4. AFFECTED ENVIRONMENT

4.1 Introduction

4.1.1 Purpose of Chapter 4

This chapter provides a description of the physical (*e.g.*, sea floor relief, mixing regimes), chemical (*e.g.*, sea surface temperature), and biological (*e.g.*, whale population) environment that is characteristic of coastal waters of the Atlantic Ocean along the east coast of the United States from Maine to Florida. Also included in this chapter is a discussion of the socioeconomic environment, which describes activities that take place in the same coastal environment as the marine resources described in the biological environment.

This chapter is not intended to provide comprehensive descriptions of the affected environment; this would require several volumes. Rather, it is intended to provide the reader with an overview of the ocean environment. Sufficient background is given to provide an understanding of the assessment of potential linkages between USCG operations and activities in the marine environment.

4.1.2 Organization of Chapter 4

The four major sections of this chapter are the physical, biological, chemical, and socioeconomic environment. Each major section contains several subsections on more specific topics. The discussion for each of these sections is presented by region. Some discussions are divided into two regions — the North Atlantic (Maine to Virginia) and the South Atlantic (North Carolina to Florida). Other environments are discussed according to three regions — the North Atlantic (Maine to Cape Cod), the Middle Atlantic (Nantucket Shoals to Cape Hatteras), and the South Atlantic (Cape Hatteras to Florida).

4.2 Physical Environment

The description of the physical features of the Atlantic Ocean along the east coast of the United States provides a basis for understanding the oceanographic processes (Figure 4-1) that are critical to marine resources.

4.2.1 Geology

The U.S. Atlantic continental shelf consists of a tectonically stable wedge of Mesozoic and Cenozoic sediments overlying deeply buried fault blocks (MMS 1992). The margin is characterized by a series of platforms, basins, and fracture zones, and large sediment accumulations that include continental clastics, volcanics, intrusives, and marine evaporites deposited during the Upper Triassic-Middle Jurassic period (MMS 1992). Major differences among the offshore basins are found in the regional geology, petroleum potential, and nonenergy marine mineral deposits. Numerous potentially economic mineral deposits are know to occur in the offshore Atlantic, but no mineral mining is presently occurring (MMS 1992).

North Atlantic

In the North and Middle Atlantic, offshore glacial deposits of sand and gravel may provide future aggregate, particularly for the large urban areas in New England, New York, and New Jersey (MMS 1986, 1992). Several coastal states have mined sand in state waters and have used the sand for beach replenishment. Heavy mineral deposits (*e.g.*, gold, platinum, ilmenite, staurolite, rutile) are often associated with winnowed aggregate deposits, which may enhance the value of those combined resources (MMS 1986). The potential for placer mining also exists offshore New Jersey and Virginia (MMS 1992).

Gulf of Maine. The Gulf of Maine is a rectangular basin in the continental shelf that has an average depth of 150 m and covers an area of 90,700 km^2 (Uchupi and Austin 1987; Figure 4-2). It is bounded landward by Nova Scotia to the north and east, and by New Brunswick, Maine, New Hampshire, and Massachusetts to the west (NOAA 1995; MMS 1991). The Gulf is open to the south at the surface, but at depths greater than 50 m, Georges Bank — a topographical feature — forms a boundary that makes the Gulf semi-enclosed (NEFSC 1995). The interior of the Gulf is characterized by three large and deep basins (>200 m): Georges Basin near the mouth of the Northeast Channel; Jordan Basin to the northeast; and Wilkinson Basin in the southwestern region. Jeffreys Ledge, located near Cape Ann, is one of the two broad ridges (Stellwagen Bank is the other) that dominate the seafloor between Cape Ann and Cape Cod (NOAA 1993b). This ledge also separates Jordan and Wilkinson Basins (NEFSC 1995).

Limited data are available that characterize the petroleum potential of the Gulf of Maine (MMS 1992). Although the sediment thickness is insufficient for petroleum generation, some rift basins may contain mature petroleum source rock. Oil-prone shales may also be present in thick continental slope deposits, but those areas remain unexplored (MMS 1992).

Georges Bank. Georges Bank is a large shallow submarine bank that is 150 km wide and 280 km long. Georges Bank rises more than 100 m above the Gulf of Maine floor and has an average depth of less than 40m at the crest (Backus and Bourne 1987; Figure 4-2). Georges Bank is distinguishable on navigation charts by the 100-m isobath. Georges Bank is connected to the Gulf of Maine by the Northeast Channel (70 m deep), which also separates the Bank from the Scotian Shelf. The Great South Channel (140 m deep), at the extreme southwesterly boundary of Georges Bank, separates the Bank from Nantucket Shoals. The Great South Channel also connects the Gulf of Maine and the Atlantic Ocean.

The area encompassing Georges Bank contains the largest and most attractive petroleum exploration targets in the U.S. North Atlantic (MMS 1986, 1992). That continental shelf-edge area contains Jurassic-Lower Cretaceous structural traps and shelf-edge carbonate buildup which has not been drilled.

Great South Channel. The Great South Channel is one of the most used cetacean habitats off the northeastern United States (NOAA 1993a; Figure 4-2). The Great South Channel is a large funnel-shaped feature (DOC 1994) located in the southern extreme of the Gulf of Maine, between Georges Bank and Cape Cod (NOAA 1993a). Cape Cod and Nantucket Shoals border the Great South Channel to the west and Georges Bank borders it to the east. The Great South Channel is deeper to the north and shallower to the south (DOC 1994). The channel narrows to the south and rises to the continental shelf edge. To the north, the channel opens into Murray and Wilkinson Basins. The average depth is about 175 m. Silty sand is the predominant sediment type, with finer sediments occurring at the deeper depths.

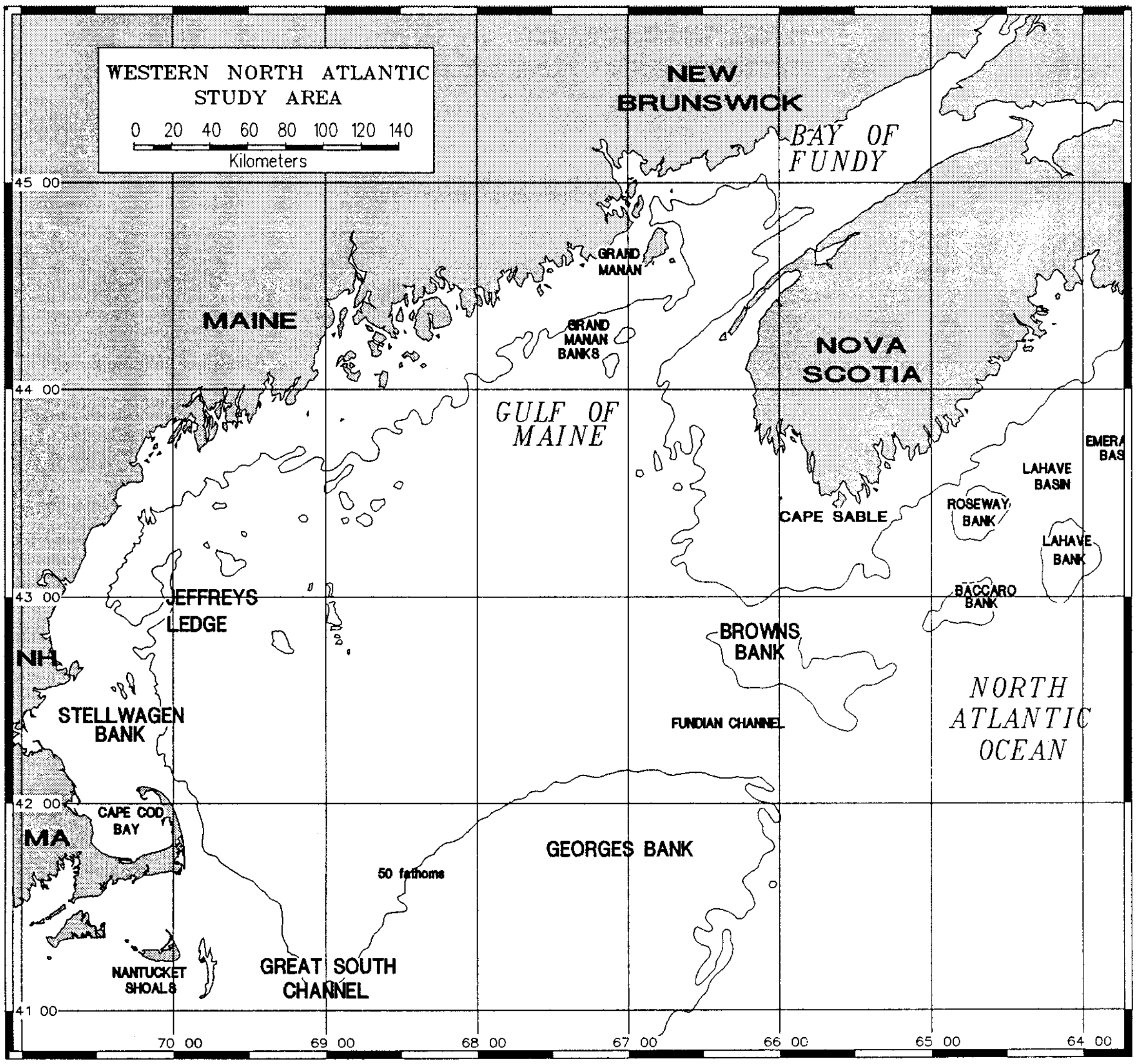

Figure 4-2. The Western North Atlantic

Cape Cod Bay. Cape Cod Bay is a large embayment that is bordered on three sides by Massachusetts; specifically Cape Cod on the south and east, and the coast of Massachusetts (south of Plymouth) to the west. To the north, the Bay opens into Massachusetts Bay and the Gulf of Maine (DOC 1994; Figure 4-2). The average depth of Cape Cod Bay is 25 m, with maximum depths occurring in the northern section bordering Massachusetts Bay (NOAA 1993a). Cape Cod Bay water flows in a general counter-clockwise direction, flowing in from the Gulf of Maine into the western portion of the Bay, then to the eastern portion of the Bay, and returning to the Gulf of Maine through a channel between the north end of Cape Cod and the southeast end of Stellwagen Bank (DOC 1994).

Stellwagen Bank. Stellwagen Bank is a submarine bank that lies just north of Cape Cod (NOAA 1993b; Figure 4-2). Stellwagen Bank, which is located in the southwestern Gulf of Maine, is 37.2 km long. It is isolated from the deeper water of the North Atlantic, except for the Northwest Channel, by a series of shallow banks at its southern border. Current flow over the Bank is in a counter-clockwise direction. Internal waves, which are periodic phenomena, are formed over Stellwagen Bank and move into Massachusetts Bay. The sediments are comprised mostly of sand and gravel (EPA 1993).

Middle Atlantic

The Middle Atlantic or Middle Atlantic Bight includes the area of the continental shelf between the Great South Channel and Cape Hatteras (NEFSC 1995). The Baltimore Canyon Trough, the elongated depression structurally dominating the Middle Atlantic region, is geologically similar to the Georges Bank Basin (MMS 1991). The continental shelf in the Middle Atlantic region gently slopes offshore and is relatively shallow (<60 m) (NEFSC 1995).

The Baltimore Canyon Trough sediments represent the most prospective area for hydrocarbon potential (MMS 1992). Five of eight wells drilled in the trough revealed large, but subeconomic, quantities of natural gas, and one well showed a small amount of light oil. Most of the hydrocarbons generated by the wells are likely gas rather than oil (MMS 1992).

The major non-petroleum minerals in the Middle Atlantic are sand, gravel, and placer deposits of heavy minerals. Presently, no offshore mining is conducted in the Middle Atlantic (MMS 1986).

Delaware Bay. Delaware Bay is in the lowest of three zones of the Delaware Estuary. The Delaware Estuary was formed after seaward flooding of the river valley during the last glaciation (Biggs 1978). The Bay is approximately 1600 km^2 (80-95% of the estuary surface area) and extends from Artificial Island to the Bay mouth (Gastrich 1992). The mean depth is 9.7 m; however, 80% of the Bay is <9 m deep (Versar 1991). The depth of the western portion of the Bay is 46 m (Versar 1991).

Chesapeake Bay. Chesapeake Bay is the largest estuary in the contiguous United States (EPA 1989). Chesapeake Bay was formed from drowned stream beds resulting from the rise in sea level at the close of the Pleistocene Era. The Bay is 320 km long and varies in width from 6 to 48 km. The Bay encompasses 5720 km^2 and has an average depth of 7 m. A few deep troughs, believed to be the remains of the ancient Susquehanna River valley, run the length of the Bay.

South Atlantic

The continental shelf in the southern and northern portion of the South Atlantic Bight is very narrow; the shelf break is only 5 km offshore of West Palm Beach and 50 km offshore of Cape Canaveral. In the central portion of the South Atlantic Bight (Jacksonville to Cape Romain), the continental shelf is very broad, extending 120 km off the coast of Georgia and South Carolina. The seafloor in this area is a gently sloping plain comprised of fine sands and muds. Coarser sands dominate the sediments on the continental shelf (Menzel 1993).

Three major sedimentary basins are found in the U.S. South Atlantic: the Southeast Georgia Embayment, the Carolina Trough, and the Blake Plateau Basin. Test wells have been drilled only in the Southeast Georgia Embayment, and all of the wells were dry (MMS 1992). The Carolina Trough appears to offer good potential for hydrocarbon production, as does the Blake Plateau Basin, due to sufficient sediment depths and age (MMS 1992).

In the South Atlantic, deposits of phosphorites have been found offshore North Carolina and Georgia, and manganese nodules and pavements on the Blake Plateau have been identified. Placer sands have been examined for shallow deposits of ilmenite (MMS 1992).

4.2.2 Physical Oceanography

North Atlantic

The North Atlantic is comprised of two major areas, the Gulf of Maine and Georges Bank. The circulation patterns of these two areas dominate the physical oceanographic processes of the North Atlantic.

Gulf of Maine. The two primary sources of water in the Gulf are Scotian Shelf water and water from the continental slope (NEFSC 1995). The cold low-salinity Scotian Shelf water and warm high-salinity Slope water enter the Gulf through the Northeast Channel between Georges Bank and Browns Bank. Scotian Shelf water also enters the Gulf through passages formed between Cape Sable and Browns Bank (NEFSC 1995). The circulation pattern of these two types of water, as they mix in this semi-enclosed sea, is in a counter-clockwise direction (EG&G 1982) and is strongest in the spring (NEFSC 1995). The shelf-slope front, which begins on the Scotian Shelf and continues south, separates the colder homogenous shelf water from stratified, warmer, more saline slope water (MMS 1991). Gulf of Maine water also contains a mixture of fresh water from local Maine rivers, such as the Androscoggin, Penobscot, Merrimack, and Kennebec (NEFSC 1995). Currents near the coast move in a general counter-clockwise direction, except south of the Penobscot Bay region, where a portion of the coastal flow is offshore towards Jeffreys Ledge (NEFSC 1995).

Gulf of Maine sediment types range from silty clay or clay in the deep basins, to sandy sediments in shallower areas between the basins and in near-coastal regions. Jeffreys Ledge contains the highest content of gravel in this general area (NOAA 1993b).

Georges Bank. The Scotian Shelf provides low-salinity cold water to the southern flank of Georges Bank in the late winter and spring. The combination of shallow bottom topography and semidiurnal tides results in a vertically well-mixed water column within the 60-m isobath throughout the year. Tidal currents are responsible for much of the sediment transport that is not associated with storm events. Recirculation of water on the Bank exhibits a clockwise flow, and is strongest in the spring and summer. During the winter, recirculation is minimal and much of the circulation escapes southwestward into the New York Bight. The well-mixed environment is a key contributor to the productivity, abundance, and diversity of marine populations on the Bank. In addition, the shelf/slope water front, which is a feature of the continental shelf of North America, has been known for decades to concentrate fish.

Great South Channel, Cape Cod Bay, and Stellwagen Bank. Two critical habitats for the right whale (Great South Channel and Cape Cod Bay) and one National Marine Sanctuary (Stellwagen Bank, an important foraging area for humpback and fin whales) have been established in the Gulf of Maine area (Figure 4-3). All three of these areas are off the coast of Massachusetts. The physical features of these areas provide an environment in which listed species, especially right, humpback, and fin whales, concentrate.

Middle Atlantic

The Middle Atlantic surface water is characterized by shelf, slope, and Gulf Stream water masses (MMS 1986). Shelf waters are subject to tidal effects (MMS 1986). Slope water circulates in an elongated gyre (Williams and Godshall 1977). The events of the Gulf Stream, which flows to the northeast, include periodic meanders, filaments, and warm- and cold-core rings that significantly affect the physical oceanographic processes of the continental shelf and slope (MMS 1991). Because of the meander, the Gulf Stream boundary oscillates between on shore and off shore. The Middle Atlantic area is strongly influenced by the Chesapeake and Delaware Bays. These Bays were formed by melting glaciers at the end of the Pleistocene era (Thurman 1985). Fresh water from the mouth of the Hudson-Raritan, Delaware, and Chesapeake Bays enters the Middle Atlantic Bight. The net flow of surface water in the Middle Atlantic moves from Georges Bank southwest towards Cape Hatteras. The shelf-slope front, which originated on Georges Bank, ends in the southern portion of the Middle Atlantic areas.

Delaware Bay. Delaware Bay is well mixed; stratification is not a long-term feature (Biggs 1978). However, short-term vertical stratification, which is most common during summer, results from freshwater input from the Delaware and Schuylkill Rivers (Versar 1991). The bottom sediments are sandy (Biggs and Church 1984) and current flow is northwest to southeast.

Chesapeake Bay. As compared to the well-mixed Delaware Bay, Chesapeake Bay is characterized by two-layer flow or stratification characteristic of a salt-wedge estuary. Fresh water from more than 50 tributaries flows seaward at the surface and saltier denser Atlantic Ocean water flows inward at depth. During summer, the combined thermal and salinity stratification as well as nitrification of deeper waters results in hypoxia in deeper waters of the Bay. In the upper Bay, the stratification is greatest in the spring when freshwater input is the highest. However, sometimes the two layers are mixed by strong tides. In the lower Bay, the water column is fully mixed due to the Coriolis force and locations of major rivers (which provide freshwater input) on the western edge. The two-layer circulation in the Bay is disrupted by wind and barometric pressure.

South Atlantic

The South Atlantic Bight, which extends from Cape Hatteras in the north to Cape Canaveral in the south, is a key area for right whales. However, the most important nesting/foraging habitat for sea turtles in the entire United States is Cape Canaveral to Key Biscayne in Florida. The South Atlantic Bight is dominated by a northerly flowing Gulf Stream and shallow continental shelf. The southern boundary of the Gulf Stream is marked by the westward flowing Antilles Current and the northeast flowing Florida Current. The Antilles Current flows westward along the north edge of the Bahamas Bank to Cape Canaveral. The Florida Current flows northeast along the southeast coast of Florida and the Florida Keys, coming within a few kilometers of the shore. The Gulf Stream links southeast Florida with the South Atlantic Bight.

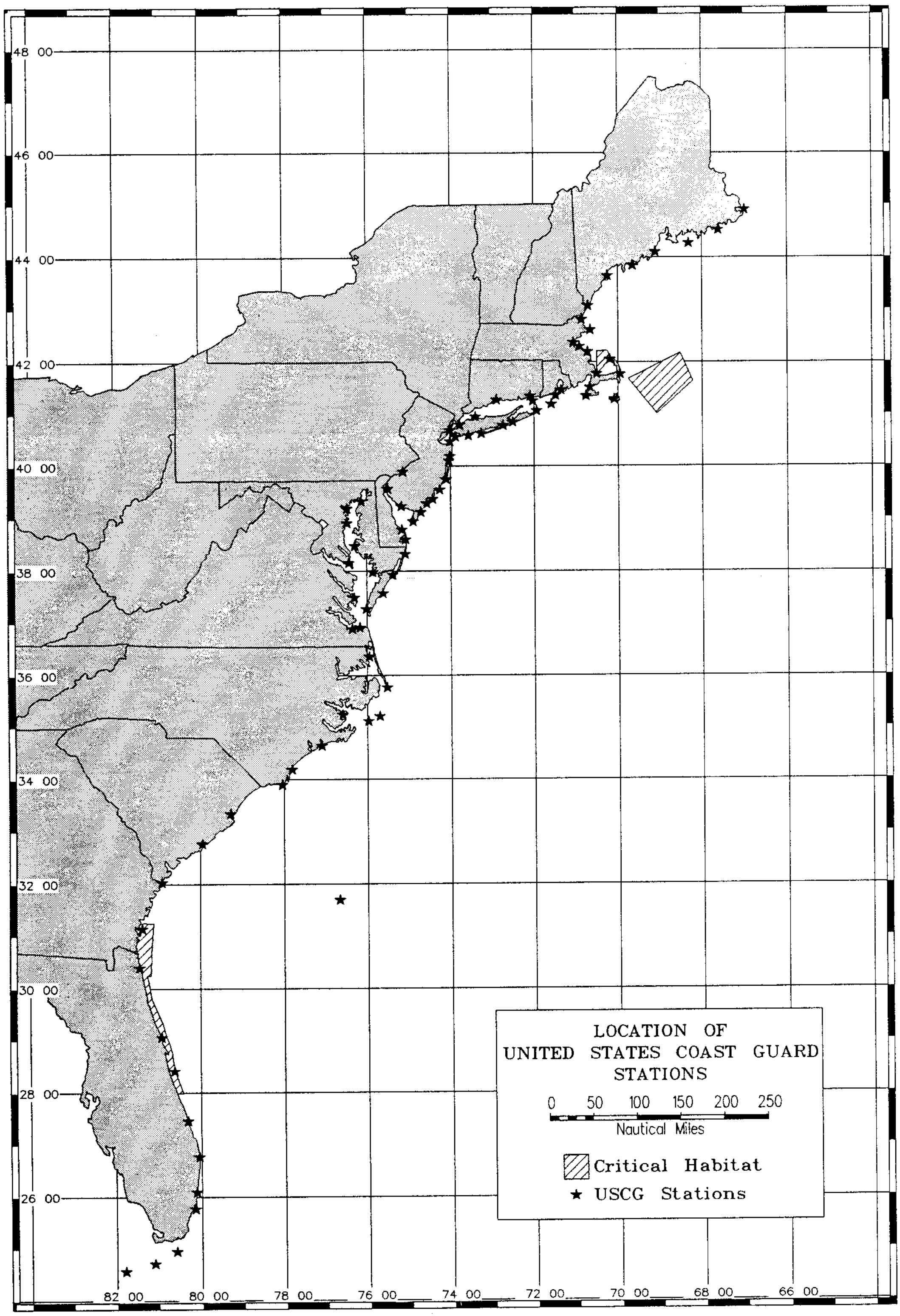

Figure 4-3. Locations of USCG stations (USCG Districts 1,5, and 7) and critical habitats along the East Coast of the United States.

Three hydrographic or depth zones characterize the South Atlantic Bight: the inner shelf, the middle shelf, and the outer shelf. The inner shelf is dominated by tidal currents, freshwater input from rivers, and short-term winds that cause upwelling and downwelling (Menzel 1993). Input from several large rivers has a significant influence on the near-coastal environment. In the mid-shelf zone, current variability is great due to the influences of wind, tide, or the Gulf Stream. Stratification in the mid-shelf region occurs in the spring and summer. In fall and winter, waters are well mixed. The Gulf Stream is the primary influence on hydrography of the outer-shelf area. Wind has much less influence in this area than in the inner- and mid-shelf zones. Associated with the Gulf Stream in this zone are sporadic northward-propagating meanders, frontal anti-cyclonic filaments, and cyclonic frontal eddies that exist for a short time.

4.2.3 Meteorology

Surface winds, air temperatures (Table 4-1), and air-sea or air-land heat exchange are controlled by two semi-permanent pressure centers in the Atlantic region: the Icelandic Low and the Bermuda High (MMS 1992). The location of these centers varies by season, and they alternate in dominating the pressure and circulation patterns of the region (Dowgiallo *et al.* 1987, as cited in MMS 1992). The Icelandic Low extends as far south as South Carolina in the winter, and produces winter winds from the west and northwest, ranging in speed from 3.1 to 7.2 m/s (6 to 14 knots). During the summer, the Icelandic Low is generally confined to areas above 55°N, when the Bermuda High is centered over the Atlantic coast of Florida. Southwesterly winds offshore the eastern United States draw warm air from the Gulf of Mexico into the southeastern United States; the speed of these winds ranges from 1.5 to 4.1 m/s (3 to 8 knots) during the summer months (Williams and Godshall 1977; Godshall *et al.* 1980; Weisberg and Pietrafesa 1983, as cited in MMS 1992).

Table 4-1. Summary of Average Climatic Conditions

	North Atlantic	Middle Atlantic	South Atlantic
Temperature			
Winter	4°C (39°F)	7°C (45°F) at Cape Hatteras	28°C (83°F) at Cape Canaveral
Summer	19°C (66°F)		
Winds			
Winter	West to northwest, 7-12 kt	West to northwest, 8-10 kt	Southwest, 10 kt
Summer	Southwest, 3-6 kt	South to southwest, 4-5 kt	Southwest, 8 kt
Precipitation (Annual)	98 cm (39 in) at Bridgeport, Connecticut	141 cm (55 in) at Cape Hatteras	142 cm (56 in) at Cape Canaveral
Air Quality	Generally good; non-attainment of air quality standards (primarily CO and O_3) in several large metropolitan areas	Same	Same

Source: Adapted from MMS (1992).

Extratropical and tropical cyclones are the most significant meteorological phenomena affecting the Atlantic coast (MMS 1992). Extratropical cyclones derive their energy from temperature and moisture differences between fronts (ERT 1979, as cited in MMS 1992). Cyclogenesis occurs somewhere in the Atlantic region in every month except September, when the air-land temperature contrast reaches a yearly low. Cyclogenesis is at a maximum in February and March.

Tropical cyclones typically develop over the warm waters of the Caribbean, Gulf of Mexico, or the Atlantic Ocean south of Cape Hatteras (MMS 1992). The cyclones derive their energy from the latent heat of water vapor condensation (ERT 1979, as cited in MMS 1992), and typically develop after April and before December. Hurricanes also occur during this period, but are most common between August and October (MMS 1992). By late August, the area of cyclone formation extends across the Atlantic, from the western Caribbean to the Cape Verde Islands. Between 1899 and 1991, 787 tropical cyclones were reported in the Atlantic, nearly 40% of which made landfall or passed immediately adjacent to the United States between Texas and Maine. During that same time period, 67 major hurricanes have affected the same area (MMS 1992).

4.3 Chemical Environment

Either directly or indirectly, water quality affects the distribution of listed species in the Atlantic Ocean. Water quality is controlled by oceanic circulation (MMS 1991), such as the influx of warm slope water and low-salinity fresh water. Circulation in the North Atlantic is influenced by the Gulf of Maine and Georges Bank gyres. In the Middle-Atlantic, the slope-sea gyre has the strongest influence on circulation. The Gulf Stream controls circulation in the South Atlantic. Oceanic circulation is directly related to sea surface temperature, salinity, and dissolved oxygen, as well as to the distribution of nutrients (*e.g.*, nutrient upwellings), chemical contaminants, and suspended solids. Dissolved oxygen concentrations, nutrient levels, chemical contaminants, and suspended solids provide an indication of the health of an ecosystem.

North Atlantic

Nutrient budgets that have been constructed for the Gulf of Maine-Georges Bank region indicate that nutrient-rich slope waters, which enter the areas through the Northeast Channel, dominate nutrients provided by other sources.

Gulf of Maine. Variations in surface temperature and salinity in the Gulf of Maine are associated with seasonal cycles (*e.g.*, winter cooling, increased freshwater input in the spring). The surface temperature ranges from 4°C in March to about 18°C in August. The lowest salinity values occur in the western Gulf in the spring due to freshwater inflow, and in the eastern Gulf during the winter due to the inflow of Scotian Shelf water. Several investigators have reported that nutrients are depleted in near-surface waters of the Gulf of Maine between May and October when phytoplankton production is high, and that nutrient concentrations are higher below the thermocline. Salinity along the coast is greatly influenced by input from local rivers, which results in a band of low-salinity water that extends from the coast 20 km or more. Bottom waters, which are comprised of nutrient-rich slope water, are generally warmer and saltier than surface or middle layer waters (NEFSC 1995).

Georges Bank. Waters on Georges Bank undergo considerable variations in temperature and salinity (Flagg 1987). This is due to wind forces, interaction with Gulf of Maine waters through the Northeast Channel, and the influx of Scotian Shelf waters (Flagg 1987). Temperature and salinity of Georges Bank water ranges from 3 to 16°C and from 33 to 32.2‰ from winter to summer, respectively (Flagg 1987).

The shelf/slope front, which extends from Georges Bank to Cape Hatteras, is a region of strong horizontal salinity gradients year round.

Great South Channel. In the Great South Channel, the surface water temperature typically ranges from 3 to 17°C between winter and summer. During the spring and summer, the Channel becomes thermally stratified. The salinity remains stable at 32-33‰ throughout the year (Hopkins and Garfield 1979).

Cape Cod Bay. Cape Cod Bay is thermally stratified in the summer. During this time, nutrient levels are highest in the western and southeastern portion of the Bay due to nearshore upwelling caused by southwest winds and resuspension of nutrients in very shallow waters, respectively (EPA 1993). In addition, nutrient levels in the Bay become depleted in late spring and summer because water in the Bay remains static (Geyer *et al.* 1992). Dissolved oxygen levels ranged from a minimum of 70% saturation in October 1989 to supersaturation in March 1990 (Townsend *et al.* 1991; Geyer *et al.* 1992). Surface water temperature during the year ranges from 0 to 19°C, with salinity remaining stable between 31 and 32‰ (DOC 1994).

Stellwagen Bank. Stellwagen Bank is a high-energy environment and is, therefore, unlikely to experience hypoxic events. Low dissolved oxygen would be expected near the end of the summer after an extended period of water column stratification (EPA 1993).

Middle Atlantic

Each of the water masses that characterizes the Middle Atlantic surface water has its own distinct characteristics. The shelf water temperatures seasonally exhibit spring and summer thermal stratifications and have relatively low salinity. Stratification of the water column results in decreased nutrient levels in the surface water. However, wind-induced upwelling may replenish nutrient-depleted surface waters (Pacheco 1988). Shelf waters are locally influenced by outflow from the Delaware and Chesapeake Bays. The Gulf Stream waters are less variable and have high temperature and salinity. The characteristics of the slope water are a combination of the adjoining Gulf Stream and shelf waters (MMS 1986). Slope waters, which are nutrient rich, provide a reservoir for nutrients in other areas through cross-shelf transport and upwelling (Pacheco 1988).

Delaware Bay. Delaware Bay is characterized by high salinities (Academy of Natural Sciences 1974): 28‰ at the mouth to 8‰ in the upper boundary (Najarian 1991). The Bay is vertically well mixed, but variations in river flow often result in short-term vertical stratifications. Fresh water from the rivers mixes with seawater and results in a horizontal salinity gradient along the north-south axis of the Bay (Versar 1991). The Bay has low suspended particulate matter (Versar 1991). A study conducted from 1987 to 1990 indicates that a relative maximum for nutrients (ammonia, nitrate, nitrite, and phosphate) and chlorophyll values exists at the mouth of Delaware Bay (Battelle 1992).

Chesapeake Bay. Surface water temperature in Chesapeake Bay fluctuates considerably from 0 to 29°C over the year (EPA 1989). Salinity is highest at the mouth of the Bay and decreases towards the northeast. Salinity also varies with freshwater inflows: salinity decreases in spring with increased freshwater flow and decreases in the fall. The results of a study conducted from 1984 to 1992 indicate that phosphorus in the Bay was significantly lower especially near the mouth of the Bay, nitrogen levels were somewhat higher, and there was a continuous degradation of dissolved oxygen concentrations (EPA 1994). These results were confirmed by another study that found that significant reductions in phosphorus and corresponding improvements in dissolved oxygen have not been achieved (EPA 1991). Another study conducted from 1987 to 1990 indicated that relative maxima for nutrient (ammonia, nitrate, nitrite, and phosphate) and chlorophyll values existed at the mouth of Chesapeake Bay (Battelle 1992).

South Atlantic

The Gulf Stream influences the chemical characteristics of the shelf water. There is a general increase in salinity seaward to a maximum of 36‰ (MMS 1986). Dissolved oxygen is generally high and decreases from north to south and seaward (MMS 1986). In the inner-shelf zone, Atkinson *et al.* (1985) reported high turbidity, low salinity, thermal stratification, and a fairly distinct frontal zone. The most significant source of nutrients for the middle shelf and outer shelf is from the Gulf Stream upwellings. Upwellings are common in the area of the continental shelf break; north of the major shoals; and in the Charleston Trough northwest of the Charleston Bump (Steel 1993).

4.4 Biological Environment

4.4.1 Marine Mammals

Marine mammals commonly found in the western North Atlantic Ocean are described below. Detailed descriptions are included for those species listed as endangered or threatened under the Endangered Species Act (ESA). A discussion of the natural history of the harbor porpoise, *Phocoena phocoena,* is included because NMFS has proposed listing the Gulf of Maine population as threatened.

Cetaceans: Endangered and Threatened Species

Northern Right Whale (Eubalaena glacialis).

Population Status and Trends of the Northern Right Whale — The northern right whale, *Eubalaena glacialis*, was a prime target of early whale fisheries from the 1100s through the early 1900s due to its coastal nature, slow swimming speed, high oil yield, and the fact that it floats when dead (Brown 1986; Aguilar 1986). Due to this intense exploitation, it is now the rarest of the large whales and is in danger of becoming extinct. Historically, there was an eastern and western stock of right whales in the North Atlantic, but current evidence suggests that the eastern stock may be extinct or on the verge of extinction (Brown 1986; Best 1993). For the purposes of this report, the review is limited to the western North Atlantic population.

The majority of right whales sighted in the North Atlantic Ocean are approximately 11-15 m in length and weigh up to 70 tons (Kraus *et al.* 1988). Females are larger than males. Right whales can be distinguished from other baleen whales by their black color, the absence of a dorsal fin, short, paddle-shaped flippers, a large head (more than 25% of the total body length), and a strongly bowed lower jaw. The distinct "V-shaped" blow provides a means of identification from a distance. The distribution and size of thickened, cornified patches of epidermis ("callosities") on the rostrum, chin, and lower lips varies among right whales and can be used in conjunction with other unique features, such as scars and pigmentation patterns, to identify individuals (Kraus *et al.* 1986; Payne *et al.* 1983).

The pre-exploitation western North Atlantic population is estimated to have numbered 10,000 animals (NMFS 1991a). Commercial harvest of the species over the centuries resulted in the decimation of the population to possibly less than 50 animals at the turn of the century (Reeves *et al.* 1992; Kenney *et al.* 1995). Although protected by international law since 1935, current studies indicate that there are fewer than 350 right whales in the western North Atlantic (Knowlton *et al.* 1994). Based on three years of aerial survey data, CeTAP researchers (1982) estimate that there are 380 (95% CI= 688; dive time correction = 2.997) whales in the population. After eliminating animals known to be dead, 325 animals have been photographically identified and cataloged to date (Kenney *et al.* 1995). This latter estimate is the best available population estimate because it is believed to be a nearly complete census (NMFS 1995) and very few new animals are photographed each year. However, some of these animals have not been seen in several years and could be dead. It appears that animals in the western North Atlantic are from a single stock (Knowlton *et al.* 1992). Although reduced to very low numbers, this is the largest remaining population of northern right whales, and it stands to benefit most from recovery actions (NMFS 1991a, 1994; Kenney *et al.* 1995). The western North Atlantic population will be considered "recovered" when it reaches 60-80% of its pre-exploitation number (NMFS 1991a), or about 7000 animals.

Despite the cessation of whaling, and the implementation of the Marine Mammal Protection Act (1972) and the Endangered Species Act (1973), this population of right whales appears to be growing at a very slow rate. In contrast to the closely related southern right whale (*Eublaena australis*) which is exhibiting signs of recovery in the eastern and western South Atlantic populations and in the Australian population, the situation for northern right whales is less encouraging. South Atlantic stocks are increasing at 2 to 3 times the 2.5% (Knowlton *et al.* 1994) to 3.8% (Kenney *et al.* 1995) estimated increase for the North Atlantic population. This low rate of increase is surprising because the population is far below carrying capacity and should be growing exponentially (Pianka 1983). Numerous causes of this low rate of recovery have been proposed. Because female right whales were preferentially targeted by whalers, it is possible that there is a shortage of females in the population, but recent mitochondrial DNA evidence indicates that the ratio of males to females is not significantly different than unity (Brown *et al.* 1994). However, there are proportionally fewer parous females in the North Atlantic population (58/152 or 38%) than there are in the South Atlantic population (320/595 or 54%) (Brown *et al.* 1994). Overall, the northern population is increasing at a lower rate than expected, the pool of reproductively active females is not increasing, and calving intervals are longer than expected. This may be evidence of poor reproductive health in this population (Knowlton *et al.* 1994). This slow recovery could also be caused by inherently low reproductive rates (Reeves *et al.* 1978; Brown *et al.* 1994), inbreeding (Kraus *et al.* 1988; Schaeff *et al.* 1992), or reduction of the population below some "critical population size" (Allen 1974).

Seasonal Distribution of the Northern Right Whale — Generally, right whales are found along the east coast of North America (Figure 4-4, CeTAP 1982) but, in the last century, have been seen as far north as Greenland, as far east as Bermuda, and as far south as the Gulf of Mexico (NMFS 1991a). Right whales, like other large whales, are migratory animals (Gaskin 1982). Some female right whales have been observed to migrate more than 2900 km from their northern feeding grounds to the southern calving/wintering grounds (Knowlton *et al.* 1992). Seasonal movements are among the following five "high use" areas in the North Atlantic: (1) Cape Cod Bay, (2) the Great South Channel, (3) the Bay of Fundy, (4) the Nova Scotian Shelf and (5) the coastal waters of Georgia and Florida.

Cape Cod Bay (CCB): Cape Cod Bay is primarily a spring feeding ground and nursery area for right whales. In February through April, an average of 40 animals arrive and feed in Cape Cod Bay (Marx and Mayo 1992). Between 1978 and 1987, more than one half of all photographically identified animals were seen in this area. Peak abundance, including cow-calf pairs, is in April (Hamilton and Mayo 1990). Feeding, nursing, and mating behavior have all been observed in Cape Cod Bay (Schevill *et al.* 1986; Hamilton and Mayo 1990; Mayo and Marx 1990).

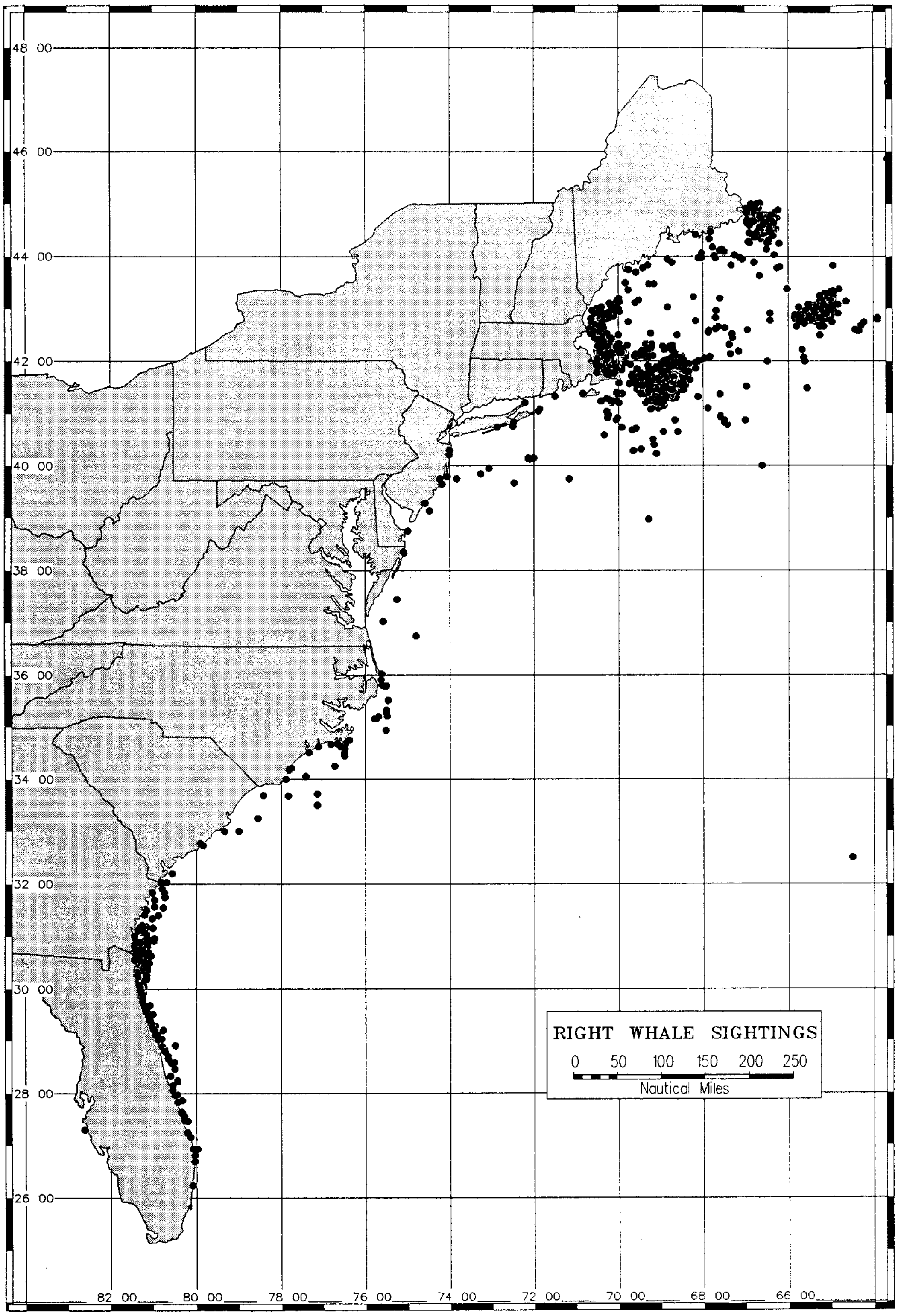

Figure 4-4. Cumulative sightings, 1960-1992, of Right whales along the East Coast of the United States.

Great South Channel (GSC): In the spring, many animals (6 to 22% of the population, and 0 to 57% of all calves), also use the Great South Channel as feeding and nursery ground (Kraus and Kenney 1991). Use peaks in May, when up to 179 animals have been seen in the area. Individuals are usually in temperature-stratified waters north of a persistent thermal front and in water deeper than 100 m. The movement of whales into the Great South Channel is apparently in response to extremely dense aggregations of zooplankton. It is likely that this is the primary feeding ground for the northern right whale (Kenney *et al.* 1995).

Bay of Fundy (BOF) and the Scotian Shelf: In the summer and fall, the lower Bay of Fundy is used as a feeding and nursery area for some animals, including nearly all mother/calf pairs. An additional summer/fall feeding ground, on the southern Nova Scotian shelf, is used almost exclusively by mature right whales (NMFS 1994).

Southeastern United States (SEUS): The coastal waters of Georgia and Florida are the only known calving ground and winter nursery area for the northern right whale. Typically, the majority of animals seen in this area are females about to give birth, females with their newborn calves, and some juveniles. In the winter of 1993-1994, there were 54 sightings of right whales in this region. Of these, 30 sightings were of mother/calf pairs, and 11 were of juveniles in surface active groups (Slay *et al.* 1994). The winter distribution of the remaining population, including all of the adult males and most of the juveniles, is unknown.

Originally it was assumed that right whales remained in these discrete high-use areas for well-defined periods of time (NMFS 1991a). However, recent satellite-telemetry data have shown that some animals regularly move among these high-use areas within seasons (Mate *et al.* 1992). In addition, right whale use of preferred habitats may vary with fluctuating prey availability. During 1986, major shifts in the distribution of many cetaceans occurred apparently in response to changes in prey abundance. Right whales remained in Cape Cod Bay and were also regularly seen on Stellwagen Bank and Jeffreys Ledge throughout the summer (Payne *et al.* 1990). Therefore, movements within and among these high-use areas may vary substantially from year to year.

Critical Habitat of the Northern Right Whale — The northern right whale was listed as endangered on 2 June 1970 (35 FR 8495). The NMFS approved a recovery plan in December 1991, under Section 4(f) of the Endangered Species Act (NMFS 1994). One of the recommendations of the plan was that the designation of critical habitat was essential to the recovery of the northern right whale. On 3 June 1994, NMFS published the "Final Rule Designating Critical Habitat for the Northern Right Whale" (50 CFR Part 226). Based on the best available scientific information and after considering public comment, the following areas were designated critical habitat for the northern right whale, and are considered to be "essential for the reproduction, rest and refuge, health, continued survival, conservation and recovery of the northern right whale population:"

(1) Great South Channel (GSC)
41°40' N/69°45'W; 41°00'/69°05'W; 41°38'N/68°13'W; 42°10'N/68°31'W

(2) Cape Cod Bay (CCB)
42°04.8'N/70°10.0'W; 42°12'N/70°15'W; 42°12'N/70°30'W; 41°46.8'N/70°30'W

(3) Southeastern United States (SEUS)
31°15'N (approximately at the mouth of the Altamaha River, Georgia) and 30°15N (approximately Jacksonville, Florida) from the shoreline out to 15 nm offshore; and the waters between 30°15'N and 28°00'N (approximately Sebastian Inlet, Florida) from the shoreline out to 5 nm.

This designation does not restrict human activities within the critical habitat, but instead is a means of alerting interested parties, including Federal agencies, to the importance of the area, and helps to focus conservation efforts.

Food and Feeding Behavior of the Northern Right Whale — Right whales are known "skim feeders" (Nemoto 1970). As they swim through the water with their mouth agape, large volumes of seawater are filtered through a triangular opening in the baleen at the front of the mouth. As water flows through the mouth, zooplankton are trapped on the fine fringe of the inner surface of their baleen plates (Watkins and Schevill 1976, 1979; Kraus *et al.* 1982; Mayo and Marx 1990). The whale then closes its mouth periodically to swallow its prey. The majority of feeding occurs at depth, but occasionally skim feeding occurs at the surface. When skim feeding, individuals change swimming direction more often than when traveling (Mayo and Marx 1990).

The primary prey of right whales in the western North Atlantic are the calanoid copepod, *Calanus finmarchicus*, and juvenile euphausiids (Nemoto 1970; Watkins and Schevill 1976; Kraus and Prescott 1982; Murison and Gaskin 1989), and secondarily *Pseudocalanus minutus* and *Centropages sp.* (Mayo and Marx 1990). Both the density of plankton patches and the proportion of caloric-rich adult (Stage V) copepods appear to be factors influencing the foraging threshold of right whales (Kenney *et al.* 1986; Murison and Gaskin 1989; Mayo and Marx 1990; Payne *et al.* 1990). Kenney *et al.* (1986) estimated that the "average" 40,000-kg right whale would need up to 2.4×10^3 kcal m^{-3}. In other words, right whales must target extremely dense patches of zooplankton. A group of right whales was associated with such a patch (4.16×10^4 copepods m^{-3} or a median of 2.8×10^3 kcal m^{-3}) for four days while in the Great South Channel (Wishner *et al.* 1988). It is not known how right whales locate these dense patches of food.

Feeding behavior has been observed in Cape Cod Bay, Stellwagen Bank (Watkins and Schevill 1976, 1979; Payne *et al.* 1990), the Great South Channel (CeTAP 1982; Winn *et al.* 1995), Jeffreys Ledge, the lower Bay of Fundy (Kraus *et al.* 1982; Gaskin 1982) and the Scotian Shelf (Brownell *et al.* 1986; NMFS 1991a), and is likely to occur in other areas as well when planktonic conditions are suitable. The broad-scale migratory movements of right whales appear to be correlated with zooplankton "blooms" in areas such as Cape Cod Bay (Mayo and Marx 1990) and the Great South Channel (Kenney *et al.* 1995). The majority of feeding in these areas occurs underwater, and surface skim feeding has not been reported south of New York (NMFS 1991a). Feeding has not been observed in the southern wintering grounds off Georgia and Florida, and it is possible that right whales fast while in that area (Kraus and Kenny 1991).

The vertical distribution of right whales is also influenced by the distribution of their prey. Recent evidence indicates that a foraging right whale modifies its dive patterns to follow the vertical movements of *Calanus finmarchicus*. In the Great South Channel, during years when zooplankton exhibited diel vertical migration patterns, there were diel differences in right whale diving behavior. However, in other years, vertical plankton distribution was more stable throughout the day, and there were no day-night differences in right whale diving patterns (Winn *et al.* 1995). Individuals studied by satellite-monitored radio tags exhibited tremendous variation in their dive patterns (Mate *et al.* 1992).

Reproduction of the Northern Right Whale —The coastal waters of Georgia and northeastern Florida are the only known calving ground of the northern right whale. The late November – early March calving season appears to peak in January. Females give birth to a single 4.0- to 5.5-m calf after a gestation period of at least 12 months (Klumov 1962; IWC 1986). The estimated age of first parturition, 7.57 years, is lower than that estimated for the Argentine population, but it is likely that the estimate for the northern right whale is artificially low due to a lack of data. The mean calving interval for female right whales is 3.67 years and appears to be increasing (Knowlton *et al.* 1994).

From 1980 to 1992, 65 photo-identified cows gave birth to 145 calves (Knowlton *et al.* 1994). Sixty-six calves and 87 photo-identified non-calves, or 48% (153/319) of all cataloged right whales have been observed in the SEUS region. Cows with newborn calves appear to stay in this region longer than other classes of right whales. This, combined with the tendency of cow-calf pairs to stay significantly closer to shore than other right whales (Kraus *et al.* 1993), may increase their risk of human interactions.

The use of a given nursery by females is culturally transmitted (Schaeff *et al.* 1992). Not all mother-calf pairs that are seen in the SEUS wintering grounds are observed the following summer in the Bay of Fundy (Knowlton *et al.* 1994). In addition, based on mtDNA data, one of the three known matrilines does not appear to bring its calves to the Bay of Fundy summer nursery area (Schaeff *et al.* 1993). Therefore, it is likely that at least one other nursery area exists.

Causes of Mortality of the Northern Right Whale — Analyses of sighing data between the northern feeding areas (Bay of Fundy and Cape Cod Bay) and the southern calving areas (SEUS) indicate that about 17% of calves die within their first year of life. After the first year, mortality rates drop to an average of 3% for the next three years, or a total of 27% mortality for the first four years of life (Kraus 1990). Thirty-two percent of this mortality and 53% of the documented non-neonatal deaths are human-induced. The estimated rate of mortality for adults is 1% (Kraus 1990) to 4% (Gaskin 1982). Even a few incidental deaths may greatly affect the rate of increase in a drastically reduced population with such a long reproductive cycle (Best 1988).

Sei whales (*Balaenoptera borealis*) (Mitchell 1975; Mitchell *et al.* 1986), sand lance (*Ammodytes spp.*) (Payne *et al.* 1990; Kenney *et al.* 1986), and other planktivorous species could represent a source of competition for the preferred prey *(Calanus finmarchicus)* of the right whale. In 1986, when *C. finmarchicus* levels were high in the Gulf of Maine, right whales, fin whales, and sei whales were the dominant cetaceans in the area. Although Kenney *et al.* (1995) and Knowlton *et al.* (1994) report an increase in sei whales in the GSC and Nova Scotian Shelf, there is little quantitative evidence of direct competition between right whales and the other species. In addition, *C. finmarchicus* populations are highly variable, and little of this variation is due to predation pressure (McLaren *et al.* 1989; Tande and Slagstad 1992).

It has been suggested that killer whales (*Orcinus orca*) may, in part, be responsible for the lack of bowhead whale population recovery in the eastern Arctic (Mitchell and Reeves 1982). This could also be true for right whales. At least 3% (NMFS 1991a) to 9% (Kraus 1990; Kenney and Kraus 1993) of the cataloged right whales bear scars, primarily on the flukes, from killer whale attacks (Kraus *et al.* 1986; Kraus 1990). Killer whales are relatively uncommon in the North Atlantic, but have been observed in the coastal waters of Georgia and Florida (Layne 1965), and in the Gulf of Maine (Katona *et al.* 1988). Deaths due to killer whale attacks have been documented for other species of baleen whales (Hancock 1965; Baldridge 1972; Silber *et al.* 1990).

Many investigators consider habitat change to be the key environmental factor affecting the rate of recovery of the right whale (NMFS 1991a; Gaskin 1991). Of primary concern are the anthropogenic sources of change such as pollution, oil and gas exploration, sea-bed mining, and a general increase in coastal activities due to an increase in human population along the east coast (NMFS 1994c; EPA 1993). Numerous dump sites are located in Cape Cod Bay, near Stellwagen Bank (NMFS 1991a) and all along the east coast of the United States. Many municipalities discharge treated and untreated wastewater into the coastal waters of New England and Georgia/Florida. These discharges, as well as dredging and disposal of dredged material, may alter the physical and chemical properties of nearshore waters and sediments, making them unsuitable for right whale feeding and reproduction (EPA 1993). Intensive human use of areas such as Delaware Bay, the New York Bight, and Long Island Sound may have resulted in the exclusion of right whales from areas they once frequented (Reeves *et al.* 1978). Pollution resulting from intentional or accidental releases of chemicals to coastal waters has also been suggested as an important factor in the apparent poor recovery of North Atlantic right whale populations (Gaskin 1991). Although trace concentrations of several chemicals have been found in tissue samples from right whales (Woodley *et al.* 1991), there is no direct evidence to date that right whales have been adversely affected by pollutants, either through a pollution-induced increase in mortality rates or decrease in reproductive rate or success (EPA 1993). In the future, the EPA has agreed to analyze tissue samples, obtained from biopsy sampling or strandings, for contaminants so that contaminant loads can be monitored (NMFS 1994c).

Currently, there is no active drilling for oil and gas along the North Atlantic coastline, and MMS does not plan to offer leases for such activities in this area as part of its five-year outer continental shelf oil and gas leasing program (MMS 1996). However, such leases could occur in the future. Possible adverse effects to right whales include acoustic disturbance from seismic vessels and drilling rigs, and pollution resulting from accidental releases during performance of these activities. Previous studies of oil exploration activities conducted off the east coast in the 1980s concluded that cetacean distributions around oil rigs were no different than distributions in undisturbed areas (Sorenson *et al.* 1984). Studies off the California and Alaska coastlines have shown that most species of cetaceans adjust to the presence of drilling equipment (Geraci and St. Aubin 1987). However, studies of bowhead whales in the Arctic indicate that individuals will often change course and behavior when exposed to active rigs and seismic vessels (Ljungblad *et al.* 1988; Richardson *et al.* 1985, 1986). Bowhead whales in the Beaufort Sea react, at least briefly, to aircraft, ships, seismic exploration, marine construction and offshore drill sites (Richardson and Malme 1993). To date, there is no conclusive evidence that this short-term disturbance leads to long-term effects on individuals or populations (Richardson *et al.* 1995). Oil and gas exploration inevitably leads to increased ship traffic in the area which, as discussed, is problematic for right whales.

Although right whales spend a great deal of time underwater (Mate *et al.* 1992) they also spend prolonged periods at the surface while surface skim-feeding, resting, and in surface courtship groups (NMFS 1991a). This, and the fact that many of the high-use areas for right whales include major shipping lanes or high-traffic areas along the east coast, makes them susceptible to interactions with ships. Vessel activities can change whale behavior, disrupt feeding practices, disturb courtship rituals, disperse food sources, and injure or kill whales through collisions (NMFS 1994). Twelve percent of all photo-cataloged individuals have scars from ship propellers (S. Kraus, pers. comm. 1995), and 27% (8/30) of right whale mortalities documented between 1970 and 1993 were due to collisions with ships (Kenney and Kraus 1993). Lately, research has pointed to ship-whale interactions as a possible barrier to the recovery of the species (Reeves *et al.* 1978; Kraus *et al.* 1988; Kraus 1990). The majority of human-induced right whale mortalities documented since 1970 were due to collisions with ships (Kenney and Kraus 1993). Right whales monitored by satellite telemetry frequently swam through or near the shipping lanes off Boston, Portland, Maine, and New York (Mate *et al.* 1992). As has been documented for bowhead whales (George *et al.* 1994), the size and extent of scarring among right whales indicates that collisions are primarily with large vessels such as container ships and tankers. These collisions are fatal to right whales approximately 19% of the time (Kraus 1990). Adjusting shipping lanes to reduce ship/whale collisions may be only partly effective because right whales appear to use much of the North Atlantic coastline (Mate *et al.* in prep).

More than half (57%) of the appropriately photographed population of right whales have scars indicative of entanglement in commercial fishing gear. Between 1975 and 1990, 14 right whales were observed tangled in fishing gear in the Gulf of Maine. Gill nets appear to be the most problematic type of fixed gear, but individuals appear to swim through all types of gear including wires, lobster gear, seines, and cod traps. Gear and lines become wrapped around the peduncle or tail stock, around the pectoral fins, or are caught in the gape of the mouth and become wrapped around the head (Kraus 1985, 1990; NMFS 1994). If animals are unable to surface to breathe, they will drown. Nets and lines may stay attached for long periods of time due to the use of synthetic, rot-resistant materials by the fishing industry. This may be especially dangerous for juveniles that become entangled while still actively growing. Of the 30 known mortalities since 1970, two (7%) have been attributed to entanglement in fishing gear (Kenney and Kraus 1993). In 1994, three whales were reported entangled in gear in the Gulf of Maine and the Bay of Fundy, and two or three additional animals were reported to be injured by gill nets in the SEUS (NMFS 1995a). At least two individuals ("Stars" and "Necklace") were entangled for more than four years and have been recently photographed without the gear (NMFS 1991a). Although entanglement is less likely to result in a direct mortality (2.9% of gear entanglements are fatal, based on revised Kenney and Kraus 1993 data), it may weaken an animal, making it more susceptible to disease, killer whale attacks, or collisions with ships (Kenney and Kraus 1993). Seasonal and regional restrictions on fishing areas have been proposed as a means of minimizing interactions between the fishing industry and right whales. However, recent studies indicate that individual right whales do not remain in discrete areas for well-defined periods or seasons. Regional closures may therefore be ineffective, and alternatives related to gear modifications or fishing methods may be necessary (Mate *et al.* in prep).

Recovery Program for the Northern Right Whale — Management can be most effective in reducing the sources of human mortality. Finn (1992), using an age- and stage-based population model, concluded that a reduction in ship strikes and fishing gear entanglements would significantly improve the growth of the population. The Right Whale Recovery Plan (NMFS 1991a) was developed to coordinate actions that will promote the recovery of the species so that protection under the Endangered Species Act is no longer necessary. In recent years, the NMFS has collaborated with numerous Federal (including the USCG) and State agencies to implement major actions included in the Right Whale Recovery Plan. In addition to basic research efforts, numerous actions have been taken to reduce anthropogenic sources of mortality in both northern and southern right whale habitat. In the northern feeding areas, mariners are advised of the locations of right whales via NOAA weather radio broadcasts. In the Southeast Region, 10 agencies are coordinating their efforts to educate mariners and prevent whale-ship collisions under the auspices of the Southeast U.S. Implementation Team. Specifically, an early warning system, utilizing the extensive USCG communications system and the NAVTEX system, have been used to successfully mitigate ship strikes (Slay *et al.* 1994). This system is not always effective due to variations in the atmospheric conditions and because NAVTEX coverage is incomplete. By 1999 (mandatory use date), the NAVTEX system will be capable of enhancement through INMARSAT (International Marine Satellite), a satellite-based system unaffected by atmospheric conditions. Also, the USCG has initiated a study of the feasibility of installing additional NAVTEX transmission devices. The NAVTEX warning system is backed up by "Notice-to-Mariner" broadcasts on VHF radio. An extensive education program is also being developed through the University of Georgia.

Humpback Whale **(Megaptera novaeangliae).**

Population Status and Trends of the Humpback Whale — The humpback whale (*Megaptera novaeangliae*) is the fifth largest of the baleen whales, reaching lengths in the Atlantic Ocean of 16 m. The Latin name, roughly translated as "big-winged New Englander," is derived from the distinct long pectoral fins that are one-third the length of the body (and usually white in the North Atlantic) and the fact that these whales are common in the waters of New England. Other distinguishing features include fleshy protuberances or "tubercles" that cover the whale's rostrum, a small variably shaped dorsal fin located two-thirds down on the back, and well-defined ventral grooves. The body of the humpback is generally black in color, but individually distinctive black and white pigment and scar patterns occur on the underside of the broad tail or "flukes," the belly, and the pectoral fins. These patterns, along with dorsal fin shape and scarring, are used to identify individual whales (Katona *et al.* 1980; Katona and Whitehead 1981). Calves appear to inherit the fluke pigmentation patterns of their mothers (Rosenbaum and Clapham 1993).

Humpback whales are found in all of the world's oceans and tend to be more coastal and gregarious than other species. In the North Atlantic Ocean, there are at least two "stocks" of humpback whales — an eastern and a western stock. The western stock includes about 5500 animals and winters in the Caribbean Sea. The summer feeding grounds of this western stock include the Gulf of Maine, the Bay of Fundy, the Gulf of St. Lawrence, and waters off Newfoundland (Figure 4-5). For the purposes of this report, our discussion will be primarily limited to whales in the western North Atlantic and, specifically, the Gulf of Maine feeding aggregation. Before commercial exploitation, it is estimated that there were 125,000 humpback whales worldwide (Braham 1984; NMFS 1991b). By 1865, harvesting had reduced the western North Atlantic population to 4400-4700 animals (Mitchell and Reeves 1983) and, by 1932, to as few as 700 animals (Breiwick *et al.* 1983). Recent evidence indicates that humpback whales are increasing at an annual rate of 9.4%; however this calculated trend was not strong (r^2=0.33, 95% CI of slope=-0.12 to 0.30; Katona and Beard 1990). "Current" population estimates range from 2000-6000 individuals (Whitehead 1982) to 5505 ± 2617 individuals (95% CI; Katona and Beard 1990) in the western North Atlantic stock. CeTAP researchers (1982) estimated the mean number of humpbacks in U.S. waters (Cape Hatteras to southern Nova Scotia) during the spring to be 658 ± 590 (95% CI). Recent estimates range from 5543 individuals (CV = 0.16; Katona *et al.* 1994) for all aggregations west of Iceland to 294 whales (CV = 0.45) for the northeastern U.S. EEZ (NMFS 1995a). Based on the College of the Atlantic humpback whale photograph catalog, the western North Atlantic population numbers around 800 animals (P. Stevick, pers. comm., March 1995). A large-scale, multi-institutional effort is underway (Years of the North Atlantic Humpback or "YONAH") to further refine stock structure and population estimates of these whales in the western North Atlantic.

The humpback whale is a migratory species, and spends the summer in northern latitude feeding grounds (40° to 75° N) in areas of high productivity (NMFS 1991b). Because of the patchy distribution of their prey, humpback whales must target locations where the chance of prey encounter is high. Like other baleen whales, they are found in areas of upwelling, along the edges of banks, and all along the continental shelf and other physically dynamic areas. Fine-scale movements among these features are most likely controlled by the distribution of their prey (Kenny and Winn 1986; Gaskin 1982; Payne *et al.* 1990; Brodie *et al.* 1978; Dolphin 1987a,b; Mayo *et al.* 1988). Although there appears to be some broad-scale, matrilineal feeding-site fidelity (Clapham and Mayo 1990, 1987), shifts in summer distributions of humpbacks along the Newfoundland coast (Whitehead and Carscadden 1985) and in the Gulf of Maine (Payne *et al.* 1986) have occurred in apparent response to changes in prey abundance. Historically, humpback whales were most abundant in the northern Gulf of Maine, where herring and mackerel were plentiful. However, in the 1970s, herring and mackeral stocks declined due to increased commercial fishing efforts. Simultaneously, sand lance stocks in the southern Gulf of Maine increased, and humpback whales moved south to exploit this alternative food source. Stellwagen Bank, Jeffreys Ledge, and the Great South Channel became the primary humpback whale feeding areas in the western North Atlantic. In 1986, sand lance populations decreased, zooplankton populations increased, and humpback whales temporarily abandoned these banks and basins, and were replaced by plantivorous species such as right whales and small numbers of sei whales (Payne *et al.* 1990).

One of the primary feeding grounds of the humpback whale is Stellwagen Bank, a submerged glacial deposit of sand and gravel that extends for 37 km between Cape Cod and Cape Ann, Massachusetts. On 4 November 1992, this area was designated a national marine sanctuary under Title III of the Marine Protection, Research and Sanctuaries Act (MPRSA). Drilling, dredging, and other activities considered to have adverse effects on the wildlife in the area are prohibited. Recreational and commercial fishing activities, while monitored, are not prohibited. Since 1988, a dramatic decline in the use of Stellwagen Bank by adult humpback whales has occurred, apparently due to the decline in sand lance populations in the area (Weinrich *et al.* 1993).

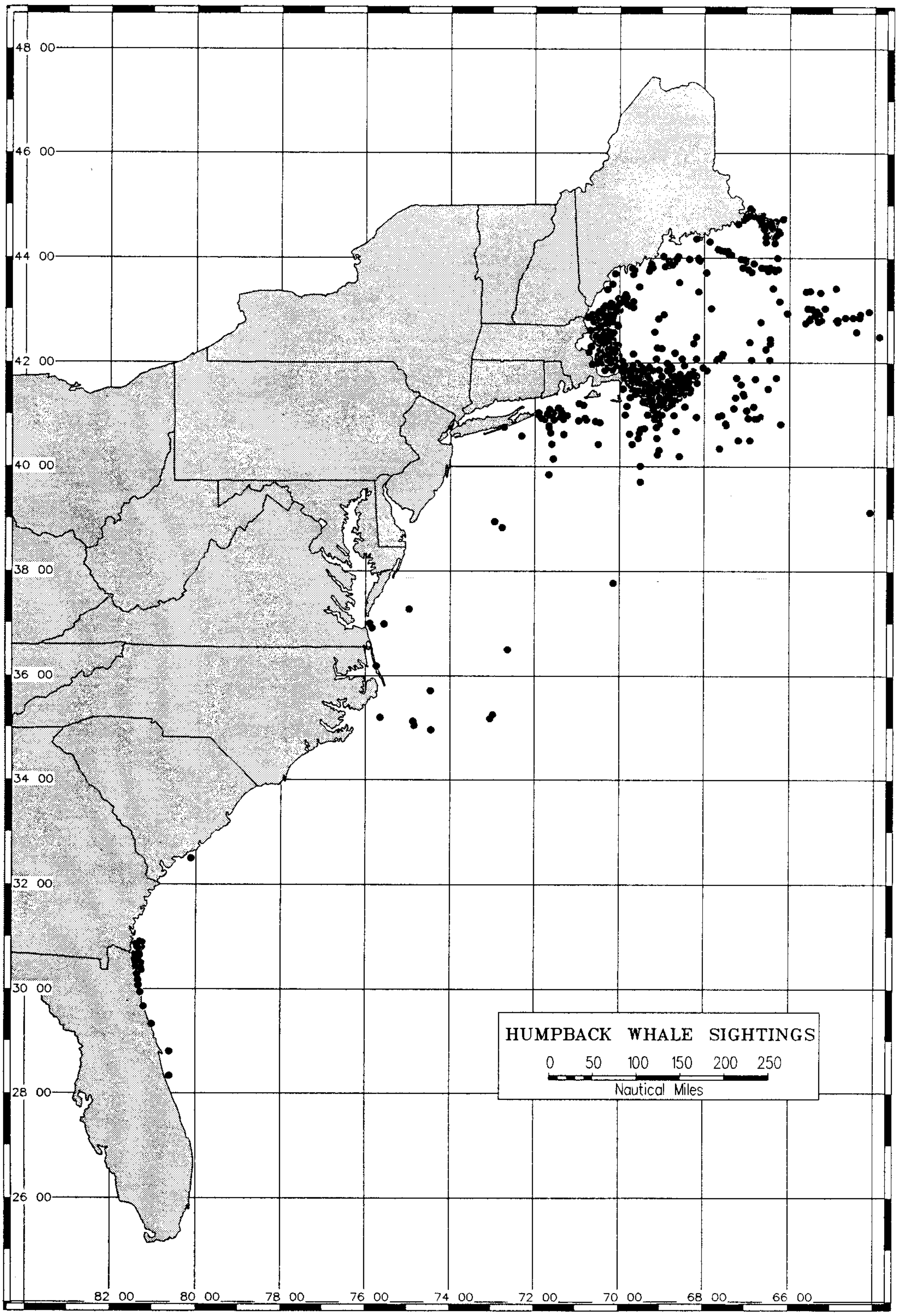

Figure 4-5. Cumulative sightings, 1960-1992, of Humpback whales along the East Coast of the United States.

There is increasing evidence that some juvenile humpback whales may remain in northern latitudes during the winter. Swingle *et al.* (1993) report an increase in juvenile humpback whales off the coast of Virginia, especially in the mouth of Chesapeake Bay, during January through March 1991-1992. Many of these individuals were observed feeding. Wiley *et al.* (1995) report an increase in stranded juvenile humpback whales along the Virginia and North Carolina coasts between 1985 and 1992. It appears that these mid-Atlantic waters are becoming an increasingly important winter habitat for juveniles, possibly due to the expanding range of humpback whales or changes in prey distribution (Wiley *et al.* 1995). Because this distribution overlaps with some of the busiest commercial and military shipping lanes on the east coast of the United States, and due to the substantial anthropogenic use of the area, adverse interactions are likely (Wiley *et al.* 1993; Swingle *et al.* 1993; Wiley *et al.* 1995).

Individuals leave the feeding grounds in the fall and winter and swim south to the Caribbean, primarily to areas between 10° and 20°N latitude (Whitehead and Moore 1982). The endpoints of this migration are well established (Martin *et al.* 1984; Matilla *et al.* 1989; Katona and Beard 1990). However the exact route between the summering and wintering grounds is unknown, although it is likely to be well offshore (Clapham and Matilla 1990). Humpback whales from all of the western North Atlantic feeding areas use the same wintering grounds (Matilla *et al.* 1989; Katona and Beard 1990). The majority (85%) of whales from the western North Atlantic population winter on Silver and Navidad Banks (Balcomb and Nichols 1978; Whitehead and Moore 1982; Mattila *et al.* 1989), located off the north coast of the Dominican Republic. Virgin Bank, the northern Leeward Islands; Mona Passage, Puerto Rico; and Samana Bay, Dominican Republic are also used, although to a lesser degree (Matilla and Clapham 1989). Individual speeds of 3.29 km/h (21° latitude/month) and 2.28 km/h (14.8° latitude/month) were calculated for two whales migrating between the Greater Antilles and Massachusetts Bay (Clapham and Mattila 1988). Currently, there is little evidence of age-class or sexual segregation among migrating humpback whales (NMFS 1991b).

On the wintering grounds, groups of 2-25 males compete for access to females, ramming each other or pounding with flippers or flukes (Tyack and Whitehead 1983; Baker and Herman 1984). Male humpback whales also produce very long, complex vocalizations or "songs" that appear to be part of a courtship display (Tyack 1981; Tyack and Whitehead 1983; Chu and Harcourt 1986). The significance of the few songs recorded on summer ranges (Matilla *et al.* 1987) is unknown (NMFS 1991b). While in these southern latitudes, it is likely that whales fast most of the winter, although some limited feeding has been observed (Baraff *et al.* 1991).

Food and Feeding Behavior of the Humpback Whale — Humpback whales feed primarily on small schooling fish and krill (Nemoto 1970; Kreiger and Wing 1984, 1986). In the western North Atlantic, herring (*Clupea harengus*), sand lance (*Ammodytes americanus*), and capelin (*Mallotus villosus*) appear to be the preferred prey. Mackerel (*Scomber scombrus*), small pollack (*Pollachius virens*), haddock (*Melanogrammus aeglefinus*), and krill (*Meganyctiphanes norvegica*) are also exploited opportunistically (Meyer *et al.* 1979; Overholtz and Nicolas 1979; Whitehead 1987).

Humpback whales are considered "gulpers" (Nemoto 1970) and use innovative feeding methods to capture their prey. Feeding styles vary among whales and may be correlated with the species of prey and its distribution. In the Gulf of Maine, individuals often use their flukes and pectoral fins to slap the water, possibly to concentrate or stun prey into a tight mass that will be easy to engulf (Weinrich *et al.* 1992). The long, white pectoral fins may also be used to concentrate schooling fish (Sharpe and Dill 1993). A second method, "lunge feeding," involves rushing from below a school of fish with the mouth closed and, once the fish are trapped against the water's surface, opening the mouth, lunging through the school of fish and occasionally through the water's surface. The mouth is then closed, water is strained from the mouth, and the prey are swallowed (Watkins and Schevill 1979). Humpbacks will lunge feed alone or in groups of up to 22 animals (Hain *et al.* 1982) and the technique is most dramatic when schools of fish or krill are close to the surface.

Bubble-feeding is the most unique of the feeding behaviors. Humpback whales force air from the mouth through the baleen plates to form a 4- to 7-m "net" of small, uniformly sized bubbles, or a "column" of randomly sized bubbles that encircle or confuse prey (Hain *et al.* 1982). Recent laboratory studies of herring and simulated bubble nets and columns have shown that these bubbles produce a strong startle response in schooling fish, and that fish rarely swim through bubbles even when startled (Sharpe and Dill 1993).

Reproduction of the Humpback Whale —To date, reliable observations of copulation in humpback whales have not been published. Humpback whales reach sexual maturity at about 4-6 years of age. The gestation period is 10 to 12 months, and mothers usually nurse their calves for one year or less (Clapham 1992; Baraff and Weinrich 1993). Mothers and calves are closely associated throughout the period of lactation and usually separate at some point toward the end of the calf's natal year (Clapham 1992). Females usually calve every two to three years and have a mean annual reproductive rate of 0.41 calves per year (Clapham and Mayo 1990). At birth, calves are about 4 m long. Calving has occasionally been observed in consecutive years (Clapham and Mayo 1990; Weinrich *et al.* 1993). Therefore, females can produce viable offspring after becoming pregnant during post-partum estrus. Calves are born primarily in the winter in the Caribbean and accompany their mothers to high-latitude feeding areas during the following spring or summer. Migration routes and the location of feeding areas are probably learned by calves as they accompany their mothers (Martin *et al.* 1984; Baker *et al.* 1986).

Causes of Mortality of the Humpback Whale —Very little is known about the natural mortality of humpback whales. Parasites, ice entrapment, and fluctuating prey populations due to events such as El Niño may affect humpback mortality rates (NMFS 1991b). The only natural mass mortality on record was that recorded between November 1987 and January 1988, when 14 humpback whales died in the Gulf of Maine, apparently after consuming mackeral contaminated with saxitoxin (Geraci *et al.* 1989). In the western North Atlantic, 14% (464/3365) of the appropriately photographed humpback whales bear scars, primarily on their flukes, from killer whale (*Orcinus orcas*) attacks (Katona *et al.* 1988; NMFS 1991b). Although humpback whales and killer whales have been observed feeding near one another without aggressive interactions (Dolphin 1987c), killer whales have been observed attacking and killing other species of baleen whales (Silber *et al.* 1990; Baldridge 1972; Hancock 1965).

The most common anthropogenic source of mortality for humpback whales in the western North Atlantic is entanglement in commercial fishing gear (Hoffman 1990; NMFS 1991b; Volgenau, Kraus and Lien 1995). Between 1975 and 1990, 47 humpback whales were reported entangled in various types of fishing gear. Five of these entanglements were fatal (10.6%). Overall, 12.4% of the photographed flukes and 6.3% of the tail stocks of the western North Atlantic population are scarred due to encounters with fishing gear (Volgenau, Kraus and Lien 1995; Kraus 1990). Twenty-five percent (5/20) of juvenile humpback whales stranded along the central and southeast Atlantic coastlines had injuries indicative of entanglement in fishing gear (Wiley *et al.* 1995).

Increasing vessel traffic along the continental shelf can result in acoustic and physical disturbance of the environment. To date, there is little information on the reaction of humpback whales to acoustic disturbance. Some studies indicate that whales may react to short-term acoustic disturbances by moving away from the sound source, changing breathing and diving patterns, or through possible agonistic displays (NMFS 1991b). Proposed studies of marine mammal reactions to low frequency noise are currently under review. Studies in Hawaii revealed that increase in human activities in some coastal areas may have displaced humpback whale mother-calf pairs (Forestell 1986). However, the primary threat of overlapping shipping activities and humpback distributions is whale-ship collisions. Humpbacks are more habituated to vessel approach than any other cetacean in the Gulf of Maine (Watkins 1986). A large whale-watching industry has taken advantage of this phenomenon; some whales even appear to be attracted to boats (S. Nieukirk, pers. obs.). Major shipping lanes into Massachusetts, New Hampshire, and Maine cross the Great South Channel, Stellwagen Bank, and Jeffreys Ledge feeding grounds (NMFS 1991b), and humpback whales are frequently seen near commercial vessels, fishing, and tourist boats. If whales become habituated to such vessel traffic, the chance of collision could increase (Beach and Weinrich 1989). There is some evidence of increased incidents of ship collisions in the Gulf of Maine (NMFS 1991b). In a recent study of stranded humpback whales along the mid-Atlantic and southeast United States, 30% (6/20) had injuries potentially associated with a ship strike (Wiley *et al.* 1995).

***Fin Whale* (Balaenoptera physalus).**

Population Status and Trends of the Fin Whale —The fin whale, *Balaenoptera physalus*, is the second largest of the cetaceans, reaching lengths of 24 m (Leatherwood *et al.* 1976) and weighing up to 73,000 kg (Minasian *et al.* 1984). These "greyhounds of the sea" are among the fastest of the baleen whales, and are reported to swim at speeds approaching 20 knots. For this reason, they became a commercially important species only after the development of fast catcher boats and the depletion of other large species such as the right whale and blue whale (Leatherwood *et al.* 1976).

Fin whales have a long slender body that is primarily dark gray or brown in color. The ventral sides of the belly, flukes, and flippers are white. Like humpback whales, fin whales can be individually identified from their natural marks and scars. Distinctive features include the tall falcate dorsal fin, the light pigmentation or "blaze" on the right side of the head, and the V-shaped grey-white "chevron" on the back and sides (Agler *et al.* 1990). One of the most unusual features of the fin whale is its asymmetrical coloration. The right side of the head, lower lip, upper lip, and a portion of the baleen is white, while the entire left side of the head is dark in color. It has been hypothesized that this coloration is a feeding-related adaptation (Katona *et al.* 1993). However, to date there is no evidence of this (Tershey and Wiley 1992).

The average adult size calculated for fin whales in the western North Atlantic is 16.1 m and is smaller than for adults captured in Iceland (18.3 m), Canada (16.9-18.4m), and Norway (17.6-18.9m) (Hain *et al.* 1992). This may be due to sexual differences, seasonal or environmental factors, latitudinal differences, or a sampling bias. It may also be due to segregation in the population (Seargent 1977). It is unclear whether fin whales in the North Atlantic split into separate feeding stocks. Mitchell (1974) suggested that fin whales seen off the United States, Nova Scotia, and Labrador coasts were from one or a few closely related populations. Fin whales often travel alone but, on average, group sizes range from 2 to 3 animals and can be as large as 65 animals. Large groups (more than 10 whales) are uncommon (CeTAP 1982).

Pre-exploitation fin whale population estimates for the entire North Atlantic Ocean range from 30,000 to 50,000 individuals (Katona *et al.* 1993). World-wide, there are currently an estimated 105,000 to 125,000 fin whales (Wursig 1990). During the CeTAP (1982) study, 24% of all cetaceans and 51% of all baleen whales counted were fin whales. Between Cape Cod and Labrador, 7200 fin whales were estimated to be on the continental shelf between 1966 and 1971 (Mitchell 1974). Hain *et al.* (1992) estimate that, after correcting for animals underwater during aerial surveys, there were 1500 animals on the Cape Hatteras-to-Cape Cod continental shelf area during the fall and winter, and 5000 animals on the shelf in the spring and summer. If fin whales are increasing at a rate similar to that estimated for unexploited stocks of right whales in the southern hemisphere (6.8%), then there could currently be more than 10,000 fin whales in the western North Atlantic (Hain *et al.* 1992), and the population will have recovered to about 25-33% of its pre-exploitation size. Because the fin whale is the most numerous of the large cetaceans, it probably has the largest impact on the continental shelf ecosystem, and may be a valuable indicator of the health of this area (Hain *et al.* 1992).

Seasonal Distribution of Fin Whales —Fin whales are the most common of the large whales in the temperate waters of the western North Atlantic, and are found all along the continental shelf between Cape Hatteras and southeastern Canada in all seasons (Figure 4-6; Hain *et al.* 1992). Their distribution is cosmopolitan, with a less distinct seasonal latitudinal migration than other rorquals (Evans 1987). The distribution, abundance, and general ecology of the species is poorly understood, primarily because fin whales were not heavily exploited by commercial whalers in U.S. waters to the degree that they were exploited in other areas. However, studies have recently been organized to fill these gaps in our understanding of fin whale ecology. Fin whales are commonly seen on the shelf in water 2-100m deep, and rarely on the continental slope or beyond. Jeffreys Ledge, Stellwagen Bank, and Cape Cod Bay experience a spring influx of fin whales and, by summer, numbers may reach 3000 in the Gulf of Maine (CeTAP 1982). There is some evidence of feeding site fidelity in females (Clapham and Seipt 1991), although this varies among individuals (Seipt *et al.* 1990). During the fall and winter, 75% of these whales leave the area, and the distribution of the remaining whales contracts to the mid-shelf east of New Jersey, Stellwagen Bank, and Georges Bank. It is not known where the majority of the population spends the winter; however, recent acoustic data indicate that fin whales are present far offshore during the winter months (Clark *et al.* 1993). During the winter and spring, the area east of the Delmarva Peninsula and the mouth of the Delaware Bay appear be an important habitat (CeTAP 1982).

Food and Feeding Behavior of the Fin Whale — The sand lance (*Ammodytes spp.*) is an important food source for fin whales (Watkins and Schevill 1979; Overholtz and Nicolas 1979; Payne *et al.* 1990). Additional prey includes other schooling fish, euphausids, and copepods (Mitchell 1975). Herring may have been the preferred food at one time but, due to the decline in stocks in recent years, may no longer be an important food source (CeTAP 1982). Fin whales will feed either alone or, when food is densely concentrated, in groups of 2-65 animals, and will "lunge feed" when food is close to the surface. As they make a horizontal approach to a school of fish, individual fin whales will open their mouths just before reaching the school, often rolling to their right (Tershey and Wiley 1992), engulf the fish with ventral pleats extended, and roll upright to surface for a breath (Watkins and Schevill 1979). In Newfoundland, several authors observed fin whales in fairly large, stable, foraging groups and speculated that fin whales may "coordinate" their foraging activities to minimize prey dispersion (Perkins and Whitehead 1977; Whitehead and Carlson 1988) and because high-density prey patches are uncommon (Piatt 1990). Fin whales usually feed at depth and, although rarely observed, limited observations suggest that subsurface feeding behavior is similar to that of lunge feeding (Tershey and Wiley 1992). Feeding was observed in 14% of all CeTAP (1982) sightings, and occurred primarily in the spring and summer, and along the Great South Channel to Jeffreys Ledge and east of Montauk Point.

As previously discussed for right whales and humpback whales, the distribution of fin whales is likely a function of the distribution of their food (Katona and Whitehead 1988). Capelin abundance alone accounted for 63% of the seasonal variation in baleen whale abundance in Newfoundland waters (Piatt *et al.* 1989). Because of their large size, fin whales may depend on higher density prey patches than other smaller baleen whales. However, the foraging thresholds of baleen whales may vary in relation to the overall abundance of their prey (Piatt and Methven 1992). Fin whales are euryphagous and, therefore, in years when their preferred prey is scarce (*i.e.*, 1986), their distribution within the Gulf of Maine varied to a lesser degree than that of stenophagous species (Payne *et al.* 1990).

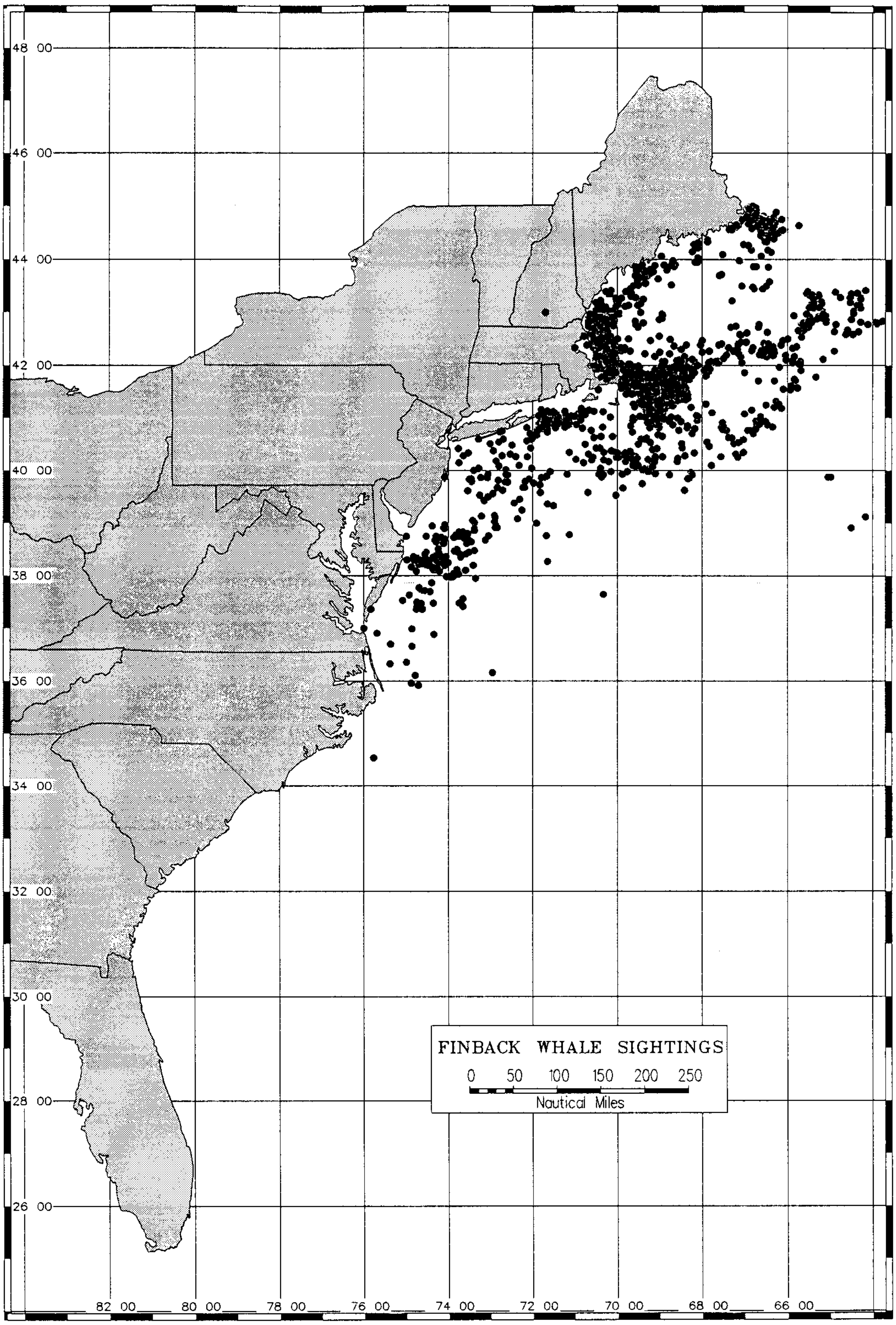

Figure 4-6. Cumulative sightings, 1960-1992, of Finback whales along the East Coast of the United States.

Reproduction of the Fin Whale — Female fin whales become sexually mature at 4 to 6 years of age and bear a single calf about every two years (Slijper 1978). Female fin whales that summer in the Gulf of Maine produce a calf every 2.71 years (Agler *et al.* 1993). Calving is likely to occur in winter and, based on stranding data, may take place between October and January in the mid-Atlantic Bight. Like other species of baleen whales, calves grow rapidly while ingesting very high-fat milk, are weaned within 5-7 months (Slijper 1978), and probably accompany their mothers to more northern latitudes. Stranding data indicate that young calves (8-12m in length) appear to move as far north as Cape Cod (42°N), where they are found stranded in all other months except March (Hain *et al.* 1992).

Causes of Mortality of the Fin Whale —Very little is known about the natural causes of mortality in fin whales. In the last century, 72 fin whales have stranded along the east coast of the United States. The cause of death in most of these animals is unknown. Fin whales stranded most often on Cape Cod, Cape Hatteras, and Long Island during all months of the year (Hain *et al.* 1992). There have been six recorded strandings of neonate fin whales (animals less than 8 m in length) along the east coast of the United States. All of these animals stranded south of New Jersey (40°N latitude). At least one fin whale death was reported during the humpback whale mass mortality that was linked to saxitoxin (Geraci *et al.* 1989). Lambertson (1986) reported that the nematode *Crassicauda boopis* appears to be a common parasite in many fin whale kidneys, and may cause renal failure and possibly death in this species.

There have been few reports of killer whale scars on finback whales. This could be because these scars appear primarily on the flukes in other species, and fin whales rarely raise their flukes during a terminal dive. Fin whales are also fast swimmers, and may be able to elude killer whales. However, there are reports in the literature of killer whales attacking fin whales (Tomilin 1957).

Fin whales are one of the more difficult cetaceans to approach by boat (Katona *et al.* 1993; Watkins 1986). However, some of the photographed fin whales have prominent scars indicative of boat collisions (*i.e.*, "Braid," whale #0081) (Agler *et al.* 1990; Seipt *et al.* 1990). In the Smithsonian Institution's marine mammal database, there are nine records of fin whale-ship collisions or propeller scars between 1980 and 1994 (NMFS 1995a). While feeding, fin whales often change direction unpredictably and seem unaware of boats in the area (S. Nieukirk, pers. obs.).

Fin whale vocalizations are among the lowest on earth. Typically, calls are about 20 Hz, occur in pulses 8-12 seconds apart, and are possibly part of a reproductive display (Watkins 1981; Watkins *et al.* 1987). Fin whales react strongly to low-frequency ship sounds (Watkins 1986) and, therefore, may be adversely affected by low-frequency acoustic disturbances such as those produced by large ships. If fin whales become acclimated to the increasing vessel traffic in coastal waters, they may be more susceptible to collisions with ships.

Fin whales are often caught in fish traps deployed in offshore Canadian waters. Between 1969 and 1986, 12 fin whales were entangled in fishing gear, usually groundfish gill nets, in inshore waters of Newfoundland (Hoffman 1990). Five (42%) of these whales died. Between 1975 and 1992, nine fin whales were reported to be entangled in fishing gear in U.S. waters. Two of these entanglements were fatal.

Sei Whale (Balaenoptera borealis).

Population Status and Trends of Sei Whales — Sei whales are slightly smaller than fin whales and, in the Atlantic, grow to 19 m. A single head ridge, tall (0.25-0.6 m) and strongly falcate dorsal fin located two-thirds of the way down on the back, and lack of asymmetrical jaw coloration distinguish the sei whale from the fin whale. The body is dark grey on the back and sides, and is often covered with oval-shaped scars possibly due to lamprey bites inflicted during migrations into warmer waters. Sei whales have 32-60 very short ventral grooves that terminate between the flippers and the navel (Leatherwood *et al.* 1982). Sei whales travel alone or in groups of 2-5 individuals, but may form dense aggregations when food is concentrated and plentiful (Leatherwood *et al.* 1976). They are the fastest swimmers of the great whales and can attain speeds in excess of 38 km/h (24 miles/h; Minasian *et al.* 1984).

There are two stocks of sei whales in the western North Atlantic Ocean. One stock is off eastern Nova Scotia and the other stock is in the Labrador Sea (Mitchell and Chapman 1977). These two stocks, plus a third stock in the Gulf of Mexico are thought to number 2600 individuals (Leatherwood *et al.* 1976). Sei whales in the southern Gulf of Maine have been photographically matched to individuals sighted on both Georges Bank and the Scotian Shelf; thus individuals periodically seen in the Gulf of Maine may be from the Nova Scotia stock. However, very little is known about sei whales in the western North Atlantic, and given the previously reported record of a sei whale moving 4000 km in 10 days (Brown 1977), this may not be the case.

There are no current estimates of the abundance of sei whales in U.S. waters of the western North Atlantic Ocean. The most recent data are from the CeTAP (1982) study, where it was estimated that were 253 (CV=0.63) individuals in U.S. waters during the spring. There are insufficient data to determine the trend for this population of sei whales.

Seasonal Distribution of Sei Whales —The two western North Atlantic stocks of sei whales tend to remain in offshore waters north of about 40°N latitude during the summer feeding season (Figure 4-7). Individuals from the Nova Scotia stock appear to move periodically into shelf waters primarily in spring and summer, probably seeking food (CeTAP 1982). Typically, they are found in the deeper waters off the shelf-edge (Kenney and Winn 1986; Hain *et al.* 1985).

Sei whales were regularly seen on Stellwagen Bank and Jeffreys Ledge between June and September 1986, a time when *Calanus finmarchicus* levels where unusually high (Payne *et al.* 1990). Therefore, movements of sei whales into Gulf of Maine coastal waters may reflect changes in local prey distribution.

Food and Feeding Behavior of Sei Whales —In northern latitudes, sei whales feed primarily on surface-dwelling plankton such as copepods and euphasids (Leatherwood *et al.* 1982). Individuals also feed opportunistically on a wide variety of planktonic crustaceans and small shoaling fish (Jonsgard and Darling 1977; Watkins and Schevill 1979). It is possible that, on a local scale, sei whales compete directly with right whales, fin whales, and humpbacks for food. Sei whales are primarily skim feeders (Mitchell 1976; Nemoto 1970) and do not usually dive deeply. Unlike other baleen whales, individuals do not surface at an acute angle but instead, the head, back, and dorsal fin appear at the surface simultaneously (like a submarine). When diving, sei whales rarely arch the back or raise the flukes. Instead, they submerge as they surface and often travel just below the surface, leaving a series of "fluke-prints" in their wake. Sei whales may feed in this manner for long periods of time (Leatherwood *et al.* 1976). Studies in the Gulf of Maine confirm that most submergences were between 45-90 seconds and that long dives were infrequent (Schilling *et al.* 1992). Individuals often stay within a small area (~0.5 km^2) and often change swimming direction when exploiting dense patches of plankton (Schilling *et al.* 1992).

Causes of Mortality of the Sei Whale — Because the distribution of sei whales is usually well offshore, there are virtually no data on human interactions. There are no recorded reports of entanglement in fishing gear, and few reports of collisions with ships. However, the New England Aquarium did report a sei whale carcass hung on the bow of a container ship in Boston Harbor (NMFS 1995a).

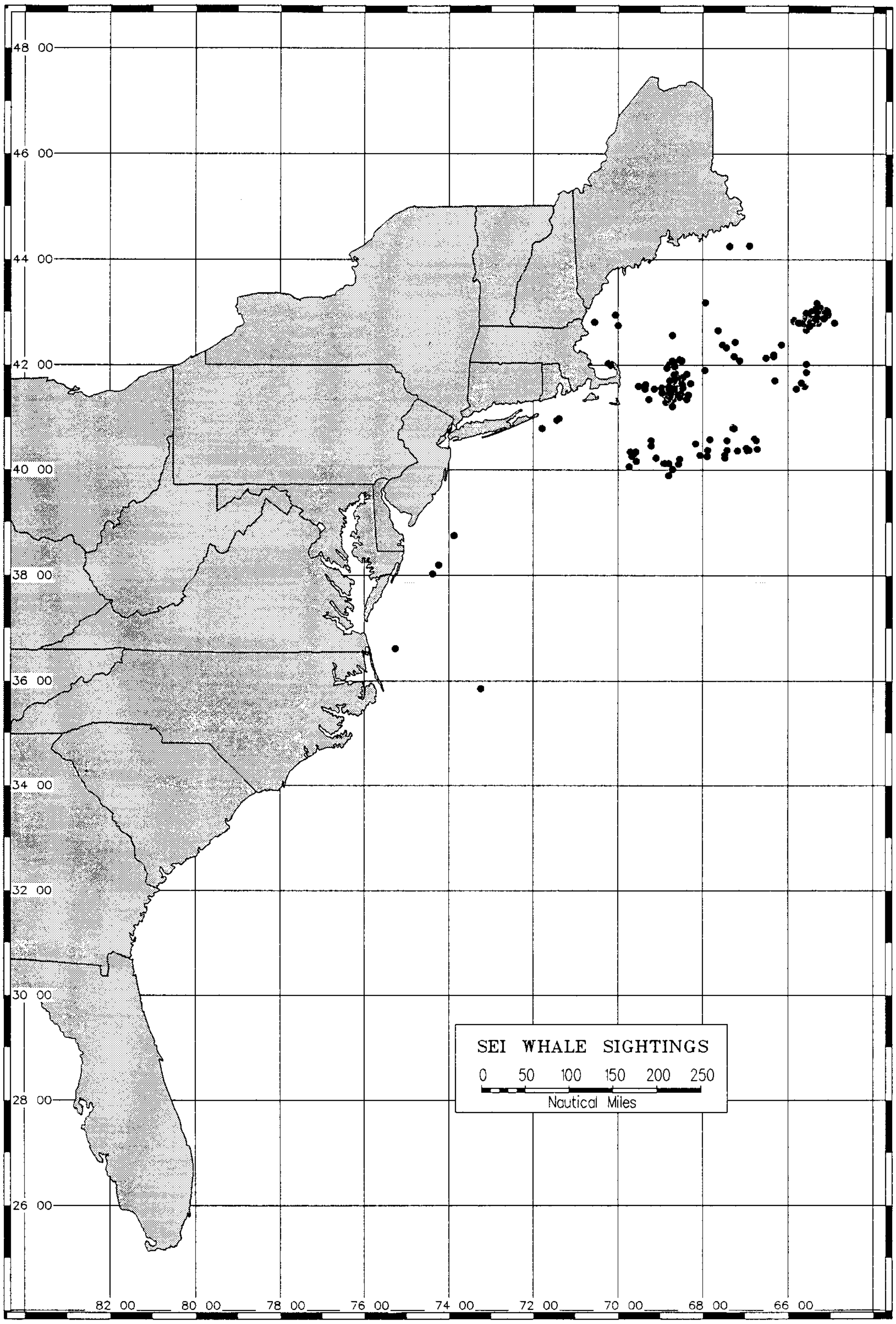

Figure 4-7. Cumulative sightings, 1960-1992, of Sei whales along the East Coast of the United States.

Blue Whale (Balaenoptera musculus).

Population Status and Trends of the Blue Whale — The blue whale, *Balaenoptera musculus*, is the largest of all the cetaceans, averaging 30 m in length and weighing up to 136 MT. The body is bluish gray in color and often mottled with white spots. The dorsal fin is quite small (<30 cm) and is located further down the back than in other whale species (Leatherwood *et al.* 1976). Blue whale populations are severely depleted in all oceans of the world despite international protection since 1966. Currently, it is believed that only a few hundred blue whales are in the western North Atlantic (Mitchell 1974; NMFS 1995). There are insufficient data to calculate a minimum population estimate and current population trend (NMFS 1995a).

Seasonal Distribution of the Blue Whale — Blue whales are found worldwide but primarily in the higher latitudes. In the western North Atlantic Ocean, they are found from the Arctic Ocean south to the mid-latitudes (Figure 4-8). There are limited records of sightings as far south as Florida (Yochem and Leatherwood 1985). Blue whales are rare visitors to U.S. coastal waters (CeTAP 1982; Wenzel *et al.* 1988). The only photo-documented sightings in the Gulf of Maine occurred during the 1986-1987 episodic influx of plantivorous cetaceans. These movements into coastal waters were likely in response to an unusual abundance of zooplankton. Three blue whales were seen in the Gulf of Maine, and one individual was observed <2 km from shore (S. Nieukirk, pers. obs.). Recent acoustic evidence indicates that blue whales may spend most of their time in deep water and their range may extend further south than expected. Because blue whale vocalizations are individually unique, scientists were able to track an individual as it moved from northeast of Bermuda to the Bahamas and back during a period of 43 days (Gagnon and Clarke 1993).

Food and Feeding Behavior of the Blue Whale — Blue whales are planktivorous, feeding on swarms/dense patches of krill, often lunging or rolling at the surface when consuming their prey.

Reproduction of the Blue Whale — The gestation period is about 12 months, and females calve every 2-3 years. Calves are 7-8 m in length and can weigh up to 3.6 MT. The location of calving grounds of blue whales in the North Atlantic is unknown.

Causes of Mortality of the Blue Whale — Because the distribution of blue whales is usually well offshore, there is likely to be very little interaction with humans. There are no documented collisions with ships, and few reports on record of entanglement in fishing gear. However, one of the rare visitors to the Gulf of Maine was seen trailing a rope wrapped around the pectoral fin during part of the time that it was in the area (NMFS Cetacean Entanglement Database, Record #87, 9 August 1987).

Sperm Whale (Physeter macrocephalus).

Population Status and Trends of the Sperm Whale — The sperm whale, *Physeter macrocephalus*, is the largest of the odontocetes or toothed whales. Males can reach lengths up to 18.3 m and are larger than females, which rarely exceed 12.2 m in length (NMFS 1994). Sperm whales have an extremely large square head that can be one-third the length of the entire body. The long, narrow lower jaw contains 20-50 conical teeth, and the interior of the mouth and part of the lower jaw are white in color. There are no teeth in the upper jaw. The body is dark gray in color and, except for the head, appears wrinkled. The sperm whale has no dorsal fin, but instead a doral hump is followed by a series of bumps or "knuckles" along the dorsal surface of the tail stock. Sperm whales, like other odontocetes, have a single exterior blowhole that, in this species, is asymmetrically situated on the left side of the head (Leatherwood *et al.* 1976).

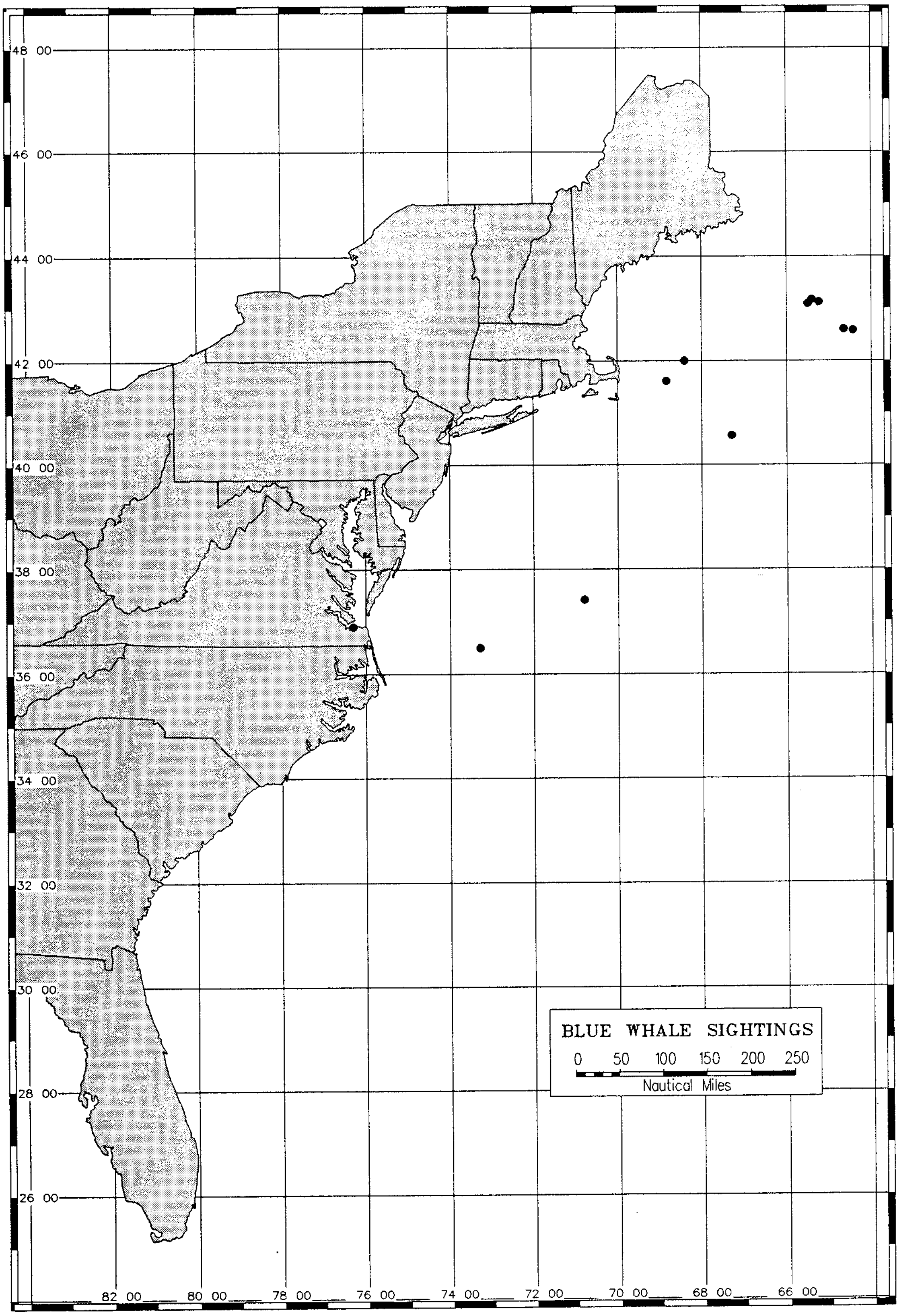

Figure 4-8. Cumulative sightings, 1960-1992, of Blue whales along the East Coast of the United States.

An estimate of the total number of sperm whales in U.S. waters is not available, but there are some data on seasonal abundance. There are an estimated 219 (CV=0.36) sperm whales in continental shelf and shelf-edge waters between Cape Hatteras and Nova Scotia during the spring and summer. This estimate is based on CeTAP (1982) spring and summer data and is not corrected for missed animals. Estimates based on more recent data range from 337 (CV=0.50) to 736 (CV=0.36) sperm whales (NMFS 1995a). There are insufficient data to determine a population trend for this species.

Seasonal Distribution of the Sperm Whale — Sperm whales inhabit all oceans of the world and are found primarily in deep water. Like the other cetaceans discussed in this report, their distribution is most influenced by the distribution of their prey. Sperm whales feed heavily on squid. In the western North Atlantic, most species of squid are found in deep water, and they migrate into shallower waters in the summer and fall (Figure 4-9, NMFS 1993a). The sperm whale generally does not occur in the Gulf of Maine or Georges Bank area. In the winter, the majority of sperm whales in U.S. waters are located east and northeast of Cape Hatteras. In spring, this distribution shifts to the north, and sperm whales are seen on southern Georges Bank and the mid-Atlantic Bight. During the summer, this distribution expands to include the northern edge of Georges Bank and the Northeast Channel. Adult males often are common during the summer on the continental shelf south of Nova Scotia, particularly over a submarine canyon called the Gully (Whitehead *et al.* 1992). Sperm whales also begin to move onto the continental shelf south of New England. In the fall, this movement onto the shelf peaks (CeTAP 1982; Hain *et al.* 1985; NMFS 1995a). It is unclear whether sperm whales in U.S. waters are a discrete stock or part of stocks in the northwestern and northeastern Atlantic.

Food and Feeding Behavior of the Sperm Whale — Sperm whales are known for their spectacular diving abilities. Individuals can remain submerged in excess of one hour and can dive to depths of 3000 m. The primary prey of sperm whales is squid, including the giant squid.

Reproduction of the Sperm Whale — Sperm whales have one of the lowest (if not the lowest) reproductive rates of all cetaceans. Females reach sexual maturity at about 9 years of age, and calve every 3 to 6 years after a gestation period of 15 months. Males do not become sexually mature until 20 years of age. A complex social structure results in age-class and sexual segregation during the majority of the year.

Causes of Mortality of the Sperm Whale — Currently, there are few records of human-induced mortality of sperm whales in U.S. waters, other than those from the sperm whale fishery which was banned in 1982. Subsistence hunting of sperm whales in the Azores and Madeira ceased in the mid-1980s (Evans 1987). Because of their offshore distribution, sperm whales are less likely to be affected by most human activities and, when affected, any interactions are less likely to be reported (NMFS 1995a). Sperm whales have become entangled in and killed by submarine cables (Slijper 1978). A sperm whale became entangled in and subsequently was released from a swordfish drift net on Georges Bank (NMFS 1995a). Because this individual was injured by the encounter with the net, it was listed as a mortality. There are several reports of entanglement of sperm whales in swordfish and shark gill nets, and in longlines set for sablefish and halibut in the eastern North Pacific Ocean (NMFS, pers. comm.). Encounters with fishing gear often result in injury; carcasses of sperm whales stranded on the U.S. Atlantic coast often exhibit signs of entanglement injury. It is probable, however, that sperm whales become entangled in fishing gear much less frequently than humpback and fin whales.

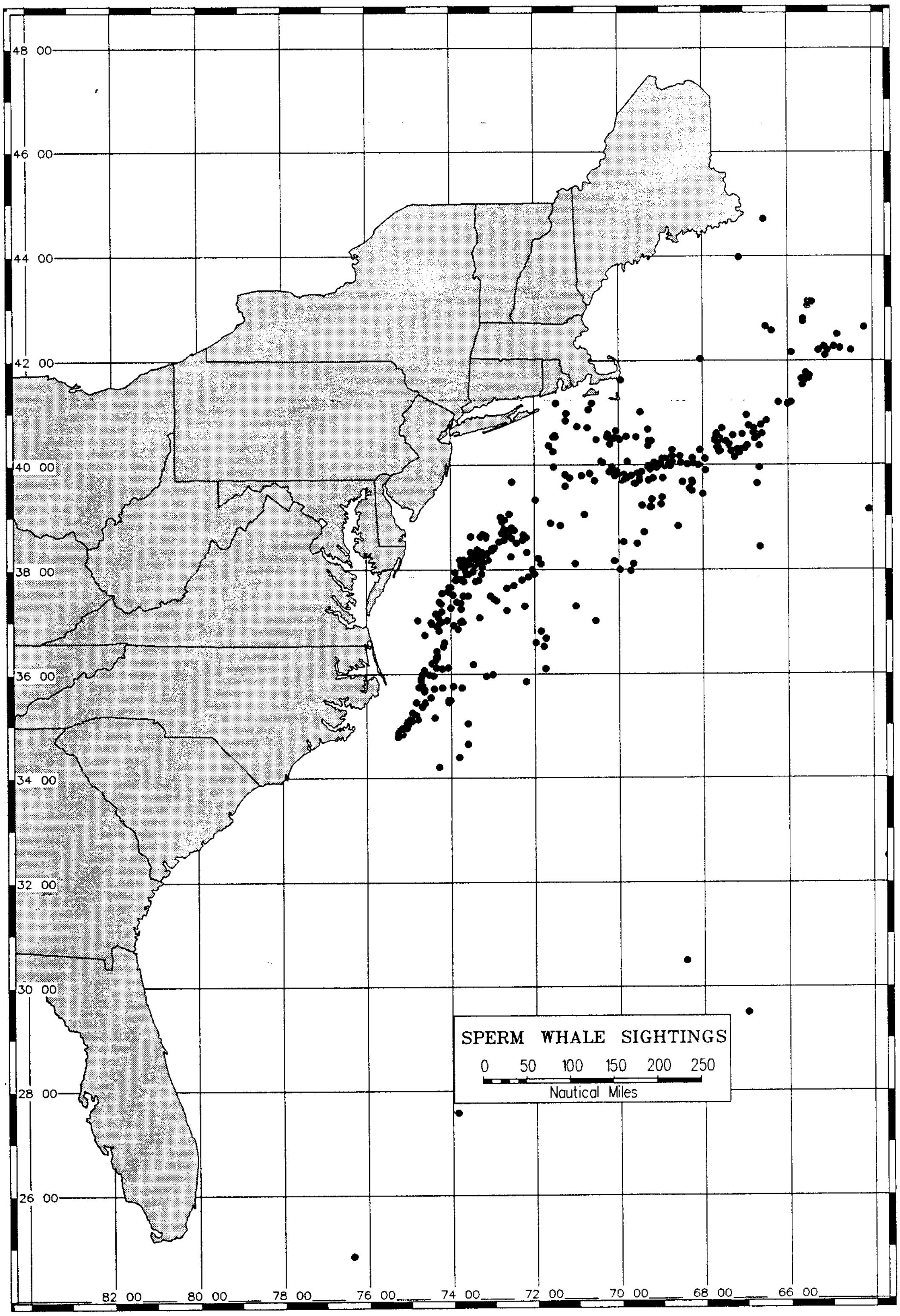

Figure 4-9. Cumulative sightings, 1960-1992, of Sperm whales along the East Coast of the United States.

***Harbor Porpoise* (Phocoena phocoena).**

Population Status and Trends of the Harbor Porpoise — The harbor porpoise *(Phocoena phocoena)* is the smallest of the western North Atlantic cetaceans and rarely exceeds 1.5 m in length. Distinguishing features include a small chunky body, a small rounded head, and a triangular dorsal fin. The upper body is dark brown or gray, and fades to white ventrally (Leatherwood *et al.* 1976). As the common name implies, the harbor porpoise is found primarily near shore in shallow waters and in bays and harbors (Gaskin 1984). Because of the small size of individuals, "quiet" surface behavior, and shy nature, harbor porpoises are often difficult to spot, especially in rough seas (Gaskin 1992). NMFS has proposed to list the harbor porpoise is a threatened species (NMFS 1993b).

Gaskin (1984) suggested that the following four populations occur in the western North Atlantic: West Greenland, Eastern Newfoundland-Western Davis Strait, St. Lawrence Estuary, and Southern Nova Scotia-North Carolina. Although there is some question whether these populations are indeed discrete, animals from the Gulf of Maine and Bay of Fundy are believed to be from the same stock (Smith *et al.* 1993; Palka 1994). This discussion will be confined to the Southern Nova Scotia-North Carolina population which is often referred to as the "Gulf of Maine" (GME) population.

The "best" GME harbor porpoise population estimate is considered the average abundance estimate of 54,300 (95% CI 41,300-71,400) calculated from 1991, 1992 and 1995 survey data (D. Palka, NMFS, pers. comm. July 1996). There were considerable differences between the 1991, 1992, and 1995 survey estimates (1991:37,500, 95% CI 26,700 to 86,400; 1992: 67,500, 95% CI 32,900 to 104,600;1995: 74,000, 95% CI 40,900 to 109,000) possibly due to interannual changes in water temperature and availability of primary prey species (Palka 1994). Currently, there are insufficient data to determine the population trends for this species (NMFS 1993b).

Seasonal Distribution of the Harbor Porpoise — Available data indicate a strong seasonal component in the north-south movements of GME harbor porpoises (CeTAP 1982). Sighting data indicate a south-north movement of animals in the spring. During the summer (July to September), harbor porpoises are concentrated in the northern Gulf of Maine/southern Bay of Fundy region, generally in waters <150 m deep (CeTAP 1982). The greatest density of harbor porpoise occurs during late summer in a "high density" area north of 43° 176' N latitude in the northern Gulf of Maine/Bay of Fundy (NMFS 1993b). During fall (October to December) and spring (April to June), harbor porpoises are widely dispersed from North Carolina to Maine. No specific migratory routes to the northern Gulf of Maine/lower Bay of Fundy region have been documented. Very little is known of the winter distribution of GME harbor porpoise. Stranded animals have been reported in winter from New England to North Carolina, and rarely to Florida (Polacheck and Wenzel 1990 in Haley and Read *et al.* 1993). There is no evidence of geographic segregation of the sexes (Read and Hohn 1995).

Food and Feeding Behavior of the Harbor Porpoise — GME harbor porpoises feed on pelagic schooling fish such as herring and mackerel, and occasionally when in deeper water, hake, squid, and octopus (Gaskin 1992). Their primary prey, the Atlantic herring (*Clupea harengus*) is a commercially exploited species; therefore, harbor porpoises may compete directly with fishermen. However, in recent years, herring stocks have increased dramatically, providing an abundant source of food for this population (Read and Gaskin 1990). The distribution of harbor porpoises has been roughly correlated with the distribution of herring (Watts and Gaskin 1985).

Reproduction of the Harbor Porpoise — Most harbor porpoises live less than 10 years (Read and Hohn 1995), and females are slightly larger than males at all ages (Gaskin 1992). Individuals reach sexual maturity at 3-4 years of age (Read 1990b). Reproduction is highly synchronous and seasonal, occurring in spring and early summer (Read and Hohn 1995). Females calve yearly; the gestation period is about 10.6 months and lactation probably lasts about nine months (Read 1990a). In general, harbor porpoises mature earlier, reproduce more frequently, and live for shorter periods of time than other odontocetes (Read and Hohn 1995).

Causes of Mortality of the Harbor Porpoise — The majority of human-induced mortalities for this species is from incidental catches from the groundfish gillnet fishery, although a small number of individuals is also entrapped and killed in herring weirs (Read and Gaskin 1988; Polacheck 1989). The GME sink-gillnet fishery interacts with this stock throughout the year, but the estimated bycatch from this fishery is greatest during fall and spring (NMFS 1996). Bycatch occurs primarily between June and September in the northern Gulf of Maine, and from January to May and September to December in the southern Gulf of Maine. Stranding data indicate that the greatest number of mid-Atlantic interactions occurs from mid-March through May in North Carolina and Virginia (NMFS 1996). Bycatch patterns appear to largely reflect the seasonal movements of animals.

There are about 350 vessels in the New England Multispecies Sink Gillnet Fishery. The estimated harbor porpoise bycatch from this fishery exceeds that of all other fisheries combined (NMFS 1996). In 1992 and 1993, approximately 1300 porpoises were taken annually (NMFS 1996). The 1994 bycatch estimate for the Gulf of Maine was 2000 porpoise (CV 18%, 95%CI 1,400-2,900; D. Palka, NMFS, pers. comm. July 1996). Additional incidental takes occur in the Canadian gillnet fishery and in other U.S. fisheries south of Cape Cod (Read *et al.* 1993). The bycatch of harbor porpoise in the gillnet fisheries that operate in state waters from New Jersey south to North Carolina is unknown. There is no evidence of differential mortality from the gillnet fishery due to age and sex (Read and Hohn 1995). However, there was substantial interannual variation in age and sex composition of incidentally caught porpoises (Read and Hohn 1995), probably due to interannual variation in the distribution of harbor porpoise (Smith *et al.* 1993).

Harbor porpoise bycatch data indicate that the rate of bycatch in the sink-gillnet fishery is large relative to estimates of the total GME population. In addition, harbor porpoises have a limited capacity for population increase and cannot sustain even moderate levels of incidental mortality (Woodley and Read 1991). Therefore, NMFS has proposed to list the harbor porpoise as threatened under the Endangered Species Act (50 CFR Part 227, 7 January 1993). The stock is also considered strategic (under MMPA) because total annual fishery related mortality and serious injury exceeds the estimated Potential Biological Removal (PBR) of 403 animals (NMFS 1996).

Numerous measures have been undertaken to reduce this human-induced mortality. A Take Reduction Team has been formed, regional and seasonal closures of the sink-gillnet fishery have been implemented, and data critical for the proper management of this species are being gathered. In addition, there has been some success in using "pingers" as acoustic deterrents on gillnets (Kraus *et al.* 1995). NMFS has chosen to delay designation of critical habitat for the harbor porpoise until a later date.

No other significant sources of mortality, natural or human-induced, have been discovered. Harbor porpoise blubber is high in lipids and may concentrate lipophilic contaminants such as organochlorines (Gaskin *et al.* 1983). Although pollutants may be a problem, to date there is no concrete evidence such as physical manifestations (NMFS 1995). Additional threats to the species include loss of habitat and displacement from preferred habitat due to increases in vessel traffic (NEFSC 1992).

Cetaceans: Species Not Listed Under the Endangered Species Act

***Minke Whale* (Balanoptera acutorostrata).** The minke whale, *Balanoptera acutorostrata*, is the smallest of the baleen whales, and is found in tropical, temperate, and polar waters. Minke whales in the western North Atlantic are considered part of the Canadian East Coast population and are found as far north as the eastern half of Davis Strait and as far south as the Gulf of Mexico (NMFS 1995). It is the third most commonly sighted whale along the east coast of the United States (CeTAP 1982). During spring and summer, minke whales are often seen along the continental shelf, with highest densities in New England waters. During fall, numbers begin to decline until, during the winter, very few minkes are seen within inshore waters (CeTAP 1982). It has been suggested that this population may winter off North Carolina (Manomet Bird Observatory 1989; Lee 1985) or in the West Indies (Mitchel 1991). The total number of minke whales in the Canadian East Coast population is unknown. The minimum population estimate, based on 1991 and 1992 Georges Bank-to-Scotian Shelf shipboard surveys, is 2053 (NMFS 1995a). There are insufficient data to determine a population trend for this species.

Ship strikes and pollution may be a source of injury or mortality for minke whales because they inhabit coastal waters. Entanglement in fishing gear kills an unknown number of minkes each year (NMFS 1995a). Minke whales in the North Atlantic are still being harvested by a few countries (NMFS 1995a). Because the known "takes" from this population do not exceed the PBR of 21 individuals (NMFS 1995a), this stock is not considered strategic under the MMPA. In addition, the minke whale is not listed as endangered or threatened under the ESA.

***Bryde's Whale* (Balaenoptera edeni).** The Bryde's Whale (*Balaenoptera edeni*) is relatively uncommon is U.S. waters. The natural history of the species is virtually unknown, most likely because it is often confused with fin and sei whales. Stranding data and shipboard sightings indicate a distribution from Virginia south to the Caribbean and West Indies, and into the northeast Gulf of Mexico. Bryde's whales feed on small schooling fish such as herring, mackerel, and pilchards, and on euphausiids (Leatherwood *et al.* 1976).

Other Odontocetes. There are more than 20 species of odontocetes found in the North Atlantic waters of the United States. In general, they can be divided into two groups. The nearshore or "on-shelf" group includes the white-sided dolphin *(Lagenorhynchus acutus)*, the common dolphin *(Delphinus delphis)*, and the bottlenose dolphin *(Tursiops truncatus)*. Other species, such as pilot whales *(Globicephala spp.)*, grampus *(Grampus griseus)*, spotted dolphins *(Stenella sp.)*, and striped dolphins *(Stenella coeruleoalba)*, are part of a diverse assemblage of offshore species typically associated with the continental shelf edge. The seasonal distribution of the offshore species may shift inshore in response to the movements of their prey (CeTAP 1982).

Pinnipeds

Five species of pinnipeds occur along the east coast of the United States. All of these are phocids (true seals) and their distribution is limited primarily to the nearshore waters of New England. Occasionally, individual animals stray as far south as South Carolina. The harbor seal (*Phoca vitulina*) is the most abundant pinniped on the east coast. It is commonly found in waters north of 30°N, breeds from New Hampshire to the Arctic, and winters south to New York (and occasionally to the Carolinas). The greatest summer concentrations of harbor seals are along the coast islands and ledges of Maine (J. Gilbert pers. comm. 1995) and, in winter, on Cape Cod and Nantucket Island (Payne and Selzer 1989).

Gray seals (*Halichoerus grypus*) are the second most common pinniped along the Atlantic seaboard of the United States. They inhabit temperate and subarctic waters and, in the United States, are found from Maine to Long Island Sound. Pupping colonies have recently been identified at Muskeget Island (Nantucket Sound), Monomoy National Wildlife Refuge, and in eastern Maine (Rough 1995).

The ice seals — harp (*Phoca groenlandica*), hooded (*Cystophora cristata*), and ringed (*Phoca hispida*) seals — are uncommon in U.S. waters, although recent stranding data indicate that their wintering range may be expanding southward.

None of these seals is Federally listed as an endangered or threatened species in Canada or in the United States, and there is strong evidence that both harbor and gray seal populations are increasing.

Sirenians

The West Indian manatee *(Trichechus manatus)* is a large, slow-moving herbivore, and the only Sirenian in North American waters (USFWS 1989a, Geraci and Lounsbury 1993). The manatee is listed as endangered. There are two subspecies of manatee. The Antillean manatee (*Trichechus manatus manatus*) is found in the Caribbean islands, the northern coast of South America, Central America, and coastal Mexico, while the Florida manatee (*Trichechus manatus latirostris*) is found in the southeastern United States (USFWS 1989). The Florida manatee is found primarily in the shallow fresh, brackish, and marine waters along the coast of Florida. Individuals usually remain in 3- to 5-m-deep waters, and rarely venture into water exceeding 6 m. Historically, the distribution of manatees shifts south of central Florida in winter because of their intolerance of temperatures below 20°C (Irvine 1983). However, over the past 30 years, the winter distribution has shifted northward due to habitat loss and the construction of power plants/industrial sites that discharge warm-water effluent. In the spring and summer, manatees appear around the warm-water outfall pipes in Georgia (Rathbun *et al.* 1982), and occasionally move as far north as the Rhode Island and Connecticut (Florida DEP pers. comm. 1995; USFWS pers. comm. 1996).

The manatee is one of the most endangered marine mammals in the United States. A recent synoptic aerial survey conducted by the Florida Department of Environmental Protection in February 1996 documented the presence of 2,639 manatees throughout the winter range of the Florida manatee (USFWS pers. comm. 1996). One-third or more of manatee deaths are human related (MMC 1995). The largest single human-induced mortality factor is collision with watercraft; most deaths are due to impact, not propeller wounds. In a recent study, the mean length of the longest fatal cut from a propeller indicated that death was most often caused by a direct-drive vessel, while impact fatalities may have resulted from fast-moving watercraft of many sizes and types (Wright *et al.* 1995). Watercraft-related mortality is highest in eastern Florida (Ackerman *et al.* 1995; O'Shea *et al.* 1985) but has increased most rapidly in southwestern Florida (Ackerman *et al.* 1995). No-wake zones, manatee protection areas, and an extensive educational effort have been implemented by State and Federal agencies to mitigate these adverse human impacts (Florida DEP, pers. comm. 1995).

During the spring of 1996, an unusual combination of cold weather and toxic blooms of dinoflagellates (*i.e.,* red tide) in coastal waters of southwest Florida caused an unprecedented number of manatee deaths. A total of 158 manatees died in March and April by ingesting brevetoxin released from the red tide. An usually cold winter forced large numbers of manatees southward into waters where they were exposed to a persistent red tide event.

4.4.2 Sea Turtles

The Loggerhead Turtle (*Caretta caretta* Linnaeus, 1758)

Population Status and Trends of the Loggerhead Turtle. The loggerhead sea turtle (*Caretta caretta*) is listed as threatened throughout its range under the Endangered Species Act (USFWS 1986). It is the most common and seasonally abundant turtle in inshore coastal waters of the Atlantic (NMFS & USFWS 1991a). Estimates of the abundance of loggerheads along the U.S. Atlantic coast are made difficult by the short time turtles spend on the surface where they can be spotted from a plane or boat. Radio-tagging experiments have shown that loggerheads spend about 2.3 minutes (3.8%) out of each hour on the surface (Thompson 1988). An estimated 7,000 and 10,000 individuals of both sexes of this turtle occur during the summer in coastal waters from North Carolina to the Gulf of Maine (CeTAP 1981; Shoop and Kenney 1992). Aerial surveys performed by NMFS between Cape Hatteras and Key West between 1982 and 1984, corrected for submergence time, yielded an estimated peak abundance of sea turtles in spring and summer of 387,594 (±20,154, 95% CI) individuals with straight-line carapace lengths (SLCL) of 60 cm or greater (Thompson 1988). Most of these were loggerheads. The two estimates are not additive because loggerheads readily move between northern (north of Cape Hatteras) and southern waters on a seasonal basis (Epperly *et al.* 1992).

Most nesting in U.S. territory occurs on sandy shores between Key Biscayne and Cape Hatteras (Shoop *et al.* 1985). An estimated 50,000 to 70,000 loggerhead nests are deposited annually on beaches in the southeastern United States, mostly along the east coast of central and south Florida (NMFS & USFWS 1991a). Between 1980 and 1983, an annual average of 52,073 (±16,459, 95% CI) nests was excavated by female loggerheads along the south Atlantic coast (Thompson 1988). Between 1979 and 1992, the number of loggerhead nests reported annually from track surveys in Florida alone ranged from 10,121 to 68,614 (Meylan *et al.* 1994). Female loggerheads may nest from one to six, and exceptionally seven, times per year (Dodd 1988). The average renesting frequency for loggerheads on beaches from Florida to North Carolina is in the range of 1.37 to 4.18 times per year. Murphy and Hopkins (1984) derived a stochastic mean of 4.1 nests per female per year. However, Cook (1994) reported that most female loggerheads (53%) nested once in a season at Bald Head Island, North Carolina, only 19% nested four or more times in a season. If an average of 2.5 nests per female per year is used, these numbers of nests recorded each year indicate that 20,000 to 28,000 female loggerhead turtles nest along the Atlantic coast of the United States each year. Remigration intervals for female loggerhead turtles along the U.S. Atlantic coast are in the range of one to seven years, with most females returning to nest every two to three years (Richardson *et al.* 1978; Bjorndal *et al.* 1983). At an average remigration frequency of 2.6 years, the total number of adult female loggerhead turtles in the U.S. Atlantic coast nesting population is in the range of 52,000 to 72,800 individuals. There probably is a nearly equal number of adult males; sub-adults represent approximately 80% of the loggerheads recorded off Cape Canaveral (Schmid 1995). Thus, there is reasonable agreement between the direct counts and the nesting frequency estimates of the total population of loggerhead turtles along the Atlantic coast of the United States (about 387,000 sub-adult and adult loggerhead turtles with SLCL > 60 cm).

The estimated population of loggerhead turtles along the southeast coast of the United States remained relatively stable at about 387,000 individuals during the early 1980s (Thompson 1988). An estimated 10,000 to 23,000 loggerheads are killed by fishing activities along the Atlantic and Gulf of Mexico coasts each year (Henwood and Stuntz 1987). This loss can be made up by a 1% survival of hatchlings (Thompson 1988). However, Frazer (1986) estimated that a survivorship of 0.25% from egg to reproducing adult is needed to sustain the loggerhead population. Estimated survivorship from egg to adult in a declining population, such as the one at Little Cumberland Island, Georgia, between 1965 and 1981, is 0.09 to 0.19%.

Owen *et al.* (1994) reported that loggerhead nesting on beaches of the Brevard County portion of the Archie Carr National Wildlife Refuge (Melbourne Beach, Florida) remained relatively constant around a mean of 9,400 nests/year (447/km) during the 1980s, but increased by 43% to an average of 13,425 nests/year (640/km) in the first three years of the 1990s. A similar pattern was observed at Patrick Airforce Base, just north of the Archie Carr National Wildlife Refuge (Bagley *et al.* 1994). In addition, the hatching success of eggs has increased in recent years, resulting in increased recruitment per unit reproductive effort. The trend is less clear in South Carolina where there was a 26.4% decline in loggerhead nesting between 1980 and 1982 and between 1985 and 1987, followed by a decrease or stoppage of the decline along different parts of the South Carolina coast between 1985 and 1987 and between 1990 and 1992 (Hopkins-Murphy and Murphy 1994). Shoop and Ruckdeschel (1982) suggested that improved survival of sub-adult loggerheads along the southeast Atlantic coast in the early 1980s may have been due to the increased food supply provided by disposal of bycatch by shrimp trawlers. However, attraction of loggerheads to the vicinity of shrimp boats by bycatch disposal may lead to an increase in entanglement in shrimp trawls and increased strandings along the shore.

The hypothesis of improved survival is supported by the stranding statistics from the Sea Turtle Stranding and Salvage Network (Teas and Martinez 1989, 1992; Teas 1992, 1993, 1994a). The number of loggerheads stranded along the U.S. Atlantic coast has declined from 1072 individuals in 1988 to 793 individuals in 1993 (Table 4-2). Most strandings are in Florida, and these have declined from a high of 550 in 1989 to 259 in 1993. The stranding data do not extend long enough to determine if the trend is real or merely represents a phase of a multi-year cycle. However, the improving trend, if it is real, could be due, in part, to the fact that use of turtle-excluding devices (TEDs) in shrimp trawls became mandatory in 1990, making possible enforcement of this turtle conservation measure by the USCG and others (Crowder *et al.* 1994; Hopkins-Murphy and Murphy 1994).

Seasonal Distribution of the Loggerhead Turtle. During their first three to five years after hatching, the so-called "lost years," juvenile loggerheads are pelagic, drifting and feeding in the *Sargassum* community (Carr 1986a,b). During this long pelagic period, the young turtles may make several transits of the North Atlantic Ocean in the Great Gyre of the Gulf Stream and Azorean Current. They are often encountered around the Azores and Madeira (Carr 1986a,b; Bolten *et al.* 1993, 1994). Juveniles grow from about 4.5 cm to a length of about 40 cm SLCL before they adopt a coastal distribution as sub-adults (Dodd 1988). However, some sub-adults up to 65 cm SLCL may be encountered drifting in the Gulf Stream and Azorean Current (Bolten *et al.* 1994).

The center of distribution of sub-adult (≈40-80 cm SLCL) and adult (>80 cm SLCL) loggerhead turtles along the U.S. Atlantic coast seems to be in central Florida off Cape Canaveral (Schmid 1995). Loggerheads captured off Cape Canaveral during a period of several years were mostly (80%) sub-adults, and were most abundant between November and January. The abundance of sub-adults decreases between April and July when adults become more abundant. Adult males are most abundant in April and May, and adult females are most abundant in May through July (Henwood 1987; Schmid 1995). Most sub-adult loggerheads tagged off Cape Canaveral during the winter move as far north as southern Chesapeake Bay (Schmid 1995) during the spring and summer. Large numbers of sea turtles, particularly loggerheads, migrate into coastal bays, particularly Core Sound, in the spring and feed there throughout the summer (Epperly *et al.* 1995a).

Table 4-2. Strandings of Loggerhead Turtles *(Caretta caretta)* along the U.S. Atlantic Coast from 1988 to 1993, all months combined each year. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

State	1988	1989	1991	1992	1993
Florida	504	550	337	354	259
Georgia	160	136	118	121	99
South Carolina	92	76	60	66	82
North Carolina	158	124	107	192	133
Virginia	120	111	91	121	150
Maryland	0	1	13	14	21
Delaware	0	0	0	5	12
New Jersey	18	15	27	27	15
New York	14	5	16	16	12
Connecticut	0	1	0	1	0
Rhode Island	1	1	1	0	0
Massachusetts	5	4	6	17	9
New Hampshire	0	0	0	0	0
Maine	0	0	0	0	0
Puerto Rico	0	0	18	0	1
U.S. Virgin Islands	0	0	0	1	0
Total Atlantic Strandings	1072	1024	801	934	793

Sub-adult loggerhead turtles migrate northward in the spring and become abundant during spring and summer months in coastal waters off New York and the middle Atlantic states, particularly in the southern part of Chesapeake Bay (Figure 4-10, Henwood 1987; Keinath *et al.* 1987; Morreale *et al.* 1989; Shoop and Kenney 1992). Between 2,000 and 10,000 sub-adult loggerhead turtles use Chesapeake Bay south of the Potomac River for feeding during the summer (Keinath *et al.* 1987). Smaller numbers are encountered in Delaware Bay, particularly in July (Eggers 1989). Loggerheads also are encountered frequently in Long Island Sound, New York Harbor-Raritan Bay, and along the south coast of Long Island during the summer (Morreale *et al.* 1989). Loggerheads frequently strand due to cold stunning between November and January each year along the north shore of Long Island Sound and in the Bays of eastern Long Island (Morreale *et al.* 1992). Loggerheads occur only rarely north of Long Island around Cape Cod and in the Gulf of Maine (Shoop and Kenney 1992). Several sub-adult loggerheads strand along the south shore of Cape Cod Bay each winter (Matassa *et al.* 1994). The stranded turtles measure 27-47 cm SLCL, indicating that they are late juveniles and early sub-adults.

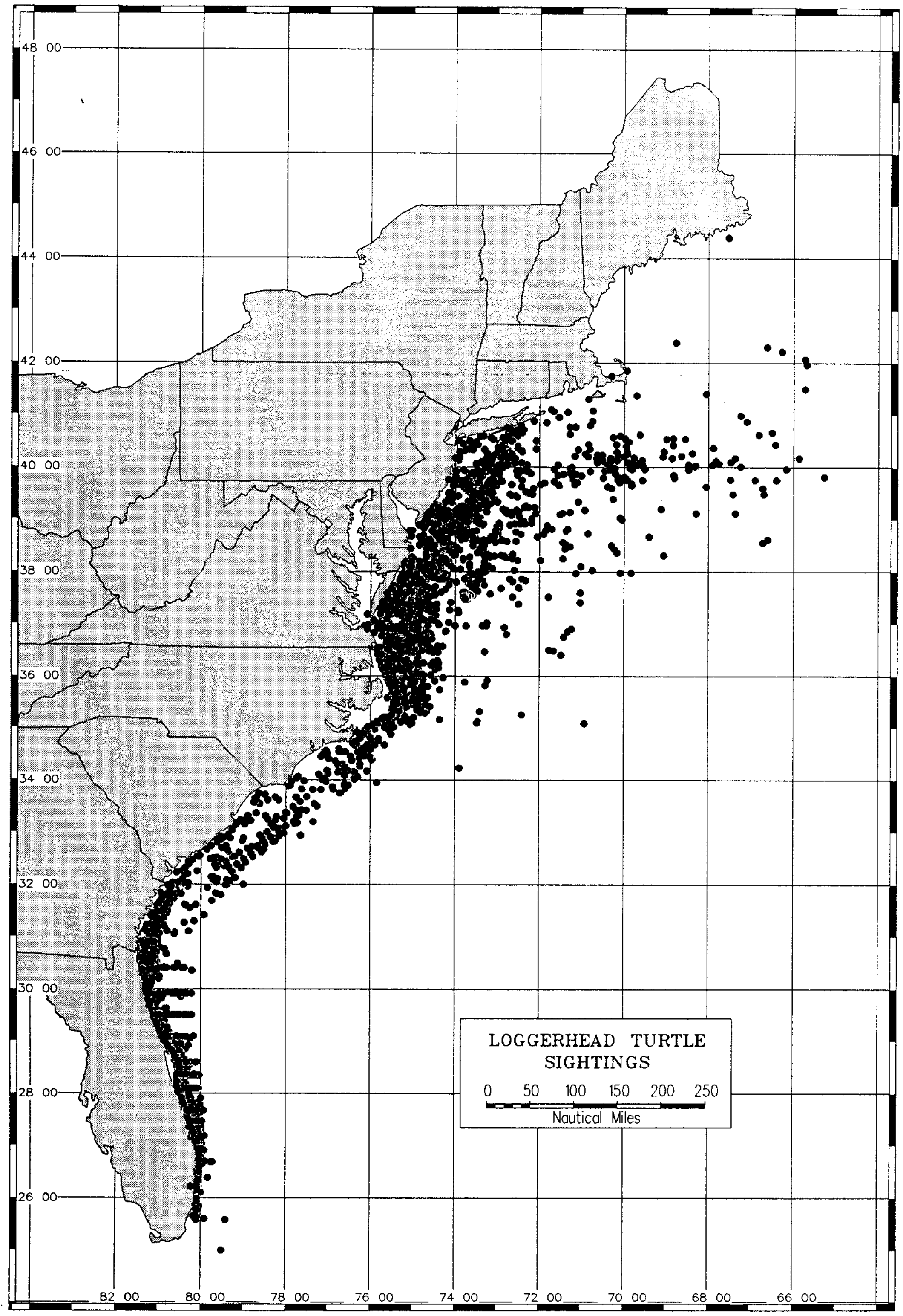

Figure 4-10. Cumulative sightings, 1960-1992, of Loggerhead turtles along the East Coast of the United States.

Migratory behavior seems to be cued to sea surface temperatures, with preferred water temperatures off Cape Hatteras falling in the range of 14 °C to 28 °C (Coles *et al.* 1994). In the fall, loggerheads migrate southward to coastal waters off the south Atlantic states, particularly Florida, and in the Gulf of Mexico, with peak numbers passing Cape Hatteras in November (Musick *et al.* 1994). Some juvenile loggerheads remain through the winter in nearshore waters of North Carolina south of Cape Hatteras where water temperatures remain at or above 11 °C (Epperly *et al.* 1995b). In the winter and spring, they congregate off southern Florida before migrating northward to their summer feeding ranges (CeTAP 1982). Peak numbers of northward-migrating sub-adult loggerheads occur off Cape Hatteras in April and May each year (Musick *et al.* 1994). During the winter, the turtles tend to aggregate in warmer waters along the western boundary of the Gulf Stream off Florida (Thompson 1988). They also may hibernate in bottom waters and soft sediments of channels and inlets along the Florida coast (Ogren and McVea 1981; Butler *et al.* 1987).

Adult female loggerheads nest above the high tide line and sometimes in vegetation at the top of the beach (Carr 1952) on sandy shores from about Boca Raton to New Smyrna Beach, Florida and in scattered locations along the coasts of Georgia, South Carolina, and Florida (Shoop *et al.* 1985). They seem to prefer continental over island beaches (Dodd 1988). Approximately 90% of the loggerhead nesting activity in the United States is in Florida (Meylan *et al.* 1994). Some loggerhead nesting occurs in the Florida Keys (Wells and Bellmund 1990; Wilmers 1994) and rarely along the U.S. Atlantic coast north of Cape Hatteras (Dodd 1988). There are three genetically distinct populations of nesting loggerheads along the U.S. Atlantic coast: Florida, Georgia/South Carolina, North Carolina (Sears 1994).

In Florida, nesting may occur from late April (rare) to the beginning of September, with peak nesting activity in June and July (NMFS & USFWS 1991a). In Georgia and in the Carolinas, nesting occurs from mid-May to mid-August. Most nesting occurs at night, usually associated with high tide (Dodd 1988). Each nest may contain from 43 to 198 eggs and a female may nest once to as many as seven times in a season at 13- to 15-day intervals (Dodd 1988). The eggs hatch after 49-76 days, depending on temperature. Average hatching success in nests laid along the U.S. Atlantic coast is in the range of 55-80%, with nearly 100% successful hatch having been reported in a few cases (Dodd 1988). The newly hatched turtles may remain in the nest for two to seven days before emergence (Miller 1982). Hatchlings emerge from a nest all at once, usually at night (Demmer 1981). The newly emerged turtles immediately crawl toward the sea, probably orienting toward the reflected light of the moon (Dodd 1988). Once in the water the juvenile turtles swim rapidly offshore at a speed of about 20 m/min (1.2 km/h) (Salmon and Wyneken 1987). The period of beach occupation by adult females, eggs, and juvenile loggerheads is a period of great vulnerability to natural and anthropogenic disturbance (NMFS & USFWS 1991a).

Food and Feeding Behavior of the Loggerhead Turtle. Pelagic-stage juvenile loggerheads feed opportunistically on available small prey associated with *Sargassum* weeds. Witherington (1994) identified 43 categories of plant, animal, and synthetic materials in the stomachs of juvenile turtles (4.0-5.6 cm SLCL). The most abundant food items were jelly fish (coelenterates and ctenophores), small crustaceans, hydrozoans, insects, gastropods, and pieces of *Sargassum*. About 17% of the juvenile turtles examined had ingested plastics and 63% had ingested tar balls.

Sub-adult and adult loggerheads are primarily bottom feeders, foraging in coastal waters for benthic molluscs and crustaceans (Bjorndal 1985). During feeding, they spend more than 57 minutes of each hour submerged (Thompson 1988) and 25-58% of their time on the bottom (Standora *et al.* 1994). Dives can last from 4 to 172 minutes (Renaud and Carpenter 1994).

Sub-adult loggerheads collected in lower Chesapeake Bay feed on horseshoe crabs *(Limulus polyphemus)*, cancer crabs *(Cancer* spp.), and blue crabs *(Callinectes sapidus)*, with traces of *Sargassum* weed (Lutcavage 1981; Lutcavage and Musick 1985; Keinath *et al.* 1987) primarily in deep water in river mouths. In New York coastal waters, they feed primarily on small benthic crabs and smaller amounts of molluscs, algae, plastic, and debris (Burke *et al.* 1990). More than 75% of the diet of sub-adult loggerheads feeding around Long Island in the summer consists of crabs, particularly spider crabs *(Libinia* spp.) and Atlantic rock crabs *(Cancer irroratus)*. Two loggerheads collected off Nova Scotia had been eating primarily pelagic prey associated with *Sargassum* weed (Bleakney 1965). Loggerheads have been observed feeding on horseshoe crabs, blue crabs, and occasionally mullet *(Mugil cephalus)* in Mosquito Lagoon, Brevard County, Florida, and on sponges and basket starfish off Palm Beach, (Mortimer 1981).

During the first three to five years of life, juvenile loggerhead turtles grow from about 4 cm to 40 cm, a rate of 7-11.6 cm/y. Sub-adults in coastal lagoons of Florida grow at a mean rate of 5.9 cm/y (Mendonça 1981). Based on tag-recapture studies, Schmid (1995) estimated that loggerheads along the east coast of central Florida grow at a rate of 5.56 cm/y. Foster (1994) performed a similar tag-recapture study in Florida and fitted the data to a Von Bertalanffy growth function. She estimated that juvenile loggerheads grow from a hatching length of 4.5 cm to a length of about 10 cm in one year. After 10 years, the turtles reach a length of about 48 cm SLCL, and after 20 years they are about 70 cm long. Growth rate slows as the turtles approach sexual maturity, which may occur after 12-45 years in the wild (Zug *et al.* 1983; Frazer and Ehrhart 1985; Foster 1994) when the turtles are about 74-90 cm SLCL (Dodd 1988; Foster 1994). Adult loggerheads from the Florida population may grow to >120 cm SLCL and weight >180 kg (Ehrhart and Yoder 1978).

Causes of Mortality of the Loggerhead Turtle. Between 1980 and 1983, there were 6691 reported strandings of loggerhead turtles along the U.S. Atlantic and Gulf of Mexico coasts (Thompson 1988). Most strandings (77%) were along the southeast coast from North Carolina to Florida; 12% of the strandings were along the Gulf of Mexico coast. Only 11% of strandings of loggerhead turtles occurred north of North Carolina. Less than 1% of strandings occurred along the shores of the Gulf of Maine, including Cape Cod Bay.

In recent years, the Sea Turtle Stranding and Salvage Network has provided detailed summaries of sea turtle strandings along the Atlantic and Gulf coasts of the United States (Teas and Martinez 1989, 1992; Teas 1992, 1993, 1994a). Between 1988 and 1993, most loggerhead strandings occurred in Florida; other Atlantic states with high stranding frequencies include Georgia, South Carolina, North Carolina, and Virginia (Table 4-2). Between 5 and 27 strandings have occurred each year in New Jersey and New York. There have been relatively few strandings in most years in other northeastern states, in Puerto Rico, and in the U.S. Virgin Islands.

Strandings of loggerhead turtles occur most frequently along the Atlantic coast of Florida in April through September (Table 4-3). A similar seasonal pattern exists for the other southern states. In most years, strandings in New Jersey are most frequent between July and November. Strandings occur most frequently in Massachusetts along the south shore of Cape Cod Bay and in New York along the north shore of Long Island in the fall and winter; these strandings may be caused by cold stunning (Morreale *et al.* 1992; Matassa *et al.* 1994). Like most marine turtles, prolonged exposure of loggerheads to low water temperatures, below ~8°C, may result in dormancy, shock, and death. In December 1992, 17 loggerheads were cold-stunned and stranded in Cape Cod Bay (Teas 1993). Cold stunning is not restricted to the northern United States. Cold stunning incidents involving loggerhead and green turtles have been documented several times in the northern part of the Indian River Lagoon system in east central Florida (Witherington and Ehrhart 1989; Schroeder *et al.* 1990).

Table 4-3. Temporal pattern of strandings of Loggerhead Turtles *(Caretta caretta)* along the Atlantic Coast of Florida. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

Month	1988	1989	1991	1992	1993	Total
January	23	40	17	3	17	100
February	22	23	14	14	6	79
March	43	19	19	23	24	128
April	36	37	62	58	25	218
May	50	68	52	72	54	296
June	48	32	38	43	48	209
July	42	73	26	34	24	199
August	95	111	27	29	26	288
September	50	48	25	42	17	182
October	31	60	22	19	10	87
November	32	29	14	9	4	88
December	32	10	21	8	4	75
Total	504	550	337	354	259	2004

Stranded loggerheads documented by the Sea Turtle Stranding and Salvage Network were examined for different anomalies that might reveal something about the cause of stranding. It was recognized that the anomalies may not have been the cause of death of the turtles. Boat-related injuries (propeller or collision damage) occurred in 7.3-13.5% of stranded loggerheads (Table 4-4). Carapace, plastron, and skull injuries, that could have been caused by interactions with vessels, accounted for an additional 10-17% of anomalies in stranded turtles. These results suggest that vessel collisions are an important cause of death among stranded loggerhead turtles. Injuries caused by boat-turtle interactions have increased from about 105 turtles in 1986 to about 140 turtles in 1993 (Teas 1994a,b). Loggerheads suffered the most boat-related injuries, followed by green turtles. A wide variety of other injuries was recorded in stranded loggerheads, including some due to predation, probably by sharks, and interactions with commercial and recreational fishing gear.

Table 4-4. Percent incidence of anomalies (not necessarily the cause of death) of turtles (all species) stranded along the U.S. Coasts of the Gulf of Mexico and Atlantic Ocean. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

Anomaly	1987	1988	1989	1990	1991	1992	1993
Boat-related injury (prop. or collision	7.3	8.6	8.2	8.7	13.0	10.3	13.5
Carapace damage (unknown cause)	7.3	10.3	9.6	10.4	10.4	12.2	12.2
Plastron damage (unknown cause)	1.3	0.9	1.0	1.2	1.3	2.1	1.5
Skull injuries	2.4	2.4	2.8	2.3	2.1	2.5	2.4
Skull missing	2.1	3.2	3.4	1.8	2.2	3.6	2.1
Skull & flipper(s) comb. missing	7.0	7.4	7.2	7.8	7.0	7.8	5.4
Flipper(s) missing (unknown cause)	4.0	7.7	6.3	6.7	8.0	6.3	5.9
Flipper(s) missing (man-induced)	1.9	0.9	0.3	0.1	0.1	0.2	0.2
Partial flipper damage (unknown cause)	7.9	9.5	7.8	8.0	6.1	8.7	9.1
Bullet wounds	0.8	0.5	0.7	0.5	0.4	0.3	0.3
Apparent shark wounds	1.2	1.0	1.9	2.8	3.2	2.4	2.3
External tumors	1.5	1.3	1.9	2.7	3.3	2.8	2.0
Apparent deliberate mutilation	3.3	3.0	2.8	1.6	1.9	1.8	1.2
Tar or oil impact	0.6	0.2	0.2	0.6	1.1	0.2	0.9
Cold stunning	3.4	0.3	5.3	2.9	2.2	2.4	3.4
Entangled in fishing line	0.7	0.6	1.1	1.0	1.3	1.5	0.8
Entangled in fishing net	0.2	0.3	0.2	0.4	0.6	0.6	0.4
Entangled in non-fishing gear materials	0.3	0.2	0.3	0.6	0.6	0.3	0.4
Rope(s) tied to flippers , neck or body	0.6	0.7	0.4	0.2	0.2	0.1	0.3
Ingested fishing line	0.9	1.1	0.3	1.6	1.4	0.1	1.9
Fish hook in mouth	0.1	0.3	0.3	0.2	0.4	0.2	0.2
Ingested plastic (non-fishing gear)	3.8	4.9	3.2	2.3	5.8	3.8	3.9
Fishing hook in gut	0.8	0.7	0.0	1.8	1.2	1.3	3.0

The major causes of mortality of sea turtles, including loggerheads, resulting from human activities include incidental take in bottom trawls, particularly shrimp and summer flounder nets (Henwood and Stuntz 1987; Thompson 1988; National Research Council 1990; Anonymous 1992; Chester *et al.* 1994), and coastal gill net and pound net fisheries (Thompson 1991; Henwood *et al.* 1992; NOAA & NCDE 1992; Witzell and Cramer 1995), ingestion of marine debris (Carr 1987; O'Hara 1989; Sadove and Morreale 1990; Lutz 1990; Witzell and Teas 1994), and channel dredging (Thompson 1988; NMFS 1992). Along the south Atlantic coast, loss of nesting habitat caused by coastal development and disturbance of nesting habitat has probably also slowed recruitment of sea turtles (NMFS 1994a).

Shrimp fishing is the best quantified and probably the dominant source of anthropogenic mortality among North Atlantic loggerhead turtles (Thompson 1988; National Research Council 1990). Before regulations were enacted in 1987 requiring use of TEDs on shrimp nets, an estimated 7,913 to 18,148 loggerheads were killed each year in shrimp nets along the southeast coast of the United States. An additional 3555 to 4716 loggerhead turtles were killed this way each year in the Gulf of Mexico, bringing the total shrimp-fishery-related deaths of loggerhead turtles to approximately 10,000 to 23,000 individuals per year. The National Research Council (1990) estimated annual loggerhead mortality between 5,000 and 50,000 individuals in U.S. waters due to the commercial shrimping. Crowder *et al.* (1994) reported that use of TEDs has decreased strandings of sea turtles along the coast of South Carolina by 42-52%. Henwood *et al.* (1992) estimated that compliance with the TED regulations has resulted in a 67% reduction in mortalities of all sea turtles, including loggerheads, due to capture in shrimp trawls. In the Atlantic, turtle mortalities decreased from an estimated 7395 without TEDs to 3200 turtles with current TED regulations. If there was 100% TED coverage, estimated turtle mortalities resulting from shrimp trawling in the Atlantic would decrease to 217 individuals.

Other fisheries account for 500-5000 turtle mortalities each year (National Research Council 1990). Between 1983 and 1991, three loggerhead turtles were reported entangled in lobster gear by the Sea Turtle Stranding and Salvage Network (NMFS 1994b). Two of the strandings were in New Jersey and one was in New York. Two of the turtles died. Loggerhead and other turtles are trapped and sometimes killed in pound nets set in shallow waters of Pamlico and Core Sounds in North Carolina, and in southern Chesapeake Bay (Thompson 1991). An estimated 1063 sea turtles, 60% of them loggerheads, were caught in the summer flounder *(Paralichthys dentatus)* trawl fishery along the U.S. southeast coast between November 1991 and February 1992 (NOAA & NCDE 1992; Epperly *et al.* 1995b). Between 89 and 181 of the turtles may have died. In 1992, 123 loggerhead turtles were captured in the pelagic long-line fishery for tuna *(Thunnus* spp.) and swordfish *(Xiphias gladius)* in the western North Atlantic (Witzell and Cramer 1995). In 1993, an estimated 116 loggerheads were captured.

Dredging operations and collisions with boats may each account for an additional 50-500 loggerhead deaths per year (National Research Council 1990). Between 1980 and 1991, 70 loggerheads were entrained in hopper dredges in the Cape Canaveral entrance channel, and 22 loggerheads were entrained in the King's Bay, Georgia entrance channel (Dickerson *et al.* 1992). Entrainment in electric power plant cooling-water intakes accounts for <50 loggerhead deaths per year (National Research Council 1990). On the U.S. east coast, the largest number of sea turtle entrainments has been at the St. Lucie nuclear power plant located on Hutchinson Island, Florida. During the first 15 years of operation (May 1976 to December 1990), 2193 sea turtles of all five species were removed from the cooling water intake canal (Ernest *et al.* 1989; NMFS & USFWS 1991a). Loggerheads accounted for nearly 85% of all captures. Most turtles were released alive, but approximately 7% died before release.

Ingestion of or entanglement in plastic debris undoubtedly contributes to the death of many loggerhead turtles each year; however, the magnitude of this mortality is difficult to estimate (National Research Council 1990). Of 33 necropsied loggerheads that had stranded in the New York Bight, 10% contained ingested synthetic materials, mostly plastic materials (Sadove and Morreale 1990). Loggerheads in the New York Bight become entangled most frequently in pound nets and lobster pot lines. More than 50% of the necropsied loggerheads that stranded on beaches of south Texas between 1986 and 1988 contained ingested marine debris (Plotkin and Amos 1990). Most of the ingested material was buoyant plastic. More than 7% of the turtles stranded in Texas were entangled in commercial and recreational fishing gear. More than 20% of the loggerheads examined near Malta in the central Mediterranean Sea were contaminated with plastic or metal litter or had ingested tar balls (Gramentz 1988). Of 22,547 sea turtles (72.4% loggerheads) stranded on the U.S. Atlantic and Gulf of Mexico shores between 1980 and 1992, 676 (3%) were affected in some way by debris (Witzell and Teas 1994). Of the different species of sea turtles, loggerheads were least affected by entanglement; when entanglement occurred, it most frequently involved monofilament lines with fish hooks, fishing nets, and rope. More than 40 loggerheads stranded along the south Atlantic coast of the United States had ingested monofilament lines or hooks; a few had ingested plastic or balloons. Fourteen loggerheads stranded on the south Atlantic coast had ingested or become contaminated with oil or tar balls.

The loggerhead turtle's nesting environment — sandy beaches — is also a very desirable environment for human use. Most human uses of the shoreline interfere with its use as loggerhead nesting habitat (NMFS & USFWS 1991a). Loggerheads prefer to nest above the high tide line. This area of the shore often is altered or destroyed by coastal development that results in armoring of the upper shore with sea walls, rock revetments, riprap, sandbag installations, groins, and jetties to control beach-front erosion. Armoring has occurred along approximately 21% of the beach front in Florida, and along 10% of the beach front in Georgia and South Carolina. This type of beach armoring prevents loggerheads from nesting in optimal supra-tidal habitat; nests layed in front of sea walls often are inundated by high tides and destroyed.

Despite extensive preventative coastal engineering activities, beach erosion continues to decrease the amount of desirable beach-front land available for human use. Beaches often are restored by beach nourishment, which involves pumping, trucking or scraping sand onto the beach to rebuild it (NMFS & USFWS 1991a). Beach nourishment may adversely affect nesting turtles by disturbing nesting females or burying nests if carried out during the nesting season. The texture of the imported sand may not be suitable for nest construction. In addition, beach nourishment may result in compaction of the surface of the beach so that it is too hard for nest construction. Although beach nourishment may increase potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during construction (Crain *et al.* 1995).

Artificial lighting of loggerhead nesting beaches can adversely affect nesting success of adult females and survival of newly hatched turtles (Witherington 1990; NMFS & USFWS 1991a). Emergence patterns of nesting females are cued to lighting patterns on the shore. Unnatural light intensities or light wavelengths on the shore may deter emergence or result in false crawls (emergence without nesting). White light from mercury vapor lamps deterred emergence and nesting of loggerheads, but light from low pressure sodium vapor lights did not (Witherington 1990).

In the presence of artificial lights, newly hatched loggerhead turtles tend to become disoriented (unable to maintain a uniform orientation) or misoriented (failing to move toward the ocean and most often moving toward the light). These effects increase with increasing light intensity, and are greatest for light in the near-ultraviolet and green range (Witherington 1990). Yellow lights and low pressure sodium vapor lights produce little or no disorientation or misorientation in hatchling loggerheads. Disoriented and misoriented hatchlings suffer high mortalities from desiccation, entrapment in debris or vegetation on the beach, and predation.

Vehicular traffic on nesting beaches may disrupt nesting activity of females, compact the sand interfering with nest construction, destroy nests, kill hatchlings migrating down the beach, disorient adults and hatchlings by vehicular headlights, and create ruts in the beach that hatchlings find difficult to surmount in their rush to the sea (NMFS & USFWS 1991a). Increased uses of all types of beach-front property by humans can disrupt nesting activities of adults and ocean-finding success of hatchlings (Fangman and Rittmaster 1994).

Kemp's Ridley Turtle (*Lepidochelys kempii* Garman, 1880)

Population Status and Trends of the Kemp's Ridley Turtle. The Kemp's ridley and its congener, the olive ridley *(L. olivacea),* are the smallest living sea turtles; adult females have shell lengths of 62-70 cm and weigh 35-45 kg (National Research Council 1990; USFWS & NMFS 1992). Pelagic-phase juvenile ridleys range in size from 5 to 20 cm SLCL; sub-adults are 20-60 cm long; and mature adults generally are >60 cm SLCL (Marquez 1994). Kemp's ridley turtles are distributed throughout the Gulf of Mexico and into the Atlantic Ocean. Most of the ridleys that visit the east coast of the United States are juveniles, averaging 25-30 cm long and weighing 3 kg or less (NMFS 1988; NOAA 1991). The olive ridley is a tropical species; its distribution in the western Atlantic Ocean is from Venezuela to Brazil and among the islands of the Caribbean Sea to as far north as the south coast of Puerto Rico (Reichert 1993).

The Kemp's ridley turtle is the most endangered sea turtle in the world (Goombridge 1982) and is listed as endangered throughout its range (USFWS 1986). The number of females nesting at the only significant ridley nesting beach has dropped from an estimated 40,000 individuals in 1947 to 500-600 females in the mid 1980s (Pritchard 1990; Marquez 1994). Only 842 nests were found in 1988 (Ross *et al.* 1989). Since 1978, the number of nesting females has declined at a rate of about 3% per year (Thompson 1988). Recent estimates of the fecundity of female ridleys indicate that as few as 400 females may nest each year (Rostal *et al.* 1992). The total world population of adults, mostly in the Gulf of Mexico, is approximately 2200 individuals, down from an estimated 162,400 individuals in 1947 (Marquez 1989). As many as 200-300 sub-adult ridleys were sighted historically each year in Chesapeake Bay (Byles 1989). Between 1979 and 1986, 6-15 young ridleys were sighted each summer in lower Chesapeake Bay by Keinath *et al.* (1987). This is the most severe population decline documented for any species of sea turtles (National Research Council 1990). The decline is thought to have been due to predation (animal and human) of eggs on the major nesting beach and incidental take in commercial fisheries in the U.S. and Mexican Gulf of Mexico, and in the western North Atlantic (Marquez 1994).

Nearly all reproduction takes place along a single 15-km stretch of beach near Rancho Nuevo, Mexico, about 322 km south of Brownsville, Texas (Marquez 1994). One to three nests may be layed each year on Padre Island, Texas. An additional 70-95 nests may be deposited elsewhere along the Mexican coast between Playa Lauro Villar, Tamaulipas, Mexico and Isla Aguada, Campeche, Mexico, compared to 650±100 nests at Rancho Nuevo. Nesting occurs in a highly synchronized manner with large numbers of females (called an arribada) coming ashore within a period of a few hours during daylight (National Research Council 1990; Marquez 1994).

Sexually mature males and females migrate toward the nesting area in early spring. Courtship and mating occur during several weeks before the females emerge (Owens 1980). Mating occurs about 4 weeks before nesting. The females come ashore to dig nests and deposit eggs during April through July and occasionally into August. Nesting takes only about 45 minutes and each female may lay from 1-4 clutches of eggs, averaging about 2.3 (Pritchard 1990), over several days. Each clutch contains an average of 104 eggs. The average number of eggs deposited per nest has decreased from 110 in 1966 to 97 in 1992 (Marquez 1994). Most females nest every year after reaching sexual maturity.

The eggs hatch after 50-55 days (Ross *et al.* 1989). The hatchlings migrate rapidly down the beach and out to sea where they spend a period of perhaps two years in the pelagic zone. They are about 20 cm long at the end of the pelagic period (National Research Council 1990). It may require 6-10 years for a female to reach sexual maturity (Marquez 1994).

Seasonal Distribution of the Kemp's Ridley Turtle. The Kemp's ridley sea turtle is found mainly in the Gulf of Mexico (Hildebrand 1982), but small numbers of juveniles and sub-adults also occur during the summer along the Atlantic seaboard from Florida to Long Island Sound, Martha's Vineyard, and occasionally north of Cape Cod, in Cape Cod Bay, Massachusetts Bay, the Gulf of Maine, and as far north as the Canadian Maritime Provinces (Lazell 1980). Groups of dozens of young ridleys occasionally are observed feeding in shallow waters of Vineyard Sound and Buzzards Bay, Massachusetts (Carr 1967; Lazell 1980). The northern and northeastern Gulf of Mexico are prime foraging areas for juvenile, sub-adult, and post-nesting female ridleys (Marquez 1994). They often are observed associated with portunid crabs *(Callinectes* spp.), their favorite prey (Ogren 1989).

Virtually all the Kemp's ridley turtles in Atlantic waters are juveniles and sub-adults. It is generally thought that hatchlings and young juveniles from the western Gulf of Mexico drift to the east in the Gulf gyres and are caught in the eastern Gulf Loop Current (Collard and Ogren 1990). They are carried by the Florida Current through the Straits of Florida into the Gulf Stream, in which they are carried up the eastern seaboard of the United States (Collard 1987; Marquez 1994). By the time they reach New England waters, the juvenile ridleys are 24-30 cm SLCL and are able to swim against the current. They forage in shallow coastal waters of New England, New York, and New Jersey, and gradually migrate southward as the summer progresses.

Although Carr (1980) suggested that the juvenile ridleys that are carried by the Gulf Stream as far north as New England, and especially those carried all the way to Europe, can not return to the Gulf of Mexico and are lost to the reproducing population, recent studies have shown that juvenile and sub-adult ridleys do migrate southward from New England waters toward Florida and the Gulf of Mexico.

Turtles that were tagged off Cape Canaveral, migrated north in the spring as water temperatures increased and moved south in the fall as water temperatures dropped (Henwood and Ogren 1987; Schmid 1995). The longest recorded northward migration was about 880 km. Three sub-adult ridleys that were tagged and released at Virginia Beach in the fall migrated southward in nearshore waters (Keinath *et al.* 1992). One turtle traveled as far south as Cape Canaveral before the transmitter stopped. A young ridley tagged in eastern Long Island in October was tracked as it swam southward for a distance of 350 km in two weeks (Standora *et al.* 1992). The turtle intersected the Gulf Stream off Virginia and was drifting northwestward in the current when contact was lost in mid-December. Of 3245 yearling ridley turtles tagged and released off the west and southwest coasts of Florida as part of the Sea Turtle Head Start Program, 92 were recovered after 1 to 1563 days (Manzella *et al.* 1988). Sixty-six percent of the returns were from the Atlantic; the rest were from the Gulf of Mexico. Two of 8562 ridleys released off Texas were recovered off North Carolina; six were recovered off Georgia and South Carolina, and one was recovered off the coast of France. These results suggest that many of the juvenile ridleys that enter the coastal waters of the eastern Gulf of Mexico eventually swim or are carried by water currents around the southern tip of Florida into the Atlantic Ocean. Just under 46% of the returns were from Atlantic coast states north of Florida, indicating that, once ridleys move into the Atlantic, there is a high likelihood that they will be carried northward along the coast by the Gulf Stream. There were three recoveries from Chesapeake Bay, three from the New York Bight area, and one each from the coasts of France and Morocco. Young ridleys are the most abundant sea turtles that strand during fall and winter on northward-facing shores of Long Island (Morreale *et al.* 1992), and are the second most abundant sea turtles in southern Chesapeake Bay (Keinath *et al.* 1987). In some years, ridleys are common in Virginia's lower York and Potomac Rivers (Barnard *et* *al.* 1989). Between 211 and 1083 young ridleys visit southern Chesapeake Bay each summer (Keinath *et al.* 1994). The data of Keinath *et al.* (1992) indicate that sub-adult ridleys summering in Chesapeake Bay do migrate southward toward the Gulf of Mexico in the fall and winter.

There is a gradient in size of young ridley turtles along the Atlantic coast. Most ridleys observed in New England waters are 20-30 cm long, with a mean length 27.1 cm in turtles stranded in Cape Cod Bay (Danton and Prescott 1988); in Chesapeake Bay, they average slightly longer than 30 cm (NMFS 1988). Ridleys captured in South Carolina and Georgia had a mean carapace length of 34.8 cm (20.3-57.2 cm range) (Henwood and Ogren 1987). The mean size of ridleys in the vicinity of Cape Canaveral is 37.0 cm (21.5-60.3 cm range) (Schmid 1995). A 66-cm individual reported by Henwood and Ogren (1987) off Cape Canaveral was considered to be sexually mature. This size gradient indicates that small ridleys may forage and grow rapidly in the north and move south as they grow. Juvenile ridleys feeding in coastal waters of Long Island Sound during the summer may grow at a rate of 500 g or more per month (Morreale *et al.* 1989; Standora *et al.* 1989). Because ridleys may remain in Florida waters for several years until they reach sexual maturity, the southern Atlantic population contains a wider range of sizes than northern populations.

Adults are restricted almost entirely to the Gulf of Mexico, where they range widely between northern (U.S.) and southern (Mexico) regions, but rarely east of Alabama in the northern Gulf (Pritchard and Márquez 1973). The distribution of juveniles is restricted primarily to U.S. waters of the northern Gulf of Mexico from Texas to Florida and along the Atlantic coast. There have been reports of large numbers of adult Kemp's ridley turtles congregating offshore just south of the U.S. border shortly before the onset of the nesting season at Rancho Nuevo in April, May, and June (National Research Council 1990).

Food and Feeding Behavior of the Kemp's Ridley Turtle. Following a pelagic feeding stage shortly after hatching and lasting for several months (Carr 1986a,b), the juvenile ridleys move into shallow coastal waters to feed and grow. The young sub-adults often forage in water <1 m deep (Ogren 1989), but they tend to move into deeper water as they grow.

Little is known about the feeding behavior and food preferences of hatchling Kemp's ridley turtles during their pelagic stage (National Research Council 1990). During the pelagic period, they presumably feed on zooplankton and floating matter, including *Sargassum* weed and the associated biotic community (Pritchard 1979).

In coastal waters of New York, young ridleys consume several species of crabs including, in order of decreasing preference, spider crabs *(Libinia emarginata)*, lady crabs *(Ovalipes ocellatus)*, and rock crabs *(Cancer irroratus)* (Morreale and Standora 1992). In Chesapeake Bay, sub-adult ridleys concentrate in seagrass (*Zostera* and *Rupia*) beds and feed primarily on blue crabs (*Callinectes sapidus*) and cancer crabs (*Cancer irroratus*) (Lutcavage 1981; Byles 1989). Juvenile to adult ridleys stranded on Texas beaches contained a wide variety of foods in their digestive tracts; crabs were most abundant, followed by molluscs and small fish (Shaver 1991). More than 60% of the turtles contained some plant materials in their stomachs, but it represented <1% of the total gut contents.

Sub-adults and adults feed on a variety of mostly demersal or benthic crabs, shrimp, clams, snails, squid, sea urchins, starfish, coelenterates, and even small fish (Dobie *et al.* 1961; Pritchard and Marquez 1973; Bjorndal 1985). Crabs seem to be the favorite food throughout their range. Juvenile and sub-adult ridleys in Florida and Georgia were observed to feed on the crabs *Ovalipes ocellatus* and *Heppatus ephiliticus* (De Sola and Abrams 1933; Carr 1952). Blue crabs *(Callinectes sapidus)* are the favorite food of sub-adult ridleys in Virginia (Hardy 1962; Musick 1979). In New England waters, they probably feed primarily on shallow-water benthic crustaceans. Because of their preference for crabs and other primarily shallow-water demersal prey, juvenile and adult ridley turtles concentrate in coastal waters <100 m deep throughout their range (Thompson 1988). They make long dives to the bottom and may feed on the bottom for one hour or more at a time; one turtle was observed burrowing in the bottom of Long Island Sound (NMFS 1988).

Growth of Kemp's ridley turtles seems to be faster than that of loggerheads. Typical growth rates of ridleys tagged in Texas are in the range of 2.28-19 cm/y SLCL (McVey and Wibbles 1984). Ridleys tagged and recaptured off Cape Canaveral had a mean growth rate of 8.28 cm/y (Schmid 1995). A growth model proposed by Marquez (1972) indicated that ridleys reach a length of about 40 cm after about four years and reach sexual maturity at a carapace length of 60 cm after about six or seven years. Captive ridleys reach a length of about 40 cm and a weight of about 12 kg after two years (Fontaine *et al.* 1985).

Causes of Mortality of the Kemp's Ridley Turtles. Several stages in the life cycle of Kemp's ridley turtles are sensitive to natural and anthropogenic disturbance. Recent data from the Sea Turtle Stranding and Salvage Network indicate that fewer ridleys than loggerheads (63-143 per year versus 793-1072 per year) strand along the east coast of the United States (Table 4-5). This undoubtedly is due mainly to the much smaller population size of ridleys than of loggerheads in the western Atlantic Ocean. Most of the ridley strandings along the U.S. Atlantic coast are in Florida and Georgia (Table 4-5). In some years, relatively large numbers also stand in North Carolina and Virginia. Most strandings in the northeastern United States are in New York (north shore of Long Island) and Massachusetts (north shore of Cape Cod), and are usually due to cold stunning.

Each year between November and January, when ocean water temperatures fall, small numbers of ridley turtles become stranded due to cold stunning and die on beaches of inner Cape Cod and along the north shore of Long Island (NOAA 1991). When the water temperature drops below about 12°C, the metabolic rate of these cold-blooded reptiles decreases to the point where they are unable to swim and digest food; they become comatose and may die if not warmed quickly. A total of 115 ridley turtles stranded on Cape Cod beaches between 1977 and 1987 (Danton and Prescott 1988). In the winter of 1985-1986, 52 turtles (41 ridleys, 9 loggerheads, and 2 green turtles) stranded in Long Island Sound (Meylan and Sadove 1986). Nine of the ridleys and one each of the loggerheads and green turtles survived following gradual warming at a rehabilitation center. Similar cold strandings have occurred as far south as the Indian River Lagoon in Florida (Wilcox 1986; Morreale *et al.* 1992). During the winters of 1986 and 1987, 28 ridleys stranded along the north shore of Long Island; six of the turtles survived. In all three years, the strandings took place between November and March, with most strandings in December. Between 1987 and 1993, 0.3-3.3% of all species of turtles stranding each year were cold-stunned (Table 4-4).

Other contributing causes to strandings of all turtles, including ridleys, are boat collisions, entanglement in shrimp trawls and other fishing gear, ingestion or fouling with man-made debris and petroleum/tar balls, and various injuries of uncertain origin (Table 4-4). Ridleys are particularly susceptible to being taken in shrimp trawls and bottom fishing gear.

A major cause of sea turtle mortality attributable to man is entanglement in fishing gear, particularly shrimp nets (National Research Council 1990). Henwood and Stuntz (1987) estimated an annual incidental capture of approximately 47,000 sea turtles of all species, with an estimated mortality of about 11,000 in the shrimp fisheries of the Gulf of Mexico and southern U.S. Atlantic coast. These estimates are thought to be low (National Research Council 1990). Of all the turtles killed during commercial shrimping, 500-5000 are Kemp's ridley turtles.

Table 4-5. Strandings of Kemp's Ridley Turtles (*Lepidochelys kempi)* along the U.S. Atlantic Coast from 1988 to 1993, all months combined each year. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

State	1988	1989	1991	1992	1993
Florida	68	15	14	2	10
Georgia	37	21	26	11	37
South Carolina	6	4	5	6	5
North Carolina	11	2	6	12	29
Virginia	13	5	6	14	17
Maryland	0	0	1	0	1
Delaware	0	0	0	1	0
New Jersey	0	1	3	1	4
New York	2	12	10	7	4
Connecticut	0	0	0	0	0
Rhode Island	0	0	0	0	0
Massachusetts	4	26	11	9	36
New Hampshire	0	0	0	0	0
Maine	0	0	0	0	0
Puerto Rico	0	0	0	0	0
U.S. Virgin Islands	0	0	0	0	0
Total Atlantic Strandings	141	86	82	63	143

Other fishing-related deaths, caused by entanglement in lobster gear (O'Hara *et al.* 1986) and pound nets (Morreale and Standora 1989), may result in an additional 50-500 deaths of Kemp's ridley turtles each year. Ridley turtles, being benthic feeders, tend to become entangled in bottom debris, including abandoned fish and crab traps. They frequently become trapped in pound nets in coastal waters of the New York Bight (Sadove and Morreale 1990). Between November 1991 and February 1992, 30 ridleys were caught in the summer flounder trawl fishery off North Carolina, and one of those died (NMFS & NCDE 1992; Epperly *et al.* 1995b).

The total incidental catch of Kemp's ridley turtles, associated with the different commercial fisheries in the U.S. Gulf of Mexico and the Atlantic Ocean, may approach 6000 individuals per year, representing 7.5% of the hatchling ridleys produced each year, assuming that the 800 nests produced a total of 80,000 hatchling ridley turtles each year. This extra mortality undoubtedly is contributing to the rapid decline in the population of Kemp's ridley turtles.

Large numbers of sea turtles, including some Kemp's ridley turtles, die from eating or becoming entangled in plastic and other man-made debris (O'Hara 1989; National Research Council 1990). Sea turtles are particularly prone to becoming entangled in monofilament fishing line and phantom fishing nets (Balazs 1985). Plastic bags and plastic particles are the most common forms ingested because these items are probably mistaken for food. Ridley turtles seem to be less susceptible to entanglement than other species of sea turtles (Witzell and Teas 1994). Sub-adult ridleys in the northeast United States and along the Atlantic coast of Florida rarely, if ever, ingest plastic debris (Bjorndal *et al.* 1994; Burke *et al.* 1994).

Under some circumstances, chemical pollution may be a threat to ridley turtles. As part of the Sea Turtle Head Start Program, 12,422 one-year-old ridley turtles were tagged and released between 1979 and 1987 (Manzella *et al.* 1988). In 1982, 1325 ridleys were released 6-10 km off the Texas coast in floating patches of *Sargassum* weed. More than 28% of the turtles washed ashore within 14 days of release, and most were coated with oil or had ingested tar balls, probably associated with the *Sargassum*. Because early pelagic-stage ridleys are thought to congregate and feed in rafts of *Sargassum*, they may be vulnerable, as juvenile loggerhead turtles are (Carr 1987), to floating oil and nondegradable debris that collects in driftlines of *Sargassum*. Young ridleys off Texas (Plotkin and Amos 1990) may have a high incidence (>50%) of fouling with oil or tar. Ridleys feeding in *Sargassum* rafts or on benthic prey, may accumulate metal and organic contaminants from their prey. Closely related olive ridley turtles (*Lepidochelys olivacea*) collected from coastal Ecuador contained elevated concentrations of copper, lead, and zinc in their bones (Witkowski and Frazier 1982).

Heavy rains, storms, and erosion may damage or destroy eggs on the nesting beach. Because all nesting takes place along a single beach, a single severe storm during the nesting season can destroy a large part of a year class of turtles. In 1988, Hurricane Gilbert severely scoured the nesting beach at Rancho Nuevo; in 1989, the returning females were displaced about 15 km to the north (National Research Council 1990). It is uncertain if the storm damage contributed to a lower-than-usual nesting success.

The main threat to eggs and newly emerged hatchlings is from predation by fish, birds, mammals, and man. Since 1966, the Mexican government has posted armed guards on the nesting beach to protect the nests from poachers (National Research Council 1990). However, it is more difficult to protect the eggs and hatchlings from animal predators.

The Leatherback Turtle (*Dermochelys coriacea* Vandelli, 1761)

Population Status and Trends of the Leatherback Turtle. Leatherback turtles (*Dermochelys coriacea*) are the largest and most distinctive of the living sea turtles. Because of their distinct anatomy and physiology, they are placed in a separate family, the Dermochelyidae, containing a single species (NMFS & USFWS 1992). Leatherbacks reach a length of 150-170 cm SLCL and a weight of 500 and exceptionally 900 kg. Large outstretched front flippers may span 270 cm in an adult. Lacking a keratinized shell, they are covered instead with a tough hide. Leatherbacks have a layer of subcutaneous fat that is 6-7 cm thick and circulatory adaptations to reduce the rate of heat loss through the flippers (Greer *et al.* 1973). They respond to drops in ambient temperature by increasing metabolic heat production and so can maintain an internal body temperature well above ambient (Standora *et al.* 1984; Paladino *et al.* 1990). A leatherback in 7.5°C seawater was able to maintain its core body temperature at 25.5°C (Friar *et al.* 1972). This endothermy allows leatherbacks to survive and feed in colder temperate waters than other sea turtles can tolerate. Therefore, leatherbacks are more widely distributed as adults than other sea turtles in temperate and boreal waters throughout the world. However, all leatherbacks return to subtropical and tropical shores to nest.

Leatherback turtles are the second most common turtle along the eastern seaboard of the United States, and the most common north of the 42°N latitude. Between 100 and 900 leatherbacks visit coastal and continental shelf waters of the western North Atlantic Ocean between Canada and North Carolina each year, with peak abundance in summer (Shoop and Kenney 1992). As many as 115,000 adult female leatherbacks remain worldwide (Pritchard 1982). Nevertheless, the leatherback sea turtle is listed as endangered throughout its range (USFWS 1986).

Because they are a largely oceanic, pelagic species, estimates of their population status and trends have been difficult to obtain. In addition, only a small fraction of the North Atlantic population nests on beaches of the continental United States, mostly in Florida (National Research Council 1990; Meylan *et al.* 1994) and the U.S. Virgin Islands (Boulon *et al.* 1994). Leatherbacks that visit U.S. Atlantic waters nest primarily along the coasts of Surinam and French Guiana, and to a lesser extent on the island of St. Croix and at Culebra, Puerto Rico (National Research Council 1990; NMFS & USFWS 1992; Boulon *et al.* 1994). Nesting is scattered along isolated beaches throughout the Caribbean. Nesting females do not have the nest-site fidelity exhibited by Kemp's ridley turtles and tend to move to different beaches in different years (Tucker 1990). Therefore, it has been difficult to estimate temporal trends in population size. However, it appears that populations of leatherbacks in the North Atlantic are stable.

Nearly all nesting occurs in the tropics. An estimated 50% of the adult female leatherbacks nest along the west coast of Mexico (Pritchard 1982). Most nesting of the Atlantic/Caribbean population occurs along the mainland coast of the southern Caribbean from Costa Rica to Columbia, from French Guiana to Surinam, and in Trinidad and the Dominican Republic (National Research Council 1990; NMFS & USFWS 1992).

Between 10 and 188 leatherback nests are reported each year along the Atlantic coast of Florida (NMFS & USFWS 1992; Meylan *et al.* 1994). Between 10 and 25 female leatherbacks probably account for all the nests deposited each year along the Atlantic coast of Florida (NMFS & USFWS 1992). Nesting in Florida is wide spread but erratic from year to year and from one place to another. Most of the remaining leatherbacks nesting on U.S. shores occur in the U.S. Virgin Islands (St. Croix, St. Thomas, and St. John) and in Puerto Rico, including the small islands of Culebra, Vieques, and Mona (NMFS & USFWS 1992). Between 50 and 70% of the total nesting on St. Croix occurs at Sandy Point (NMFS & USFWS 1992). Between 18 and 55 leatherback turtles nest each year at Sandy Point, a 3-km beach on St. Croix (Boulon 1992; Boulon *et al.* 1994). Because of the importance of Sandy Point, St. Croix for leatherback nesting, it has been designated as critical habitat for leatherback turtles (NMFS 1994a). There is one record of a leatherback turtle nesting on a North Carolina beach (Pritchard 1989).

Each female may nest up to 10 times (mean frequency 5-7 times, depending on year) in a single season (Tucker 1989) at intervals of about 10 days. Females usually nest only every other year (National Research Council 1990; Boulon *et al.* 1994). Most nesting takes place during March and April (NOAA 1991). A typical nest on a Culebra beach contains about 30-115 eggs (mean 70), each about 5.4 cm in diameter (Hall 1990). Some of the eggs do not have a yolk and are infertile. The eggs hatch after about 65 days.

Seasonal Distribution of Leatherback Turtles. Leatherback turtles are common during the summer in North Atlantic waters from Florida to Massachusetts, the Canadian Maritime Provinces, and occasionally as far north as Baffin Island (Figure 4-11, Goff and Lien 1988). New England and Long Island Sound waters support the largest populations on the Atlantic coast during the summer and early fall (Lazell 1980; Prescott 1988; Shoop and Kenney 1992). Leatherbacks are observed frequently in lower Chesapeake Bay and off the mouth of the Bay during the summer, where they probably are feeding on the locally abundant jellyfish (Barnard *et al.* 1989).

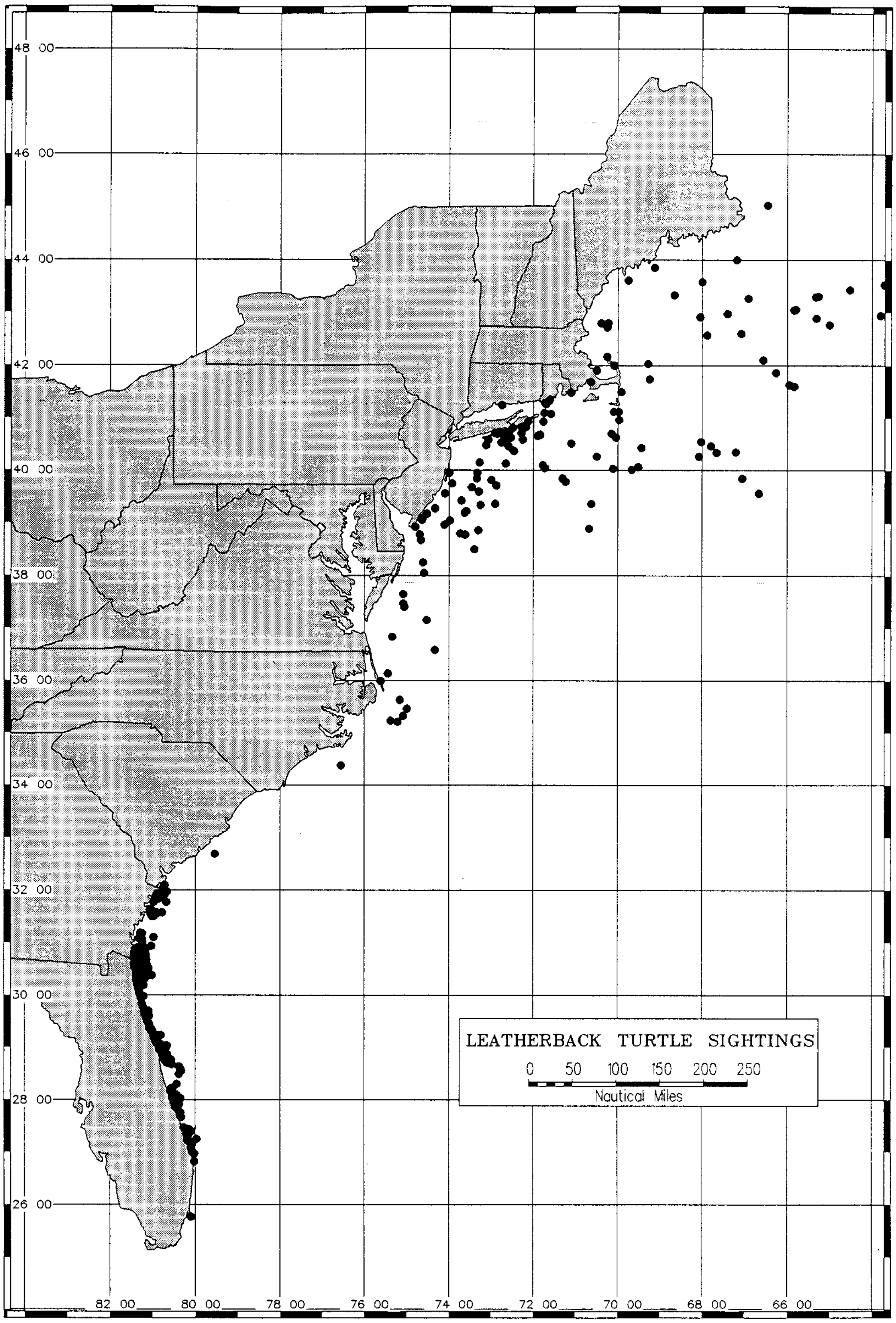

Figure 4-11. Cumulative sightings, 1960-1992, of Leatherback turtles along the East Coast of the United States.

Leatherbacks are rarely sighted north of Cape Hatteras during the winter. Three leatherbacks were sighted in Core Sound, just south of Cape Hatteras, in December 1989 (Epperly *et al.* 1992). In some years, they are abundant in nearshore waters off the east coast of Florida. Knowlton and Weigle (1989) reported sighting 168 leatherbacks in coastal waters between Sebastian Inlet and St. Augustine, Florida in February 1988. During most of the year, they are pelagic and remain far offshore in oceanic waters. However, periodically, especially during the summer, they may come relatively close to shore pursuing their jellyfish prey (Lee and Palmer 1981).

Leatherback turtles nest on tropical beaches, after which the adults move into temperate waters to feed. Most leatherbacks that visit New England waters are adult males, usually >150 cm and weighing >450 kg (NOAA 1991). Adults migrate extensively throughout the Atlantic basin in search of food. There are numerous records of leatherback turtles in New England, and as far north as Nova Scotia and Newfoundland (Goff and Lien 1988). Sightings off Massachusetts are most frequent in the late summer months (Shoop *et al.* 1981; CeTAP 1982; Shoop and Kenney 1992).

In the spring, following breeding and nesting in the tropical Caribbean and Florida, and aided by the northward flow of the Gulf Stream, leatherback turtles move northward beyond the shelf break. For this reason, there are few sightings of leatherbacks in coastal and outer continental shelf waters in the spring months (CeTAP 1982). They appear in offshore waters of the middle Atlantic states and in the Gulf of Maine in late May-June, and in shelf waters from June through October (Shoop *et al.* 1981; Shoop and Kenney 1992). In New England waters, they are seen most frequently in the southern Gulf of Maine, including Cape Cod and Massachusetts Bays. Leatherbacks occur most frequently in coastal waters of Newfoundland in August and September when water temperatures are at their highest (Goff and Lien 1988).

During the summer, they move into fairly shallow coastal waters, apparently following their preferred jellyfish prey. In the fall, leatherbacks move offshore and begin their migration south to the winter breading grounds in the tropical Caribbean (Payne *et al.* 1984). Leatherbacks may travel great distances between nesting and feeding areas. Tagging studies have shown that some of the leatherbacks that visit New England waters nested in the U.S. Virgin Islands and along the southern coast of the Caribbean or in the Guianas (Boulon 1989; National Research Council 1990). A 157-cm leatherback found entangled in fishing nets near Fox Harbor, Newfoundland, on 17 September 1987, bore a tag indicating that it had migrated 5000 km from French Guiana, South America, in 128 days at an estimated speed of at least 39 km/day (Goff *et al.* 1994).

Food and Feeding Behavior of the Leatherback Turtle. Leatherback turtles are pelagic feeders, though they can dive to considerable depths. They feed throughout the water column to depths of at least 1000 m (Eckert *et al.* 1989) on jellyfish and other gelatinous zooplankton, such as salps, ctenophores, and siphonophores (Limpus 1984). Most feeding dives average about 60 m, but frequently extend to 300-400 m (Eckert *et al.* 1986, 1989) where they feed on deep-water gelatinous zooplankton, such as siphonophores and salps. Their seasonal inshore movements in New England waters have been linked to inshore movements of their preferred prey, the jellyfish *Cyanea capillata* (Lazell 1980; Payne and Selzer 1986). A leatherback collected near Malta in the Mediterranean Sea contained in its stomach two species of siphonophores and one species of scyphozoan (den Hartog 1980). Off the coast of France, leatherbacks feed primarily on the medusa *Rhizostoma plumo* (Dugay 1983).

Leatherbacks have a notched upper jaw, an adaptation for grasping soft prey (Pritchard 1971). They also possess a long digestive tract, about nine times longer than the length of the carapace, and a large caecum for holding the large amount of watery, gelatinous prey they need to consume to fulfill their caloric needs (Bjorndal 1985).

Causes of Mortality of the Leatherback Turtle. Many of the same natural and anthropogenic factors that affect survival of loggerhead and Kemp's ridley turtles also affect leatherbacks. In 1987 and 1988, 119 and 63 leatherbacks, respectively, stranded along the U.S. coast (National Research Council 1990). Most of the strandings occurred along the coasts of Delaware, New Jersey, and New York. There was only one stranding in New England. The cause of death of most of these turtles was not known. Being temperate water species, leatherbacks do not seem to be sensitive to cold temperatures, and strandings can not be attributed to cold stunning.

Between 1988 and 1993, 69-135 leatherback turtles were stranded on the U.S. Atlantic coast each year (Table 4-6). Most strandings were in Florida and New York. In some years, there were several strandings in either or both New Jersey and Massachusetts. The causes of these strandings are not known, but entanglement in fishing gear may be a major factor.

Leatherbacks apparently are not frequently caught in commercial shrimp nets. However, they are very susceptible to entanglement in other fishing gear and in plastic debris (Mager 1985; Witzell and Teas 1994). Because they are adapted to a pelagic existence, leatherbacks have trouble maneuvering in tight places and swimming backwards, and have difficulty avoiding obstructions in shallow waters (Payne and Selzer 1986; NOAA 1991). In January-February 1992, a leatherback turtle became entangled and died in a summer flounder trawl south of Cape Hatteras (Epperly *et al.* 1995b). Leatherbacks have been entangled in lobster gear (O'Hara *et al.* 1986; Sadove and Morreale 1990) and long-lines (Balazs 1985) in New York Bight and New England waters. In 1992, 50 leatherbacks were taken in the long-line fishery between Cape Hatteras and the Grand Banks (Brady and Boremen 1994). An estimated 356 leatherbacks were captured in 1992 and 242 were captured in 1993 in the entire long-line fisheries for tuna and swordfish in the western North Atlantic Ocean (Witzell and Cramer 1995). Records from the Sea Turtle Stranding and Salvage Network show that 45 leatherback turtles became entangled in lobster gear between 1983 and 1993 in coastal waters of New Jersey, New York, and southern New England (NMFS 1994b). Eleven of the entangled turtles died. The leatherback's large front flippers (often 1 m long) often bear cuts, chafing marks, or are severed altogether, possibly due to entanglement (Fretey 1982).

Because of their preferred diet of gelatinous zooplankton, particularly jellyfish, leatherback turtles often ingest floating plastic debris, mistaking it for food (Wallace 1985; O'Hara 1989). Plastic bags blocked the stomach openings of 11 of 15 leatherbacks that washed ashore on Long Island during a two-week period (Balazs 1985). The largest leatherback ever recorded washed ashore on the coast of Wales, dead in tangled fishing gear and with a large piece of plastic blocking the entrance to its small intestine (Eckert and Eckert 1988).

Although leatherbacks are not harvested commercially for meat or other products, there is extensive subsistence harvesting of the females that come ashore to nest throughout much of the tropical nesting range, including Guyana, Trinidad, and Columbia (National Research Council 1990). Egg collecting is also intense in some areas.

Table 4-6. Strandings of Leatherback Turtles *(Dermochelys coriacea)* along the U.S. Atlantic Coast from 1988 to 1993, all months combined each year. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

State	1988	1989	1991	1992	1993
Florida	26	27	24	17	15
Georgia	2	5	36	11	5
South Carolina	1	12	11	34	12
North Carolina	1	9	6	7	13
Virginia	3	3	5	7	3
Maryland	0	0	0	1	0
Delaware	0	0	0	1	1
New Jersey	7	3	11	5	28
New York	14	11	24	9	28
Connecticut	0	0	1	0	2
Rhode Island	1	7	11	9	13
Massachusetts	13	0	5	8	5
New Hampshire	0	0	0	0	0
Maine	0	1	0	0	0
Puerto Rico	0	1	1	1	0
U.S. Virgin Islands	1	0	0	1	0
Total Atlantic Strandings	69	79	135	111	125

The Green Sea Turtle (*Chelonia mydas* Linnaeus 1758)

Population Status and Trends of the Green Sea Turtle. The green turtle *(Chelonia mydas)* is the largest of the thecate (hard-shelled) sea turtles. Adult green turtles may reach a length of 110 cm or more SLCL and a weight of at least 150 kg (Witherington and Ehrhart 1989). It is listed as threatened throughout its range, except for breeding populations in Florida and the Pacific coast of Mexico, which are listed as endangered (USFWS 1986; NMFS 1994a). These turtles were once very abundant throughout shallow coastal waters in tropical and subtropical climates; their rapid decline in the 20th century is attributed, in part, to heavy predation by man on its eggs, and on adults for food and shell products (Thompson 1988; NMFS 1994a). A commercial fishery for this species extended from Texas to North Carolina (Thompson 1988). The maximum annual catch of green turtles in the Indian River was 2500 individuals in 1886, but the annual catch had declined to 500 individuals by 1895. Annual catches in this area of Florida were in the range of 200-500 individuals during 1970-1974 (Thompson 1988). Late in the last century, as many as 2800 adult females nested each year on Dry Tortugas (near Key West), but this nesting population was harvested to extinction early in this century.

Adult green turtles mate off nesting beaches during the summer months. The females then emerge at night to deposit their eggs in the upper intertidal and supratidal zones of sandy shores (NMFS & USFWS 1991b). In a season, each female may lay from 1-7 clutches of eggs, each containing 110-136 eggs. Re-emergence intervals for green turtles are in the range of 2-4 years. Females have moderately high site fidelity, returning to the same beach to nest within years and over years (Johnson and Ehrhart 1994). Unless preyed upon by animals, particularly raccoons (Wells and Bellmund 1990) and human predators, hatching success of green turtle eggs is usually high. However, human disturbance of nesting habitat may reduce egg survival substantially (NMFS & USFWS 1991b).

The greatest green turtle nesting area in the Florida Keys is on Long Key (Wells and Bellmund 1990). Between 30 and 35% of the green turtle nesting in the United States occurs along a 33-km stretch of barrier island coast between Melbourne Beach in Brevard County and Wabasso Beach in Indian River County (Tritaik 1994). A record of 477 green turtle nests was recorded at Melbourne Beach in 1990 (Owen *et al.* 1992). In 1992, 44 green turtles nested at Jupiter/Carlin Park, Florida (Davis *et al.* 1994). Also in 1992, there were 12-50 green turtle nests per kilometer, with a mean of 29 nests/km, along the shore of the Archie Car National Wildlife Refuge in south Florida (Owen *et al.* 1994). The total number of green turtle nests each year at the refuge has ranged from 32 in 1984 to 686 in 1992, with strong years interspersed with weak years. Between 1979 and 1992, the number of green turtle nests reported each year along the entire east coast of Florida ranged from 62 to 2509 (Meylan *et al.* 1994). Green turtle nesting also occurs frequently on islands off Puerto Rico, such as Mona Island and Isla Caja de Muertos (van Dam *et al.* 1990; Diaz 1994). In 1993, green turtles nested on 55% of the St. Croix beaches monitored by Mackay (1994). Heaviest nesting was at Sandy Point National Wildlife Refuge and at Jack's Bay.

Seasonal Distribution of the Green Sea Turtle. Green turtles are found in moderate numbers along the coasts of Florida, in the U.S. Virgin Islands and Puerto Rico, and throughout the Gulf of Mexico (NMFS & USFWS 1991b). An estimated 1500 green turtles, most of them sub-adults, use coastal waters of east central Florida each year (Ehrhart 1983) and the numbers of juveniles in this area may be increasing (Thompson 1988). Based on the relative numbers of green turtles stranded along the U.S. southeast coast each year, Thompson (1988) estimated that green turtles represent 3-4% of the total turtle numbers in the southeastern United States. This represents about 600-800 nesting females during May-August each year and approximately 11,000-16,000 total green turtles along the U.S. southeast coast throughout the year. Since about 1980, the number of green turtles nesting each year and the total population of green turtles in Florida waters appear to have increased gradually (Thompson 1988; NMFS 1994a).

During the summer, small numbers of green turtles may venture as far north as the New York Bight and New England, where some become cold-stunned each year by falling water temperatures in the fall and winter (Burke *et al.* 1992; Morreale *et al.* 1992). Green turtles, the only species of sea turtle that is a strict herbivore as an adult, feed in shallow coastal waters on sea grasses and marine algae; they are abundant wherever these plants are abundant. Sub-adult green turtles are occasionally observed in the late summer feeding on seagrass beds in Chesapeake Bay (Barnard *et al.* 1989) and along the shores of Long Island (Burke *et al.* 1992). They are the second most frequently caught sea turtle by recreational fishermen in coastal waters of North Carolina (Epperly *et al.* 1992). Important feeding areas for green turtles include the Indian River Lagoon and Florida Keys on the Atlantic coast of Florida, and Florida Bay, Homosassa, Crystal River, and Cedar Key on Florida's west coast (NMFS & USFWS 1991b). Both juvenile (<20 cm SLCL) and sub-adult (20-90 cm SLCL) green turtles are abundant in the Indian River Lagoon, and on nearby offshore sabellariid reefs and hard bottoms (Henwood and Ogren 1987; Wershoven 1989; Ehrhart *et al.* 1990; Wershoven and Wershoven 1989, 1992; Guseman and Ehrhart 1990). More than 80% of the green turtles captured by Schmid (1995) off Cape Canaveral were sub-adults <40 cm SLCL. Sub-adult green turtles are most abundant in Florida coastal waters during the winter. They probably migrate northward to summer feeding grounds in North Carolina, Chesapeake Bay, and the New York Bight in the spring and return to Florida waters in the fall.

Food and Feeding Behavior of the Green Sea Turtle. Post-hatchling green turtles, like other sea turtles, disappear or are very difficult to find for a year or more after hatching. They are presumed to congregate along drift lines and convergences, particularly those containing masses of floating *Sargassum* weed. Carr (1986a) cites nine reports of juvenile green turtles (≤ 20 cm) associated with *Sargassum* rafts. While associated with the floating algae, they undoubtedly subsist on the *Sargassum* itself as well as on the small plants and animals associated with the drift line and *Sargassum.*

After green sea turtles become sub-adults and shift to benthic feeding in coastal waters, they are almost completely herbivorous (NMFS & USFWS 1991b). Green turtles are the only living herbivorous marine turtles; they subsist as sub-adults and adults entirely on seagrasses and marine algae (Bjorndal 1985). Most local populations of green turtles feed on either seagrasses or marine algae, but rarely both. A favorite seagrass food of green turtles throughout the Caribbean and south Florida is *Thalassia testudinum. Thalassia* is a highly productive grass and can support as many as 138 adult female green turtles per hectare (Bjorndal 1982). Individual green turtles may maintain a grazing plot of seagrass which they repeatedly re-graze, helping to maintain the rapid growth of the new, more nutritious young leaves (Bjorndal 1985). In the Mosquito Lagoon, Brevard County, Florida, sub-adult green turtles weighing 7-50 kg graze exclusively on the seagrasses *Syringodium filforme*, *Halodule wrightii*, and *Halophila* sp. (Mortimer 1981).

Reef areas off Broward County, Florida, do not contain seagrasses. Most of the sub-adult green turtles that congregate in that region feed on marine algae associated with the reefs (Wershoven and Wershoven 1989). The predominant food of these turtles is algae of the family Gelidiaceae, including *Pterocladia, Gelidium,* and *Geliciella* spp.

During feeding, sub-adult green turtles do not wander far, but remain within a small area of $1km^2$ or less (Nelson 1994). A typical dive cycle during feeding in Florida lasts about 33 min, of which 1min is spent at the surface between dives, and 30 min is spent on the bottom foraging on seagrass or algae (Nelson 1994). Thus, green turtles in their feeding grounds are hard to monitor because they spend more than 50 min of each hour submerged.

In waters around Long Island, green turtles feed primarily on algae, followed by the seagrass *Zostera marina* (Burke *et al.* 1992). The most abundant algae consumed by the green turtles are *Fucus, Sargassum, Codium,* and *Ulva*. Some green turtles consume small numbers of molluscs, crabs, and synthetic materials. The crabs and molluscs may be ingested with the preferred algae and grass.

The growth rate of green turtles in Australia is about 1.0 cm/y and decreases with size (Limpus and Walter 1980). In waters around the Bahamas, Florida, the U.S. Virgin Islands, and Puerto Rico, green turtles grow from a length of 30 cm to 75 cm in about 17 years, an annual growth rate of 2.6 cm/y (Bjorndal and Bolten 1988; Boulon and Frazer 1990; Bjorndal *et al.* 1995). In the wild, green turtles may reach sexual maturity in 20-50 years (Frazer and Ehrhart 1985).

Causes of Mortality of the Green Sea Turtle. The same natural and anthropogenic disturbances to shoreline habitat and to offshore waters that adversely affect loggerhead populations also affect populations of green sea turtles throughout their range in U.S. waters (NMFS & USFWS 1991a,b). Between 1988 and 1993, 138-200 green turtles were stranded each year along the east coast of the United States (Table 4-7). Most strandings each year were in Florida, followed by North Carolina. In some years, large numbers of green turtles strand in Puerto Rico. Green sea turtles are relatively rare visitors north of Virginia, and the stranding records reflect this. An occasional green turtle is stranded in New York or Massachusetts, usually as a result of cold-stunning (Morreale *et al.* 1992). Between 1979 and 1993, 25 green turtles stranded in Georgia (Maley *et al.* 1994). Many of the strandings along the south Atlantic coast may have been associated with entrapment in shrimp trawls; strandings of green and other sea turtles have decreased since institution of TED requirements for shrimp trawls (Maley *et al.* 1994). Between November 1991 and February 1992, two green sea turtles were caught in summer flounder trawls south of Cape Hatteras; both turtles were alive when released (Epperly *et al.* 1995b). Between 1988 and 1989, 266 sub-adult green turtles stranded in a six-county area from Brevard to Broward County in Florida (Ehrhart *et al.* 1990). Several turtles were ensnared and killed by an abandoned gill net.

Green turtles ranked second to loggerhead turtles in frequency of propeller and boat-collision injuries (Teas 1994b). The incidence of entanglement in anthropogenic debris was about the same for green and loggerhead turtles along the southeast U.S. coast; given the much larger population size of loggerheads than green turtles, this pattern indicates that green turtles are unusually vulnerable to entanglement (Teas 1994a; Witzell and Teas 1994). Green turtles seem to be particularly vulnerable to entanglement in fish hooks, monofilament line, and fishing nets. They are also sensitive to entanglement in non-fishing gear and marine debris. About 45 green turtles, stranded along the U.S. southeast Atlantic coast, had been impacted by petroleum or tar balls (Witzell and Teas 1994). However, green sea turtles are not particularly prone to ingesting synthetic materials such as plastics (Sadove and Morreale 1990).

The Hawksbill Turtle (*Eretmochelys imbricata* Linnaeus, 1766)

Population Status and Trends of the Hawksbill Turtle. The hawksbill sea turtle *(Eretmochelys imbricata)* is a medium-sized sea turtle, slightly larger than the ridley turtle. Adult nesting females have a carapace length of about 87 cm and weigh about 80 kg (NMFS & USFWS 1993). Hawksbills nesting in Puerto Rico had carapace lengths of 67.1-85.6 cm SLCL (Thurston and Wiewandt 1976). The largest hawksbill on record weighed 125 kg. Hatchlings are about 4.2 cm long and weigh 13-20 g (Witzell 1983).

The hawksbill turtle is a tropical and subtropical species, inhabiting warm waters of the Atlantic, Pacific, and Indian Oceans (Witzell 1983; NMFS & USFWS 1993). In U.S. territorial waters, hawksbills occur along the Gulf of Mexico coast, especially in south Texas, along the Gulf and Atlantic coasts of Florida, particularly around reefs off Palm Beach County and in the Florida Keys where the warm Gulf Stream comes close to shore, and in Puerto Rico, particularly the islands of Mona, Culebra, and Vieques, and in the U.S. Virgin Islands. Hawksbill turtles are listed as endangered throughout their range worldwide (USFWS 1986). Their decline throughout their range is attributed largely to hunting pressure for their valuable shells (NMFS 1994a).

Table 4-7. Strandings of Green Turtles *(Chelonia mydas)* along the U.S. Atlantic Coast from 1988 to 1993, all months combined each year. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

State	1988	1989	1991	1992	1993
Florida	121	173	155	123	118
Georgia	5	2	1	1	1
South Carolina	0	2	1	2	0
North Carolina	20	14	4	28	10
Virginia	2	2	0	0	2
Maryland	0	0	0	0	0
Delaware	0	0	0	0	0
New Jersey	0	0	0	0	1
New York	0	0	1	1	0
Connecticut	0	0	0	0	0
Rhode Island	0	0	0	0	0
Massachusetts	0	1	1	1	0
New Hampshire	0	0	0	0	0
Maine	0	0	0	0	0
Puerto Rico	3	1	18	11	3
U.S. Virgin Islands	2	5	7	5	3
Total Atlantic Strandings	153	200	188	172	138

Hawksbill turtles are solitary nesters, making it difficult to gain insights into their population sizes in areas where they nest (Witzell 1983). An estimated 4975 hawksbills nest each year throughout the wider Caribbean Sea (including U.S. territories) (Meylan 1989). As many as 36 female hawksbills lay about 160-200 nests each year on Mona Island in Puerto Rico between May and January (Dodd 1978; van Dam *et al.* 1990, 1992). Several hawksbills nest year-round on Isla Caja de Muertos, Puerto Rico (Diaz 1994). Between 15 and 30 hawksbills may nest on beaches in St. Croix each year during June-November (Dodd 1978; Eckert 1992). Between 46 and 99 hawksbill nests have been recorded at Buck Island Reef National Monument each year between 1987 and 1992 (Hillis 1994a,b). Only a few nests are deposited between April and August each year on Florida beaches (Lund 1978; Meylan *et al.* 1994). Juveniles and sub-adults tend to remain and feed on coral reefs near their natal beaches (Witzell 1983). Hawksbills show a high fidelity to their nesting beach and return to the same or to a nearby beach year after year (Bjorndal *et al.* 1985).

Hawksbill turtles nest over a long season, April-August in Florida, and May-January in Puerto Rico (Witzell 1983). Mating occurs off nesting beaches. Females usually come ashore at night, and are easily disturbed by lights and activity on the beach. Nesting requires 1-3 h and may be repeated several times a year (average 4.5 times per year). There are a few records of up to 12 clutches of eggs produced by a single female in a season (Melucci *et al.* 1992). Remigration occurs at intervals of 2-3 years. Clutch size increases with age of the female; in Florida and the U.S. Caribbean, it averages about 140 eggs per nest, with a maximum of about 200 eggs. In Puerto Rico, the average number of eggs per nest is 124, with a range of 114-134 (Thurston and Wiewandt 1976). Hatching occurs after about 60 days of incubation, and hatching success averages about 80% on U.S. beaches (NMFS & USFWS 1993).

Most nesting populations of hawksbills are considered in decline due to overexploitation of adults for their shells and because of nesting habitat destruction (Witzell 1983). In the U.S. Caribbean and the Florida Keys, hawksbill turtles were severely depleted during the 20th century due mainly to overexploitation. At present, since the sale of turtle-shell products was banned, they may no longer be in decline, but their numbers are not increasing (NMFS & USFWS 1993). In the western North Atlantic and Caribbean Sea, hawksbill nesting populations have continued to decline (Meylan 1989). There appears to be a low, but positive, net recruitment rate to the nesting population at Buck Island reef in St. Croix (Hillis 1994a,b).

Seasonal Distribution of the Hawksbill Turtle. Like most sea turtles, hatchling hawksbills are pelagic for a period of one to several years. Carr (1987) identified ten sightings of juvenile hawksbills associated with offshore *Sargassum* rafts. When the juveniles reach a carapace length of about 20-25 cm, they return to coastal waters to feed and grow as sub-adults (NMFS & USFWS 1993). Sub-adult and adult hawksbill turtles feed in shallow, high-energy habitats over reefs, rock bottoms or other hard substrates that support dense populations of sponges, which are their favorite foods (Witzell 1983; NMFS & USFWS 1993). Many hawksbills are relatively sedentary, rarely making long migrations (Carr 1977); however, migrations over great distances have been documented (Witzell 1983). Young hawksbill turtles tagged in the U.S. Virgin Islands were subsequently recovered in the islands as well as at distant locations, suggesting that some of the turtles are migratory (Boulon 1989). After nesting at Buck Island reef on St. Croix, tagged female hawksbills dispersed throughout the Caribbean (Hillis 1994a,b). One turtle was recovered dead in Miskito Cays, Nicaragua. Three hawksbills tagged on Buck Island, St. Croix, remained in the vicinity of the Virgin Islands and Puerto Rico (Groshens and Vaughan 1994).

There have been a few reports of hawksbills in the western Atlantic Ocean as far north as Cape Cod (Bleakney 1965; Lazell 1980) and Virginia (Musick 1979). They are occasionally encountered in North Carolina waters (Schwartz 1961, 1976). Three hawksbills were stranded in Georgia between 1979 and 1993 (Maley *et al.* 1994).

Feeding and Growth of the Hawksbill Turtle. Like other species of sea turtles, hatchling hawksbills congregate in *Sargassum* rafts to feed and grow for a year or more after emerging from the nest (Witzell 1983; NMFS & USFWS 1993). While in the *Sargassum* rafts, they consume pelagic fish eggs and larvae, small invertebrates associated with the floating algae, and the *Sargassum* itself.

Sub-adults and adults are omnivorous scavengers. Their narrow sharp beaks are well adapted for foraging in crevices of coral reefs and rock outcroppings (Witzell 1983). Witzell (1983) lists dozens of food items consumed by hawksbills throughout their range. They seem to have a preference for benthic invertebrate prey, particularly sponges. Between Cayo Luis Pena and Culebra Island, Puerto Rico, hawksbills forage on sponges inhabiting the coral reefs lining the bottom in 12-15 m of water (Vincente and Carballeira 1992). The favorite food was the haplosclerid sponge *Niphates digitalis*. About 75% of the sponges in the area showed evidence of grazing by hawksbills. Some hawksbills from the area had been grazing on the sponges *Geodia neptuni* and *Chondrilla nucula*. Eleven hawksbills found stranded on the shores of Puerto

Rico contained predominantly desmosponges in their stomachs (Vincente 1994). The most abundant sponges in the hawksbill stomachs were *Chondrilla nucula, Chondrosia collectrix,* and *Geodia* spp. Hawksbill turtles from the Costa Rican coast have a similar diet (Carr and Stancyk 1975).

There is little information about the growth rates of wild hawksbill turtles. Hawksbills from the southern Bahama Islands grow at a rate of 2.4-5.9 cm/y (Bjorndal and Bolten 1988). Adult females in Costa Rica grow at a rate of about 0.3 cm/y (Bjorndal *et al.* 1985). Sub-adult hawksbills from the vicinity of St. Thomas, U.S. Virgin Islands, grow at a rate of about 3.36 cm/y (Boulon 1983). As for other marine turtles, 30 or more years may be required for hawksbill turtles to reach sexual maturity (Limpus 1992).

Causes of Mortality of the Hawksbill Turtle. Hawksbill turtles are subjected to many of the natural and anthropogenic disturbances affecting other sea turtles in U.S. Atlantic waters. However, their limited distribution along the east coast of the United States subjects them to less involvement with U.S. commercial and recreational fisheries. Strandings of hawksbills are restricted almost exclusively to Florida, Puerto Rico, and the U.S. Virgin Islands (Table 4-8). Since 1988, total strandings along the Atlantic coast have ranged from 10 to 38 per year. One hawksbill turtle stranding was reported in South Carolina in 1988 and one in Massachusetts in 1989. The disturbances contributing to these strandings are not known but probably are similar to those contributing to strandings of other sea turtle species along the Atlantic coast (Table 4-4).

Hawksbill turtles appear to be unusually vulnerable to ingestion of marine debris, particularly plastic materials. Plotkin and Amos (1990) reported that 87.5% of hawksbills stranded along the northwest coast of the Gulf of Mexico had ingested marine debris. Nearly 90% of the debris ingested by hawksbills is plastic bags, plastic and styrofoam particles, and tar (Balazs 1985). Six hawksbills that were stranded also were entangled in marine debris or fish nets. Juvenile hawksbills frequently are reported entangled in monofilament gill nets, fishing line, and synthetic rope (Balazs 1985).

Because of the great value of the hawksbill carapace, called tortoiseshell or bekko, there is a large illegal trade in sub-adult and adult hawksbill turtles, particularly in Puerto Rico, the U.S. Virgin Islands, and the wider Caribbean (NMFS & USFWS 1993). As many as 250,000 hawksbills from the wider Caribbean were slaughtered between 1970 and 1989 for tortoise shell exports to Japan alone (Canin 1989). The primary cause of hawksbill mortalities in Puerto Rican waters is believed to be poaching at sea for meat and tortoiseshell (NMFS & USFWS 1993).

Egg poaching also is common in Puerto Rico and the U.S. Virgin Islands (Matos 1987). Although the incidence of poaching has decreased in recent years because of policing of nesting beaches, the loss of eggs from isolated beaches is considered great (NMFS & USFWS 1993).

Vehicular traffic, particularly recreational vehicles, is a serious problem at Sandy Point National Wildlife Refuge in St. Croix, and other hawksbill nesting beaches in the U.S. Virgin Islands and Puerto Rico (Basford *et al.* 1988; NMFS & USFWS 1993). Although the practice is illegal, it continues to be commonplace. Vehicles may compact the sand, making it unsuitable for nest-building. Vehicular traffic may also crush emerging hatchlings, create disturbance from noise and headlights that will deter emergence and nesting of adult females, and create ruts in the sand that will make it difficult for hatchlings to migrate to the sea.

Table 4-8. Strandings of Hawksbill Turtles *(Eretmochelys imbricata)* Along the U.S. Atlantic Coast from 1988 to 1993, all months combined each year. From Teas and Martinez (1989, 1992) and Teas (1992, 1993, 1994).

State	1988	1989	1991	1992	1993
Florida	7	6	17	5	19
Georgia	0	0	0	0	0
South Carolina	1	0	0	0	0
North Carolina	0	0	0	0	0
Virginia	0	0	0	0	0
Maryland	0	0	0	0	0
Delaware	0	0	0	0	0
New Jersey	0	0	0	0	0
New York	0	0	0	0	0
Connecticut	0	0	0	0	0
Rhode Island	0	0	0	0	0
Massachusetts	0	1	0	0	0
New Hampshire	0	0	0	0	0
Maine	0	0	0	0	0
Puerto Rico	1	1	6	30	5
U.S. Virgin Islands	3	2	2	3	0
Total Atlantic Strandings	12	10	25	38	24

4.4.3 Fish

The Atlantic coast of the United States supports a wide range of fish species with specific habitat requirements and distributions. This section provides a summary description of the fish in the two major regions of the U.S. Atlantic coast. The regions have been designated by the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS); NMFS monitors Atlantic coast fish stocks by region. The Northeast Region extends from the coast of Maine to Cape Hatteras, North Carolina. The Southeast Region begins at Cape Hatteras and extends south.

NMFS assigns species to groupings that reflect the ocean environment in which they reside: pelagic – water column; groundfish – near or on the ocean floor; and reef – on or associated with natural or artificial reefs. These groupings have been defined by the NMFS, Northeast and Southeast Fisheries Science Centers (NEFSC and SEFSC). NMFS monitors fish populations to determine their "status." The status of a fish stock (*i.e.,* a population of fish of a specific species with physical characteristics that distinguish it from another population of fish of the same species) is classified on the basis of its current exploitation rate and abundance level. Fishing mortality for the species described below relates to the amount or number of fish killed by fishing and is associated with fishing effort (*e.g.,* number of vessels, number of days fishing, net mesh size). Compared to commercial fishing, the impact of recreational fishing on most species is small. However, most bluefish and striped bass are caught by recreational fishermen (E. Anderson, NMFS, pers. comm. 1995). The NMFS uses the exploitation rate (*i.e.,* the proportion of a population at the beginning of a given time period that is caught during that time period) to describe the effect of current fishing effort on a population (NOAA 1995a). The status of a stock determines the type of appropriate management action (fishing seasons, fish closure areas, mesh size restrictions, catch restrictions) necessary to ensure continued viability of the stock. A fish stock is most often expressed as underexploited, overexploited, or fully exploited. Individual states, the Atlantic States Marine Fisheries Commission, and the Fishery Management Councils (in cooperation with NMFS) are also involved in managing fish stocks in marine and coastal waters (E. Anderson, NMFS, pers. comm. 1995).

Species of Special Concern

Only one species found in the Northeast Region, the shortnose sturgeon *(Acipenser brevirostrum),* is endangered; this species has not been observed in marine waters in several years. The Atlantic salmon *(Salmo salar)* has been proposed for listing as a threatened species in the Sheepscot, Pleasant, Narraguagus, Ducktrap, Denny's, Machias, and East Machias Rivers of Maine (NMFS and USFWS 1995). Other species that could be of concern are those with a status of overexploited. Conservation methods (*i.e.,* management and enforcement of management) are implemented to ensure viability of fish stocks.

Unless otherwise indicated, the following text is summarized from the NMFS Status of the Fishery Resources publications produced by the NEFSC and SEFSC (NOAA 1995a; NOAA 1995b). Many of these species are also under the management of state agencies.

Northeast Region

In the Northeast Region, the NEFSC monitors the abundance of numerous fish species of commercial and recreational importance. The commercial yield of fish in the northeast is 49.35% of the eastern United States (including the Gulf of Mexico and the U.S. Caribbean) commercial yield by weight, compared to 7.35% in the southeast, and 0.01% in Puerto Rico and the U.S. Virgin Islands (NOAA 1995b). The annual Status of the Fishery Resources report includes a summary on 30 species of fish. These species are categorized as pelagic (4 species), groundfish (22 species), and other species (4 species, including river herring). As indicated by the number of species, the groundfish grouping is the most important for commercial species. The groundfish are divided into principal groundfish and others. The principal groundfish have historically been the main component of the trawl fisheries (NOAA 1995a). The other groundfish species (*e.g.,* goosefish, dogfish), although they have not been the dominant species of the trawl fisheries, are becoming more important (NOAA 1995a). Of the 30 species assessed by the NEFSC, 18 species are overexploited. Nearly all (17 of 18) of the species that are overexploited are groundfish; 77% of the groundfish are overexploited. Four species are underexploited. Of the total number of species monitored, only seven are fully exploited.

Tables 4-9 through 4-12 provide species, status, and distribution of species by category as determined by NOAA, NMFS, NEFSC (NOAA 1995a). In the Northeast Region, other species of recreational and commercial importance that are not listed in the NEFSC annual report include croaker, spot, weakfish, bluefin and yellowfin tuna, swordfish, sand lance, menhaden, and pelagic sharks.

Although the distribution of many of these species extends into the Southeast Region (under the jurisdiction of the SEFSC), traditionally the greatest concentrations of the species and the largest commercial fishery are located in the Northeast Region.

Table 4-9. Principal Groundfish in the Northeast Region

Common Name	Species Name	Status	Distribution (N to S)
Atlantic Cod	*Gadus morhua*	Overexploited	Greenland – North Carolina
Haddock	*Melanogrammus aeglefinus*	Overexploited	West Greenland – Cape Hatteras
Redfish	*Sebastes* spp.	Overexploited	Gulf of Maine, Georges Bank
Silver Hake	*Merluccius bilinearis*	Overexploited	Newfoundland – South Carolina
Red Hake	*Urophycis chuss*	Underexploited	Gulf of St. Lawrence – North Carolina
Pollock	*Pollachius virens*	Fully Exploited	Scotian Shelf, Gulf of Maine, Georges Bank
FLOUNDERS			
Yellowtail	*Pleuronectes ferrugineus*	Overexploited	Labrador – Chesapeake Bay
Summer	*Paralichthys dentatus*	Overexploited	Southern Gulf of Maine – South Carolina
Winter	*Pleuronectes americanus*	Overexploited	Labrador – Georgia
American Plaice	*Hippoglossoides platessoides*	Overexploited	Southern Labrador – Rhode Island
Witch	*Glyptocephalus cynoglossus*	Overexploited	Gulf of Maine, Georges Bank; Continental Shelf Edge – Cape Hatteras
Windowpane	*Scophthalmus aquosus*	Overexploited	Gulf of St. Lawrence – Florida

Table 4-10. Other Groundfish in the Northeast Region

Common Name	Species Name	Status	Distribution
White Hake	*Urophycis tenuis*	Fully Exploited	Newfoundland – Southern New England
Cusk	*Brosme brosme*	Overexploited	Gulf of Maine
Black Sea Bass	*Centropristis striata*	Overexploited	Entire Atlantic Coast
Scup	*Stenotomus chrysops*	Overexploited	Cape Cod – Cape Hatteras
Weakfish	*Cynoscion regalis*	Overexploited	Massachusetts Bay – Florida[1,2]
Spot	*Leiostomus xanthurus*	Not Available	Southern New England – Florida[1]
Atlantic Wolffish	*Anarhichas lupus*	Overexploited	Nova Scotia – Gulf of Maine[1]
Ocean Pout	*Macrozoarces americanus*	Fully Exploited	Labrador – Delaware
Tilefish	*Lopholatilus chamaeleonticeps*	Overexploited	Nova Scotia – South[3]
Goosefish	*Lophius americanus*	Overexploited	Gulf of St. Lawrence – Cape Hatteras

[1]Bigelow and Schroeder (1953).
[2]Few may be found in Bay of Fundy and Newfoundland.
[3]South includes the southernmost tip of Florida or further south to the Gulf of Mexico or South America.

Table 4-11. Pelagic Fish in the Northeast Region

Common Name	Species Name	Status	Distribution
Atlantic Herring	*Clupea harengus*	Underexploited	Labrador – Cape Hatteras
Atlantic Mackerel	*Scomber scombrus*	Underexploited	Labrador – North Carolina
Butterfish	*Peprilus triacanthus*	Underexploited	Southern New England – Cape Hatteras
Bluefish	*Pomatomus saltatrix*	Overexploited	Maine – Florida

Table 4-12. Other Fish Species of Commercial Importance in the Northeast Region

Common Name	Species Name	Status	Distribution
Spiny Dogfish	*Squalus acanthias*	Fully Exploited	Newfoundland – Georgia
Skate	Family Rajidae[1]	Fully Exploited	Gulf of Maine – Chesapeake Bay
Atlantic Salmon	*Salmo salar*	Fully Exploited	Canada and Maine
Striped Bass	*Morone saxatilis*	Fully Exploited	St. Lawrence Estuary – Florida

[1]Include seven species that occur in the Northeast Region.

Southeast Region

In the Southeast Region, the SEFSC monitors the abundance of numerous recreational and commercially important fish species. The commercial yield of fish species in the southeast is significantly less than in the Northeast Region. The annual Status of the Fishery Resources report includes a summary on 24 species of fish and several species of sharks in the south Atlantic (Cape Hatteras to Florida). Of the 23 species, 42% are overexploited. All of the large coastal sharks are overexploited. Only one fish species — the Atlantic stock of king mackerel — is considered underexploited. The remaining species are either fully exploited (38%) or the status is unknown/unavailable. These species are categorized by SEFSC as oceanic pelagics, coastal pelagics, reef fish, sciaenids, sharks, menhadens, butterfish, and coastal herrings. For the purpose of efficiency, these fish are further categorized into billfish, coastal pelagics, reef fish, sciaenids and others, and sharks. Tables 4-13 through 4-16 below provide species, status, and distribution of species by category as determined by NOAA, NMFS, SEFSC (NOAA 1995b).

Table 4-13. Tuna and Billfishes in the Southeast Region

Common Name	Species Name	Status	Distribution
Swordfish	*Xiphias gladius*	Overexploited	Worldwide
Bluefin Tuna	*Thunnus thynnus thynnus*	Overexploited	Labrador and Newfoundland – South[3]
Yellowfin Tuna	*Thunnus albacares*	Not Available	Worldwide (tropical)
Billfish[1]	*Makaira nigricans* *Tetrapturus albidus* *Istiophorus platypterus*	Overexploited Overexploited Fully Exploited	New Jersey – South[2,3] Gulf of Maine – South[2] N. Florida – South[2]
Bigeye Tuna	*Thunnus obesus*	Fully Exploited	Gulf of Maine – South[2]
Albacore	*Thunnus alalunga*	Fully Exploited	New Jersey – South[2]
Skipjack Tuna	*Katsuwonus pelamis*	Fully Exploited	Cape Cod — South[2]

Note: Species not included in the above table are Atlantic bonito *(Sarda sarda)*, little tunny *(Euthynnus alleletteratus)*, frigate tuna *(Auxis thazard)*, blackfin tuna *(Thunnus atlanticus)*, and wahoo *(Acanthocybium solandri)*.

[1]Includes blue marlin, white marlin, and sailfish.
[2]Approximate, based on latitudes.
[3]South includes the southernmost tip of Florida or further south to the Gulf of Mexico or South America.

Table 4-14. Coastal Pelagic Fish in the Southeast Region

Common Name	Species Name	Status	Distribution[1]
King Mackerel	*Scomberomorus cavalla*	Underexploited[2]	Gulf of Mexico - South
Spanish Mackerel	*Scomberomorus maculatus*	Overexploited[2]	Maine - South
Dolphin	*Coryphaena* sp.	Not Available	Georges Bank - South
Cobia	*Rachycentron canadum*	Not Available	New England - South
Cero	*Scomberomorus regalis*	Not Available	Massachusetts - South

[1]South includes the southernmost tip of Florida or further south to the Gulf of Mexico or South America.
[2]Refers to the Atlantic stock only.

Table 4-15. Reef Fish in the Southeast Region

Common Name	Species Name	Status	Distribution[1]
Wreckfish	*Polyprion americanus*	Fully Exploited	Grand Banks, Newfoundland – South
Gag	*Mycteroperca microlepis*	Overexploited	North Carolina – South
Scamp	*Mycteroperca phenax*	Fully or Overexploited	North Carolina – South
Gray Snapper	*Lutjanus griseus*	Fully Exploited	Northern Florida – South
Yellowtail Snapper	*Ocyurus chrysurus*	Fully Exploited	North Carolina – South
Red Porgy	*Pagrus pagrus*	Overexploited	North Carolina – South

[1]South includes the southernmost tip of Florida or further south to the Gulf of Mexico or South America.

Note: Other species of reef fish that are important in this region, but not included in NOAA (1995b) are red snapper, vermillion snapper, triggerfish, snowy grouper, and tilefish.

Table 4-16. Sciaenids and Other Commercially Important Fish in the Southeast Region

Common Name	Species Name	Status	Distribution[1]
Red Drum	*Sciaenops ocellatus*	Overexploited	Chesapeake Bay – South
Weakfish	*Cynoscion regalis*	Overexploited	Massachusetts – Florida
Atlantic Croaker	*Micropogonias undulatus*	Not Available	Massachusetts – South
Atlantic Menhaden	*Brevoortia tyrannus*	Fully Exploited	Nova Scotia – West Palm Beach, Florida

[1]South includes the southernmost tip of Florida or further south to the Gulf of Mexico or South America.

4.4.4 Sharks

More than 350 species of sharks occupy the Atlantic Ocean on the east coast of the United States. This number of species is relatively small compared to the number of fish species. The sharks that are caught along the east coast to the tip of Florida are grouped into two categories for management: large coastal sharks and pelagic sharks. There are 22 species of large coastal sharks, including sandbar *(Carcharhinus plumbeus)*, reef *(Carcharhinus perezi)*, tiger *(Galeocerdo cuvier)*, lemon *(Negaprion brevirostris)*, and the great hammerhead *(Sphyrna mokarran)*. There are 10 species of pelagic sharks, including the thresher *(Alopias vulpinus)*, longfin mako *(Isurus paucus)*, blue *(Prionace glauca)*, shortfin mako *(Isurus oxyrinchus)*, and oceanic whitetip *(Carcharhinus longimanus)*. The large coastal sharks are the target of commercial fishermen and shark tournaments. As a group, they are considered overexploited because of the fishing mortality. The pelagic sharks are caught as bycatch of other commercial fishing operations. The population status of the group is unknown.

4.4.5 Invertebrates

The Atlantic coast of the United States is inhabited by many species of macrobenthic arthropods and molluscs. Among these, several are important because they form the basis of regional fisheries or are important components of the diets of whales and marine turtles. Included are two species of cancer crabs (*Cancer borealis* and *C. irroratus*), two species of spider crabs (*Libinia dubia* and *L. emarginata*), two species of lady crabs (*Ovalipes ocellatus* and *O. stephensoni*), the horseshoe crab (*Limulus polyphemus*), the blue crab (*Callinectes sapidus*), the green crab (*Carcinus maenas*), the mantis shrimp (*Squilla empusa*), and two species of whelk (*Busycon carica* and *Busycotypus canaliculatus*). A brief summary of the geographic and depth distribution, migration patterns, and distribution within selected geographic regions is presented in Table 4-17.

Table 4-17. Summary of Invertebrates Found in the Atlantic Ocean From Maine to Florida

Species	Geographic Range	Depth Range	Migration Patterns	Special Areas[a]	Refs[b]
Jonah Cancer Crab (*Cancer borealis)*	Nova Scotia to Tortugas	Intertidal to 800 m	Small to medium individuals found near shore; larger individuals move offshore into deeper waters. May migrate toward edge of shelf in winter.	*NE Atl:* Probable seasonal migration in Gulf of Maine. *Mid Atl:* Abundance greater along shelf edge than in coastal waters; scarce south of Delaware. *SE Atl:* Habitat shifts to soft sediment; stocks may be much greater than in northern areas.	7, 10, 13, 16, 17
Rock Cancer Crab *(Cancer irroratus)*	Labrador to Miami	0 to 575 m	Migrates into lower Chesapeake Bay in late fall; remains in Bay until late March-April, then moves offshore.	*NE Atl:* In coastal zones year-round. *Mid Atl:* Wide bathymetric distribution indicates continuous population from New England to Chesapeake Bay.	

Species	Geographic Range	Depth Range	Migration Patterns	Special Areas[a]	Refs[b]
Longnose Spider Crab *(Libinia dubia)*	Cape Cod to Texas, Bahamas, Cuba	nearshore to 46 m	Adults live in relatively deep estuarine waters; sluggish, probably little movement.	*Mid Atl.:* Juveniles often found in association with jellyfish.	15, 17, 18
Portly Spider Crab (*Libinia emarginata*)	Nova Scotia to W. Gulf of Mexico	near shore to 49 m	Unknown	Mid Atl: Most abundant in DE Bay in spring and summer. SE Atl.: Most abundant winter and spring; abundance similar within region	
Lady Crab (*Ovalipes ocellatus*)	Prince Edward Is. to Georgia	surface to 95 m	Young found near shore; migrate into harbors (CT) in summer, leave before winter; inactive or buried in winter.	Mid Atl: Highest concentrations near shore from Long Island to Chesapeake Bay; also off Nantucket, Georges Bank. SE Atl: less abundant than coarsehand lady crab; abundances decreased from north to south	13, 15, 17
Coarsehand Lady Crab (*Ovalipes stephensoni*)	southern New Jersey to Biscayne Bay, FL	surface to 227 m	Young found near shore, adults well offshore; burrow in winter.	Mid Atl: Found from NJ to Cape Hatteras, mostly offshore. SE Atl: abundant; more numerous off North and SC, lowest off FL	
Green Crab (*Carcinus maenas*)	Introduced from Europe in 1800s; Nova Scotia to Virginia	Intertidal to 6 m, rarely to 200 m	Limited migration to avoid extremes of cold and low salinity; moves shoreward with rising tide to feed.	High potential for introduction to areas with temperatures <22 °C.	3, 17
Blue Crab (*Callinectes sapidus*)	Nova Scotia to Argentina, rare north of Cape Cod	0 to 35 m, occasional-ly to 90 m	Egg-bearing females migrate from upper estuarine areas of lower salinity to higher salinity at mouth; eggs hatch (June), young crabs migrate up estuary to maturing areas (may take two years); males remain up estuary	NE Atl: Uncommon. Mid Atl: Major fishery in Chesapeake Bay. SE Atl: High biomass compared to other crabs; most abundant spring and summer.	9, 15, 17
Mantis Shrimp (*Squilla empusa*)	Massachusetts to South America	shallow to 154 m	Unknown	Abundant throughout its range; SE Atl: more common off FL than NC, SC, GA. More common Spring and Summer.	8, 15
Horseshoe Crab (*Limulus polyphemus*)	Maine to Louisiana	0 to 200 m	Move from deeper to shallower water April-June, after spawning disperses back to deep water	Mid Atl: DE Bay has one of highest concentrations, particularly along Cape May shore of NJ, abundance decreased north of the Bay. SE Atl: more frequently caught Mar-Aug than Sep-Oct; not associated with scallop beds	2, 5, 11, 12

Species	Geographic Range	Depth Range	Migration Patterns	Special Areas[a]	Refs[b]
Knobbed Whelk (*Busycon carica*)	Cape Cod to Cape Canaveral, FL	Intertidal to shallow subtidal	Annual migration into estuaries to mate and deposit egg cases in north; semi-annual in south. Moves into intertidal areas in fall and spring; to subtidal areas in winter and summer	NE Atl: Uncommon. Mid Atl: Most common whelk off NJ and NC. SE Atl: Most frequently caught May-June and Sep-Oct.. Most common whelk off GA	1, 4, 5, 12
Channeled Whelk (*Buscotypus canaliculatum*)	Cape Cod to St. Augustine, FL	Usually shallow subtidal	Annual migration into estuaries to mate and deposit egg cases. Rarely moves into intertidal areas.	NE Atl: Most common whelk species. Mid Atl: Uncommon. SE Atl: Common subtidally off GA, uncommon off FL.	

[a] NE Atl: ME, NH, MA, RI, CT. Mid Atl: NY, NJ, DE, MD, VA, NC. SE Atl: SC, GA, FL

[b] 1. Abbott 1974
2. Botton and Haskin 1984
3 Cohen *et al.* 1995
4 Davis and Sisson 1988
5 Edwards and Harasewych 1988
6 Hall 1995
7 Krouse 1980
8 Manning 1974
9 Millikan and Williams 1984
10 Musick and McEachran 1972
11 Schuster and Botton 1985
12 Schwartz and Porter 1977
13 Stehlik *et al.* 1991
14 Walker 1988
15 Wenner and Wenner 1988
16 Wenner *et al.* 1992
17 Williams 1984
18 Winget *et al.* 1974

4.4.6 Seagrasses

Seagrass is often referred to as submerged aquatic vegetation (SAV). In the Middle Atlantic, approximately 10 species are found in seagrass beds in Chesapeake Bay. The largest concentration of seagrass beds is in the SEUS. The three most abundance species are turtle grass *(Thalassia testudinum),* manatee grass *(Syringodium filiforme),* and shoal grass *(Halodule wrightii).* Because seagrass beds are sensitive to strong wave action, they are most often found in calmer sheltered locations. Sea grasses are not found at extreme depths because of their dependence on sunlight. From Cape Canaveral south to Biscayne Bay, seagrass beds are located in lagoons behind the barrier islands. Because of the large number of canal inlets that discharge into the lagoons, this area is subject to fluctuations in salinity which affect species domination: turtle and manatee grass is most often found near the mouths of the inlets; shoal grass is most often found offshore of the inlet. South of Biscayne Bay to the Florida Keys, extensive seagrass beds are found in Hawk Channel and behind the outer reef line (approximately 12 miles from shore). The abundance of seagrasses changes little during the year (J. Thompson, pers. comm. 1995). Seagrasses are the preferred food of green turtles *(Chelonia mydas)* along the U.S. Atlantic coast.

Johnson's Seagrass *(Halophila johnsonii)*

Johnson's seagrass *(Halophila johnsonii)* has been proposed as a threatened species under the Federal Endangered Species Act (Federal Register, September 15,1993), and is listed as threatened by the State of Florida. Perhaps the rarest seagrass in the world, this species has the most limited distribution of any known seagrass (Figure 4-12); it occurs in only a few locations along the east coast of Florida, in coastal

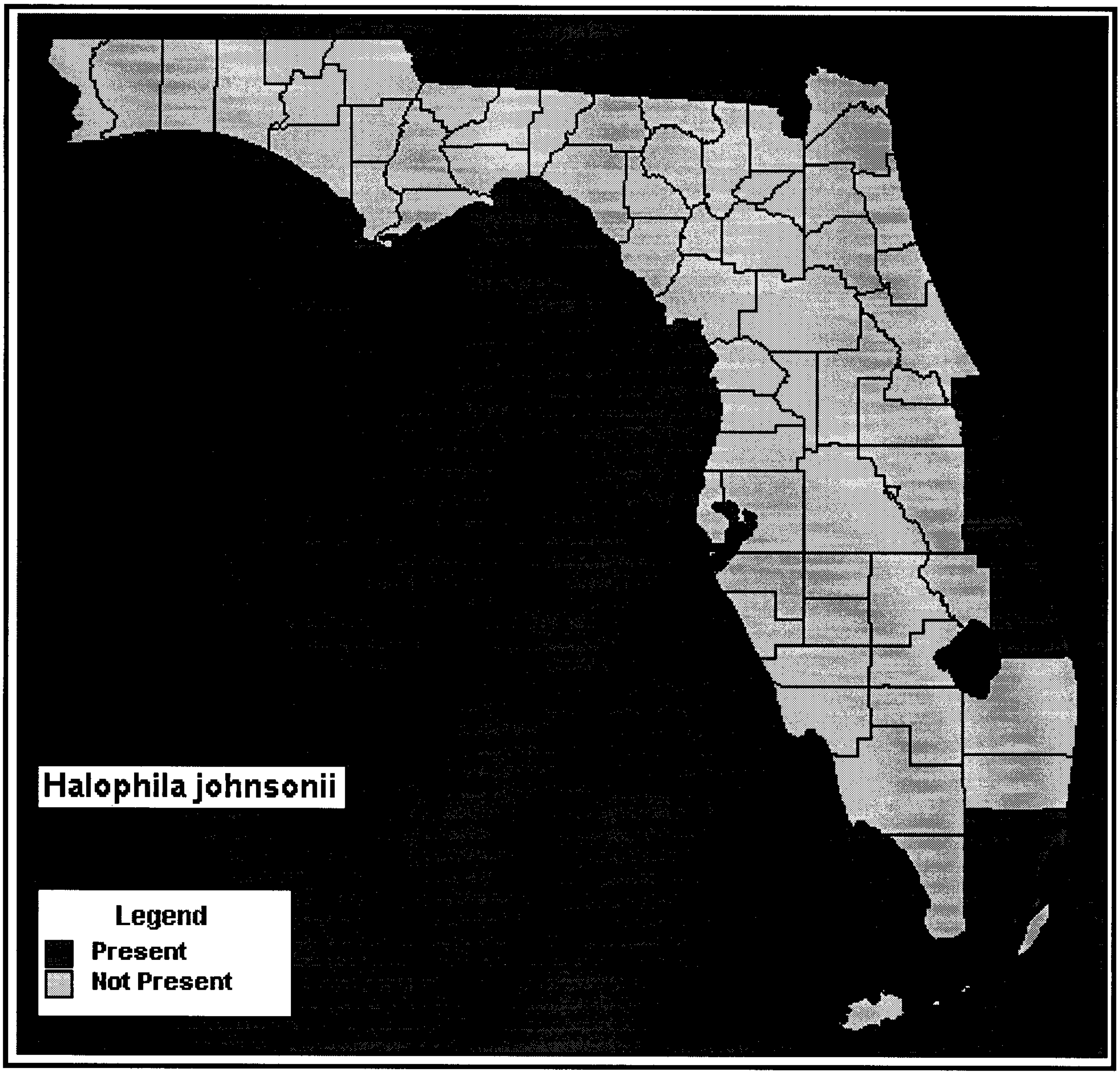

Figure 4-12. Distribution of Johnson seagrass *(Halophila johnsonii)* in Florida coastal counties.

lagoons from the Sebastian Inlet (27°50'N. lat.) to central Biscayne Bay (25°45'N. lat.) (Wunderlin *et al.* 1995; Federal Register, August 4, 1994). In this narrowly defined area, where it does not have to compete with other, more robust species of *Halophila*, Johnson's seagrass forms extensive meadows of vegetation which serve as an important food source for grazing marine animals such as the green sea turtle *(Chelonia mydas)* and the West Indian manatee *(Trichechus manatus)*, and for herbivorous fish (Durako and Wettstein 1994).

While its growth rate is comparatively high, Johnson's seagrass is unique among the *Halophila* grasses in that only female plants have been found. This finding suggests the hypothesis that, in the absence of sexual reproduction, the unpollinated seeds of the female plant may become clones identical to the female parent. This method of asexual reproduction would make it significantly more difficult for a surviving population to reestablish itself after sustaining severe damage. The plant survives by continuously branching out to cover lagoon bottoms adjacent to the shoals and channels of the inlets along the coastal lagoons to which its distribution is limited. Tolerant of a wide range of salinity and temperature, Johnson's seagrass can also withstand drying out at low tide, intense sunlight, and strong currents.

Due to the location of its established habitat, Johnson's seagrass is particularly susceptible to stochastic events such as storm surges, which could conceivably wipe out a large percentage of the population. In addition to the threat from natural events, a number of human activities impact this fragile plant. The viability of the species is threatened by human trampling attributable to increasing land use, reduced water quality due to nutrient over-enrichment from urban and agricultural land runoff, activities related to inlet maintenance, channel dredging, anchor mooring, and vessel traffic with resulting propeller scouring.

4.4.7 Plankton

Phytoplankton

North Atlantic. Phytoplankton in the Gulf of Maine/Massachusetts Bay/Cape Cod Bay area consist of a diverse assemblage of temperate and boreal representatives of both coastal and oceanic species (EPA 1993). The rich flora in this region are the result of the complex hydrogeography of the area. The species composition and successional patterns of the phytoplankton community of the Gulf of Maine/Massachusetts Bay/Cape Cod Bay Complex has been characterized by Smayda (1992). Due partially to low water temperature and reduced daylight, the sparse winter (October through January) community is characterized by numerous species of low individual and total abundance, and is dominated by diatoms and dinoflagellates. The winter community is replaced in March or April by the start of a spring diatom bloom, which includes about 30 species of *Chaetoceros*. During this season, species composition of *Chaetoceros* undergoes a gradual succession in response to increasing water temperature. The spring diatoms are replaced primarily by dinoflagellates in the summer. Dominant nearshore dinoflagellate species can include *Peridinium faroense* and the red-tide species *Alexandrium tamarense, Scrippsiella trochoidea,* and *Heterocapsa triquetra.* Blooms of *A. tamarense*, occurring far offshore on Georges Bank have led to toxic shellfish beds in nearshore waters. *A. tamarense* produces a family of neurotoxins collectively called saxitoxins (STX). STX is the cause of paralytic shellfish poisoning in molluscs commercially important to humans (EPA 1993). Offshore waters in summer are dominated by anoxia-causing *Ceratium* species. During the late summer/early fall, dinoflagellates are replaced again by localized increases in diatoms dominated by a complex of *Rhizosolenia* species. The *Rhizosolenia* species soon decline, leaving a sparse dinoflagellate assemblage. The transition into winter is characterized by a gradual increase in the dominance of *Coscinodiscus* as other diatoms decline (EPA 1993).

Georges Bank is one of the most productive continental shelf ecosystems in the world. Chlorophyll *a* and primary production generally decrease from shallow to deep water over Georges Bank. Phytoplankton biomass, approximated by chlorophyll *a*, varies seasonally as is characteristic for temperate continental shelf ecosystems. The high summer rate of primary production explains much of the overall annual productivity of Georges Bank. Although phytoplankton biomass, estimated by chlorophyll, is lowest during the summer, summer production is comparable to the spring and fall blooms (O'Reilly *et al.* 1987). Major gradients in size composition of the primary producers are found between shallow and deep waters on Georges Bank. In the deeper, less productive water of the Bank, nanoplankton strongly dominate primary production and chlorophyll stocks. In the highly productive shallow water, netplankton are approximately equal to nanoplankton. These differences in size composition reflect differences in species; diatoms are more abundant in the shallow water. Such differences are ecologically significant because, in addition to the amount of primary production, the abundance, species, and size composition of phytoplankton communities strongly determine the nature of the herbivore fauna, and the transfer rate of energy, matter, and contaminants through the food web of Georges Bank (O'Reilly *et al.* 1987).

Middle Atlantic. The Mid-Atlantic Bight is divided into five depth-delineated regions: Region 1 (1-20 m), Region 2 (20-40 m), Region 3 (40-60 m), Region 4 (60-200 m), and Region 5 (200-2000 m). The annual cycle of chlorophyll *a* is generally bimodal in all five regions. The highest chlorophyll *a* concentrations occur during the spring bloom (February in Regions 1and 2; March in Regions 3, 4, and 5). The lowest concentrations occur from May through July in Regions 1 and 2. At depths >40 m (Regions 3, 4, and 5), corresponding to mid- to outer- shelf and slope, chlorophyll *a* concentrations are low from May through October. A secondary peak in chlorophyll *a* occurs during November and December across the entire shelf. Additional peaks of abundance occur in late summer for the two nearshore regions. During the stratified season in and around the thermocline, a subsurface chlorophyll *a* maximum is present where relatively high concentrations of phytoplankton are available as food for zooplankton. During the unstratified season, chlorophyll *a* and phytoplankton generally are distributed evenly throughout the water column (Pacheco 1988).

Phytoplankton community size composition also varies over the year. Generally, netplankton strongly dominate the February-March spring bloom over the entire shelf and account for 70% of the standing stock. In contrast, nanoplankton generally dominate communities during the mid-year stratified periods when chlorophyll *a* concentrations are at a low. During the fall bloom, netplankton and nanoplankton contribute to the phytoplankton community chlorophyll *a* in near equal amounts.

The Delaware River Estuary represents a nutrient-rich system where phytoplankton development is influenced by a combination of interrelated factors, such as turbidity levels, stratification, and river flow. In general, productivity decreases down the estuary to a low in the turbidity maximum zone (75-110 km into the estuary), then increases further down the estuary. The upper estuary is dominated by diatoms, chlorophytes, cyanobacteria, and cryptomonads, with diatoms becoming more dominant downstream and into the lower estuary. The species that characterize the lower estuary are typical of those found in coastal waters and estuaries of the northeastern United States, including Chesapeake Bay and Narragansett Bay. Typically, higher concentrations of phytoplankton occur upstream in summer and downstream during spring and fall. Lowest abundance of phytoplankton is associated with the turbidity maximum zone (Marshall 1992).

South Atlantic. Fritts *et al.* (1983) reported that phytoplankton abundances decrease seaward. Diatoms are the predominant phytoplankton from Cape Hatteras to south of Cape Canaveral and east to the Gulf Stream. In the Gulf Stream, coccolithophores and dinoflagellates are predominant (Hurlburt 1967). Phytoplankton densities vary seasonally, but the Gulf Stream minimizes the amount of variation (MMS

1986). The stabilizing effect of the Gulf Stream contributes to the large diversity of diatoms and coccoliths that are found south of Cape Hatteras in comparison to north of Cape Hatteras (MMS 1986).

Zooplankton

North Atlantic. Although large-scale (100-1000 km) seasonal and annual variability in abundance of zooplankton is associated with advective processes in the northeastern Atlantic, no large-scale changes in abundance of zooplankton off the northeast coast of the United States have been observed (NOAA 1988). Within this region, the greatest variation in biomass from year to year is on Georges Bank itself; this is attributed to variable retention of zooplankton resulting from the seasonal formation and decay of the Georges Bank Gyre (Sherman *et al.* 1987).

In the Gulf of Maine, zooplankton are characterized by high numbers of species and low evenness. Calanoid copepods dominate. Localized concentrations of other zooplankters include barnacle nauplii, euphausids, and ctenophores. In general, the calanoid copepod community consists of approximately seven to nine species with two to three of the members dominating. The dominant species are *Calanus finmarchicus, Pseudocalanus minutus,* and *Centropages typicus* (EPA 1993).

In the winter, zooplankton populations in the Gulf of Maine decrease because only adults survive the winter months. Increases in abundance begin in March with the appearance of copepod nauplii. Zooplankton biomass peaks in the spring following the spring phytoplankton bloom. During the peak period (May-June), the calanoid community, including *C. finmarchicus,* a prey species of right whales, is dominant. Populations decrease again in the summer months due to mortality in the post-spawning, over-wintered adults and high mortality in the spring brood possibly due to natural predation. Some changes in species composition and dominance occur in the fall. The abundance of ichthyoplankton appears to follow the pattern of other zooplankton and is low in late winter, peaks in June, and declines considerably in August (EPA 1993).

In Massachusetts and Cape Cod Bays, zooplankton consists mainly of neritic or coastal species. The central Gulf of Maine counterclockwise current carries oceanic plankton species into Massachusetts Bay; currents and plumes may mix nearshore and offshore species (EPA 1993).

Zooplankton standing stocks, dominance patterns, and the abundance of principal species on Georges Bank are unique compared with other parts of the North Atlantic region. On Georges Bank, zooplankton abundance peaks in mid-spring and declines precipitously in summer. Prior to the spring peak, 80% of the dominance is shared between the copepods *Pseudocalanus minutus* and *Centropages typicus.* From January to June, *P. minutus* and *Calanus finmarchius* dominate the zooplankton community in all four subareas (central shoal, intermediate water, northern deep water, southern deep water). By spring, *P. minutus* dominance declines and *C. finmarchius* accounts for 70% of the dominance. In the second half of the year, dominance shifts to *C. typicus.*

Biomass and species composition of zooplankton in southern New England waters have not changed substantially over the past 70 years (NOAA 1988). The persistent patterns of abundance and species composition reflect coherence within the range of interannual variability observed since the early part of the century. These findings are in contrast with the 30-year decline in zooplankton, including the copepod component, reported for large areas of the North Atlantic. It appears that the climatic changes influencing the zooplankton decreases in the northeast Atlantic are more pronounced in the open ocean areas of the North Atlantic drift.

Within southern New England waters, variation of zooplankton standing stocks, seasonal abundance, and distribution patterns is a function of water depth. Waters of southern New England appears to be a transition zone between the oceanic Georges Bank area and the continental shelf west of the Hudson Canyon, in which the principal driving force is likely the large estuarine outflow from the Delaware and Chesapeake Bays (Pacheco 1988). Zooplankton biomass is bimodal; an initial pulse occurs in May followed by a low in July, and a second peak occurs in August, followed by a decline in autumn and winter. In southern New England waters, the bimodal peaks in zooplankton standing stock represent *C. finmarchicus* and *P. minutus* dominance in spring and early summer followed by a large-scale *C. typicus* swarming in late summer and autumn.

Middle Atlantic. Within the Mid-Atlantic Bight, zooplankton distribution, variation of standing stocks, and seasonal abundance patterns are a function of water depth (Pacheco 1988). Zooplankton biomass increases from an annual low in winter to an annual high in autumn. Further south in the Mid-Atlantic Bight, *C. finmarchicus* abundance is diminished, and is replaced by *P. minutus* and *C. typicus* in late winter and early spring, followed by an increase in the standing stock of zooplankton from summer through autumn related to the growing abundance of cladocerans and other zooplankters in summer and large-scale swarming of *C. typicus* in autumn. *C. finmarchicus* is less abundant in the Mid-Atlantic Bight than in southern New England waters. Greatest densities are reached on the midshelf, one order of magnitude greater than inshore densities. As in southern New England waters, the seasonal cycle reaches a peak in April and May, but there is a sharp decline in abundance in July, a feature not present in southern New England waters.

In Delaware Bay, the major factor affecting distribution of zooplankton is salinity. Therefore, the lower portion of the Bay is dominated by marine species, such as *Acartia tonsa, Pseudodiaptomas coronatus,* and *Temora longicornis.* Copepods account for more than 90% of all zooplankton. High abundances occur more often in the spring than in the summer (Versar 1991).

South Atlantic. Zooplankton concentrations are greater in the summer than the winter and decrease seaward (MMS 1986). Copepods dominate the inshore community, but several species (including euphausids and coelenterates) dominate the offshore community (MMS 1986). Ichthyoplankton are found year round in this region (Fahay 1975).

4.4.8 Coastal and Marine Birds

Federally Threatened and Endangered Species

The marine and coastal environment of the Atlantic Ocean along the eastern United States is a habitat for numerous species of birds and a migratory flyway for other species. The birds using this habitat include threatened and endangered species. The following is a brief description of important biological information on the threatened and endangered species that could be impacted by USCG activities:

- **Bald Eagle *(Haliaeetus leucocephalus)*:** The bald eagle is the only representative of the sea eagles found in North America (SC DNR 1985). The decline of the bald eagle was primarily caused by the increased use of the pesticide DDT. Since the implementation of restrictions on the use of DDT, the number of bald eagles has increased (USFWS 1990), resulting in the bird being downlisted from endangered to threatened in the lower 48 states (50 CFR Part 17). Bald eagles reside in both coastal and inland habitats. The northeast contains a large number of bald eagles that inhabit and nest in coastal or estuarine areas of several states. A major component of the bald eagle's diet consists of fish; in the winter the diet is supplemented by birds and small mammals (SC DNR 1985).

- **Peregrine Falcon *(Falco peregrinus)*:** The decline of the peregrine falcon was also primarily caused by the increased use of DDT (USFWS 1991). Since the prohibitions on the use of DDT and other organochlorines in the early 1970s, the number of peregrine falcons has increased. The USFWS has published an advance Notice of Intent to delist the peregrine falcon (Federal Register, July 12, 1995). Breeding in the northeast occurs from mid-March to early August; breeding in the south Atlantic begins earlier in the year. Peregrines in the eastern United States are year-round residents and are not considered migratory (USFWS, pers. comm. 1995). However, large numbers of peregrines that reside in the northernmost areas of North America (*e.g.,* Canada, Labrador, Greenland) use the Atlantic seaboard as a flyway during the winter and spring migrations to and from the Bahamas and Florida (USFWS, pers. comm. 1995). Because their diet may consist of seabirds, peregrines spend time foraging along the coasts and over open water.

- **Piping Plover *(Charadrius melodus)*:** This species is a shorebird that prefers areas with expansive sand or mudflats. The breeding and winter census data for the Atlantic coast population of piping plovers indicate that breeding is concentrated from Maine to North Carolina. The piping plover nests above the high-tide line on coastal beaches, dunes, and sandflats. Breeding occurs between March and August. The southeastern U.S. coastline does not support large numbers of wintering birds; the majority of birds overwinter along the Gulf of Mexico. Piping plovers that winter on the east coast are found on barrier islands, sandy peninsulas, and near coastal inlets. The plover's foraging area includes intertidal zones, mudflats, sandflats, and shorelines of coastal ponds, lagoons, or salt marshes. Rarely have plovers been sighted (inland or offshore) away from the outer beaches. Habitat loss and degradation and disturbance by humans are important factors contributing to the decrease in the piping plover population (USFWS 1995).

- **Roseate Tern *(Sterna dougallii)*:** The roseate tern, which is exclusively marine and a colonial water bird, occurs all over the world, but breeds on islands in only two distinct locations (*i.e.,* two populations) in the northern hemisphere: from Maine, and some adjacent portions of Canada, to New York; Florida Keys to Lesser Antilles. As of 1994, there are 1150 pairs that reside (*i.e.,* non-wintering) along the east coast from Newfoundland to North Carolina. The population that breeds in the northeastern United States is classified as endangered. Although breeding may occur from New York to Maine, the majority of nesting occurs on two small islands — in Buzzards Bay, Massachusetts, and at the eastern tip of Long Island, New York. The decrease in the number of nesting sites is attributable to competition with black-backed gulls. The northeastern United States population lays eggs during May and June. The roseate tern forages over open water. It dives into the water to capture small schooling marine fish. Migration occurs between late August and September (USFWS 1989b).

- **Wood Stork *(Mycteria americana)*:** The wood stork is the only stork found in the United States; it occurs south of Virginia. The wood stork is one of the largest wading birds. It feeds and nests in fresh, brackish, and saltwater environments. Nesting begins in December in Florida, and at later times in other areas. In 1986, the population was estimated to be approximately 5850 pairs nesting in Florida and Georgia. Since that time, nests have also been observed in South Carolina (Cocker and Murphy 1992).

State-Listed Threatened, Endangered, and Rare Species

Many species of birds are not on the Federal lists of threatened and endangered species; however, states may list species as threatened, endangered, or of special concern (*e.g.*, rare). The following list presents some of those species categorized by habitat, feeding habits, and other unique characteristics. Below is a general description of species of concern whose habitat includes the coast, shore, coastal estuaries, and the ocean.

- **Pelagic Seabirds:** The Atlantic coast supports several species of pelagic birds. These birds are present on the Atlantic coast, but breed in other hemispheres. Examples of pelagic birds include the greater shearwater *(Puffinus gravis)*, sooty shearwater *(Puffinus gravis),* and the common loon *(Gavia immer)* (D. Pence, pers. comm. 1995).

- **Shorebirds:** Shorebirds inhabit open beaches, tidal flats, and marshes. Some species breed within inland areas. Shorebirds may be colonial or solitary in nesting habitat. The endangered piping plover is a shorebird. Other species included in this category are Wilson's plover *(Charadrius wilsonia)* and the willet *(Catoptrophorus semipalmalus)* (MMS 1992; D. Pence, pers. comm. 1995).

- **Water Fowl:** The preferred habitat of water fowl includes coastal oceanic waters, bays, sounds, estuaries, lagoons, and tidal wetlands. The Atlantic coast contains areas defined as important water fowl habitat. One important area is Chesapeake Bay. Water fowl, as with shorebirds, breed within inland regions. Waterfowl include the American black duck (*Anas rubripes*), harlequin duck *(Histrionicus histrionicus),* Canada goose *(Branta canadensis)*, common *(Somateria mollissima)* and king *(Somateria spectabilis)* eiders, and scoters [*e.g.*, black scoter *(Melanitta nigra)*] (MMS 1992; D. Pence, pers. comm. 1995).

- **Colonial Water Birds:** This category includes many coastal birds. The endangered roseate tern is a colonial water bird. Wading birds, which walk through the water searching for prey, are also included in this category. Colonial water birds are distinguishable by the colonies of nests that they build along the coast. Wading birds occur in all Atlantic coastal states, but they prefer tidal creeks, ponds, marshes, mangrove flats, and similar shallow-water habitats. Examples of colonial water birds are the brown pelican *(Pelecanus occidentalis)*, great blue heron *(Ardea herodias)*, black-crowned night heron *(Nycticorax violaceus)*, great egret *(Casmerodius albus),* snowy egret *(Egretta thula)*, glossy ibis *(Plegadis falcinellus)*, Leach's storm petral *(Oceanodroma leucorhoa)*, American oystercatcher *(Haematopus palliatus)*, gull-billed tern *(Stena nilotica),* and least tern *(Sterna antillarum).*

- **Raptors:** Raptors hunt for food while in flight; many species hunt along the coast. The peregrine falcon (which is endangered), northern harrier *(Circus cyaneus),* osprey *(Pandion haliaetus),* peregrine falcon, and bald eagle, which are threatened, and the short-eared owl *(Asio flammeus)* are raptors found along the coast.

- **Marsh Birds:** Marsh birds are found in shallow estuaries where they feed and breed. The king rail *(Rallus elegans)* and the black rail *(Laterallus jamaicensis)* are marsh birds that are of special concern.

- **Song Birds:** The coastal environment is also the home to various song birds. Two examples of song birds found in the coastal environment are the sharp-tailed sparrow *(Ammospiza caudacuta)* and the seaside sparrow *(Ammospiza maritima).*

4.4.9 Marine Sanctuaries, Critical Habitats, and Areas of Intermittent Protected Species

Table 4-18 lists marine sanctuaries, national wildlife refuges, national parks, and other Federally protected areas where the USCG will take appropriate action as described in the Preferred Alternative. The location of nests will be considered an area of intermittent use by protected species and the USCG activities in these areas will be conducted as described in the Preferred Alternative.

4.5 Socioeconomic Environment

4.5.1 Fishing

Commercial Fisheries

Data on the socioeconomic aspects of commercial fisheries have been collected for many years. The NMFS annually produces the report entitled "Fisheries of the United States," which includes summary data on commercial (United States and foreign) and recreational fishing, and associated activities (*e.g.*, supply of fishery products, cold storage) for the United States and the world. The following data are from the reports produced for 1993 and 1994 (NMFS 1994e, 1995b; P. Logan, pers. comm. 1996). The most recent data for landings (*i.e.*, brought into port), and value of landed fish and shellfish in the eastern U.S. regions (northeast and south Atlantic) are provided for 1993 and 1994. In 1993, the 862 thousand tons (1.72 billion lbs) of fish landed were worth $1 billion. Landings in 1994 decreased to 1.7 billion pounds, but value increased slightly to $1.1 billion. The number of vessels participating in the commercial fishing industry is provided for 1993, the most recent year for which data are available (see Table 4-19). In the Northeast Region (Maine to Virginia), 4582 vessels (>5 net registered tons) and 18,475 boats (<5 net registered tons) participated, for a total of 23,057 craft. In the south Atlantic region (North Carolina to Florida, including east and west coasts), 3760 vessels and 16,760 boats participated, for a total of 20,520 craft.

Detailed regional socioeconomic fishery statistics are summarized for the northeast (Maine to Virginia) and the south Atlantic (North Carolina to Florida, east coast only) for 1993 (P. Logan, pers. comm. 1996), the latest year for which both vessel and landings data are available by gear. These data provide detail on the number of vessels and boats using various gear, and the landings and revenue generated from fish and shellfish caught using these gear. The gear are classified as fixed or mobile. Fixed gear are deployed in a specific location and allowed to "fish" for a specified period of time; mobile gear "fish" while in motion, which may include towing by a vessel or boat. Specific types of fixed gear have been identified as being problematic because of entanglement of non-targeted marine resources. The most frequently used mobile gear, which is operated by a vessel or boat, in the northeast and south Atlantic is the otter trawl. Rakes are also frequently used in the south Atlantic. Rod and reel dominate the fixed gear in the northeast; gill nets dominate in the southeast.

Table 4-18. Federally Protected Areas by State

State	Protected Areas
Delaware	Prime Hook National Wildlife Refuge
Florida	St. Johns National Wildlife Refuge Merrit Island National Wildlife Refuge Archie Carr National Wildlife Refuge Pelican Island National Wildlife Refuge Hobe Sound National Wildlife Refuge Loxahatachee National Wildlife Refuge (Inland Lake) Biscayne National Park Crocodile Lake National Wildlife Refuge Key Largo National Marine Sanctuary National Key Deer National Wildlife Refuge Looe Key National Marine Sanctuary Great White Heron National Wildlife Refuge Dry Tortugas National Park
Georgia	Gray's Reef Marine Sanctuary Tybee National Wildlife Refuge Savannah National Wildlife Refuge Wassaw National Wildlife Refuge Harris Neck National Wildlife Refuge Blackbeard Island National Wildlife Refuge Wolf Island National Wildlife Refuge Cumberland Island National Seashore
Maine	Moosehorn National Wildlife Refuge Cross Island National Wildlife Refuge Petit Manan National Wildlife Refuge Acadia National Park Seal Island National Wildlife Refuge Franklin Island National Wildlife Refuge Pond Island National Wildlife Refuge Rachel Carson National Wildlife Refuge
Maryland	Chincoteague National Wildlife Refuge
Massachusetts	Thacher Island National Wildlife Refuge Parker River National Wildlife Refuge Stellwagen Bank National Marine Sanctuary Cape Cod National Seashore Monomoy National Wildlife Refuge Nantucket Island National Wildlife Refuge Massoit National Wildlife Refuge Nomans Land Island National Wildlife Refuge
New Jersey	Edwin B. Forsythe National Wildlife Refuge Cape May National Wildlife Refuge
New York	Fire Island National Seashore Gateway National Recreation Area

State	Protected Areas
North Carolina	Mackay Island National Wildlife Refuge Currituck National Wildlife Refuge Cape Hatteras National Seashore Pea Island National Wildlife Refuge Alligator River National Wildlife Refuge Mattamuskett National Wildlife Refuge Swanquarter National Wildlife Refuge U.S.S. Monitor National Marine Sanctuary Cedar Island National Wildlife Refuge Cape Lookout National Seashore
Rhode Island	Sachuest Point National Wildlife Refuge Pettaquamscutt Cove National Wildlife Refuge Truston Pond National Wildlife Refuge Block Island National Wildlife Refuge Ninigret National Wildlife Refuge
South Carolina	Cape Romain National Wildlife Refuge Ace Basin National Wildlife Refuge (Inland Lake) Pinckney Island National Wildlife Refuge
Virginia	Wallops Island National Wildlife Refuge Eastern Shore of Virginia National Wildlife Refuge Fisherman Island National Wildlife Refuge Back Bay National Wildlife Refuge

Table 4-19. Commercial Fishing Vessels (>5 Tons), Fishing Boats (<5 Tons) and Total Boats Registered by the USCG in the Atlantic Coast States of the United States in 1993. The total boats includes registered freshwater and marine recreational vessels.

State	Commercial Fishing Vessels	Commercial Fishing Boats	Total Boats Registered
Maine	1,822	5,409	113,590
New Hampshire	144	410	80,520
Massachusetts	832	4,529	120,944
Rhode Island	276	2,895	29,629
Connecticut	128	472	96,516
New York	692	2,970	442,745
New Jersey	391	1,429	159,084
Total 1st District	**4,285**	**18,114**	**1,043,028**
Delaware	24	361	42,144
Maryland[1]	75	NA	181,850
Virginia[1]	198	NA	210,323
North Carolina	930	5,775	294,761
Total 5th District	**1,227**	**6,136**	**729,078**
South Carolina	383	970	362,277
Georgia	319	571	298,012
Florida[2]	2,128	9,444	719,071
Puerto Rico	NA	NA	29,883
U.S. Virgin Islands	NA	NA	3,822
Total 7th District	**2,830**	**10,985**	**1,413,065**
TOTAL	**8,342**	**35,235**	**3,185,171**

[1]Only data collected for Federal waters are available. Inshore data are not available.
[2]Includes both Atlantic (east) and Gulf of Mexico (west) coasts.
NA = No data available.
Source: NOAA 1995.

Table 4-20 summarizes the socioeconomic fishery statistics for the northeast and south Atlantic by fixed and mobile gear. The number of vessels permitted to operate fixed and mobile gear is also included in the table. Because multiple gear permits may be issued to one vessel/boat, the total number of permits is greater than the number of unique vessels or boats. As indicated in the table, mobile gear accounts for the majority of the landings and revenues in the northeast. Significantly more vessels than boats are used in the deployment and operation of mobile gear. Because the vessels (>5 net registered tons) are larger than boats (<5 net registered tons), they generally operate further offshore. The fishing industry in the south Atlantic is very different. First, although landings and revenue from mobile gear is greater than from fixed gear, there is no clear dominance of one gear as in the Northeast Region. In addition, it appears that significantly more boats are used for fishing than vessels. This implies that fishing in the South Atlantic takes place closer to shore than in the northeast because boats can travel as far offshore as vessels.

Table 4-20. 1993 Fishing Statistics by Gear and Region

Statistic	Fixed Gear[1]		Mobile Gear[2]		Other Gear	
	Northeast[3]	South Atlantic[4]	Northeast[3]	South Atlantic[4]	Northeast[3]	South Atlantic[4]
Landings (mt)	115781	54999	624911	58194	7080	659
Revenues ($1000)	293236	77893	548947	88671	43979	3192
Fishermen	NA	32790	NA	48395	NA	22
Vessels[5]	7351	1356	3631	1609	2623	0
Boats[6]	4915	16185	343	22811	858	8

Source: Unpublished data (1993) NMFS SEFSC, 1993, Miami, FL; NMFS, Fisheries Statistics Division, pers. comm. (1996).
[1]Fixed gear is gear set in a fixed location and that operates while stationary (*e.g.*, gill net, longlines).
[2]Mobile gear is gear that operates while in motion or when towed (*e.g.*, otter trawl, seines).
[3]Northeast includes Maine to Virginia.
[4]South Atlantic includes North Carolina to Florida (east coast).
[5]Vessels are >5 net registered tons.
[6]Boats are <5 net registered tons.

The fishing industry provides employment on fishing vessels (*i.e.*, fishermen; Table 4-20), and in processing and wholesale plants. A summary of the number of fishermen employed on vessels by gear type in the northeast is not available. However, data from two census conducted between 1987 and 1992 provide very different estimates on the number of persons employed as harvesters. One census indicates that more than 72,000 people are employed, at least part time, as harvesters. Approximately 36,000 of these people are employed full time as vessel and boat owners and crew. The other census estimates a much lower employment in the harvesting sector (15,300) (P. Logan, pers. comm. 1996). The yearly employment for 1993 generated by the processors and wholesalers is summarized by region: 15,809 in the northeast (Maine to Virginia) and 6013 in the south Atlantic (North Carolina to the east coast of Florida).

Recreational Fishery

Marine recreational fishery statistics have been collected continuously and systematically since 1979. The NMFS produces an annual report entitled, "Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts," which includes comprehensive data on the recreational fishery and its participants (*e.g.*, age, number of fishing trips). The preliminary 1993 data are presented in the "Fisheries of the United States" (NMFS 1995b). The estimated total number of fish caught in the north, mid-, and south Atlantic recreational fisheries is 184 million, an increase of 50 million over 1993 (NMFS 1994e). These fish were caught during 40,539 fishing trips by coastal, non-coastal, and non-resident recreational fishing participants. These fish were caught from shore (18 million), party/charter boats (3 million), and private/rental boats (20 million). Approximately one-third of all fishing trips takes place in the south Atlantic (North Carolina to Florida).

Fishing patterns of anglers in the northeast and south Atlantic from 1992 to 1994 are compared in Table 4-21. Over the three-year period, on average, more anglers were reported in the northeast. The average number of trips per angler was three in the northeast compared to two in the south Atlantic. Most fish is caught within 3 miles of shore. This is most evident in the south Atlantic where more than 70% of the fishing takes place close to shore.

Table 4-21. Recreational Fishing Statistics for the Atlantic Ocean

Year	Participants (thousands)		Fishing Trips[1] (thousands)		Estimated Total Number of Fish Caught by Primary Fishing Location (thousands)			
					≤ 3 miles offshore		≥ 3 miles offshore	
	Northeast[2]	South Atlantic	Northeast	South Atlantic	Northeast	South Atlantic	Northeast	South Atlantic
1992	3892	4077	11295	7692	18,624	20,004	10,545	7,016
1993	4674	4000	14338	7517	23,933	20,829	13,250	5,636
1994	4921	4550	14382	9032	21,137	34,083	12,220	7,461

Source: NMFS (1995b).
[1]Includes trips private/rental, party/charter boats.
[2]Includes north Atlantic and mid-Atlantic.

4.5.2 Shipping

Commercial

The western North Atlantic is heavily used by commercial vessels (passenger, dry cargo, tug, and barge). The number of commercial vessels using the area has doubled since 1960. However, during the same time period, the level of port traffic has actually decreased, possibly because of increases in vessel sizes and loads (A. Knowlton, pers. comm. 1995). More than 50,000 large merchant vessels visited Atlantic ports and channels in 1989. The majority of these visits was to ports in the Seventh USCG District.

Table 4-22 summarizes the activities at the leading U.S. Atlantic Ocean coastal ports in 1994, as well as at ports located in areas where threatened and endangered species have been observed. In terms of total tons, the Port of New York/New Jersey is the largest port on the east coast of the United States and the third largest port in the country. Norfolk, Virginia, which is the second largest port on the east coast in terms of total tons, is the sixth largest in vessel traffic. After the Port of New York/New Jersey, Baltimore and Boston have the highest vessel traffic. Portland, Maine, which is located in an area where right whales are frequently observed, has the fourth highest vessel traffic. Vessel traffic in other selected ports (in areas frequented by threatened and endangered species) is significantly less.

4.5.3 Whale Watching

Whale watching has become an economically important industry along the east coast of the U.S. Motorized whale watch boats are the most popular platform for commercial whale watching, but charter fishing vessels, sailboats, ferries, kayaks, and small aircraft are also used. Whale watching vessels carry between 20 and 300 passengers, and some vessels make up to 3 trips/day during peak tourist season (NMFS 1994d).

The following is a list of ports along the Atlantic coast of the U.S. from which whale watching tours are conducted (NMFS 1994):

Northeast

Maine:	Bar Harbor, Boothbay, Cutler, Eastport, Kennebunkport, Kittery, Lubec, Northeast Harbor, Pembroke, Portland, Seal Harbor and Trenton
New Hampshire:	Durham, Hampton Beach, Portsmouth, Rye
Massachusetts:	Barnstable, Boston, Bourne, Eastham, Gloucester, Hyannis, Martha's Vineyard, Nantucket, New Bedford, Newburyport, Plymouth, Provincetown, Rockport, South Yarmouth
Connecticut:	Mystic, Waterford
New York:	Hampton Bay, Montauk
New Jersey:	Brigantine, Cape May, Long Beach Island, Brielle, Brigantine, Sandy Hook, Sea Isle City, Wildwood
Maryland:	Ocean City
Virginia:	Virginia Beach

Southeast

South Carolina:	Hilton Head Island
Georgia:	Jekyll Island
Florida:	Key West

Table 4-22. Total Tons (net volume of tonnage for area; descending order) and Vessel Trips for the Top Ten and Selected Atlantic Ocean Coastal Ports

Port (City, state)	Total (domestic + foreign) Tons (millions)	Number (thousand) of Vessel Trips In/Out of Port[1]
Top Ten Ports		
D1 (Maine to New Jersey)		
New York, NY and NJ	126.1	68,235/51,015
Philadelphia, PA	40.7	16,030/16,042
Boston, MA	18.9	18,393/18,403
Portland, ME	14.2	16,615/16,568
D5 (Delaware to North Carolina)		
Norfolk Harbor, VA	45.8	15,500/15,584
Baltimore, MD	41.4	20,740/20,578
Newport News, VA	15.7	4772/4763
D7 (South Carolina to Florida)		
Jacksonville, FL	18.9	5848/5822
Port Everglades, FL	18.1	6992/6961
Savannah, GA	15.9	6115/6091
Selected Ports[2]		
D1 (Maine to New Jersey)		
Cape Cod Canal, MA	10.8	1498/1567
Portsmouth, NH	3.4	966/971
D5 (Delaware to North Carolina)		
Chesapeake and Delaware Canal	13.6	3683/3690
Morehead City, NC	4.1	1639/1635
D7 (South Carolina to Florida)		
Canaveral, FL	3.6	2264/2252
Brunswick, GA	1.6	720/718
Fernandina, FL	0.6	929/759
Fort Pierce, FL	0.2	218/218
St. Augustine, FL	none reported	5848/5822

Source: USACE (1994); USACE, pers. comm. (1996).

[1]Based on number of trips (inbound/outbound; upbound/downbound) of passenger and dry cargo, tanker, and tow or tug vessels.

[2]Selected ports are located in areas near high concentrations of endangered and threatened species.

The Stellwagen Bank/Jeffreys Ledge areas off Massachusetts, and the Cox Ledge region off Long Island (New York) have traditionally been the areas most frequented by whale-watching vessels in the northeast. However, recent changes in the distribution of whales have made the central coast of Maine, and the New Jersey and Virginia coastline increasingly popular destinations for whale watching. The season extends from April through October, and the species targeted include humpback whales, fin whales, minke whales, white-sided dolphins and, opportunistically, right whales, blue whales, and sei whales. In Virginia, the season runs from December through March, and the whales "watched" include humpback whales and fin whales. Dolphin-watching trips are conducted from June through September. As of 1994, Maryland, New Jersey, and New York whale-watch activities generally were conducted from June through September, focusing on bottlenose dolphins in the mid-Atlantic, and dolphins and whales off Montauk Point, New York (NMFS 1994d).

There are a total of 66 whale-watching companies in the northeast; some of these companies operate more than one boat. In Maine, Massachusetts, and New Hampshire, 35-40 boats operate whale-watching cruises. In the northeast, the majority of vessels are 100 ft in length, aluminum-hulled, have a displacement of 50-90 tons and use two to four 12-cylinder diesel engines. More than 1000 people are employed by the northeast whale-watching industry. The New England Whale Watching Association estimates that $22.5 million is generated each year directly from whale watching. Sixty million dollars is generated indirectly (through sales of hotel rooms, transportation, food, clothing, and souvenirs) from whale watching in New England (NMFS 1994d).

In the southeast, "whale watching" operations primarily target dolphins, and vessels usually operate 1-2 miles from shore in coastal waters. Twenty-five companies offer whale-watching tours in this region. Approximately 70 people are employed full-time and 25 people are employed part time by whale-watching companies in the southeast. Approximately $3.2 million each year is generated in the southeast directly by this industry. No data are available on indirect revenues generated by the whale-watching industry in the southeast (NMFS 1994d).

4.5.4 Vessel Activity along the Atlantic Coast of the United States

Commercial, recreational, and federal agency vessels all contribute to the vessel traffic along the Atlantic coast of the United States. Summaries of commercial and recreational fishing vessels and recreational boats are summarized in Section 4.5.1 (see Table 4-19). The number of vessels (*i.e.,* trips) traveling to and from ports along the east coast are summarized in Table 4-22. In addition to the commercial and private vessels, federal agencies (including the USCG) also operate vessels in this area. Table 4-23 summarizes vessels by federal agency. In comparison to all registered vessels operating on the east coast of the United States (Table 4-22), Federal agency vessels represent less than .01% of all registered vessels. Many of these vessels are significantly larger than the registered vessels listed in Table 4-19. Because of the importance of advance warning to ensure the ability to maneuver in a timely fashion to avoid maritime collisions, such vessels typically post more lookouts and have better trained crews than smaller vessels and recreational boaters. In addition, many of the larger vessels spend extended periods away from the homeport, so there is less activity moving in and out of coastal ports in comparison to recreational and fishing vessels.

Table 4-23. Summary of Federal Agency Vessels by USCG District

USCG District[1]	Federal Agency	Number of Vessels
D1 (Maine to New Jersey)	Navy	27
	USCG	33
	NOAA	2
	EPA	1
	USACE	13
D5 (Delaware to North Carolina)	Navy	108
	USCG	29
	EPA	2
	NOAA	2
	USACE	66
D7 (South Carolina to Florida)	Navy	32
	USCG	42
	EPA	0
	NOAA	4
	USACE	66
TOTAL		426

[1]Homeports were assigned to USCG Districts. Source: NMFS pers. comm. 1996; U.S. Navy pers. comm. 1996; EPA pers. comm. 1996; USACE pers. comm. 1996; USCG pers. comm. 1996.

A snapshot of the number of vessels operating along the east coast of the United States at a specific time is provided in Table 4-24. This table provides the number of vessels by category that were detected during the first week of specific months from June 1994- June 1996. The number of vessels is a very conservative estimate of the actual number of vessels and represent fewer than 10% of the actual number of vessels in the area. During June to December of 1994 and 1995 vessel densities exceeded 1400 vessels operating along the east coast of the United States. The number of vessels decreased from 1994 through January to May 1995, but increased again to more than 1400 in 1996. If these numbers represent only 10% of the total vessel activity, then potentially more than 7,000 vessels are operating during any week. This is approximately equal to more than 1,000 vessels per day. Most of the vessel activity provided in the table is from North Carolina and South Carolina and represent bulk/cargo and tanker vessels.

Table 4-24. Vessel Traffic Density Data

Year[1]	Bulk/ Cargo	Fishing	Tanker	Passenger/ Research	Service/ Tug	Military	Total
1994	479	1	204	53	20	8	765
1995a	505	3	147	34	16	9	714
1995b	378	2	112	18	9	0	519
1996	512	1	177	26	19	1	736

[1]1994, 1995a - June-Dec; 1995b, 1996 -Jan - May. Source: USCG database.

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