CHAPTER

10

Cetaceans

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Introduction

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Cetaceans are the sub-group of marine mammals that includes whales, dolphins, and porpoises. Because of their extensive migrations, they have very large geographic ranges often encompassing hundreds of thousands of miles in an individual's lifetime. One consequence of these large geographic ranges is frequent opportunity to interact with humans. These interactions, including exposure to shipping traffic, fishing gear, pollution, underwater noise, and the effects of climate change on them and their food sources, can pose serious threats to marine mammal populations. Species chosen for inclusion in this assessment represent the diversity of cetaceans in the Northwest Atlantic. Some of the target whales are considered threatened or endangered, and the porpoise and dolphin species selected represent a range of species that inhabit the region.

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Selection of Target Species

Technical team members and external experts identified the target species for this group as well as the most appropriate data sources and approaches for documentation and analysis. Several factors were considered when selecting the target cetacean species, including population status and distribution in the region. The home ranges of the species included in this assessment extend through part or all of the region (and beyond), from inshore to offshore and north to south. The selected set of species also was chosen to represent the diversity of cetacean species that occur in the region. The final list of targets is:

Baleen Whales

- Fin whale *(Balaenoptera physalus)*
- Humpback whale *(Megaptera novaeangliae)*
- Minke whale *(Balaenoptera acutorostrata)*
- North Atlantic right whale *(Eubalaena glacialis)*
- Sei whale *(Balaenoptera borealis)*

Toothed Whales

- Atlantic white-sided dolphin *(Lagenorhynchus acutus)*
- Bottlenose dolphin *(Tursiops truncatus)*
- Harbor porpoise *(Phocoena phocoena)*
- Sperm whale *(Physeter macrocephalus)*
- Striped dolphin *(Stenella coeruleoalba)*

Population Status and Importance of the Northwest Atlantic Region

Cetaceans targeted by this assessment primarily use the Northwest Atlantic for feeding, nursing, and migration. For most baleen species, breeding occurs outside of the region or the location is unknown, while some small toothed whales may use the region for breeding. The fin, humpback, North Atlantic right, sei, and sperm whales are listed as Endangered by the Endangered Species Act. The IUCN Red List documents the fin, sei, and North Atlantic right whales as "endangered," sperm whales as "vulnerable," and minke and humpback whales and Atlantic white-sided, bottlenose, and striped dolphins as species of "least concern" (IUCN 2008). Unfortunately, there are limited data to determine the population status of most target species at this time. The majority of existing data are derived from marine mammal aerial and ship surveys, and a large portion of the information consists of individual sightings. Survey effort is higher in the summer and generally occurs when researchers know cetaceans will be sighted. Researchers and observers are often hindered by weather, and have varying missions and research goals, usually dictated by funding sources.

A species of particular concern in this region is the North Atlantic right whale, which is considered to be one of the most critically endangered large whales in the world and could be facing extinction (Clapham and Mead 1999; Kenney 2002). The right whale population is currently estimated to be approximately 438 individuals (North Atlantic Right Whale Consortium 2009.) Calculations based on demographic data through 1999 indicate that their current mortality rate would reduce population growth by approximately 10% per year (Fujiwara and Caswell 2001; Kraus et al. 2005; NMFS 2007a). However, minimum population counts (photo-identifications) suggest a small level (<2%) of growth in recent years (North Atlantic Right Whale Consortium 2009).

Ecosystem Interactions and Ecological Dependencies

Relationships between cetaceans and their environment are complex and can vary by ecosystem. While the exact ecological function of cetaceans is not fully known, insights into their role in the marine ecosystem have emerged through large-scale studies of species-ecosystem interactions and community structure (Bowen 1997). Katona and Whitehead (1988) hypothesized that marine mammals could play a major role in determining the behavior and life history traits of their prey species, affecting nutrient storage and cycling, and altering benthic habitats.

For example, as predators, cetaceans are major consumers of production at most trophic levels, specifically feeding on organisms like zooplankton, invertebrates, and forage fish in the region. Cetaceans studied in this assessment are split into two suborders based on morphological structure used in feeding: Mysticeti and Odontoceti (baleen and toothed whales). Mysticetes, including fin, humpback, minke, right, and sei whales, use baleen, a highly structured filtration system made of plates of keratin (similar to human fingernails), to separate prey from water. They typically forage for pelagic prey, consuming large quantities of prey at one time, including zooplankton (e.g., copepods), euphausiids (e.g., krill), and small fish (e.g., sand lance, herring, mackerel) (Nemoto 1959; Jonsgard 1966; Mitchell 1975c; Kawamura 1982; Mizroch et al. 1984; Kenney et al. 1985; Haug et al. 1995; Flinn et al. 2002; Perrin and Brownell 2002). Some baleen species like sei and right whales are dependent on euphausiids and copepods when feeding in the North Atlantic, while other species are less selective in their diet (Nemoto 1959; Kraus et al. 1988).

Odontocetes possess teeth and include the Atlantic white-sided dolphin, bottlenose dolphin, striped dolphin, and sperm whale. Typically, toothed whales prefer larger prey than baleen whales and consume individual organisms. Primary food sources for toothed whales are cephalopods (e.g., small and large squid), small fish (e.g., smelt, herring, mackerel), and demersal fish (e.g., cod, skate) (Smith and Whitehead 2000; Archer 2002; Sergeant et al. 1980; Katona et al. 1978). Within the boundaries of the study area both baleen and toothed whales have two other potential predators besides humans, the killer whale, *Orcinus orca,* and large sharks (Hancock 1965; Dolphin 1987; Perry et al. 1999; Heithaus 2001; Pitman et al. 2001; Perrin and Brownell 2002; Horwood 2002).

Northwest Atlantic Distribution and Important Areas

Methods

Geospatial analyses for cetaceans were obtained from the United States Navy (see Department of Navy 2005). These analyses were completed for the Navy's Marine Resource Assessments (MRA), a program used to develop comprehensive data and literature concerning protected and managed marine resources found in their operating areas for use in environmental and biological assessments prepared in accordance with various federal laws (e.g., Marine Mammal Protection Act, National Environmental Policy Act). Data were from the Navy's Northeast MRA study region, which covers the entire Northwest Atlantic study area except for the mouth of the Chesapeake Bay west of 75.67°W longitude. This gap was filled with data from the Navy's Southeast MRA study region, shown in pink in Figure 10-1. The initial sightings used in the Navy's analysis were taken from National Marine Fisheries Service-Northeast Fisheries Science Center (NMFS-NEFSC) Aerial Surveys, NMFS-NEFSC Shipboard Surveys, and the North Atlantic Right Whale Consortium Database. Data used in these analyses were primarily collected via aerial and shipboard surveys during daylight hours, weather permitting. Each MRA used different dates to determine their seasons. The seasons used in the Northeast were winter: Jan - March, spring: April - June, summer: July - August, and fall: Oct - Dec. The dates used in the Southeast were winter: Dec 6 - April 5, spring: April 6 - July 13, summer: Jul 14 - Sept 16, and fall: Sept 17 - Dec 5. Because of the different season dates, data were processed independently, but displayed together on the map.

One issue with interpreting marine mammal data is the bias introduced by uneven survey coverage or "effort." For example, an area may have few sightings because of the absence of cetaceans or there just may be little survey effort in that location. A standard approach to overcoming this bias is using effort-corrected sightings data (Kenney and Winn 1986; Shoop and Kenney 1992). Calculating sightings per unit effort or SPUE, an index of relative density, allows for comparison of data spatially and temporally within a study area (Shoop and Kenney 1992). SPUE is calculated as:

$$\text{SPUE} = 1000^{*}(\text{number of animals sighted})/\text{effort}$$

Geospatial analysis obtained from the United States Navy included shapefiles of valid sightings for cetaceans studied in this assessment and pre-calculated effort grids for each

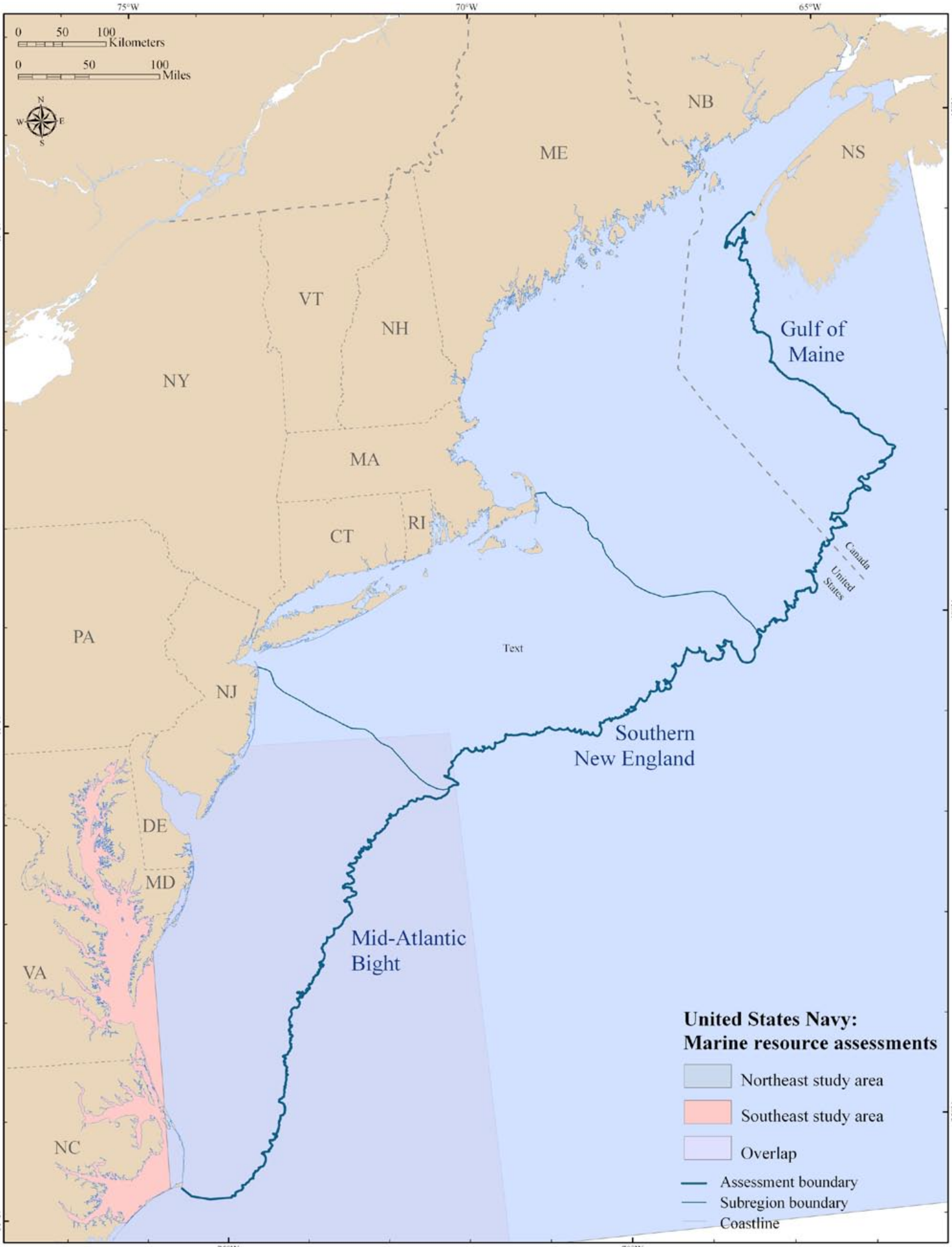

Figure 10-1. United States Navy Marine Resource Assessment study boundaries.

season. The validity of sightings was carefully screened and verified by Navy contractors before inclusion in the model. Invalid records were not included in the analysis. Using the formula above, SPUE was calculated for each target species, for each season, and for each ten minute square.

Maps, Analysis, and Areas of Importance

Baleen Whales

Fin Whale

Fin whales appeared to move throughout the region, both inshore and offshore, and aggregate in some spots. As with other baleen whales, they typically used the southern part of the region for migration and the northern parts for feeding during months with large abundances of prey species. Distribution maps indicated the presence of some fin whales along the southeast portion of the region during the winter months (Figure 10-2a). Data also indicated larger aggregations of fin whales in the highly productive waters of the Gulf of Maine and Bay of Fundy in the spring and summer inshore of the Continental Shelf break, with a significant congregation at the 100 m isobath around Georges Bank in the spring (Figures 10-2b and 10-2c). Other studies have presented similar findings, reporting that the most important northern areas for fin whales appeared to be the Great South Channel, along the 50 m isobath past Cape Cod, Stellwagen Bank, and Cape Ann to Jeffreys Ledge (Hain et al. 1992).

Important Marine Areas for Fin Whale

Gulf of Maine (Cape Cod Bay, Jeffreys Ledge, Stellwagen Bank, Georges Bank and Great South Channel), Bay of Fundy

Humpback Whale

The humpback whale population included in this study travels annually between winter breeding grounds in the Caribbean and summer feeding areas in the Gulf of Maine, Georges Bank and the Bay of Fundy (Figure 10-3a). This species is therefore largely absent from those feeding areas in winter, but it has been sighted off the Mid-Atlantic states and the southeast United States (Swingle et al. 1993; Barco et al. 2002). In spring, the greatest concentrations of humpback whales occurred in the southwestern Gulf of Maine and Massachusetts Bay (Figure 10-3b). This species was more broadly distributed in summer and fall, with areas of concentration in the southern Gulf of Maine and the Bay of Fundy (Figure 10-3c and 10-3d).

These results are largely consistent with the results of prior studies using older datasets (CeTAP 1982). Prior work has also shown that humpback whale distribution across the northern study range depends on physical factors such as bottom depth and slope (CeTAP 1982; Hamazaki 2002) as well as the abundance and distribution of herring and sand lance (Payne et al. 1986; Payne et al. 1990; Weinrich et al. 1997). Prey fish distribution can also result in significant temporal variation in distribution patterns, even from one year to the next (Payne et al. 1986; Payne et al. 1990; Weinrich et al. 1997). On an individual level, humpback whales are known to return preferentially to one or more areas within their feeding range, but also to move among available feeding sites within and between years (Robbins 2007). In addition, although all ages and sexes can be found across the feeding range of this species, the southern Gulf of Maine is more frequently used by mature females and juveniles as compared to northern Gulf of Maine and Bay of Fundy areas (Robbins 2007). This distribution suggests that there may be other demographic factors to consider when evaluating habitat importance, in addition to observed densities. However, such information is rarely available for the other species under investigation.

Important Marine Areas for Humpback Whale

Gulf of Maine (Massachusetts Bay, Jeffreys Ledge, Stellwagen Bank, Great South Channel, northern edge of Georges Bank), Bay of Fundy

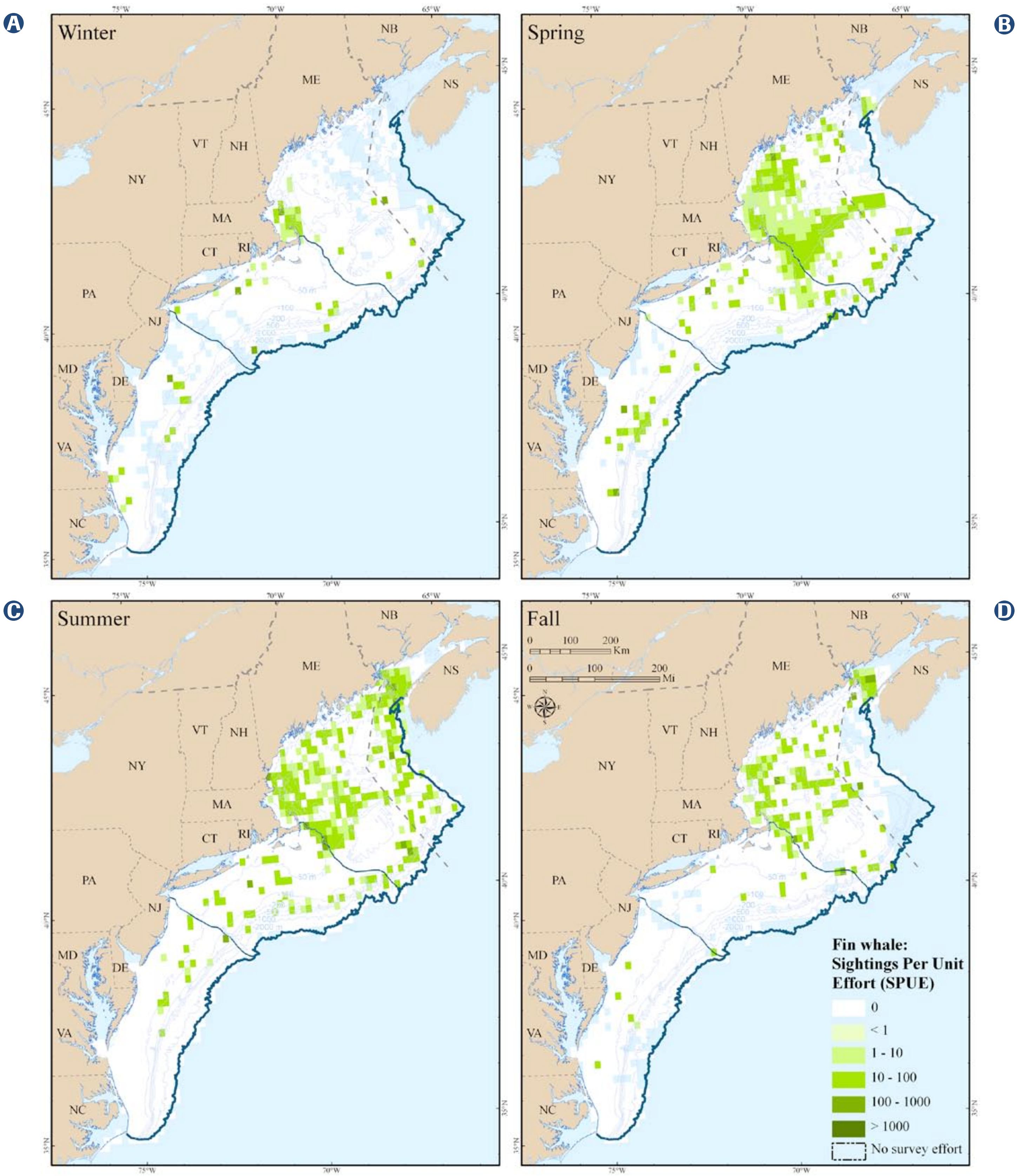

Figure 10-2. Fin whale sightings per unit effort (SPUE) by season.

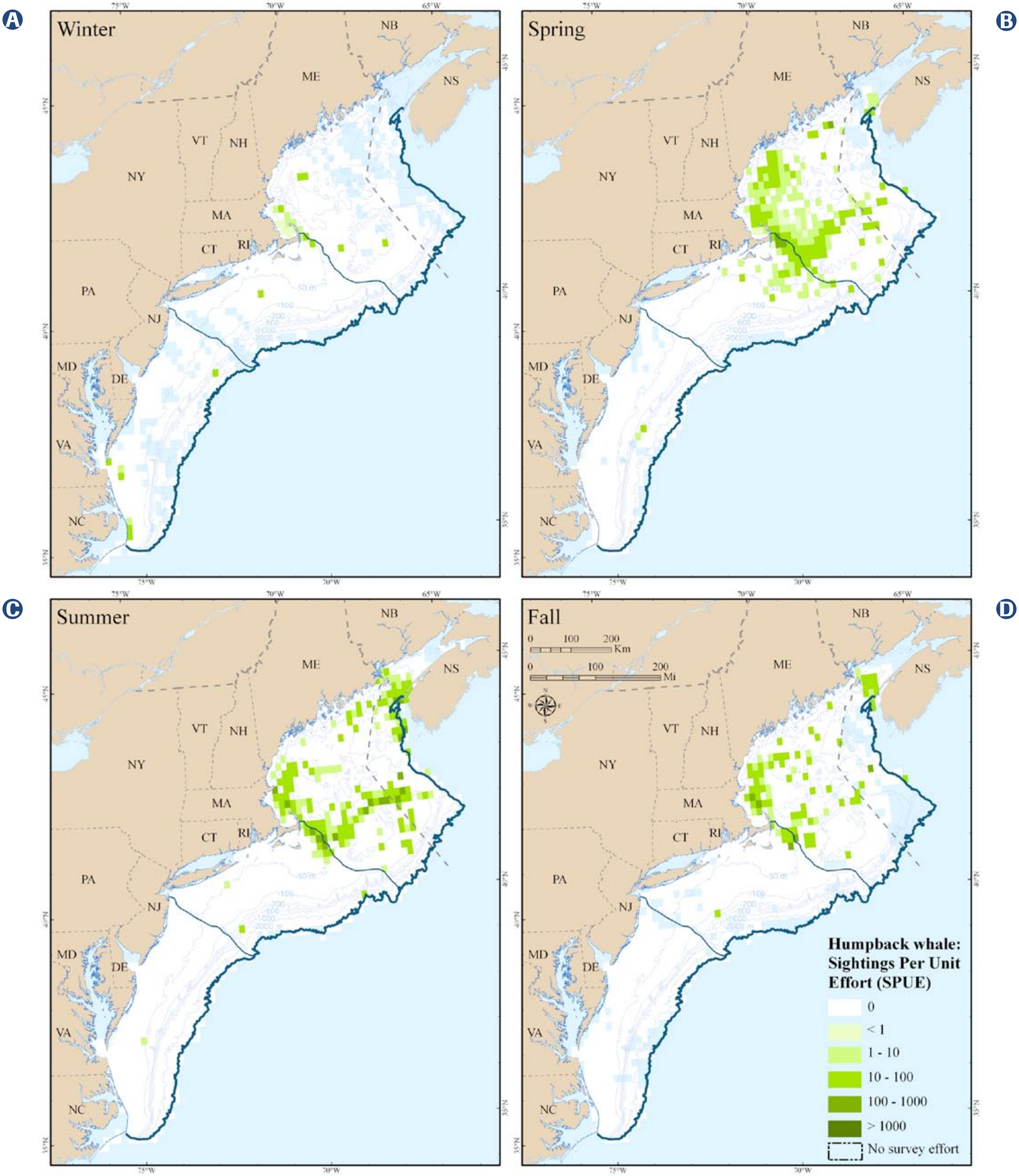

Figure 10-3. Humpback whale sightings per unit effort (SPUE) by season.

Minke Whale

Following patterns similar to fin and humpback whales, minke whales migrated to the productive areas of the Gulf of Maine and were sighted there in the spring and summer months (Figure 10-4b and 10-4c). In studies in the northern Atlantic, they have been found to be positively correlated with gravel/sand seabed types as well as the distribution of sand eel and herring populations in the summer in New England waters (Naud et al. 2003; Macleod et al. 2004). There were limited sightings in the fall and winter (Figure 10-4a and 10-4d).

Important Marine Areas for Minke Whale

Gulf of Maine (Cape Cod Bay, Jeffreys Ledge, Stellwagen Bank, and Great South Channel)

North Atlantic Right Whale

North Atlantic right whales are known to migrate seasonally and spend time in the Northwest Atlantic region in spring through early summer. They are found on feeding grounds off the northeastern United States and eastern Canada. In the spring, feeding aggregations of right whales have been found in the Gulf of Maine especially in Cape Cod Bay and along the Great South Channel into deeper basins in the north (Kenney and Winn 1986, Mitchell et al. 1986, Kenney et al. 1995). The Bay of Fundy is a well known feeding site for right whales during the summer and early fall and aggregations of whales have been seen there every year (Figure 10-5a, 10-5b, 10-5c, 10-5d). Standardized visual survey effort in the Stellwagen Bank National Marine Sanctuary (SBNMS) (Wiley et al. 2003) and increasing passive acoustic monitoring efforts over the winter months on Jeffreys Ledge and in the Stellwagen Bank Marine Sanctuary (Mussoline et al. in review) have detected the presence of right whales in the northeastern portion of the sanctuary and on Jeffreys Ledge beginning in late December through March. These data indicated that some fraction of the right whale population overwinters in this region.

Important Marine Areas for North Atlantic Right Whale

Gulf of Maine (Cape Cod Bay, Jeffreys Ledge, Stellwagen Bank and Great South Channel), Bay of Fundy

Sei Whale

In the Northwest Atlantic, sei whales were sighted predominantly in the deep waters off the Continental Shelf edge in areas like the eastern edge of Georges Bank, the Northeast Channel and Hydrographer Canyon (CeTAP 1982; Hain et al. 1985; NOAA 2008c); however, they have been known to sporadically move into shallower, inshore waters like Stellwagen Bank and Great South Channel as they switch prey species. Assessment data indicated the same general pattern (Figure 10-6a, 10-6b, 10-6c, 10-6d). Whales were reported in more inshore locations, such as the Great South Channel in 1987 and 1989 and Stellwagen Bank in 1986 (Payne et al. 1990). In the past five years, sei whales have been sighted more frequently inshore than in previous years and this has been linked to prey availability (Waring et al. 2008).

Important Marine Areas for Sei Whale

Gulf of Maine (Georges Bank, Northeast Channel, Canyons); Inshore (Cape Cod Bay, Jeffreys Ledge, Stellwagen Bank, Great South Channel)

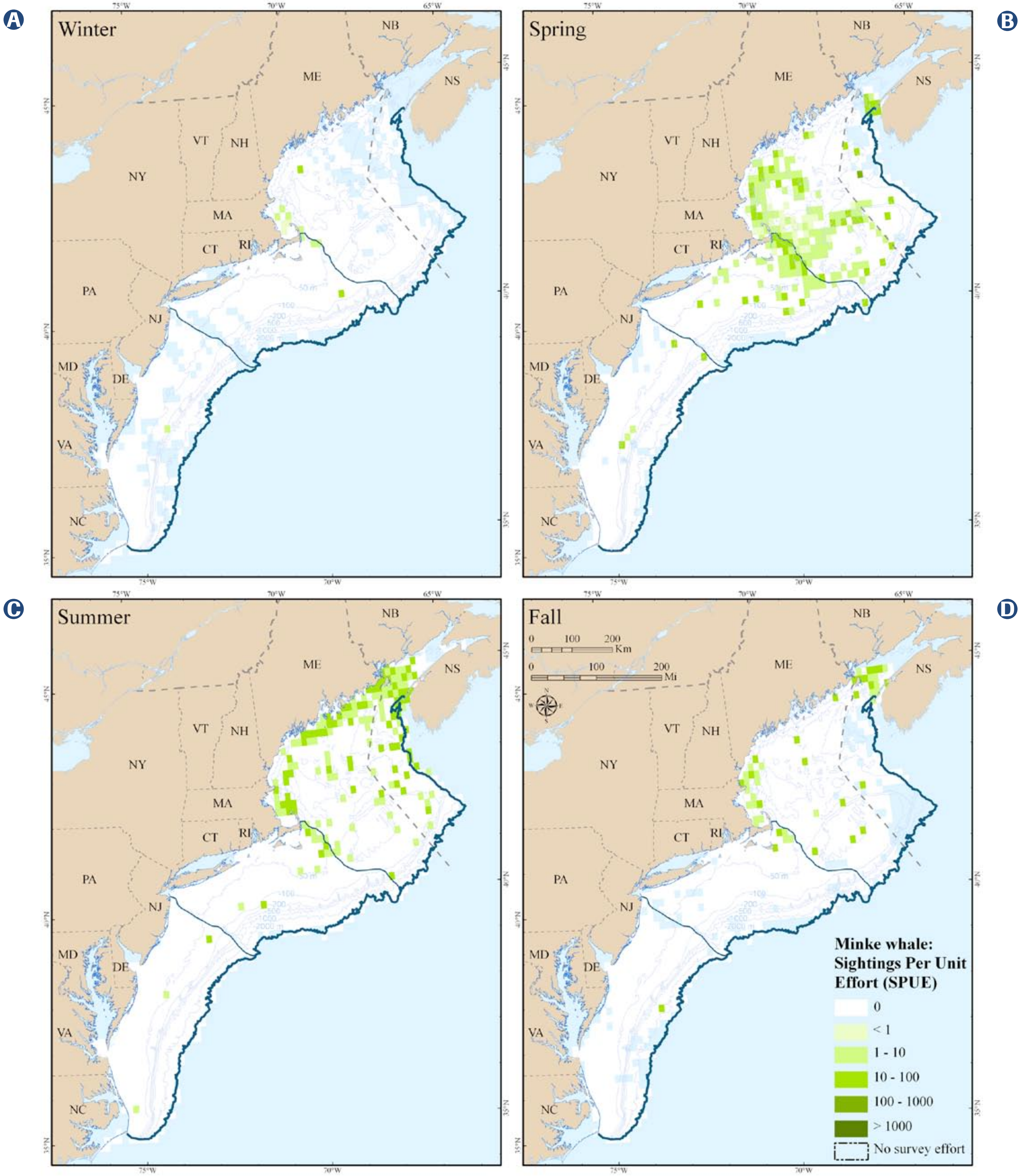

Figure 10-4. Minke whale sightings per unit effort (SPUE) by season.

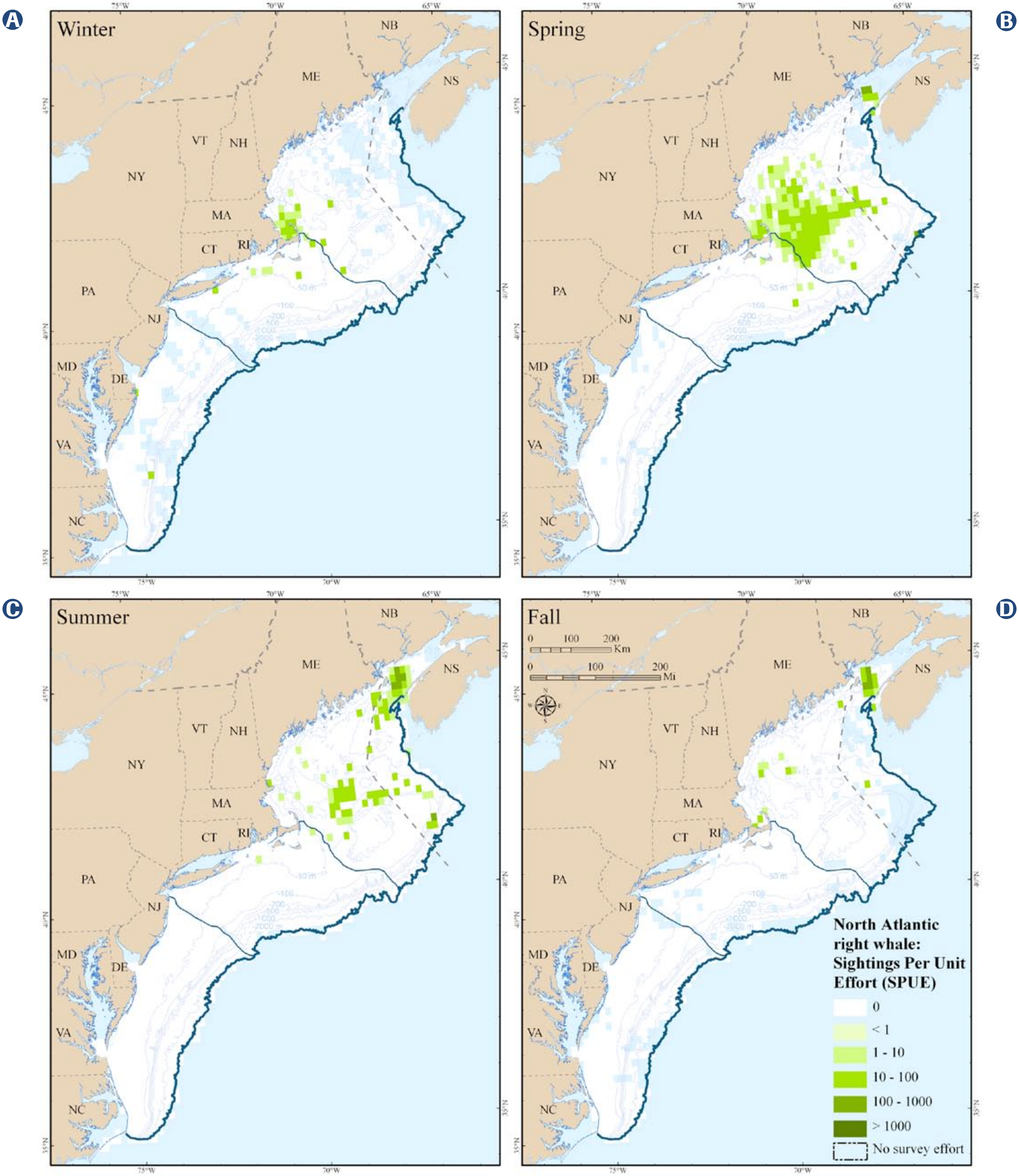

Figure 10-5. North Atlantic right whale sightings per unit effort (SPUE) by season.

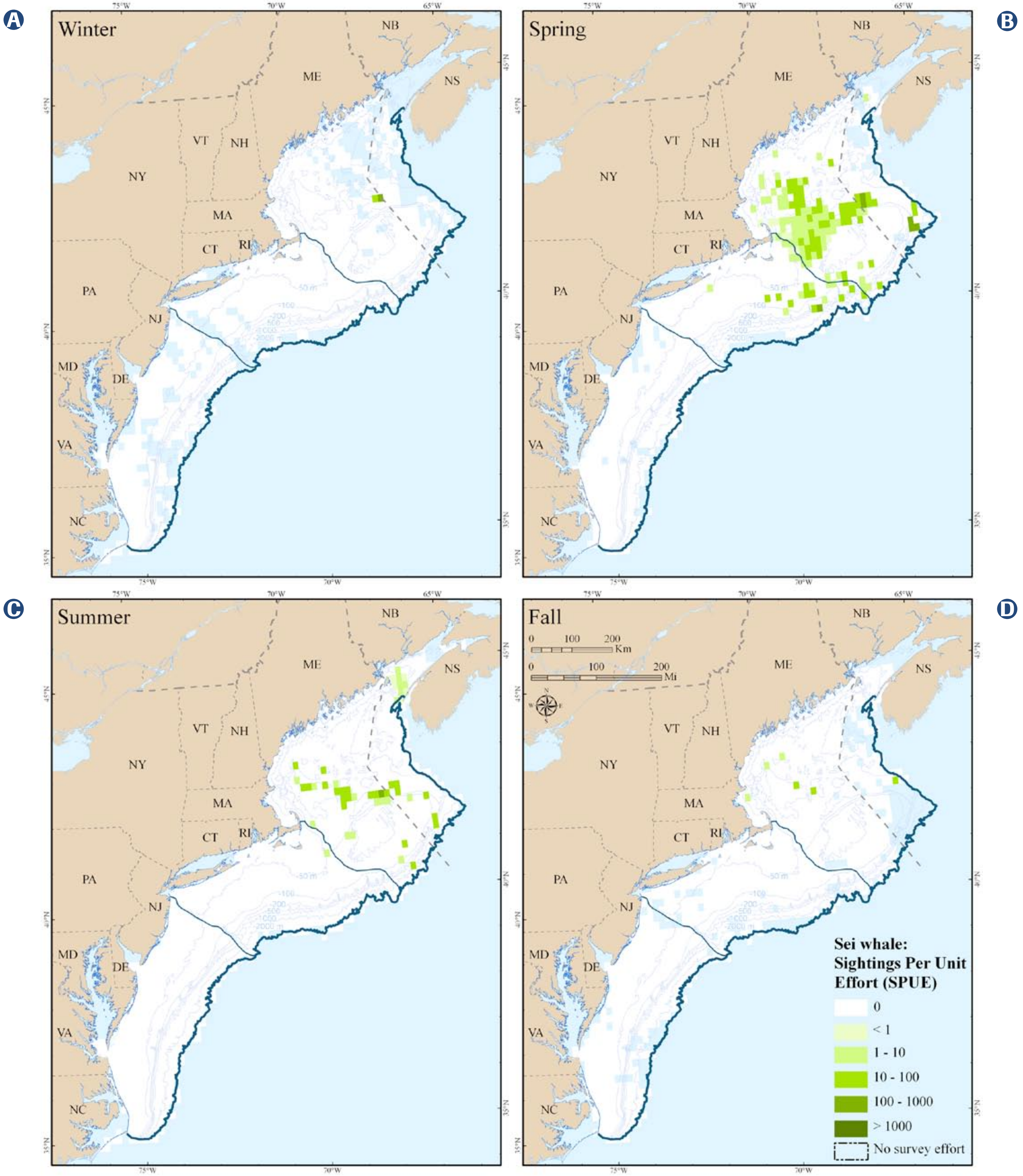

Figure 10-6. Sei whale sightings per unit effort (SPUE) by season.

Toothed Whales

Atlantic white-sided dolphin

Atlantic white-sided dolphins display movement patterns that appeared to vary greatly by season. Although white-sided dolphins were sighted in the Gulf of Maine, they migrated south in the winter months. Bycatch records show presence of this species in the Mid-Atlantic Bight, but the species distribution in these areas was not well reflected in this analysis because of the limited survey data (Figure 10-7a). In the spring and summer, Atlantic white-sided dolphins were located throughout the Gulf of Maine, east of Long Island, and east of Cape Cod to the eastern edge of the assessment boundary in high abundances (Figure 10-7b and 10-7c). Fall patterns showed sparsely distributed sightings throughout the Gulf of Maine (Figure 10-7d).

Important Marine Areas for Atlantic White-sided Dolphin

Gulf of Maine to the edge of Georges Bank, east of Long Island; Not enough data to determine areas in the Mid-Atlantic Bight

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Bottlenose Dolphin

The data indicated that bottlenose dolphins are found mostly offshore in the region, from the 100 m contour to the Continental Shelf edge. In the winter, bottlenose dolphins were present in the southern portion of the region and along the Continental Shelf edge (Figure 10-8a). In the spring, summer, and fall, bottlenose dolphins were found in high abundances along the shelf-slope break, with a clear area of mid- to high abundance at the mouth of Chesapeake Bay in the summer (Figure 10-8b, 10-8c, 10-8d). Mid-Atlantic surveys have indicated that bottlenose are also abundant in coastal areas of Virginia and North Carolina, especially in the winter when more than half of the sightings were between the shoreline and 3 km from shore (Barco et al. 1999; Torres et al. 2005).

Important Marine Areas for Bottlenose Dolphin

Throughout the region from 100 m to the Continental Shelf edge, coastal and estuarine environments including the Chesapeake Bay

Harbor porpoise

Distinct distribution patterns vary greatly by season in harbor porpoise populations in the Northwest Atlantic. Similar to the Atlantic white-sided dolphin, harbor porpoises migrated south in the winter months (Figure 10-9a). Current survey effort does not capture their true distribution in the southern portion of our region, but bycatch records have indicated the species is present. In the spring, harbor porpoises were distributed throughout the Gulf of Maine and east and south of Long Island. During the summer, harbor porpoises were concentrated in the northern part of the Gulf of Maine and the Bay of Fundy in high abundances. Fall patterns for harbor porpoises showed a coastal distribution in the Gulf of Maine with high abundances in the Bay of Fundy.

Important Marine Areas for Harbor Porpoise

Gulf of Maine to the edge of Georges Bank, east and south of Long Island; Not enough data to determine areas in the Mid-Atlantic Bight

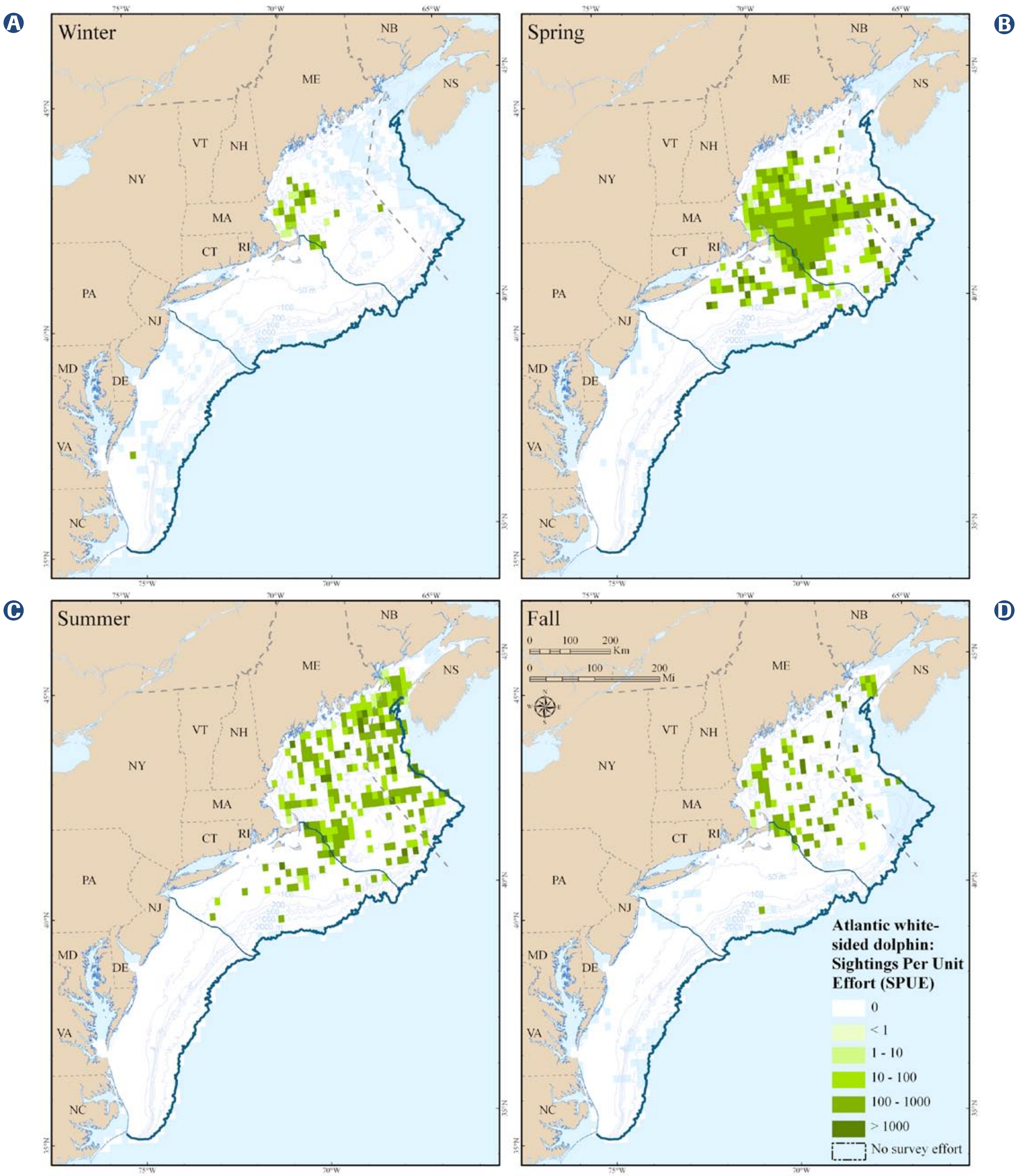

Figure 10-7. Atlantic white-sided dolphin sightings per unit effort (SPUE) by season.

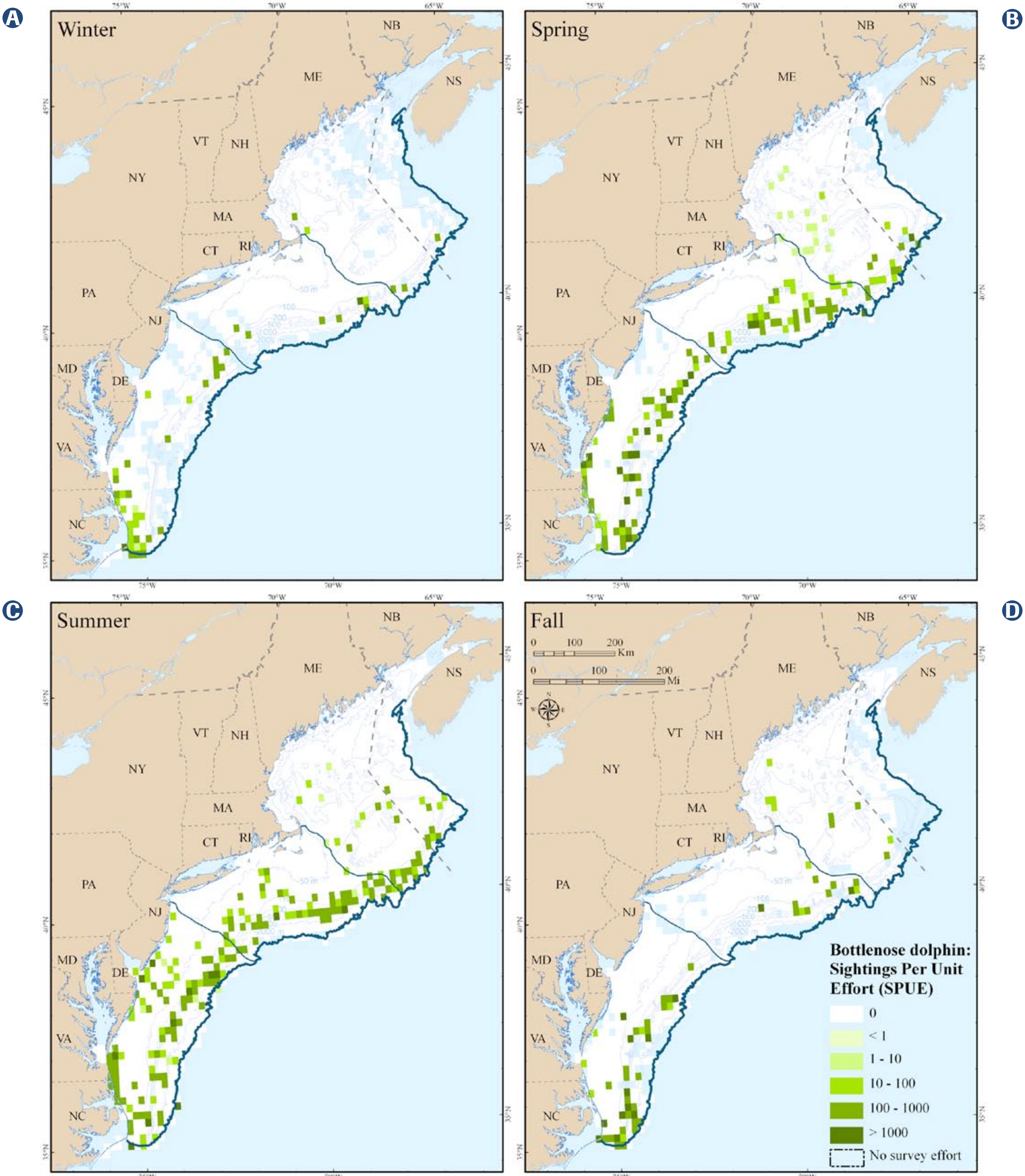

Figure 10-8. Bottlenose dolphin sightings per unit effort (SPUE) by season.

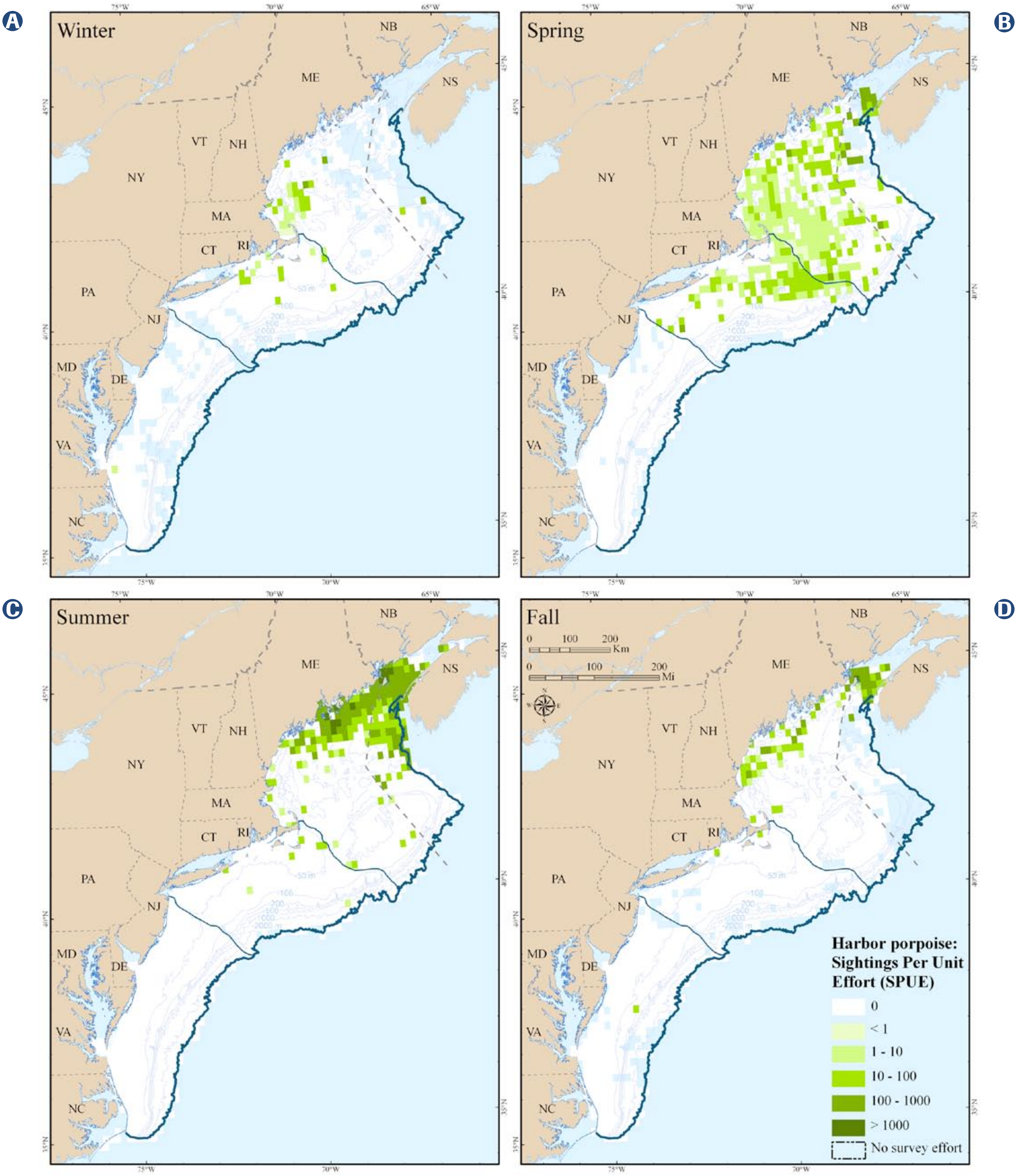

Figure 10-9. Harbor porpoise sightings per unit effort (SPUE) by season.

Sperm Whale

Data indicated that sperm whales were present along the shelf-slope break, primarily between 200-2000 m, in the Mid-Atlantic portion of the region, with most sightings occurring in the summer months (Figure 10-10a). Other studies have indicated similar patterns in sperm whale distribution, reporting that sightings are centered along the Continental Shelf break and over the Continental Slope from 100 to 2000 m deep and in submarine canyons and edges of banks (Mitchell 1975b; Waring et al. 2008).

Important Marine Areas for Sperm Whale

Continental Shelf edge and canyons throughout the region

Striped Dolphin

Based on data used in this assessment, striped dolphins were distributed in low numbers offshore along the shelf-slope break throughout the region (Figure 10-11a). Current survey effort may not capture the full pattern of distribution in the region. CeTAP (1982) reported that striped dolphins are known to range along the Continental Shelf and out to the slope from Cape Hatteras to the southern edge of Georges Bank.

Important Marine Areas for Striped Dolphin

Continental Shelf edge, canyons and Continental Slope throughout the region

Human Interactions

Cetaceans are vulnerable to pressures caused by direct and indirect interactions with humans for many reasons, including their longevity, low fecundity, high position in the food chain, and highly migratory nature. Threats to Northwest Atlantic marine mammal populations include bycatch and entanglement in fishing gear; collisions with vessels at sea; depletion of prey resources; disturbance caused by ship noise, drilling on the sea floor, and other acoustic inputs to the marine environment; and high levels of marine contaminants (Reeves et al. 2003). The full effects of these interactions throughout the region are not fully known. However, intensive research on the interactions between cetacean and humans is taking place in the SBNMS (Clark et al. 2009; Hatch et al. 2008; Hatch et al. 2008; Scheifele and Darre 2005; SBNMS 2009; Wiley et al. 2003; Wiley et al. 2008). This is an area with a particularly strong overlap between humans and cetaceans, and frequent reports of entanglement and vessel strikes (Jensen and Silber 2003; Wiley et al. 2003; SBNMS 2008).

All large whale species in the region are known to be vulnerable to vessel strikes, but the frequency and sites of those interactions are also poorly understood. Ship strikes accounted for 53% of the resolved deaths in necropsied right whales (Campbell-Malone et al. 2008). There is little evidence that right whales avoid vessels, and whales may even become tolerant to vessel noise and ignore it (Nowacek et al. 2004). In the absence of better data, shipping lanes have already been shifted within several high density cetacean habitats, such as the SBNMS and the Bay of Fundy, to reduce the probability of a strike. It is not yet clear to what degree the higher frequency of reports of interactions is due to a greater number of possible observers. Cetaceans in the North Atlantic are also the target of a large commercial whale watching industry. Although the effects of whale watching are not well understood, recent research in the Stellwagen Bank area has failed to detect an impact on juvenile survival or calving rates (Weinrich and Corbelli 2009).

Interaction between the fishing industry and cetaceans in United States waters has been documented by federal monitoring programs. Entanglement is a documented source of injury and death for a wide range of cetacean species in the region (Waring et al. 2009). Small toothed whales, such as Atlantic white-sided and bottlenose dolphins, have been observed as bycatch in a variety of fisheries, including those utilizing sink gillnets, bottom trawls, mid-water trawls, and herring trawls (NMFS 2006b; ATGTRT 2007). Large whales have also been shown to interact with fishing gear. For example, minke whales are prone to entanglement in fishing gear and collision with vessels due to their predominantly coastal distribution in spring and summer (NMFS 2007b). Incidental capture of minke whales has been observed in the northeast bottom

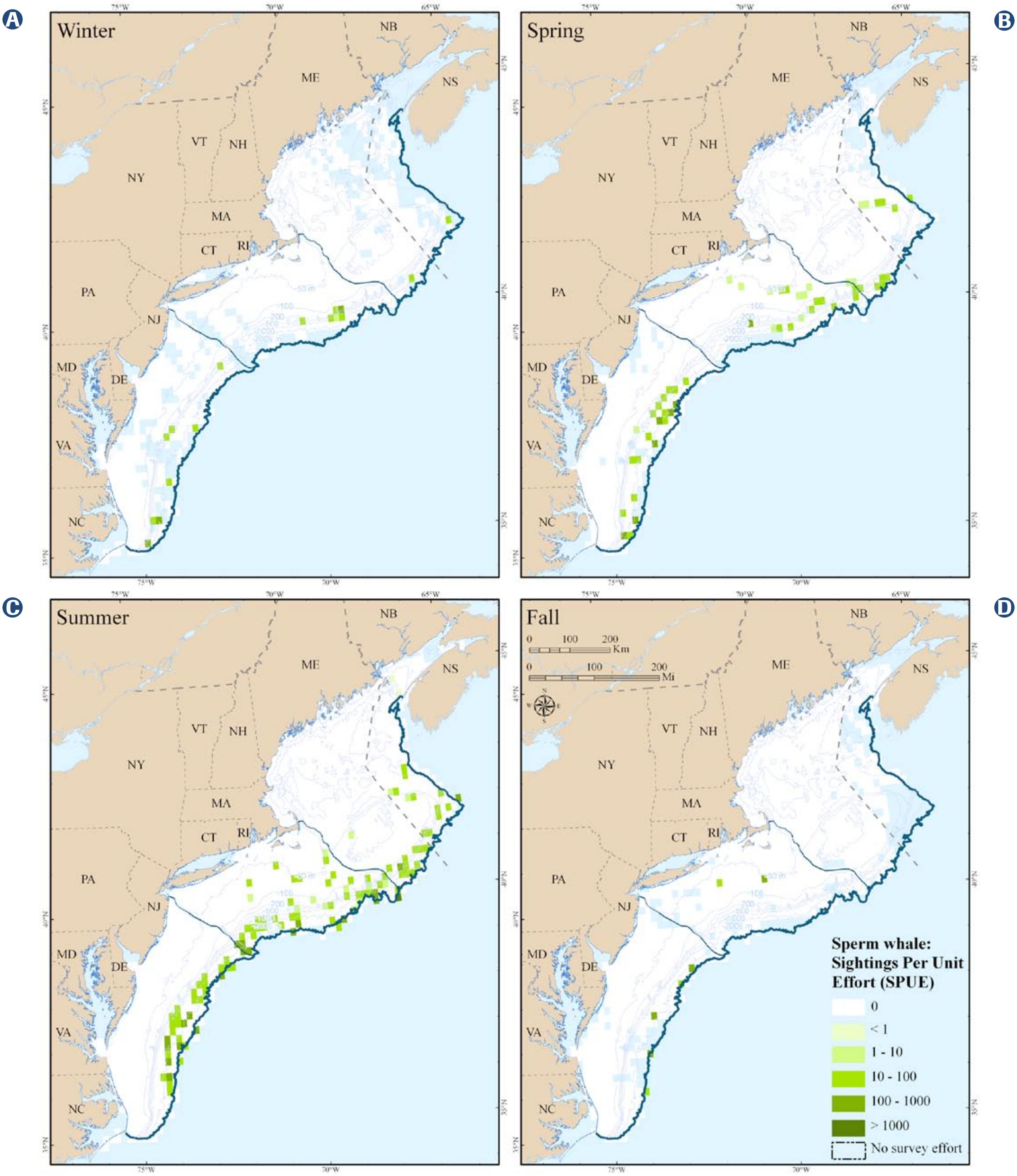

Figure 10-10. Sperm whale sightings per unit effort (SPUE) by season.

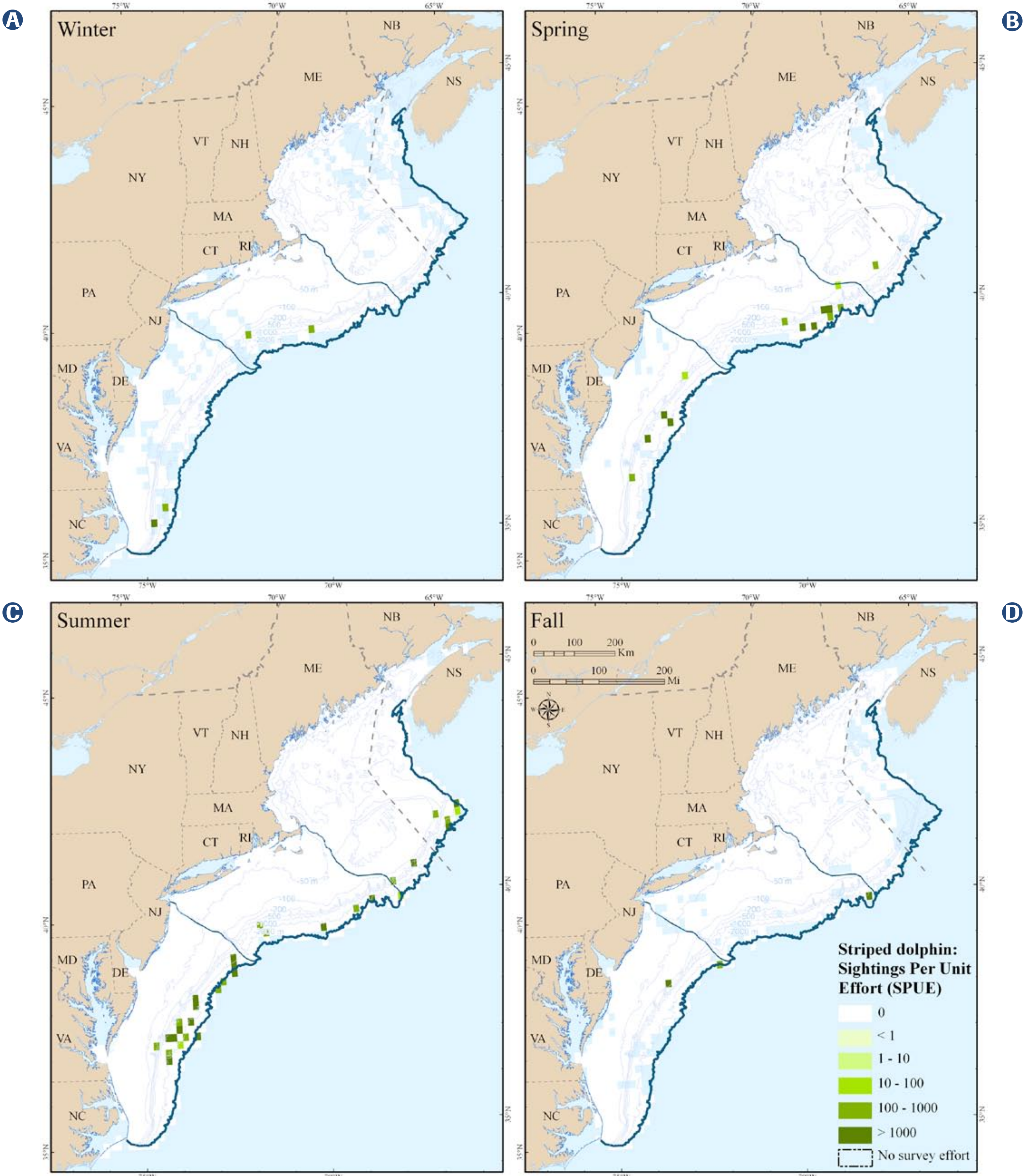

Figure 10-11. Striped dolphin sightings per unit effort (SPUE) by season.

trawl, northeast and mid-Atlantic lobster trap/pot, and other unidentified fisheries, although not all captures have resulted in mortalities (NMFS 2007b). Entanglement of humpback and northern Atlantic right whales in fishing gear such as bottom gillnets, lobster gear, weirs, longlines, and purse seines (Johnson et al. 2005) has been documented. Scar-based studies of humpback and right whales indicate that reported events underestimate true entanglement frequency (Robbins and Mattila 2004, Knowlton et al. 2005). At present, there are few data on where large whale entanglements actually occur within the region, and therefore which areas, if any, pose greatest risk.

The effect of human-generated noise on cetaceans remains a highly controversial and poorly understood conservation issue (see review in Clark et al. 2007 and Parks and Clark 2007; Richardson et al. 1995; NRC 2003). Human-generated sound in the sea comes from a variety of sources, including commercial ship traffic, oil exploration and production, construction, acoustic research, and sonar use. Underwater sounds are also generated by natural occurrences such as wind-generated waves, earthquakes, rainfall, and marine animals. Cetaceans are highly vocal and dependent on sound for almost all aspects of their lives (e.g. food-finding, reproduction, communication, detection of predators/hazards, and navigation), heightening concerns regarding the impacts of human-induced noise (NRC 2003). Due to the behavior of sound in the ocean (particularly low frequency sound), noise can propagate over large distances, thus both spatial and temporal scales of potential impact can be large. There is a great deal of observed variation in noise responses among both cetacean species and individuals of different genders, age classes, with different prior experiences with noise, and in different behavioral states (Southall et al. 2007). Species with similar hearing capabilities have been found to respond differently to the same noise.

Observed effects of noise on cetaceans include changes in vocalizations, respiration, swim speed, diving, and foraging behavior; displacement; avoidance; shifts in migration path; hearing damage; and strandings (Parks and Clark 2007). For example, in a Newfoundland inlet, two humpback whales were found dead near the site of repeated sub-bottom blasting with severe mechanical damage to their ears (Ketten 1995). Sperm whales exposed to the sounds of pingers used in calibration systems to locate hydrophone arrays temporarily stopped communicating, and fell silent, changed their activities, scattered, and moved away from the source of the sound (Watkins and Schevill 1975; Watkins et al. 1985). Responses of cetaceans to noise can often be subtle, and there are many documented cases of apparent tolerance of noise. However, marine mammals showing no obvious avoidance or changes in activities may still suffer important consequences. Observed reactions to noise in marine mammals could result in population-level impacts such as decreased foraging efficiency, higher energetic demands, less group cohesion, higher predation, and decreased reproduction (NRC 2005). However, the whales showed no signs of avoidance or disturbance which may indicate habituation to noise. Alternatively, the noises may have no biologically significant effects. Much research effort is currently focused on better known cetacean populations that have been exposed to long-term human-induced noise to assess population consequences (i.e. North Atlantic right whales, Clark et al. 2009).

The effects of marine contaminants like endocrine disruptors and biotoxins from harmful algal blooms on cetaceans are not fully known. Mass stranding events have been documented and connected to ingestion of contaminated food sources. For example, in the winter of 1989, a mass stranding of humpback whales in Cape Cod Bay, Massachusetts was linked to a recent food source, Atlantic mackerel (Geraci et al. 1989). These mackerel were contaminated with *saxitoxin*, a toxin produced by the microscopic marine algae, *Alexandrium spp.*, which is the cause of paralytic shellfish poisoning in humans. Determination and tracking of the effects of these contaminants is a rapidly evolving science (see review in Rolland et al. 2007). Because of the size, free-swimming nature, and endangered status of many cetaceans, it has been difficult to collect the type of non-lethal samples (e.g. blood and tissue) needed to diagnose diseases or monitor physiological responses to these contaminants. Analysis of free-floating scat samples has provided a suite of new information about cetaceans, their prey and the containments that affect them, including the DNA from the originating animal, DNA from their prey, marine biotoxins, and stress hormones, and is providing many new insights and data about the interaction between cetaceans and contaminants.

Management and Conservation

Regulatory Authorities

All of the species studied in this assessment are federally protected by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the "take" of marine mammals in United States waters and by United States citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States (NOAA 2007b). The Endangered Species Act (ESA) also lists the fin, humpback, sei, sperm, and North Atlantic right whales as "endangered" and prohibits "take" of these species, in addition to mandating that critical habitat is designated for these species, where appropriate, and recovery plans are developed and implemented. Where these species are found within National Marine Sanctuaries, they are also protected under the United States National Marine Sanctuaries Act.

Current Conservation Efforts

Many ongoing cooperative conservation efforts focus on marine mammals, including federal, international, and state agencies and academic institutions and non-profit organizations. Internationally, one of the first protection measures for whales came when right whales were protected by the 1st International Convention for the Regulation of Whaling in 1935. Their protected status has been continued by the International Whaling Commission, since its founding in 1946 (Donovan 1991).

In the United States, as part of their listing as Endangered Species, the ESA requires NMFS to develop and implement recovery plans; many species listed as conservation targets in this assessment have draft plans in review or final plans being implemented. A final Recovery Plan has been published for the North Atlantic right whale under the Marine Mammal Protection Act and is being implemented (NMFS 2005). Critical habitat has also been designated for this species, including portions of Cape Cod Bay and Stellwagen Bank, and the Great South Channel (NMFS 1994). An intensive long-term effort, based primarily at the New England Aquarium in Boston, Massachusetts and NOAA's Northeast Fisheries Science Center in Woods Hole, Massachusetts, monitors the North Atlantic right whale population, identifies risk factors, and develops and implements measures to reduce human-induced mortality and injury. A final Recovery Plan (1991) was also released by NMFS for the conservation of humpback whales that either occur seasonally or are residents of United States waters. The plan has four main objectives: 1) to maintain and enhance historical and current known humpback whale habitats, 2) to identify and reduce human related injury and mortality, 3) to research population structure, and 4) to improve administration and coordination of the recovery plan.

A draft Recovery Plan for fin and sei whales was issued by NMFS, and released for public comment and review. However, it was not finalized and it was subsequently determined that separate Recovery Plans should be issued for each species. A revised Draft Recovery Plan for the fin whale was released by NMFS for public comment in 2006, but a Recovery Plan has not been drafted for the sei whale at this point. The Fin Whale draft Recovery Plan suggests continued international cooperation to protect the fin whale and further research on fin whale population structure (NMFS 2006a). A draft Sperm Whale Recovery Plan was also released and suggests continued research on the structure of sperm whale populations, identification and protection of relevant habitats within and outside of United States waters, reduction of the frequency of human caused injury and mortality, and maximization of efforts to obtain scientific information from stranded or entangled individuals (NMFS 2006c). To date, these two draft plans have not been finalized.

Under Section 118 of the Marine Mammal Protection Act, NMFS convened the Large Whale Take Reduction Team with a goal to develop a Take Reduction Plan (TRP) for large whales. The purpose of the submitted plan was to reduce the level of serious injury and mortality of three strategic stocks of large whales (North Atlantic right, humpback, and fin) in commercial gillnet and trap/pot fisheries (LWTRT 1997). The measures identified in the TRP were also intended to benefit minke whales, which are not designated as a strategic stock, but are known to be taken incidentally in gillnet and trap/pot fisheries. The TRP consists of both regulatory and non-regulatory measures, including broad-based gear modifications, time/area closures, and extensive outreach efforts.

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NMFS also assembled the Atlantic Trawl Gear Take Reduction Team to develop a TRP to limit the incidental injury and mortality of Atlantic white-sided dolphins, long-finned pilot whales *(Globicephala melas)*, short-finned pilot whales *(Globicephala macrorhynchus)*, and common dolphins *(Delphinus delphis)* in the northeast and mid-Atlantic trawl fisheries (ATGTRT 2007). The bottlenose dolphin TRP aimed to reduce incidental injury and mortality within six months and provided a framework for long-term reduction of dolphin mortality, taking into account the economics of the commercial fishing industry (NMFS 2006b). There is no recovery or management plan for the striped dolphin, as it is not listed as endangered or threatened under the Endangered Species Act and is not subject to high fisheries-related mortality.

Regulations governing activities in SBNMS, situated at the mouth of Massachusetts Bay, provide protection for a portion of the northern habitat range of many species studied in this report. Research at SBNMS has focused on standardized surveys of large whales and tagging programs and multiple monitoring efforts to support spatially-explicit risk assessments of various human-induced threats, including ship strikes, fishing gear entanglement, and shipping noise. This research has supported the rerouting of traffic in Massachusetts Bay to reduce risk of vessel collisions, tools for assessing the impact of noise masking on large whale communication, and support for East-Coast wide regulations on gear types to reduce entanglements. These programs are highly collaborative in nature, involving staff from the sanctuary, NOAA's Northeast Fisheries Science Center and Northeast Regional Office, the United States Coast Guard, as well as academic partners (listed below) and collaborators from private industry in the region (i.e. Marine Acoustics, Inc., ICAN, and Oasis, Inc.).

A variety of government agencies, academic institutions and non-profit organizations are actively involved in cetacean research and/or conservation in the region. Colleges and universities at which there are research programs studying many aspects of cetacean biology, genetics, and distribution include (but are not limited to) Cornell University, Dalhousie University, Duke University, Trent University, University of North Carolina Wilmington, University of Rhode Island, and Woods Hole Oceanographic Institution. Non-profit organizations involved in cetacean research or conservation include the Canadian Whale Institute, Cetacean Society International, Georgia Environmental Policy Institute, Grand Manan Whale and Seabird Research Station, International Fund For Animal Welfare, Marine Mammal Commission, New England Aquarium Right Whale Project, Ocean Conservancy, North Atlantic Right Whale Consortium, Nova Scotia Museum of Natural History, Provincetown Center For Coastal Studies, The Humane Society of the United States, Virginia Aquarium & Marine Science Center, Whale and Dolphin Conservation Society, Whale Center of

New England, World Wildlife Fund Canada, WhaleNet. Other United States and Canadian federal agencies engaged in research and conservation activities include, Fisheries and Oceans Canada/Marine Fish at Division St. Andrews Biological Station, Fisheries and Oceans Canada/Maritimes Species at Risk Office, Florida Fish and Wildlife Conservation Commission/Fish and Wildlife Research Institute, Georgia Department of Natural Resources/Coastal Nongame and Endangered Wildlife Program, and the Office of Naval Research Marine Mammal Program.

Species Accounts

Atlantic White-sided Dolphin *(Lagenorhynchus acutus)*

Atlantic white-sided dolphins, one of the most abundant cetaceans in the Northwest Atlantic (Kenney et al. 1996), are a pelagic species that inhabits Continental Shelf waters. They are most abundant in areas of steepest subsurface topographic relief (Gaskin 1992), and are known to inhabit temperate and sub-polar waters throughout the northern North Atlantic (Cipriano 2002). Within the boundaries of the region, white-sided dolphins are most common in Continental Shelf waters to the 100-m depth contour (CeTAP 1982) from Hudson Canyon (approximately 39°N) to Georges Bank, in the Gulf of Maine, and lower Bay of Fundy. They have also been sighted occasionally in the Gulf of St. Lawrence (Northridge et al. 1997).

Atlantic white-sided dolphins have seasonal distribution patterns in this region. These animals have been sighted in high numbers from Georges Bank to the lower Bay of Fundy from June to September, while an intermediate number of sightings occur from October to December and low sightings occur from January to May. Sightings south of Georges Bank, particularly around Hudson Canyon, occur year round, but at low densities (Payne and Heinemann 1990). This species is sighted in small groups of up to several thousand (superpods) throughout the region, a possible strategy for foraging or cooperative feeding. This species is also known to be associated with fin and humpback whales, since they consume similar prey species (Reeves et al. 2003). Gaskin (1992) suggested a separation between the population in the southern Gulf of Maine and the Gulf of St. Lawrence based on the decrease in sightings during the summer months along the Atlantic coast of Nova Scotia. The life span of Atlantic white-sided dolphins is reported to be up to 22 years for males and 27 years for females. The average adult length is 250 cm for males and 224 cm for females. They are thought to calve every two to three years with a gestation period of 10-12 months (Cipriano 2002). Calving has been estimated to occur from May to August, predominantly in June and July (Sergeant et al. 1980). The species in known for its tendency to mass strand, particularly in the area of Cape Cod Bay (Wiley et al. 2001)

Bottlenose Dolphin *(Tursiops truncatus)*

Bottlenose dolphins utilize a wide variety of coastal, inshore, and pelagic habitats in tropical and temperate waters of the world (Wells and Scott 1999). Bottlenose dolphins have been documented along the entire Western Atlantic coast, and in the eastern Atlantic, including the Azores, the British Isles, the Faroe Islands, the Baltic Sea, and the Mediterranean and Black Seas. Bottlenose dolphin ranges are restricted by temperature, occurring in North American waters of about 10 °C to 32°C; they are rarely seen poleward of 45° in either hemisphere (Wells and Scott 2002). In the Northwest Atlantic region, there are two genetically and morphologically distinct bottlenose dolphin populations, described as the coastal and offshore morphotypes (Duffield 1986).

While the offshore bottlenose dolphin stock occurs in waters beyond the Northwest Atlantic, the offshore stock occurs regionally along the outer Continental Shelf and shelf/slope break (CeTAP 1982; Kenney 1990). This population has been documented in the far northern areas of the region on the Scotian shelf and as far south as coastal areas off Cape Hatteras in the spring and summer (Gowans and Whitehead 1995; NMFS 2008a). The coastal stock, originally thought to one migratory stock, has been proven to be a collection of many complex stocks (NMFS 2001). In this region, the coastal stock is reported to extend from North Carolina to New York and the different groups have been shown to exhibit a variety of patterns, including seasonal residency, year-round residency with large home ranges, and migratory and transient movements (Barco et al. 1999; NMFS 2008a). Coastal dolphins are further defined by their habitat use, where some bottlenose dolphins are seasonal residents in estuarine areas and may be genetically distinct from other coastal migratory stocks. For example, there are several stocks of estuarine bottlenose dolphins that have been identified from North Carolina in the Pamlico Sound (Torres et al. 2005). Seasonally, both northern and southern coastal migratory stocks can be found in the region, with large aggregations of bottlenose dolphins around the Chesapeake Bay mouth during the summer months (Barco et al. 1999). The most northerly resident group has been reported from Cape Cod Bay, but this is atypical (Wiley et al. 1994).

Bottlenose dolphins tend to feed cooperatively and are commonly found exhibiting gregarious behavior while in groups (Caldwell and Caldwell 1972). Female bottlenose dolphins can live more than 50 years and males from 40 to 45 years old (Wells and Scott 1999). Female bottlenose dolphins usually produce calves every three to six years (Wells and Scott 2002). Breeding whales in captivity are over 20 years of age and females can continue to give birth up to 48 years of age (Wells and Scott 2002). Spring and summer or spring and autumn calving peaks are known for most populations (Wells and Scott 2002). Calving occurs after a one-year gestation, peaking in the warmer months. Calves are born at 84-140 cm depending on the region. Calves grow rapidly during their first 1.5-2 years. Females often reach sexual maturity before males (Wells and Scott 2002). Age at sexual maturity is about 5-13 years for females and 9-14 years for males (Wells and Scott 2002).

Fin Whale *(Balaenoptera physalus)*

Fin whales are found in all oceans of the world, but do not range past the ice limit at either pole (Aguilar 2002). The most important habitats identified for fin whales in the north appear to be the Great South Channel, along the 50-m isobath past Cape Cod, over Stellwagen Bank, and past Cape Ann to Jeffreys Ledge (Hain et al. 1992).

The fin whale is the most common large whale from Cape Hatteras northward, accounting for 46% of all large whale sightings and 24% of all cetaceans sighted over the Continental Shelf between Cape Hatteras and Nova Scotia during 1978 - 1982 aerial surveys (CeTAP 1982).

Fin whale movement usually occurs offshore rather than along the coastline which makes it difficult to track migration patterns (Mackintosh 1965; Perry et al. 1999). Consequently, there is little knowledge of the location of winter breeding grounds (Perry et al. 1999).There is some evidence that fin whales migrate to subtropical waters for mating and calving during the winter months and to the colder areas of the Arctic and Antarctic for feeding during the summer months. Some observations suggest site fidelity and seasonal residency by females. Often, the same whales are sighted in the Gulf of Maine year after year (Seipt et al. 1990; Clapham and Seipt 1991; Agler et al. 1993). Fin whales may be solitary or found in pairs, however larger groups may be found near feeding grounds in the region (Gambell 1985).

The fin whale is the second largest animal on Earth (after the blue whale); adult whales are known to range from 20 to 27 m in length and weigh 50 -70 tons. Mature females are approximately 5-10% longer than mature males (Aguilar and Lockyer 1987). Adult males reach sexual maturity at about 5-15 years of age and, as in some other whale species, sexual maturity is reached before physical maturity. Mating occurs in the northern hemisphere from December to February, gestation lasts 11 months, and newly born calves are 6-7m long and weigh about 1-1.5 tons (Aguilar 2002). Calves nurse for six months and are weaned when they are 10-12 m in length. Fin whales grow rapidly after birth and reach 95% of their maximum body size when they are 9-13 years old. Physical maturity is reached at about 25 years of age and fin whales are known to live up to 80-90 years (Aguilar 2002). The reproductive strategy of fin whales is closely integrated and synchronized with their annual feeding cycle; whales mate during the winter and weaning ends the following summer on productive feeding grounds (Laws 1961).

Harbor Porpoise *(Phocoena phocoena)*

Harbor porpoises are found in northern temperate and subarctic coastal waters of the North Atlantic, North Pacific, and Black Sea (Bjorge and Tolley 2002). They are known to prefer shallow inshore waters of the Continental Shelf and are commonly sighted in estuaries, harbors, fjords, and bays. In the Northwest Atlantic, they are known to range from Greenland to Cape Hatteras, North Carolina. Dense aggregations of harbor porpoises appear in the northern Gulf of Maine and Bay of Fundy in waters less than 150 m deep during the summer (Gaskin 1977; Kraus et al. 1983; Palka 1995). In the fall and spring months, they inhabit a more southerly range and are found primarily along the Continental Shelf from New Jersey to Maine from the coastline to over 1800 m in depth (Westgate et al. 1998). There are low numbers of individuals sighted north in Canadian waters and south in the Mid-Atlantic, but the majority of porpoises inhabit the middle range. In the winter, harbor porpoise sightings are predominantly absent from the Gulf of Maine and are sighted in New Jersey to North Carolina and occasionally down to Florida (Read and Westgate 1997). There does not appear to be a coordinated migration of harbor porpoises to the Bay of Fundy area (NOAA 2008d). Harbor porpoises are very difficult to study as they are smaller in size, and spend little time at the surface. Their size typically makes them extremely hard to see from aerial and vessel surveys and therefore their distribution may not be accurately represented here.

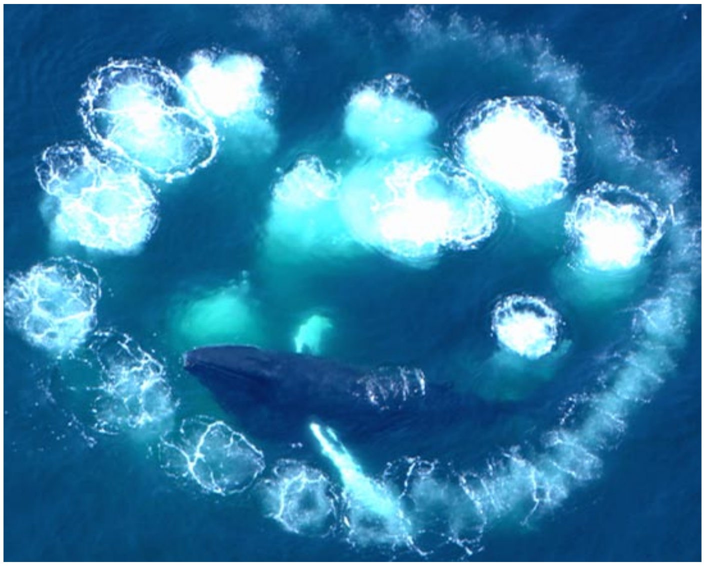
Harbor porpoises are often associated with distributions in prey species. Satellite tagging studies have found harbor porpoises to aggregate around the 92 m isobath and follow underwater ridges and banks where likely sources of prey aggregate during certain seasons (Read and Westgate 1997; Bjorge and Tolley 2002). Harbor porpoises have been shown to feed primarily on Atlantic herring *(Clupea harengus)*, but to also feed on silver *(Merluccius bilinearis)*, red, and white hake (*Urophycis* spp.) (Gannon et al. 1998). They also feed on anchovies and capelin (Read 2002). Calves have been known to feed on euphausiids *(Meganyctiphanes norvegica)* in the Bay of Fundy (Smith and Read 1992).

Adult females are an average of 160 cm in length and about 60 kg while males are usually smaller, growing to an average of 145 cm and 50 kg (Bjorge and Tolley 2002). They are known to live an average of 8-10 years although there have been porpoises known to live to over 20 years of age. Harbor porpoises become sexually mature between 3 and 4 years old and have seasonal patterns of reproduction. There is a defined calving season that varies from region to region but is usually between May and August. Gestation lasts about 10.5 months and calves are weaned after less than a year. Calves are born at 70-75 cm and 5 kg, but grow quickly in their first year and begin to feed on euphausiids after just a few months. In the Atlantic harbor porpoise population, females have calves yearly, but in the Pacific they only calve every other year. Harbor porpoises are not known to be monogamous as they repeatedly mate with several individuals. Once adults, they tend to occur alone or in very small groups (Read 2002).

Humpback Whale *(Megaptera novaeangliae)*

Humpback whales inhabit all major ocean basins from the equator to subpolar latitudes (Clapham 2002). Most humpback whales are known to spend the summer feeding in northern waters and migrate south to low-latitude tropical waters for the winter where they breed and calve. In the North Atlantic Ocean, humpback whales aggregate in several feeding areas: Iceland-Denmark Strait, Norway, western Greenland, Southern Labrador and east of Newfoundland, Gulf of St. Lawrence, and the Gulf of Maine/Nova Scotia region (Katona and Beard 1990; Stevick et al. 2006). Individual humpback whales maintain fidelity to a specific oceanic feeding ground, a preference that is transmitted from mother to offspring (Martin et al. 1984; Clapham and Mayo 1987).

During spring, summer, and fall, humpback whales can be found from the waters off Nantucket north to the Bay of Fundy and east to the edge of the Continental Shelf. In addition, there is documented exchange with the Scotian Shelf (Clapham et al. 2003). Humpback whale distribution across the northern study range depends on physical factors such as bottom depth and slope (CeTAP 1982; Hamazaki 2002) as well as the abundance and distribution of herring and sand lance (Payne et al. 1986; Payne et al. 1990; Weinrich et al. 1997). Previous work has shown significant spatial variation by season, with the greatest concentrations occurring in the spring in the southern Gulf of Maine. There is also significant temporal variation correlated with trends in prey abundance (Payne et al. 1986; Payne et al. 1990; Weinrich et al. 1997). On an individual level, humpback whales are known to return



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preferentially to some areas within their feeding range (Weinrich 1998; Larsen and Hammond 2004; Robbins 2007). However, they also move among available feeding sites within and between years. In the Gulf of Maine, individual humpback whales move most frequently among a few adjacent aggregation sites, but also undertake larger movements that span the region (Robbins 2007). In addition, although all ages and sexes can be found across the feeding range, the southern Gulf of Maine is more frequently used by mature females and juveniles compared to northern Gulf of Maine and Bay of Fundy areas (Robbins 2007).

In the winter months, habitat requirements appear to be tied to calving needs rather than prey resources. Optimal calving conditions are warm waters and shallow, flat ocean bottoms in protected areas and calm seas often close to islands or coral reefs (Clapham 2002). Recent research suggests that a relatively narrow water temperature range (21.1–28.3°C) is more important than latitude per se in the location of oceanic breeding grounds (Rasmussen et al. 2007). The primary breeding range in the North Atlantic is along the Atlantic margin of the Antilles, from Cuba to Venezuela. Calving takes place there between January and March. Individual females produce a calf every 2–3 years on average (Clapham and Mayo 1987; Clapham and Mayo 1990; Robbins 2007); only approximately 2% of observed calving events are in consecutive years (Robbins 2007).

Adult humpback whales are 14-17 m in length and females are 1-1.5 m longer than males (Clapham and Mead 1999). Age at first birth was estimated to average 5 years in the 1980s (Clapham 1992), but has subsequently increased to over 8 years of age (Robbins 2007). Gestation is about 11 months and lactation is about one year (Clapham 1992). Calves are from 3.96 to 4.57 m at birth and 8-10 m after their first year (Clapham 2002). Trends in offspring survival after weaning have been linked to trends in the relative abundance of primary prey (Robbins 2007; Weinrich and Corbelli 2009).

Humpback whales seen sporadically off the Mid-Atlantic states and the southeast United States in winter are a mixed stock of those that summer in the Northwest Atlantic and those from other oceanic feeding grounds (Barco et al. 2002). This is apparently a supplemental feeding area for young whales, but the factors that drive their presence and distribution are poorly understood.

Minke Whale *(Balaenoptera acutorostrata)*

Minke whales are found from the Canadian Arctic in the summer to the Caribbean and the Straits of Gibraltar in the winter (Perrin and Brownell 2002). Because they are difficult to see by aerial and ship surveys, much remains unknown about their true range (Perrin and Brownell 2002).There appears to be a strong seasonal component to minke whale distribution. They are abundant and appear to feed in New England waters in the spring and summer, but may be relatively undercounted, predominantly because of their solitary nature, small body size, inconspicuous blow, and very short surface intervals. They become scarce in New England waters in the fall and during winter the species appears to be largely absent. There is some evidence that they move south into the West Indies and east of Bermuda, but this is speculative (Mitchell 1991).

Like most other baleen whales, minke whales are generally found over the Continental Shelf. This species tends to be solitary or travel in small groups, but larger aggregations may form near abundant prey (Horwood 1990). Minke whales in the north Atlantic are known to live about 50 years and mature adults range from 8.5 to 8.8 m in length for females and 7.8 to 8.2 m in length for males (Horwood 1990; Jefferson et al. 1993). Females mature at 6-8 years of age and calve in intervals of 1 to 2 years, although some females are known to calve annually (Perrin and Brownell 2002). Calves are probably born between October to August, peaking in July and August after 10 to 11 months gestation (IWC 1991; Katona et al. 1993; Perrin and Brownell 2002). Calves are born at 2.4-3.5 m in length and weigh about 318-454 kg (Katona et al. 1993). The calf is weaned after 4-6 months and once the offspring leaves its mother, it often remains solitary for the rest of its life.

North Atlantic Right Whale *(Eubalaena glacialis)*

North Atlantic right whales historically ranged from Florida and northwestern Africa to Labrador, southern Greenland, Iceland, and Norway (see complete review in Kraus and Rolland 2007a). Currently, this species is found in the Northwest Atlantic in Continental Shelf waters between Florida and Nova Scotia (Winn et al. 1986) in six known habitats: the coastal waters of the southeastern United States; the Great South Channel; Georges Bank/Gulf of Maine; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Scotian Shelf (Waring et al. 2008). The southeastern United States, Great South Channel, and Cape Cod Bay are explicitly defined as critical habitat under the Endangered Species Act.

North Atlantic right whales move seasonally (Kraus and Rolland 2007b). In the spring, feeding aggregations of right whales are found in the Gulf of Maine especially around the Great South Channel along the 100-m isobath and in Cape Cod Bay (Kenney and Winn 1986; Kenney et al. 1995). The Bay of Fundy is also a well-known feeding site for right whales during the summer and dense aggregations of whales are found there every year. These feeding grounds are areas where bottom topography, water column structure, currents, and tides combine to physically concentrate zooplankton in high quantities (Wishner et al. 1988; Baumgartner et al. 2003). While on feeding grounds, right whales are often associated with nearshore Continental Shelf areas from 100 to 200 m deep, steeply sloped bottom topography, and areas with distinct frontal zones (Winn et al. 1986). Historical whaling records include accounts of whales taken in areas other than current feeding grounds, indicating that there may have been offshore feeding grounds that are unknown today (Kenney 2002).

During the winter, many mature females move south and are found in coastal waters off the southeastern United States, where they are known to give birth (Winn et al. 1986; Kenney 2002). The geographic location of most of the population, including adult males and juveniles, during the winter months is largely unknown. However, recent passive acoustic monitoring efforts in the SBNMS and Jeffreys Ledge indicate that right whales are predictably present in both areas during the winter months (Mussoline et al. in review).

Right whale calving takes place between December and April in the North Atlantic (Kraus and Rolland 2007b). Calving grounds along the southern United States coast are in cool, shallow coastal regions inshore off Georgia and northeastern Florida (Kraus et al. 1993; Kraus and Rolland 2007b). Although the average age of first calving is nine to ten years, calving has been observed in females as young as five years old (Kenney 2002). Calving occurs at three- to five-year intervals, which may be so that the mother can replenish energy stores lost in long migrations and calving (Kraus et al. 2001; Kenney 2002). Right whale calves are usually born after 12-13 months of gestation at 4.5–6.0 m in length (Best 1994; Kenney 2002). Right whale calves weigh approximately 900 kg at birth, and they grow more than a centimeter every day for the first ten months of their lives. Mothers and calves form a strong bond and the calf spends most of its time swimming close to its mother, often carried in the mother's "slip stream," the wake which develops as the mother swims (Hamilton et al. 1995; Moore et al. 2005). Calves reach 9-11 m in length and are weaned at one year. After year one, growth rates vary depending on the population and feeding success (Kenney 2002). Because of an absence of teeth (which can be used to estimate age in other mammals), it is difficult to tell how old right whales are when they die, but it is estimated that they live up to 70 years and perhaps even older (Kenney 2002).

Sei Whale *(Balaenoptera borealis)*

In the Northwest Atlantic, sei whales are found in temperate waters from Labrador and Newfoundland to the southern Gulf of Maine and New Jersey (CeTAP 1982; Mizroch et al. 1984). This species appears to migrate long distances from high-latitude summer feeding areas to lower latitude winter breeding areas, but the location of these winter areas remains unknown (Horwood 2002). In the Northwest Atlantic, sei whales have been sighted along the eastern Canadian coast in June and July on their way to and from the Gulf of Maine and Georges Bank, where they occur in winter and spring (CeTAP 1982). Peak abundance in the region is in the spring along eastern Georges Bank, into the Northeast Channel, and along the southwest edge of Georges Bank in the area of Hydrographer Canyon (CeTAP 1982). Sighted predominantly in offshore deep waters, they have been known to move sporadically into shallower, inshore waters, including sightings in the Great South Channel in 1987 and 1989 and Stellwagen Bank in 1986 (Payne et al. 1990). In the past five years, sei whales have been sighted more frequently inshore than in previous years likely because of prey availability.

Sei whale distribution is thought to be dependent on prey availability and distribution (Baumgartner and Fratantoni 2008). When copepods are abundant throughout inshore Continental Shelf waters, more whales are found inshore in areas such as in the Great South Channel, on Stellwagen Bank, and inshore in the Gulf of Maine (Payne et al. 1990; Schilling et al. 1992; Horwood 2002). The sei whale is often found in deeper waters of the Continental Shelf edge, often near the 2,000-m contour (Mitchell 1975a; Hain et al. 1985). Sei whale distribution has also been correlated with surface and subsurface fronts, bottom topography, and flow gradients at depths shallower than 100 m (Skov et al. 2008). This species usually feeds on zooplankton in the upper 100 m of the water column, which may explain the positive correlation between whale distribution and flow gradients over steep bottom topography (Genin et al. 1994). Like other baleen species, sei whales are often found in groups when prey items are in high abundances, but are generally seen in smaller groups (Horwood 2002).

Mature adult sei whales range from 12 to 18 m in length, with females being larger than males (Martin 1983). Sexual maturity is reached between the ages of 5 and 15, when males are about 12.2 m and females are 13.1 m (Horwood 2002). Conception is thought to occur during the winter in high latitudes. After a gestation period of about 12 months, females give birth to calves about 4.4 m in length. Calves are weaned 6-9 months after birth at about 9 m in length, and females calve approximately every two to three years (Mizroch et al. 1984).

Sperm Whale *(Physeter macrocephalus)*

Sperm whales have the most extensive geographic distribution of any marine mammal besides the killer whale *(Orcinus orca)*. They are found in all deep, ice-free marine waters from the equator to the edges of polar pack ice (Rice 1989). Sperm whales are also known to be present in some warm-water areas; these might be discrete resident populations (Jaquet et al. 2003; Mellinger et al. 2004). Sperm whales exhibit sex-specific migratory behavior. Only adult males move into high latitudes, while all age classes and both sexes range throughout tropical and temperate seas (Whitehead 2002b). There is some evidence of north-south migration, as whales move towards the poles in the summer months, but in many areas of the world sperm whale migration patterns remain unknown (Whitehead 2002a). Offshore surveys have shown that sperm whales are often solitary and can stay submerged for over 60 minutes at recorded depths of over 2,000 m (Watkins et al. 1993), which makes them difficult to spot by surveyors.

Sperm whale distribution on the East Coast of the United States is centered along the Continental Shelf break and over the Continental Slope from 100 to 2,000 m depth and in submarine canyons and edges of banks (CeTAP 1982; Waring et al. 2008; Mitchell 1975b). Sperm whales are also known to move into waters less than 100 m deep on the southern Scotian Shelf and south of New England, particularly between late spring and autumn (CeTAP 1982; Scott and Sadove 1997). Those areas with historically large numbers of sperm whales and resident populations often coincide with areas of high primary productivity from upwelling (Whitehead 2002b). In addition, sperm whale habitats usually have high levels of deep water biomass. Female sperm whales may be restricted by water temperature, as they have only been sighted in areas with sea surface temperatures greater than 15°C.

Sperm whale life span can be greater than 60 years (Rice 1989). Adult female sperm whales reach up to 11 m in length and 15 tons, while males are much larger at 16 m and 45 tons (Whitehead 2002b). Sperm whales have low birth rates, slow growth and maturation, and high survival rates. Although much about sperm whale breeding is unknown, it is estimated that the peak breeding season in the North Atlantic occurs during spring (March/April to May). Gestation for females is estimated to last 15-18 months and calves average 4 m at birth (Perry et al. 1999). Female sperm whales reach physical maturity at 30 years old and 10.6 m long. Males continue growing into their thirties and do not reach physical maturity until about 50 years old. Males reach sexual maturity at 10-20 years of age, but do not appear to breed until their late twenties (Whitehead 2002b). Female sperm whales are inherently social, and related and unrelated female sperm whales live in groups of up to a dozen individuals accompanied by their male and female offspring (Christal and Whitehead 1997). Males leave the female groups when they are 4-21 years old, after which they live in "bachelor schools" of other juvenile males (Whitehead 2002b). Male sperm whales in these bachelor schools in their late twenties and older are known to rove among groups of females on tropical breeding grounds.

Striped Dolphin *(Stenella coeruleoalba)*

Striped dolphins are found around the world in warm temperate and tropical seas (Archer and Perrin 1999). They appear to prefer Continental Slope waters offshore to the Gulf Stream and have been sighted in dense aggregations along the 1,000-m depth contour in all seasons (CeTAP 1982; Perrin et al. 1994). Off the northeastern coast of the United States, striped dolphins are known to range along the Continental Shelf and out to the shelf slope from Cape Hatteras to the southern edge of Georges Bank (CeTAP 1982). There are also striped dolphins off the coast of the United Kingdom and throughout the Mediterranean Sea (Archer 2002). Striped dolphins are usually uncommon in Canadian waters because of the cold temperatures, but sightings in the Nova Scotia region in the past decade indicate that this species may range farther than previously thought (Gowans and Whitehead 1995).

Striped dolphins are usually found in association with convergence and upwelling zones with high primary productivity. They appear to prefer temperatures of 18-22°C, but are sometimes seen in waters down to 10°C and up to 26°C (Archer 2002). This species mates seasonally and gestation is 12-13 months. Calf length at birth is estimated to be 93-100 cm and sexual maturity is reached at 7-15 years for males and 5-13 years for females and at 2.1-2.2 m for both sexes. Striped dolphins are known to live a maximum of 57.5 years (Archer and Perrin 1999).

Literature Cited

Agler, B. A., R. L. Schooley, S. E. Frohock, S. K. Katona, and I. E. Seipt. 1993. Reproduction of photographically identified fin whales, *Balaenoptera physalus*, from the Gulf of Maine. Journal of Mammology. 74(3): 577-587.

Aguilar, A. 2002. Fin whale *Balaenoptera physalus*. In: W. F. Perrin, B. Würsig, and J. G. M. Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA. pp. 435-438.

Aguilar, A. and C. H. Lockyer. 1987. Growth, physical maturity and mortality of fin whales *Balaenoptera physalus* inhabiting the temperate waters of the northeast Atlantic. Canadian Journal of Zoology. 65(2): 253-264.

Atlantic Trawl Gear Take Reduction Team (ATGTRT). 2007. Atlantic trawl gear take reduction team meeting: Final summary. http://www.nero.noaa.gov/prot_res/atgtrp/meeting/ATGTRT%20Meeting%20Summary%20-%20April%202007%20FINAL.pdf.

Archer, F. I. 2002. Striped dolphin (*Stenella coeruleoalba*). In: Perrin, W. F., B. Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp. 1201-1203.

Archer, F. I., and W. F. Perrin. 1999. *Stenella coeruleoalba*. Mammalian Species. 603: 1-9.

Barco, S. G., W. M. Swingle, W. A. McLellan, R. N. Harris, and D. A. Pabst. 1999. Local abundance and distribution of bottlenose dolphins (*Tursiops truncatus*) in the nearshore waters of Virginia Beach, Virginia. Marine Mammal Science. 15(2): 394-408.

Barco, S. G., W. A. McLellan, J. M. Allen, R. A. Asmutis-Silvia, R. Mallon-Day, E. M. Meagher, D. A. Pabst, J. Robbins, R. E. Seton, W. M. Swingle, M. T. Weinrich, and P. J.
Clapham. 2002. Population identity of humpback whales (*Megaptera novaeangliae*) in the waters of the US mid-Atlantic states. Journal of Cetacean Research Management. 4(2): 135–141.

Baumgartner, M. F., T. V. N. Cole, R. G. Campbell, G. J. Teegarden, and E. G. Durbin. 2003. Associations between North Atlantic right whales and their prey, *Calanus finmarchicus*, over diel and tidal time scales. Marine Ecology Progress Series. 264: 155-166.

Baumgartner, M. F. and D. M. Fratantoni. 2008. Diel periodicity in both sei whale vocalization rates and the vertical migration of their copepod prey observed from ocean gliders. Limnology and Oceanography. 53(5, part 2): 2197–2209.

Best, P. B. 1994. Seasonality of reproduction and the length of gestation in southern right whales *Eubalaena australis*. Journal of Zoology. 232: 175-189.

Bjorge, A. and K. A. Tolley. 2002. Harbor porpoise (*Phocoena phocoena*). In: Perrin, W. F., B.Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp. 549-551.

Bowen, W. D. 1997. Role of marine mammals in aquatic ecosystems. Marine Ecology Progress Series. 158: 267–274.

Caldwell, D. K. and M. C. Caldwell. 1972. The World of the Bottlenose Dolphin. J.B. Lippincott Company. New York, NY. 157 pp.

Campbell-Malone, R., S. G. Barco, P-Y. Daoust, A. R. Knowlton, W. A. McLellan, D. S. Rotstein, M. J. Moore. 2008. Gross and histologic evidence of sharp and blunt trauma in North Atlantic right whales (*Eubalaena glacialis*) killed by vessels. Journal of Zoo Wildlife Medicine. 39(1): 37–55.

CeTAP (Cetacean and Turtle Assessment Program, University of Rhode Island). 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the United States outer continental shelf, final report. Contract #AA551-CT8-48. Bureau of Land Management, Washington, DC. 538 pp.

Christal, J. and H. Whitehead. 1997. Aggregations of mature male sperm whales on the Galápagos Islands breeding ground. Marine Mammal Science. 13: 59-69.

Cipriano, F. 2002. Atlantic White-sided dolphin (*Lagenorhynchus acutus*). In: Perrin, W.F., B.Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. San Diego, CA. pp.49-51.

Clapham, P. J. and C. A. Mayo. 1990. Reproduction of humpback whales (*Megaptera novaeangliae*) observed in the Gulf of Maine. Report to the International Whaling Commission, Special Issue. 12:171-175.

Clapham, P. J. 1992. Age at attainment of sexual maturity in humpback whales, *Megaptera novaeangliae*. Canadian Journal of Zoology. 70: 1470-1472.

Clapham, P. J. 2002. Humpback whales. In: E. D. Perrin, W. F., B.Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp. 589-592.

Clapham, P. J. and C. A. Mayo. 1987. The attainment of sexual maturity in two female humpback whales. Marine Mammal Science. 3(3): 279-283.

Clapham, P. J. and I. E. Seipt. 1991. Resightings of independent fin whales, *Balaenoptera physalus*, on maternal summer ranges. Journal of Mammology. 72: 788-790.

Clapham, P. J. and J. G. Mead. 1999. *Megaptera novaeangliae*. Mammal Species. 604: 1-9.

Clapham, P. J., J. Barlow, M. Bessinger, T. Cole, D. Mattila, R. Pace, D. Palka, J. Robbins, and R. Seton. 2003. Abundance and demographic parameters of humpback whales from the Gulf of Maine, and stock definition relative to the Scotian Shelf. Journal of Cetacean Research and Management. 5: 13-22.

Clark, C. W., D. Gillespie, P. Nowacek, and S. E. Parks. 2007. Listening to Their World: Acoustics for Monitoring and Protecting Right Whales in an Urbanized Ocean. In: Kraus, S. D. and R. M. Rolland RM, eds. The Urban Whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA. pp 333-357.

Clark C. W., W. T. Ellison, B. L. Southall, L. T. Hatch, S. M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395: 210-222.

Department of Navy. 2005. Marine Resource Assessment for the Northeast Operating Areas: Atlantic City, Narragansett Bay, and Boston. Naval Facilities Engineering Command, Atlantic; Norfolk, Virginia. Contract Number N62470-02-D-9997, Task Order 0018. Prepared by Geo-Marine, Inc., Newport News, Virginia.

Dolphin, W. F. 1987. Observations of humpback whale, *Megaptera novaeangliae*, killer whale, *Orcinus orca*, interactions in Alaska: comparison with terrestrial predator-prey relationships. Canadian Field Naturalist. 101(1): 70-75.

Donovan, G. P. 1991. A review of IWC stock boundaries. Report to the International Whaling Commission, Special Issue. 13:39-68.

Duffield, D. A. 1986. Investigation of genetic variability in stocks of the bottlenose dolphin (*Tursiops truncatus*). Final report to the NMFS/SEFSC, Contract No. NA83-GA-00036, 53 pp.

Flinn, R. D., A. W. Trites, and E. J. Gregr. 2002. Diets of fin, sei, and sperm whales in British Columbia: An analysis of commercial whaling records, 1963-1967. Marine Mammal Science. 18(3): 663-679.

Fujiwara, M., and H. Caswell. 2001. Demography of the endangered North Atlantic right whale. Nature. 414: 537–541.

Gannon, D. P., J. E. Craddock, and A. J. Read. 1998. Autumn food habits of harbor porpoises, *Phocoena phocoena*, in the Gulf of Maine. Fisheries Bulletin. 96(3): 428-437.

Gambell, R. 1985. Fin whale, *Balaenoptera physalus* (Linnaeus 1758). In: S. H. Ridgeway and R. Harrison, eds. Handbook of Marine Mammals. Academic Press, London, UK. pp. 171-192.

Gaskin, D. E. 1977. Harbour porpoise, *Phocoena phocoena* (L.), in the western approaches to the Bay of Fundy 1969-75. Report to the International Whaling Commission. 27: 487-492.

Gaskin, D. E. 1992. Status of Atlantic white-sided dolphin, *Lagenorhynchus acutus*, in Canada. Canadian Field Naturalist. 106: 64-72.

Genin, A., C. Greene, L. Haury, P. Wiebe, G. Gal, S. Kaartvedt, E. Meir, C. Fey, and J. Dawson. 1994. Zooplankton patch dynamics: daily gap formation over abrupt topography. Deep Sea Research. 41: 941-951.

Geraci, J. R., D. M. Anderson, R. J. Timperi, D. J. St. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Canadian Journal of Fisheries and Aquatic Sciences. 46: 1895-1898.

Gowans, S. and H. Whitehead. 1995. Distribution and habitat partitioning by small odontocetes in the Gully, a submarine canyon on the Scotian Shelf. Canadian Journal of Zoology. 73: 1599-1608.

Hain, J. H. W., M. A. M. Hyman, R. D. Kenney, and H. E. Winn. 1985. The role of cetaceans in the shelf-edge region of the United States. Marine Fish Review. 47(1): 13-17.

Hain, J. H., M. J. Ratnaswamy, R. D. Kenney, and H. E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northwestern United States continental shelf. Report to the International Whaling Commission. 42: 653-669.

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, USA to Nova Scotia, Canada). Marine Mammal Science. 18(4): 920-939.

Hancock, D. 1965. Killer whales kill and eat a minke whale. Journal of Mammalogy. 46(2): 341-342.

Hatch, L. T., C. W. Clark, R. Merrick, S. M. Van Parijs, D. Ponirakis, K. Schwehr, M. Thompson, and D. Wiley. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management. 42: 735–752.

Hatch L. T. and K. M. Fristrup. 2009. No barrier at the boundaries: implementing regional frameworks for noise management in protected natural areas. Marine Ecology Progress Series. 395: 223-244.

Hatch, L.T., C. W. Clark, R. Merrick, S. M. Van Parijs, D. Ponirakis, K. Schwehr, M. Thompson, and D. Wiley. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management. 42:735–752.

Haug, T., H. Gjøsæter, U. Lindstrøm, and K. Nilssen. 1995. Diet and food availability for northeast Atlantic minke whales (*Balaenoptera acutorostrata*) during the summer of 1992. ICES Journal of Marine Science. 52: 77-86.

Heithaus, M. 2001. Predator-prey and competitive interactions between sharks (order Selachii) and dolphins (suborder Odontoceti): a review. Journal of Zoology. 253(1): 53-68.

Horwood, J. 1990. Biology and Exploitation of the Minke Whale. CRC Press, Boca Raton, FL.

Horwood, J. W. 2002. Sei Whale (*Balaenoptera borealis*). In: Perrin, W. F., B.Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp.1069-1071.

IWC (International Whaling Commission). 1991. Appendix 11. Biological parameters of North Atlantic minke whales in Annex F Report of the sub-committee on North Atlantic minke whales. Report to the International Whaling Commission. 41:160.

IUCN (International Union of Concerned Scientists). 2008. IUCN Red List of Threatened Species. http://www.iucnredlist.org. Accessed 6/28/08.

Jaquet, N., D. Gendron, and A. Coakes. 2003. Sperm whales in the Gulf of California: Residency, movements, behavior, and the possible influence of variation in food supply. Marine Mammal Science. 19(3): 545-562.

Jefferson, T. A., S. Leatherwood, and M. A. Webber. 1993. FAO Species identification guide. Marine mammals of the world. United Nations Environment Programme/Food and Agriculture Organization. Rome, Italy. 320 pp.

Jensen, A. and G. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-F/OPR-25, 37 pp.

Johnson, A., G. Salvador, J. Kenney, J. Robbins, S. D. Kraus, S. Landry, and P. Clapham. 2005. Fishing gear involved in entanglements of right and humpback whales. Marine Mammal Science. 21(4): 635-645.

Jonsgård, Å. 1966. Biology of the North Atlantic fin whale *Balaenoplera physalus* (L.) Taxonomy, distribution, migration, and food. Hvalradets Skr. 49: 1-62.

Katona, S. K. and J. A. Beard. 1990. Population size, migrations, and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Report to the International Whaling Commission, Special Issue. 12:295-306.

Katona, S. and H. Whitehead. 1988. Are Cetacea ecologically important? Oceanography And Marine Biology: An Annual Review. 26: 553-568.

Katona, S. K., V. Rough, and D. T. Richardson. 1993. A field guide to whales, porpoises, and seals from Cape Cod to Newfoundland. Smithsonian Institution Press, Washington D.C. 316 pp.

Katona, S. K., S. A. Testeverandde, and B. Barr. 1978. Observations on a white-sided dolphin, *Lagenorhynchus acutus*, probably killed in gill nets in the Gulf of Maine. Fishery Bulletin. 76: 475-476.

Kawamura, A. 1982. Food habits and prey distributions of three rorqual species in the North Pacific Ocean. Scientific Report to the Whale Research Institute. Tokyo, Japan. 34:59-91.

Kenney, R. D., M. A. M. Hyman, and H. E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States outer continental shelf. NOAA Tech. Memo. NMFS-F/NEC-41, National Marine Fisheries Service, Woods Hole, MA. 39 pp.

Kenney, R. W. and Winn, H. E. 1986. Cetacean high-use habitats of the northeast United States continental shelf. Fishery Bulletin. 84: 345-357.

Kenney, R. D. 1990. Bottlenose dolphins off the northeastern United States. In: S. Leatherwood and R. R. Reeves, eds. The bottlenose dolphin. Academic Press, Inc. San Diego, California.

Kenney, R. D., H. E. Winn, and M. C. Macaulay. 1995. Cetaceans in the Great South Channel, 1979–1989: right whale (*Eubalaena glacialis*). Continental Shelf Research. 15(4-5): 385-414.

Kenney, R. D., P. M. Payne, D. W. Heinemann, and H. E. Winn. 1996. Shifts in Northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. In: K. Sherman, N.A. Jaworski and T. Smayda, eds. The northeast shelf ecosystem: assessment, sustainability, and management. Blackwell Science, Cambridge, MA. pp. 169-196.

Kenney, R. D. 2002. North Atlantic, North Pacific, and southern right whales (*Eubalaena glacialis*, *E. japonica*, and *E. australis*). In: Perrin, W. F., B.Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp. 806-813.

Ketten, D. R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. In R. A. Kastelein, J. A. Thomas, and P. E. Natchigall, eds. Sensory systems of aquatic mammals, De Spil Publ., Woerden, Netherlands. pp. 391-407.

Knowlton, A. R., M. K. Marx, H. M. Pettis, P. K. Hamilton, and S. D. Kraus. 2005. Analysis of scarring on North Atlantic right whales (*Eubalaena glacialis*): Monitoring rates of entanglement interaction: 1980 - 2002. Report No. Contract #43EANF030107.

Kraus, S. D., J. H. Prescott, and G. S. Stone. 1983. Harbor porpoise, *Phocoena phocoena*, in the United States coastal waters of the Gulf of Maine: A survey to determine seasonal distribution and abundance. National Marine Fisheries Service, Woods Hole, MA. 15 pp.

Kraus, S. D., M. J. Crone, and A. R. Knowlton. 1988. The North Atlantic right whale. In: Audubon Wildlife Report 1988/1989. W. J. Chandler, ed. New York: Academic Press.

Kraus, S. D., R. D. Kenney, A. R. Knowlton, and J. N. Ciano. 1993. Endangered right whales of the southwestern North Atlantic. Final report, Minerals Management Service Contract No. 14-35-0001-30486. Edgerton Research Laboratory, New England Aquarium, Boston, MA.

Kraus, S. D., P. K. Hamilton, R. D. Kenney, A. Knowlton and C. K. Slay. 2001. Reproductive parameters of the North Atlantic right whale. Journal of Cetacean Research and Management, Special Issue. 2: 231-236.

Kraus, S. D., Brown, M. W., Caswell, H., Clark, C. W., Fujiwara, M., Hamilton, P. K., Kenney, R. D, A. R. Knowlton, S. Landry, C. A. Mayo, W. A. McLellan, M. J. Moore, D. P. Nowacek, D. A. Pabst, A. J. Read, and R. M. Rolland. 2005. North Atlantic right whales in crisis. Science. 309: 561–562.

Kraus S. D. and R. M. Rolland, eds. 2007a. The Urban Whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA.

Kraus, S. D. and R. M. Rolland. 2007b. Right whales in the Urban Ocean. In: Kraus, S. D. and R. M. Rolland, eds. The Urban Whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA. pp. 1-38.

Large Whale Take Reduction Team (LWTRT). 1997. Draft large whale take reduction plan. Submitted to National Marine Fisheries Service. http://www.nero.noaa.gov/whaletrp/plan/1997%20Draft%20ALWTRP.pdf.

Larsen, F. and P. S. Hammond. 2004. Distribution and abundance of West Greenland humpback whales (*Megaptera novaeangliae*). Journal of Zoology. 263: 343-358.

Laws, R. M. 1961. Reproduction, growth, and age of southern fin whales. Discovery Reports. 31: 327-486.

Mackintosh, N. A. 1965. The stocks of whales. Fishing News (Books) Ltd., London, UK. 232 pp.

Macleod, K., R. Fairbairns, A. Gill, B. Fairbairns, J. Gordon, C. Blair-Myers, and E. C. M. Parsons. 2004. Seasonal distribution of minke whales *Balaenoptera acutorostrata* in relation to physiography and prey off the Isle of Mull, Scotland. Marine Ecology Progress Series. 277: 263-274.

Martin, A. R. 1983. The sei whale off western Iceland. I. Size, distribution and abundance. Report to the International Whaling Commission. 33: 457-463.

Martin, A. R., S. K. Katona, D. Mattila, D. Hembree, and T. D. Waters. 1984. Migration of humpback whales between the Caribbean and Iceland. Journal of Mammalogy. 65:330-333.

Mellinger, D. K., K. M. Stafford, and C. G. Fox. 2004. Seasonal occurrence of sperm whales (*Physeter macrocephalus*) sounds in the Gulf of Alaska, 1999-2001. Marine Mammal Science. 20: 48-62.

Mitchell, E. 1975a. Preliminary report on Nova Scotia fishery for sei whales (*Balaenoptera borealis*). Report to the International Whaling Commission. 25: 218-225.

Mitchell, E. 1975b. Preliminary report on Nova Scotian fishery for sperm whales (*Physeter catodon*). Report to the International Whaling Commission. 25: 226-235.

Mitchell, E. 1975c. Trophic relationships and competition for food in Northwest Atlantic whales. Proceedings of the Canadian Society of Zoology Annual Meeting. 1974: 123-133.

Mitchell, E., V. M. Kozicki, and R. R. Reeves. 1986. Sightings of right whales, *Eubalaena glacialis*, on the Scotian Shelf, 1966-1972. Report to the International Whaling Commission, Special Issue. 10: 83-107.

Mitchell, E. D. 1991. Winter records of the minke whale (*Balaenoptera acutorostrata* Lacepede 1804) in the southern North Atlantic. Report to the International Whaling Commission. 41: 455-457.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984. The sei whale, *Balaenoptera borealis*. Marine Fish Review. 46(4): 25-29.

Mussoline, S. E., C. W. Clark, P. J. Corkeron, R. Dickey, L. T. Hatch, J. Keiran, R. Merrick, A. Rhoads, D. Risch, M. Thompson, M. Weinrich, F. Wenzel, D. Wiley, and S. M. Van Parijs. In review. Seasonal and spatial patterns of North Atlantic right whale upcalling behavior in the northwest Atlantic: implications for management and conservation.

NMFS (National Marine Fisheries Service). 1991. Recovery Plan for the Humpback Whale (*Megaptera novaeangliae*). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service. Silver Spring, Maryland.

NMFS (National Marine Fisheries Service). 1994. Designated critical habitat; northern right whale. Final rule. Federal Register. http://www.nmfs.noaa.gov/pr/pdfs/fr/fr59-28805.pdf. Accessed 06/24/08.

NMFS (National Marine Fisheries Service). 2001. Stock structure of coastal bottlenose dolphins along the Atlantic coast of the US. NMFS/SEFSC Report prepared for the Bottlenose Dolphin Take Reduction Team.

NMFS (National Marine Fisheries Service). 2005. Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*). National Marine Fisheries Service, Silver Spring, Maryland.

NMFS (National Marine Fisheries Service). 2006a. Draft Management Plan for the Fin Whale (*Balaenoptera physalus*). Silver Spring, Maryland.
http://www.nmfs.noaa.gov/pr/pdfs/recovery/draft_finwhale.pdf. Accessed June 27, 2008.

NMFS (National Marine Fisheries Service). 2006b. Taking of marine mammals incidental to commercial fishing operations; Bottlenose Dolphin Take Reduction Plan Regulations; Sea turtle conservation; Restrictions to fishing activities. Federal Register. Silver Spring, Maryland.

NMFS (National Marine Fisheries Service). 2006c. Draft recovery plan for the sperm whale (*Physeter macrocephalus*). Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/recovery/draft_spermwhale.pdf. Accessed 6/27/2008

NMFS (National Marine Fisheries Service). 2007b. Large Whale Entanglement and Ship Strike Report. National Marine Fisheries Service, Protected Resources Division, Gloucester, Massachusetts.

NOAA (National Oceanic and Atmospheric Administration). 2007b . The Marine Mammal Protection Act of 1972 As Amended. Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/laws/mmpa.pdf . Accessed June 27, 2008.

NOAA (National Oceanic and Atmospheric Administration). 2008a. Bottlenose Dolphin (*Tursiops truncatus*): Western North Atlantic Offshore Stock. Silver Spring, Maryland.http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2008dobn-wnos.pdf. Accessed November 15, 2009.

NOAA (National Oceanic and Atmospheric Administration). 2008b. Bottlenose Dolphin (*Tursiops truncatus*): Western North Atlantic Coastal Morphotype Stocks. Silver Spring, Maryland.
http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2008dobn-wnco.pdf. Accessed November 15, 2009.

NOAA (National Oceanic and Atmospheric Administration). 2008c. Sei Whale (Balaenoptera Borealis): Nova Scotia Stock. Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2008whse-ns.pdf. Accessed November 23, 2009.

NOAA (National Oceanic and Atmospheric Administration). 2008d. Harbor Porpoise (Phocoena phocoena): Gulf of Maine/Bay of Fundy Stock. Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2008poha-gmeb.pdf. Accessed November 20, 2009.

Naud, M-J, B. Long, J-C. Brethes, and R. Sears. 2003. Influences of underwater bottom topography and geomorphology on minke whale (*Balaenoptera acutorostrata*) distribution in the Mingan Islands (Canada). Journal of the Marine Biology Association of the UK. 83: 889-896.

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. Scientific Reports of the Whales Research Institute, Tokyo 14:149-290.

North Atlantic Right Whale Consortium. 2009. 01 November 2007 – 30 April 2009. North Atlantic Right Whale Consortium, New England Aquarium, Boston, MA.

Northridge, S., M. Tasker, A. Webb, K. Camphuysen, and M. Leopold. 1997. White-beaked *Lagenorhynchus albirostris* and Atlantic white-sided dolphin *L. acutus* distributions in northwest European and United States North Atlantic waters. Report to the International Whaling Commission. 47: 797-805.

Nowacek, D., M. P. Johnson, and P. L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London. B 271: 227-231.

NRC (National Research Council of the US National Academies). 2003. Ocean noise and marine mammals. National Academy Press, Washington, DC.

NRC (National Research Council of the US National Academies). 2005. Marine mammal populations and ocean noise: determining when ocean noise causes biologically significant effects. National Academy Press, Washington, DC.

Palka, D. 1995. Influences on spatial patterns of Gulf of Maine harbor porpoises. In: A.S. Blix, L. Walle and . Ulltang, eds. Whales, seals, fish and man. Elsevier Science B.V., Netherlands. pp. 69-75.

Parks, S. E. and C. W. Clark. 2007. Acoustic Communication: Social Sounds and the Potential Impact of Noise. In: Kraus, S. D. and R. M. Rolland, eds. The Urban Whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA, pp. 310-332.

Payne, M. and D. W. Heinemann. 1990. A distributional assessment of cetaceans in the shelf and shelf edge waters of the northeastern United States based on aerial and shipboard surveys, 1978-1988. National Marine Fisheries Service, Woods Hole, MA. 108 pp.

Payne, P. M., J. R. Nicholas, L. O'Brien, and K. D. Powers. 1986. The distribution of the humpback whale, *Megaptera novaeangliae*, on Georges Bank and in the Gulf of Maine in relation to changes in selected prey. Fisheries Bulletin. 84: 271-277.

Payne, P. M., D. N. Wiley, S. B. Young, S. Pittman, P. J. Clapham, and J. W. Jossi. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fisheries Bulletin. 88: 687-696.

Perrin, W. F., C. E. Wilson and F. I. Archer II. 1994. In: S. H. Ridgway and R. Harrison, eds., Handbook of Marine Mammals, Volume 5: The first book of dolphins, Academic Press, London. pp. 129-159.

Perrin, W. F., and R. L. Brownell. 2002. Minke whales (*Balaenoptera acutorostrata* and *B. bonaerensis*) In: Perrin, W.F., B.Wursig, and J. G. M. Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press, London. pp. 750-754.

Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999. The great whales: History and status of six species listed as endangered under the United States Endangered Species Act of 1973. Marine Fisheries Review. 61:1-74.

Pitman, R. L., L. T. Ballance, S. I. Mesnick, and S. J. Chivers. 2001. Killer whale predation on sperm whales: Observations and implications. Marine Mammal Science. 17(3): 494-507.

Rasmussen, K., D. M. Palacios, J. Calambokidis, M. T. Saborio, L. Dalla Rosa, E. R. Secchi, G. H. Steiger, J. M. Allen, and G. S. Stone. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. Biology Letters. 3: 302-305.

Read, A. 2002. Porpoises, overview. In: Perrin, W.F., B.Wursig, and J. G. M. Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp. 982-983.

Read, A. J. and A. J. Westgate. 1997. Monitoring the movements of harbour porpoises (*Phocoena phocoena*) with satellite telemetry. Marine Biology. 130: 315-22.

Reeves, R. R., B. D. Smith, E. A. Crespo, and G. Notarbartolo di Sciara. 2003. Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Rice, D. W. 1989. Sperm whale *Physeter macrocephalus.* In: S. H. Ridgway and R. Harrison, eds. Handbook of Marine Mammals, Volume 4: The First Book of Dolphins, Academic Press, London. pp. 177-233.

Richardson, W. J., C. R. Greene, C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Elsevier, New York, NY. 576 pp.

Robbins, J., and D.K. Mattila. 2004. Estimating humpback whale (*Megaptera novaeangliae*) entanglement rates on the basis of scar evidence. Report to the National Marine Fisheries Service. Order number 43ENNF030121.

Robbins, J. 2007. Structure and dynamics of the Gulf of Maine humpback whale population. Ph.D., University of St. Andrews.

Rolland, R. M., K. E. Hunt, G. J. Doucette, L. G. Rickard, and S. K. Wasser. 2007. The Inner Whale: Hormones, Biotoxins, and Parasites. In: Kraus, S.D. and R. M. Rolland, eds. The Urban Whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA. pp 232-266.

SBNMS (Stellwagen Bank National Marine Sanctuary). 2009. Science: Shifting the Boston Traffic Separation Scheme (TSS). http://stellwagen.noaa.gov/science/tss.html. Accessed November 13, 2009.

Scheifele, P. M. and M. Darre. 2005. Noise levels and sources in the Stellwagen Bank National Marine Sanctuary and the St. Lawrence River Estuary. Marine Conservation Series MSD-05-1. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Marine Sanctuaries Division, Silver Spring, MD. 26pp.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg, and P. J. Clapham. 1992. Behavior of individually-identified sei whales Balaenoptera borealis during an episodic influx into the southern Gulf of Maine in 1986. Fishery Bulletin. 90: 749–755.

Scott, T. M., and S. S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science. 13: 317-321.

Seipt, I. E., P. J. Clapham, C. A. Mayo, and M. P. Hawvermale. 1990. Population characteristics of individually identified fin whales, *Balaenoptera physalus*, in Massachusetts Bay. Fishery Bulletin. 88: 271-278.

Sergeant, D. E., D. J. St. Aubin, and J. R. Geraci. 1980. Life history and Northwest Atlantic status of the Atlantic white-sided dolphin, *Lagenorhynchus acutus*. Cetology. 37: 1-12.

Shoop, C. R., and R. D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetology Monographs. 6: 43-57.

Skov, H., T. Gunnlaugsson, W. P. Budgell, J. Horne, L. Nottestad, E. Olsen, H. Soiland, G. Vikingsson, and G. Waring. 2008. Small-scale spatial variability of sperm and sei whales in relation to oceanographic and topographic features along the Mid-Atlantic Ridge. Deep Sea Research II. 55(1-2): 254-268.

Smith, R. J., and A. J. Read. 1992. Consumption of euphausiids by harbor porpoise (*Phocoena phocoena*) calves in the Bay of Fundy. Canadian Journal of Zoology. 70: 1629-1632.

Smith, S. and H. Whitehead. 2000. The diet of Galapagos sperm whales *Physeter macrocephalus* as indicated by fecal sample analysis. Marine Mammal Science 16(2): 315-325.

Stevick, P. T., J. Allen, P. J. Clapham, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, R. Sears, J. Sigurjønsson, T. D. Smith, G. Vikingsson, N. Øien, and P. S. Hammond. 2006. Population spatial structuring on the feeding grounds in North Atlantic humpback whales. Journal of Zoology. 270:244-255.

Southall, B. L., A. E. Bowles, W. E. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammology. 33: 411-521.

Swingle, W. M., S. G. Barco, and T. D. Pitchford. 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3): 309-315.

Torres, L. G., W. A. McLellan, E. Meagher, and D. A. Pabst. 2005. Seasonal distribution and relative abundance of bottlenose dolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast. Journal of Cetacean Research and Management. 7(2): 153–161.

Waring, G. T., E. Josephson, C. P. Fairfield-Walsh, and K. Maze-Foley, eds. 2008. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2007. NOAA Tech. Memo. NMFS-NE-205. National Marine Fisheries Service, Woods Hole, MA. 423 pp.

Watkins, W. A. , M. A. Paker, K. M. Fristrup, T. J. Howald, and G. Notarbartolo Di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Marine Mammal Science. 9(1):55-67.

Watkins, W. A., and W. E. Schevill. 1975. Sperm whales (*Physeter catodon*) react to pingers. Deep Sea Research. 22: 123-129.

Watkins, W. A., K. E. Moore, and P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Weinrich, M. T., M. Martin, R. Griffiths, J. Bove, and M. Schilling. 1997. A shift in distribution of humpback whales, *Megaptera novaeangliae,* in response to prey in the southern Gulf of Maine. Fishery Bulletin. 95: 826-836.

Weinrich, M. T. 1998. Early experience in habitat choice by humpback whales *Megaptera novaeangliae*. Journal of Mammalogy. 79: 163-170.

Weinrich, M., 1999. Behavior of a humpback whale (*Mepagptera novaeangliae*) upon entanglement in a gill net. Marine Mammal Science. 15: 559-563.

Weinrich, M., and C. Corbelli. 2009. Does whale watching in Southern New England impact humpback whale (*Megaptera novaeangliae*) calf production or calf survival? Biological Conservation. 142:2931-2940.

Wells, R. S. and M. D. Scott. 2002. Bottlenose dolphins. In: Perrin, W. F., B. Würsig, and J. G. M. Thewissen, eds. Encyclopedia of marine mammals. Academic Press, San Diego, CA. pp.122-128.

Wells, R. S. and M. D. Scott. 1999. Bottlenose dolphin - *Tursiops truncatus* (Montagu, 1821) In: Handbook of Marine Mammals. Ridgway, S. H. and S. R. Harrison, Vol. 6: The second book of dolphins and porpoises. pp. 137 – 182.

Westgate, A. J., A. J. Read, T. M. Cox, T. D. Schofield, B. R. Whitaker, and K. E. Anderson. 1998. Monitoring a rehabilitated harbor porpoise using satellite telemetry. Marine Mammal Science. 14(3): 599-604.

Whitehead, H. 2002a. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series. 242: 295-304.

Whitehead, H. 2002b. Sperm whales (*Physester catodon*). In: Perrin, W.F., B.Wursig, and J. G. M Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press. pp.1165-1172.

Wiley, D. N., G. Early, C. A. Mayo, and M. J. Moore. 2001. The rescue and release of mass stranded cetaceans from beaches on Cape Cod, MA: A review of some response actions. Aquatic Mammals. 27(2): 162-171.

Wiley, D. N., F. W. Wenzel and S. B. Young. 1994. Extralimital residency of bottlenose dolphins in the western North Atlantic. Marine Mammal Science 10(2): 223-226.

Wiley, D. N., J. C. Moller and K. Zilinskas. 2003. The distribution and density of commercial fisheries and baleen whales within the Stellwagen Bank National Marine Sanctuary: July 2001-June 2002. Marine Technology Society Journal. 37(1): 35-53.

Wiley, D. N., J. C. Moller, R. M. Pace, and C. Carleson. 2008. Effectiveness of Voluntary Conservation Agreements: Case Study of Endangered Whales and Commercial Whale-Watching. Conservation Biology. 22(2): 450-457

Winn, H. E., C. A. Price and P. W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Report to the International Whaling Commission, Special Issue 10:129-138.

Wishner, K., E. D. Durbin, A. Durbin, M. Macaulay, H. Winn, and R. Kenney. 1988. Copepod patches and right whales in the Great South Channel off New England. Bulletin of Marine Science. 43(3): 825-844.

CHAPTER

11

Sea Turtle

Adam Whelchel and Melissa Clark

Introduction

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Sea turtles are an important component of the north Atlantic ecosystem because they are highly migratory, long-lived, slow growing, and utilize a diverse array of oceanic, neritic, and terrestrial ecosystems. For these very reasons, sea turtles present a unique conservation challenge. While they have been the focus of a multitude of international treaties, conventions, national laws, and regulatory protection, there is still a clear need for greater understanding of temporal and spatial distribution and migratory patterns, degree and importance of threat sources on various life stages, and ongoing population trend analyses via international monitoring and research efforts. Three sea turtle species were chosen for inclusion in this analysis.

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Selection of Target Species

The three species of sea turtle selected for the assessment are currently found within the Northwest Atlantic region:

- Green sea turtle *(Chelonia mydas)*
- Leatherback *(Dermochelys coriacea)*
- Loggerhead *(Caretta caretta)*

The Kemp's ridley turtle *(Lepidochelys kempii)* is the fourth species of turtle found in the region. Currently, there is not adequate information on the distribution of this species in the region to include it in this report.

Population Status and the Importance of Northwest Atlantic region

In the United States, all three target species are federally listed as endangered or threatened species. Loggerhead turtles are considered threatened throughout their range; green sea turtles are listed as endangered in Florida and the Pacific Coast of Mexico and threatened for all other populations; leatherback turtles are listed as endangered throughout their range. According to the International Union for Conservation of Nature (IUCN) Red List (2007a, b, c), both the loggerhead and green turtles are categorized as "Endangered" while the leatherback is considered "Critically Endangered." These species are protected against international trade (CITES 1979).

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Variable and/or sporadic survey efforts coupled with species specific sources of variation (e.g., remigration intervals and clutch frequency) have precluded a comprehensive global population abundance and trend analysis over long periods for these species. For the loggerhead, the two primary global nesting aggregations with greater than 10,000 nesting females per year are South Florida (United States) and Masirah (Oman, Arabian Sea) (Baldwin et al. 2003; NMFS USFWS 2008). Over the past decade, estimates for United States nesting aggregations have fluctuated between 47,000 and 90,000 nests per year, with 80% of nesting occurring in eastern Florida (NMFS USFWS 2008). Over an 18 year period, the total number of nests in Florida has declined by 28% with a more pronounced decline of 43% since 1998. Declining population trends have also been reported over the past decade for nesting aggregations outside Florida including the southeastern United States, the Bahamas, and Mexico (NMFS USFWS 2008). For the green turtle, the mean annual number of nesting females has declined by approximately 48% (173,429 to 90,403 individuals) to 67% (266,133 to 88,499 individuals) over the last three generations across 32 globally distributed subpopulations (IUCN Marine Turtle Specialist Group 2004). Despite the global decline of green turtles over the past 150 years, all but one of the subpopulation index sites (Venezuela, Aves Island) in the IUCN's Western Atlantic Ocean and Caribbean Region witnessed percentage increases including the United States (Florida). This IUCN region represents approximately 30% of the overall global population of nesting females. For the leatherback, population decreases and collapse have been documented in major nesting areas globally. A recent assessment puts the current adult population in the North Atlantic between 34,000 and 94,000 adult females (Turtle Expert Working Group 2007). For seven Atlantic Ocean populations with a minimum of 10 years of nesting data, populations appear to be stable or increasing with the exception of West Africa and Western Caribbean (Turtle Expert Working Group 2007). Standardized nest counts suggest that the Florida population has increased from 98 nests (1989) to 900 nests per season (2006).

In the Northwest Atlantic, the most comprehensive study of the distribution of loggerhead and leatherback turtles was completed by Shoop and Kenney (1992). Based on three years of aerial and shipboard surveys, they estimated that the total summer population of loggerhead was between 2,200 and 11,000 individuals and the leatherback population was between 100 and 900 individuals (Shoop and Kenney 1992).

Ecosystem Interactions and Ecological Dependencies

Sea turtle diet varies by species, life stage and habitat zone (i.e., oceanic, neritic (< 200m)). During the loggerhead's post-hatchling transition stage, individuals forage on organisms associated with floating material such as *Sargassum* including hydroids and copepods (Witherington 2002). During the oceanic stage, juveniles typically consume coelenterates and salps (Bjorndal 1997, 2003). As juveniles transition from oceanic to neritic habitats, diets become more diverse and shift according to season and geographic position. In the North Atlantic, neritic stage adults forage primarily on mollusks and benthic crabs. The diet of oceanic stage adults is currently unknown (NMFS USFWS 2008).

Information regarding green turtle ecosystem interactions during the juvenile oceanic stage is largely unknown. Upon recruitment back to coastal areas, neritic juveniles subsist primarily on sea grasses and marine algae (NMFS USFWS 2007a). The availability of food items within coastal foraging areas may vary seasonally and interannually. The diet of migratory oceanic adults is currently unknown.

Leatherbacks forage primarily on pelagic gelatinous organisms including jellyfish (medusae), siphonophores, and salps in temperate and boreal latitudes (NMFS USFWS 1992, 2007b). Surface feeding is the most commonly observed foraging habit for leatherbacks, but dive data indicate that they may forage throughout the water column.

The ecological significance of these species within both the neritic and oceanic zones during juvenile and adult life stages may be relatively limited due to current population sizes in the Northwest Atlantic. As populations of these long-lived, slow growing species recover, their importance and potential habitat modification ability (e.g., bioturbation, infaunal mining) may become more apparent particularly for loggerhead and green turtles within coastal estuaries of the Northwest Atlantic (Bjorndal 2003). The large migrations undertaken by leatherback turtles across geographically disparate habitats may further limit this species' ecological influence; however, this species' highly specialized diet may help regulate population levels of preferred prey items in certain coastal and shelf habitats within the region.

Northwest Atlantic Distribution and Important Areas

Methods

Geospatial data for turtles were obtained from the United States Navy's Marine Resource Assessments, primarily collected via aerial and shipboard surveys during daylight hours, weather permitting. Data used were from the Navy's Northeast Marine Resource Assessment study region, which covers the entire region except for the mouth of the Chesapeake Bay west of 75.67°W longitude. This gap was filled with data from the Navy's Southeast Marine Resource Assessment study region, shown in pink in Figure 1. The seasons used in the Northeast were winter: January – March; spring: April – June; summer: July – September; and fall: October - December. The dates used in the Southeast were winter: December 6 - April 5; spring: April 6 - July 13; summer: July 14 - September 16; and fall: September 17 - December 5. Therefore, data for each study were processed independently, but displayed together on the map.

A standard approach to overcoming potential survey bias introduced by uneven effort (actual sightings or artifact of enhanced survey effort) is by using effort-corrected sightings data (Kenney and Winn 1986; Shoop and Kenney

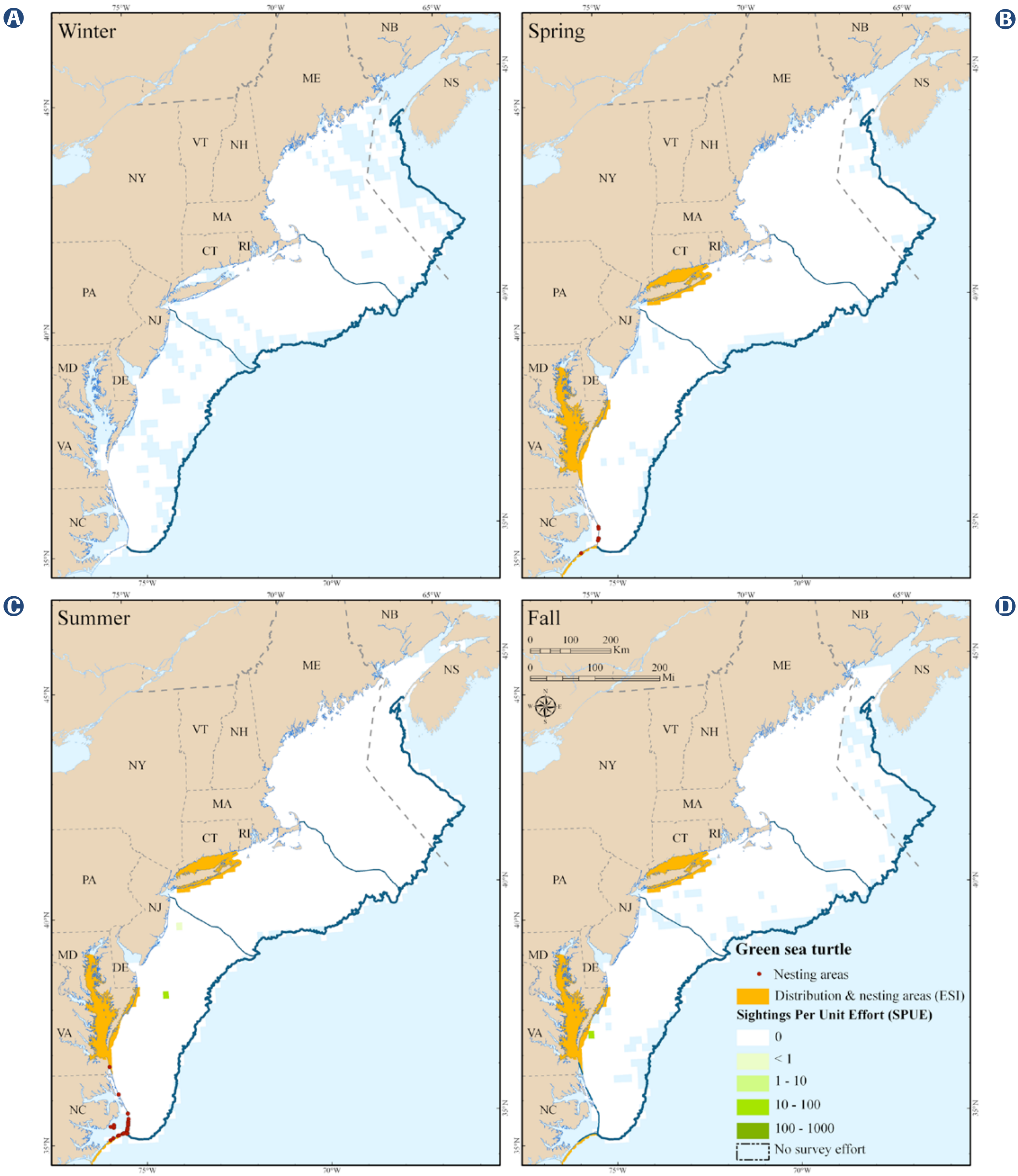

Figure 11-1. Green sea turtle sightings per unit effort (SPUE) and nesting locations by season.

1992). Calculating sightings per unit effort (SPUE) allowed for comparing data spatially and temporally within a study area (Shoop and Kenney 1992). SPUE is calculated as:

$$SPUE = 1000*(\text{number of animals sighted})/\text{effort}$$

Data obtained from the Navy included point shapefiles of valid sightings for all turtle species and pre-calculated effort grids for each season. The original sightings data were taken from National Marine Fisheries Service and Northeast Fisheries Science Center (NMFS-NEFSC) aerial surveys, NMFS-NEFSC shipboard surveys, and the North Atlantic Right Whale Consortium database. The data were carefully screened and verified by Navy contractors before inclusion in the model. Invalid records were not included in the analysis. The data set constitution (multiple efforts, geographic scope over several decades) precludes the ability to assess trends. Sightings were spatially and temporally oriented towards marine mammals with opportunistic recording of sea turtles. Using the formula above, SPUE was calculated for each species, for each season, and for each ten minute square.

Nesting data, compiled from state sources, were mapped and incorporated into the analysis to identify important coastal areas. For Virginia and North Carolina, nesting locations were obtained from state experts. For the other states in the region, the National Oceanic and Atmospheric Administration (NOAA) Environmental Sensitivity Index (ESI) data were used to represent the nesting and distribution areas.

Maps, Analysis, and Areas of Importance

Leatherback Turtle

The assessment results suggest that the distribution of leatherbacks within the region varies by season (Figure 11-1). Observations (n = 187; years = 1979 to 2003) were primarily in the summer months. The sightings during the spring and fall were limited and widely distributed. No observations were available during the winter months. Observations during the summer months were concentrated along the inner Continental Shelf and adjoining coastal areas from Maryland to southern Long Island, New York. In addition, a relatively large number of sightings were concentrated along the shelf break off Virginia to the northern portions of the region. The leatherback had a more northern distribution than the loggerhead turtle, with multiple sightings in the Gulf of Maine, the Southern New England shelf, and off the coast of Nova Scotia. Documented nesting initiated during the months of April, May, and June occurred in North Carolina (n=4). According to the ESI data, areas of concentration were more northern in extent than the other two species: northern New Jersey, Connecticut, and Rhode Island Coasts.

The seasonality of the sightings, with the majority of the sightings in the summer, follow the general pattern of increased turtle sightings as waters warm in the summer months (Braun-McNeil and Epperly 2002). The relatively high concentrations of sightings in the south central portion of inner shelf and coastal areas suggests that those areas are potentially of greater importance for the leatherback. The data set precludes an assessment by life stage (adult, juvenile) as well as use of larger coastal estuaries such as Chesapeake Bay, Delaware Bay, and Long Island Sound.

Green Sea Turtle

Green sea turtle observations in the region included in the dataset were limited to five sightings during the summer and fall months in the south central portions of the shelf (Figure 11-2). A limited number of nests initiated during the months of June, July, and August were documented in northern North Carolina (n=15) and the ocean coast of Virginia (n=1). Areas of concentration, as per the ESI data, were more widespread than the loggerhead turtles: around Long Island, the Maryland and Virginia Shore, and the majority of the Chesapeake Bay. Because of the limited amount of data currently available for this species, interpretations of potentially important areas in the region are unwarranted.

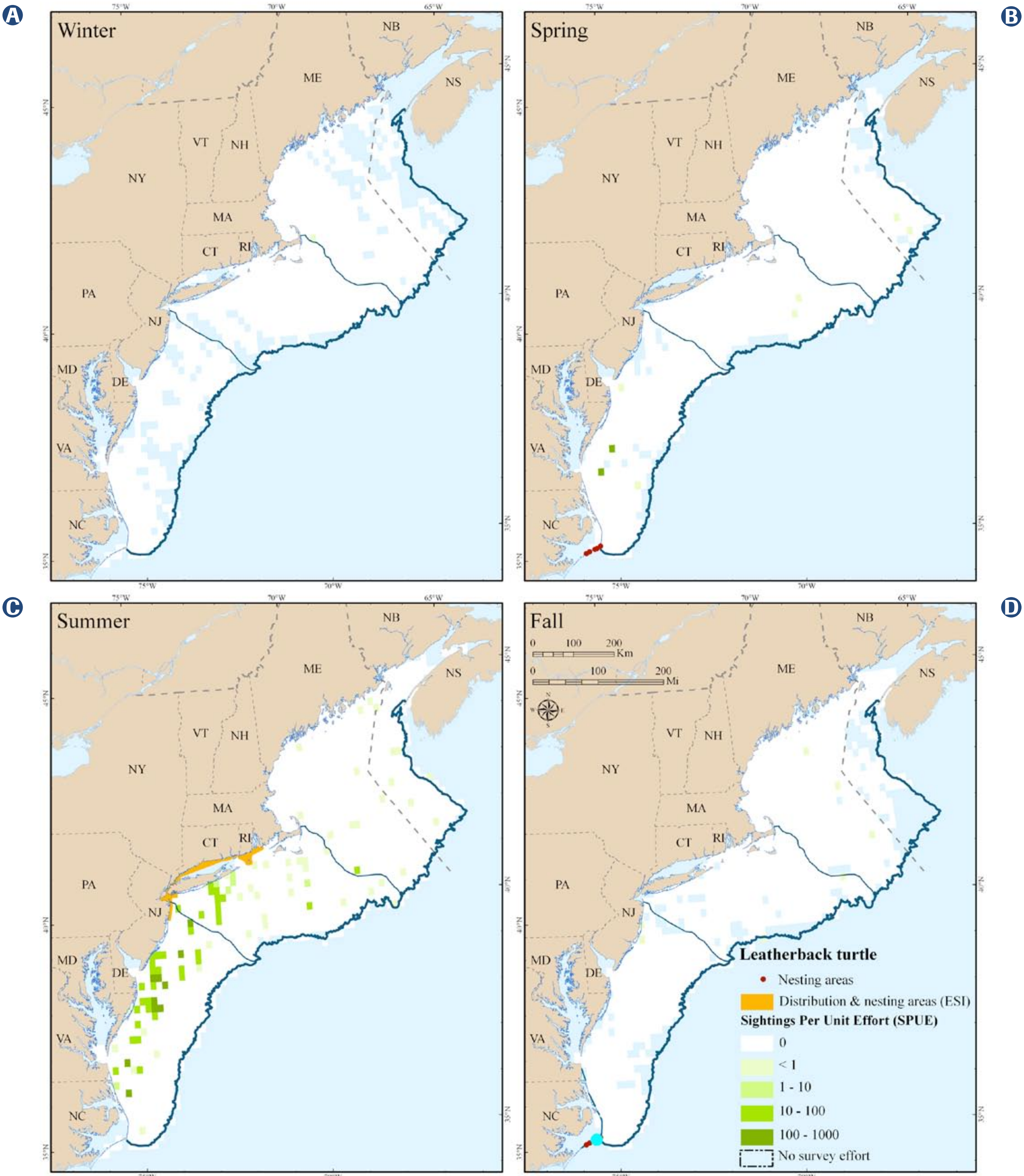

Figure 11-2. Leatherback turtle sightings per unit effort (SPUE) and nesting locations by season.

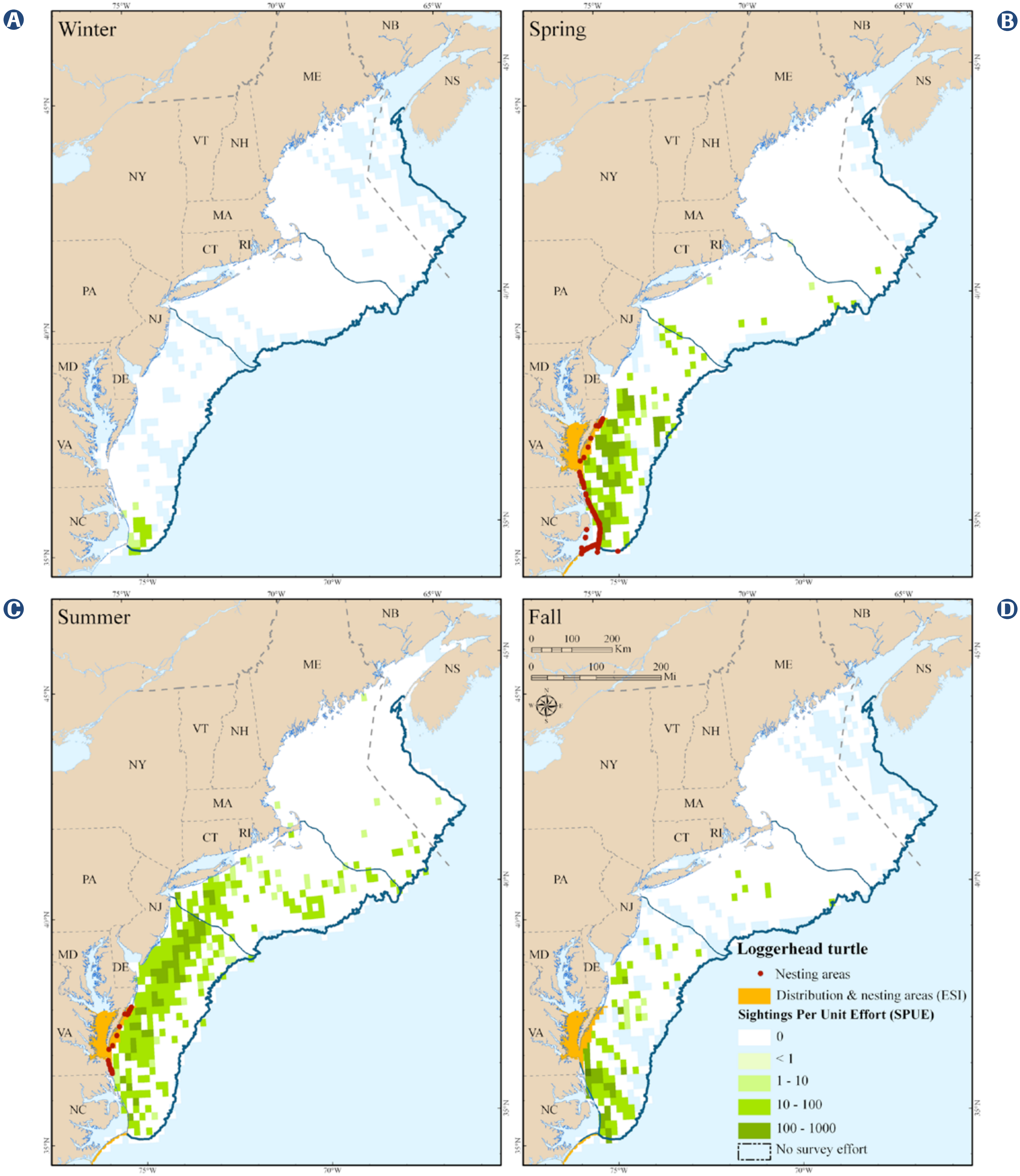

Figure 11-3. Loggerhead turtle sightings per unit effort (SPUE) and nesting locations by season.

Loggerhead Turtle

Based on the observations (n = 1,876; years = 1979 to 2003), the loggerhead turtle was the most abundant of the target turtles in the region (Figure 11-3). The assessment results indicate that the distribution of loggerheads within the region varied by season. During the winter months (December – February), individuals were confined to southern portions of the region on the shelf or along the shelf break. During the spring (March – May) and particularly the summer months (June – August), the number and northward extent of observations increased. Areas of frequent observations were concentrated on the shelf from Cape Hatteras up to Delaware Bay during the spring. During the summer months, the distribution extended up to Long Island, New York with a higher number of observations in closer proximity to the coast. A contraction in distribution and abundance of observations was apparent during the fall (September – November). Areas of loggerhead turtle concentration identified in the ESI data were in the southern part of the region, specifically northern North Carolina, mouth of the Chesapeake Bay, and the Virginia coast.

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Nesting by loggerhead turtles was confined to primarily the northern North Carolina and secondarily in Virginia along the ocean coast south of Chesapeake Bay with a total of 503 documented nests. Nesting dates have ranged from May through September with peaks during June and July.

Interpretation of the aggregate dataset suggests that the southern portion of the region, in association with the continental shelf and shelf break, were utilized year round particularly off of Cape Hatteras. The Continental Shelf, coupled with adjoining coastal systems in the south central portion (Long Island to Cape Hatteras), represented relatively high concentrations or potential areas of greater importance. Furthermore, the concentration of observations along the shelf break in the warmer months is noteworthy. The data set precludes an assessment of habitat use by life stage (adult, juvenile) as well as use of larger coastal estuaries such as Chesapeake Bay, Delaware Bay, and Long Island Sound.

Human Interactions

Threats to sea turtles in the region vary by species. For loggerheads, the most comprehensive threat assessment to date is provided in the Recovery Plan for the Northwest Atlantic population (NMFS USFWS 2008), perhaps the largest nesting aggregation globally. This study assessed the impacts of seven threat categories (i.e., fisheries bycatch, resource use (nonfisheries), construction and development, ecosystem alterations, pollution, species interactions, and other factors) for eight life stages across three ecosystems utilized by this species (terrestrial (nesting beaches), neritic, and oceanic). The study quantified impacts using a stage-based demographic model with a conversion to a "total estimated adjusted annual mortality" (units = number of adult females) by threat category, life stage, and ecosystem type.

The results indicate that the principal threats to loggerheads in the Northwest Atlantic are fisheries bycatch; specifically, in order of magnitude of the threat, bottom trawl (neritic – juvenile and adult), demersal longline (neritic – juvenile and adult), demersal large mesh gillnet (neritic – juvenile and adult), and pelagic longline (oceanic – juvenile). Total estimated annual mortality was greatest within this threat category for the neritic juveniles followed by the neritic adults. There is currently insufficient data to accurately estimate mortality of oceanic adults and neritic juveniles and adults due to pelagic longlines in the Northwest Atlantic. The resource use (nonfisheries) category assessment indicates that legal harvest of neritic juveniles and adults (isolated to the Caribbean) results in estimated mortality similar to demersal longline and gillnets.

The next largest threat categories are primarily the terrestrial ecosystem impacts to nesting females (direct and indirect), eggs, hatchlings, and post-hatchlings. The principal sources of mortality are habitat modification from beach replenishment projects and armoring (nesting females, eggs, hatchlings), erosion of active nesting beaches due to climatic events (eggs), light pollution on nesting beaches (hatchlings), predation by native species (eggs, hatchlings, and post-hatchlings), and other factors such as climate change and natural catastrophes (eggs).

Secondary sources of mortality identified by this study include pollution: marine debris ingestion (neritic and oceanic juvenile and adult), entanglement in derelict gear (particularly neritic juvenile and adult), and oil pollution (all ecosystems – most life stages). Additional data are required to clarify the estimated mortalities from these sources. Vessel strikes (propeller and collisions) were also indentified as a large mortality source for neritic juvenile and adults.

Anthropogenic impacts to green turtles occur at all life stages (reviewed by IUCN's Marine Turtle Specialist Group 2004; NMFS USFWS 2007a). The greatest current threat is the legal and illegal harvest of eggs, juveniles, and adults from both terrestrial nesting beaches and neritic foraging areas. Of particular concern to the recovery of this slow-to-mature species is the harvest of juveniles in the Caribbean Sea (for example, in Nicaragua 11,000 juveniles and adults were taken annually during the 1990s), Southeast Asia, Eastern Pacific, and Western Indian Ocean (NMFS USFWS 2007). Illegal and legal harvest of juveniles and adults occurs throughout the world in over 30 nations. The IUCN report (2004) identifies entanglement in fisheries gear (e.g., drift nets, shrimp trawls, longlines, pound nets) as the primary threat in marine environments. Habitat degradation of nesting areas in the form of beach replenishment and armoring, coastal development, and sand removal have also been identified as principal threats during terrestrial life stages (Lutcavage et al. 1997). Light pollution at nesting beaches results in disorientation of emerging hatchlings and decreased nesting success. Alterations in water quality of coastal estuaries due to development related increases in effluent and contaminant loading (PCBs, heavy metals) has been linked to adverse impacts to green turtles including recent increases in disease (e.g., Fibropapilloma, resulting in internal and external tumors) (George 1997). Affliction rates have reached as high as 62% and 69% in Florida and Hawaii, respectively (NMFS USFWS 2007a). Population level impact from this disease is currently unknown. Red tide events in coastal feeding areas have been linked to increased mortality in juveniles and adults (NMFS USFWS 2007a). In Florida, boat strikes have been singled out as a large source of injury and mortality (Singel et al. 2003). Declines in coastal estuary habitat suitability for green turtles are widespread throughout this species' range including the larger systems along the western Atlantic coast.

Anthropogenic impacts to leatherback turtles occur at all life stages; however, accurate estimates of the relative importance of impacts currently do not exist (NMFS USFWS 2007b). The principal threat to the terrestrial portion of their life cycle is the decrease in the quantity and suitability of nesting habitat. Detrimental habitat alterations include coastal development, beach armoring, sand mining, accumulation of wood and marine debris (reduced access), and artificial lighting. Many of these impacts can alter habitat indirectly by modifying thermal profile and advancing erosion. Currently, many of the globally significant nesting areas remain remote and are not subject to these types of activities. This may not remain the case as human populations increase and migrate towards coastal areas. As with other sea turtle species, the legal and illegal harvest of eggs and nesting adults is globally extensive and in some cases severe (e.g., Malaysia). Harvest of eggs is particularly detrimental for this species given the relatively low hatching success (NMFS USFWS 2007b).

In the oceanic and neritic zones the principal impact is incidental capture by artisanal and commercial fisheries (reviewed by NMFS USFWS 2007b), primarily by pelagic longlines (Lewison et al. 2004; NMFS 2001). Localized declines in populations have coincided with increased use of longline and gillnet fisheries (e.g., in Mexico). Kaplan (2005) estimated a 5% annual mortality due to longline fisheries for the eastern Pacific population with an aggregate of 28% annual mortality due to coastal impacts (e.g., egg/adult harvest and inshore fisheries bycatch). An estimated 50,000 individuals were taken by pelagic longline fisheries globally in 2000 (Lewison et al.

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2004). This level of take suggests pelagic longlines are one of the more important human impacts. In United States waters, the pelagic longline and shrimp trawl fisheries have been identified as the largest documented source of leatherback mortality (NMFS 2001). Alternative methods and gear innovations (e.g., circle vs. J hooks; bait switching, TEDs) have reduced bycatch levels in recent years (NMFS USFWS 2007b). Fixed fishing gear (e.g., gill nets, pot/trap buoy lines, pound nets) is problematic in coastal foraging grounds (James et al. 2005) and in close proximity to nesting areas. Other documented impacts include vessel strikes, ingestion of marine debris (e.g., plastics, hooks, nets, oil), and high contaminant levels (e.g., pesticides, heavy metals).

Resource limitation in the eastern Pacific during cyclical climatic events (El Niño Southern Oscillation) has been linked to decreased reproductive success and increased vulnerability to anthropogenic mortality (NMFS USFWS 2007b). This is not currently the case in the western Atlantic, however, anthropogenic climatic changes that alter oceanic structure could influence prey availability and subsequent reproductive condition. Increased temperatures at nesting sites have been linked to changes in hatchling sex ratios on some beaches (NMFS USFWS 2007b).

Recent work with molecular markers suggests that this species' lower natal philopatry (tendency to return to the place of an individual's birth) and physiological ability to utilize higher latitudes and colder waters have enabled it to recolonize nesting and neritic foraging habitat (NMFS USFWS 2007b). This characteristic may have important ramifications for recovery as detrimental human interactions are reduced. The molecular marker studies also revealed low genetic diversity or division of populations globally, highlighting the need to exercise conservation measures based on larger population aggregates (e.g., French Guiana, Suriname) that appear to be stable or increasing (NMFS USFWS 2007b).

Conservation

Regulatory Authority

All life stages of all three turtle species are currently protected on United States nesting beaches and in United States waters by the Endangered Species Act (ESA). In the United States, National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) jointly manage all three species; USFWS has lead jurisdiction on nesting beaches while NMFS has lead jurisdiction for marine waters.

Current Conservation Efforts

Global conservation efforts for all three species are principally comprised of international conventions and treaties. The United States is one of 12 signatory nations on the only international treaty dedicated solely to sea turtles: Inter-American Convention for the Protection and

Conservation of Sea Turtles. One of the most significant conservation efforts to date for sea turtle species is the United States embargo (November 21, 1989) on shrimp harvested with commercial gear that may adversely impact sea turtles (Public Law 101-162, Section 609 (16 U.C.S. 12537)). Under authority of the ESA and the Magnuson-Stevens Fishery Conservation and Management Act, NMFS has initiated a series of regulations designed to re-

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duce adverse impacts to sea turtles including requiring use of turtle excluder devices (TEDs) and circle hooks, gillnet closures, and pound net modifications. In 2003, NMFS initiated a program (Strategy for Sea Turtle Conservation and Recovery in Relation to Atlantic and Gulf of Mexico Fisheries) to comprehensively identify strategies to reduce bycatch across jurisdictional boundaries for priority gear types on a per-gear basis versus by individual fishery for the Atlantic and Gulf of Mexico. There are currently NMFS USFWS Recovery Plans for United States populations in the Atlantic (October 29, 1991), Pacific (January 12, 1998) and Eastern Pacific (January 12, 1998) for green sea turtles, and for United States Caribbean, Atlantic, and Gulf of Mexico (April 6, 1992) and the United States Pacific (January 12, 1998) populations for loggerheads. Five year reviews of these Recovery Plans occurred in 1991 (56 FR 56882) and 2007 (70 FR 20734).

Species Accounts

Loggerhead Turtle *(Caretta caretta)*

The loggerhead turtle is distributed globally in both temperate and tropical portions of the Indian, Pacific, and Atlantic Oceans. Distribution in the Atlantic Ocean extends from Argentina to Newfoundland while distribution in the eastern Pacific Ocean ranges from Chile to Alaska. This species nests on highly energetic, oceanic beaches. Hatchlings utilize the neritic convergent zones along the Continental Shelf while juveniles occupy oceanic (> 200m) areas followed by a transition back to neritic habitats. Adults are considered primarily neritic with occasional use of oceanic habitat.

Green Sea Turtle *(Chelonia mydas)*

The green turtle is distributed globally primarily between 30° north and south latitude in most of the major oceans and in association with inshore and neritic waters of 140 countries. Along the Gulf of Mexico and the Atlantic coast the species ranges from Texas to Massachusetts with breeding subpopulations in the State of Florida. This species nests on coastal beaches located between 30° north and south latitude. Hatchlings are pelagic during a near surface development stage. Juveniles use oceanic habitats, followed by neritic habitats when they achieve certain age and size thresholds. Adults are both oceanic and neritic, returning to coastal beaches to nest.

Leatherback Turtle *(Dermochelys coriacea)*

The leatherback is distributed globally in sub-polar, temperate, and tropical portions of the Indian, Pacific, and Atlantic Oceans. Distribution within the western Atlantic includes the entire eastern United States continental coast from the Gulf of Maine south to Puerto Rico and the Gulf of Mexico. This species nests on high energy, continental beaches. Hatchlings likely occupy oceanic zones in tropical waters while juveniles (<100 cm CCL) are associated with both oceanic and coastal waters with temperatures above 26° C. Adults utilize both oceanic and coastal waters with temperatures above 12° C on average.

Literature Cited

Baldwin, R., G. R. Hughes, and R. I. T. Prince. 2003. Loggerhead turtles in the Indian Ocean. Pages 218-232 in Bolten, A.B. and B.E. Witherington (eds.). Loggerhead Sea Turtles. Smithsonian Books, Washington D.C.

Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. Pages 199-231 in Lutz, P.L. and J.A. Musick (eds.). The Biology of Sea Turtles. CRC Press. Boca Raton, Florida.

Bjorndal, K. A. 2003. Roles of loggerhead sea turtles in marine ecosystems. Pages 235-254 in Bolten, A.B. and B.E. Witherington (eds.). Loggerhead Sea Turtles. Smithsonian Books. Washington, D.C.

Braun-McNeil, J. and S. P. Epperly. 2002. Spatial and temporal distribution of sea turtles in the Western North Atlantic and the U.S. Gulf of Mexico from Marine Recreational Fishery Statistics Survey (MRFSS). Marine Fisheries Review. 64(4):50-56.

CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora. Signed at Washington, D.C., on 3 March 1973. Amended at Bonn, on 22 June 1979. Appendix I.

George, R. H. 1997. Health problems and diseases of sea turtles. Pages 363-409 in Lutz, P. L. and J. A. Musick (eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

IUCN (International Union for Conservation of Nature). 2004. Green Turtle *(Chelonia mydias)* Assessment. (Assessor: Seminoff, J.A.) Marine Turtle Specialist Group, Washington, DC. http://www.iucn-mtsg.org/red_list/cm/MTSG_Chelonia_mydas_Assessment_April-2004.pdf.

IUCN (International Union for Conservation of Nature). 2007a. Red List of Species: Loggerhead Turtle. Washington, DC.

IUCN (International Union for Conservation of Nature). 2007b. Red List of Species: Green Turtle. Washington, DC. http://www.iucnredlist.org/apps/redlist/details/4615/0.

IUCN (International Union for Conservation of Nature). 2007c. Red List of Species: Leatherback Turtle. Washington, DC. http://www.iucnredlist.org/apps/redlist/details/6494/0.

James, M. C., C. A. Ottensmeyer, and R. A. Myers. 2005. Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. Ecology Letters. 8:195-201.

Kaplan, I. C. 2005. A risk assessment for Pacific leatherback turtles *(Dermochelys coriacea).* Canadian Journal of Fisheries and Aquatic Sciences. 62(8):1710-1719.

Kenney, R. D. and H. E. Winn. 1986. Cetacean high-use habitats of the northeast United States Continental Shelf. Fishery Bulletin. 84(2): 107–14.

Lewison, R. L., S. A. Freeman, and L. B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters. 7:221-231.

Lutcavage, M. E., P. Plotkin, B. Witherington, and P. L. Lutz. 1997. Human impacts on sea turtle survival. Pages 107-136 in Lutz, P.L. and J.A. Musick (eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

NMFS (National Marine Fisheries Service). 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of impacts of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum. NMFS-SEFC-455.

NMFS USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 1992. Recovery Plan for Leatherback Turtles in the U.S., Caribbean, Atlantic and Gulf of Mexico. Silver Springs, Maryland. http://ecos.fws.gov/docs/recovery_plan/920406.pdf.

NMFS USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007a. 5-Year Review: Summary and Evaluation, Green Sea Turtle (Chelonia mydas). Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/species/greenturtle_5yearreview.pdf.

NMFS USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007b. 5-Year Review: Summary and Evaluation, Leatherback Turtle *(Dermochelys coriacea).* Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/species/leatherback_5yearreview.pdf.

NMFS USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle *(Caretta caretta),* Second Revision. Silver Spring, MD. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_loggerhead_atlantic.pdf.

Shoop, R. and R. D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs. 6:43-67.

Singel, K., T. Redlow, and A. Foley. 2003. Twenty-two years of data on sea turtle mortality in Florida: trends and factors. Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum. NMFS-SEFSC-503.

Turtle Expert Working Group. 2007. An Assessment of the Leatherback Turtle Population in the Atlantic Ocean. NOAA Technical Memorandum. NMFS-SEFSC-555.

Witherington, B. E. 2002. Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front. Marine Biology. 140:843-853.