjunction with the development of a Bottlenose Dolphin Take Reduction Plan to reduce the incidental mortality and serious injury of the Atlantic coastal stock of bottlenose dolphins in commercial fisheries to below the potential biological removal level for the stock (NMFS 2002). The mid-Atlantic coastal gillnet fishery has the highest document levels of mortality for the coastal stock (Friedlander et al. 2001; Steve et al. 2001; Waring et al. 2002). A best estimate of the number of bottlenose dolphins present in the inshore waters of North Carolina is 1,033 individuals (Read et al. 2003a).

***Habitat Preferences*—**Bottlenose dolphins off the northeast U.S. are frequently found over the continental shelf, and especially along the shelf break (Kenney 1990). Bottlenose dolphins may make their way up rivers (Caldwell and Caldwell 1972; Gannon 2003). Bottlenose dolphins may also be found in very deep waters (Kenney 1990).

Water temperature may directly or indirectly affect bottlenose dolphin movements (Wells and Scott 1999). Water temperature may directly affect movements by acting as a thermal barrier to dolphin movement (Barco et al. 1999). Alternatively, water temperature may indirectly affect movements by directly affecting prey movements (Barco et al. 1999; Wells and Scott 1999). The coastal bottlenose dolphin stock off the Atlantic U.S. coast shows a temperature-limited distribution (Kenney 1990). Sightings of coastal bottlenose dolphins (contrasted with the offshore stock) during CETAP surveys occurred in significantly warmer waters, had a distinct northern boundary to their distribution, and were absent from the study area during the winter (Kenney 1990). There are reports of sightings of the coastal stock of bottlenose dolphins as far north as Massachusetts during the winter (January); these movements are not considered typical of the species (Blaylock and Hoggard 1994; Wiley et al. 1994; NMFS-SEFSC 2001). Along the California coastline, the bottlenose dolphin's range expanded during an El Niño warm-water event (Wells et al. 1990). Some dolphins remained in the northern waters following return to normal water temperatures, suggesting that the dolphins might have responded more to secondary effects of the warm-water incursion, such as changes in prey distribution, than to the temperature changes themselves (Wells and Scott 1999).

Risk of predation and food availability influence 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). Predators of bottlenose dolphins include the bull shark (*Carcharhinus leucas*) and dusky shark (*Carcharhinus obscurus*) (Heithaus 2001), which are known to North Carolina waters (Schwartz 2000). The bull shark is known to penetrate the tributaries of Pamlico and Curriticuk sounds of North Carolina (Schwartz 2000).

Observations of habitat use by coastal bottlenose dolphins (particularly in Florida) suggest a preference for feeding in shallow seagrass habitats; however, Allen et al. (2001) rejected these findings based on an examination of the scale addressed in sampling and analysis during all studies examined. Allen et al. (2001) found that dolphins forage in non-seagrass habitats where fish prey is both larger and perhaps more available. Although seagrass habitats support greater abundance of smaller fishes, they also provide a structural refuge that obscures fishes both visually and possibly acoustically (Allen et al. 2001; Heithaus and Dill 2002). *Tursiops* frequently use structural features, such as dredged or natural channels and spoil islands, as a means of enhancing the efficiency of prey detection or capture (Shane et al. 1986; Allen et al. 2001). Tidal flow often affects short-term movements of *Tursiops*, which is most probably a response to movements of their prey (Shane et al. 1986; Acevedo 1991; Ingram and Rogan 2002; Mendes et al. 2002). The distribution of dolphins within the Neuse River estuary in North Carolina is correlated most strongly with the sounds of prey aggregations (Atlantic croaker *Micropogonias undulatus*) (Gannon 2003).

Certain locations in shallow, inshore waters are often attractive to mothers rearing young calves due to abundant food resources, reduced exposure to more turbulent sea conditions outside sheltered areas, and, in many cases, also predation (Scott et al. 1990; Heithaus and Dill 2002). Some areas appear to have a larger percentage of mothers and calves than others, suggesting “nursery areas.” These nursery areas are attractive to other age classes of dolphins as well, for many of the same reasons.

***Distribution*—**The overall range of *Tursiops* is worldwide in tropical and temperate waters. *Tursiops* generally do not range poleward of 45º, except around the United Kingdom and northern Europe (Jefferson et al. 1993). Climate changes can contribute to range extensions. For example, a 600 km northward range extension to Monterey Bay (for some bottlenose dolphins known to the San Diego, California, area) was linked to the 1982 to 1983 El Niño event (Wells et al. 1990).

In the U.S. Atlantic, the bottlenose dolphin is distributed along the coast from Long Island, New York, to the Florida Keys (Wang et al. 1994). As noted by NMFS-SEFSC (2001), based on current information, it is expected that multiple coastal stocks of bottlenose dolphins exist and include year-round residents, seasonal residents, and migratory groups. There are no true year-round resident dolphins in Virginia (Swingle 1994). There is a migratory component to the bottlenose dolphins occurring north of Cape Hatteras (NMFS-SEFSC 2001). South of Cape Hatteras, the nearshore (coastal)/offshore distribution pattern is less distinct, and there appears to be latitudinal clusters of animal concentration rather than the longitudinally discrete concentration areas found north of Cape Hatteras (Kenney 1990; Wang et al. 1994). In contrast to north of Cape Hatteras, there is little genetic mixing among management units south of North Carolina (NMFS-SEFSC 2001). Photo-identification and tagging efforts support the genetic work. Based on photo-identification work, there appears to be generally less movement between areas south of Cape Hatteras along the Atlantic U.S. coast (Urian et al. 1999; NMFS-SEFSC 2001). At least some of the bottlenose dolphins in North Carolina are resident year-round; this is the northern limit of year-round residency documented for bottlenose dolphin in the western North Atlantic (Koster et al. 2000). The longest distance match to date south of

Cape Hatteras, NC is between Jacksonville, FL and Murrell's Inlet, SC (approximately 450 km) (NMFS-SEFSC 2001). There is speculation of a resident group of bottlenose dolphins in Pamlico Sound, NC based on stable isotope studies, photo-identification, and satellite telemetry (Urian et al. 1999; Waring et al. 2002). It is unclear whether dolphins in bays, sounds, and estuaries of North Carolina are part of a single population unit, or whether more than one population resides in these waters (Read et al. 2003a).

A net fishery for bottlenose dolphins took place at Cape Hatteras from circa 1797 to 1929, peaking in 1885 to 1890 (Mead 1975). The primary products of the fishery were hides and oil (True 1885; Mead 1975). Catches were largest during the fall (November) and spring (March through May) (Mead 1975). This corresponds to periods of migratory movement, when the largest numbers of dolphins would be expected to be moving along the beach (Kenney 1990).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Area—The coastal bottlenose dolphin stock is not well represented here in terms of the amount of available data (Figure 3-20). Much of the data from dedicated coastal bottlenose dolphin surveys that are conducted by National Marine Fisheries Service (NMFS), non-profit organizations, and universities were not available for inclusion in this report. Bycatch records were also not available from NMFS for the nearshore and inshore waters of the study area, where it is well known that fishery interactions with dolphins occur (e.g., Steve et al. 2001). In fact, the level of incidental mortality and serious injury of the Atlantic coastal stock of bottlenose dolphins in commercial fisheries is such a concern, that it has prompted NMFS to address this issue with an EIS (NMFS 2002). It should also be noted that the occurrence patterns are drawn on a large scale and do not necessarily reflect the localized movements and detailed occurrence patterns of bottlenose dolphins, particularly inside the barrier islands. For example, as noted earlier, dolphins prefer habitat along shorelines (which likely concentrate their preferred prey). Therefore, while it is unlikely that dolphins are sighted in the middle of the Neuse River, the scale of the map requires a less-detailed presentation of the occurrence of dolphins in that area.

Bottlenose dolphins in Virginia waters occur seasonally from late April to November (Blaylock 1988; Barco et al. 1999; NMFS-SEFSC 2001) (Figure 3-20). Dolphins move from south to north in the spring as ambient water temperatures increase and vice versa in the fall as temperatures decrease (Swingle 1994; Barco et al. 1999). Barco et al. (1999) reported the largest numbers of dolphins during August and the smallest during November. Barco et al. (1999) also found that dolphin counts were always highest outside Chesapeake Bay, in the ocean. After August, no dolphins were sighted in the bay portion of Barco et al.'s (1999) study area, while dolphin counts remained high in the ocean. It has also been suggested that some of the dolphins may move further north during the mid-summer (Swingle 1994; NMFS-SEFSC 2001; Palka et al. 2001). Swingle (1994) noted the sighting of large (25 to 100 dolphins) groups in Virginia coastal waters within 1.5 km of shore in January and February. Dolphins are frequently observed near the mouth of Chesapeake Bay and along the southern coastline of Virginia (Blaylock 1988; Swingle 1994; Barco et al. 1999). The northern shoreline of Cape Henry is considered a "nursery" area (Jones 1995; Barco et al. 1999). This rounded shoreline may offer protection from constant wave action or may harbor a higher prey density than other areas in Chesapeake Bay (Barco et al. 1999). A tidal intrusion front occurs inside the mouth of the Chesapeake (Marmorino et al. 1999). Dolphins may be using the frontal region as a feeding habitat, as has been suggested for a tidal intrusion front in Kessock Channel in Scotland (Mendes et al. 2002). Bottlenose dolphins in other locales, including the Gulf of California and at Ensenada de La Paz (Mexico), also have been observed in high relative abundance and feeding frequently near the mouths of estuaries (Acevedo 1991; Ballance 1992; Ingram and Rogan 2002).

Kenney (1990) found that no bottlenose dolphins were observed in inshore waters during winter north of Cape Hatteras. However, other studies have reported sighting some individuals north of Cape Hatteras during the winter (Blaylock and Hoggard 1994; Wiley et al. 1994; Torres et al. 2003). The waters off Cape Hatteras are consistently utilized habitat for bottlenose dolphins, with

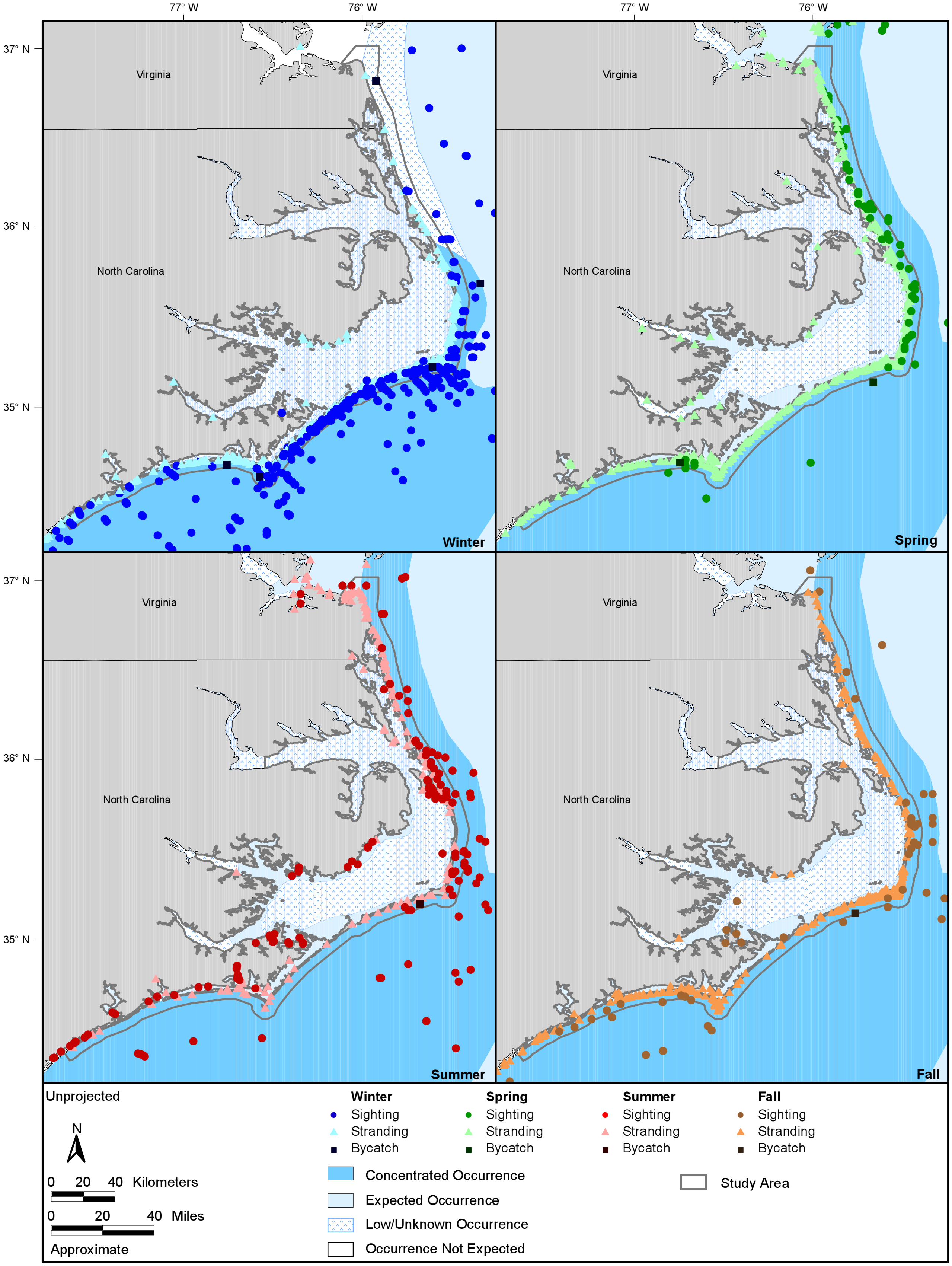

Figure 3-20. Occurrence of the bottlenose dolphin in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

extremely high abundance rates in this area during the fall and winter (Torres et al. 2003). Bottlenose dolphins are found throughout the year in some estuaries, inlets, and rivers south of Cape Hatteras (Hohn 1997, personal communication; Rittmaster and Thayer 1995; Thayer personal communication). Peak numbers of dolphins have been noted throughout the bays, sounds, and estuaries of the area south of Cape Hatteras during the summer (May through September) (Rittmaster and Thayer 1994, 1995; Mazzarella 2001; Read et al. 2001; Read et al. 2003a). During the winter, most sightings are in the nearshore ocean (Blaylock and Hoggard 1994; Rittmaster and Thayer 1995; Torres et al. 2003). Aerial surveys conducted south of Cape Hatteras from 2000 through 2002 determined that bottlenose dolphin sightings peaked within 3 km of the shore (Torres et al. 2003). Movement from estuaries into coastal waters is impeded by the presence of barrier islands in North Carolina, although dolphins can leave the bays and sounds through a small number of passes that lead to the ocean (Mazzarella 2001; Read et al. 2003a).

Dolphins in North Carolina concentrate in shallow water habitats along shorelines, and few, if any, individuals are present in the central portions of the sounds (Gannon 2003; Read et al. 2003a). Bottlenose dolphins are rarely sighted in Albermarle Sound (Read et al. 2003a), and then only occasionally during the summer in the eastern portion (Hohn personal communication). Dolphins sighted in the eastern portion of Albermarle Sound are likely to be individuals moving through the passes leading to the ocean. There appears to be a resident population of dolphins in Pamlico Sound during the spring, summer, and fall (Hohn personal communication; NMFS-SEFSC 2001). During the winter, this population moves into nearby nearshore areas in the winter when Pamlico Sound may have an inadequate resource base (Rittmaster and Thayer 1994; NMFS-SEFSC 2001; Rittmaster personal communication; Waring et al. 2002).

Bottlenose dolphins in this area select shallow habitats, such as tributary creeks and the edges of the Neuse River, where the bottom depth is less than 3.5 m (Gannon 2003). Dolphins are using the bombing ranges in the study area. Bottlenose dolphins have been sighted during surveys recently conducted for the U.S. Marine Corps of the Brant Island Shoal Bombing Target (BT-9) and the Piney Island Bombing Range (BT-11) and adjacent waters (Read et al. 2002, 2003b, 2003c). Most sightings were clustered along the shoreline of BT-11. Some large groups of dolphins have been reported in these restricted areas. On one occasion, in December 2002, a group of 70 dolphins moved inside the BT-11 range (Read et al. 2003b). In October 2002, a sighting of 50 dolphins was made near the target in BT-9 (Read et al. 2003b). Dolphins use the downstream portion of the Neuse River estuary and lateral creeks more than the upstream area (Gannon 2003). Dolphin density is highest during the spring (May and June) and lowest during the summer (July and August) in the Neuse River estuary (Gannon 2003). Fine-scale distribution of dolphins seems to relate to the presence of vertical structures, such as the steeply-sloping bottom nears the shore and oyster reefs, which could be used to facilitate prey capture.

The confluence of the Newport River and Core Creek in North Carolina may be a "nursery" area (Rittmaster personal communication; Rittmaster and Thayer 1994; Thayer personal communication), particularly during the peak calving season in summer (Rittmaster and Thayer 1995).

Thousands of bottlenose dolphins can be found on the continental shelf, outside the bay systems. It is expected that there will be higher numbers of dolphins in nearshore waters rather than inside the bays and sounds, which is reflected by the areas of concentrated occurrence in nearshore waters (Figure 3-20). While we know that inshore dolphin numbers change, it is not known whether this is a reflection of migration inshore between bays and/or sounds, coastally alongshore, directly offshore, or even whether resident dolphins may simply be congregating seasonally near the passes to the ocean (in response to prey movements).

The coastal bottlenose dolphin stock shows a temperature-limited distribution, with winter records occurring further south (south of the Virginia/North Carolina border) than during other seasons (Figure 3-20). During the winter, bottlenose dolphins are not expected to occur in Chesapeake Bay. There is primarily a low or unknown occurrence of bottlenose dolphins in the inshore waters of North Carolina (Figure 3-20). There is an expected occurrence in a narrow strip just inside the barrier islands of North Carolina, south of Albermarle Sound, to account for the probability of dolphins moving back and forth through the passes from the ocean to the fringes of the sounds. Mean sea surface temperatures near the passes in Pamlico Sound are within the same range as temperatures on the ocean side south of the vicinity of Oregon Inlet (Figure 2-5). It also has been noted that Pamlico Sound does not provide an adequate resource base for bottlenose dolphins during the winter. This is likely a reflection of low salinities during winter in that area (Figure 2-6). There is, however, no reason to believe that dolphins would not venture back and forth from the area of concentrated occurrence through the passes in attempts to locate food.

During spring, summer, and fall, mean sea surface temperatures are warmer and salinity is greater, to which the dominant prey species of these bottlenose dolphins–sciaenids (croaker, drum, and trout) – likely respond. Also taken into consideration were the historic catches using beach seines in the Cape Hatteras porpoise fishery. This fishery reported the highest catches in November and March through May (Mead 1975). While this net fishery for dolphins is referred to as the Hatteras porpoise fishery, it is likely that it included the whole Outer Banks, with reports from Ocracoke Inlet down to the Cape Lookout area (Mead 1975). Bottlenose dolphins are expected in the northern portion of the study area, in the mouth of Chesapeake Bay (Figure 3-20). Dolphin occurrence is low or unknown in upstream rivers or creeks, so a primarily low or unknown occurrence is presented in those areas to reflect the possibility that a dolphin could be sighted there (Figure 3-20).

Behavior and Life History—*Tursiops* are very gregarious; they are typically found in groups of 2 to 15 individuals, although groups of 100 have been reported (Shane et al. 1986). Based on photo-identification techniques using dorsal fin shapes and markings (Würsig and Würsig 1977), it is well known that *Tursiops* has a fluid social organization (Connor et al. 2000). Habitat structure, in terms of complexity and water depth, is generally a major force that shapes *Tursiops* groupings (Shane et al. 1986). Shallow-water areas typically have smaller group sizes than open or oceanic areas. Open coastlines, however, differ in habitat structure and prey distribution from more protected areas. Protected areas have been found to foster relatively small school sizes, some degree of regional site fidelity, and limited movement patterns (Wells et al. 1987). In contrast, semi-open habitats often sustain larger school sizes, diminished levels of site fidelity, and more expansive home ranges (Defran and Weller 1999). Coastal bottlenose dolphins exhibit a full spectrum of movements, including seasonal migrations, year-round home ranges, periodic residency, and a combination of occasional long-range movements and repeated local residency (Wells and Scott 1999).

Along the Atlantic Coast of the U.S., male and female bottlenose dolphins reach physical maturity at 13 years, with females reaching sexual maturity as early as 7 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). For the same central U.S. Atlantic coast areas, Hohn (1980) reported one (spring) and possibly two calving seasons (spring and fall), whereas Mead and Potter (1990) reported a prolonged calving season with a spring peak. Sighting data from the Beaufort, NC area suggests a diffuse peak during March through May, plus a smaller, secondary peak during the fall (Thayer et al. 1999). There is a gestation period of one year (Caldwell and Caldwell 1972). Calves of bottlenose dolphins typically remain with their mothers for 3 to 6 years (Wells et al. 1987).

Tursiops are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Wells and Scott 1999). Bottlenose dolphins likely detect and orient to fish prey by listening for the sounds they produce (Barros and Myrberg 1987; Gannon 2003). Sciaenids (croakers, drums, and seatrouts) are the dominant group of organisms found in stomachs of bottlenose dolphins stranded in Virginia (McGurk et al. 1995) and North Carolina (Waples et al. 2002; Gannon 2003); these are soniferous fish species. *Tursiops* use a wide variety of feeding strategies (Shane 1990). In the mid-Atlantic U.S., bottlenose dolphins often feed in association with shrimp trawl nets (Davis 1988; Fertl and Leatherwood 1997; Fleming et al. 2003).

Bottlenose dolphins can reach maximum diving depths of about 390 m, with dive durations of 8 or 9 min; it is very common for them to dive to depths of 200 m, with dive durations of 4 min (Ridgway 1986).

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 bands (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 3.5 to 14.5 kHz and 125 to 173 dB re 1 μPa-m, respectively (Ketten 1998). Generally, whistles range in frequency from 4 to 20 kHz, though Schultz et al. (1995) described whistles with fundamental frequencies entirely below 2 kHz.

The bottlenose dolphin has a functional high-frequency hearing limit of 160 kHz (Au 1993) and can hear sounds at frequencies as low as 40 to 125 Hz (Turl 1993). Inner ear anatomy of this species has been described (Ketten 1992). Electrophysiological experiments suggest that the bottlenose dolphin brain has a dual analysis system: one specialized for ultrasonic clicks and the other for lower-frequency sounds, such as whistles (Ridgway 2000). The audiogram of the bottlenose dolphin shows that the lowest thresholds occurred near 50 kHz at a level around 45 dB re 1 μPa-m, with 10 dB-down bandwidth extending from 15 to 110 kHz (Nachtigall et al. 2000). Below the frequency region of maximum sensitivity, thresholds increased continuously up to a level of 137 dB at 75 Hz. Above 50 kHz, thresholds increased slowly up to a level of 55 dB at 100 kHz, then increased rapidly above this to about 135 dB at 150 kHz. Scientists have reported a range of best sensitivity between 25 and 70 kHz, with peaks in sensitivity occurring at 25 and 50 kHz at levels of 47 and 46 dB re 1 μPa-m (Nachtigall et al. 2000). Richardson (1995) noted that the differences between the reported audiograms for these two studies might be attributable in part to tank problems. A neurophysiological method was used to determine the high-frequency audiograms (5 to 200 kHz) of five bottlenose dolphins (Richardson 1995). Temporary threshold shifts (TTS) in hearing have been experimentally induced in captive bottlenose dolphins (Ridgway et al. 1997). Changes in behavior were observed at the following minimum levels for 1 sec tones: 186 dB at 3 kHz, 181 dB at 20 kHz, and 178 dB at 75 kHz. TTS levels were 194 to 201 dB at 3 kHz, 193 to 196 dB at 20 kHz, and 192 to 194 dB at 75 kHz.

♦ <u>Common Dolphin</u> (*Delphinus* spp.)

Description—There are at least two species in the genus *Delphinus*: the long-beaked common dolphin (*Delphinus capensis*) and the short-beaked common dolphin (*Delphinus delphis*) (Heyning and Perrin 1994; Rosel et al. 1994; Rice 1998). Common dolphins are moderately slender animals with a medium to long beak and a tall, slightly falcate dorsal fin. Common dolphins are distinctively marked, having a V-shaped dark saddle that produces an hourglass pattern on the side of the body (Jefferson et al. 1993). The back is a dark, brownish gray, the belly is white, and an anterior flank patch is tan in color. The lips are dark and there is a stripe running from the apex of the melon to encircle the eye. There is also a black to dark gray chin-to-flipper stripe. Adults can reach lengths of up to 2.6 m (Jefferson et al. 1993).

Status—The best estimate of abundance for the western North Atlantic stock of common dolphins is 30,768 individuals (Waring et al. 2002). There is no information available for common dolphin stock structure for the western North Atlantic (Waring et al. 2002). The northwest Atlantic population of this species is considered a strategic stock (Waring et al. 2002).

Habitat Preferences—Common dolphins appear to preferentially travel along bottom topographic features such as escarpments and sea mounts (Evans 1994). Globally, common dolphins are distributed along most coasts over the continental shelf, roughly along the 200 to 300 m isobaths, or over prominent underwater topography (e.g., mid-Atlantic Ridge and seamounts) (Evans 1994). In tropical regions, where common dolphins are routinely sighted, they are found in upwelling-modified waters (Au and Perryman 1985; Ballance and Pitman 1998).

Selzer and Payne (1988) reported on the distribution of common and Atlantic white-sided dolphins along the northeastern U.S. They found that common dolphins were abundant within a broad band paralleling the continental slope from 35ºN to the northeast peak of Georges Bank. Sightings of the common dolphin were distributed primarily along the edge of the continental shelf south of 40ºN in spring and north of this latitude in fall. Both common and Atlantic white-sided dolphins were sighted more frequently in areas of high seafloor relief, but common dolphins were found in warmer, more saline waters than the white-sided dolphins. Peak abundance of common dolphins in the southern Gulf of Maine and over Georges Bank appears to coincide, at different times of year, with peak abundances of mackerel, butterfish, and common squid (Selzer and Payne 1988).

Distribution—This is a widely distributed genus of cetaceans. It is found worldwide in temperate, tropical, and subtropical seas. Along the U.S. Atlantic coast, this species is typically found in temperate to cooler waters (Waring and Palka 2002). Records of the short-beaked common dolphin from the western North Atlantic range from at least Florida to Newfoundland (Heyning and Perrin 1994). The long-beaked common dolphin is known from the coast of eastern South America from Venezuela to northern Argentina (Heyning and Perrin 1994).

On the northeastern U.S. coast, common dolphins are concentrated between the 100 and 200 m isobaths (CETAP 1982; Selzer and Payne 1988). In the fall, this species is particularly abundant along the northern edge of Georges Bank (CETAP 1982). Common dolphins are less common south of Cape Hatteras (Waring et al. 2002).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Area— Any sightings of common dolphins in the study area should be considered extralimital, since they are typically found in deeper waters than those occurring in the study area (Kenney personal communication). There are three sightings of common dolphins recorded for the study area; all three of these sightings occurred close to one another north of Cape Hatteras on the same day in mid-March 1998. These were recorded during a NMFS-NEFSC shipboard sighting survey. Perhaps there was a concentrated occurrence of prey in the area during these sightings. It is noteworthy that common dolphins have never been sighted with all the survey effort in this area for right whales, bottlenose dolphins, and sea turtles.

Behavior and Life History—Group size ranges from several dozen to over 10,000 (Jefferson et al. 1993). Common dolphins are fast-moving swimmers, are active bowriders, and often jump in the air. Calving peaks differ from stock to stock. Calving peaks in spring and autumn, or spring and summer, have been reported (Jefferson et al. 1993). Common dolphins feed on a wide variety of epipelagic and mesopelagic schooling fishes and squids in the deep-scattering layer. Common dolphins feed opportunistically on those species most abundant locally and change their diet according to fluctuations on the abundance and availability of prey (Young and Cockcroft 1994). Long-finned squid and Atlantic mackerel are important prey for common dolphins; herring, whiting, pilchard, and anchovy are also eaten (Waring et al. 1990; Overholtz and Waring 1991). 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 during the same time (Goold 2000).

Acoustics and Hearing—Recorded common dolphin vocalizations include whistles, chirps, barks, and clicks (Ketten 1998). Clicks and whistles have dominant frequency ranges of 23 to 67 kHz and 0.5 to 18 kHz, respectively (Ketten 1998). Popov and Klishin (1998) recorded auditory brainstem responses from a common dolphin. The audiogram was U-shaped with a steeper high-frequency branch. The audiogram bandwidth was up to 128 kHz at a level of 100 dB above the minimum threshold. The minimum thresholds were observed at frequencies of 60 to 70 kHz.

- Killer Whale (*Orcinus orca)*

Description—The black-and-white color pattern of the killer whale is striking, as is the tall, erect dorsal fin of the adult male (1.0 to 1.8 m in height) (Jefferson et al. 1993). The white oval eye patch and variably shaped saddle patch, in conjunction with the shape and notches in the dorsal fin, help in identifying individuals. The killer whale has a blunt head and large, oval flippers. Females may reach 7.7 m in length and males 9.0 m (Dahlheim and Heyning 1999).

Status—There are no abundance estimates for the killer whale for the U.S. Atlantic (Blaylock et al. 1995). Killer whales are characterized as uncommon or rare in these waters. No updated information on this species appears in more recent NMFS stock assessment reports.

Habitat Preferences—Killer whales can be found in the open sea, as well as in coastal areas (Dahlheim and Heyning 1999). In coastal areas, killer whales often enter shallow bays, estuaries, and river mouths (Leatherwood et al. 1976). Killer whale sightings in the northwest Atlantic are concentrated (based on a review of sighting and whaling records) along the shelf break and further offshore of the mid-Atlantic states (Katona et al. 1988; Mitchell and Reeves 1988). Killer whale distribution in this area probably has more of an offshore component than has been previously noted. Killer whales in the Hatteras-Fundy region probably respond to the migration and seasonal distribution patterns of non-cetacean prey such as bluefin tuna (*Thunnus thynnus*), herring (*Clupea harengus*), and squid (Katona et al. 1988; Gormley 1990). The timing of tuna migration is somewhat variable, since it depends partly on oceanic currents, weather conditions, and prey distribution.

Distribution—This is a cosmopolitan species found throughout all oceans and contiguous seas, from equatorial regions to the polar pack-ice zones. Though found in tropical waters and the open ocean, the killer whale as a species is most numerous in coastal waters and higher latitudes (Dahlheim and Heyning 1999). Ford (2002) noted that this species has a sporadic occurrence in most regions. In the western North Atlantic, sightings have been recorded off Baffin Island and in Lancaster Sound (Mitchell and Reeves 1988) and south along the eastern coasts of Canada and the U.S. (Katona et al. 1988; Mitchell and Reeves 1988; Gormley 1990). Regular occurrence year-round is in the area south of 35ºN.

There is some indication of a seasonal or migratory population(s) of killer whales for the northern portion of the northwest Atlantic. A northward migration occurs into the latitude of Cape Cod Bay and Massachusetts Bay beginning in May or June, with somewhat fewer sightings during the colder months (Katona et al. 1988; Gormley 1990). Actual home range size for any killer whale in the northwest Atlantic is not known. Perhaps the widest documented movement for killer whales is a number of individuals seen both in central California and in southeastern Alaska–a linear distance of 2,660 km (Goley and Straley 1994).

- <u>Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Area</u>—There is a low or unknown occurrence of killer whales from the shore to the shoreward boundary of the VACAPES and Cherry Point OPAREAs throughout the year, based on the small number of killer whale sightings and strandings recorded in the study area (Figure 3-21). Although in many coastal areas, killer whales often enter shallow bays, estuaries, and river mouths (Leatherwood et al. 1976), killer whales are not expected to make their way into inshore waters of the study area (for example, within Chesapeake Bay or inside of the barrier islands of North Carolina). Killer whales are extremely distinctive marine mammals, and if they had been sighted in the inshore waters of the study area, there would likely be an available record of such an occurrence. This is not the case. The earliest recorded sighting is from March 1934 off New River Inlet in North Carolina (Caldwell and Golley 1965). There is one sighting from March 1987 that appears to be inside the barrier island north of Cape Hatteras. This sighting likely occurred on the ocean side of the barrier island, and the coordinates provided in Katona et al. (1988) are not accurate. The other two sightings are from April 1980 (CETAP 1982) and one reported during May 1981. Strandings are reported throughout most of the year.

Behavior and Life History—In all areas where longitudinal studies have been carried out, evidence suggests that there are long-term associations between individuals and limited dispersal from maternal groups (Baird 2000). Killer whales normally occur in small groups in the northwestern Atlantic Ocean; the largest recorded group size was 40 individuals (Katona et al. 1988). There is no published information on killer whale reproductive behavior in the western North Atlantic Ocean.

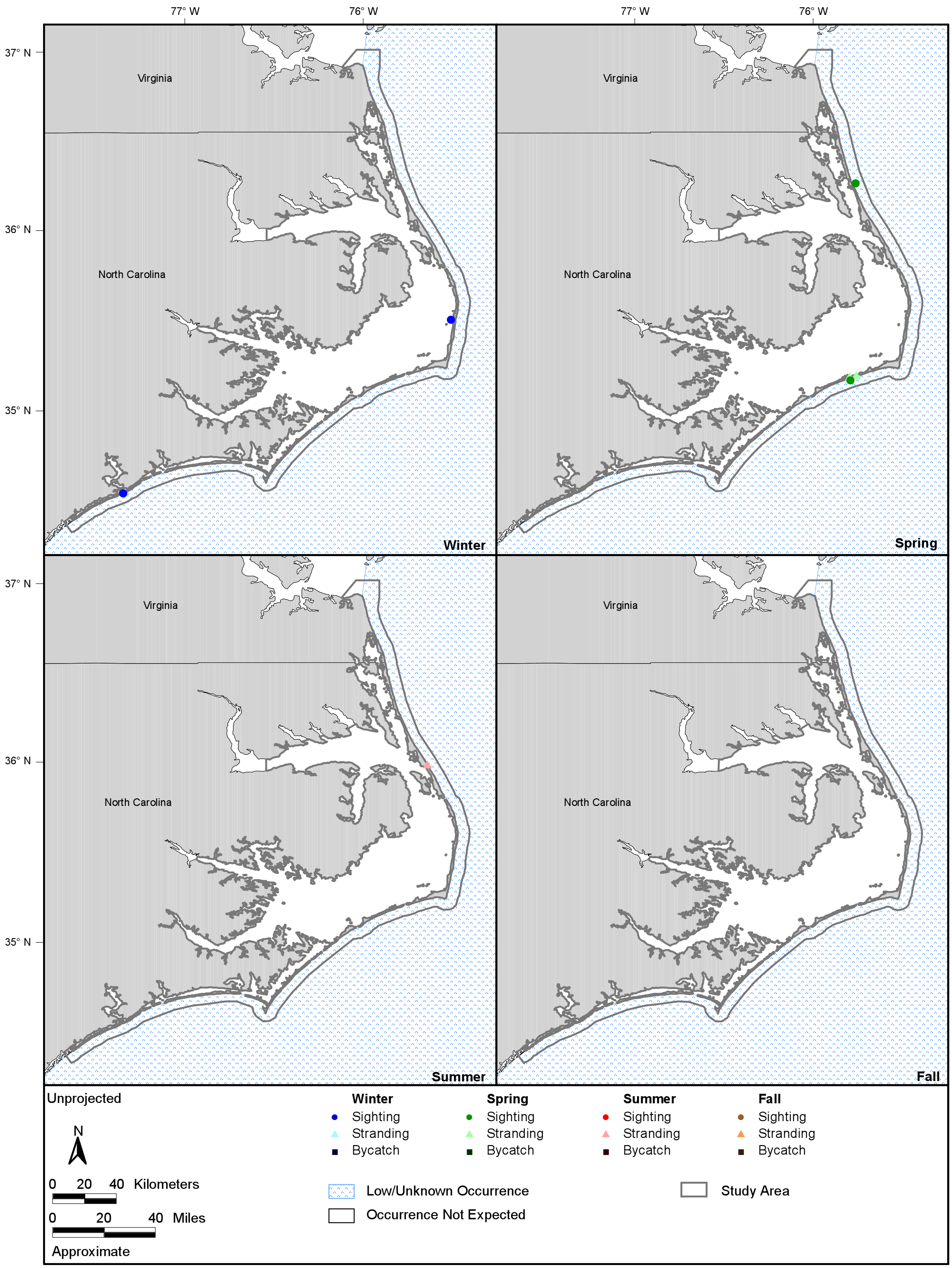

Figure 3-21. Occurrence of the killer whale in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

Killer whales feed on bony fishes, elasmobranchs, cephalopods, seabirds, sea turtles, and other marine mammals (Katona et al. 1988; Jefferson et al. 1991; Fertl et al. 1996). Killer whales use passive listening as a primary means of locating prey and use different echolocation patterns for different hunting strategies (Barrett-Lennard et al. 1996). For example, they mask their clicks and encode their signals in background noise when hunting other cetaceans, prey that can hear their high-frequency clicks. In contrast, killer whales do not mask their high-frequency signals when hunting fish that do not hear in this frequency range.

The maximum recorded depth for a killer whale diving off British Columbia was 173 m; a trained killer whale dove to a maximum of 260 m (Dahlheim and Heyning 1999). The longest recorded dive from a radio-tagged killer whale was 17 min (Dahlheim and Heyning 1999).

Acoustics and Hearing—The killer whale produces a wide variety of clicks and whistles, but most of its sounds are pulsed and at 1 to 6 kHz; source levels range up to 160 dB re 1 µPa-m (Thomson and Richardson 1995). Acoustic studies of resident killer whales in British Columbia discovered that there are dialects, which are highly stereotyped, repetitive discrete calls that are group-specific and shared by all group members (Ford 2002). These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely related whales (Ford 2002). Dialects have been documented in killer whales occurring in northern Norway, and likely occur in other locales as well (Ford 2002).

The killer whale has the lowest frequency of maximum sensitivity and one of the lowest high-frequency limits among toothed whales (Szymanski et al. 1999). The upper limit of hearing is 100 kHz for this species. The most sensitive frequency, in both behavioral and in auditory brainstem response audiograms, is 20 kHz (Szymanski et al. 1999).

♦ Harbor Porpoise (*Phocoena phocoena*)

Description—Harbor porpoises are the smallest cetaceans occurring in the North Atlantic; they reach a maximum length of 2 m (Jefferson et al. 1993). The body is stocky, dark gray to black on the back and white on the belly. 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, and located slightly behind the middle of the back.

Status—It has been proposed that there are four separate populations of harbor porpoises in the western North Atlantic: Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland (Gaskin 1992). The best estimate of abundance for the Gulf of Maine/Bay of Fundy stock of harbor porpoises is 89,700 individuals (Waring et al. 2002).

Habitat Preferences—The harbor porpoise appears to be restricted to relatively cool waters, where aggregations of prey are concentrated (Watts and Gaskin 1985). They are seldom found in waters warmer than 17ºC (Read 1999); these temperatures correlate quite closely with the preferred temperature range of main prey, for example, Atlantic herring (Gaskin 1992). Harbor porpoises are usually scarce in areas without significant coastal fronts or topographically generated upwellings (Gaskin 1992). Harbor porpoises occur mostly on the continental shelf. However, based on a catch in a pelagic drift net, as well as movements of a satellite-tracked individual, which swam offshore into water over 1,800 m deep, this species appears to have an offshore component to its distribution (Read et al. 1996; Westgate et al. 1998). Genetic evidence also suggests limited trans-Atlantic movements of this species (Rosel et al. 1999a).

Distribution—Harbor porpoises occur in cool temperate to subpolar waters around both the North Atlantic and North Pacific (Read 1999). Off the northeast 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). The southern limit in the western North Atlantic is northern Florida, based on stranding information (Read 1999).

During summer, harbor porpoises are concentrated in the northern Gulf of Maine and lower Bay of Fundy region, generally in waters less than 150 m deep (Waring et al. 2002). During fall, Gulf of Maine harbor porpoise densities are very low, and sightings were concentrated in the northern Gulf of Maine and around Cape Cod/Massachusetts Bay (CETAP 1982). Sightings in the spring are concentrated in the southwestern Gulf of Maine around Nantucket Shoals, Great South Channel, and western Georges Bank, as well as in the northern Gulf of Maine and Bay of Fundy (CETAP 1982). During winter, 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. The animals present occur primarily in the northern Gulf of Maine along the Maine coast. The New Jersey shore and approaches to New York harbor may represent an important winter habitat (Westgate et al. 1998). More recent data have shown that significant numbers of porpoises occur along the mid-Atlantic shore from New Jersey to North Carolina during the winter, where they are subject to incidental capture in a variety of coastal gillnet fisheries (Cox et al. 1998; Waring et al. 2002). Mid-Atlantic porpoise bycatch occurs in December–May (Waring et al. 2002). Data indicate that only juvenile harbor porpoises are present in nearshore waters of the mid-Atlantic during the winter (Cox et al. 1998). Harbor porpoises are not tied to shallow nearshore waters during winter, as evidenced by a harbor porpoise catch in a pelagic drift net off North Carolina (Read et al. 1996). A largely offshore distribution of harbor porpoises during winter would explain the paucity of sightings in the Bay of Fundy and Gulf of Maine (CETAP 1982). Genetic data from mid-Atlantic stranded and by-caught porpoises, however, show them to be a mixture of animals from different stocks rather than simply migrants from the Gulf of Maine/Bay of Fundy stock (Rosel et al. 1999b).

- Information Specific to the Cherry Point and Southern VACAPES Inshore and Estuarine Area—In the North Atlantic, the harbor porpoise primarily occurs on the continental shelf, in cool temperate to subpolar waters (Waring and Palka 2002). This species is not expected to make its way into inshore waters (for example, within Chesapeake Bay or inside of the barrier islands of North Carolina) (Hohn personal communication; Figure 3-22). During the winter, the harbor porpoise is expected from the shore to the shoreward boundary of the VACAPES and Cherry Point OPAREAs. The southern boundary of the harbor porpoise's expected occurrence is the warm waters of the Gulf Stream (Figure 3-22). There is an increase in stranding records in the study area during the winter, most probably due to catches in coastal gillnets and haul/beach seines (Steve et al. 2001). There is a low or unknown occurrence of harbor porpoise during the spring, summer, and fall in the nearshore waters of the study area, north of the Gulf Stream (Figure 3-22). During the summer, the area of low or unknown occurrence is further north, since water temperatures would be higher during this time of year. There is the possibility that some individual porpoises might make their way into this area during the winter months. The strandings reported for the summer are puzzling and might reflect strandings that actually occurred during spring but were not found until summer when there are more people on beaches (Kenney personal communication).

Behavior and Life History—Harbor porpoises are not known to form stable social groupings (Read 1999). In many areas, harbor porpoises are found in small groups consisting of 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 3 years of age and give birth to a calf each year (Read and Hohn 1995). Calves are born in late spring (Read 1990a; Read and Hohn 1995). Many females are pregnant and lactating simultaneously (Read 1990b; Read and Hohn 1995). Relative to other cetaceans, harbor porpoises seem to allocate a larger percentage of their total body mass to blubber (McLellan et al. 2002), which helps them meet the energetic demands of living in a cold-water environment.

Harbor porpoises feed on a variety of small, schooling clupeoid (herring-like) and gadid (cod-like) fishes up to 40 cm long, and usually less than 30 cm (Read 1999). Primary prey in the Bay of Fundy is Atlantic herring and silver hake (Recchia and Read 1989). Atlantic herring is the most important prey of Gulf of Maine harbor porpoises in fall (Gannon et al. 1998). At 4 to 7 months of age (Read and

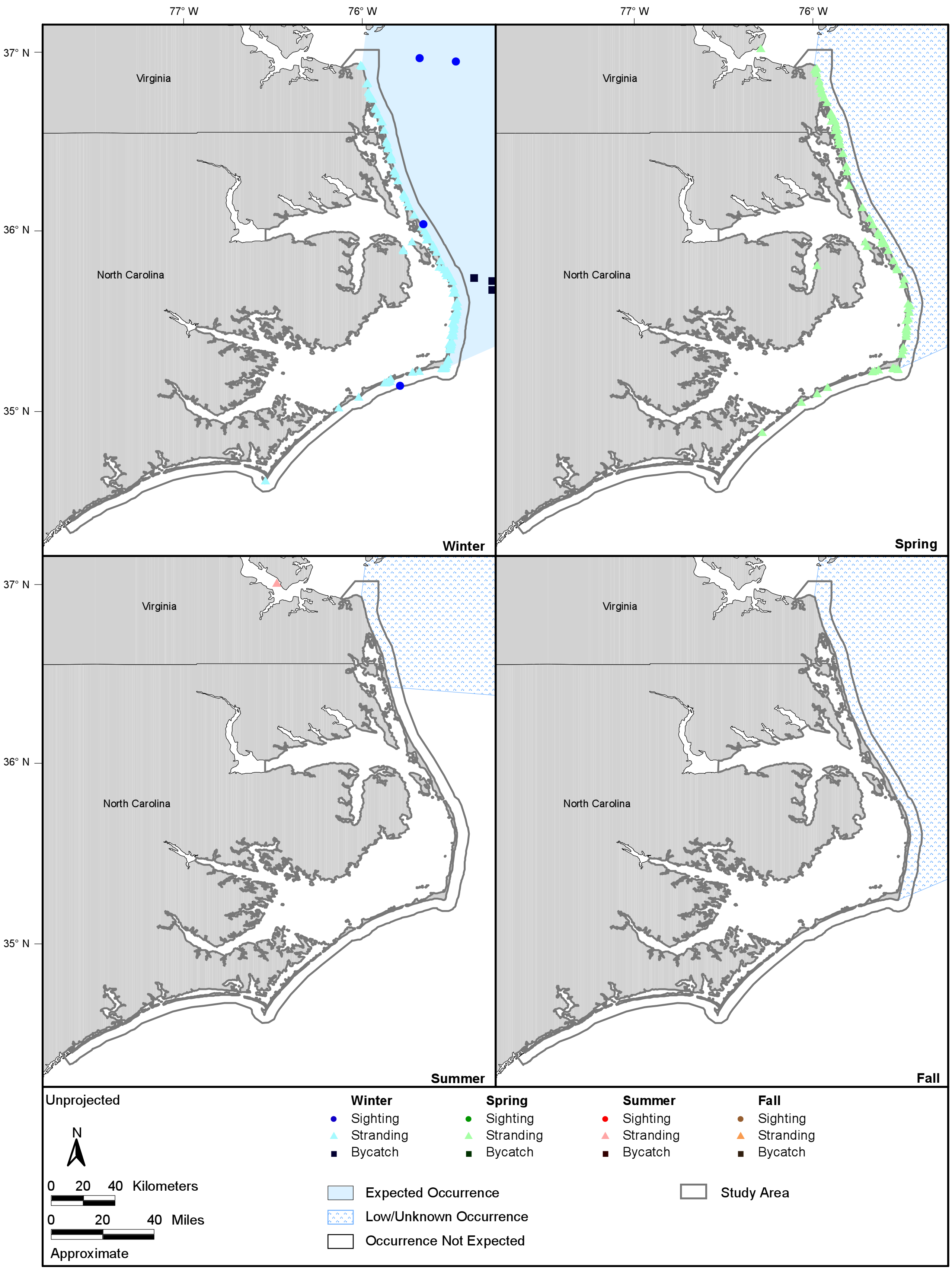

Figure 3-22. Occurrence of the harbor porpoise in the Cherry Point and southern VACAPES inshore and estuarine areas. Available sighting, stranding, and incidental fisheries bycatch records are represented by season. Source data: refer to Appendix A.

Hohn 1995), 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 (Westgate et al. 1995; Read and Westgate 1997). Average dive depths ranged from 14 to 41 m with a maximum dive of 226 m, and average dive durations ranged from 44 to 103 sec (Westgate et al. 1995). Westgate and Read (1998) noted that dive records of tagged porpoises did not reflect the vertical migration of their prey; porpoises made deep dives during both day and night.

Acoustics and Hearing—Harbor porpoise vocalizations include clicks and pulses (Ketten 1998), as well as whistle-like signals (Verboom and Kastelein 1995). The dominant frequency range is 110 to 150 kHz, with source levels of 135 to 177 dB re 1 µPa-m (Ketten 1998). Echolocation signals include one or two low-frequency components in the 1.4 to 2.5 kHz range (Verboom and Kastelein 1995). A behavioral audiogram of a harbor porpoise indicated the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re 1 µPa-m (Andersen 1970); however, auditory-evoked potential studies showed a much higher frequency of approximately 125 to 130 kHz (Bibikov 1992). The auditory-evoked potential method suggests that the harbor porpoise actually has two frequency ranges of best sensitivity. More recent studies found the range of best hearing to be 16 to 140 kHz (Kastelein et al. 2001).

Seals

Although there are four species of seals found in the western North Atlantic, no seal species normally ranges as far south as the study area. Any sightings of seals represent uncommon extralimital occurrences of animals that strayed from their normal distributional range. These extralimital occurrences typically occur during winter and spring months. Winter and spring are the seasons with the highest number of seal occurrence records (primarily strandings). The northern part of the U.S. eastern seaboard has experienced a significant increase in stranded “ice seals” ((harp and hooded seals) since the late 1980s (McAlpine and Walker 1990; Slocum et al. 1999; Mignucci-Giannoni and Odell 2001). The cause for this increase may be that collapsed fish stocks no longer support current high populations, forcing the seals to move to poorer feeding areas further south (McAlpine et al. 1999). The majority of seals moving into the mid-Atlantic area are thought to be subadults and juveniles, which may reflect the higher energy requirements of younger animals (Whitman and Payne 1990).

♦ Hooded Seals (*Cystophora cristata*)

Hooded seals are found in the Atlantic region of the Arctic Ocean and in high latitudes of the North Atlantic, especially near the outer edge of the pack ice. Hooded seals (particularly young ones) are recognized as great wanderers. They appear in places far from their normal breeding and foraging range and have traveled as far south as Puerto Rico and the Virgin Islands (Mignucci-Giannoni and Odell 2001; Mignucci-Giannoni and Haddow 2002). Appearances along the Atlantic U.S. usually occur between January and May. There are three records for hooded seals for North Carolina (Mignucci-Giannoni and Odell 2001).

♦ Harp Seals (*Pagophilus groenlandicus*)

Harp seals are closely associated with pack ice and undergo extensive spring and fall migrations to and from summer feeding and pupping grounds in subarctic and arctic waters (Hannah 1998). Pupping and breeding in the western North Atlantic occurs off the coast of Newfoundland and Labrador and near the Magdalen Islands in the middle of the Gulf of St. Lawrence (Waring et al. 2002). Harp seals feed intensively in the winter and summer, but eat less during the spring and autumn migrations and during spring pupping and molt (Ronald and Healey 1981). During the summer, the northwest Atlantic population extends from Thule, Greenland and Jones Sound between Devon and Ellesmere islands, south to northern Labrador waters and from Cape Farewell west to northwest and southeast Hudson Bay (Ronald and Healey 1981). The movement south of the

Canadian archipelago begins in late September and early October, and by early November, large numbers have passed Cape Chidley in northern Labrador to reach the Strait of Belle Isle in late December (Ronald and Healey 1981). Only the adults and older subadults are involved in this migration (Ronald and Healey 1981). The remaining subadults move later although some stay behind in the West Greenland waters throughout the winter (Ronald and Healey 1981). On occasions during the winter, a harp seal will wander south of the normal feeding and breeding areas off Newfoundland. A few of these wandering seals will even survive into the summer months in southern waters (McAlpine and Walker 1990). Strandings outside of the normal species range occur between early February and late May and involve animals of both sexes and various ages. There is a record of an adult harp seal that was found in March 1945 at Cape Henry, VA (McAlpine and Walker 1990).

- Gray Seals (*Halichoerus grypus*)

Gray seals occur from southern New England to Labrador, but the highest concentration of this species is centered in the Sable Island region off Nova Scotia (Waring et al. 2002). Vagrants have been reported as far south as Assateague Island, VA in the late 1980s (Katona et al. 1993) and north of Oregon Inlet in North Carolina in February 2000.

- Harbor Seals (*Phoca vitulina concolor*)

Harbor seals inhabit temperate, subarctic and some arctic waters of the northern hemisphere and are found from New Jersey/eastern New York to Greenland and Hudson Bay in the western North Atlantic (Jefferson et al. 1993). They are year-round inhabitants of the coastal waters of eastern Canada and Maine and seasonal migrants into southern New England and New York. Breeding and pupping normally occurs southward to the Gulf of Maine (Katona et al. 1993). Harbor seals are found near land and frequently haul-out on rocks and beaches.

The harbor seal is the most common seal found along the U.S. Atlantic coast (Wynne and Schwartz 1999). Vagrants are occasionally found as far south as South Carolina and Daytona Beach, FL (Caldwell 1961; Caldwell and Golley 1965; Caldwell and Caldwell 1969). Harbor seals that occur in this area are apparently young individuals that disperse from the north (Winn et al. 1979). In Virginia, an occasional harbor seal hauls 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 in spring and summer (Blaylock 1985). Brimley (1931b) reported on three harbor seals found in North Carolina waters: one taken in the estuary of the Neuse River in the early 1880s, another killed on Judith Island, Pamlico Sound, in 1898, and a third that was found in February 1931 near Ocracoke in Pamlico Sound.

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4.0 HUMAN ACTIVITIES

The coastal population of the United States has been experiencing the highest rate of growth in the nation. This growth is attributed to both the movement of people to coastal areas and to the expansion of an already large population base (Culliton 1998). Increased human activities impacting marine coastal environments have accompanied the population growth. Commercial uses of coastal nearshore and inshore waters include domestic and international shipping, mineral resource prospecting and collection, and fishery resource harvesting for domestic and international markets. The port facilities of the Chesapeake Bay represent a significant focus of commercial trade routes, and inland waterways from the Chesapeake south to Florida aid in domestic transport of goods and materials. Commercial fisheries within the Cherry Point and southern VACAPES inshore and estuarine areas (study area) supply global and domestic demands for seafood products and industrial materials. Recreationally, the waters of the study area are destinations for coastal and inland populations seeking a variety of activities including fishing, boating, and scuba diving. Human population centers in the study area are located in southeastern Virginia (Virginia Beach) and in North Carolina near Cape Lookout. Much of the area of the mainland and Outer Banks between Cape Henry and Cape Lookout is state and federal wildlife lands. Although most of the parks and preserves are remote, the natural areas attract people seeking recreational activities. Nearly every portion of the study area experiences some degree of human activity.

4.1 FISHERIES

4.1.1 Introduction

The waters in and around the study area contain habitats important to both the production and harvest of fishery resources (e.g., fish spawning and nursery grounds) (Waite et al. 1994). In fact, the Albemarle-Pamlico estuarine system (APES) is among the most productive (Gusey 1981) and intensively fished areas of the U.S. coast (Waite et al. 1994).

4.1.1.1 History

The productive bays, estuaries, wetlands, and marshes of the mid-Atlantic and southeastern U.S. have played key roles in supporting rich and diverse fisheries for centuries (Gusey 1981). Native Americans harvested and lived off the fishery resources of the coastal estuaries long before the first Europeans arrived. After the colonial period, during the late 1700s to early 1800s, fishing for anadromous fish species (i.e., those that migrate inshore to spawn) became more important to coastal inhabitants of the Chowan, Tar, Neuse, and Cape Fear rivers (Freeman and Walford 1976; Waite et al. 1994). The fishing activities of the 1800s were carried out for leisure, sustenance, and commercial profit (Gusey 1981).

Currently, both commercial and recreational fishermen of coastal North Carolina and Virginia vigorously pursue fishery resources with a wide variety of gear types and methods, which traditionally have had relatively little regulation (Waite et al. 1994). There is considerable overlap between the commercial and recreational fisheries. Many of the species targeted by commercial fisheries are also taken recreationally, often with commercial-type fishing gear. This has led to an increase in user conflicts between recreational and commercial entities. Conflicts within the commercial industry have increased in recent years as well (Waite et al. 1994).

4.1.1.2 General Importance

Estuarine-dependent fishery resources far outrank offshore fishery resources in effort, landings, and value. In the U.S., nearly 90% of all fishery landings come from coastal waters and two-thirds of these come from estuaries (Gusey 1981). Furthermore, 95% of the commercial fish species landed in North Carolina depend on estuarine habitats during part of their lives (i.e., estuarine-dependent species)(Taggart and Henderson 2000). In North Carolina and Virginia, fisheries play a major socioeconomic role. The total annual value of North Carolina's coastal commercial and recreational fisheries has been estimated to be nearly $1 billion, while jobs in and related to commercial and recreational fisheries provide employment to many coastal inhabitants (Waite et al. 1994).

Estuaries additionally are vital to the existence of the fishery resources themselves. Habitats within estuaries act as spawning grounds and nurseries for many inshore and offshore fishery species. A number of economically important anadramous species spawn in the freshwater creeks and rivers of North Carolina and Virginia. These fishes use estuarine routes to travel up into their freshwater spawning grounds. Many fishery stocks are affected by spawning events and the health of their nurseries (Waite et al. 1994). This is especially significant since many of the economically important marine fishery species landed on the east coast are estuarine dependent (Saila and Pratt 1973; Gusey 1981; Wilk et al. 1988). A number of species that are targeted in offshore fishing grounds spend part of their lives in or near estuaries, and even pelagic species strictly found in offshore waters rely on large numbers of estuarine-dependent fishes and invertebrates for food.

4.1.1.3 The Nature of Fisheries

The occurrence and distribution of fishery activity is naturally related to the occurrence and distribution of the target species and to the ability of fishermen to locate and catch them. For most commercial and recreational fishing endeavors, successful fishing stems from the ability to anticipate the occurrence of target species at a given place and time. The distribution and abundance of fishery species in the study area depends greatly on the physical and biological factors of the environment: salinity, temperature, dissolved oxygen, food/prey availability, habitat quality, reproductive/life cycles, migrations, and population dynamics, among others (Helfman et al. 1999). With a few exceptions (such as bivalve harvests), the process of fishing involves constant searching and waiting (even stationary fishing gear such as fish pots/traps require deciding on the appropriate location to set the gear). The affinity of target species for particular habitats, the physiological tolerance to environmental factors (e.g., salinity, temperature, and dissolved oxygen levels), and the availability of food items are the primary factors influencing spatial distributions. Life stages and migrations along with seasonal environmental changes (e.g., salinity and temperature) are the primary factors that influence the seasonal distribution of fishes (Helfman et al. 1999).

Variations in the inter-annual distribution and abundance of fishery species are natural (Grosslein and Azarovitz 1982) and keep fishermen continually guessing to some degree. Successful fishermen are able to “read the signs” in their search for good/profitable catches. The causes of variations in availability and abundance of fishery species are believed to have both natural and human sources (Waite et al. 1994).

4.1.1.4 Fisheries Problems

Although natural patterns of variation, extreme at times, are expected in marine fishery stocks, human activities are known to have definite effects on the patterns of fish distributions and abundances. Primary among these human impacts are excessive fishing, habitat alteration, and water quality degradation (Saila and Pratt 1973; Malakoff 1997; Williams 1998; Lazaroff 2001). Human impacts on estuarine systems have greatly affected the viability of coastal fisheries (e.g., blue crabs, oysters, and striped bass) in the recent past, and nearly all estuarine species have been affected to some degree by human activities (Boesch et al. 2001; Jackson et al. 2001). Over the past two centuries, the overall intensity of fishery effort (commercial and recreational) has been increasing, especially within the last 50 years, yet overall landings have been decreasing (MMS 1990b). Military-turned-civilian technologies such as precision sonar, radar, and the Global Positioning System (GPS), along with high detail bathymetric maps, have made finding fish easier, giving fishes fewer places to hide (SeaWeb 2002). As fishery landings diminish, species that are targeted as commercially desirable have changed to include those species still available in commercially harvestable quantities. Smaller fish as well as those species once discarded as bycatch are now being targeted for commercial sales (Caddy et al. 1998; Pauly et al. 1998). Shellfish fisheries especially depend on water quality and may be subject to fluctuations in availability due to pollution and mandatory area closures (Waite et al. 1994).

As recently as 10 to 20 years ago, marine fishery resource studies of the Mid-Atlantic and South Atlantic bights had indicated that these areas had untapped fishery resources (Saila and Pratt 1973; Klima 1977; Grosslein and Azarovitz 1982). Currently, nearly all major fisheries are in need of management.

Signs of environmental stresses on coastal resources include declining fishery landings, fish and shellfish diseases and kills, algal/microbial blooms, and habitat losses (Waite et al. 1994). High demand for fishery products and increases in recreational fishing activities have resulted in increased fishing pressure on the available coastal resources, causing a decrease in fishery landings (Waite et al. 1994; Parker and Dixon 1998). While improvements in fishing gear and methods continue, overall catch rates in relation to effort expended are continuing to decrease. In the study area and its vicinity, there are at least eight species of finfish and shellfish, including crabs, shrimp, and bivalves, whose stocks are overfished or severely depleted. Fishery declines are directly and indirectly attributed to several factors: habitat loss, physical habitat damage, natural events and cycles, fishing pressure, stream flow alteration, and degradation of water quality. Overfishing is considered one of the main causes in current declining catch rates (Waite et al. 1994). Fishery resources of the Albemarle-Pamlico estuary system (APES) that are currently highly stressed include: Atlantic sturgeon, oyster, Atlantic croaker, river herring, striped bass, bay scallop, bluefish, catfish, hard clam, spot, and blue crab (Waite et al. 1994). In 1997, the striped bass stock was considered recovered by the Atlantic States Marine Fisheries Commission (ASMFC) (APNEP 1999).

4.1.1.5 Fisheries Management

Wise management has become crucial to protecting fishery industries and maintaining fishery resources in a harvestable condition. At the federal level, laws, executive orders, proclamations, and regulations have been created to aid in the conservation of fishery resources. One of the mandates of the Sustainable Fisheries Act (SFA) was the creation of a number of interstate management agencies called fishery management councils (FMCs) to oversee the condition of fishery stocks in the federal waters of the exclusive economic zone (EEZ; 3 to 200 NM from shore). The FMCs use fishery management plans (FMPs) to describe the conservation strategies of specific fishery resources. The NMFS participates in fishery management efforts by providing fisheries information and data and by managing the highly migratory fishery species (over 80 species of sharks, tunas, and billfishes; NMFS 2002a).

Both the Mid Atlantic Fishery Management Council (MAFMC) and the South Atlantic Fishery Management Council (SAFMC) manage waters off Virginia and North Carolina. These two FMCs together are responsible for roughly 10 FMPs near the study area, covering nearly 100 species of fishes and invertebrates (NMFS 2002a). Virginia and North Carolina state agencies oversee the management of fishery resources in state waters out to 3 NM. In Virginia, the agency responsible for marine fisheries is the Marine Resources Commission, while in North Carolina it is the Division of Marine Fisheries (NCDMF) and the Marine Fisheries Commission (NCMFC). North Carolina has or is working on eight state FMPs. North Carolina FMPs are currently in place for striped bass, red drum, blue crab, oyster, and hard clam. The North Carolina Marine Fisheries Commission expects FMPs for several more commercial and recreational species, including southern flounder, striped mullet, and shrimp (Waite et al. 1994). Virginia does not currently have any state FMPs, but does comply with the ASMFC FMPs.

The ASMFC helps with the management of shared marine fishery resources in state waters. Through the Interstate Fisheries Management Program, the ASMFC coordinates the conservation and management of 22 Atlantic coast species (ASMFC 2002), 19 of which occur in the study area and vicinity. Additional FMPs and species are continually being considered and developed for further management (NMFS 2002a). Along with the management of fishery landings, fisheries and coastal resource managers also work with the problems of habitat destruction, bycatch reduction, and water quality maintenance (Waite et al. 1994).

4.1.2 Vital Fisheries Habitats

There are a number of habitats that are vital to the commercial and recreational resources of the APES. These include fisheries nursery areas, submerged aquatic vegetation (seagrass) beds, spawning areas, and shellfish beds (Waite et al. 1994). The APES contains a large areal extent of these habitats, which directly or indirectly support the extensive commercial and recreational fisheries in North Carolina and Virginia and are significant in supporting fish populations along the entire east coast (Waite et al. 1994). Land and marine-based activities impact the health of these habitats (Waite et al. 1994). Damage to the vital habitat areas affect the human uses of the resources that rely on them. Damage and disturbance to habitats such as seagrass beds can reduce the strength of fishery resources and can negatively impact both commercial and recreational fisheries among other things (Waite et al. 1994).

4.1.2.1 Fishery Nurseries

Primary nursery areas for fisheries comprise 1.5% (nearly 10,120 hectares [ha]) of the total waters of the APES. Fisheries nursery areas are generally found in tributary creeks and embayments with mid- to high salinity levels over muddy or grassy bottoms. The nursery areas of the APES are critically important to over 75 species of fish and shellfish in North Carolina. Nursery areas have a special protective designation in North Carolina (Waite et al. 1994).

4.1.2.2 Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) has historically been more abundant in the study area but now has a more limited distribution; SAV is primarily found along the inside of the barrier islands and in some of the smaller estuaries (Figure 2-10). SAV, comprised mainly of seagrasses, provides important habitat for many estuarine species for a number of reasons, including the reduced water current velocities, increased attachment sites, reduced water turbidity, increased refuge sites, and increased food (Waite et al. 1994). SAV can be negatively impacted by direct physical disturbances and by degradation of water quality (Waite et al. 1994) (see sections 2.3.3.7 and 3.1.1.3 for more information about SAV in the study area).

4.1.2.3 Spawning Sites

The rivers of the APES provide spawning habitat for anadramous species (those species that live offshore and travel inshore to spawn) such as striped bass, shad, and herring. Human impacts on the spawning success of striped bass have been linked to population declines of striped bass (Waite et al. 1994). Spawning of other estuarine species occurs in regions of the APES where fish aggregate, such as near coastal inlets, shoals, tidal flats, and salt marshes.

4.1.2.4 Shellfish Beds

Clams, oysters, and bay scallops have historically supported very important commercial fisheries in North Carolina. The productivity of these beds has declined in recent times. Ecologically, shellfish are important to estuarine systems for their action of natural water filtration. Shellfish can be negatively impacted by direct physical disturbances and by degradation of water quality (Waite et al. 1994). Shellfish beds are found throughout the study area (see section 4.1.5.7; Figure 4-8). Harvests are contingent on current water quality and health conditions.

4.1.2.5 Structural Habitats

Many species of fishes and invertebrates prefer structurally complex habitats (Stephan and Lindquist 1989). Natural occurrences of benthic structural complexity have a tendency to concentrate both fishes and fishery activities targeting the fishes (Huntsman and Macintyre 1971; Potts and Hulbert 1994). These natural habitats include live/hard bottom structures including oyster, clam, and scallop beds, and seagrass beds. With the loss of seagrass habitats, oyster reefs have assumed a greater role as a fishery habitat (Lenihan et al. 2001). Historically, fishermen have fished near sunken tree trunks, rubble piles, and other objects sunk or lost at sea and in the bays (Freeman and Walford 1976). Fish aggregating devices (FADs) have been in use in nearshore habitats for centuries as well, whether as floating objects or intentionally sunk objects such as tree trunks and branches weighted down with rocks. More recently, offshore, nearshore, and inshore structures such as platforms, towers, piers, and docks have attracted fish and fishermen alike (Klima 1971; Samples and Hollyer 1989; Kellison and Sedberry 1998). Numerous accidental shipwrecks and deliberately sunk artificial reefs in and near the study area are focus points for commercial and recreational fishermen (Beets 1989; Gregg and Murphey 1994).

4.1.3 Offshore Fishing

Coastal ports, cities, and towns act as home base for commercial and recreational fishermen fishing in the bays, rivers, and sounds, as well as for those traveling to nearshore and offshore fishing grounds. Marinas, commercial ports, and boat ramps are dispersed throughout the study area (Freeman and Walford 1976). The major coastal cities and many of the small coastal towns act as unloading points for commercial and recreational landings harvested in nearby or far-off oceanic waters. A series of inlets along the barrier islands of the study area, as well as the mouth of the Chesapeake Bay, provide passage for commercial and recreational fishermen to and from the offshore fishing grounds (Waite et al. 1994).

Fishing vessels leave from the small towns located on the western shores of Pamlico Sound and the seaside towns south of Cape Lookout. Some of the major ports within the study area are Beaufort, Morehead City, Wanchese, Stumpy Point, Englehard, Swanquarter, Oriental, and Vandemere (NMFS 2000, 2001a). Some additional ports of local importance include Sneads Ferry, Harkers Island, Atlantic, Ocracoke, and Hatteras. Offshore fishing carried out by far-ranging vessels, including longliners, involves vessels that travel to the area from ports as far away as New England. These vessels may land their catches at North Carolina ports (Gloeckner personal communication).

The offshore commercial and recreational fisheries are substantial (NMFS 2002b). The primary offshore commercial fishing gears used off the study area include purse seines, gillnets, trawls, pots/traps, longlines, handlines, troll lines, and dredges (NMFS 2002b). Recreational anglers head offshore to fish anywhere from several kilometers out to the edge of the Gulf Stream and beyond. Privately owned vessels have become larger and more technologically advanced (with GPS and radar). Heading out of North Carolina ports, charter vessels and party boats have been plying the offshore waters with paying customers for many years.

4.1.4 Regional Summaries

4.1.4.1 Chowan River

Fishing has been important to the inhabitants of the Chowan River basin since colonial times, especially fisheries for shad, herring, and striped bass (mainly anadramous fishes). The Chowan and many of its tributary rivers and streams serve as spawning grounds for these fishes. Gear types used in this region include pound nets, sink gillnets, catfish pots, eel pots, and trotlines (Waite et al. 1994; NCDMF 2002).

4.1.4.2 Currituck Sound and Albemarle Sound

Oregon Inlet is the closest connection to the Atlantic Ocean from the Currituck and Albemarle sounds. The region supports a variety of important brackish water species. Both commercial and recreational fishing are important in these waters (Taggart and Henderson 2000). Striped bass, herring, and shad migrate to freshwater through this region to spawn in streams and rivers. In the Currituck Sound basin, fishermen use sink gillnets, river herring pound nets, and eel pots. Striped bass are of major concern in the Albemarle Sound region. In the Pasquotank River/Albemarle Sound region, fishermen employ pound nets, crab pots, sink gillnets, catfish pots, eel pots, and trotlines (NCDMF 2002).

Commercial fishing activity in the Albemarle Sound is relatively intense. In contrast, the fishing intensity in the Currituck Sound and the Pasquotank, Perquimans, and Alligator rivers is relatively light. The fishing activity in the Croatan and Roanoke sounds is very intense in terms of the number of trips taken there in relation to their relative sizes (Figure 4-1; NCDMF 2002). The city of Manteo is one of the main commercial ports in the area (Steve et al. 2001). There are roughly 26 marinas located throughout this region. Most of these are concentrated on Roanoke Island and along both sides of Currituck Sound. There are about four marinas located along the Albemarle Sound. There are roughly 21 public boat ramps located in the region (NOS 2001).

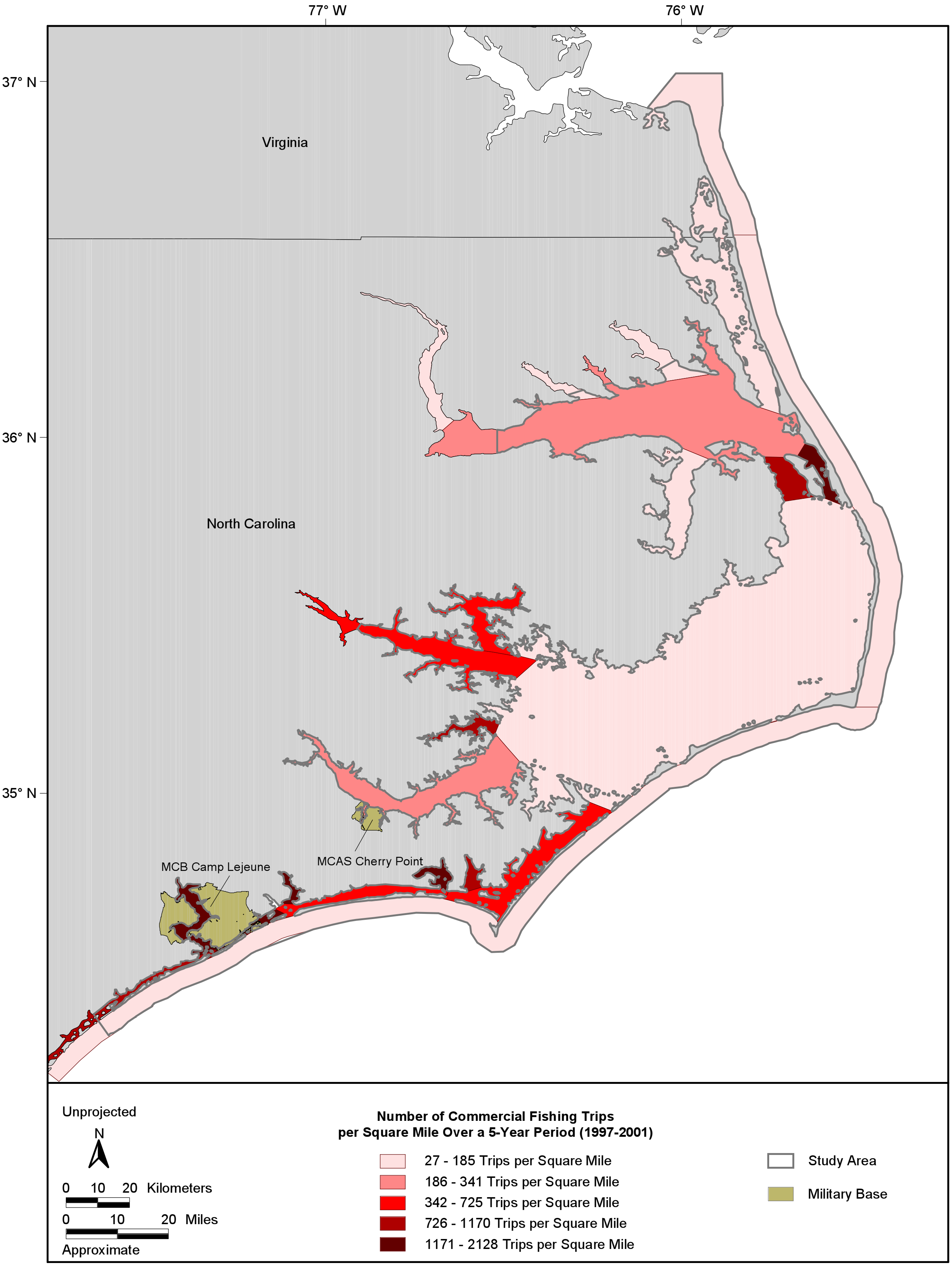

Figure 4-1. Comparative commercial fishing intensity per square mile among the water bodies of the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NCDMF (2002).

4.1.4.3 Pamlico River and Pamlico Sound

Inlets in the region include Oregon, Hatteras, Ocracoke, and Swash. Pamlico Sound has an abundance of constantly changing shoals. The SAV has almost completely disappeared from its historical distribution in this region. Fishery nursery areas of the Pamlico Sound basin comprise nearly 16,200 ha. These vital habitats support fish populations throughout North Carolina and the east coast. Anadramous fish pass through the region to spawn along 201 km of the basin's rivers and streams (Waite et al. 1994).

Both commercial and recreational fishing are important to the Pamlico Sound basin. Blue crabs, oysters, shrimp, and finfish are abundant in the area. The fishery activities of the area are of great importance to the coastal economy. Fishing practices that occur in the area include pound nets, long haul seines, shrimp and crab trawls, crab pots, and sink gillnets. Shellfish, including crabs, oysters, and bay scallops, are taken by tonging, raking, bull raking, hand harvesting, and dredging (Waite et al. 1994; NCDMF 2002).

The Pamlico and Pungo rivers are very intensely fished water bodies relative to their sizes. The Pamlico Sound, however, is relatively low in fishing intensity, although the overall greatest number of commercial trips in the study area takes place there (Figure 4-1; NCDMF 2002). The towns of Wanchese, Englehard, Hatteras, Swan Quarter, and Belhaven are the main fishing ports in this region. There are roughly 35 marinas in this region. Most of these are located along the Pamlico and Pungo rivers. Several are also concentrated on the Pamlico Sound along Hatteras Island. There are roughly 15 public boat ramps in this region. Most of these are located along the Pamlico and Pungo rivers.

4.1.4.4 Neuse River, Core Sound, and Bogue Sound

Inlets near the Core and Bogue sounds include Bogue, Beaufort, Barden, and Drum inlets. The Core and Bogue sounds have higher salinities than the Albemarle or Pamlico sounds. Bogue and Core sounds contain important fishery spawning grounds, nursery areas, SAV habitat, and shellfish habitat (Waite et al. 1994).

The Neuse estuarine waters include approximately 1,113 ha of primary fishery nursery areas and 506 ha of secondary nursery areas. These areas are considered essential to the continued production of coastal fisheries. The upriver areas and streams provide spawning grounds for shad and herring. The SAV is abundant in the Core and Bogue sounds. The bay scallop has its only North Carolina distribution in these sounds. The SAV of the sounds is also important habitat and nursery grounds for other fishery species (Waite et al. 1994).

Recreational and commercial fisheries are important economic activities in the estuarine waters of the Neuse River basin. Important fishery species include flounder, catfish, bass, blue crab, and oyster. Commercial activities include long haul seines, shrimp trawls, crab trawls, crab pots, oyster dredging, drift gillnets, bait fish pound nets, and eel pots (Waite et al. 1994; NCDMF 2002). The Core and Bogue sounds are very important estuarine fishing areas for both recreational and commercial fishermen. Commercial fishing is an important component of the economy in this area. Fishermen target a variety of fishes using many different gear types. Commercial activities include pound nets, long haul seines, shrimp and crab trawls, crab pots, sink gillnets, and channel nets. Shellfish are harvested with tongs, rakes, bull rakes, dredges, by hand, and by clam kicking. Recreational fishing is also important in this area and supports a large portion of the local economy. The Bogue and Core sounds are particularly important for their shellfish beds. Nearly all of North Carolina's bay scallops and many of its hard clams and oysters are harvested here via hand harvest and mechanical harvest. There is an abundance of vital fishery habitats in these two sounds as well. These sounds possess the second largest amount of fishery nursery habitat after the Pamlico Sound basin. Most of the vital habitat in this area consists of fishery nursery areas. Recreational and commercial fisheries of the area are vital to the region's local economy (Waite et al. 1994).

The Neuse River experiences a medium level of fishing intensity relative to the other water bodies of the study area. The Bay and North rivers and Core and Bogue sounds experience high levels of commercial fishing intensity while the Newport River is a very heavily fished river for its size (Figure 4-1; NCDMF 2002). The main fishing towns in this region are Vandemer, Oriental, Atlantic, Harkers Island, and Beaufort-Morehead City. There are roughly 55 marinas in this region, of which 13 are located along the Neuse River, 22 are located in Core Sound (and Back Sound), and 20 are located in Bogue Sound. There are roughly 20 ramps in this region, with 12 located along the Neuse River and eight along Core, Back, and Bogue sounds (NOS 2001).

4.1.4.5 White Oak and New Rivers

Both the White Oak and New rivers are very intensely fished relative to their small sizes (Figure 4-1; NCDMF 2002). There are roughly 14 marinas in this region, four along the White Oak River and five along the New River. Several marinas are located south of the New River near Topsail Beach. Eleven public boat ramps are located in this region. Most are along the White Oak and New rivers, with several near Turkey Creek (NOS 2001).

4.1.5 Commercial Fisheries

The dominant commercial fisheries for finfish (i.e., not mollusks or crustaceans) in the study area are the winter trawl, sink gillnet, long haul seine, and pound net fisheries (Ross 1991; NCDMF 2002). The long haul fishery, which operates throughout much of the estuaries of North Carolina from Bogue Sound to northern Pamlico Sound, and the pound net fishery are the two primary inshore fisheries. The two principal coastal offshore commercial fisheries presently account for more than 50% of the finfish landed in North Carolina. These consist of the winter trawl fishery and the sink gillnet fishery (Table 4-1; NCDMF 2002). Other important offshore commercial fisheries include reef fishes, king mackerel, and tuna (NMFS 2002b). A significant amount of the commercial catch from the inshore and nearshore waters of the study area goes to industrial uses (e.g., fish meal, fish oils, solubles, bait, and pet foods) (MMS 1990b).

The top commercial species taken in and near the study area are menhaden, flounder, spot, weakfish, croaker, black sea bass, scup, king mackerel, bluefish, striped bass, river herring, shrimp, blue crab, hard clam, oyster, and bay scallop (Table 4-2; NCDMF 2002). Additional species commercially landed in North Carolina include snappers and groupers, porgies, mullet, butterfish, harvestfish, and Spanish mackerel (MMS 1990b). Many of the local fisheries have experienced decreases in landings despite increases in fishery efforts.

4.1.5.1 Trawl Fisheries

Trawl fisheries in the area include the winter trawl fishery (composed of flounder trawls, flynets, and deepwater trawls), shrimp trawls, and crab trawls. The winter trawl fishery targets a variety of fishes and some invertebrates (such as squids). The crab trawls also land commercial fish species such as flounder, croaker, and weakfish.

Winter Trawl Fishery—For descriptive purposes, fishery managers separate the winter trawl fishery into three components. These fisheries, which are not entirely distinct from each other, are the nearshore flounder fishery, the deepwater fishery, and the flynet (surface trawl) fishery (Ross and Moye 1989). The deepwater fishery occurs near the shelf edge and is not described in this report. The winter trawl fishery does not include inshore trawling activities for finfish, blue crab, and shrimp (Ross 1991). Catches from the winter trawl fishery are landed at ports from Wanchese to Morehead City and Beaufort and throughout Pamlico Sound (Ross 1991).

The winter trawl fishery occurs near the study area from mid-September through April (Figure 4-2). Off Virginia and North Carolina, it is mainly a coastal nearshore fishery that employs a variety of trawl gear, including bottom trawls, pair trawls, and flynets. Bottom trawlers are slow-moving vessels that range from 12 to 21 m in length and that pull a net or multiple nets behind and off the sides (from out- slung side booms) of the vessels. When in the water, the opening of the net is kept wide open with boards called “otter doors.” These trawls are often called otter trawls and can target a variety of mostly bottom

Table 4-1. Seasonal commercial fishery gear activity in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity ranked by the total number of trips per gear type over a five-year period (1997-2001), including total seasonal pounds landed per gear type.

Season	Gear	Trips	Pounds
Winter	Gillnets	60,668	37,379,481
(Jan-Mar)	Bivalve Fisheries	56,329	1,546,451
	Pots and Traps	19,650	5,450,403
	Trawls	6,819	12,530,982
	Pound Nets	3,332	1,362,431
	Seine Nets	959	307,150
	Hook and Lines	513	136,015
	Other	408	15,217
Spring	Pots and Traps	238,388	66,144,668
(Apr-Jun)	Bivalve Fisheries	70,353	1,140,290
	Gillnets	59,522	11,698,202
	Trawls	26,093	6,523,781
	Pound Nets	6,989	4,065,140
	Hook and Lines	1,603	286,772
	Seine Nets	2,112	3,064,400
	Other	2,857	165,024
Summer	Pots and Traps	273,599	128,925,949
(Jul-Sep)	Bivalve Fisheries	65,323	994,520
	Gillnets	64,839	9,347,374
	Trawls	46,893	25,349,462
	Pound Nets	9,967	3,955,643
	Hook and Lines	1,536	142,322
	Seine Nets	1,584	4,373,980
	Other	4,426	330,246
Fall	Gillnets	78,614	27,062,091
(Oct-Dec)	Pots and Traps	71,105	37,634,680
	Bivalve Fisheries	53,420	1,229,409
	Trawls	19,397	15,921,087
	Pound Nets	10,643	6,736,329
	Seine Nets	1,878	5,082,103
	Hook and Lines	1,096	177,212
	Other	1,775	139,069

Source: NCDMF (2002)

Table 4-2. Target species and total pounds landed by gear type in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity (1997-2001).

Gear Type	Target Species	Pounds
Trawls	Shrimp	33,879,402
	Crab	11,662,126
	Croaker	7,452,217
	Flounder (Fluke)	3,769,335
	Weakfish (Gray Trout)	705,577
	Mullet	632,191
	Menhaden	338,430
	Striped Bass	304,072
	Spot	261,935
	Bluefish	232,257
	Spiny Dogfish Shark	177,778
	Black Sea Bass	87,184
	Squid	73,283
	Horseshoe Crab	58,870
	Butterfish	57,033
	Monkfish	54,694
	Catfish	47,666
	Conch/Whelk (lbs meat)	39,790
	Spanish Mackerel	293
	Total:	59,834,133
Seines	Spot	6,251,542
	Weakfish (Gray Trout)	2,280,219
	Menhaden	987,435
	Mullet	739,979
	Bluefish	621,595
	Striped Bass	474,395
	Spotted Seatrout	396,190
	Croaker	331,407
	Bait	147,037
	Harvestfish	110,447
	Catfish	2,190
	Total:	12,342,437
Gillnets	Croaker	12,666,329
	Mullet	12,129,145
	Spiny Dogfish Shark	11,068,160
	Flounder (Fluke)	10,736,386
	Bluefish	6,775,917
	Spot	6,169,025
	Weakfish (Gray Trout)	5,654,786
	Menhaden	3,248,001
	Spanish Mackerel	2,463,534
	Spotted Seatrout	630,183

Table 4-2. Continued.

Gear Type	Target Species	Pounds
Gillnets (Cont'd)	Drum (Red and Black)	213,506
	Total:	71,754,971
Pound Nets	Flounder (Fluke)	5,753,992
	Catfish	2,001,798
	Menhaden	1,382,589
	Herring	1,375,167
	Shrimp	1,103,361
	Gizzard Shad	833,576
	Sciaenids	692,439
	Bait	461,583
	Harvestfish	406,686
	Butterfish	279,388
	Spanish Mackerel	192,069
	Crab	154,670
	Squid	1,323
	Total:	14,638,638
Hook and Line	Catfish	221,338
	King Mackerel	167,323
	Shark	73,674
	Reef Fish	40,152
	Black Sea Bass	22,500
	Tuna	19,163
	Spotted Seatrout	14,459
	Flounder (Fluke)	13,449
	Cobia	6,834
	Red Drum	4,752
	Dolphin	3,243
	Spanish Mackerel	2,684
	Bluefish	1,860
	Wahoo	1,826
	Total:	593,258
Pots and Traps	Crab	236,217,299
	Eel	551,946
	Catfish	542,556
	Flounder (Fluke)	299,065
	Minnows	112,809
	Black Sea Bass	76,689
	Mullet	44,525
	Menhaden	44,356
	Bluefish	20,351
	Conch/Whelk (lbs meat)	15,125

Table 4-2. Continued.

Gear Type	Target Species	Pounds
Pots and Traps (Cont'd)	Snapping Turtles	12,363
	Spot	11,707
	Bait	8,789
	White Perch	5,278
	Octopus	3,939
	Croaker	1,043
	Spotted Seatrout	617
	Striped Bass	431
	Total:	237,968,888
Bivalves	Clam	3,439,966
	Oyster	1,130,285
	Scallop	218,466
	Total:	4,788,717
Other Gear Types	Flounder (Fluke)	373,240
	Mullet	128,252
	Minnows	13,912
	Drum (Red and Black)	7,806
	Shrimp	6,848
	Spotted Seatrout	4,337
	Sheepshead	3,244
	Total:	537,638

Source: NCDMF (2002)

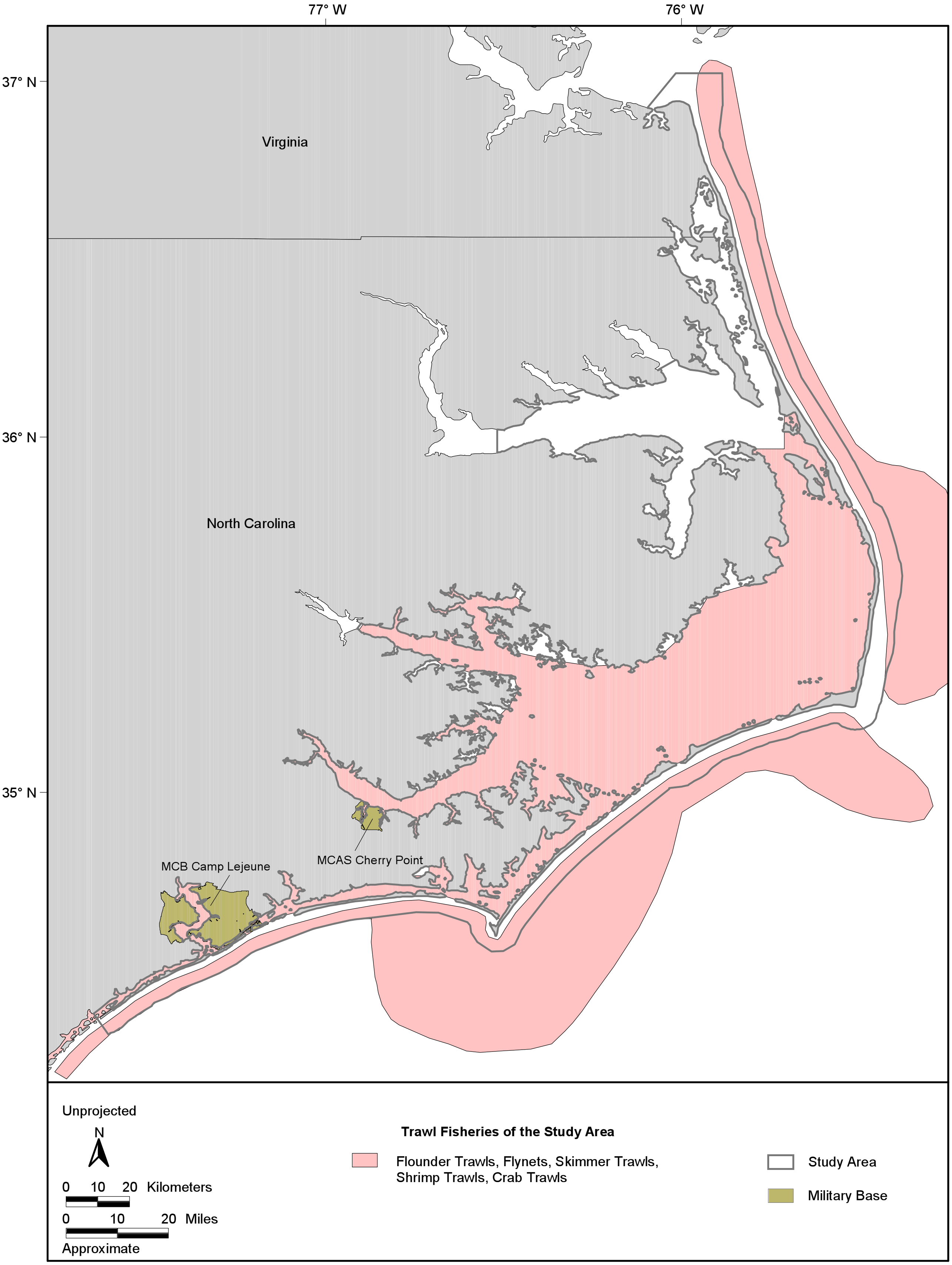

Figure 4-2. Fishing grounds of trawl gear fisheries in the Cherry Point and southern VACAPES inshore and estuarine areas, including the winter trawl fishery, the shrimp fishery, and the crab trawl fishery. Map adapted from: Gusey (1981), Ross (1991), APES (1992), and NCDMF (2002).

fish species. Flynet trawls are specially rigged to allow fishing in the upper portion of the water column near the surface. Flynets can target the coastal pelagic fishery species such as weakfish, Atlantic croaker, king mackerel, bluefish, and cobia as opposed to the more traditional groundfish (e.g., flounder, black sea bass, and scup) targeted by the bottom trawlers (Ross et al. 1988; Ross and Moye 1989; Ross 1991).

Flounder Trawls—Nearshore flounder trawlers are active November through January from the mouth of the Chesapeake Bay to north of Cape Hatteras (Wimble Shoals) and from south of Cape Hatteras to just south of Drum Inlet. Summer flounder, or fluke, has dominated the nearshore winter trawl fishery as the main target species (Ross 1991). Several species of flounder are landed in North Carolina's commercial fisheries. Summer flounder is the major flatfish species caught in flounder fisheries. The summer flounder and southern flounder comprise the majority of commercial flounder landings in North Carolina (MMS 1990b; Ross 1991).

Flounder have traditionally been one of the area's most valuable food fish (Ross 1991). Landings have fluctuated dramatically in recent years, with an overall downward trend. The winter trawl fishery landings of flounder have decreased greatly due to a severely stressed fishery stock. Management efforts have been emplaced to aid in the recovery of these stocks (MMS 1990b). Although trawls are the primary gear type that lands flounder in the study area, flounder are also caught using pound nets and, to a lesser degree, channel nets, gigs, gillnets, and long haul seines (MMS 1990b)

Flynets—The flynet component of the winter trawl fishery operates in nearshore waters (1.6 to 8 km offshore) throughout the winter trawl season (September through April) from just north of Oregon Inlet to just north of Cape Hatteras (Wimble Shoals) and from south of Cape Hatteras to just south of Drum Inlet (Ross 1991). The season begins off Oregon Inlet in September and moves to the waters south of Cape Hatteras in December. Weakfish and Atlantic croaker have been the dominant species in the flynet fishery. Additional species landed in the winter trawl fishery include spot, black sea bass, scup, and bluefish (Ross 1991). Although not traditionally a trawl species, bluefish landings have increased with the use of flynets that catch pelagic fish living near surface waters (MMS 1990b).

Also known as Grey trout, gray seatrout, or squeteague, weakfish are an abundant food fish species. The overall stocks of weakfish have declined and the average individual fish size has decreased. Weakfish are landed year round in North Carolina and are taken in the same fisheries with spot and croaker. However, the sink gillnet fishery is the primary fishery that lands weakfish. They are also taken in pound nets in the estuaries during warmer months (MMS 1990b).

Catches of Atlantic croaker have recently been in decline. They are harvested mainly from Oregon Inlet to Beaufort Inlet. Historically, the winter trawl fishery and the long haul seine fishery have produced the largest catches in the Pamlico Sound area during spring to fall (MMS 1990b).

Spot is an important trawl-caught species in North Carolina. It is one of the more abundant fish in the area and is used commonly as a food fish. Spot fishery stocks experience large annual fluctuations, but have declined overall recently. A portion of the catch goes to industrial uses, such as for fish meal, oil, and pet food (MMS 1990b). Spot are caught in the winter trawl fishery off the Outer Banks. They are also caught in the long haul fishery and pound net fishery in Pamlico and Core sounds, and their tributaries from April to October. The chief part of the fishery occurs from October to November when spot migrate from inshore to offshore waters. Spot are also landed in the long-haul fishery and pound net fishery (MMS 1990b).

Deepwater Trawls—Black sea bass is the most abundant of the sea bass species (Family Serranidae) landed in North Carolina. Sea basses are usually associated with live/hard bottom and rocky outcroppings. They are taken primarily from nearshore areas and along the continental shelf and are taken most often in the deepwater winter trawl fishery off the Outer Banks. Black sea bass are also taken in the handline and trap fisheries over the continental shelf (MMS 1990b). Scup and porgy species, to a lesser degree, are landed from live/hard bottom habitats between the shore and the shelf edge. Scup are mainly taken in the winter trawl fishery north of Cape Hatteras (MMS 1990b).

Shrimp Trawls—Three species of shallow water penaeid shrimp make up the commercial shrimp trawl fishery landings in and near the study area (Figure 4-2): brown, pink, and white. Shrimp are mainly captured in the sounds (mostly Pamlico) and nearshore waters south of Cape Lookout using otter trawls. Pamlico Sound is the most productive area, followed by Core and Bogue sounds. The White Oak and New rivers and the mouths of the Neuse and Newport rivers also are fished. Pink shrimp prefer higher salinities and are taken in estuaries from April through June and September through November. Brown shrimp prefer muddy/sandy bottoms and are landed in estuaries from mid-June through mid-August and in nearshore ocean waters in late June through September. White shrimp prefer lower salinities and are taken in nearshore waters during the fall of the year near Cape Lookout. The landings of shrimp can greatly fluctuate (MMS 1990b).

Crab Trawls—Part of the blue crab landings in the study area are made with trawl gear (Figure 4-2). The blue crab is a shallow water crab that occurs over a variety of bottom types and in a wide range of salinities from fresh to full seawater. Approximately 99% of the blue crabs are caught in the sounds and bays. Of these, about 80% are taken with pots/traps and the remaining 20% are taken with trawls (MMS 1990b).

4.1.5.2 Seine Fisheries

Seine nets are a common commercial fishery gear type that takes a variety of forms. Generally, seine nets consist of a length of mesh netting strung between two ends tied to separate rope lines, which are pulled through the water. The top portion of the net is held at the surface of the water with a series of floats and is called the float line. The bottom portion of the net contains a series of lead weights that keep the net vertical in the water column and is called the lead line. After the seine nets are pulled some distance through the water, the two ends are pulled toward each other to enclose the fish, and the net is then usually hauled out onto a beach or shoal or pulled into a boat. Purse seines are used in deeper waters and use a modification that allows the bottom lead line to be closed cinched, thereby entrapping fish in the water column. Seine gear include purse seines, beach (haul) seines, and long haul seines.

Purse Seines—Menhaden are caught using purse seines in the offshore areas in the vicinity of the study area (Figure 4-3). Other gear types make incidental catches of menhaden, but the largest directed fishery for menhaden is the purse seine fishery. Spotter planes are used to locate schools of menhaden at sea. There are two active parts of the menhaden fishery season. The first occurs in the summer and fall from Maine to central Florida. The second is intensive and occurs in the fall off North Carolina from Cape Lookout to the New River Inlet. This fall fishery targets the large schools of menhaden as they pass close to land south of Cape Hatteras (MMS 1990b).

Historically, menhaden had been the top fishery in terms of shear volumes landed. Recently, the decline in menhaden landings has been attributed to local economic problems in the menhaden fishery rather than declining stocks, which are thought to be in good shape. Only one of the four North Carolina menhaden reduction plants currently remains open (MMS 1990b).

Beach (Haul) Seine—The beach seine (or haul seine) fishery occurs along the northeastern waters of the study area (Figure 4-3). This gear type involves fishermen working from a beach, setting the net in the water, and pulling it up onto the beach. The North Carolina Department of Marine Fisheries (NCDMF) includes the beach gillnet fishery statistics, with the beach seine fishery statistics because of their similarities. Beach gillnets involve the use of a net, staked on the beach, strung out to generally 457 m offshore. Fishermen often use both beach seines and beach gillnets when fishing a beach. A small boat is usually launched from the shore and hauls one end of the net out into the waters or surf. Crews of four to six fishermen participate in the fishing process. The nets are generally hauled in on low tide after a 12-hour soak-time. The end of the net is hauled in using a four-wheel drive vehicle. The nearshore gillnets use anchors to secure the nets to the bottom and are set in close proximity to the beaches in either a perpendicular or parallel orientation to the beach (Steve et al. 2001).

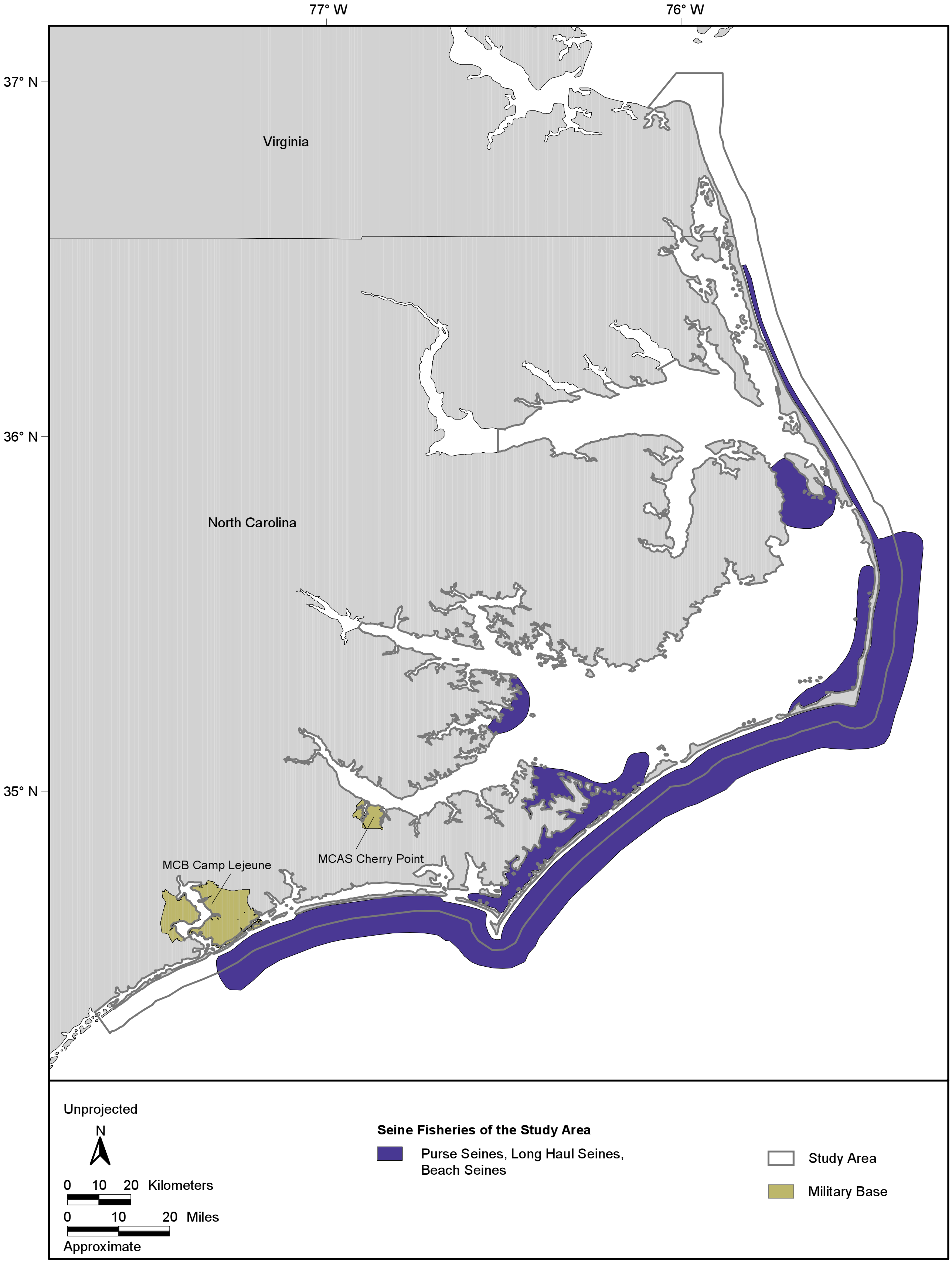

Figure 4-3. Fishing grounds of seine gear fisheries in the Cherry Point and southern VACAPES inshore and estuarine areas, including the menhaden purse seine fishery, the long haul seine fishery, and the beach seine fishery. Map adapted from: Gusey (1981), Smith (1999), and Steve et al. (2001).

The beach seine and gillnet fisheries target weakfish, spotted seatrout, bluefish, spot, striped mullet, kingfish, croaker, and harvestfish. The targeted species are incidental to the season and location of the fishing site. The beach seine fisheries occur on seaside beaches from Virginia to Ocracoke Island, with the majority of the activity taking place between the towns of Corolla and Hatteras. Fishing activity occurs primarily in the spring and fall, with peaks occurring in April, May, September, October, and December (Steve et al. 2001). A directed striped bass beach seine fishery exists but is restricted to seasonal striped bass fishery management quotas (Steve et al. 2001).

Long Haul Seine**—**Long haul seines are essentially drag nets up to 1,006 to 1,372 m in length and usually 3.7 m in height. Each end of the net is pulled by a 9 to 14 m motorboat for a distance of 1 to 2 NM (Steve et al. 2001). In some areas, smaller nets called swipe nets are used with only one boat pulling an end around a stationary pole (Ross et al. 1988; Steve et al. 2001). There are only a few participants who use swipe netting techniques in the waters of the study area.

Long haul seines target mainly croaker, spot, weakfish, and menhaden in two major areas of the Pamlico and Core sounds (Figure 4-3; Steve et al. 2001). The northern area encompasses shallow regions of the inshore waters from Croatan Sound to the northern portion of Pamlico Sound, including most major tributaries and bays. The southern area includes the Pamlico and Pungo rivers, Bay River, Neuse River, West Bay, Core Sound, Back Sound, North River, and other major tributaries and bays. It also includes portions of the Pamlico Sound off Pamlico Point and Brant Island and the shallow waters between Ocracoke Inlet and Cedar Island. An additional region of activity occurs at Bluff Shoal in the center of the Pamlico Sound (Ross et al. 1988; Ross and Moye 1989). Fishing in the northern regions involves deeper waters of up to 6 m deep. The southern grounds are generally shallower (2 m), and the fishermen target fish in proximity to shoal areas with firm bottoms where the nets are hauled and the fish gathered. The entire process of one long haul set often can be a daylong event (Ross et al. 1988).

The greatest activity of long haul fishing has been in northern Pamlico and Croatan sounds, north of and including Long Shoal. Long haulers have been based in Wanchese, Stumpy Point, Englehard, Rodanthe, Avon, and Hatteras. In the south, long haul crews have worked out of Atlantic, Sea Level, and Davis. In the early part of the season (June), these crews target Royal Shoal, West Bay, Point of Marsh, Core Sound (northern portion), and the adjacent bays and then concentrate on fishing in Core Sound later during late summer until early November. Additional long haul crews working out of Harkers Island participate in the fishery in the latter half of the season, fishing the waters of southern Core Sound, North River, Back Sound, and Cape Lookout Bight (Ross et al. 1988).

Altogether, the long haul fishery can last from February through November, but the peak months are June through October (Steve et al. 2001). The northern segment of the fishery is generally active from April through October, with the largest landings occurring in the early and mid-summer months. The fishery in the southern segment (including Bluff Shoal) is active from June through November, with most of the landings occurring regularly throughout the summer and early fall (Ross et al. 1988). Historically, the long haul seine fishery, along with the winter trawl fishery, has produced the largest catches of croaker in the Pamlico Sound. Spot and weakfish are also caught in large numbers in the long haul fishery in Pamlico and Core sounds and their tributaries (MMS 1990b).

Striped bass once supported a major fishery, but their numbers dropped to extreme levels toward the end of the twentieth century. Problems with breeding success have been suspected as the cause for the decline. Important spawning areas, located in freshwater rivers and creeks, had been altered by human activities such as diversions and damming. Severe management rules have helped bring the species back to healthy stock sizes (MMS 1990b). Striped bass are caught either in the open ocean or inshore, with the inshore fishery being the larger of the two. Striped bass are landed mostly by ocean gillnets, trawling, long-haul seines, and pound nets (MMS 1990b).

4.1.5.3 Gillnet Fisheries

The gillnet fisheries are collectively important to the commercial fishery industry in the study area, harvesting a variety of inshore coastal fish species (Figure 4-4; Steve et al. 2001). These fisheries fall into

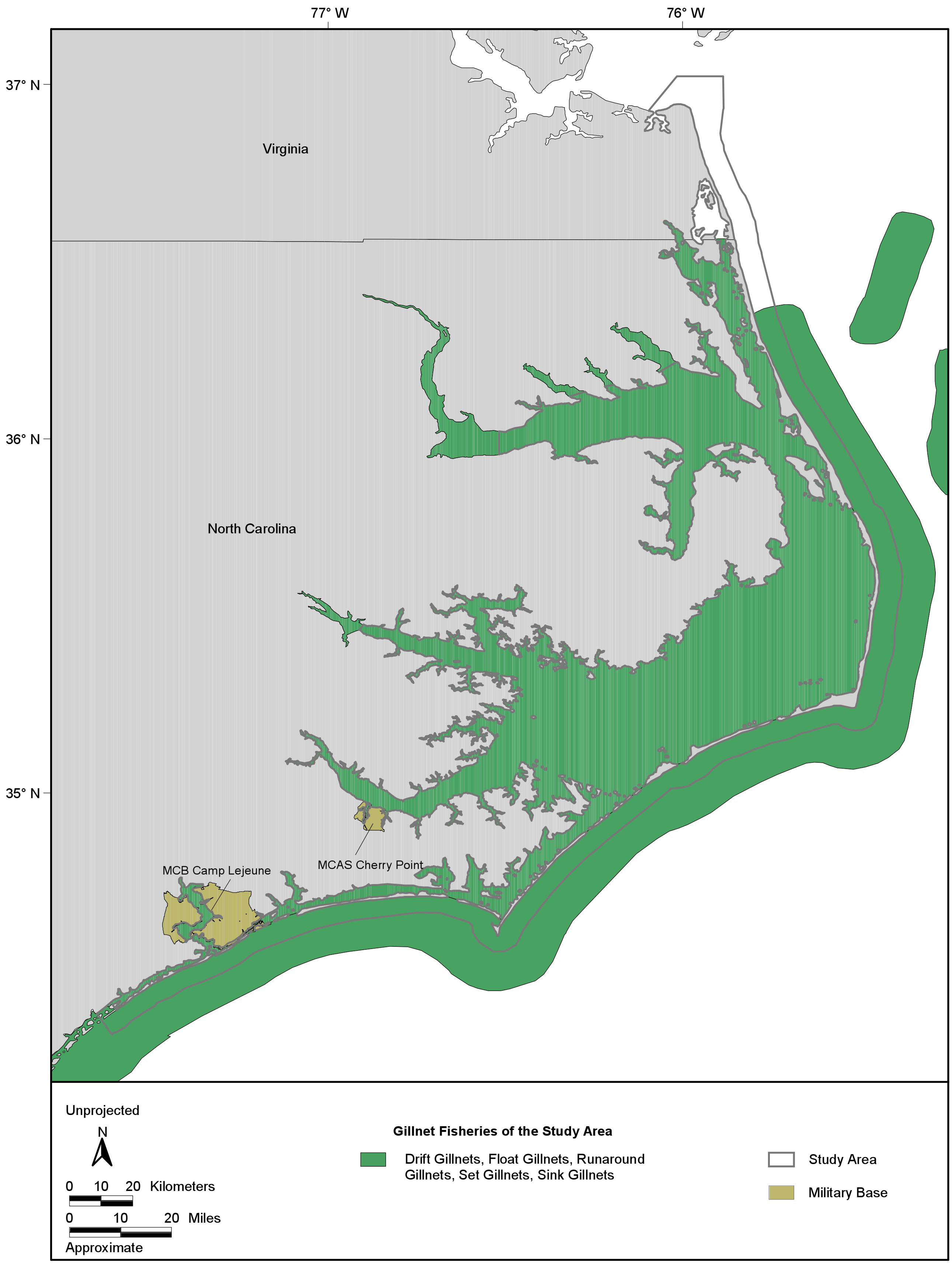

Figure 4-4. Fishing grounds of gillnet fisheries in the Cherry Point and southern VACAPES inshore and estuarine areas, including the set, drift, sink, float, and runaround gillnet fisheries. Map adapted from: Steve et al. (2001).

three categories: set net gillnets, drift gillnets, and runaround gillnets. In general, gillnets are lengths of netting that hang vertically in the water column (Steve et al. 2001). Gillnets capture fish when they swim unwittingly into the netting, allowing their heads to pass through the mesh but not the entire body. The fish's gills become ensnared in the netting lines. This method of fishing relies on the fish's inability to sense the netting until it is too late. Modern gillnet netting is made of strong, translucent monofilament line. Fish that are small enough generally pass through unharmed (Steve et al. 2001).

Although somewhat confusing, the NCDMF defines set net gillnets as either anchored or unanchored gillnets. Unanchored set net gillnets are the primary gillnet type used in the study area. They are subdivided into floating types and sink types. Any gillnet with its top "float" line below the surface is considered a sink type. Drift gillnets are always unanchored gillnets and are subdivided into float and sink types as well (although the NCDMF does not differentiate sink and float drift nets in their fishery statistics). As implied by its name, the drift nets are unanchored and allowed to drift in the currents when they are deployed. According to the NMFS definition of gillnets, the fishery is divided into anchored (instead of set) and unanchored (instead of drift), and each of these types is either a sink or a float net. In the North Carolina area, anchored set gillnets are referred to as "stab nets." The third gillnet type is the runaround gillnet, which is used to encircle a school of fish (similar to purse seines). Runaround gillnets are generally 91 to 914 m in length. The target species and location of the set determines the type of gillnet used. Beach gillnets, an anchored set net type of gillnet, are classified with beach and haul seine fisheries by the NCDMF (Steve et al. 2001). The gillnet fisheries of the study area can also be separated geographically as ether coastal (nearshore and offshore) or inshore.

***Coastal Gillnets*—**The dominant gillnet type used in the coastal nearshore environment is the set net gillnet. These sink nets target bottom and mid-water fishes. Float gillnets are not common in coastal waters. Coastal gillnets vary from 183 to 2,743 m in length. Buoys are used to float the net at the desired depth in the water. Gillnet soak-times (the amount of time the net is left in the water to fish) range from several hours to several days. Several factors affect soak time: target species (if they decompose quickly, they have shorter soak-times), weather conditions, and the potential for catching more fish with minimal damage to the nets. The primary target species taken in this coastal fishery are bluefish, weakfish, croaker, and Spanish mackerel (Steve et al. 2001; NCDMF 2002). This fishery is mainly a winter fishery, active from October through March. A portion of the fishery in the northern coastal region targets king and Spanish mackerel in summer months, and some fishermen in the southern portion of the coastal fishery target a variety of species in some summer months. The coastal gillnet fishery also includes a recreational component in nearshore waters. Recreational gillnets can be a maximum of 91 m long per person fishing, or 183 m long per vessel (Steve et al. 2001).

The coastal sink gillnet fishery occurs along most of the nearshore waters of the inshore area, from off Currituck Beach to South Carolina. The majority of sink gillnet activity occurs off Dare and Hyde counties in nearshore waters from December through April, with Hatteras and Wanchese as the primary homeports. The fishery off Carteret County is most active from October through February. The fisheries off the southern counties are active in the fall and in the spring (March through April). The lowest activity occurs from May through August. Bluefish, croaker, dogfish shark, striped bass, and weakfish are the primary species targeted in the winter. The southern counties target spot in the months of September and October (Steve et al. 2001; NCDMF 2002).

The coastal sink gill net fishery for bluefish expanded to the Outer Banks in the 1980s. Bluefish occur in coastal waters out to the edge of the continental shelf. It is an important commercial species and is also among the most important sport fish off the Atlantic coast. The bluefish stocks were being harvested at maximum levels by 1990 (MMS 1990b). Bluefish are also captured in the sounds of North Carolina with sink gillnets, long haul seines, hook and line, purse seines, and trawls. However, bluefish are primarily targeted with coastal sink gillnets (MMS 1990b).

The offshore component of the sink gillnet fishery (greater than 3 NM) is made up of fishermen leaving from ports in Dare County. The activity in the offshore sink net grounds occurs primarily in the winter. This offshore fishery includes a large effort targeted at spiny dogfish and monkfish, but also targets some of the same nearshore species.

Some coastal runaround gillnet fishery activities are active in the nearshore environment of the study area near coastal beaches. This fishery targets striped mullet in the fall, with incidental catches of bluefish and spotted sea trout. In the southern coastal portion of the study area, runaround gillnets are used to capture Spanish mackerel, bluefish, and spot. The primary nearshore fishing ground is located off Carteret County, with the greatest levels of activity occurring in October and November (Steve et al. 2001).

King mackerel are often taken with coastal gillnets. Historically, commercial supplies of king mackerel have come from recreational fishermen selling their catch. They are now commonly targeted commercially. There have been conflicts between recreational and commercial fishermen, and the stocks are considered to be fully exploited (MMS 1990b). Most king mackerel are harvested beyond the 3 NM limit. Fishing off the Outer Banks occurs from April to early June and through the fall into late December (MMS 1990b). King mackerel are also taken by trolling with hook and line

***Inshore/Estuarine Gillnets*—**The inshore/estuarine gillnet fishery is a multi-species fishery operating year-round in the waters of the study area. Peaks in activity occur in the spring and then again in the fall of the year (NCDMF 2002). The target species and type of gillnets used vary throughout the estuaries and sounds. The estuarine fisheries also include a large number of recreational fishermen (Steve et al. 2001).

Set net gillnets are the main gillnet type used in estuarine waters (Steve et al. 2001). This inshore fishery is far more active than the coastal nearshore fishery. Methods of fishing are similar to those used in the coastal fisheries. Two-thirds of the set net gillnets used inshore are the sink variety. Sink gillnets target bluefish, croaker, spot, striped mullet, weakfish, spotted seatrout, Spanish mackerel, striped bass, and southern flounder. This fishery occurs throughout the Albemarle, Pamlico, and Core sounds and their tributaries (including the New River). Activity in the Pamlico and Core sounds peaks in October and in the spring. Activity in the Albemarle Sound peaks in September (Steve et al. 2001; NCDMF 2002).

The float gillnet fishery targets mainly southern flounder, striped mullet, spot, spotted seatrout, weakfish, and bluefish. Activity is concentrated in the Pamlico and Core sounds with peaks in the spring and fall. The float gillnet fishery of the New River has an active fishery that occurs from summer through the fall (Steve et al. 2001; NCDMF 2002).

Runaround gillnets are used in the estuarine waters of the Pamlico, Core, and Albemarle sounds, primarily targeting striped mullet. This fishery has been increasing in activity with the majority of fishing occurring during summer and fall months. Estuarine runaround gillnets can be from 91 to 1,097 m in length. The methods employed in the runaround gillnet fishery are similar to those used nearshore, with short soak-times of less than one hour. In addition to the striped mullet, commercial species taken also include spotted seatrout, spot, and sometimes incidental catches of red drum, which are currently a restricted commercial species. Other incidental catches include summer flounder, croaker, and bluefish (Steve et al. 2001). There is a very small drift gillnet fishery in the Pamlico and Core sounds. This fishery lands striped mullet, spot, and southern flounder. Activity peaks in October (Steve et al. 2001).

Striped bass have been a traditionally important recreational and commercial species that are caught both offshore and inshore. The inshore fishery is the larger of the two. Striped bass are landed mostly by ocean gillnets, trawling, long haul seines, and pound nets (MMS 1990b). Striped bass are caught either in the open ocean or inshore, with the inshore fishery being the larger of the two.

4.1.5.4 Pound Net Fisheries

Pound nets have been used in the inshore waters of North Carolina since 1870 and are currently one of the area's major fisheries (NCDMF 2002). They are a stationary gear type that, when set, direct and collect fish into "pound" areas by a series of leads that discourage egress. The exact configuration varies by location and by species targeted. Leads can be up to 305 m long and set at depths of up to 6 m. A series of stakes driven into the mud support the net along its length. The entrance to a "semi-pound" area at the end of the lead is usually 9 m on each side. A tunnel net (6 m) then leads the fish into the main impoundment (9 to 12 m^2), where the fish remain. A crew of two to three fishermen uses a small motorboat (6 to 8 m) to gather the corralled fish. The process generally takes 10 minutes and usually more than one pound net is harvested in a day. Pound nets are generally set in the deepest waters of the sound over muddy bottoms (Ross and Moye 1989). They capture mainly croaker, menhaden, and weakfish and also include important incidental capture of harvestfish, spot, southern flounder, Spanish mackerel, and bluefish (Ross and Moye 1989; Ross 1991). However, at least 44 species of fish and four species of invertebrates are landed for commercial sale by this fishery (NCDMF 2002).

Sciaenid Pound Nets—Sciaenid pound nets are used in inshore waters along the Outer Banks between Ocracoke Island and Rodanthe and sometimes near Oregon Inlet (Figure 4-5; Ross and Moye 1989). Additional sciaenid pound net fishing sites include some small areas just south of Roanoke Island and Roanoke Sound (Ross et al. 1988). Sciaenids are a family of fish known as the drums because of the drumming or croaking sounds they make. These fish include red drum, black drum, croaker, and spot. Also in this family, but less vocal, are weakfish and spotted sea trout.

Landings at the northern inshore sites along the Outer Banks and at the sites in Pamlico Sound occur from May through October, with the greatest landings occurring in mid- and late summer. Spot is landed in the pound net fishery in Pamlico and Core sounds, and their tributaries from April to October (MMS 1990b). Sciaenid pound net use decreased in the 1980s and they are no longer used in the lower Pamlico Sound, around the Neuse River, or in the Pamlico River. The Hatteras area is now the center of activity for this fishery.

Flounder and Herring Pound Nets—Pound net fisheries in other parts of the study area target a variety of other species. One of these is an inshore pound net fishery that targets flounder mainly in Core Sound (for southern flounder) in the fall of the year (MMS 1990b). River herring are another major species targeted by a pound net fishery. River herring include the alewife and the blueback herring (APES 1992). The fishery for these anadramous fish is concentrated in the Albemarle Sound. Landings have declined greatly since the mid-twentieth century. Commercial fishing occurs primarily during the spawning runs into the estuaries and rivers. Pound nets are the most often used gear in the North Carolina river herring fishery (MMS 1990b).

4.1.5.5 Pot/Trap Fisheries

The pot/trap fisheries near the study area target both fish and invertebrates. Pots and traps are passive fishing gears that are usually baited and set in the home range of the target species. The pots or traps rest on the bottom substrate and are marked at the surface with a buoy. Estuarine pots are used to capture mainly crabs, eels, and catfish, but take other commercial fish opportunistically. The offshore pot/trap fishery is directed at deeper hard-bottom species such as black sea bass and scup.

Crab Pots—Blue crabs made up a large part of the shellfish catch in the past and are one of the most profitable commercial species in the study area. Blue crabs are the most important fishery species in the North Carolina area for socioeconomic reasons (e.g., jobs, materials, landing values, wholesale and retail values, etc.) (MMS 1990b; McKenna and Camp 1992; Steve et al. 2001). Several life stages of the crab are targeted including the traditional hard-shell (between molting events) and soft-shell crabs or “peelers” (after a molting event when the hard shell is shed and a new larger shell begins to harden) (Steve et al. 2001). Soft-shell crab landings have been an important part of the fishery (NCDMF 2002; NMFS 2002b).

The pot fishery for blue crabs increased in the 1980s and 1990s. The competition generated by this fishery has caused conflicts among crabbers and other fisheries in the area. The blue crab is a shallow water crab that occurs in estuaries over a variety of bottom types and in a wide range of salinities from fresh to full seawater. Although common in all the estuarine waters of the study area, blue crabs are most populous in the Albemarle and Pamlico sounds where most of the fishery effort is concentrated. The peak months of landing blue crabs are May through August (Steve et al. 2001).

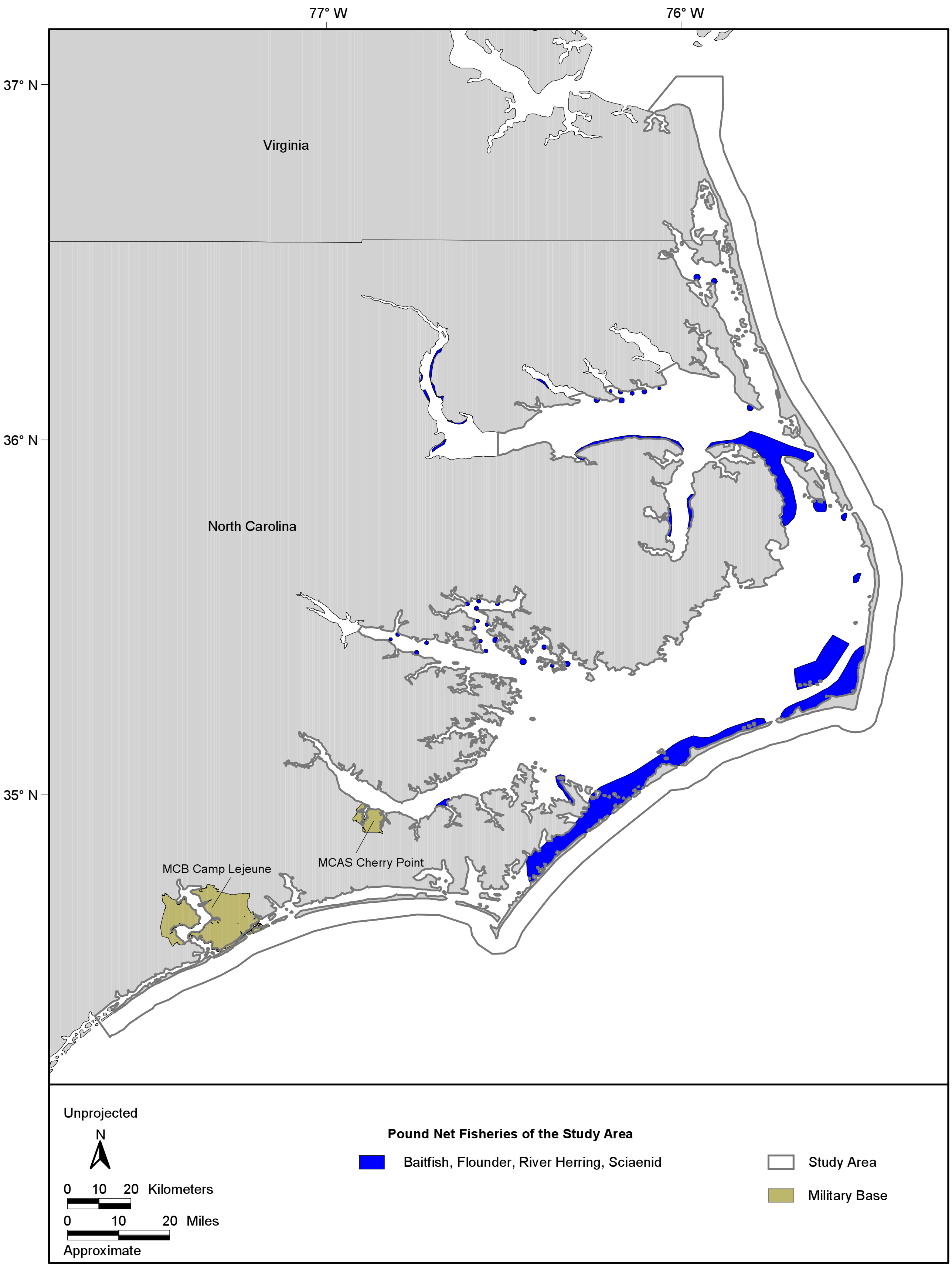

Figure 4-5. Fishing grounds of pound net fisheries in the Cherry Point and southern VACAPES inshore and estuarine areas, including the flounder, sciaenid, river herring, and baitfish pound net fisheries. Map adapted from: Ross et al. (1988), Ross and Moye (1989), and APES (1992).

Approximately 95% of the blue crabs are caught in the sounds and bays. About 80% of these are taken with pots and the remainder are taken with trawls and trotlines (Figure 4-6) (MMS 1990b; Steve et al. 2001). There are anywhere from 1.0 to 1.2 million commercial crab pots used every year in the waters of the study area. The number of crab pots set at any given location by a fisherman varies from 150 to 200 in southern regions and as many as 2,000 in the Pamlico Sound area. In addition, there are a large number of blue crabs taken recreationally. The recreational blue crab fishery is very popular, equaling nearly 30% of the commercial landings (Steve et al. 2001).

Commercial crab pots are baited with some sort of meat and set in a row in shallow estuarine waters. The pots are actually wire mesh traps roughly 61 cm^3 in size. The pots are sunk to the bottom at the fishing location and marked with a small buoy at the surface (APES 1992).

***Eel Pots*—**Eel pots are not as common as crab pots in and near the study area (APES 1992; NCDMF 2002). Nearly 1,500 trips were recorded in the period from 1997 through 2001 (NCDMF 2002). Eel pots are set in the inshore waters from Currituck Sound south to Croatan Sound and also in the Albemarle Sound and Alligator River. Some pots are also set in the Pamlico and Bay rivers (APES 1992). Eel pots are set year-round with only a slight increase in trip numbers occurring in October through December (NCDMF 2002).

***Fish Pots*—**Fish pots in the inshore and nearshore coastal waters of the study area are about as common as eel pots. About 1,300 trips were recorded from 1997 through 2001 (NCDMF 2002). Fish pots are set in a variety of waters from the oceanic shoreline to the Intracoastal Waterway and other inshore water bodies including the Albemarle Sound, the Alligator River, the Newport River, the Chowan River, and the North River (APES 1992; NCDMF 2002). Fish pots are set year-round, with the months of October through December experiencing the highest amount of activity (NCDMF 2002).

***Offshore Pots/Traps*—**The offshore pot fishery for black sea bass centers in the Cape Lookout and Cape Hatteras areas (MMS 1990b). Pots/traps are primarily used around live/hard bottom areas, artificial reefs, and shipwrecks (Figure 2-10) for catching black sea bass in waters no deeper than 37 m, but the pots/traps also target and land other species such as summer flounder and scup (Casey personal communication). Black sea bass are landed all year but mostly from May through December (NMFS 2002b). Roughly 30 potting vessels operate south of Cape Hatteras (Gloeckner personal communication).

4.1.5.6 Hook-and-Line Fisheries

The offshore commercial hook-and-line gears used in the study area include longlines, handlines, and trolling lines. Fishing vessels leave from the small towns located on the western shores of Pamlico Sound and the seaside towns south of Cape Lookout. Some of the major ports near the study area are Beaufort, Morehead City, Wanchese, Stumpy Point, Englehard, Swanquarter, Oriental, and Vandemere (NMFS 2001a). Some of this offshore fishing is carried out by far-ranging vessels, including longliners, which travel to the area from ports as far away as New England. These vessels may have commercial licenses that allow them to land their catches at North Carolina ports (Gloeckner personal communication). Trotlines and rod and reels are small-scale hook-and-line gear used commercially, to a small degree, in the estuarine waters of the study area.

***Trotlines*—**The recorded amount of trotline activity is small in the study area and vicinity. Trotlines are deployed in some of the upper reaches of the Pamlico and Pungo rivers (Figure 4-7) (APES 1992; NCDMF 2002). Trotlines consist of a series of baited hooks spaced along a fishing line that is laid perpendicularly to the flow of a stream or river on its bottom. Trotlines primarily target catfish, crab, and flounder. Trotline fishing occurs year-round, but the months of April through June have the greatest amount of activity. In the five-year period of 1997 through 2001, no activity was recorded in either 1997 or 1999, and the total number of trips recorded for that period was only 146 (NCDMF 2002).

***Trolling*—**A relatively small amount of trolling occurs in coastal waters within 3 NM from shore. From 1997 to 2001, only 922 commercial fishing trips recorded trolling activity in the 3 NM coastal zone.

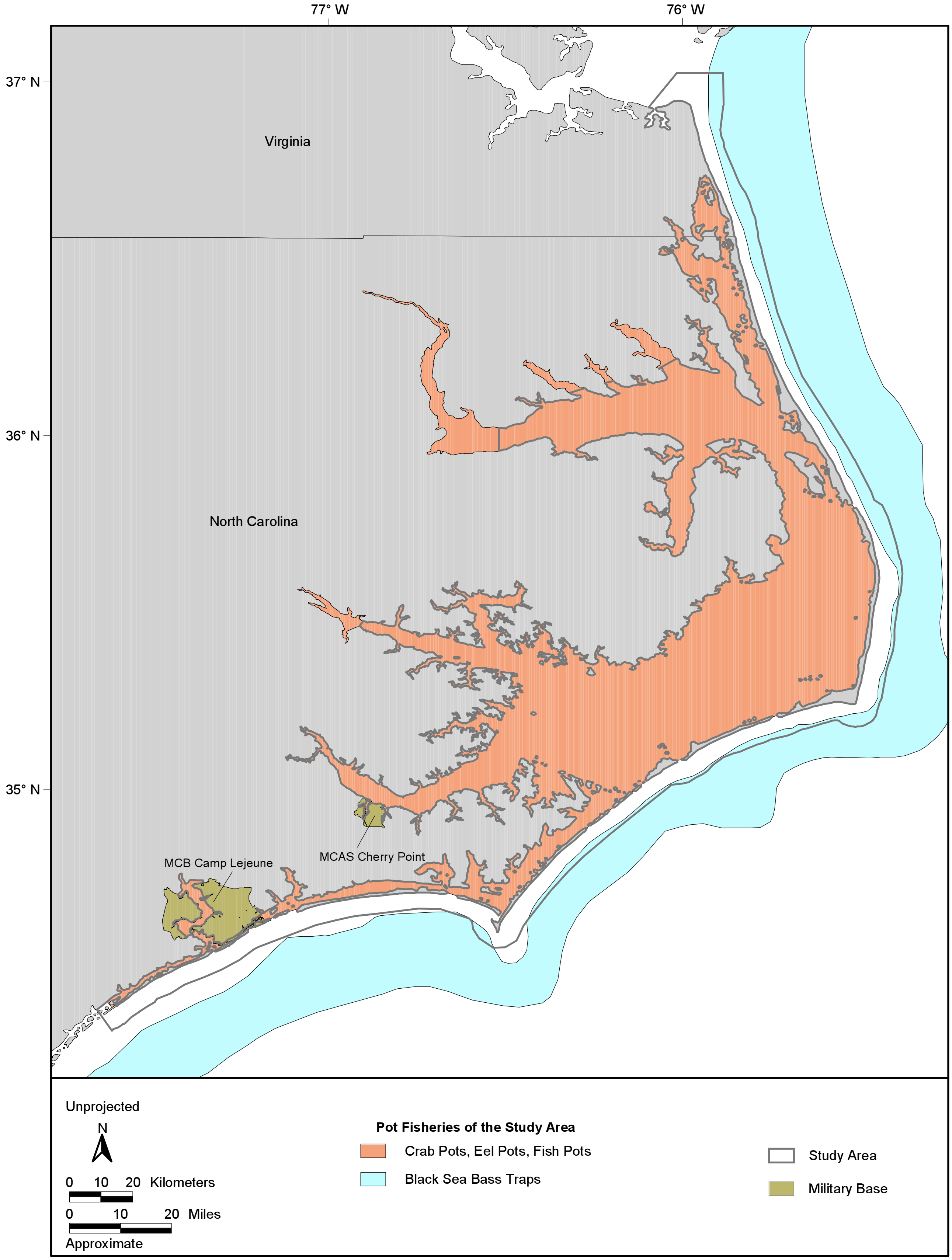

Figure 4-6. Fishing grounds of pot/trap fisheries in the Cherry Point and southern VACAPES inshore and estuarine areas, including crab pots, eel pots, fish pots, and black sea bass pots/traps. Map adapted from: Gusey (1981), Mercer (1989), APES (1992), and Steve et al. (2001).

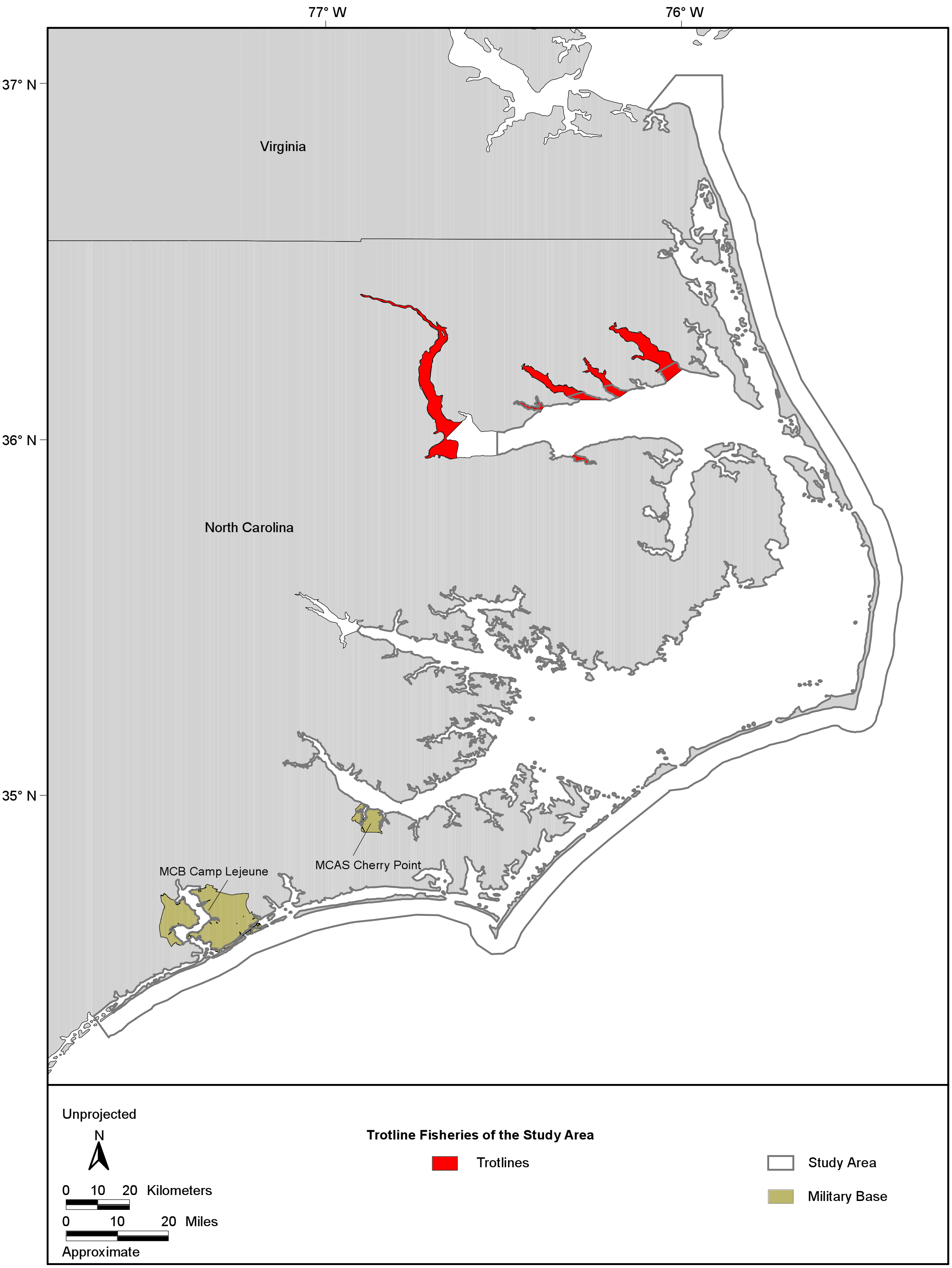

Figure 4-7. Fishing grounds of the trotline fishery in the Cherry Point and southern VACAPES inshore and estuarine areas. Map adapted from: APES (1992).

Trolling involves a vessel pulling four or five lines with baited or lured hooks at slow speeds in waters known to have commercial target species. King and Spanish mackerel and tuna are the main species landed by trollers in the near coastal waters. Cobia, dolphinfish, bluefish, and wahoo are also landed in large numbers. Trolling in these coastal waters occurs year-round, but the greatest amount of activity occurs roughly from October through December.

***Longlines*—**No pelagic longline activity occurs within 3 NM from shore in the study area. Longlining targets mainly highly migratory species such as swordfish, shark, and tuna primarily near the continental shelf edge (NMFS 2001a). Bottom longlining only rarely occurs within the 3 NM nearshore zone. A total of 32 trips was recorded between 1997 and 2001. These trips primarily targeted coastal shark species. Activity occurred in April through September.

***Handlines*—**Handlines commonly target snappers and groupers and are employed offshore (mostly beyond 3 NM) by nearly 100 commercial vessels near the study area (Gloeckner personal communication). The handline fishing grounds extend from the continental shelf break shoreward to about 3 NM. Handline fisheries for black sea bass center in the Cape Lookout and Cape Hatteras areas (MMS 1990b). No handline activity was recorded between 1997 and 2001 in the 3 NM coastal zone of the study area.

***Rod and Reels*—**Commercial rod-and-reel activity is not overly common and is not a major fishery gear in the study area and vicinity. The greatest commercial activity with fishing rods occurs off the coast of North Carolina and mainly south of Cape Hatteras. Inshore activity occurs in the Neuse and Bay rivers (NCDMF 2002). Most rod-and-reel fishing occurs in the recreational fishery where it is one of the most common gear types.

4.1.5.7 Bivalve Shellfish Fisheries

Three main species of bivalves are harvested near the study area (Figure 4-8). The waters in and near the Bogue, Back, and Core sounds are heavily harvested for bay scallops, hard clams, and oysters (APES 1992; NCDMF 1998, 2002; NCDEH 2000). Most of the remaining portions of the study area are also harvested for oysters (APES 1992; NCDMF 2002).

Shellfishes are harvested throughout the southern portions of the study area (south of Roanoke Island) at scattered private and public lease sites. Some areas are permanently closed to shellfish harvesting (prohibited areas) while others are conditionally approved areas for harvesting depending on recent local water quality conditions determined by the North Carolina Department of Environmental Health (NCDEH). The North Carolina Department of Marine Fisheries (NCDMF) is in the process of mapping shellfish habitat in the southern estuaries and sounds. The NCDMF keeps records of lease owners listed by body of water. The NCDEH provides maps of prohibited areas and keeps records of the conditional approved areas (APES 1992).

***Bay Scallops*—**Bay scallops live exclusively in estuaries or in nearshore coastal waters. In addition to harvesting pressures, they are vulnerable to recreational activities and industrial development. They are harvested using small dredges, dip nets, rakes, and hand picking (MMS 1990b; APES 1992). This fishery is small but locally important (Waite et al. 1994). Bay scallops are affected by water quality and algal bloom events (MMS 1990b; Waite et al. 1994).

Bay scallops are harvested in the greatest amounts in the western and central parts of Bogue Sound, and to a lesser degree in the southeastern portion of Bogue Sound. Scattered harvest areas occur in Core Sound along the inside shore of the barrier islands from Drum Inlet to Cape Lookout and in Back Sound. Harvests also occur in Pamlico Sound on both sides of Ocracoke Inlet and along the inner shore of the barrier island from Oregon Inlet to the town of Avon.

***Hard Clams*—**North Carolina is the leading source of hard clams along the Atlantic coast. Landings have increased since the fishery gained popularity and since the introduction of new mechanized harvesting tools. They are mainly taken from Core and Bogue sounds (APES 1992; NCDMF 2002). Water quality

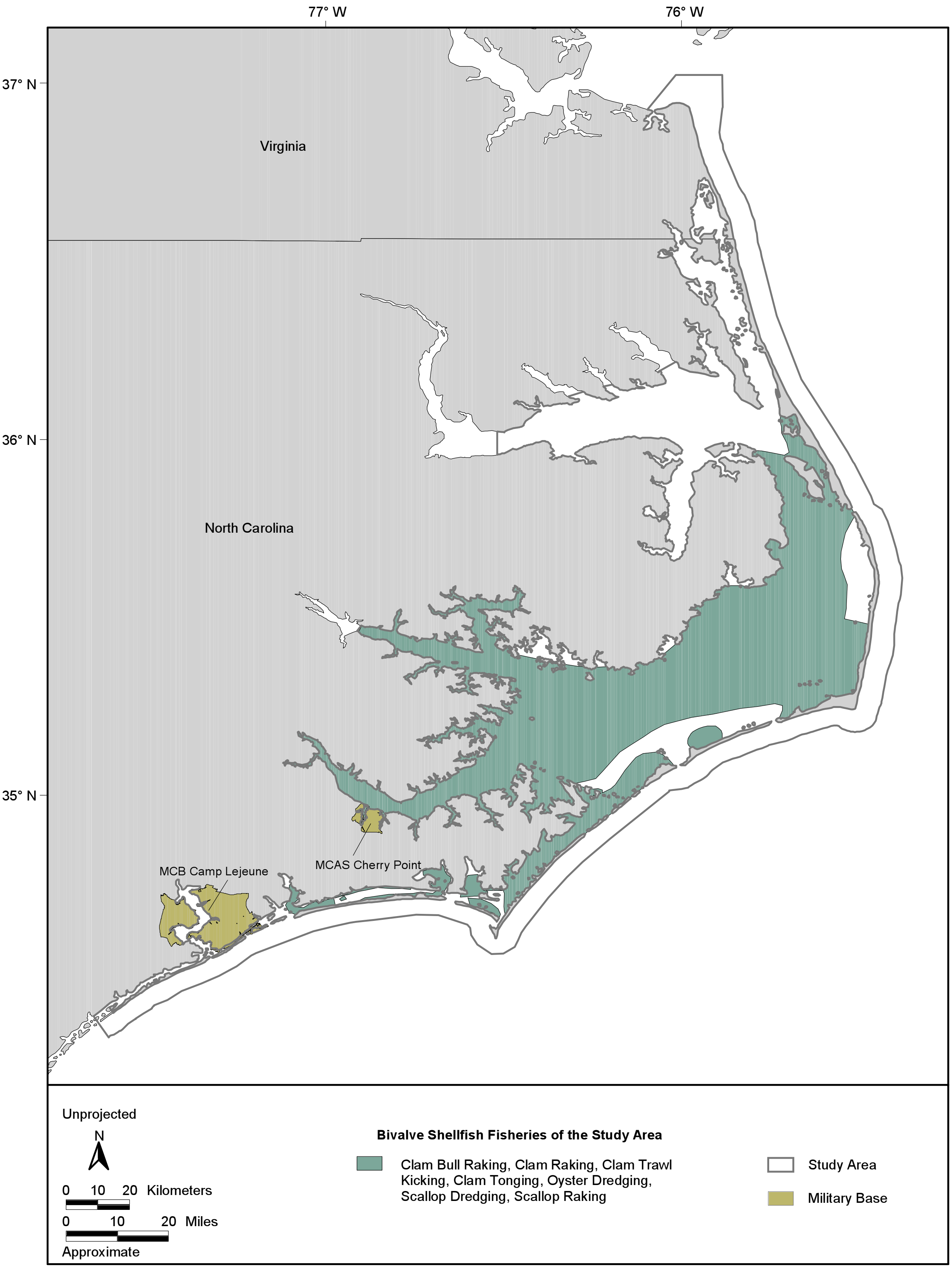

Figure 4-8. Traditional harvesting grounds of the bivalve shellfish fisheries (hard clams, oysters, and bay scallops) in the Cherry Point and southern VACAPES inshore and estuarine areas. Shellfish harvesters in these areas utilize rakes, bull rakes, tongs, kicking trawls, and dredges. Map adapted from: APES (1992).

and algal bloom events can affect harvesting activities (MMS 1990b; Waite et al. 1994). Traditionally, clams have been harvested with hand gear such as rakes or tongs. In North Carolina, a method called clam kicking has been used to harvest clams. Kicking involves the use of a boat's propeller to generate water currents that dislodge whole clam beds. The clams are then collected with a trawl net pulled behind the vessel. This method is somewhat controversial in the North Carolina area, although it is highly efficient. The use of hydraulic escalator harvesters is also an efficient method of harvest that has increased the overall landings of hard clams. Hydraulic dredge harvesters can reach clam beds previously out of reach of hand harvesting methods. These mechanical harvesting methods generally account for one-third of the hard clam landings (MMS 1990b; APES 1992; Waite et al. 1994).

Hard clams are harvested in the mid to lower parts of the White Oak, Newport, and North Rivers (with some scattered areas in the upper parts of these rivers). Harvests areas are also scattered throughout Core Sound, scattered around the shores and shallows of Bogue Sound, in most of Back Sound, and on both sides of Ocracoke Inlet in Pamlico Sound.

***Oysters*—**Oysters occur inter-tidally in most of the study area and sub-tidally in Pamlico Sound. Historically, the oyster fishery has been very large in North Carolina. However, landings have declined steadily in the twentieth century until 1970, when they leveled out. Oyster harvest activities are affected by water quality and algal bloom events (MMS 1990b). Oysters are harvested throughout Pamlico Sound as far north as northern Roanoke Island. However, a closed area exists just inside the barrier islands from Oregon Inlet to Core Sound (APES 1992).

4.1.5.8 Other Gear Types

Several other gear types of a small-scale nature are used commercially in and near the study area to a significant degree. Both gigs and cast nets are used along the shores of the study area. These gear types are implemented by single individuals from shore or in shallow water and do not require the use of any vessel. A gig is a short, hand spear used to impale fish in shallow waters. Between 1997 and 2001, over 5,000 trips were recorded as using gigs to catch fish. Gigging occurs year-round, yet most activity takes place during summer months. The primary species targeted by gig fishing are flounders. Red drum and speckled trout are also caught using gigs. Gigging takes place mainly in the southern portions of the study area, from the Neuse River to Cape Fear (NCDMF 2002).

Cast nets are used to a lesser degree. Just over 1,000 cast net trips were recorded from 1997 through 2001. Cast nets are circular nets that are flung into the water from shore or in shallow areas where fish can be visibly located swimming near the surface. Cast nets are often used to collect baitfish for use with other gear types, such as hook and line or fish and crab pots. Cast nets are used year-round with the majority of activity occurring from July through September and a minimal amount of activity occurring from January through March. Mullet are the primary fish species landed and menhaden (used for bait) are the second most common species caught with cast nets. Shrimp are also caught with cast nets. Fishing effort occurs along the ocean shoreline and in the Bogue and Roanoke sounds. Some cast net fishing occurs in the Intracoastal Waterway. Both of these gear types are commonly used in non-commercial fisheries (NCDMF 2002).

4.1.5.9 *Sargassum*

Sargassum in the North Atlantic Ocean occurs mainly within the physical bounds of the North Atlantic Gyre between 20°N and 40°N and between 30°W and the western edge of the Gulf Stream (Figure 4-1). The greatest concentrations of *Sargassum* in the North Atlantic Gyre lie between 28°N and 34°N in the area known as the Sargasso Sea (SAFMC 1998). Butler et al. (1983) indicate that the abundance of *Sargassum* at any single location is unpredictable. The nature and behavior of the North Atlantic mesoscale currents are considered principal factors governing the unpredictable and patchy distribution of *Sargassum* (Butler et al. 1983). Further, quantities of drifting *Sargassum* can separate from the main circular flow of the Sargasso Sea and, depending upon the prevailing surface currents, either travel over the continental shelf for extended periods of time, remain in the Gulf Stream, or wash ashore on beaches and pass into inshore waters (SAFMC 1998).

Sargassum is collected for use in such products as fertilizers and animal feed supplements (Campbell personal communication; SAFMC 1998). Currently, only one company harvests *Sargassum* in the North Atlantic Ocean (Figure 4-9). The Aqua-10 Corporation, based in Beaufort, NC, commercially harvests a limited amount of *Sargassum* out to 130 NM offshore of the North Carolina coast. Harvesting activities are limited to the waters south of the Virginia/North Carolina border and north of Cape Fear (Campbell personal communication). Potential harvesting grounds for *Sargassum* encompass a relatively large portion of the coastal area of North Carolina (Figure 4-2). Approximately 10,283 NM^2 of offshore waters are considered as potential harvesting grounds in the Atlantic Ocean for Aqua-10 harvesters. *Sargassum* harvests occur during spring and summer months, when the algae are most abundant in the area. Spotter planes are often used to locate concentrations of *Sargassum.* Occasionally, large amounts of *Sargassum* reach inshore waters and are found and collected in the sounds and rivers of North Carolina and even as far up river as small tidal creeks (Campbell personal communication). The Aqua-10 Corporation has harvested around 200 tons of *Sargassum* (wet weight) during its 14 years of operation (SAFMC 1998). In the past, the Aqua-10 Corporation contracted shrimp, snapper-grouper, and longline vessels to collect *Sargassum*; however, it now operates its own converted snapper-grouper vessel on directed harvesting trips (SAFMC 1998). One to three trips are conducted per year, landing anywhere from one-half to 10 tons per trip. The greatest number of harvesting trips made during one year was 14, while six and seven trips occurred during a couple of harvest years. In addition to harvesting in and near the Gulf Stream, the Aqua-10 Corporation also harvests beyond the EEZ in the Sargasso Sea. As of March 2002, new fishery management rules were being developed by SAFMC for pelagic *Sargassum* harvesting in state and federal waters (Iverson personal communication).

4.1.6 Recreational Fisheries

Marine recreational fishing can be divided into inshore and offshore components (Figure 4-10). Recreational fishing inshore involves fishing from boats, beaches, marshes, docks, piers, etc. Boats often fish near beaches and inlets and in the sounds. Fishing in the ocean from beaches and piers also occurs along the coasts of Virginia and North Carolina. Anglers generally seek prime fishing habitats such as over submerged structures and seagrass beds, near marshes, over mud flats, and in the deeper portions of the bays and sounds. Fishing is popular off man-made structures as well as piers, docks, and bulkheads. The majority of boats fishing in the inshore areas are privately owned. Rod-and-reel fishing is the most common method used by recreational fishermen (NMFS 2001b). Peak times for inshore angling occur from July to October. Offshore fishing generally involves larger boats and also includes charters and party boats. Charter boats take any number of anglers for a fixed daily rate. Party boats, or head boats, take guests (usually on larger boats) on a per person rate (Abbas 1978). Offshore anglers fish anywhere from several kilometers out to the edge of the Gulf Stream and beyond (Freeman and Walford 1976; MMS 1990b).

In addition to rod and reels, recreational fishing gear types used in the study area include fish traps and pots, cast nets, seines, gigs, tongs, rakes, and trotlines (NMFS 2001b). Many commercial fishing gears are also used recreationally, including shrimp trawls, gillnets, beach seines, and oyster and clam harvesters (Waite et al. 1994).

Advanced recreational fishing technologies and gear have made catching fish easier in recent decades. Recreational fish stocks, which significantly overlap with commercial stocks, have been under heavy fishing pressures from both recreational and commercial fishing activities. Conflicts between the groups have been contentious at times (MMS 1990b).

Most anglers do not generally target any one species (MMS 1990a). The preferred species to catch, however, are king mackerel, summer flounder, and yellowfin tuna (NMFS 2001b). Atlantic croaker, Spanish mackerel, bluefish, spot, and black sea bass are the top five recreational species landed. Fish of the drum family (sciaenids: weakfish, spotted seatrout, red drum, black drum, croaker, and spot) are favorite recreational species to catch. Striped bass had been a very popular fish before its stocks dwindled drastically. The recovery of the stock has allowed a return of the recreational fishery for striped bass. King mackerel are one of the most important sport fish near the study area. They are found from the intertidal zone to the shelf break. Charter boats rely heavily on king mackerel landings.

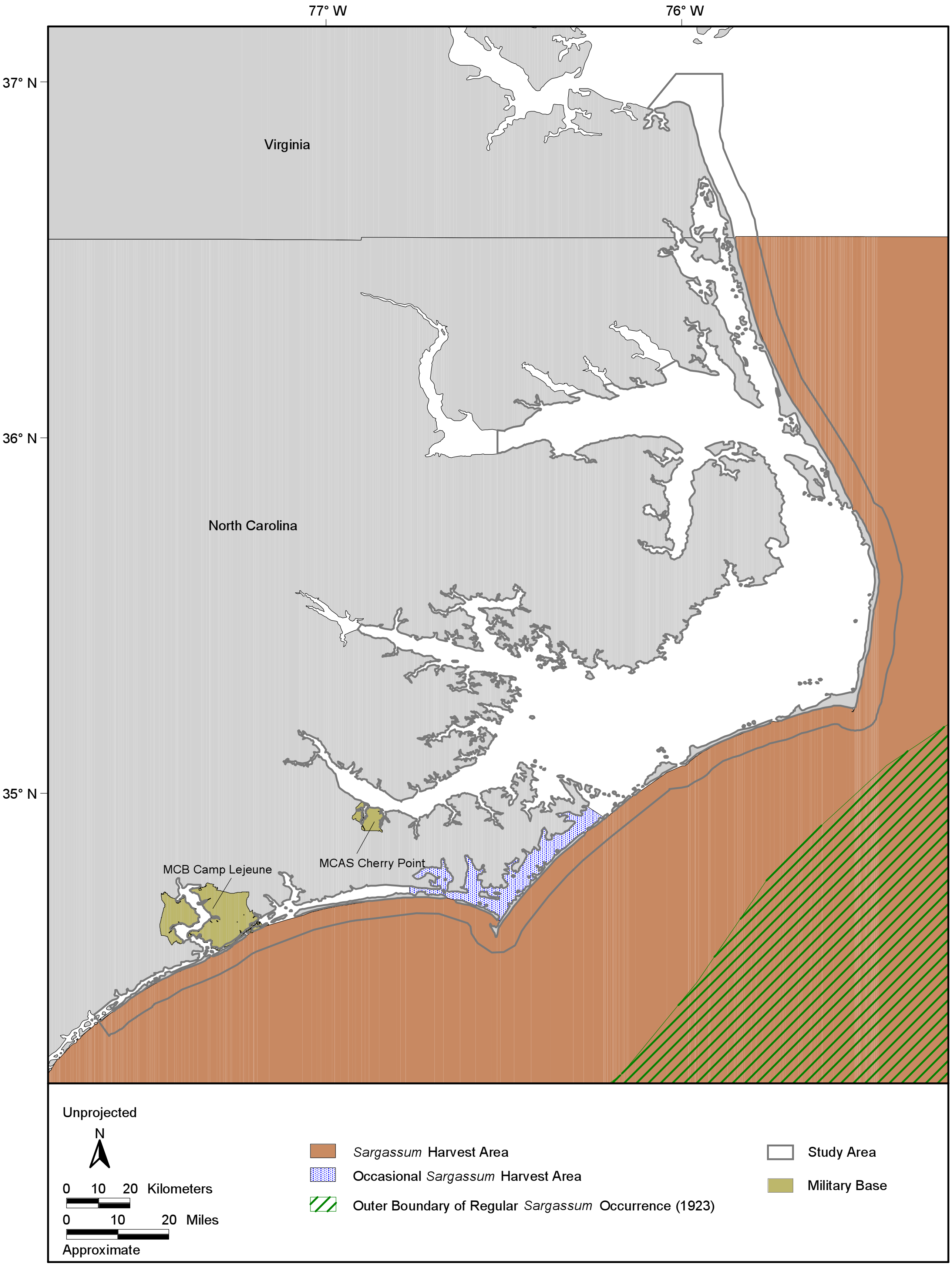

Figure 4-9. Potential *Sargassum* harvesting grounds in the Cherry Point and southern VACAPES inshore and estuarine areas. Source map (scanned): Butler et al. (1983). Source information: Campbell (2002).

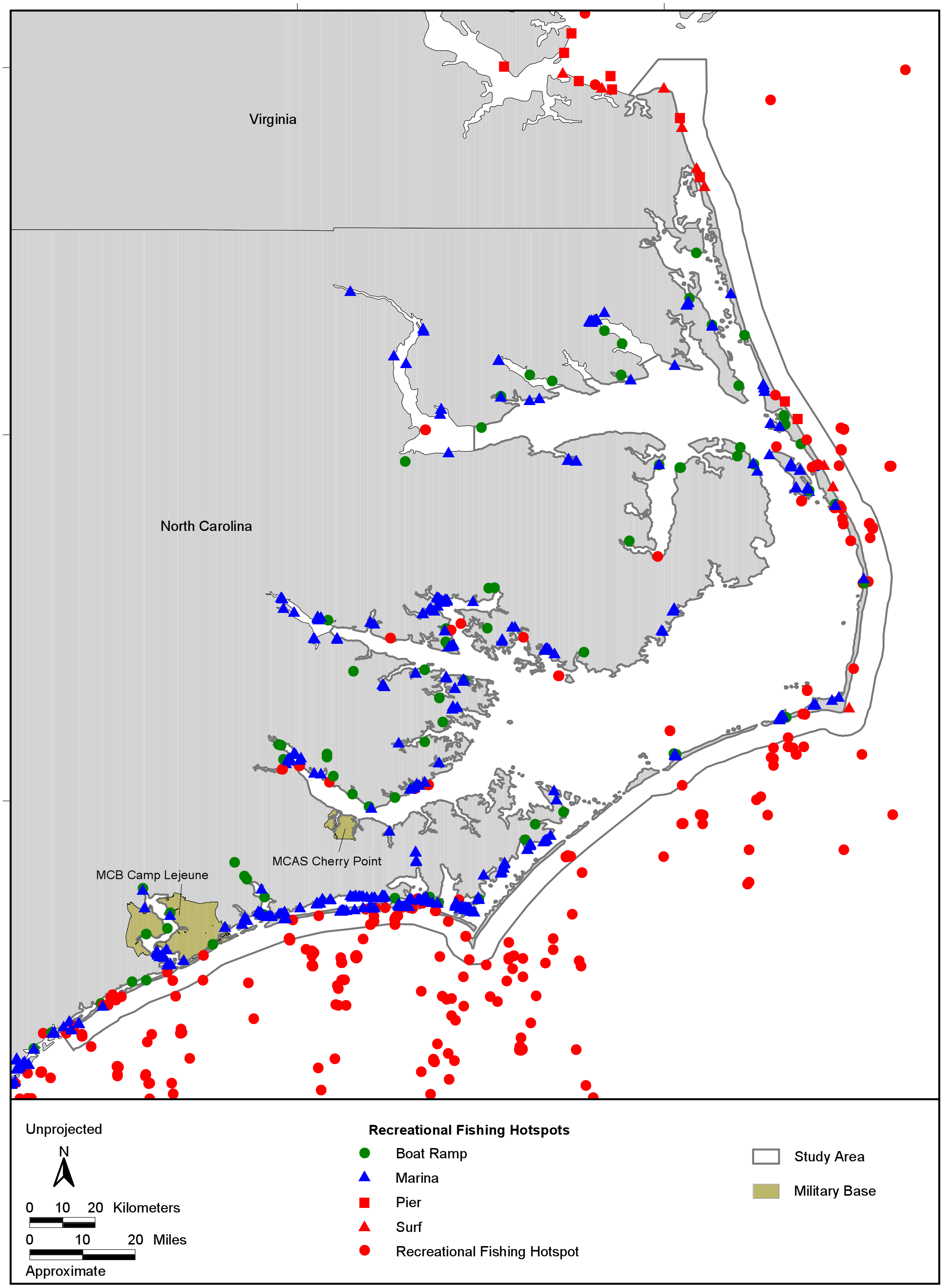

Figure 4-10. Recreational fishing elements in the Cherry Point and southern VACAPES inshore and estuarine areas, including marinas, boat ramps, and fishing sites. Source data: NCDEH (1998), NOAA (1998), NCDMF (2001), NOS (2001), SEAMAP (2001), and coastaloutdoors.com (2002). Source maps (scanned): BLM (1976), Freeman and Walford (1976), and pierandsurf.com (2002).

Every season of the year has at least 10 species of fish and invertebrates that are actively targeted by recreational anglers inshore and offshore of the Outer Banks of North Carolina. Sea trout are caught from August through April. Sea bass are caught December through February. Bluefish are caught year-round while cobia, dolphinfish, and wahoo are caught during the warmer months of May through August. King mackerel are caught throughout various months from April through December. Oyster, clam, and crab are caught in various months throughout the entire year (NMFS 2001b; Insider's Guide 2002).

Charter boats, headboats (party boats), and fishing guides are all available throughout the study area. The Outer Banks and inner sound cities and towns offer numerous fishing services to those who do not own their own boats or fishing gear. A single group of fishermen typically hires a charter boat on a per-trip basis, while head boats are regularly scheduled and take groups of anglers who pay a flat rate per person. Charter and head boats more commonly fish further offshore compared to private boats due to the high cost of private large boat ownership, the capability of the larger charter and head boats to go farther, and the greater experience of professional captains. Charter and head boats usually perform full day trips, and some charter boats may occasionally spend nights at sea (Abbas 1978). Offshore trolling in the spring and fall is the main fishing activity on charter boats (MMS 1990b). Individuals with smaller private boats sometimes hire out their services as fishing guides in inshore waters (MMS 1990b).

Popular fishing sites commonly visited by recreational anglers are known as hot spots. Near the study area, hot spots usually involve areas with some structural features such as shoals, rocks, and reefs (artificial and natural). Areas with greater vertical profiles, as found near channel edges, help fish regulate their temperatures by allowing them to quickly reach deep or shallow bottom habitats as needed. Natural and man-made features that extend over water or out into waters are generally well-fished sites, such as piers, docks, rock and concrete jetties, and beach groins. Local, state, and federal preserves are known to be good fishing locations because of their undisturbed habitats. Hydrographic features also concentrate fish and fishermen. Fishermen often target currents and waters rich with nutrients. The inlets of the Outer Banks are popular fishing sites. When possible, fishermen attempt to fish as close as possible to power plant cooling water effluents in colder months of the year. Hot spots in the study area include the Chesapeake Bay Bridge/Tunnel, Oregon Inlet, Cape Lookout, Beaufort Inlet, Drum Inlet, Harkers Island, Johns Creek, Swansboro, Atlantic Beach, Bogue Banks, and Kure Beach (Coastal Outdoors 2001).

The Outer Banks fishing piers of North Carolina are Kitty Hawk Pier and Avalon Pier in Kitty Hawk; Nags Head Pier, Jennette's Pier, Outer Banks Pier, and Sound Pier in and near Nags Head; Hatteras Island Fishing Pier in Rodanthe; Avon Fishing Pier in Avon; and Frisco Pier in Frisco (OuterBanks.com 2002).

There are a number of weigh stations that act as the official places in North Carolina to record catches with the state. State size records for recreational fish catches are weighed at these locations. These stations can also act as official weigh-in stations for state-wide fishing tournaments. There are 14 cities and towns with weigh stations in North Carolina: Corolla, Duck, Kitty Hawk, Kill Devil Hills, Nags Head, Manteo, Oregon Inlet, Rodanthe, Salvo, Avon, Buxton, Frisco, Hatteras Village, and Ocracoke (NCDMF 2000a).

Organized fishing tournaments are popular in the North Carolina and Virginia area. About 28 inshore and offshore tournaments in North Carolina were scheduled in 2002. Of these, seven are strictly nearshore (within 3 NM) or inshore events (NCDMF 2001). Both North Carolina and Virginia have state sponsored year-round fishing tournaments. King mackerel is the most commonly targeted species in North Carolina tournaments, although billfish are also very popular. Some tournaments have weigh-in categories for a number of species. Seasonally, the greatest number of tournaments occurs in the summer months (July through September), while no tournaments are scheduled during the months of January through March (Table 4-3 and Figure 4-11).

Organizations and companies usually sponsor the various tournaments throughout the year (Table 4-4). Each tournament has its own set of rules, which include time limits and geographical boundaries. Inshore tournaments usually target tarpon, sea trout, striped bass, or red drum and are generally bounded by

Table 4-3. Number of fishing tournaments held per season in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity (2000 and 2002).

Weigh-in Location	Winter	Spring	Summer	Fall
Atlantic				1
Atlantic Beach		2	7	
Beaufort			3	
Buxton				1
Cape Lookout			1	
Hatteras		2	1	2
Manteo		2	4	
Morehead City		2		1
Nags Head				1
Ocracoke		1		
Oriental			1	
Sneads Ferry			1	
Swansboro		1	1	1
Virginia Beach			1	
Total (37)	0	10	20	7

Source: NCDMF 2000b, 2001; Cape Lookout Internet Services 2001; CarolinaSaltwaterFishing.com 2001; Carteret County News-Times 2001; Fishing Works 2001; NCCOAST 2001; Sport Fishing Report 2001; This Week Magazine 2001; Fishvb.com 2002; Pamlico-NC.com 2002a; and Swansboro Parks and Recreation Board 2002

practical distances to travel inshore waters. The maximum distance typically traveled by offshore tournament participants is 75 NM from the tournament host site. The sites fished by anglers within the tournament zones are still dependent on several factors including the species targeted, tournament rules, or weather. Among the different tournaments, the level of participation varies between individual events, seasons, and years. Although most tournaments are annual events, the list of scheduled tournaments is not static. Existing tournaments may be cancelled due to a lack of participation or support or new tournaments may be organized. The exact dates and weigh-in locations of annual tournaments will vary slightly year to year.

4.2 COMMERCIAL SHIPPING

The oceans and waterways of the east coast carry a large amount of commercial shipping traffic. Commercial and industrial centers of the eastern U.S. exchange goods and materials between themselves and other major ports of the U.S. and the world. Commercial shipping transports everything from raw materials to commercial products, food, and garbage. Oceanic routes include those that head for other continents and those that run to other coastal U.S. port cities. Commercial shipping in inshore waters (i.e., those waters of the bays, estuaries, rivers, canals, and sounds) is restricted by practical navigational matters such as vessel drafts, turning ability of long vessels, clearance under cross-waterway obstructions (e.g., bridges and wires), and the vessel's beam (width) in relation to the width of the waterway. Waterway traffic, the sharing of waterway resources, is also an important consideration of inshore waterways where space is limited in contrast to the vast maneuvering spaces on the high seas.

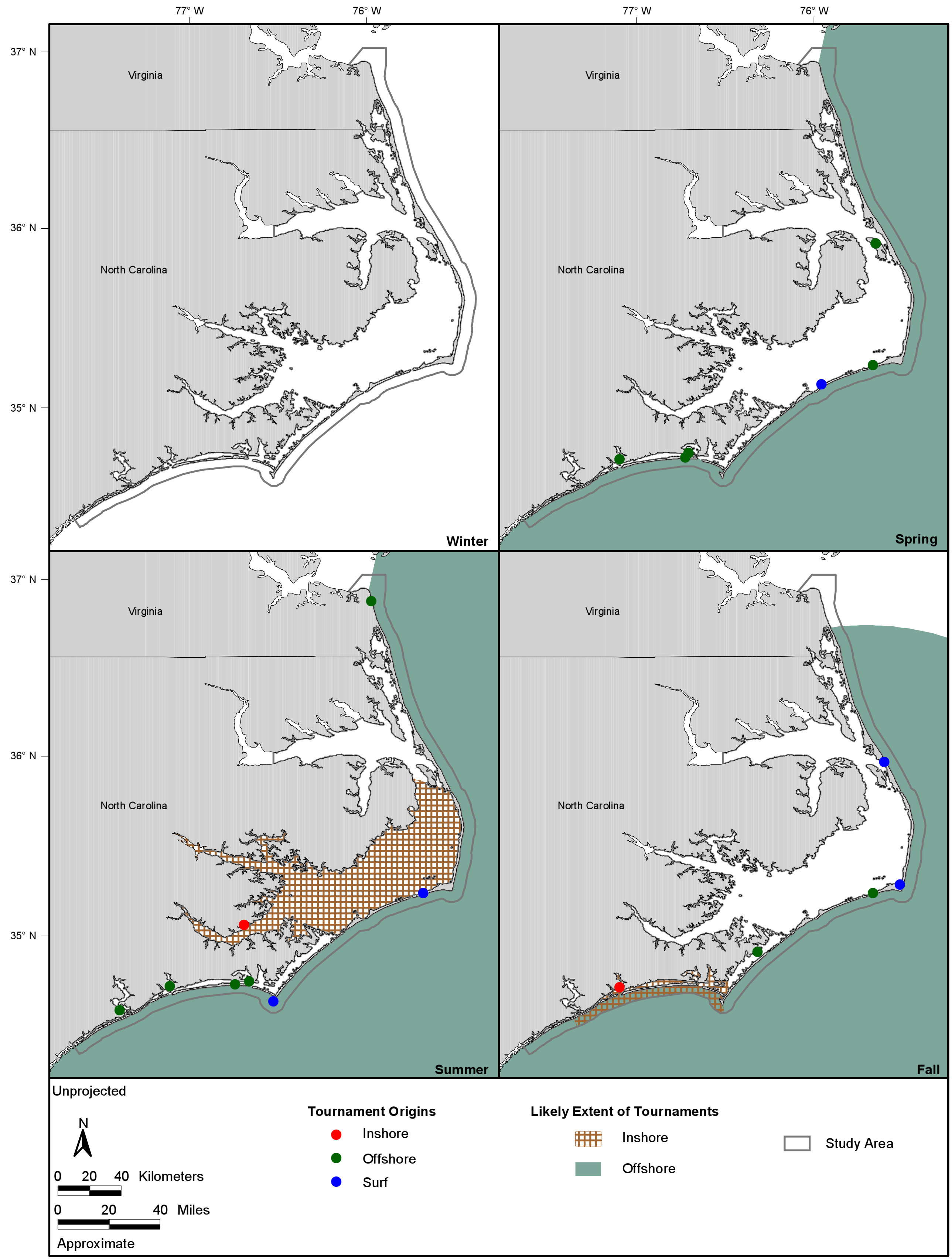

Figure 4-11. General coverage of fishing tournaments occurring in the Cherry Point and southern VACAPES inshore and estuarine areas by season. Source information: NCDMF (2000b, 2001), Cape Lookout Internet Services (2001), CarolinaSaltwaterFishing.com (2001), Carteret County News-Times (2001), Fishing Works (2001), NCCOAST (2001), Sport Fishing Report (2001), This Week Magazine (2001), Fishvb.com (2002), Pamlico-NC.com (2002a), and Swansboro Parks & Recreation Board (2002).

Table 4-4. List of fishing tournaments held in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity (2000 and 2002).

Event Date	Weigh-In Location	Type*	Event
Winter	None		
Spring			
May 3-5	Ocracoke	*S*	Ocracoke Invitational Surf Fishing Tournament
May 9-11	Hatteras	*O*	Hatteras Village Offshore Open
May 25-26	Swansboro	*O*	Swansboro Rotary Memorial Day Blue Water Fishing Tournament
May 25-26	Manteo	*O*	Pirates Cove Memorial Weekend Tournament
June 3	Atlantic Beach	*O*	Cape Lookout Tournament Series
June 3-4	Morehead City	*O*	E.J.W. Cobia Tournament
June 8-9	Manteo	*O*	Pirates Cove Annual Cobia Tournament
June 10-16	Morehead City	*O*	Big Rock Blue Marlin Tournament
June 18-23	Hatteras	*O*	Hatteras Annual Invitational Blue Marlin Tournament
June 22-24	Atlantic Beach	*O*	Annual Raleigh Saltwater Sportfishing Club
Summer			
July 6-7	Manteo	*O*	Pirates Cove 4th of July Offshore Tournament
July 6-10	Virginia Beach	*O*	Virginia Beach Red, White, & Blue Tournament
July 12-14	Atlantic Beach	*O*	Cap'n Fannies Billfish Tournament
July 15-16	Beaufort	*O*	Carteret County Sportfishing Association Ladies King Mackerel Tournament
July 21-22	Beaufort	*O*	Carteret County Sportfishing Association King Mackerel Tournament
July 27-28	Oriental	*I*	Annual Oriental Rotary Tarpon Tournament
July 29	Atlantic Beach	*O*	Cape Lookout Tournament Series
August 3-4	Atlantic Beach	*O*	Annual Ducks Unlimited Billfish Tag and Release Tournament
August 10-11	Manteo	*O*	Annual Alice Kelly Memorial Ladies Only Billfish Tournament
August 10-12	Sneads Ferry	*O*	Annual Sneads Ferry King Mackerel Tournament
August 13-17	Manteo	*O*	Pirates Cove Annual Billfish Tournament
August 25	Atlantic Beach	*O*	Cape Lookout Tournament Series
August 31	Manteo	*O*	Annual Allison White Marlin Release Tournament
September 6-7	Atlantic Beach	*O*	Atlantic Beach King Mackerel Tournament
September 7-8	Atlantic Beach	*O*	Annual Hardee's Atlantic Beach King Mackerel Tournament
September 13-14	Hatteras	*S*	Hatteras Village Surf Fishing Tournament
September 14-16	Beaufort	*O*	Morehead City King Fish Classic
September 23	Atlantic Beach	*O*	Cape Lookout Tournament Series
September 26-28	Cape Lookout	*S*	Annual Davis Island Fishing Foundation Club Tournament
September 29-30	Swansboro**	*O*	Annual Onslow Bay Open King Mackerel Tournament
Fall			
October 10-12	Nags Head	*S*	Nags Head Surf Fishing Club Invitational Tournament
October 12-14	Atlantic	*O*	Drum Inlet King Mackerel Tournament
October 13-14	Hatteras	*O*	Outer Banks King Mackerel Festival
October 26	Morehead City	*O*	Coral Bay Open
November 1-3	Buxton	*S*	Cape Hatteras Anglers Club Surf Fishing Tournament
November 2-3	Hatteras	*O*	Teach's Lair Marina Shootout
November 9	Swansboro	*I*	Friendly City by the Sea Annual Speckled Trout Tournament
Year-round			
	Official NC Weigh Stations	*O,I,S*	NC Saltwater Fishing Tournament
	Official VA Weigh Stations	*O,I,S*	VA Saltwater Fishing Tournament

Table 4-4. Continued.

* Tournament types: O = Offshore; I = Inshore; S = Surf
** Onslow Bay Open King Mackerel Tournament weigh in locations include Carolina Beach, Masonboro, New River, Bogue, Beaufort, and Bardens

Sources: NCDMF 2000b, 2001; Cape Lookout Internet Services 2001; CarolinaSaltwaterFishing.com 2001; Carteret County News-Times 2001; Fishing Works 2001; NCCOAST 2001; Sport Fishing Report 2001; This Week Magazine 2001; Fishvb.com 2002; Pamlico-NC 2002a; and Swansboro Parks and Recreation Board 2002

The entrances of most highly traveled waterways, such as at the mouths of the Chesapeake Bay and Delaware Bay, are controlled by systems called a traffic separation scheme, which aids in reducing navigation collisions and conflicts. Harbor pilots familiar with the characteristics of a particular waterway traditionally navigate commercial vessels entering deepwater ports and harbors.

Among its various other responsibilities, the U.S. Coast Guard is responsible for the safety of shipping traffic in the nation's coastal and inshore waterways. The U.S. Coast Guard garrisons several stations near the study area. A number of stations are located on the Outer Banks, near Ocracoke Inlet, at Cape Hatteras near the Cape Hatteras Light House, and near Oregon Inlet (NOS 2001). On the mainland, there are stations located near Hobucken in Beaufort County, near Beaufort Inlet, and near the White Oak River at Bogue Inlet. One U.S. Coast Guard air station is located at Elizabeth City (NOS 2001). The U.S. Coast Guard's 5th District headquarters is located in Portsmouth, VA and a Coast Guard station is located between Norfolk and Cape Henry at the entrance to the Little Creek Channel (USCG 2001).

The Intracoastal Waterway (ICW) was created and is maintained by the U.S. Army Corps of Engineers. The Atlantic coast portion of the ICW extends from Norfolk, VA to Miami, FL and allows vessels with a 2 m draft or less and a clearance height of less than 20 m to travel the entire way without having to enter offshore waters. The ICW also extends along the Gulf coast from Brownsville, TX at the Mexico border to Carabelle, FL. For much of its length, the ICW is composed of dredged channels running through pre-existing water bodies such as bays, sounds, and estuaries, but in places where necessary, the waterway is cut through low-lying land areas as a canal. The ICW requires periodic maintenance involving dredgers. The activity of dredging and the creation of dredge spoil along with the unnatural connections made among coastal water bodies can have negative impacts on local environments and habitats. The most common commercial traffic using the ICW are barges moving raw materials between coastal cities and processing plants. The ICW is also highly utilized by recreational boaters and is used by recreational and commercial fishermen.

In the study area and vicinity, there are three major deepwater ports (Figure 4-12). Two of these are in the Chesapeake Bay system of Virginia: Norfolk and Newport News. The other deepwater port is located in Morehead City, NC (North Carolina Ports 2002; Virginia Port Authority 2002). The two Virginia port cities are part of the Virginia Port Authority and contain three commercial terminals: the Newport News Terminal, the Portsmouth Marine Terminal, and the Norfolk International Terminal (Virginia Port Authority 2002). Ships entering the mouth of the Chesapeake Bay system also dock further north in Baltimore (Maryland Port Administration 2002). The port in Morehead City is located along the Newport River and Bogue Sound. Commercial traffic in the Chesapeake Bay region also includes the traffic from several commercial cruise lines stopping in or leaving from terminals in Norfolk and Baltimore (NGS 2001).

The commercial terminals in the Chesapeake Bay area had over 4,100 visits by commercial cargo ships in 2000 (2,500 in the Norfolk area and 1,600 headed to Baltimore). The terminals of the Virginia Port Authority were ranked 10th in the nation, and the port of Baltimore was ranked 18th based on commercial tonnage transported in the year 2000. With a much smaller volume of traffic and cargo, the port system in Morehead City, NC was ranked 43rd in the nation (MARAD 2002).

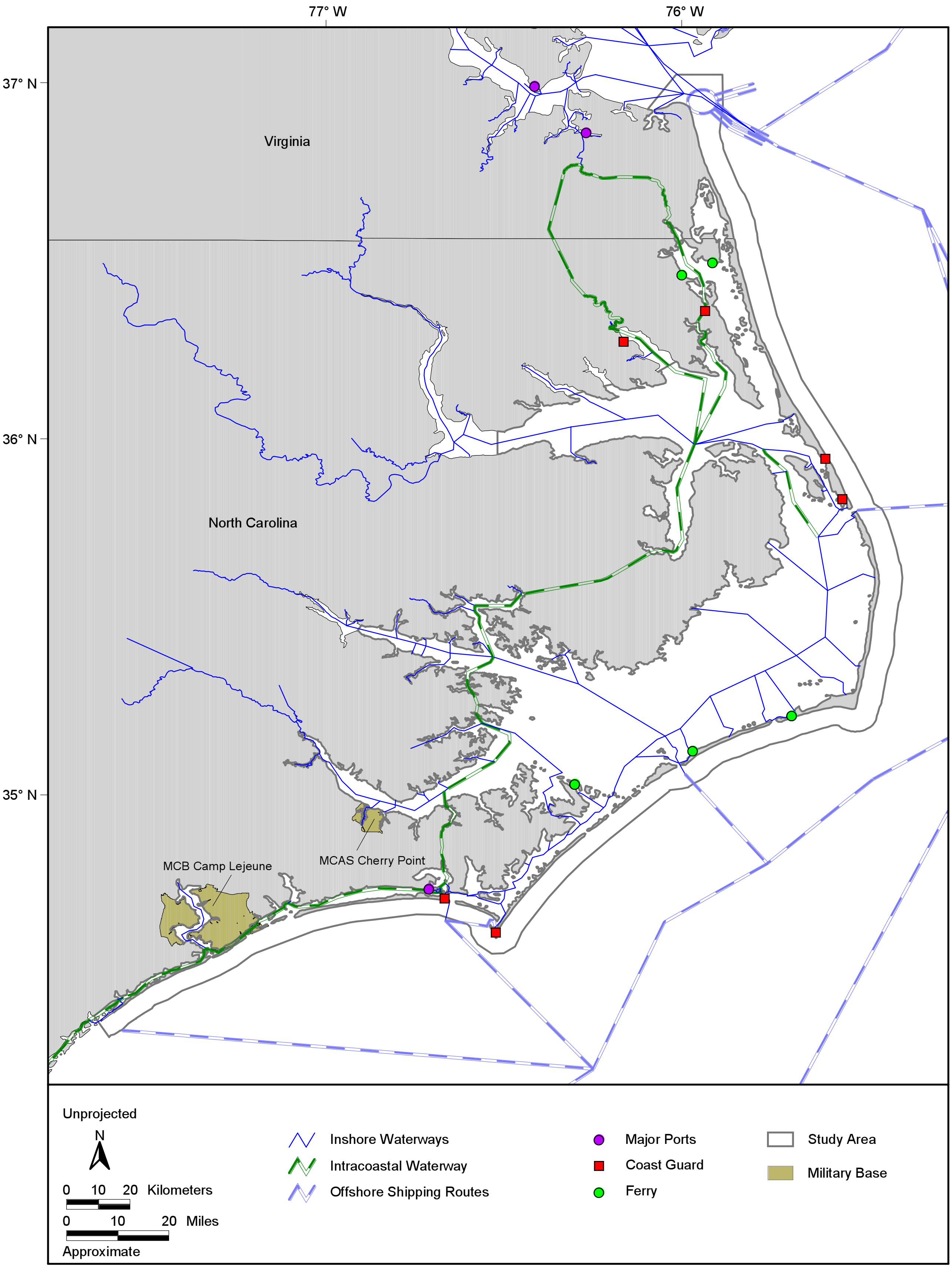

Figure 4-12. Commercial shipping elements in the Cherry Point and southern VACAPES inshore and estuarine areas, including major ports, Coast Guard stations, ferries, and shipping waterways. Source data: NCDCM (1999), NOS (2001), and GDT and ESRI (2002). Map adapted from: NOAA (1998).

A network of nearshore and inshore waterways crisscrosses the entire study area. Most of these additional waterways are generally smaller, shallower harbor channels and thoroughfares. These waterways are usually marked with a channel marker system involving buoys and posts and are generally used by recreational boaters, commercial fishing vessels, and small work vessels (e.g., tugboats, dredgers, etc.). These estuarine channels connect the various inlets and towns of the Outer Banks with the populated places on the mainland. A system of channels also runs the length of most of the sounds and estuaries except for Currituck Sound, which is an extremely shallow body of water throughout its length.

A number of ferries cross the waters of the study area. Major toll ferry routes run from Swan Quarter and Cedar Island on the mainland to Ocracoke on the Outer Banks. Free ferries run shorter distances from the mainland to the Outer Banks in various places, such as from Currituck to Knots Island and from Atlantic and Davis to the Core Banks. One ferry runs from Harkers Island to Cape Lookout. One short ferry crosses Hatteras Inlet from Hatteras to Ocracoke Island and several ferries run across the upper portions of the Neuse and Pamlico rivers (NOS 2001; NCWaterways.com 2002).

4.3 RECREATIONAL BOATING

Recreational watersports and boating are major industries and pastimes in the U.S. North Carolina and Virginia have a relatively high level of activity due to the prominence of the coastal water bodies in the area. North Carolina ranks eleventh among the states with the most registered boaters (Sarasota boating.com 2001). Traditionally, waterborne recreational activities, other than fishing, were reserved for a small segment of the population. Sailing and yachting were the primary modes of recreational activity, while canoeing was somewhat restricted in its scope of use. Currently, a much wider variety of waterborne activities is available, and these activities have larger stakes in the economies of coastal areas. Aside from the traditional sailing vessels and motor crafts, watersports and boating involve scenic canoeing trails, jet skis, water skiing, wind surfing, and ocean and traditional kayaking. In addition to the wider variety of watersport choices, an increasing segment of the population currently partakes in water activities (Insider's Guide 2002b).

Marinas and boat ramps are common throughout the study area (Figure 4-13; NCDEH 1998; NOS 2001). Many local businesses rent and sell equipment, and coastal resorts make watersports available to guests. Local, state, and federal parks and reserves are popular places for watersport activities. Chartered and scheduled boat tours of the natural and cultural heritage around the study area are available in many coastal towns. Surfing has been popular along portions of the North Carolina coast for many years. A number of surf shops cater to surfers in the Outer Banks and south of Cape Lookout. Scuba diving and swimming are popular activities on the Atlantic Ocean side of the study area. Many beach access sites from Cape Henry to Cape Fear allow people to participate in watersports along the Atlantic Coast, yet the more remote areas of the Outer Banks may experience less activity than the shorelines from Cape Henry to Virginia Beach and the shoreline south of Cape Lookout (NOS 2001).

The seasonal level of watersports and boating activity that occurs in the study area is directly related to temperature and personal free time. Throughout the year, weekends experience more activity than weekdays, and holidays such as Memorial Day, the Fourth of July, and Labor Day are traditionally very active times. Spring, summer, and early fall are the primary seasons for waterborne activities, with peaks occurring in late spring and summer. Sailing often occurs year-round. Large-scale sailing regattas are usually annual events, while local sail club sailing events and races take place periodically throughout the year, except in the worst weather months of January and December (Pamlico-NC 2002b).

While the intent of the IWC was to provide safe inland passages between the industrial ports of the coast, recreational boaters commonly traverse it to and from local destinations as well as on long distance trips along the coast. Recreational boaters often use other navigation channels within and between the rivers, sounds, and ocean near the study area. Many of the smaller channels are used mainly by recreational vessels due to their size and shallowness; however, many recreational vessels use commercial channels and canals when navigating (NCWaterways.com 2002).

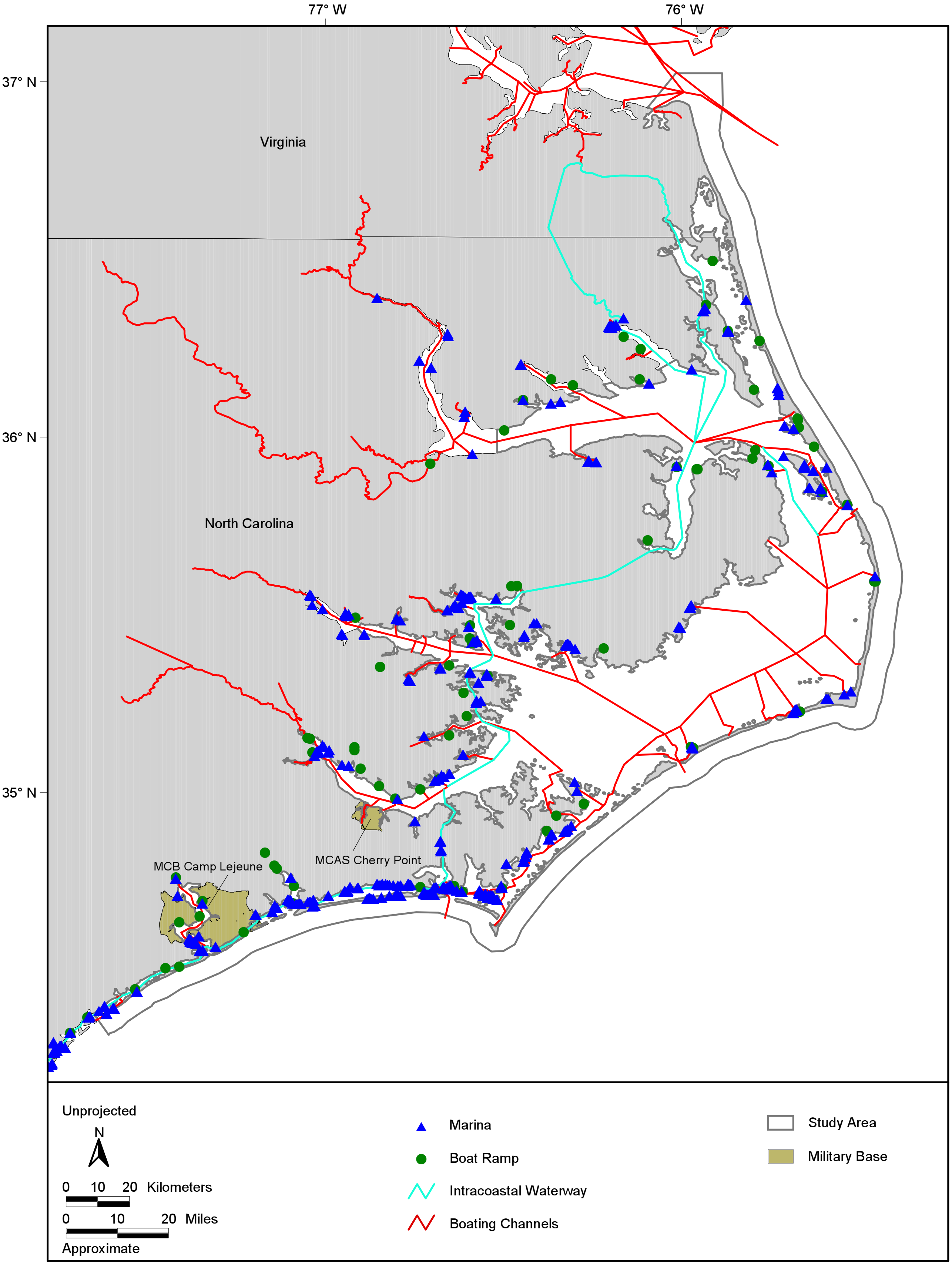

Figure 4-13. Features important to recreational boating in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NCDEH (1998), NCDCM (1999), and NOS (2001).

4.4 SCUBA DIVING

Scuba diving and snorkeling are popular recreational activities along the entire U.S. coastline but especially off North Carolina where the preponderance of shipwrecks and proximity to warm Gulf Stream water provide ideal diving locations. Although diving occurs year-round, it varies in intensity with season (i.e., there are more diving trips in summer than in winter). There are 47 diving hot spots frequented by divers near the offshore waters of the study area (Figure 4-14). Roughly 16 of these are located within the coastal waters of the study area. All the dive sites off North Carolina, however, are generally accessed primarily from boats that leave from local marinas. The region just off Cape Hatteras at Diamond Shoals contains a concentration of shipwrecks that attract divers for sport, research, and adventure. A considerable number of wrecks are located just offshore along the length of Bodie Island, NC. Another concentration of dive sites is located just off Cape Fear (Regan and Worthington 1979; BFDC 2000).

No popular recreational diving spots are located in the waters of the North Carolina sounds. The inshore waters are generally too murky with low visibility to attract large numbers of individuals to dive in these waters. Nearly 60 dive shops are located throughout North Carolina. In the study area, there are roughly 25 charter dive boat operations. Many charter boats leave from the Atlantic Beach-Beaufort-Morehead City area and from Outer Bank towns such as Hatteras. Many of the charter boats also offer recreational fishing trips (BFDC 2002).

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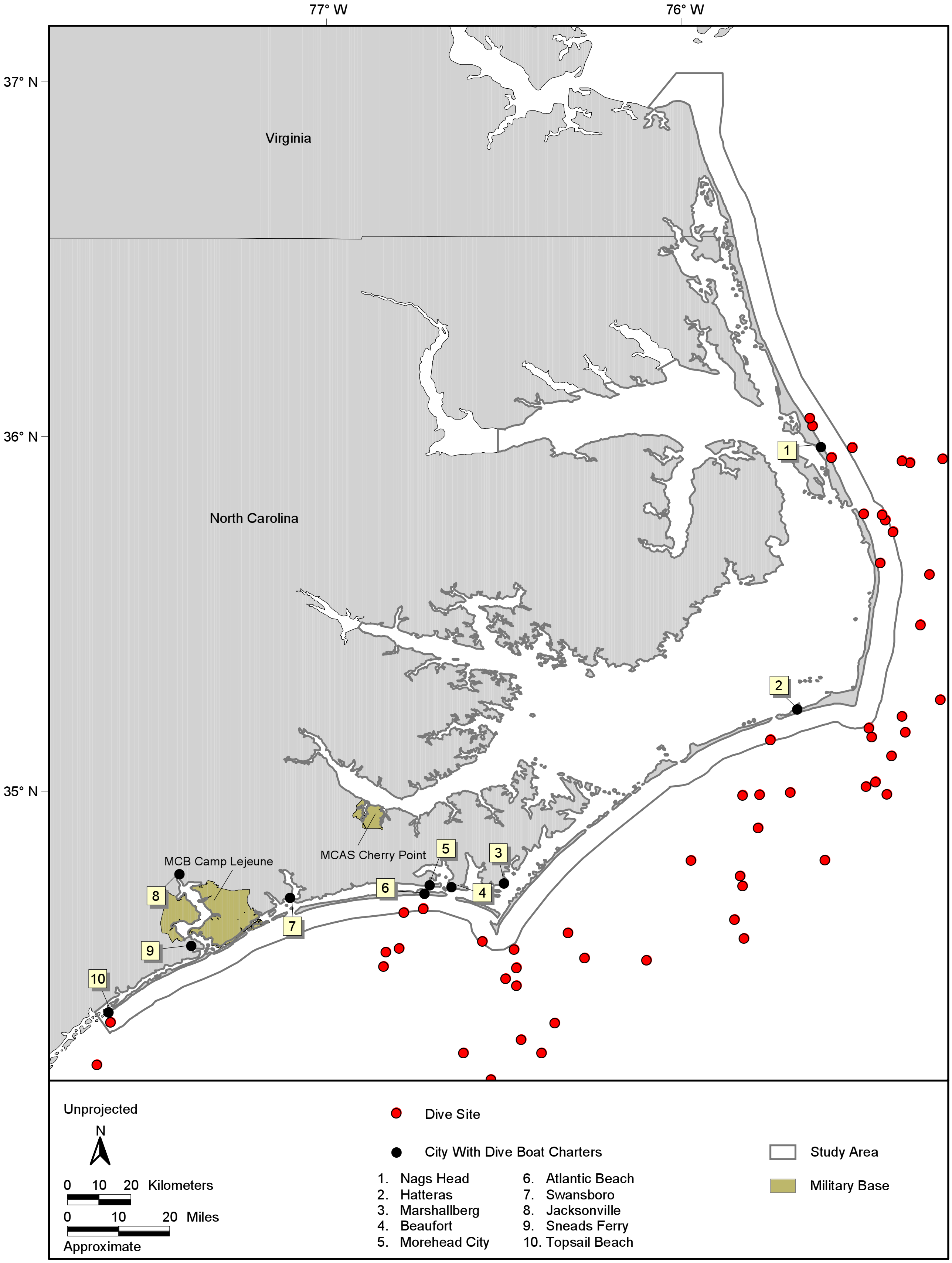

Figure 4-14. Locations of popular scuba diving sites and charter dive boat cities in the Cherry Point and southern VACAPES inshore and estuarine areas. Source map (scanned): BFDC (2000). Source information: BFDC (2000).

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5.0 MARINE PROTECTED AREAS

A marine protected area (MPA), as defined in Executive Order 13158, is "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 Executive Order 13158 stipulates, "Each Federal agency whose actions affect the natural or cultural resources that are protected by an MPA shall identify such actions. To the extent permitted by law and to the maximum extent practicable, each Federal agency, in taking such actions, shall avoid harm to the natural and cultural resources that are protected by an MPA." Executive Order 13158 also calls for the preparation of annual reports by federal agencies describing the actions they have taken over the previous year to implement the order. There are several established MPAs located in the Cherry Point and southern VACAPES inshore and estuarine areas (herein referred to as the study area) and vicinity (Figure 5-1).

MPAs are a collection of marine resource spaces that conserve and protect biological integrity and habitat diversity as well as the social or cultural value of a specific portion of the marine environment (NRC 2000). MPAs are considered an effective conservation tool for sustaining ocean ecosystems (Agardy 1999; NRC 2000). Many areas of U.S. marine waters receive some level of management protection. These marine managed areas have to meet certain criteria to be designated as an MPA. There are currently 251 federal sites that are designated as MPAs including: national marine sanctuaries, national seashores, national parks and monuments, federal fisheries management zones, federal threatened/ endangered critical habitat, federal threatened/endangered species protected areas, national wildlife refuges, national estuarine research reserves, and ecological preserves (NOAA 2002a). There are also numerous state designated MPAs in U.S. waters, such as threatened/endangered species sanctuaries, state parks, state reserves, and state recreation areas. A good summary of the legislation regarding MPA designation may be found in Zinn and Buck's (2001) review while the official federal website (http://www.mpa.gov) provides more information on U.S. MPAs, including the criteria used for site designation.

5.1 NATIONAL MARINE SANCTUARIES

There are currently 12 designated national marine sanctuaries (NMSs) in U.S. waters and one proposed site in the Great Lakes, creating a system that protects over 36,260 km^2 of ocean habitat. While no NMS lies within the study area, the Monitor NMS is located 16 NM southeast of Cape Hatteras, NC (Figure 5-1). Established as the first NMS in 1975 (NOAA 2001), this sanctuary contains the wreck of the USS *Monitor,* a Civil War ship that sank in 1862 (NPR 1997).

5.2 NATIONAL SEASHORES

The National Park Service (NPS) protects and manages 10 national seashores in the U.S. There are two national seashores in the study area. Both Cape Lookout National Seashore (NS) and Cape Hatteras NS serve as important nesting areas for loggerhead and green sea turtles, gulls, terns, and the threatened piping plover. Cape Lookout NS is a 90 km long section of the Outer Banks of North Carolina that extends from Ocracoke Inlet to the northeast to Beaufort Inlet to the southwest (NPS 2002a). North Core Banks, South Core Banks, and Shackleford Banks make up this NS. Cape Hatteras NS is a stretch of over 113 km of barrier islands, encompassing much of the Outer Banks northward of Ocracoke Inlet. Well-known lighthouses line the coast of the NS, warding off ships from the area termed the “graveyard of the Atlantic” (NPS 2002b). These barrier islands provide valuable wintering area for migrating waterfowl (NPS 2002b).

5.3 NATIONAL PARKS AND MONUMENTS

The National Park System of the U.S. is composed of 384 areas covering more than 33 million hectares (ha) in 49 states, the District of Columbia, American Samoa, Guam, Puerto Rico, Saipan, and the U.S. Virgin Islands (NPS 2000). National parks are generally large natural places having a wide variety of attributes, including significant historic assets (NPS 2000). The Antiquities Act of 1906 authorizes the President of the U.S. to publicly proclaim a landmark, structure, or other object of historic or scientific

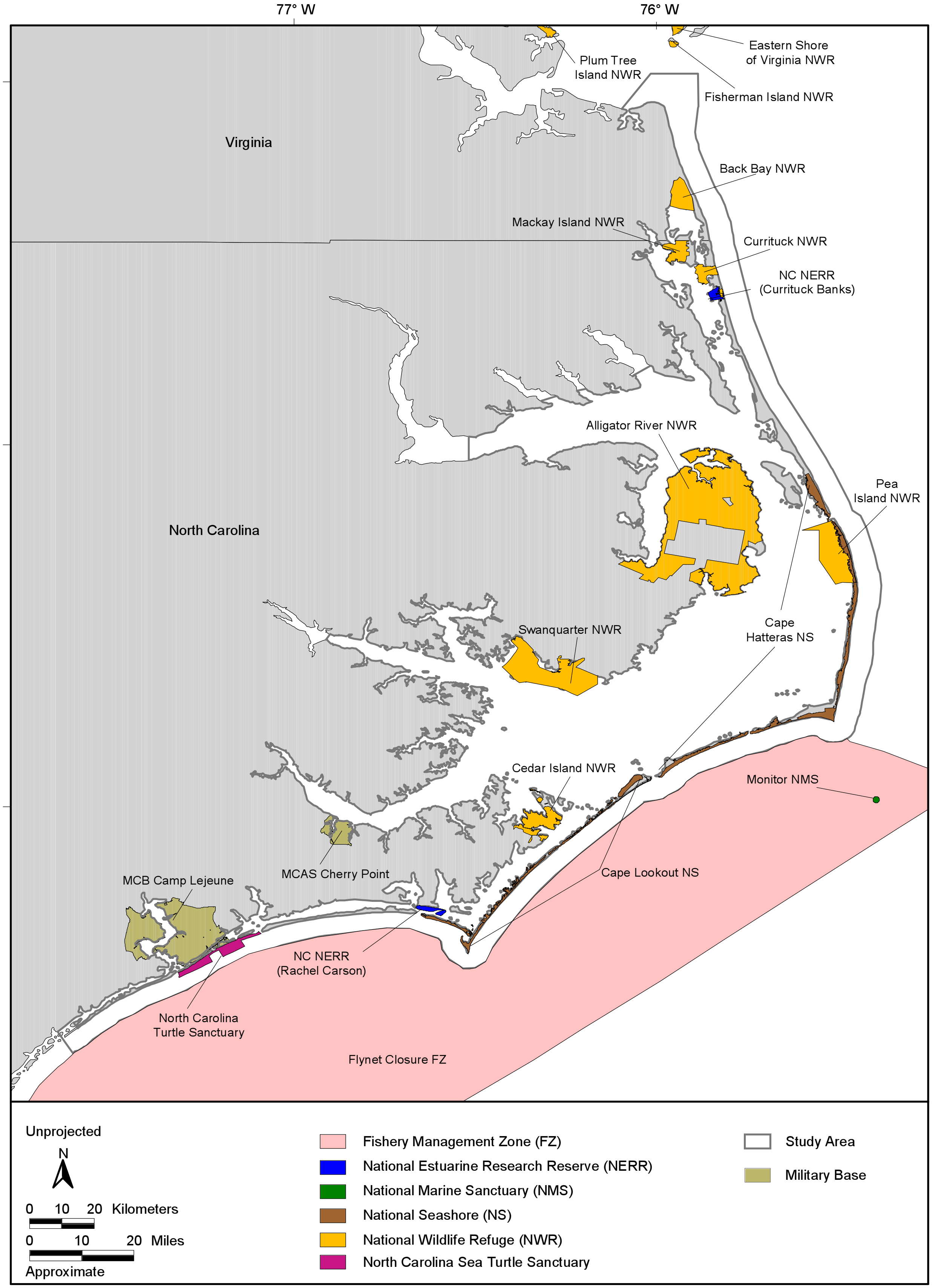

Figure 5-1. Marine protected areas (MPAs) in the Cherry Point and southern VACAPES inshore and estuarine areas. Source data: NOAA (1998) and NOS (2001). Source maps (scanned): NOAA (2002c). Map adapted from: Schwartz (1989).

interest as a national monument if it is situated on lands owned or controlled by the federal government (NPS 2000). There are no national parks or monuments in the study area.

5.4 PROTECTED HABITAT AREAS: CRITICAL HABITATS, PROTECTED AREAS, AND FISHERY MANAGEMENT ZONES

The NMFS' responsibilities include rebuilding and maintaining sustainable fisheries, promoting the recovery of protected species, and protecting and maintaining the health of coastal marine habitats. To satisfy these responsibilities, the NMFS uses protected areas as one of several tools to conserve and manage marine resources. The NMFS' MPA sites fall under three major categories: threatened/ endangered species critical habitat areas, threatened/endangered species protected areas, and federal fishery management zones. Although there are no critical habitat areas listed as federal MPAs in the vicinity of the study area, there is one threatened/endangered species protected area and one federal fishery management zone.

The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Both the physical or biological features essential to the conservation of a threatened or endangered species are included in the habitat designation. Designation of critical habitat affects only federal agency actions and federally funded or permitted activities. There is critical habitat designated for the piping plover in the study area (see Section 3.4.2 for more information). The federal government, however, currently does not classify these particular critical habitats as MPAs (Brownlee 2003).

Threatened/endangered species protected areas are similar to critical habitat areas, although in these types of MPAs activities such as fishing and recreation are not as restricted. The lone threatened/ endangered species protected area in the study area and vicinity is the federally designated Leatherback Conservation Zone. On 14 September 1995, the NMFS designated this area to include all inshore and offshore waters of the North Atlantic Ocean between Cape Canaveral, FL (28°24.6'N) and the North Carolina/Virginia border (36°30.5'N) (i.e., nearly the entire view of Figure 5-1 and hence not shown on the map). The NMFS' ruling provided for short-term (two week) closures of areas in the conservation zone when high abundance levels of leatherback turtles are documented. If aerial surveys demonstrate a continued presence of large concentrations of leatherbacks in specific areas, the NMFS will prohibit shrimping in those areas by trawlers that do not have turtle excluder devices large enough to exclude leatherbacks. The creation of this conservation zone was deemed by the NMFS as a necessary step in the attempts to reduce leatherback turtle mortality associated with incidental capture in shrimp trawls off the coasts of North Carolina, South Carolina, Georgia, and northeast Florida (NMFS 1995).

Fishery management zones (FZ) are areas that are closed, at least partially, to fishing activity. The NMFS has the jurisdiction to restrict or even prohibit the use of one or more fishing gear types in some areas in order to protect habitats, fishery stocks, or species assemblages and/or to promote the recovery of threatened or endangered species, such as marine mammals, sea turtles, or fishes. Most of these area closures are temporary; however, in some locations, they might be year-round for one or more years. For a fishing area closure to be considered an MPA, it must prohibit one or more fishing activities year-round and the closure must be intended to be permanent (NOAA 2002b). There is only one federal FZ near the study area that is also designated by the U.S. government as an MPA. The Flynet Closure area has been closed to flynet fishing since the area was established in 1997 under authority of the Atlantic Coastal Fisheries Cooperative Management Act. The closure area is from Cape Hatteras, NC to the North Carolina/South Carolina state line, from 3 NM to approximately 40 NM from shore (Figure 5-1).

5.5 NATIONAL WILDLIFE REFUGES

The USFWS protects more marine habitat area than any other federal agency through its National Wildlife Refuge System (NWRS). Nationwide, the NWRS contains terrestrial, aquatic, and marine habitats, with 538 established national wildlife refuges (NWRs) in total. All units of the NWRS, and the species and habitats they contain, are governed by the regulations found in CFR, Title 50. Approximately 140 to 150 NWRs contain marine and estuarine habitats. NWRs provide habitat for countless shorebirds as well as the endangered West Indian manatee and several species of sea turtles. Ten NWRs are found in the study area and its vicinity (Figure 5-1).

The Eastern Shore of Virginia NWR and the nearby Fisherman Island NWR are located at the southern tip of the Delmarva Peninsula. This area is one of the most important avian migration funnels in North America, acting as a critical stopover point for birds (and butterflies) (USFWS 2002a). Fisherman Island NWR was established to protect critical habitats for coastal species such as royal terns and brown pelicans. Thousands of bird species depend on the island as a resting and feeding stop along their migration route.

Back Bay NWR, located in the southeastern corner of Virginia, was established to provide habitat for migrating and wintering waterfowl, particularly greater snow geese. Nearly 300 species of birds have been observed at Back Bay NWR (USFWS 2002b). This refuge also provides habitat for loggerhead sea turtles. The refuge contains 3,130 ha situated on and around a thin strip of coastline. Habitats include beach, dunes, woodland, and marsh. The majority of Back Bay NWR's marshlands are on islands contained within the waters of Back Bay. Back Bay NWR administers Plum Tree Island NWR at Poquoson Flats in Chesapeake Bay.

Alligator River NWR was established to preserve and protect a unique wetland habitat type, the pocosin, and its associated wildlife species. A pocosin is a Native American word meaning “swamp on a hill”; these areas are characterized by poorly drained soils high in organic material (USFWS 2002c). This refuge is one of the last remaining strongholds for the black bear along the Atlantic coast and provides protection to a variety of endangered species including the American alligator, red wolf, and red-cockaded woodpecker (USFWS 2002a). Alligator River NWR is bordered on the west by the Alligator River, on the north by Albemarle Sound, and on the east by Croatan and Pamlico Sounds. Pea Island NWR, adjacent to Cape Hatteras NS, is administered by Alligator River NWR (USFWS 2002d). There are more than 265 species of birds, 25 species of mammals, and five species of amphibians recorded at Pea Island NWR (USFWS 2002d).

Mackay Island NWR is located in the extreme northeast corner of North Carolina; some portions of the refuge extend into Virginia. The habitat of Mackay Island NWR ranges from freshwater and brackish marsh to upland and lowland eastern pine hardwood forest (USFWS 2002e). Currituck NWR is one of the newest refuges in North Carolina and is located on North Carolina's Outer Banks, north of Corolla. The refuge contains two separate tracts of land totaling over 2,249 ha. This NWR is managed as a satellite of Mackay Island NWR. Currituck NWR provides a winter habitat to a variety of waterfowl. Piping plovers and loggerhead sea turtles occasionally nest on the refuge.

Cedar Island NWR is 64 km northeast of Beaufort, NC along the confluence of Pamlico and Core Sounds. The refuge's main feature is an extensive, relatively undisturbed marsh (USFWS 2002f). It provides habitat and protection for migratory waterfowl and protected species, such as the American alligator. Swanquarter NWR is located on the north shore of Pamlico Sound and supports one of the northernmost populations of the American alligator (USFWS 2002g). Both Cedar Island NWR and Swanquarter NWR are administered by Mattamuskeet NWR, which is further inshore of the study area, 14.5 km east of Swan Quarter, NC (USFWS 2002f, 2002g).

5.6 NATIONAL ESTUARINE RESEARCH RESERVES

The National Estuarine Research Reserve System (NERRS) is a network of 25 reserves, encompassing more than 404,858 ha of relatively pristine estuarine areas that contain key habitat as well as a variety of rare, endangered, and threatened species (NERRS 2001a). In 1972, the Coastal Zone Management Act created National Estuarine Research Reserves (NERRs) to protect these estuarine areas from significant ecological change or developmental impacts (NERRS 2001a). The reserves also provide reference sites for research, monitoring, and educational programs that focus on functional estuarine ecosystems.

The North Carolina NERR is comprised of four sites located near Corolla (Currituck Banks), Beaufort (Rachel Carson), and Wilmington (Masonboro Island and Zeke's Island), NC (NCNERR 2002). Currituck

Banks site is a good example of an undisturbed barrier island and low-salinity estuarine system. The Rachel Carson component is composed of several estuarine islands and a large salt marsh area situated between the mouths of the Newport and North Rivers (NERRS 2001b). Educational and research programs within the Rachel Carson reserve are organized by individuals affiliated with the Duke University Marine Laboratory. Both Masonboro Island and Zeke's Island are located south of the study area.

5.7 STATE DESIGNATED MARINE PROTECTED AREAS—NORTH CAROLINA SEA TURTLE SANCTUARY

Although it is not a federally designated MPA, North Carolina's sea turtle sanctuary (described in Section 3.3.2.1) is an important threatened/endangered species protected area located within the study area. It is significant as the only state designated sea turtle sanctuary of its kind in the entire U.S. (Godfrey 2003). Located along Onslow and Hammocks beaches, from New River Inlet to Bogue Inlet, this sanctuary was established by North Carolina Fishery Laws in 1980 to protect adult sea turtles from incidental capture in shrimp trawls during the nesting season (Schwartz 1989). Under North Carolina Code 15A NCAC 3R.0107 "it is unlawful to use any commercial fishing equipment in the sea turtle sanctuary from June 1 through August 31" unless permitted by the Fisheries Director who "may, by proclamation, modify the sanctuary within the described area and vary implementation between specified dates" depending upon the existing environmental conditions.

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6.0 RECOMMENDATIONS

While conducting the MRA for the Cherry Point and southern Virginia Capes (VACAPES) inshore and estuarine areas, several data gaps became evident. More detailed information on the population biology, ecology, and behavior of cetaceans and sea turtles is needed. Through an improved understanding of the spatial and temporal occurrence of protected and managed marine resources, any potential conflicts in usage of the area by these resources and the Navy can be assessed. Adjustments to ongoing naval operations may then be considered in order to avoid or minimize any potential impacts to these marine resources. Compiled information also serves as the groundwork for potential future environmental documentation and ensures compliance with federal laws and statutes. By being proactive in supporting suggested research initiatives, the Navy can provide leadership in acquiring the information that will help further its goal of responsible environmental stewardship.

The following are recommendations for research efforts in this operating area and region. All are important and integral to advancing knowledge of marine resources in the area and providing the Navy with the best available information for planning, as well as supporting environmental documents. Understanding that there are funding limitations, the recommendations are prioritized to assist Naval planners. Each is assigned a value of 1, 2, or 3; 1 is the highest priority while 3 is the lowest. The assignment of a priority value is based on usefulness of the recommendation in any decisions regarding deconflicting usage of the area, environmental documentation, and Section 7 consultations. The priority designations are relative to one another and in no way refer to a project's overall value. A priority-3 recommendation is still important but is considered secondary to that of a 1 or 2 rating. The recommendations are roughly ordered below by priority ranking. Although none of the recommendations were subjected to a detailed financial analysis, the relative cost of each recommendation is labeled low, moderate, or high. Low-cost recommendations may be completed at a cost of several hundred to a few thousand dollars. Moderate-cost projects could range from thousands to tens of thousands of dollars, while high-cost research initiatives from tens of thousands to over one hundred thousand dollars. Not all top-priority recommendations are expensive; there is no correlation between price and priority.

The recommendations are grouped into two general categories: those related to the production and evaluation of the marine resource assessment for the study area and others needed to adequately complete environmental documentation of the OPAREA (and foster improved planning and mitigation strategies).

6.1 MARINE RESOURCE ASSESSMENTS

- Update the MRA. As new sources of data and published literature become available, a full revision of the MRA should be made, including text, GIS maps, GIS database, and other informational components. Mitigation strategies should be based on the best available (most recent and most complete) information. Periodic updates will be of moderate cost relative to the initial MRA and should be done every two to four years. Cost: Medium. Priority: 1.

- Peer-review the MRA. To increase the usefulness of the MRA, it is necessary to have the synthesized data peer-reviewed by regulatory agencies (e.g., NMFS, USFWS, state agencies), the scientific community, and potential governmental users (MMS, Marine Corps, Air Force, or Coast Guard). It is recommended that scientists (Table 6-1) from universities and agencies conduct independent reviews to evaluate the approach taken in collection, synthesis, and interpretation of the data; data completeness; and suggestions for improvements. Cost: Low. Priority: 2.

- Obtain marine mammal and sea turtle datasets for the study area not publicly available for inclusion in this assessment. In some cases, data may have to be purchased from researchers or funding provided to assist these researchers with data compilation and quality. Acquisition and analysis of existing data will be less expensive than generating new data (particularly, marine mammal and sea turtle survey data). The potential contribution of these datasets to our understanding of the

Table 6-1. Suggested expert reviewers for the Cherry Point and southern VACAPES inshore and estuarine areas marine resource assessment.

Ms. Sue Barco	Virginia Marine Science Museum
Dr. Robert Hofman	Marine Mammal Commission, Science Program Director (retired)
Dr. Aleta Hohn	National Marine Fisheries Service
Dr. Robert Kenney	University of Rhode Island
Mr. William McLellan	University of North Carolina—Wilmington
Dr. James Mead	Smithsonian Institution
Dr. Andy Read	Duke University
Mr. Keith Rittmaster	North Carolina Maritime Museum
Mr. Mark Swingle	Virginia Marine Science Museum
Mr. Michael Street	North Carolina Department of Environment and Natural Resources
Dr. Jack Musick	Virginia Institute of Marine Science
Dr. Larry Crowder	Duke University
Dr. Molly Lutcavage	New England Aquarium

distribution of these protected species is high, and the acquisition should be a relatively low cost. Cost: Low. Priority: 1.

- NMFS right whale aerial surveys conducted by NMFS and UNCW in 2000, 2001, and 2002; (contacts: Bill McLellan–UNCW or Steve Swartz–NMFS-SEFSC);
- NMFS-SEFSC incidental fisheries bycatch for 2000, 2001, and 2002 (contact: Aleta Hohn–NMFS-SEFSC);
- NMFS MATS (Mid-Atlantic *Tursiops* surveys) 1994 and 1995 aerial survey data; data needed include bottlenose dolphin data for 1994 and 1995 as well as unidentified, green, hawksbill, and Kemp's ridley sea turtle data for 1994 (contacts: bottlenose data–Lance Garrison and sea turtle data–Sheryan Epperly, both of NMFS-SEFSC);
- NMFS MATS (Mid-Atlantic turtle surveys) 2000 through 2002, surveys flown in Virginia and Delaware coastal waters (NMFS-NEFSC–Debra Palka);
- NMFS-SEFSC bottlenose dolphin satellite-tagging data (contact: Aleta Hohn–NMFS-SEFSC);
- NMFS-SEFSC bottlenose dolphin small-boat surveys associated with live captures or biopsy work (contact: Aleta Hohn–NMFS-SEFSC);
- NMFS-SEFSC aerial surveys conducted during 1998 and 1999 to document the distribution of dolphins and fishing gear in nearshore waters (contact: Aleta Hohn–NMFS-SEFSC);
- NMFS-SEFSC sea turtle aerial surveys conducted from 1991 through 1992 in inshore NC waters (contact: Sheryan Epperly–NMFS-SEFSC);

- NMFS-SEFSC comprehensive sighting and stranding data for green, Kemp's, and hawksbill sea turtles (contact: Sheryan Epperly–NMFS-SEFSC);
- Duke University bottlenose dolphin surveys (contact: Andy Read–Duke University);
- North Carolina Maritime Museum (NCMM) bottlenose dolphin surveys (contact: Keith Rittmaster and Vicky Thayer–NCMM);
- Virginia Institute of Marine Science (VIMS) Sea Turtle Research Project aerial surveys and tagging data from 1985 through 1989 (contact: Jack Musick–VIMS);
- Virginia Marine Science Museum (VMSM) bottlenose dolphin surveys (contact: Sue Barco–VMSM);
- Humpback whale sighting and stranding data collected by the VMSM (contact: Sue Barco or Mark Swingle–VMSM); and
- Updated North Atlantic Right Whale Consortium data (contact: Robert Kenney–University of Rhode Island).

6.2 ENVIRONMENTAL DOCUMENTATION

- Continue aerial surveys offshore of the barrier islands. Although the waters off North Carolina and Virginia have been and continue to be surveyed for marine mammals and sea turtles, additional surveys are warranted to fill temporal and spatial gaps in coverage (DoN 2001; DoN 2002). Surveys should be conducted during all seasons. Additional aerial survey effort would optimize sightings of marine mammals and sea turtles. The nearshore waters of the study area form part of the migratory corridor for the northern right whale. The status of the right whale as a critically endangered species, as well as a poor understanding of how right whales use part of the study area during their migration, are key compliance drivers. Aerial surveys are expensive (thousands of dollars per day). Cost: Medium to High. Priority: 1.

- Increase aerial and boat-based survey effort inside of the barrier islands. Relatively few surveys have been conducted in the inshore waters of the study area (Figure 6-1). Better seasonal coverage is needed, especially in winter, spring, and fall. Better geographical coverage is desirable, especially in Albemarle Sound and central Pamlico Sound. Albemarle and Pamlico sounds are extremely important developmental habitats for loggerhead, green, and Kemp's ridley sea turtles, and are also important to bottlenose dolphins. Aerial surveys are expensive. The protected inshore waters allow small boats to be used in surveys; small boats perhaps are more cost-effective than aerial surveys. Cost: Medium to High. Priority: 1.

- Develop seasonal biological surveys of protected species. The Navy owns and/or utilizes significant areas of land and water in coastal North Carolina and Virginia, including bases, target ranges, and warning areas. Given the diversity of protected species in this region, and the dearth of knowledge regarding their distribution, abundance, and ecology, it would greatly benefit Navy planners to have access to better information. Seasonal bio-inventories would help document the presence of protected species. More detailed studies would provide behavioral and ecological data that would enhance our understanding of these species, to the point where informed decisions could be made as to the potential impact of specific Navy activities on these species. Cost: Medium. Priority: 1.

- Utilize satellite-tracking technology to monitor the movements of species of special interest. North Atlantic right whales and humpback whales are endangered and are known to occur in the study area. More information about their seasonal movements is necessary, especially about the offshore component of their seasonal distribution. A satellite-tagging and tracking program in the region during their spring (February through May) and fall (September through November) migrations would provide much needed information. Knowledge of the movements of sea turtles would also be aided by satellite-tracking studies. Given the endangered status of right whales, sea turtles, and other threatened or endangered species, such studies are tremendously important. Satellite-tracking programs are expensive, precluding the study of more than a few individuals. Insights on an individual's behaviors or movements may be gained; questions at the population level may go unanswered. Cost: Medium. Priority: 2.

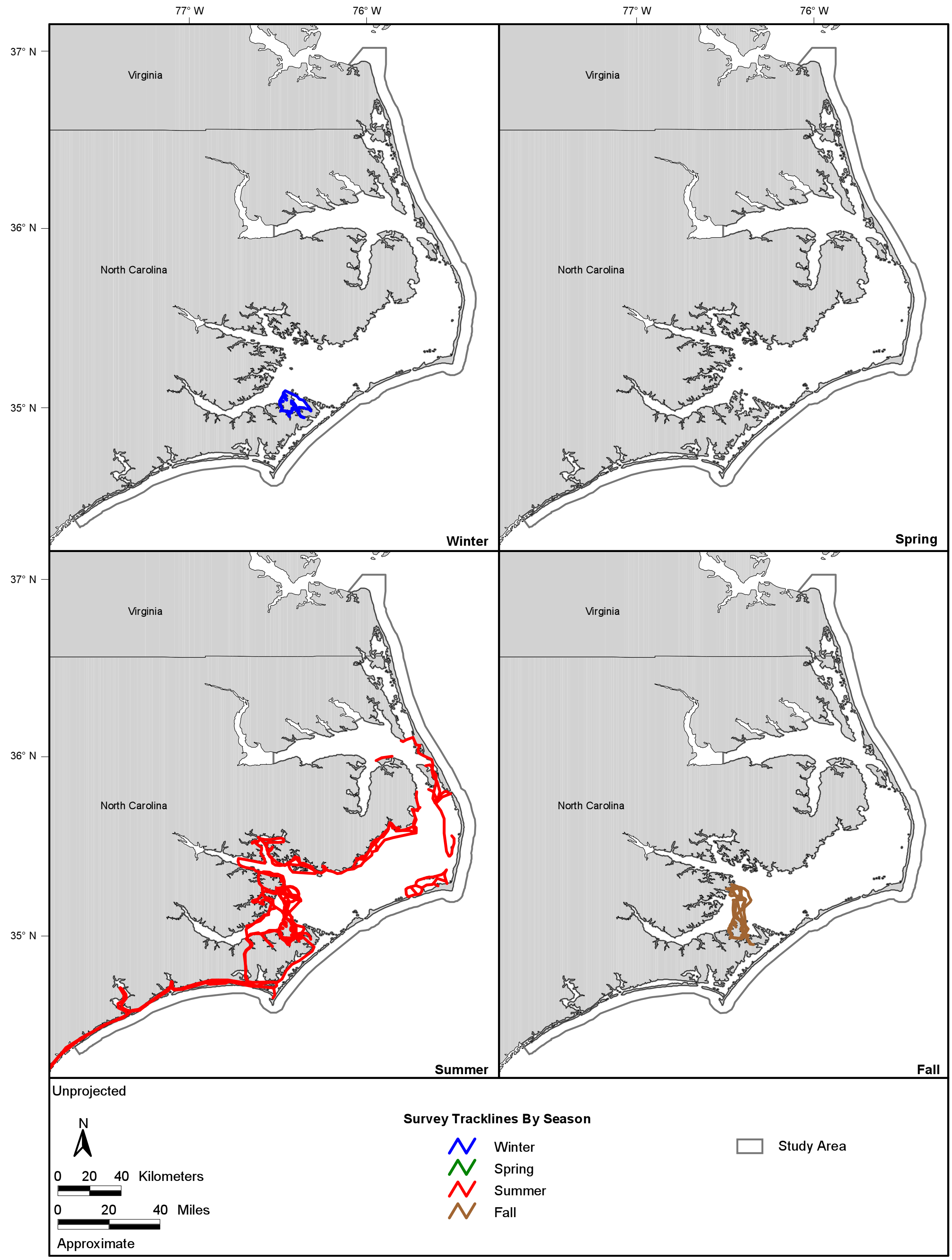

Figure 6-1. Tracklines of bottlenose dolphin surveys conducted inside of the barrier islands within the Cherry Point and southern VACAPES inshore and estuarine areas. Source maps (scanned): Read et al. (2002, 2003a, 2003b, 2003c).

- Document the locations and extent of reef and reef-like habitats within the study area to acquire navigational obstruction and scientific information. The number of existing navigational obstructions probably exceeds what is found on navigational charts. Further, the nature of mapped navigational obstructions is for the most part unknown. A detailed bathymetry of the study area produced by light detection and ranging (LIDAR) technology would be effective for mapping and quantifying the extent of bathymetric anomalies as potential navigational obstruction sites. The in situ documentation of a representative sample of these reef and reef-like habitats (as navigational obstructions) would enhance the recent work done by Steimle and Zetlin (2000). Cost: Moderate to High. Priority: 2.

- Survey the areas surrounding MCB Camp Lejeune and MCAS Cherry Point to determine if clustering of alligator sightings is higher than normal for the region. Surveys such as this may help determine what environmental or trophic factors influence the seemingly higher number of alligators in the vicinity of these two Marine Corps bases. Cost: Low to Moderate. Priority: 2.

- Support the marine mammal and sea turtle stranding networks and their analysis of the collected data. Stranding network data could be utilized to determine species occurrences in the area, to add to knowledge of life history information such as diet and reproduction, to assist with stock determination studies, and to assess impacts of human activities. Efforts to collect photographs of stranded humpback and right whales will also help determine movement patterns and unresolved stock questions. Cost: Low. Priority: 3.

- Develop a universal program to train non-Navy observers assigned to Navy ships to identify marine mammal and sea turtle species at sea, record locations of sightings, and collect hydrographic data. The program should use standardized data collection methods and data forms for consistency. Develop the program anticipating its implementation by other branches of the military at home and abroad. Manage the data using GMI's Marine Resource Database for handling and relating data that monitors complex ecosystems over time. Cost: Low. Priority: 3.

- Implement an education program for vessel captains/operators regarding the dangers of sea turtle mortality attributable to boat strikes and nearshore activities. Make boat operators aware of the annual seasons when turtles will be most abundant in inshore waters or on the beaches nesting. Cost: Low. Priority: 3.

- Collect bottom sediment information with side scan sonar as well as bottom core or grab samples for the sea floor area of Pamlico, Albemarle, and Currituck Sounds as well as the tidally influenced areas (mouths) of the Neuse and Pamlico Rivers. A better understanding of the sediment structure and characteristics underlying these inshore waters would be beneficial to Navy and Marine Corps operations planners in determining the acoustic or reflective properties of the sediments for explosive and other training exercises. Cost: Moderate. Priority: 3.

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8.0 GLOSSARY

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

Accidental—in the case of sea turtles, accidental means they have been recorded only a time or two; it is so far from its usual range, that further observations are considered unlikely; extralimital

Adult—having arrived at sexual or physical (full size and strength) maturity

Aggregation—group of animals that forms when individuals are attracted to an environmental resource to which each responds independently; the term does not imply any social organization

Anadromous—life history strategy of fishes, that includes migration between fresh-and saltwater, in which reproduction and egg deposition occurs in freshwater while rearing to the adult stage occurs in the ocean

Angiosperm—seed plant with ovules and seeds enclosed in a carpel, pistil, or fruit

Annual—plant species that complete their life cycles within a single growing season

Anthropogenic—describing a phenomenon or condition created, directly or indirectly, as a result of human activity

Arborescent—treelike in form

Artificial habitat—a human-made, estuarine/marine habitat (sunken ships, artificial reefs: rubble, concrete igloos, FADs) created in the navigable waters of the U.S. or in waters overlying the continental shelf to attract aquatic life

Audiogram—a hearing sensitivity curve drawn as a function of frequency; measures the hearing ability of an animal

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 mysticetes whales; it takes the place of teeth and serves to filter the whale's food from the water

Barnacles—any of various marine crustaceans of the order Cirripedia that in the adult stage form a hard shell and remain attached to a submerged surface

Barrier island—long broad sandy island lying parallel to a shore that is built up by the action of waves, currents, and winds and that protects the shore from the effects of the ocean

Bathymetry—the topography of the ocean floor; study and mapping of the ocean depths

Behavioral audiogram—a graphic representation of an animal's auditory threshold that is determined by tests with trained animals; measures the hearing ability of an animal

Benthic—of or relating to organisms that live on or near the sea floor

Bight—a long, gradual bend or gentle curve in a shoreline that forms an open coast or bay

Biogenic—resulting from the activity of living organisms

Biota—the fauna and flora of an area

Bloom—a high concentration of phytoplankton caused by increased production; usually triggered by an excessive nutrients concentration

Blow—air exhaled through the blowhole of a cetacean mixed with surrounding water that is displaced by the exhalation

Boreal—of or relating to the north; used to describe a region that has a northern temperate climate

Breakwaters—wave energy barriers designed to protect any landform or water area behind them from the direct assault of waves

Brown algae—division of algae (Phaeophycophyta) consisting of large macroscopic forms occurring widespread in marine habitats attached either to rocks, stones or coarser algae (kelp); commonly found in relatively shallow water in the intertidal and subtidal zones along the coast, in estuaries, and muddy bottoms of salt marshes

Bruminate—the behavior exhibited by sea turtles of burrowing into bottom sediments to escape cold water conditions

Bulkheads—structures built higher on the shore than a seawall or a revetment to retain or prevent sliding of the land

Burrowing—making holes or tunnels in the substrate for habitation and refuge

Bycatch—animals caught unintentionally during the process of harvesting fishery products

Byssus—a collection of silky filaments by which certain mollusks attach themselves to substrates

Callosities—rough, thickened, raised patches of skin found on the head of right whales; the arrangement of these patches often is used to identify specific individuals

Calving—the process of giving birth by a whale, dolphin, porpoise, or manatee

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

Carapace—the outer covering of the back of a sea turtle, which is bony for all sea turtle species with the exception of the leatherback, which has a leathery covering

Carnivore—an animal that feeds exclusively on another animal's tissue

Cephalopods—any marine mollusk of the class Cephalopoda, with the mouth and head surrounded by tentacles (squid, octopus, cuttlefish)

Cetaceans—whales, dolphins, and porpoises

Cheloniidae—the family of hard-shelled sea turtles that includes the green, hawksbill, Kemp's ridley, and loggerhead turtles

Chrysomonads—golden brown algae (Chrysophyceae) consisting of flagellated single cells or colonies of flagellated cells; cells are asymmetrically ovoid shaped with two flagella arising near the anterior end; present in both freshwater and marine environments; sometimes major components of plankton; occur in the colder months; may produce blooms

Circumglobal—the distribution pattern displayed by organisms around the world, within a range of latitudes

Cladoceran—order of microscopic crustaceans with trunk limbs enclosed in a carapace used for feeding and antennae used for swimming; called water fleas

Click—a broad-frequency sound used by toothed whales for echolocation and possibly communication, usually with peak energy between 10 kHz and 200 kHz

Coast—the boundary where land and water meet

Coastal water—water that is along, near, or relating to a coast

Coccolithophores—family of unicellular, marine, planktonic algae which are, at least at some stage in their life cycle, covered in calcareous plates (coccoliths) embedded in a gelatinous sheath; maybe spherical or oval and less than 20 microns in diameter; important component of marine phytoplankton in still, nutrient-poor water in mild temperatures; major contributor to the carbonate accumulating in deep-sea sediments

Cochlea—a spiral structure in the inner ear that looks like a snail shell and contains over 10,000 tiny hair cells that move in response to sound waves; these movements stimulate nerve cells to send messages to the brain, which the brain interprets as sound

Cold-stunning—the behavior exhibited by sea turtles in response to cold water temperatures; turtle becomes lethargic and adopts a stunned floating posture

Colonial waterbird—a bird species (e.g., cormorants, herons, ibises, storks) that feeds predominantly in water and tends to nest (often in shrubs or trees) in a group of closely associated nests

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

Concentrated occurrence—a subarea of a species' expected occurrence, where there is the highest likelihood of encountering that species; based primarily on concentrated sightings and habitat preference

Conspecific—member of the same species, and in many cases, the same age or even sex

Continental shelf—the 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 shelf break—the area where the slope of the seabed rapidly changes from gently sloping to steeply sloping and the continental shelf gives way to the continental slope

Continental slope—the 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

Copepods—very small planktonic crustaceans present in a wide variety and great abundance in marine habitats, forming an important basis of ecosystems; they are a major food of many marine animals and are the main link between phytoplankton and higher trophic levels

Coral patches—rocky outcrops colonized by sessile organisms including hard corals, soft corals, hydroids, algae, and sponges

Cosmopolitan—having a broad, wide-ranging distribution

Critical habitats—the portion (minimum) of the habitat that is essential for the survival for certain protected species (whales, sea turtles, or birds) and may include areas essential for feeding or reproduction by those species

Crustacean—member of a class of primarily aquatic organisms with paired jointed appendages and a hard outer skeleton; includes lobsters, crabs, shrimp, and copepods

Cryptomonads—small biflagellate organism of the class Cryptophyceae; considered both as a protozoan and as an algae; occur in freshwater and marine habitats as a member of nannoplankton; cells are ovoid, flattened and characterized by two flagella of unequal length arising from the anterior end; exist in interstitial water on beaches; may live as harmless zooxanthellae within other organisms

Culm—aerial stem of a grass or grass-like plant

Cyanobacteria—large and varied group of bacteria which possess chlorophyll a and carry out photosynthesis in the presence of light and air, with concomitant production of oxygen; formerly regarded as algae and called blue-green algae; may be single-celled or filamentous and may or may not be colonial; many species carry out the fixation of atmospheric nitrogen; widely distributed in freshwater and marine environments; found in marine environment in littoral zone on soil, rocks, and plants as epiphytes or symbionts; may produce harmful algal blooms in low-salinity systems with excessive nutrients (e.g., Albemarle and Pamlico sounds)

dB re 1 μPa—sound pressure level, where the reference unit for pressure is one micro-Pascal; this indicates that an underwater sound is being discussed

Deep scattering layer—a dense aggregation of fishes, squid, and/or 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

Deepwater—the area of the ocean that is past the continental shelf break, greater than 200 m of water

Deltaic—flat plane of alluvial deposits between the branches at the mouth of a river, stream, creek, or tidal inlet caused by tidal currents

Demersal—applied to fish that live close to the sea floor, such as cod and hake

Demography—birth and death rates that determine a population's dynamics; abundance, age, and sex structure of the population and reproductive status and life cycle of individuals

Density—physical property measured by mass per unit volume; in biology, the number of organisms per unit of distance

Dermochelyidae—the family of turtles to which the leatherback turtle belongs

Desiccation—to dry out thoroughly

Detritivore—organism that feeds on detritus

Developmental habitat—an environment crucial to the growth of late-stage juvenile animals; for some sea turtles, this environment can be a shallow, sheltered habitat where forage items such as seagrasses, sponges, mollusks, and crustaceans are abundant

Diatoms—microscopic algae (Bacillariophyceae) in which the cell wall (frustule) is composed of silica and consists of two major valves and girdle bands; unicellular, colonial, or filamentous; important components of freshwater and marine habitats as members of both planktonic and benthic communities; comprised of two major types based on symmetry: **pennate –** bilateral, **centric –** radial; pennate

Diel—refers to 24-hour activity cycle based on daily periods of light and dark

Dinoflagellates—microscopic single-celled plant of the class Pyrrhophyceae that has two flagella, one propelling water to the rear and providing forward motion, attached just behind the center of the body and directly posteriorly, the other causing the body to rotate and move forwards, forming a transverse ring or spiral of several turns around the center of the body; some are naked, others are covered with a membrane or plates of cellulose; often abundant; dense growths may produce luminescent bays and harmful algal blooms in marine and freshwater habitats

Dominant species—species most prevalent in a particular community, or at a given period

Dorsal—relating to the upper surface of an animal

Dorsal fin—the structure on the back of most cetaceans (not supported by bone); some species only have a dorsal hump or ridge, others have no hint of a dorsal structure

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

Dune—pile or ridge of loose sand deposited by wind action; consist of **primary**: continuous dune ridge lying nearest the ocean and running parallel to the shoreline and **secondary** or stable: dune system lying landward of and older than the primary dune, stabilized by vegetation

Echolocation—the production of high-frequency sound waves and reception of echoes to locate objects and investigate the surrounding environment

Ecosystem—a system of ecological relationships in a local environment comprising both organisms and their nonliving environment, intimately linked by a variety of biological, chemical, and physical processes

Ectotherm—an organism that regulates its body temperature behaviorally by exchanging heat with its surroundings; a poikilotherm; a cold-blooded organism

Edaphic—pertaining to or affected by geology or soil rather than climate or water

El Niño—wind-driven reversal of the Pacific equatorial currents resulting in the movement of warm water towards the coasts of the Americas, considered a natural cyclical atmospheric/oceanic phenomenon; El Niño is often termed the El Niño/Southern Oscillation, or "ENSO"

Emergent aquatic vegetation—class of wetland habitat characterized by erect, rooted, herbaceous aquatic plants growing from submerged soils in water between 0.5 and 1.5 m deep that are present for most of the growing season

Endangered species—any animal or plant species in danger of extinction throughout all or a significant portion of its range; the authority to list a species is shared by the USFWS (plants and animals on land) and NMFS (most marine species) under provisions of the ESA

Endemic—species that are unique or confined to a specific locality or drainage

Epibenthic—refers to organisms living on natural or man-made surfaces. Oysters and blue mussels are examples of epibenthic organisms

Epibiotic—that attaches to other organisms that have settled on non-living substrates

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

Epiphytic—flora growing on the surface of macrophytes

Erratic—in the geological sense, erratic means transported some natural means, such as glacial or fluvial action, from a place of origin

Essential fish habitat (EFH)—those habitats necessary to fish for spawning, breeding, feeding, or growth to maturity; designated by the NMFS

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

Euglenoids—greenish or brownish single-celled plant (Euglenophyta) that swim through the water using one flagellum or whipping tail that arises from a reservoir slightly below the anterior end of the cell; widespread in fresh and marine habitats; often common in organically enriched waters

Eurythermal—an organism that can tolerate a wide range of temperatures

Evoked potential—electrical signals emitted by an animal's nervous or sensory system in response to applied stimulus such as sound

Exclusive economic zone (EEZ)—all waters from the low-tide line outwards to 200 NM (except for those that are close together, i.e., Mediterranean countries) in which the inner boundary of that zone is a line coterminous with the seaward boundary of each of the coastal states; the country has the power to manage all natural resources

Expected occurrence—an area encompassing the expected distribution of a species based on what is known of its habitat preferences, life history, and behavior and the available stranding, sighting, and incidental fisheries bycatch data

Extant—still in existence; not destroyed, lost, or extinct

Extralimital—outside the normal limits of an animal's distributional range

Falcate—sickle-shaped and curved (refers to the dorsal fin of some cetaceans)

Fauna—animal life of a region

Finfish-an aquatic vertebrate of the superclass Pisces

Fish aggregating device (FAD)—single or multiple floating structures that are connected to the ocean floor by ballast or anchors; used to attract fish

Fishery resources—living resources found in aquatic habitats and harvested for commercial or recreational purposes

Flora—all the plant species of a given area

Flukes—the horizontally spread tail of a cetacean

Flynet—a high profile trawl net used to harvest fish in the upper portion of the water column

Forest—vegetation dominated by trees with their crowns overlapping, generally forming 60 to 100 percent cover; includes reproductive stages or immature secondary growth stands that are temporarily less than 5 m

Freshwater amphidromous—adult fish that spawn in freshwater but regularly enter saltwater habitats during their life

Fugitive species—a short-lived, fast-growing species of plant whose ultimate survival depends on continual dispersal to newly disturbed sites; a plant species that is always in transition from one place to the next due its poor competitive abilities

Gestation—period of development in the uterus from conception until birth (pregnancy)

Gillnet—a rectangular panel of mesh 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

Grassland—vegetation dominated by perennial graminoid plants (grasses, sedges, rushes)

Green algae—division of algae (Chlorophyta) consisting of plankton and benthic forms occurring widespread in freshwater and marine habitats; marine species are primarily macroscopic forms frequently attached to moist rocks, woods, pilings, or larger algae or grow on sandy bottoms on shells in quiet estuaries; consist of motile and nonmotile types; maybe unicellular, colonial, filamentous, membranous (e.g., sea lettuce), and tubular

Gregarious—used to describe organisms that form social groups

Groins—shore protection structures built to trap littoral drift or retard erosion of the shore

Gulf Stream—the strong western boundary current of the North Atlantic Ocean

Gyre—circular movement of waters, larger than an eddy; usually applied to oceanic systems

Habitat—the living place of an organism or community of organisms that is characterized by its physical or living properties

Habitat area of particular concern (HAPC)—discrete areas within essential fish habitat (EFH) that either play especially important ecological roles in the life cycles of federally managed fish species or are especially vulnerable to degradation from fishing or other human activities

Habitat preference—the choice by an organism of a particular habitat in preference to others

Hard bottom community—area of bottom habitat with three-dimensional character providing physically stable shelter and substrate for large populations of sessile or attached invertebrates and fishes

Harmful algal blooms (HABs)—proliferation or bloom of toxic/non-toxic short term single-celled microalgae/phytoplankton (dinoflagellates, cyanobacteria, diatoms) or nontoxic long term macroalgae (seaweeds) that result from nutrient enrichment/circulation factors and are responsible for a broad range of ecological effects (fish kills, shellfish poisoning, ecosystem alterations)

Hatchling—a newly hatched bird, amphibian, fish, or reptile

Hematology—the study of blood and blood-producing organs

Herbaceous—vegetation in which herbs (mostly graminoids, forbs, and ferns) form at least 25 percent cover, and woody vegetation has generally less than 25 percent cover

Herbivore—an animal that eats plants as its main source of energy

Heterocercal—tail in which vertebral axis is flexed upward and extends nearly to the tip of the upper lobe of the caudal fin; fin typically asymmetrical externally; upper lobe much longer than lower

Hydroids—any of numerous characteristically colonial hydrozoan coelenterates having a polyp rather than a medusoid form as the dominant stage of the life cycle

Hydrophone—transducer for detecting underwater sound pressures; an underwater microphone

Ichthyofauna—all fish that live in a particular area

Ichthyoplankton—fish eggs and larvae drifting in the water column

Incidental (fisheries) bycatch—the catch of additional species, such as fishes, turtles, or marine mammals that is not targeted by a fishery but is taken along with the species being sought (target species)

Indigenous—a fish or other aquatic organism native to a particular water body, basin, or region

Inflorescence—an axis or axes bearing flowers

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

Invasive—nonindigenous species that become abundant and influential invaders of communities of native species

Invertebrates—group of animals lacking a backbone

Invertivore—organisms that consume invertebrates

Isobath—bathymetric contour of equal depth; usually shown as a line linking points of the same depth

Jetties—structures 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

Juvenile—mostly similar in form to adult but not yet sexually mature; a smaller replica of the adult

Labrador current—a cold ocean current flowing southward from Baffin Bay along the coast of Labrador and turning east after intersecting the Gulf Stream

Lactation—secretion or formation of milk by the mammary glands for the purpose of nursing offspring

Lagoon—bodies of water, separated in most cases from the ocean by offshore bars or barrier islands of marine origin and [which] are usually parallel to the coastline

La Niña—when ocean temperatures in the eastern equatorial Pacific are unusually cold; it is essentially the opposite of the El Niño phenomenon; La Niña sometimes is referred to as the cold phase of an ENSO

Larval—young fish between time of hatching and attainment of juvenile characteristics

Littoral—a shore or coastal region, particularly the zone between the high and low tide marks

Live bottom community—a concentration of benthic invertebrates and demersal fishes that are associated with a region of vertical relief and structural complexity; such oasis-like communities are often surrounded by expanses of little relief and structure; the physical structure of these communities can be both organic (e.g., coral skeletons) and inorganic (e.g., rocks) in origin

Longline—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 sea floor

Lost year—the early juvenile stage (first years of life) of most sea turtle species that is spent far offshore; few turtles are observed during this time

Low/unknown occurrence—an area where the likelihood of encountering a species is rare or not known

Macroscopic algae—large algae, commonly referred to as seaweed

Macrophyte—macroscopic plant in an aquatic environment

Map projection—a mathematical formulation that transforms feature locations on the Earth's curved surface to a map's flat surface

Marsh—water-saturated, poorly drained wetland area that is periodically or permanently inundated to a depth of 2 m and that supports an extensive cover of emergent, non-woody vegetation, without peat-like accumulations.

Mean—(arithmetic) average

Melon—a fatty cushion forming a bulbous "forehead" in toothed whales; may act to focus sound for echolocation

Mesohaline—waters with salinity between 5.1 and 18 parts per thousand from ocean-derived salts

Mesopelagic—occurring in the oceanic zone from 200 to 1,000 m

Metadata—information about a geographic information system (GIS) file that describes the data in the file; may include the source of the data, its creation date and format, its projection, scale, resolution, and accuracy, and its reliability with regard to some standard

Microscopic algae—smaller algae between 20 and 200 microns in diameter

Mid-Atlantic Bight (MAB)—zoogeographic marine region of the Atlantic Ocean that includes the estuarine and the continental shelf waters between Cape Cod, Massachusetts (including the southwestern flank of Georges Bank), and Cape Hatteras, North Carolina

Migrant—a bird species that travels from its breeding range to a wintering range or area and then returns to its breeding range the following year (also called a transient)

Migration—seasonal movements of a population of organisms to more favorable habitat

Mollusks—largely aquatic phylum of bilaterally symmetrical, unsegmented invertebrates consisting of clams, oysters, snails, squid, etc.

Morphology—the form and structure of an organism considered as a whole; appearance

Mud flats—shallow areas composed of silt and other fine particles that are periodically exposed at relatively even elevations

Mysticeti—suborder of cetaceans comprised of the baleen whales (e.g., humpback whale, blue whale)

Nautical mile (NM)—one minute of latitude or 1.85 km

Nearshore—an indefinite zone that extends seaward from the shoreline

Nekton—actively swimming organisms able to move independent of water current

Neritic zone—the shallow pelagic zone over the continental shelf; usually no deeper than 200 m

North Atlantic—the part of the Atlantic Ocean found north of the Equator

Northwest Atlantic—the part of the Atlantic Ocean found north of the Equator and west of the mid-ocean ridge (or roughly the area between Iceland and Greenland); synonymous with western North Atlantic Ocean

Nursery habitat—an environment crucial for the development of early-stage animals; for some sea turtles, this environment is often an open-ocean area characterized by the presence of *Sargassum* rafts and/or ocean current convergence fronts

Occurrence not expected in study area—an area within the operating area where a species is not expected to be encountered

Oceanic zone—the part of pelagic waters away from shore but in open water; past the continental shelf

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 that are deeper than 200 m; beyond the continental shelf break

Olfactory—relating to the sense of smell

Oligohaline—waters with salinity between 0.5 and 5.0 parts per thousand from ocean-derived salts

Oligotrophic—a body of water that is lacking in nutrients, which results in low primary production

Omnivore—an animal that feeds on both plant and animal tissue

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 reefs—natural structures found between (intertidal) and beneath (subtidal) tide lines, that are composed of oyster shell, live oysters, and other organisms that are discrete, contiguous and clearly distinguishable from scattered oysters in marshes and mud flats and from wave-formed shell windrows

Panlatitudinal—having a wide north-south distribution

Pelagic—primary division of the sea that includes the whole mass of water subdivided into neritic and oceanic zones; also pertaining to the open sea

Penaeid—a group of shrimp, chiefly found in warm water

Periphyton—attached microflora growing on the bottom, or on other submerged substrates, including higher plants

Perennial—plant species with a life cycle that characteristically lasts more than two growing seasons and persist for several years

Photic zone—the uppermost zone in the water where sunlight permits photosynthesis

Photosynthesis—the chemical process using chlorophyll that plants and algae use to convert solar energy into organic matter (cellular energy) by synthesizing water and carbon dioxide

Phylogenetics—the biological discipline that studies the evolutionary relationships of organisms; taxa that are arranged phylogenetically are listed based on their evolutionary history

Phytoplankton—microscopic, photosynthetic plankton, which are the base of the food chain on which ultimately most shellfish, fish, birds, and marine mammals depend

Pinnipeds—seals, sea lions, and walruses

Pioneer species—a rapidly reproducing plant capable of invading bare sites (e.g., newly exposed soil surfaces) and persisting there until supplanted by successional species; the first plant species to colonize a new habitat

Planktivore—an animal that feeds on plankton

Plankton—organisms (plant or animal) that drift in the water column and cannot propel or move themselves

Plastron—bony shield composing the ventral side of a turtle's shell

Pocosin—elevated wetland areas characterized by poorly drained soils high in organic material

Polychaete—class of soft-bodied, metamerically segmented coelomate worms; marine; free-swimming, errant, burrowing or tube dwelling

Polyhaline—water with salinity between 18.1 and 30 parts per thousand from ocean-derived salts

Population—a group of individuals of the same species occupying the same area

Portunid—crab of the family Portunidae, which includes the swimming crabs (i.e., blue crab)

Posterior—situated near or toward the back of an animal's body

Practical salinity unit (psu)—the currently used dimensionless unit for salinity, replacing parts per thousand (ppt)

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

Pup—a young animal of various species; in this case, refers to young pinnipeds

Pupping—the process of giving birth by pinnipeds

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"

Rare—a plant or animal restricted in distribution or number; in the case of sea turtles, rare means that a species occurs, or probably occurs, regularly within the region but in very small numbers

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

Red algae—division of algae (Rhodophycophyta) consisting of benthic forms which are predominately marine in both littoral and sublittoral zones; occur as minute filamentous epiphytes, as thin, epilithic films, an as large, fleshy or membranous forms; grow attached to rocks or other algae

Reef/reef-like habitat—result of the colonization by sessile organisms of natural or man-made structures

Reef tract—an expanse of reef

Relict—a surviving trace of something

Relief—the inequalities (elevations and depressions) of the sea bottom

Remigration interval—the amount of time between successive sea turtle nesting seasons

Resident—a bird species that normally remains within it's known breeding range all year (also called a permanent resident)

Revetments—facing of stone, concrete or wood built to protect a scarp, embankment, or shore structure against erosion by wave action or currents

Robust—powerfully built

Rookery—an animal's breeding ground

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 beak of a cetacean; in fish, a forward projection of the snout

Rubble structures—mounds of random-shaped and random-placed stones protected with a cover layer of selected stones or specially shaped concrete armor units; divided into two general categories: structures perpendicular to the shoreline and structures parallel to the shoreline

Saddle—a light-colored patch behind the dorsal fin of some cetaceans

Salinity—the concentration of salt in water, measured in practical salinity units (psu)

Salt marsh—low areas covered by salt-tolerant vegetation (bushes and grasses) near a sea that are periodically flooded by seawater but not exposed to daily tides

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 planktonic brown algae commonly found in temperate and tropical waters

School—a grouping 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

Scutes—long, thickened scales that cover underlying bony plates of carapace and plastron of sea turtles and sturgeons that are used for protection

Seawalls—structures separating land and water areas, primarily designed to prevent erosion and other damage due to wave action

Secchi depth—the water depth at which sunlight is fully absorbed (or attenuated) and therefore not available for photosynthesis; the measure of water clarity/transparency obtained with a Secchi disk

Sediment—solid fragmental material, either mineral or organic

Sedimentation—deposition of suspended matter by gravity when water velocity cannot transport the bed load

Sessile—used to describe an animal that is attached to something rather than free moving

Shallow water—water that is between the shore and the continental shelf break or shallower than 200 m

Shelf break (continental)—region where the slope of the seabed rapidly changes from gently sloping to steeply sloping and the continental shelf gives way to the continental slope; on average, this change occurs at approximately 100 to 200 m in water depth

Shellfish—an aquatic animal, as a mollusk or crustacean, having a shell of shell-like exoskeleton

Shorebird—a bird that uses shallow water of open bays, ponds, lakes, reservoirs, coastal beaches, tidal flats, and/or grasslands for feeding (e.g., plovers, sandpipers)

Shrub—perennial woody species with a life form that is usually less than 4 to 5 m in height; typically, plants with several stems arising from or near the ground

Silicoflagellates—distinct group of unicellular flagellates that have a delicate siliceous skeleton made up of tubular rod-shaped elements with a single, long flagellum; are both photosynthetic and heterotrophic; widely distributed in the ocean; generally restricted to the euphotic zone; abundant with diatoms and in areas of upwelling

Sirenia—the order of marine mammals that consists of manatees and the dugong

Soft corals—an class of corals (Anthozoa) characterized by having retractable polyps with eight, branching tentacles (i.e., sea anenomes); usually attached to rocks

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—zoogeographic marine region of the Atlantic Ocean that includes the estuarine and continental shelf waters between Cape Hatteras, North Carolina, and the southern tip of Florida

Southeastern U.S.—the area of the southeastern U.S. that includes the Atlantic coastal states of North Carolina, South Carolina, Georgia, and Florida

Spatulate—spoon-shaped

Spawn—the release of eggs and sperm during mating

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

Sponges—any of numerous primitive, chiefly marine animals of the phylum Porifera, characteristically having a porous skeleton composed of fibrous material or siliceous or calcareous spicules and often forming irregularly shaped colonies attached to an underwater surface

Sprig—a small shoot or twig of a plant

Standard deviation—a statistical measure of the amount by which a set of values differs from the arithmetical mean; simply, how widely values are dispersed from the mean

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

Stock structure—the genetic diversity of a stock

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 centerline of the carapace to the posterior edge of the carapace

Stranding—the act where marine mammals or sea turtles accidentally come ashore, either alive or dead

Strategic stock—any marine mammal stock: (1) from which the level of direct human-caused mortality exceeds the potential biological removal level; (2) which is declining and likely to be listed as threatened under the ESA; or (3) which is listed as threatened or endangered under the ESA or as depleted under the MMPA

Subadult—maturing individuals that are not yet sexually mature

Submerged aquatic vegetation (SAV)—flowering, rooted, vascular plants 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 substance on or in which an organism grows or is attached

Subtropical—the regions lying between the tropical and temperate latitudes

Summer resident—a bird species that normally remains in a specified region only during the summer

Surf zone—region between the breaking waves and the shore

Taxa (taxon)—a defined unit (e.g., species, genus, or family) in the classification of living organisms

Telemetry—the science and technology of automatic measurement and transmission of data by wire, radio, or other means from remote sources, as from space vehicles or tagged migrating animals, to receiving stations for recording and analysis

Temperate—inhabiting the mid-latitudes characterized by a mild, seasonally changing climate

Temporary threshold shift—exposure to intense sound may produce an elevated hearing threshold. If the threshold returns to the pre-exposure levels after a period of time, it is a temporary threshold shift

Temperature-dependent sex determination—a phenomenon in which an organism's sex is determined at least in part by its incubation temperature

Thermoregulatory—tending to maintain a body at a particular temperature, whatever its 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 NMFS (most marine species) under provisions of the ESA

Tone—sinusoidal waveform without harmonic components; all power is at a specific frequency

Topography—physical features of the ocean floor, such as mounds or ridges

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

Tropical—the geographic region found in the low latitudes (30° north of the equator to 30° south of the equator) characterized by a warm climate

Turbidity—relative clarity of water in which light penetration is reduced from suspended materials such as clay, mud, organic matter, color, or plankton

Ultraplankton—planktonic organisms that range in size from 0.5 to 10 microns

Ultrasonic—sound at frequencies too high to be audible to humans, generally above 20 kHz

Vagrant—a bird species that is outside of its normal range and that occurs infrequently in the area

Vegetation—plant life or total plant cover of an area

Ventral—relating to the underside (or belly side) of an animal

Vertebrates—animals with a backbone

Vocalization—sound produced by an animal

Water column—a vertical column of the seawater extending from the surface to the sea bottom

Waterfowl—any bird that feeds in either an aquatic or terrestrial ecosystem and nests in wetlands, margins of aquatic habitats, or on arctic tundra (e.g., swans, geese, ducks)

Water mass—a body of water that can be identified by a specific range of temperature and salinity values from the surface to depth

Webworms-any of various usually destructive caterpillars that construct webs

Weir jetties—updrift jetties with a low section or weir

Western boundary current—strong, fast-moving current at the western boundary of an ocean (off the east coast of a continent); examples include the Gulf Stream and the Kuroshio Current

Western North Atlantic—the part of the Atlantic Ocean found north of the Equator and west of the mid-ocean ridge (or roughly the area between Iceland and Greenland); synonymous with Northwest Atlantic Ocean

Wetland—an area inundated by water frequently enough to support vegetation that requires saturated soil conditions for growth and reproduction; generally includes swamps, marshes, springs, seeps, or wet meadows; they can be freshwater or saltwater

Whistle—a narrow band frequency sound produced by some toothed whales and used for communication; they typically have energy below 20 kHz

Winter resident—a bird species that normally remains only in a specified region during the winter

Yellow-green algae—class of algae (Xanthophyceae) consisting of flagellated, coccoid, filamentous and siphonaceous forms; possess an anteriorly pointing hairy flagellum and a posteriorly pointing smooth flagellum; primarily freshwater with a few marine species

Young-of-the-year—fishes usually hatched within the past 12 months

Zooplankton—ensemble of small animals that drift freely in the water column; the zooplankton is composed of a wide range of invertebrates and the larval forms of fish and shellfish

Zooxanthallae—single-celled algae living within certain types of coral; this is what gives coral its color

Appendix A. Data sources for marine mammal and sea turtle occurrence records that are included in the Cherry Point and southern VACAPES inshore and estuarine areas and vicinity.

Data	Year(s)
Shipboard Sighting Surveys	
NMFS-NEFSC R/V *Delaware* Cruise DE 97-05	1997
NMFS-NEFSC R/V *Delaware* Cruise DE 98-04	1998
NMFS-SEFSC R/V *Oregon II* Cruise 99-05 (236)	1999
Aerial Sighting Surveys	
North Atlantic Right Whale Consortium (NARWC) Database	1894-2002
NMFS-SEFSC Southeast Cetacean Aerial Surveys (SECAS)	1992; 1995
NMFS-SEFSC Mid-Atlantic *Tursiops* Surveys (MATS)—aerial surveys; 1994: only leatherback and loggerhead sea turtles; 1995: all sea turtle species	1994; 1995
NMFS-SEFSC Southeast Turtle Surveys (SETS)—aerial surveys; only leatherback and loggerhead sea turtles	1982-1984
NMFS-SEFSC Offshore NC Sea Turtle Surveys	1991-1992
Tagging	
NMFS-SEFSC Incidental Sea Turtle Tagging Program	1986-2001
Southeast Area Monitoring and Assessment Program (SEAMAP)/South Carolina Department Natural Resources (SCDNR) sea turtle tagging	1989-2001
Incidental Fisheries Bycatch	
NMFS-NEFSC Fishery Bycatch (all fisheries)	1989-2000
Strandings	
Sea Turtle Stranding and Salvage Network (STSSN)/North Carolina Wildlife Resources Commission (NCWRC) Sea Turtle Project	1980-1998
NMFS-NEFSC Stranding data	1995-2000
Smithsonian Marine Mammal Stranding Database	1869-2001
Nesting Records	
North Carolina Wildlife Resources Commission (NCWRC) Sea Turtle Project	1972-2000
Mixed/Miscellaneous	
NMFS-NEFSC Sea Turtle Mapping and Information System (strandings, incidental fisheries bycatch, sightings)	1963-1997
NC Natural Heritage Program Database	1934-2000
NMFS-SEFSC Sea Turtle Public Sighting Program	1987-2001
Beck Unpublished data	2002
Pitchford Unpublished data	2002
Schwartz Unpublished data	2002

Appendix A. Continued

Data	Year(s)
Published Literature and Reports	
Blaylock, R.A. The marine mammals of Virginia, with notes on identification and natural history. VIMS Education Series 35 (VSG-85-05):1-34.	1985
Caldwell, D.K., and F.B. Golley. Marine mammals from the coast of Georgia to Cape Hatteras. The Journal of the Elisha Mitchell Scientific Society 81(1):24-32.	1965
Clark, M.K. Endangered, threatened, and rare fauna of North Carolina. Part I. A re-evaluation of the mammals. Occasional Papers of the North Carolina Biological Survey.	1987
Huang, T. The manatee's back in Hampton Roads - A scientist is trying to figure out why the sea animal is in the area. Virginian Pilot [Hampton Roads, Virginia] October 10:B1.	1993
Katona, S.K., J.A. Beard, P.E. Girton, and F. Wenzel. Killer whales (*Orcinus orca*) from the Bay of Fundy to the Equator, including the Gulf of Mexico. Rit Fiskideilar (Journal of the Marine Institute of Reykjavik) 11:205-224.	1988
Keinath, J.A., J.A. Musick, and W.M. Swingle. First verified record of the hawksbill sea turtle (*Eretmochelys imbricata*) in Virginia waters. Catesbeiana 11:33-38.	1991
Parker, G.L. Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. Marine Turtle Newsletter 71:19-22.	1995
Rathbun, G.B., R.K. Bonde, and D. Clay. The status of the West Indian manatee on the Atlantic coast north of Florida. Pages 152-164 in R.R. Odom and J.W. Guthrie, eds. Proceedings of the Symposium on Nongame and Endangered Wildlife. Georgia Department of Natural Resources, Game and Fish Division, Technical Bulletin WL5.	1982
Read, A., K. Urian, and D. Waples. Monitoring Bottlenose Dolphin Use of the Brant Island Shoal Bombing Target (BT-9) and the Piney Island Bombing Range (BT-11) and adjacent waters. Period: July-September, 2002. Prepared for Marine Corps Air Station, Cherry Point, North Carolina.	2002
Read, A., K. Urian, and D. Waples. Monitoring Bottlenose Dolphin Use of the Brant Island Shoal Bombing Target (BT-9) and the Piney Island Bombing Range (BT-11) and adjacent waters. Period: October-December, 2002. Prepared for Marine Corps Air Station, Cherry Point, North Carolina.	2003
Read, A., K. Urian, and D. Waples. Monitoring Bottlenose Dolphin Use of the Brant Island Shoal Bombing Target (BT-9) and the Piney Island Bombing Range (BT-11) and adjacent waters. Period: January-March, 2003. Prepared for Marine Corps Air Station, Cherry Point, North Carolina.	2003
Read, A.J., K.W. Urian, B. Wilson, and D.M. Waples. Abundance of bottlenose dolphins in the bays, sounds and estuaries of North Carolina. Marine Mammal Science 19(1):59-73.	2003
Schwartz, F.J. Florida manatees, *Trichechus manatus* (Sirenia: Trichechidae), in North Carolina 1919-1994. Brimleyana 22:53-60.	1995

Appendix B. The fish and invertebrate species with essential fish habitat (EFH) and habitat areas of particular concern (HAPC) designated in the Cherry Point and southern VACAPES inshore and estuarine areas.

Temperate Water/Northeast Species
Atlantic herring (*Clupea harengus*)
Silver hake (whiting) (*Merluccius bilinearis*)
Red hake (*Urophycis chuss*)
Goosefish (monkfish) (*Lophius americanus*)
Bluefish (*Pomatomus saltatrix)*
Butterfish (*Peprilus triacanthus*)
Scup (*Stenotomus chrysops*)
Black sea bass (*Centropristis striata*)
Summer flounder (*Paralichthys dentatus*) [1]
Windowpane flounder (*Scophthalmus aquosus*)
Witch flounder (*Glyptocephalus cynoglossus*)
Yellowtail flounder (*Pleuronectes ferrugineus*)
Spiny dogfish (*Squalus acanthias*)
Atlantic surf clam (*Spisula solidissima*)
Northern shortfin squid (*Illex illecebrosus*)
Longfin inshore squid (*Loligo pealeii*)

Highly Migratory Species:
Atlantic bluefin tuna (*Thunnus thynnus*)
Sailfish (*Istiophorus platypterus*)
Sand tiger shark (*Odontaspis taurus*)
Dusky shark (*Carcharhinus obscurus*)
Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)
Blacktip shark (*Carcharhinus limbatus*)
Sandbar shark (*Carcharhinus plumbeus*) [2]
Silky shark (*Carcharhinus falciformis)*
Tiger shark (*Galeocerdo cuvier)*
Scalloped hammerhead (*Sphyrna lewini*)
Spinner shark (*Carcharhinus brevipinna*)

Subtropical-Tropical Water/Southeast Species

Snapper-Grouper Complex [3]

Sea Basses and Groupers
Black sea bass (*Centropristis striata*)
Bank sea bass (*Centropristis ocyurus*)
Rock sea bass (*Centropristis philadelphica*)
Speckled hind (*Epinephelus drummondhayi)*
Snowy grouper (*Epinephelus niveatus*)
Yellowedge grouper (*Epinephelus flavolimbatus*)
Misty grouper (*Epinephelus mystacinus*)
Warsaw grouper (*Epinephelus nigritus)*
Scamp (*Mycteroperca phenax*)
Gag (*Mycteroperca microlepis*)

Temperate Basses
Wreckfish (*Polyprion americanus*)

Snappers
Gray snapper (*Lutjanus griseus*)
Blackfin snapper (*Lutjanus buccanella*)
Red snapper (*Lutjanus campechanus*)
Silk snapper (*Lutjanus vivanus*)
Vermilion snapper (*Rhomboplites aurorubens*)
Cubera snapper (*Lutjanus cyanopterus*)

Porgies
Sheepshead (*Archosargus probatocephalus*)
Red porgy (*Pagrus pagrus*)
Whitebone porgy (*Calamus leucosteus*)
Knobbed porgy (*Calamus nodosus*)
Longspine porgy (*Stenotomus caprinus*)
Scup (*Stenotomus chrysops*)

Grunts
White grunt (*Haemulon plumieri*)
Tomtate (*Haemulon aurolineatum*)

Jacks
Greater amberjack (*Seriola dumerili*)
Crevalle jack (*Caranx hippos*)
Blue runner (*Caranx crysos*)
Almaco jack (*Seriola rivoliana*)
Yellow jack (*Caranx bartholomaei)*
Lesser amberjack (*Seriola fasciata*)
Banded rudderfish (*Seriola zonata*)

Tilefishes
Golden tilefish (*Lopholatilus chamaeleonticeps*)
Blueline tilefish (*Caulolatilus microps*)
Sand tilefish (*Malacanthus plumieri)*

Spadefishes
Atlantic spadefish (*Chaetodipterus faber*)

Triggerfishes
Gray triggerfish (*Balistes capriscus*)
Queen triggerfish (*Balistes vetula*)

Coastal Migratory Pelagic Species Complex [4]
Cobia (*Rachycentron canadum*)
Dolphin-fish (*Coryphaena hippurus*)
Spanish mackerel (*Scomberomorus maculatus*)
King mackerel (*Scomberomorus cavalla*)
Cero (*Scomberomorus regalis*)
Little tunny (*Euthynnus alletteratus)*

Red Drum [5]
Red drum (*Sciaenops ocellatus*)

Shrimp Fishery [6]
Brown shrimp (*Penaeus aztecus)*
Pink shrimp (*Penaeus duorarum)*
White shrimp (*Penaeus setiferus*)

Golden Crab
Golden crab (*Chaceon fenneri*)

Appendix B. Continued

[1] All bed sizes or loose aggregations of native macroalgae, seagrasses, and freshwater/tidal macrophytes found in the adult/juvenile EFH areas

[2] Important nursery/pupping grounds in shallow areas and the mouth of lower Chesapeake Bay and on the Outer Banks, NC, in areas of Pamlico Sound adjacent to Hatteras and Ocracoke islands and offshore of these barrier islands

[3] Medium to high profile, offshore hard bottoms where spawning occurs, nearshore hard bottom areas, seagrass habitat, oyster/shell habitat, all coastal inlets, all state-designated nursery habitats (primary/secondary nursery areas in North Carolina), and pelagic/benthic *Sargassum*

[4] Sandy shoals of Cape Lookout and Cape Hatteras from shore to the ends of the respective shoals, but shoreward of the Gulf Stream, pelagic *Sargassum*, and estuaries with high numbers of Spanish mackerel which include spawning grounds and habitats where eggs and larvae develop (Bogue Sound–adults: May through September and New River–adults: May through October)

[5] All coastal inlets, all state-designated nursery areas (primary/secondary nursery areas in North Carolina), documented sites of spawning aggregations, other spawning areas identified in the future, and SAV habitats

[6] Estuarine shoreline habitats where juveniles congregate and seagrass beds prevalent in Core Sound and eastern Pamlico Sound

Appendix C. Descriptions of piping plover critical habitat units in North Carolina

- **Unit NC-1: Oregon Inlet, 404 hectares (ha) in Dare County**. This unit extends from the southern portion of Bodie Island to the northern portion of Pea Island. It includes all land south of the Oregon Inlet Marina and Fishing Center to 0.5 km south of the junction of Highway 12 and State Route (SR) 1257. This unit includes lands from mean lower low water (MLLW: the average of the lower low water height of each tidal day) on the Pamlico Sound across and including all land to the MLLW on the Atlantic Ocean shoreline. Any emergent sandbars south and west of Oregon Inlet are included.

- **Unit NC-2: Cape Hatteras Point, 465 ha in Dare County**. The majority of this unit is within Cape Hatteras National Seashore. The unit extends south from the Cape Hatteras Lighthouse to the point of Cape Hatteras and then extends west 6.4 km along the Hatteras Cove shoreline. The unit includes lands from the MLLW on the Atlantic Ocean and stops landward where densely vegetated habitat, not used by the piping plover, begins and where constituent elements no longer occur.

- **Unit NC-3: Clam Shoals, 28 ha in Dare County**. The entire unit is owned by the state. This unit includes several islands in Pamlico Sound known as the Bird Islands. This unit includes lands on all islands to the MLLW.

- **Unit NC-4: Hatteras Inlet, 516 ha in Dare and Hyde counties**. The majority of this unit is surrounded by Cape Hatteras National Seashore, but is privately owned. This unit extends west from the end of Highway 12 on the western portion of Hatteras Island to 1.25 km southwest of the ferry terminal at the end of Highway 12 on Ocracoke Island. It includes all lands where constituent elements occur from the MLLW on the Atlantic Ocean across to the MLLW on Pamlico Sound. All emergent sandbars within Hatteras Inlet between Hatteras Island and Ocracoke Island are also included.

- **Unit NC-5: Ocracoke Island, 80 ha in Hyde County**. The majority of the unit lies within the Cape Hatteras National Seashore. It includes the western portion of Ocracoke Island beginning 3.5 km west of the junction with Highway 12 and the unnamed local road extending west to Ocracoke Inlet. It includes all land from the MLLW on the Atlantic Ocean across to the MLLW on Pamlico Sound. All emergent sandbars within Ocracoke Inlet are also included.

- **Unit NC-6: Portsmouth Island-Cape Lookout, 3,187 ha in Carteret County**. The entire unit is within Cape Lookout National Seashore. This unit includes all land to the MLLW on the Atlantic Ocean to the MLLW on Pamlico Sound, from Ocracoke Inlet extending west to the western portion of the Pilonatary Islands. This unit includes the islands of Casey, Sheep, Evergreen, Portsmouth, Whalebone, Kathryn Jane, and Merkle Hammock. This unit also extends from the eastern side of Old Drum Inlet west to New Drum Inlet, and includes all lands from the MLLW on the Atlantic Ocean to the MLLW on Core Sound.

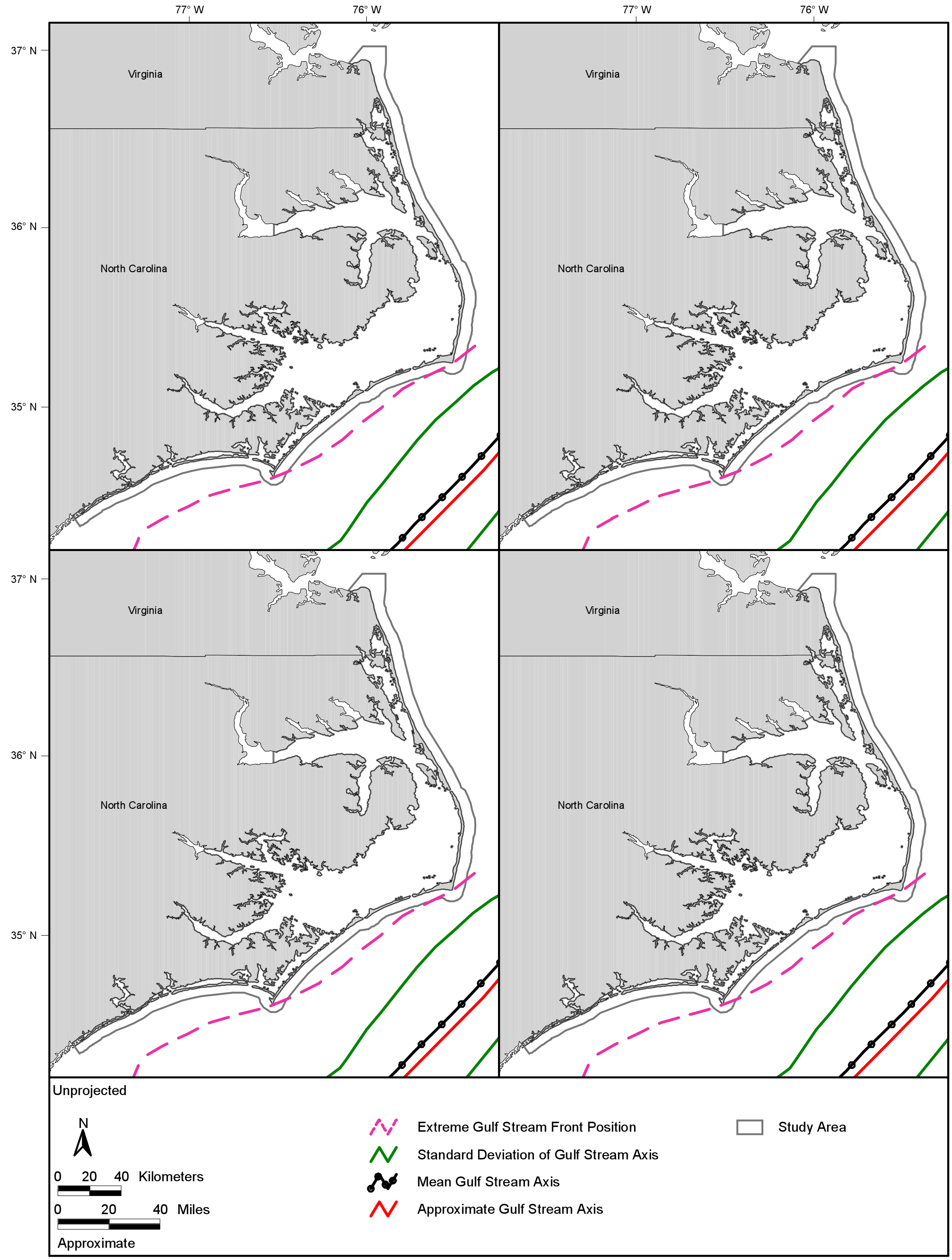
- **Unit NC-7: South Core Banks, 552 ha in Carteret County**. The entire unit is within Cape Lookout National Seashore. This unit extends south from Cape Lookout Lighthouse, along Cape Lookout to Cape Point, and northwest to the northwestern peninsula. All lands from the MLLW on the Atlantic Ocean, Onslow Bay, and Lookout Bight up to where densely vegetated habitat, not used by the piping plover, begins and the constituent elements no longer occur are included.

- **Unit NC-8: Shackleford Banks, 716 ha in Carteret County**. The entire unit is within Cape Lookout National Seashore. This unit is comprised of two parts—(1) the eastern end of Shackleford Banks from the MLLW of Barden Inlet extending west 2.4 km, including Diamond City Hills, Great Marsh Island, and Blinds Hammock; and (2) the western end of Shackelford Banks from the MLLW extending east 3.2 km from Beaufort Inlet. The unit includes all land from the MLLW to where densely vegetated habitat, not used by piping plover, begins and where the constituent elements no longer occur, and includes any emergent sandbars within Beaufort Inlet. This unit is bordered by Onslow Bay, Shackleford Slough, and Back Sound.

- **Unit NC-9: Rachel Carson, 445 ha in Carteret County.** The entire unit is within the Rachel Carson National Estuarine Research Reserve. This unit includes islands south of Beaufort including Horse Island, Carrot Island, and Lennox Point. This unit includes entire islands to MLLW.

- **Unit NC-10: Bogue Inlet, 143 ha in Carteret County and Onslow County.** The majority of the unit is privately owned, with the remainder falling within Hammocks Beach State Park. This unit includes contiguous land south, west, and north of Bogue Court to MLLW line of Bogue Inlet on the western end of Bogue Banks. It includes the sandy shoals north and adjacent to Bogue Banks and land on the Atlantic Ocean side to MLLW. This unit also extends 1.3 km west from MLLW of Bogue Inlet on the eastern portion of Bear Island.

- **Unit NC-11: Topsail, 451 ha in Pender County and Hanover County.** The entire area is privately owned. This unit extends southwest from 1.0 km northeast of MLLW of New Topsail Inlet on Topsail Island to 0.53 km southwest of MLLW of Rich Inlet on Figure Eight Island. It includes both Rich Inlet and New Topsail Inlet and the former Old Topsail Inlet. All land is included, including emergent sandbars, from MLLW on the Atlantic Ocean and sound sides to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur. In Topsail Sound, the unit stops as the entrance to tidal creeks become narrow and channelized.



Appendix D. The location of the Gulf Stream in the vicinity of the Cherry Point and southern VACAPES inshore and estuarine areas.