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Marine Mammals and Sea Turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and Nearby Waters: An Analysis of Existing Data for the Rhode Island Ocean Special Area Management Plan

by

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Executive Summary

All available sources of information on the occurrence of marine mammals and sea turtles in the waters of the Rhode Island study area—encompassing Narragansett Bay, Block Island Sound, Rhode Island Sound, and nearby coastal and continental shelf areas—were combined to assess the distribution and relative abundance of those species with respect to the Rhode Island Special Area Management Plan. Thirty-six species of marine mammals (30 cetaceans, 5 seals, 1 manatee) and four species of sea turtles are known to occur in the area. Sixteen were categorized as common to abundant (>100 total records from all sources combined), six as regular (10–100 records), and eighteen as rare to accidental (<10 records). Eleven of those species—six whales, the manatee, and four sea turtles—are listed as Endangered or Threatened under the U.S. Endangered Species Act. One other species was present historically but is now extinct in the North Atlantic—the gray whale. Eight additional species, including one Endangered sea turtle, are considered to be hypothetical in the study area—with one or more records nearby. The forty marine mammal and sea turtle species that occur in the study area have been ranked into five levels of conservation priority relative to the SAMP, taking into account such factors as overall abundance of the population, abundance in the study area, likelihood of occurrence in the SAMP area, ESA-listing status, sensitivity to specific anthropogenic activities, and existence of other known threats to the population.

The following are brief summaries of our conclusions for each of the forty species, sorted by the conservation priority rankings. Priority 1 species are all common in the study area, listed as Endangered under the ESA, and likely to occur in the SAMP area at least seasonally. Priority 2 species fall into two categories—common and ESA-listed, but not likely to occur in abundance in the SAMP area; or common, very abundant, and likely to occur frequently in the SAMP area. Priority 3 includes one ESA-listed whale species that is very unlikely to occur in the SAMP area, two ESA-listed sea turtle species where data are lacking but where juveniles may occur in or pass through the SAMP area, and several other species that are common but mainly found outside of the SAMP area. In Priority 4 is one rare to accidental ESA-listed whale species. There are also several species that are regular to rare with far offshore distributions. And there are three seal species that are all common, but where mostly juveniles occur in the study area. Finally, Priority 5 includes species that are clearly accidental in the study area. For each species, we show the priority level (1–5), the occurrence classification relative to the study area (common, regular, or rare), the ESA-listing status (Endangered, Threatened, or unlisted), and the page number in the report where the full species account can be found.

North Atlantic Right Whale (Priority 1A, Common, Endangered, p. 39): The North Atlantic right whale almost deserves to be in a category by itself. The species is one of the rarest mammals in the world, there is serious concern about long-term population viability, and there is known anthropogenic mortality from ship collisions, as well as from entanglement in commercial fishing gear. Right whales were hunted in southern New England until the early 20th Century. Shore-based whaling in Long Island took right whales year-round, but catches peaked in spring during the northbound migration from calving grounds off the southeastern U.S. to feeding grounds in the Gulf of Maine. In recent years, right whales have occurred in southern New England in all seasons, and in the SAMP area in spring and fall. There may be occasional years when they linger in the SAMP area for feeding for days or weeks rather than just transiting through on migration.

Humpback Whale (Priority 1B, Common, Endangered, p. 51): Humpbacks occur off southern New England in all four seasons, with peak abundance in spring and summer. They may be present in the SAMP area in spring and summer. Their presence in the region varies a great deal between years; they tend to most abundant in southern New England in years when stocks of sand lance, a principal prey species, are low in Cape Cod Bay and Massachusetts Bay.

Fin Whale (Priority 1B, Common, Endangered, p. 64): Fin whales are the most abundant large whale in southern New England, and are widespread in continental shelf waters. They can occur in the SAMP area and just offshore of the area in all seasons, and are most common in summer.

Leatherback Sea Turtle (Priority 1B, Common, Endangered, p. 263): Leatherbacks are the most likely sea turtle species to be encountered in the SAMP area. Their occurrence is during the warmest part of the year in summer and early fall. Although the areas where they can be abundant are beyond the SAMP area, they can occur in the SAMP area, and they are a global conservation priority with a Critically Endangered designation on the IUCN Red List.

Sperm Whale (Priority 2, Common, Endangered, p. 93): Sperm whales are primarily deep-water residents with a distribution at the shelf break and farther offshore. However, in southern

New England they frequently venture into nearshore areas. Sperm whales have been seen in the SAMP area, mainly in the summer.

Loggerhead Sea Turtle (Priority 2, Common, Threatened, p. 270): Although loggerheads are much more abundant off the Northeast than leatherbacks, they are less likely to be seen in cooler and nearshore waters. It is possible for loggerheads to occur occasionally in the SAMP area in summer or fall.

Harbor Porpoise (Priority 2, Common, Unlisted, p. 128): The harbor porpoise is one of three very abundant small cetaceans that are likely to occur frequently in the SAMP area. They can occur in the SAMP area in all seasons of the year, but are likely to be most abundant in spring when they are migrating toward Gulf of Maine feeding grounds from wintering areas in the mid-Atlantic and/or offshore.

Atlantic White-sided Dolphin (Priority 2, Common, Unlisted, p. 162): The Atlantic white-sided dolphin is one of three very abundant small cetaceans that are likely to occur frequently in the SAMP area. They can occur in the SAMP area in all seasons of the year, but are usually most abundant more offshore and beyond the SAMP area.

Short-beaked Common Dolphin (Priority 2, Common, Unlisted, p. 187): The short-beaked common dolphin, also known as the saddleback dolphin, is one of three very abundant small cetaceans that are likely to occur frequently in the SAMP area. They can occur in the SAMP area in all seasons of the year, with less variability between seasons than other species and peak occurrence in fall and winter. Common dolphins concentrate on the outer shelf offshore of the SAMP area, but may occur in the deeper parts of the SAMP area.

Harbor Seal (Priority 2, Common, Unlisted, p. 212): Seals are very difficult to spot during surveys, so their occurrence in the study area is known mainly from stranding records. Harbor seals are the only marine mammal that can be considered as resident in Rhode Island. They are common in fall, winter, and spring, and relatively rare in summer. They are known to occupy regular haul-out sites on the periphery of Block Island, where they could be subject to disturbance from development activities.

Sei Whale (Priority 3, Regular, Endangered, p. 76): Sei whales are absent from the study area in most years, but significant numbers may visit the area irregularly in an occasional year.

Their primary area of occurrence in the spring is to the east on Georges Bank. On the rare occasions when sei whales do occur in southern New England waters, it is not likely to be within the SAMP area.

Kemp's Ridley Sea Turtle (Priority 3, Regular, Endangered, p. 276): Kemp's ridley sea turtles have been sighted off southern New England only a few times, including within the SAMP area. Their main center of distribution is off the southeastern U.S. and in the Gulf of Mexico. However, small juveniles—too small to be detected during surveys—are known to utilize shallow developmental habitats around eastern Long Island and Cape Cod, and might transit through the SAMP area.

Green Sea Turtle (Priority 3, Rare, Threatened [species], Endangered [Florida nesting population], p. 280): There has been only one recent sighting of a green sea turtle off southern New England, outside of the SAMP area. They are primarily found in shallow, tropical waters. However, small juveniles—too small to be detected during surveys—are known to utilize shallow developmental habitats around eastern Long Island and Cape Cod, and might transit through the SAMP area.

Common Minke Whale (Priority 3, Common, Unlisted, p. 84): Common minke whales are relatively abundant and widespread across the shelf in southern New England in spring and summer, including within the SAMP area but mainly beyond it.

Long-finned Pilot Whale (Priority 3, Common, Unlisted, p. 138): Long-finned pilot whales are relatively abundant off southern New England. They occur widespread across the shelf, but mainly on the outer shelf. They occur year-round, with a peak abundance in spring. They may occur on occasion within the SAMP area.

Risso's Dolphin (Priority 3, Common, Unlisted, p. 155): Risso's dolphins are relatively abundant off southern New England. They may occur year-round, but are primarily concentrated during the warmer parts of the year. Their distribution is primarily offshore, and they are not likely to be seen in the SAMP area.

Common Bottlenose Dolphin (Priority 3, Common, Unlisted, p. 175): Bottlenose dolphins are relatively abundant off southern New England, but the issue is complicated by the presence of separate coastal and offshore populations, which may actually be two separate species.

Bottlenose dolphins occur in the region year-round with highest abundance in summer and a mainly offshore distribution. Only in summer are they likely to be seen in the outer part of the SAMP area.

Blue Whale (Priority 4, Rare, Endangered, p. 62): Blue whales appear to occur only accidentally within the study area. There were three sightings in 1990, which could all have been the same whale, and one killed by a ship collision in 1998. They are mainly found more to the north, with the nearest known population center in the Gulf of St. Lawrence. However, their winter range is believed to be in deep water beyond the shelf, including mid-Atlantic latitudes, so occasional migratory transits are possible.

Pygmy Sperm Whale (Priority 4, Regular, Unlisted, p. 104): Pygmy sperm whales are known to inhabit deep, offshore waters in tropical, subtropical, and warm-temperate regions. They are known mainly from strandings, and knowledge of their occurrence is complicated by detectability and species identification issues. They are not likely to occur within the SAMP area.

Dwarf Sperm Whale (Priority 4, Rare, Unlisted, p. 104): Dwarf sperm whales are known to inhabit deep, offshore waters in tropical, subtropical, and warm-temperate regions. They are known mainly from strandings, and knowledge of their occurrence is complicated by detectability and species identification issues. They are probably more common than is apparent from the existing data, but still rarer than pygmy sperm whales. They are not likely to occur within the SAMP area.

Cuvier’s Beaked Whale (Priority 4, Rare, Unlisted, p. 110): All six of the North Atlantic beaked whales have distributions that are concentrated in very deep water beyond the shelf break, and are unlikely to occur within the SAMP area. However, they all have an additional level of management concern because they appear to be especially sensitive to acoustic disturbance. Cuvier’s beaked whales are one of the three species that are probably most common off southern New England.

Blainville’s Beaked Whale (Priority 4, Rare, Unlisted, p. 110): All six of the North Atlantic beaked whales have distributions that are concentrated in very deep water beyond the shelf break, and are unlikely to occur within the SAMP area. However, they all have an additional level of management concern because they appear to be especially sensitive to acoustic disturbance. Blainville's beaked whales are one of the three species that are probably most common off southern New England.

Gervais' Beaked Whale (Priority 4, Rare, Unlisted, p. 110): All six of the North Atlantic beaked whales have distributions that are concentrated in very deep water beyond the shelf break, and are unlikely to occur within the SAMP area. However, they all have an additional level of management concern because they appear to be especially sensitive to acoustic disturbance. Gervais' beaked whales have mainly a warm-water distribution, and southern New England waters are probably near the northern edge of their range.

Sowerby's Beaked Whale (Priority 4, Rare, Unlisted, p. 110): All six of the North Atlantic beaked whales have distributions that are concentrated in very deep water beyond the shelf break, and are unlikely to occur within the SAMP area. However, they all have an additional level of management concern because they appear to be especially sensitive to acoustic disturbance. Sowerby's beaked whales have a mainly cold-water distribution, and southern New England waters are probably near the southern edge of their range.

True's Beaked Whale (Priority 4, Rare, Unlisted, p. 110): All six of the North Atlantic beaked whales have distributions that are concentrated in very deep water beyond the shelf break, and are unlikely to occur within the SAMP area. However, they all have an additional level of management concern because they appear to be especially sensitive to acoustic disturbance. True's beaked whales are one of the three species that are probably most common off southern New England.

Striped Dolphin (Priority 4, Regular, Unlisted, p. 197): Striped dolphins are probably the second most abundant cetacean species off the Atlantic coast of the U.S. after common dolphins. However, their distribution is mainly offshore in very deep water over the continental slope, and it is very unlikely that striped dolphins would occur within the SAMP area.

Gray Seal (Priority 4, Common, Unlisted, p. 231): Gray seals are very common in the stranding records from Rhode Island and the rest of southern New England. However, the majority of individuals in the study area appear to be juveniles dispersing from the main population centers of adult occurrence and breeding around Nantucket and Cape Cod, Massachusetts, on the coast of Maine, and at Sable Island, Nova Scotia. The relatively frequent strandings appear to be simply a component of natural juvenile mortality.

Harp Seal (Priority 4, Common, Unlisted, p. 240): Harp seals have been very common since the early 1990s in the stranding records from Rhode Island and the rest of southern New England. However, the majority of individuals in the study area appear to be juveniles dispersing from the main population centers of adult occurrence and breeding around Newfoundland and Greenland. The relatively frequent strandings appear to be simply a component of natural juvenile mortality.

Hooded Seal (Priority 4, Common, Unlisted, p. 249): Hooded seals have been relatively common since the early to mid-1990s in the stranding records from Rhode Island and the rest of southern New England. However, the majority of individuals in the study area appear to be juveniles dispersing from the main population centers of adult occurrence and breeding around Newfoundland and Greenland. The relatively frequent strandings appear to be simply a component of natural juvenile mortality.

West Indian Manatee (Priority 5, Rare, Endangered, p. 259): Manatees clearly occur accidentally in southern New England, with only four individuals known to have visited the region since 1996. They are tropical and subtropical animals that rarely travel north of the Carolinas.

Bryde’s Whale (Priority 5, Rare, Unlisted, p. 82): Bryde’s whales are tropical baleen whales that occur accidentally off southern New England. Only two records are known—one sighting of a live whale in 1982 and some baleen collected in a bottom dredge sample in 1952.

Northern Bottlenose Whale (Priority 5, Rare, Unlisted, p. 110): All six of the North Atlantic beaked whales have distributions that are concentrated in very deep water beyond the shelf break, and are unlikely to occur within the SAMP area. However, they all have an additional level of management concern because they appear to be especially sensitive to acoustic disturbance. Northern bottlenose whales are accidental in southern New England, with only two known occurrences in 1867. The closest known population is off Nova Scotia.

Beluga Whale (Priority 5, Rare, Unlisted, p. 122): Belugas are primarily Arctic residents, with a relict population in the Gulf of St. Lawrence in eastern Canada. Occasional wanderers from that population visit the northeastern and mid-Atlantic U.S., with three known individuals in the southern New England study area.

Short-finned Pilot Whale (Priority 5, Rare, Unlisted, p. 138): Short-finned pilot whales are the more tropical of the two pilot whale species found in the North Atlantic. A stranding on Block Island is the only confirmed record for north of New Jersey. Because at-sea sightings can rarely be identified to species, short-finned pilot whales may be somewhat more common than is apparent from the existing data, but are still not likely to occur in the SAMP area.

Killer Whale (Priority 5, Rare, Unlisted, p. 150): Despite occurring in the North Atlantic from the tropics to the sub-Arctic, killer whales have been seen in southern New England on only very rare occasions.

False Killer Whale (Priority 5, Rare, Unlisted, p. 153): False killer whales are primarily tropical and subtropical inhabitants. A few animals were seen in a localized area for short periods in three out of four summers in 1990–1993, possibly the same group each time.

White-beaked Dolphin (Priority 5, Regular, Unlisted, p. 171): White-beaked dolphins have mainly a cold-water distribution across the North Atlantic. The nearest consistent center of occurrence is in Nova Scotia.

Atlantic Spotted Dolphin (Priority 5, Rare, Unlisted, p. 205): Both species of spotted dolphins are primarily tropical and subtropical. Off the U.S. mid-Atlantic, they primarily occur in very deep slope water and farther offshore.

Pantropical Spotted Dolphin (Priority 5, Rare, Unlisted, p. 205): Both species of spotted dolphins are primarily tropical and subtropical. Off the U.S. mid-Atlantic, they primarily occur in very deep slope water and farther offshore.

Ringed Seal (Priority 5, Rare, Unlisted, p. 257): Ringed seals are very abundant residents of the high Arctic, which occur only accidentally in New England.

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Abstract

We reviewed all available information to assess the distribution and relative abundance of marine mammals and sea turtles in Block Island Sound, Rhode Island Sound, and nearby coastal and continental shelf areas. Forty species—30 cetaceans, 5 seals, 1 manatee, and 4 sea turtles—are known to occur in the area. Those species were ranked into five levels of conservation priority relative to the Ocean Special Area Management Plan, taking into account such factors as overall abundance of the population, abundance in the study area, likelihood of occurrence in the SAMP area, endangered status, sensitivity to specific anthropogenic activities, and existence of other known threats to the population. Priority 1 species are all common in the study area, listed as Endangered, and likely to occur in the SAMP area at least seasonally. They include North Atlantic right whale, humpback whale, fin whale, and leatherback sea turtle. Priority 2 species fall into two categories—common in occurrence and listed as Endangered or Threatened), but not likely to occur in abundance in the SAMP area (sperm whale and loggerhead sea turtle); or common, very abundant, and likely to occur frequently in the SAMP area (harbor porpoise, Atlantic white-sided dolphin, short-beaked common dolphin, and harbor seal). Priority 3 includes one Endangered whale species that is very unlikely to occur in the SAMP area (sei whale), two Endangered sea turtle species where data are lacking but where juveniles may occur in or pass through the SAMP area (Kemp’s ridley and green sea turtles), and several other species that are common but mainly found outside of the SAMP area (common minke whale, long-finned pilot whale, Risso’s dolphin, and common bottlenose dolphin). In Priority 4 is one rare to accidental Endangered whale species, the blue whale. There are also several species that are regular to rare with far offshore distributions—pygmy and dwarf sperm whales, five species of beaked whales, and striped dolphin. And there are three seal species that are all common, but where mostly juveniles occur in the study area—gray, harp, and hooded seals. Finally, Priority 5 includes species that are clearly accidental in the study area—manatee (Endangered); Bryde’s, northern bottlenose, beluga, short-finned pilot, killer, and false killer whales; white-beaked, Atlantic spotted, and pantropical spotted dolphins; and ringed seal.

1 Introduction

The Rhode Island State Office of Energy Resources (OER), at the request of Governor Carcieri, has set a goal of obtaining 15% (150 MW out of 1000 MW) of the state's energy needs from renewable sources, particular wind and wave-energy resources. To meet this demand requires approximately 450 MW of new energy-generating capacity, given the intermittent nature of wind and waves. The focus has been on obtaining this energy from offshore wind farms located in state and adjacent federal coastal waters. OER retained Applied Technology & Management (ATM) to identify the most viable areas for wind energy development and assess the potential energy generation for each of these sites. ATM identified the viable sites by establishing selection criteria and then performing a screening analysis using Geographic Information Systems (GIS) methods and data sources (ATM, 2007). Their report concluded that it was possible to reach the 15% target from winds, almost all from offshore areas.

One of the areas of concern that was not adequately addressed by the ATM site-selection review was the presence of protected marine species. They used the RIGIS rare-species data layer to assess all sites, however that dataset explicitly includes only terrestrial species, not aquatic or marine species. At least 25–30 species of marine mammals and 4 species of sea turtles were known or suspected to occur in the marine waters of Narragansett Bay, Block Island Sound, Rhode Island Sound, and nearby Atlantic continental shelf waters off southern New England (CETAP, 1982; Shoop & Kenney, 1992; Kenney & Nawojchik, 1996; Nawojchik, 2002; Waring et al., 2008; Whitaker et al., in prep). All marine mammals are protected under the federal Marine Mammal Protection Act (16 U.S.C. 1361–1421h), which prohibits all "takes[1]" including disturbance. In addition, 11 of the species (six whales, the manatee, and all four turtles) are listed as Endangered or Threatened under the federal Endangered Species Act (16 U.S.C. 1531–1544). Any potential impacts on federally protected species during the construction or operation of alternative energy projects, either in federal or state waters, must be assessed under these statutes before the project can proceed.

OER has agreed to fund the development of an Ocean Special Area Management Plan (SAMP) for siting of renewable energy facilities in state and nearby federal waters. The URI

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[1] By regulation, a take under the MMPA means "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill" any marine mammal. Under the ESA, a take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect," or attempt to do any of the preceding.

Center of Excellence for Offshore Renewable Energy is working cooperatively with the RI Coastal Resources Management Council (CRMC) in developing the SAMP. The SAMP project is being spearheaded by the URI Coastal Resources Center and RI Sea Grant.

As a component of the Ocean SAMP project, we proposed to collate and analyze existing data on the marine mammals and sea turtles that occur in the region. Our objective was to conduct detailed analyses and mapping of the spatial and temporal distributions and relative abundances of all marine mammals and sea turtles in the marine waters of the State of Rhode Island and adjacent areas, and to make recommendations for any future research that might be necessary. This report is the result of that analysis.

The most recent reviews of marine mammals specific to Rhode Island were a summary by Cronan and Brooks (1968) and a checklist by August et al. (2000). Lazell (1976, 1980) reviewed New England occurrences of sea turtles. A major survey program took place between late 1978 and early 1982 (CETAP, 1982). It was funded by the U.S. Dept. of the Interior, Bureau of Land Management (through the Outer Continental Shelf studies program that later moved from BLM to the Minerals Management Service). The objective of CETAP was to develop information on species diversity, distributions in space and time, and abundance for environmental impact assessments related to oil and gas exploration on Georges Bank and in the mid-Atlantic. Surveys were conducted year-round of the continental shelf from North Carolina to Maine. There have been other survey efforts since then, but none have matched CETAP in geographic scope or year-round coverage. (See section 2.2.5 for an amplified discussion of historical data sources.)

The marine mammal taxonomy and nomenclature followed here is based on Rice (1998) as modified by more recent information. This follows the standards established in the editorial policies of both *Marine Mammal Science* and *Journal of Cetacean Research and Management*. To maintain consistency, all measurements have been converted to metric units regardless of how they were originally reported, with the exception of material directly quoted from original sources.

2 Methods

2.1 Study Area

The area defined for the Rhode Island Ocean SAMP study includes Rhode Island Sound, Block Island Sound, and adjacent continental shelf waters out to about the 50-m isobath (Fig 1). Existing survey effort for marine mammals and sea turtles within the SAMP study area is relatively sparse, detectability of marine animals can be quite low during surveys, and large marine vertebrates are capable of long-distance movements over short time scales. Developing a good understanding of marine mammal and turtle occurrence with the SAMP study area therefore requires looking at data over a significantly larger area. In addition, the process of developing the relative abundance models (see 2.3.2) requires including spatial data from well beyond the actual study area for effective interpolation and to avoid artifacts from edge-effects within the study area. Initially, data were extracted for a very large area—between 68°W and 74°W and north of 39°N. Data from that area were used to derive the relative abundance models. A smaller area was used to extract the data for quantifying overall levels of occurrence and creating simple maps (see 2.3.1). That area was between 70°W and 73°W and north of 39°30’N, roughly encompassing the coastal and shelf waters south of New England between Cape Cod, Massachusetts and the middle of Long Island, New York (Fig. 1). We shall refer to this area as the “Rhode Island study area” in this report for convenience and clarity.

2.2 Data Sources

There were four primary types of data records included in this review, from a variety of original sources—survey data, opportunistic sighting records, stranding records, and fishery bycatch records.

2.2.1. Survey Data

There have been aerial and shipboard surveys for marine mammals and turtles in southern New England waters since the late 1970s. Most of the existing survey data for the region have been obtained and archived by the North Atlantic Right Whale Consortium (NARWC, http://www.rightwhaleweb.org). The NARWC database is managed and continually updated at the University of Rhode Island Graduate School of Oceanography (Kenney, 2001), with funding support from the National Marine Fisheries Service. By definition, in addition to records of all

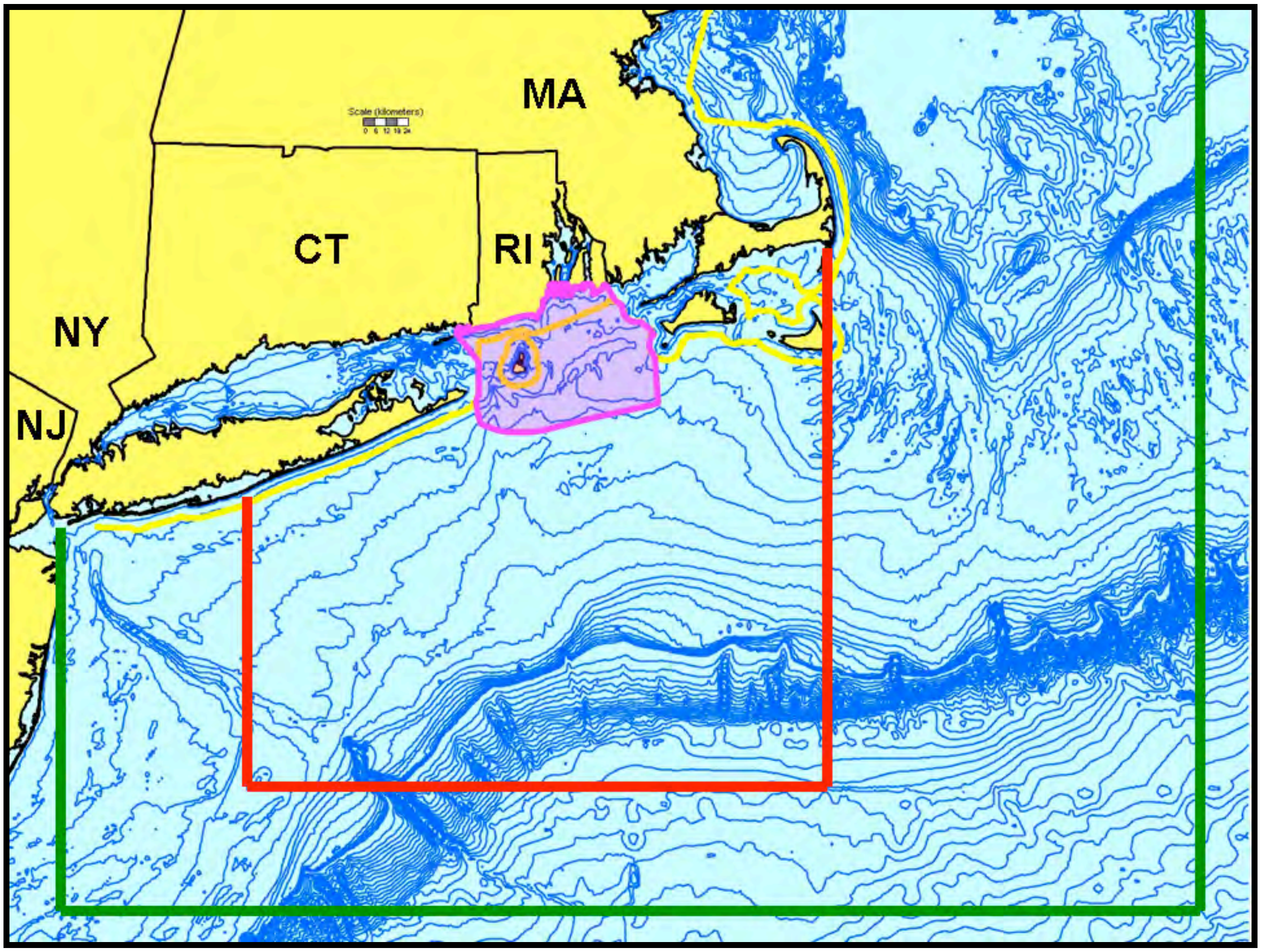

Figure 1. The study areas used in analyzing marine mammal and sea turtle occurrence for the Rhode Island Ocean SAMP. The broadest area outlined in green is the area used for extracting data for the relative abundance modeling procedure. The smaller area enclosed in the red line is the Rhode Island study area defined for this report. The smallest area outlined and shaded in pink is the formally defined SAMP study area. The yellow line shows the state waters boundary (3 nautical miles). The bathymetry shown is at 10-m contour intervals to 200 m, then at 100-m intervals.

target species (and sometimes non-target species) sighted, survey data include detailed information on the track of the survey platform (e.g., ship or aircraft) and associated environmental conditions, allowing for subsequent reconstruction of the survey and quantification of effort. The principal sources of survey data in the NARWC database from the southern New England are surveys in 1978–1982 by the Cetacean and Turtle Assessment Program (CETAP, 1982), surveys specifically focused on right whales and multi-species stock assessment surveys conducted since the 1990s by the National Marine Fisheries Service's Northeast Fisheries Science Center (NMFS-NEFSC, Woods Hole, MA), and aerial surveys for right whales conducted in 2005 and 2006 by the Riverhead Foundation for Marine Research and Preservation (Riverhead, NY).

2.2.2 Sighting Records

The NARWC database also includes substantial numbers of opportunistic sighting records that have no associated survey data. Many of these represent records collected during CETAP or historical data that were aggregated and archived as part of CETAP. Other sightings have been contributed by a variety of individuals, including Navy, Coast Guard, other federal agencies, mariners, commercial fishermen, and recreational boaters. An additional collection of opportunistic sighting records was obtained from Dr. Arthur Kopelman of the Coastal Research and Education Society of Long Island, Inc. (CRESLI). The sightings came originally from the Okeanos Ocean Research Foundation (Samuel S. Sadove, executive director; Okeanos is no longer in existence), and were recorded from commercial whale-watching vessels out of Montauk in late spring and summer of 1981–1994 (primarily the *Finback*). These sightings are heavily concentrated in the area between eastern Long Island and Block Island and during the whale-watching season, and therefore somewhat biased, but provide valuable information on several less-common species. An attempt was also made to acquire sighting records collected by naturalists working aboard whale-watching boats operating from Galilee, Rhode Island. George O. Klein provided humpback whale sighting records collected aboard the *Super Squirrel* and *Super Squirrel II* in 1986–1988. Charles Avenengo provided his logbooks from the Frances Fleet whale-watch boats (*Lady Frances* and *Gail Frances*) for 1992–1996. We have been unsuccessful thus far in getting more recent records from the Frances Fleet.

2.2.3 Stranding Records

Dead or debilitated marine mammals and sea turtles occasionally wash up on shore, or strand (Geraci et al., 1999). Sometimes apparently healthy animals (on occasion in groups) strand, which, without human intervention, often results in mortality (seals are more likely to be successfully "rescued" than cetaceans). Because of federal protection in the U.S. since the early 1970s, all stranding response in the region is conducted by organizations that have been issued federal permits and that are part of the Northeast Regional Stranding (NERS) network (marine mammals) or the Sea Turtle Stranding and Salvage Network (sea turtles). Network participants within the region are: New York plus Block Island, Rhode Island—Riverhead Foundation (who took over from Okeanos in the mid-1990s); Connecticut and the rest of Rhode Island—Mystic Aquarium and Institute for Exploration (Mystic, CT); and Massachusetts—several different organizations, with the mix changing over the years.

Both stranding networks are coordinated from the NMFS Northeast Regional Office (NERO, Gloucester, MA). The complete marine mammal stranding database for Rhode Island to New Jersey (but not including Massachusetts) for 1993–2005 was obtained from Mendy Garron, NERS Network Coordinator, NMFS-NERO. A database of pre-1993 records for the same region (plus additional records from a broader region for baleen whales only) was obtained from Dr. James G. Mead at the Smithsonian Institution, National Museum of Natural History. That dataset included strandings, museum specimen records (including a number of cross-references to specimens in the collections of other museums), sightings collected during a former program known as the Scientific Events Alert Network, records of intentional captures, and a variety of records that had been extracted from published reports. A few relevant museum specimen records were also obtained from the American Museum of Natural History and the Harvard University Museum of Comparative Zoology. Combining datasets required careful removal of duplicate records that were included in more than one source. Many of the older records in these datasets had only approximate descriptions of localities that would not have been precise enough to enable mapping them. We used Google Earth and a variety of other on-line search engines and mapping utilities to locate as many as possible and to generate latitude/longitude coordinates. The same process was used to derive corrected latitude/longitude coordinates for records where mapping uncovered obvious location errors (e.g., stranding and sighting records that mapped far inland or stranding records that mapped offshore). The Smithsonian dataset included only cetacean records, so we did not have a complete record of seal strandings prior to 1993. We were able to get pre-1993 seal stranding records for Rhode Island only from the stranding program at Mystic Aquarium, courtesy of Heather Medic, the stranding coordinator at that time. We were not able to obtain the data from the sea turtle stranding network; the only turtle stranding records we had were a few in the CETAP database, a few from the Rhode Island Sea Turtle Disentanglement Network, and 20 records from Block Island tabulated in Nawojchik (2002).

2.2.4 Bycatch Records

Marine mammals are often captured accidentally in the course of normal operations by commercial fisheries (Beddington et al., 1985; Woodley and Lavigne, 1991; Perrin et al., 1994b; Northridge and Hofman, 1999; Northridge, 2002; Waring et al., 2008). This incidental take, or bycatch, includes both animals that are killed and animals that are released alive from the gear. The NMFS Fisheries Sampling Branch (FSB, Woods Hole, MA) collects bycatch data from fishery observers placed aboard commercial fishing vessels in the northeastern U.S. to quantify fishery-related marine mammal mortality, in addition to collecting standard fisheries data. NMFS-FSB (David Potter and Sara Quinn) provided an extensive dataset of marine mammal bycatch records for the northeastern U.S. Because of confidentiality issues with the individual bycatch records, they have been fully integrated with the sighting and stranding records so they can not be identified separately, no specific information or details will be presented, and the bycatch locations will not be differentiated on the maps.

2.2.5 Notes on Historical Data Sources

In *The Mammals of Rhode Island* (first published in 1962, revised in 1968), John M. Cronan and Albert Brooks say that they have written “the first comprehensive study of the mammals of Rhode Island.” They cited two previously published checklists of the state’s mammalian fauna. One, “The Native Mammals of Rhode Island,” was published in 1900 as Circular 1 of the Newport Natural History Society by Edgar A. Mearns (1856–1916), an Army surgeon and naturalist who was stationed at Fort Adams in 1899 and 1900. That publication was essentially a request for information toward the goal of developing a detailed catalog of the state’s mammals, and included simple listings of 50 “wild mammals known to have inhabited the State of Rhode Island during the historic period” and another 32 species “whose occurrence … may be looked for with some degree of probability.” The second was by Roland C. Clement, Audubon Society of Rhode Island, in 1952. It was simply a checklist, and included only terrestrial species. Two checklists were published following Cronan and Brooks. The state Water Resources Board (WRB) published a checklist of all fish and wildlife species in 1976, but again included only terrestrial mammals. August et al. (2001) published a checklist of the state’s mammals, including an up-to-date list of marine species, as a chapter in the vertebrate volume of the Rhode Island Natural History Survey’s “Biota of Rhode Island” series.

Because of their high economic value, the baleen whales historically have been the focus of substantially more scientific effort than other cetaceans. A particularly valuable source is Glover M. Allen's[2] 1916 monograph—*The Whalebone Whales of New England*[3]. Allen exhaustively reviewed seemingly everything that had been written before him about whales in New England, back to the earliest accounts from the colonial era. The specific records he published were then painstakingly extracted and computerized in the Smithsonian Institution's database, through the efforts of marine mammal curator James G. Mead. In 1908, Joel A. Allen published a paper reviewing information on North Atlantic right whales, which was a primary source for Allen (1916) for that species. Frederick W. True's (1904) baleen whale monograph was also an important source for Allen (1916); True also published a monograph on the Delphinidae (also including Phocoenidae and Monodontidae) in 1889. Another major source for Allen (1916) was Clark (1887), which was a review of American whaling as part of a massive review of the fisheries industry for the federal government.

Joseph H. Waters and C. Jean-Jacques Rivard published a review of the mammals of Massachusetts in 1962. Their volume was intended for a non-professional audience. The marine mammal accounts were relatively sparse and seemed to be based heavily on anecdotal information. They did include a table of sightings and strandings (for cetaceans, but not for the seals; also extending to Rhode Island) since 1940. Their primary sources besides those recent occurrences were two checklists published very recently before their summary (Grayce, 1957; Carpenter and Siegler, 1958), Allen (1916) for the baleen whales, and a very small number of recent papers in the primary literature.

James Ellsworth De Kay (1842) published the first comprehensive review of the mammal fauna of New York, although his treatment of the marine mammals was relatively incomplete

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[2] There were two Harvard-educated American naturalists of the Victorian era named "Allen" who both published major works on mammals, and specifically on marine mammals. Joel Asaph Allen (1838–1921) was probably best known for his work on birds. He was the first curator of birds and mammals at the American Museum of Natural History. His major work on marine mammals was a monograph on North American pinnipeds in 1880. Glover Morrill Allen (1879–1942) was the curator of mammals at Harvard's Museum of Comparative Zoology (where J.A. Allen had gotten his professional start in 1872 as assistant in ornithology). To confuse things even more, J.A. Allen reviewed G.M. Allen's 1916 baleen whale monograph in *Science*, so there are two "Allen (1916)" publications with the same title (though we have cited only the monograph, not the review).

[3] Interestingly, many of the Rhode Island records included by Allen in this volume came to him from Major Edgar A. Mearns, who was apparently the same person who published "The Native Mammals of Rhode Island" in 1900. Since many of the observations occurred well before Major Mearns was posted to Fort Adams in 1899, it seems that he collected all available reports of Rhode Island baleen whales for his summary and also sent them on to Allen.

and relied heavily on second-hand anecdotal sources, and consequently has a number of errors. Paul F. Connor published a comprehensive review of the mammals of Long Island in 1971, as one piece of a never-completed region-by-region review of the New York mammal fauna. Connor's review summarized what was published in all of the historical sources mentioned herein and others, evidence from contemporary strandings and other specimens, and reliable reports from fishermen and others. J. G. Mead considered Connor's reports of sufficient reliability to extract them as occurrence records in the Smithsonian database. One of us (RDK) has written the marine mammal chapters for an updated *Mammals of New York* book (Whitaker et al., in preparation); much of the basic text of the species accounts included in this report has been abridged from that manuscript.

J.H. Linsley (1842) published an early review of the mammals of Connecticut, including marine species. Some of his information drew on De Kay's as-yet-unpublished treatise. A century later, Goodwin (1935) relied heavily on Linsley and De Kay for his review of Connecticut mammals.

Harold Lester Babcock, M.D. published a monograph on New England turtles in 1919, including four sea turtle species. He included listings of 19th and early 20th Century records from New England and New York, attempting to eliminate questionable reports from fishermen and others. James D. Lazell, Jr. published *This Broken Archipelago* in 1976. It was an extensive review of historical and recent data on the reptiles and amphibians of Cape Cod and the nearby islands of Massachusetts. In 1980, he published the information for only the sea turtles in a paper in *Copeia*, where he argued that New England waters comprised important habitats for as many as four of the five Atlantic sea turtle species. Lazell's work comprised the most complete source for New England sea turtles prior to results from the extensive CETAP surveys (CETAP, 1982; Shoop and Kenney, 1992).

2.3 Analytical Methods

2.3.1 General Occurrence and Distribution

All data records from the Rhode Island study area (Fig. 1) were extracted to assess the general levels of occurrence of all species in the region. Data were processed, analyzed, and archived in SAS 9.1.3 (SAS Institute, Inc., Cary, NC), using our own purpose-designed programs. Descriptive, order-of-magnitude occurrence levels were defined as:

- “common to abundant” is more than 100 records,
- “regular” is 10–100 records, and
- “rare or accidental” is fewer than 10 records.

Seasonal distribution maps of all available data, including sightings, strandings, intentional captures, and bycatch, were created for each species using MyWorld GIS 4.0.5 (Northwestern University, Evanston, IL). Seasons were defined as:

- Winter—December, January, February;
- Spring—March, April, May;
- Summer—June, July, August;
- Fall—September, October, November;

which matches very closely with the annual cycle of monthly mean air temperatures at Block Island (Shonting and Cook, 1970).

All histograms of frequency distributions were created using the GCHART procedure in SAS/GRAPH.

2.3.2 Modeling Relative Abundance Patterns

A major issue with the interpretation of distribution and habitat-use patterns based on raw sighting and stranding data is that the patterns are usually biased by the distribution of survey coverage (“effort”). We already were aware going into this project that the data were seriously biased by the intensive whale-watching concentrated in a relatively small geographic area during a few months of the year. One method to overcome this potential bias is to quantify survey effort, and then to correct sighting frequencies for differences in effort, producing an index termed sightings-per-unit-effort (SPUE). The units are numbers of animals sighted per unit length of survey track. To standardize the SPUE data even further, the data can be limited to only a subset of the survey tracklines which meet pre-defined criteria for “acceptability.” The effort criteria can vary between studies; ours included having at least one observer formally on watch, visibility of at least 2 nautical miles (3.7 km), sea state of Beaufort class 3 or below, and altitudes below 1,200 feet (366 m, applicable only to aerial surveys). SPUE values are computed for consistent spatial units and can therefore be mapped or be statistically compared across areas, seasons, years, etc. Development of this method was begun during CETAP (1982), and it has been used in a variety of analyses (Kenney and Winn, 1986; Winn et al., 1986; Kenney, 1990; Hain et al., 1992; Shoop & Kenney, 1992; Kraus et al., 1993; DoN, 2005; Pittman et al., 2006). Because the method requires regular location and environmental data to reconstruct the survey tracks and quantify effort, only a subset of the sighting data can be included, and stranding data are entirely excluded.

The SPUE method involves partitioning the study area into a regular grid based on latitude and longitude. The grid size selected is a compromise between resolution (smaller cells) and sample sizes (larger cells), and cannot be determined without preliminary examination of the available survey data. Previous studies based on the NAWRC data have used cells ranging from 1 min X 1 min (1.9 X 1.4 km) to 10 min X 10 min (18.5 X 13.9 km). For this project we used a 5 min X 5 min grid (9.3 X 7.0 km). All acceptable aerial and shipboard survey tracks were parsed into grid cells and their lengths computed and summed by season. Sightings were similarly assigned to cells and the numbers of animals sighted were summed by cell and season. Finally, the number of animals in each cell/season was divided by the corresponding effort value, then multiplied by 1,000 to avoid small decimal values, generating a SPUE index in units of animals sighted per 1,000 km of survey track. All of this analysis was done using our own custom programs in SAS 9.1.3 (SAS Institute, Inc., Cary, NC).

Species can differ substantially in their detectability from different survey platforms, especially between aircraft and ships. For example, sea turtles are very difficult to spot from shipboard surveys (Shoop & Kenney, 1992), while harbor porpoises and minke whales are more readily sighted from a shipboard survey (Kraus et al., 1983; Kenney et al., 1997). Given a large number of cells sampled with sufficient numbers of sightings from both platform types within the same cells and seasons, it is possible to derive and incorporate a correction factor into the SPUE calculation for a single species to account for inter-platform differences, as was done for a SPUE analysis of basking sharks from Florida to Nova Scotia (Campana et al., 2008). The level of analysis required to conduct the same type of scaling separately for each of the species in the Rhode Island study was beyond the scope of the SAMP project.

It is possible to map the gridded SPUE data directly (e.g., Shoop & Kenney, 1992; Kraus et al., 1993), however the effort data and resulting SPUE data are often sparse (see Fig. 2) and can be difficult to interpret. Interpolation can smooth out the relative density contours and fill in predicted values in some un-sampled areas. Pittman et al. (2006) used inverse-distance weighting to create interpolated relative density maps. For a Navy Marine Resources Assessment (DoN, 2005), the kriging function in Spatial Analyst within the ArcGIS environment was used for that purpose (Watterson et al., in review). We used the same kriging process in ArcGIS 9.2 (ESRI, Inc, Redlands, CA) to produce interpolated GIS maps of seasonal relative densities, contoured in ten levels, for all of the species with sufficient sightings during surveys. One difference from the Watterson et al. work was that we used the elliptical search option instead of circular. Marine animal distributions are expected to be related to habitat variables, and bathymetry (water depth, bottom slope) consistently has been shown to be an important habitat parameter in defining or predicting distributions (e.g., Hui, 1979; CETAP, 1982; Kenney and Winn, 1986; Baumgartner, 1997; Hamazaki, 2002; Ferguson et al., 2006). In our restricted study area the bathymetric contours are consistently east-west, although in practicality we saw very little difference between the two search options when experimenting with them during preliminary mapping trials.

3 Results

3.1 Overview

In all, 41 species of marine mammals and sea turtles have been recorded at some time within the Rhode Island study area, including 31 cetaceans, 5 seals, 1 manatee, and 4 sea turtles (Table 1). For the mammals, this represents a substantial increase over the 15 species listed by Mearns (1900)—including 11 known to occur (9 cetaceans and 2 seals) and 4 others that might be expected (3 cetaceans and 1 seal) (Table 1). There were just over 8,000 records in total for the study area (N = 8,010). Sixteen species are classified as common, six as regular, and eighteen as rare; and one species was known to have occurred historically but is now extinct. Five other cetaceans, all delphinids—pygmy killer whale (*Feresa attenuata*), melon-headed whale (*Peponocephala electra*), rough-toothed dolphin (*Steno attenuata*), spinner dolphin (*Stenella longirostris*), and Clymene dolphin (*Stenella clymene*); two pinnipeds—bearded seal (*Erignathus barbatus*) and walrus (*Odobenus rosmarus*); and one hard-shelled sea turtle—hawksbill sea turtle (*Eretmochelys imbricata*) might be considered as hypothetical species with the remote potential to occur in the region at some time, based on known occurrences off the U.S. East

Table 1. Marine mammals and sea turtles of the Rhode Island region, showing the total numbers of records, occurrence classification, and whether included as known to occur in the state (X) or possible to occur (?) by Mearns (1900).

Species	N	Occurrence	Mearns
Class Mammalia			
Order Cetacea – whales, dolphins, and porpoises			
Suborder Mysticeti – baleen whales			
Family Balaenidae – right whales			
North Atlantic right whale	156	common	X
Family Eschrichtiidae – gray whales			
Gray whale	1	extinct	
Family Balaenopteridae – rorquals			
Humpback whale	611	common	
Blue whale	5	rare	
Fin whale	1,762	common	X
Sei whale	35	regular	
Bryde’s whale	2	rare	
Common minke whale	504	common	
Suborder Odontoceti – toothed whales			
Family Physeteridae – sperm whales			
Sperm whale	103	common	X
Family Kogiidae – pygmy and dwarf sperm whales			
Pygmy sperm whale	26	regular	
Dwarf sperm whale	2	rare?*	
Family Ziphiidae – beaked whales			
Northern bottlenose whale	2	rare	X
Cuvier’s beaked whale	4	rare	
Blainville’s beaked whale	3	rare	
Gervais’ beaked whale	1	rare	
Sowerby’s beaked whale	2	rare	
True’s beaked whale	2	rare	
Family Monodontidae – beluga and narwhal			
Beluga whale	4	rare	X
Family Phocoenidae – porpoises			
Harbor porpoise	374	common	X
Family Delphinidae – dolphins			
Long-finned pilot whale	43	common*	X
Short-finned pilot whale	1	rare*	
Killer whale	7	rare	?
False killer whale	9	rare	
Pygmy killer whale	0	hypothetical	
Melon-headed whale	0	hypothetical	
Risso’s dolphin	208	common	?
Rough-toothed dolphin	0	hypothetical	
Atlantic white-sided dolphin	210	common	?
White-beaked dolphin	11	regular	
Common bottlenose dolphin	182	common	X

Table 1. (continued)

Species	N	Occurrence	Mearns
Short-beaked common dolphin	435	common	X
Striped dolphin	41	regular	
Atlantic spotted dolphin	3	rare	
Pan-tropical spotted dolphin	3	rare	
Spinner dolphin	0	hypothetical	
Clymene dolphin	0	hypothetical	
Order Carnivora – carnivores			
Suborder Caniformia – doglike carnivores			
Superfamily Pinnipedia – seals, sea lions, fur seals, and walrus			
Family Phocidae – seals			
Harbor seal	507	common	X
Gray seal	193	common	
Harp seal	703	common	X
Hooded seal	97	regular	?
Ringed seal	1	rare	
Bearded seal	0	hypothetical	
Family Odobenidae – walrus			
Walrus	0	hypothetical	
Order Sirenia – sea cows			
Family Trichechidae – manatees			
West Indian manatee	4	rare	
Class Reptilia			
Order Testudines – turtles			
Family Dermochelyidae – leatherback sea turtle			
Leatherback sea turtle	142	common	
Family Cheloniidae – hard-shelled sea turtles			
Loggerhead sea turtle	233	common	
Kemp's ridley sea turtle	14	regular	
Green sea turtle	1	rare	
Hawksbill sea turtle	0	hypothetical	

*Some species, particularly those that are difficult to identify, are known or suspected to be more abundant than is shown by the number of records alone; see the individual species accounts for details.

Coast. The hypothetical species are included in Table 1 for the sake of completeness, but are not addressed in the remainder of this report.

Out of the total sighting, stranding, and bycatch records, 1,141 or 14% were unidentified. The unidentified categories covered a wide range of observer certainty. Some were as narrow as "fin or sei whale," "Atlantic spotted or bottlenose dolphin," or "*Stenella* sp." On the other end of the scale, some were as broad as "unidentified whale," "unidentified dolphin/porpoise," "unidentified seal," or "unidentified turtle." These unidentified records have not been included in our analyses, with two exceptions. (1) Sightings identified as "unidentified fin or sei whale" were counted in the SPUE analysis, assuming a 97.8% likelihood of being a fin whale and 2.2% likelihood of being a sei whale—based on the proportions of identified sightings. This worked for fin whales, but not for sei whales. (2) Unidentified seal sightings were combined with harbor seal and gray seal sightings in one SPUE model because they represented a substantial majority of the seal sightings during surveys.

Survey coverage varied between seasons (Fig. 2). Non-zero effort values were classified into ten categories from lowest to highest, and mapped by the 5x5-minute grids without interpolation. Coverage was essentially complete in spring, and relatively complete in the other four seasons—with the fewest holes in fall, followed by summer and winter. Except for winter, the most intense survey coverage was consistently in the region east of Cape Cod and Nantucket, a known right whale habitat that has been surveyed every year since 1979 except for several years in the1990s. Cape Cod Bay, another right whale habitat, had high effort in all seasons. Survey intensity south of New England has been consistently lower. Only in spring was there high survey effort within the Ocean SAMP study area. Effort in the SAMP area was moderate during summer, and somewhat lower and about equivalent in both fall and winter.

Strandings, excluding intentional captures in the pre-1993 Smithsonian data as much as possible, are summarized in Table 2. The total number was 1,803, with 1,763 since 1970. In terms of stranding frequencies, the four species of seals are at the top of the list. Note that the comparisons between species are not entirely consistent, since seals were not included in the pre-1993 data obtained from the Smithsonian and we were unable to obtain a copy of the sea turtle stranding dataset. Additionally, we do not have the complete stranding dataset for Massachusetts, but that is consistent across all the marine mammals. Finally, identifying stranding records from electronic databases (other than the NMFS stranding network data) is not always simple, since live strandings might not be categorized the same as dead animals on the beach or floating in the water. Each dataset has its own unique formats and codes. The historical stranding data also may be complicated by capture records, and some strandings during the whaling era may actually have been animals harpooned by whalers but not recovered. Identifying strandings often required manual verification of the records, assuming that sufficient information was included. It is quite likely that a few records are mis-classified one way or the other.

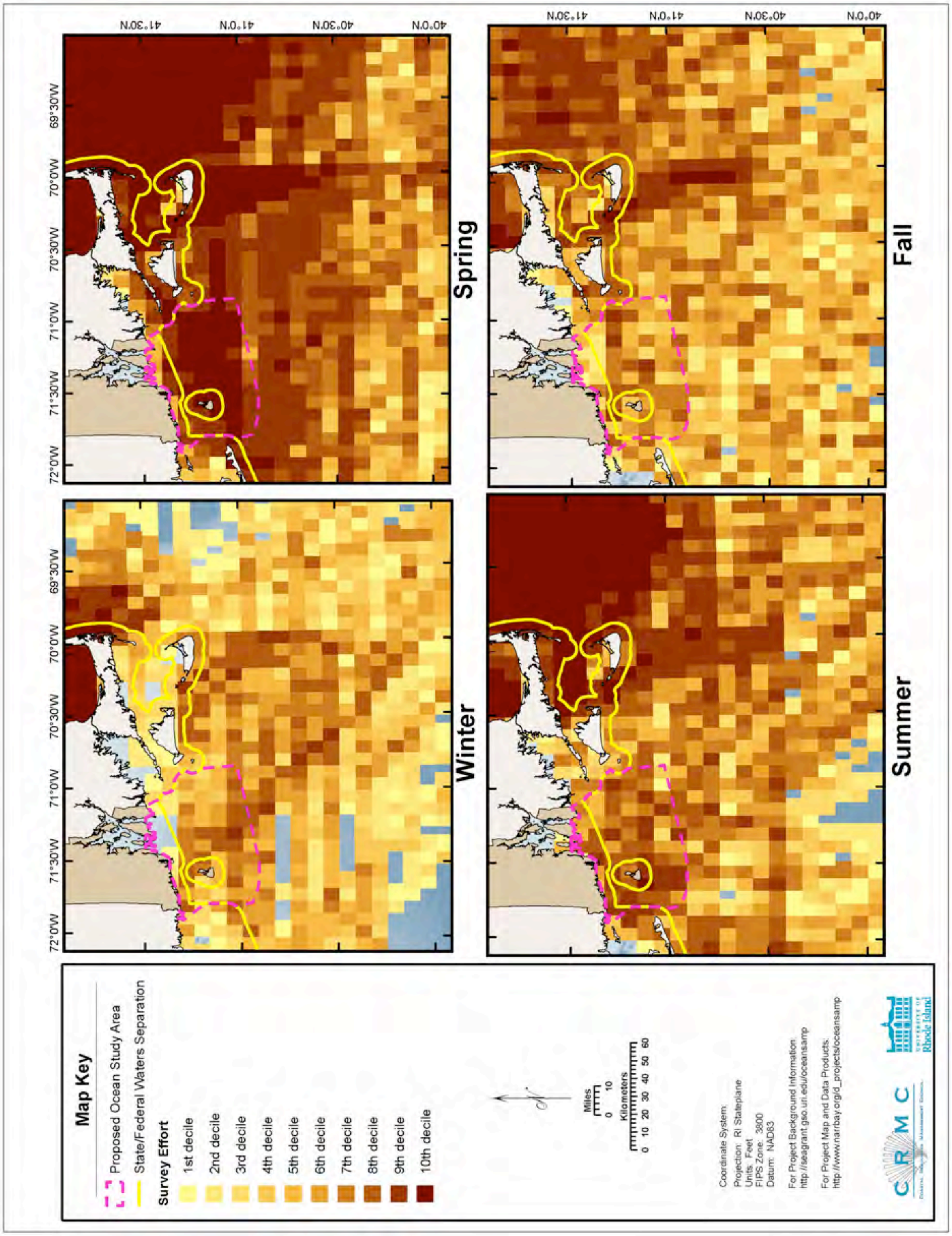

Figure 2. Seasonal summary maps of combined aerial and shipboard survey effort, in km of trackline per 5-minute grid cell.

Table 2. Stranding frequencies for marine mammals and sea turtles in the Rhode Island study area, for all years combined and for 1970–2005 only, in descending order of occurrence in the recent data.

Species	All Years	1970–2005
Harp seal	688	688
Harbor seal	446	446
Gray seal	155	155
Hooded seal	96	96
Harbor porpoise	87	83
Short-beaked common dolphin	71	68
Long-finned pilot whale	35	34
Common minke whale	31	29
Fin whale	39	28
Striped dolphin	27	25
Atlantic white-sided dolphin	21	21
Common bottlenose dolphin	23	18
Pygmy sperm whale	17	17
Humpback whale	17	16
Risso’s dolphin	13	13
North Atlantic right whale	7	5
Globicephala sp.	4	4
Sperm whale	4	2
Blainville’s beaked whale	3	2
Dwarf sperm whale	2	2
White-beaked dolphin	2	2
Blue whale	2	1
True’s beaked whale	2	1
Pan-tropical spotted dolphin	2	1
Kogia sp.	1	1
Gervais’ beaked whale	1	1
Beluga	1	1
Short-finned pilot whale	1	1
Atlantic spotted dolphin	1	1
Cuvier’s beaked whale	2	0
Northern bottlenose whale	1	0
Killer whale	1	0

3.2 Species Accounts

The following section includes species accounts for the forty species classified as common, regular, or rare in Table 1, plus an abbreviated account for the extinct North Atlantic gray whale population. Rather than include separate sections for higher-level taxa (families, orders, etc.), very brief summaries are included within the accounts for the first species in that taxon. There are four cases (i.e., pygmy and dwarf sperm whales, six species of beaked whales, long-finned and short-finned pilot whales, and Atlantic spotted and pan-tropical spotted dolphins) where the species are difficult or impossible to differentiate in the field, with the result that much of the available information is for all species combined. In those cases, one species account combining all of the species is presented, including species-specific information where available. Each species account includes the seven sections and primary sources outlined below. The extent of the information that is included for any particular species tends to be proportional to a combination of three factors—the species' regional abundance, management concerns or the significance of potential threats to the species, and the likelihood of it being present in or near the SAMP study area:

Description: a brief description of the species characteristics, mainly based on Wynne & Schwartz (1999) and Jefferson et al. (1993).

Status: Current status of a species or population under the U.S. Endangered Species Act[4] was obtained from USFWS (2009). Rhode Island state status[5] is as shown in *Rare Native Animals of Rhode Island* (RIDEM, 2006). International status[6] is as shown on *The IUCN Red List of Threatened Species* (IUCN, 2008). Current estimates of abundance of the population that occurs in the Rhode Island study area were based on the most recently published edition (2007) of the NMFS marine mammal stock assessment report (SAR: Waring et al., 2008) that was available at the time this report was first written. Note that: (1) The SAR abundance estimate may not cover the entire range of a population, so it may only be relevant to the portion of the range off the U.S. East Coast. If estimates are available for wider areas from the literature or other sources, they will also be included. (2) The SAR is updated annually and consequently the numbers are always subject to change. For example, the draft 2008 edition has been released for public review and comment, and should be published in final form soon (Note: it was officially released on 29 April 2009, however the estimates and citations in this report have not been updated; many did not change). (3) The current SAR, all previous editions, and the draft of the next edition, once released for comment, are all available on the NMFS Office of Protected Resources web page

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[4] Categories, in decreasing order, are Endangered, Threatened, or Candidate (i.e., proposed for listing).

[5] Categories are Federally Endangered, Federally Threatened, State Endangered, State Threatened, Concern, and State Historical (i.e., extirpated).

[6] Categories are Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, and Data Deficient.

(http://www.nmfs.noaa.gov/pr/sars/). (4) The SAR does not include sea turtles, as there is no statute equivalent to the MMPA that mandates annually updated reviews of abundance and mortality. The SAR is also the source for estimates of human-caused mortality to marine mammal populations, which are presented as 5-year averages (2001–2005 in the 2007 edition). Other conservation and management issues are summarized from the SAR and other sources.

Ecology and life history: a summary of information on biology, feeding, reproduction, etc., focusing on aspects relevant to habitat use and/or occurrence in the Rhode Island study area.

General distribution: a description of the species' distribution pattern, world-wide and in the North Atlantic.

Historical occurrence: details of known occurrences prior to the early or mid-1970s (i.e., before passage of the MMPA and ESA) in Rhode Island, in the Rhode Island study area, and in nearby areas of southern New England. These are based primarily on the records included in the data obtained from the Smithsonian, although many of those records were originally obtained from published literature.

Recent occurrence: This section will present the details of the analyses conducted specifically for this report. Each species (or species complex for those which were combined) account will include seasonal maps of the combined sighting, stranding, and bycatch records. For species with sufficient sightings in the survey data, there will also be seasonal maps of the effort-corrected relative abundance model outputs. Any analyses of recent trends within the study area will also be addressed here.

Conclusions: a summary of any information and details about species occurrence that are particularly relevant to the Rhode Island Ocean SAMP. See also Section 4, Recommendations, for a ranked list of species in the area prioritized by conservation concerns.

3.2.1 North Atlantic Right Whale *Eubalaena glacialis* (Müller 1776)

Cetacea includes 14 families and approximately 90 species world-wide, with 8 families and 30 species confirmed as occurring within the Rhode Island study area and 1 more extinct species in another family. Cetaceans are fully aquatic; their dramatic modifications for life in the water have obscured their evolutionary relationships to hoofed mammals (Barnes, 2002a). The body is more or less fusiform and covered by smooth, hairless skin; they are insulated by a layer of blubber. The hind limbs have been lost, and the forelimbs have been simplified into paddle-like flippers. Swimming is powered by the tail, which is modified into a horizontal pair of "flukes" that are supported only by stiff connective tissue. The external nostrils have migrated to the top of the head.

Baleen whales (Mysticeti) are a suborder of Cetacea. They are readily distinguished from Odontoceti (toothed whales) by having baleen instead of teeth, two nostrils ("blowholes") rather than one, and a variety of skeletal features (Bannister, 2002; Hooker, 2002; Rommel and Reynolds, 2002; Rommel et al., 2002). Baleen consists of hundreds of keratin plates that grow down from the palate (Pivorunas, 1976, 1979; St. Aubin et al., 1984; Rice, 2002). The plates are oriented perpendicular to the body axis and set in two rows along the sides of the palate. They grow continuously, and the inner edges separate into fibers that are used for filtering prey from the water. The number, size, shape, and color of the plates and the color and diameter of the fibers are species-specific characteristics, and the plate spacing and fiber diameter are correlated with the size range of prey that can be filtered. Mysticetes and odontocetes also differ significantly in sociality and associated life history characteristics (Tyack, 1986). Mysticetes are largely asocial and do not form stable groups, while most odontocetes live in permanent herds (or "pods").

The family Balaenidae includes three species of right whales, in the North Atlantic, North Pacific, and Southern Ocean (Rosenbaum et al., 2000; Kenney, 2009), plus the bowhead whale, an Arctic species that does occur in the northernmost extremes of the North Atlantic (Reeves and Leatherwood, 1985; Rugh and Shelden, 2002). Balaenids are characterized by rotund bodies with thick blubber layers, relatively large heads with strongly bowed skulls, absence of a dorsal fin, and forelimbs that retain all five digits (Kenney, 2009; Rugh and Shelden, 2002; Reeves and Kenney, 2003). The baleen plates of balaenids are long, narrow, and flexible with very fine fringing hairs, and they feed on smaller prey organisms than other baleen whales (Nemoto 1970).

Description: North Atlantic right whale adults are 11–17 m long, with a maximum recorded length of 18 m (Cummings, 1985b; Jefferson et al., 1993; Wynne and Schwartz, 1999). Females are slightly larger than males. Calves are about 4.5 m in length and 800 kg in weight at birth. The body is very robust, with girth frequently exceeding half or even three-quarters of body length.

The back is very broad and smooth, with no dorsal fin. The color is usually black, and some animals have irregular white patches on the belly. The head is relatively large, comprising about a quarter or third of the body length. The top of the head in front of the blowholes (the rostrum) is narrow and arched, and the curve of the mouth opening is very strongly arched. There are irregular whitish patches called "callosities" on the rostrum, on the chin, along the lower jaw, and over the eye, usually behind the blowholes, and sometimes on the lower lips. The callosities are patches of thickened, keratinized skin inhabited by dense populations of light-colored whale lice (Payne and Dorsey, 1983). The callosity patterns are individually distinctive and used for photographic identification of individuals (Payne et al., 1983; Kraus et al., 1986). The flippers are large (up to 1.7 m long) and squarish. The flukes are broad (up to 6 m across), black on both surfaces, and tapered to points with a smooth trailing edge and deep central notch. Right whale baleen plates are mostly dark gray to black and are relatively long and narrow (Nemoto, 1970; Pivorunas, 1979). The maximum length is 2.7 m, with the longest plates in the middle of the row (see Figs 21.3 and 21.5 in Reeves and Kenney, 2003). There are 200–270 plates in each row (Jefferson et al., 1993; Wynne and Schwartz, 1999). The fringing hairs are very fine, about the same thickness as human hair (Mayo et al., 2001).

Status: North Atlantic right whales are listed as Endangered under the U.S. Endangered Species Act, as Federally Endangered on the Rhode Island state list, and as Endangered on the IUCN Red List. They are considered to be one of the most imperiled mammals in the world (Clapham et al., 1999). The most recent SAR gives the minimum number known to be alive in the population in 2002 as 313, but work in progress shows the number to have increased to at least 345 in 2005 (Kenney et al., in preparation), and the current population is probably around 400 animals (NARWC, 2007).

North Atlantic right whales were the first targets of commercial whaling, beginning along the Bay of Biscay in about the 11th century (Aguilar, 1986). By the 16th century, right whaling had expanded throughout the North Atlantic (Barkham, 1984). Along the south shore of Long Island, a shore-based fishery for right whales operated from 1650 to 1924 (reviewed by Reeves and Mitchell, 1986), although the last whale landed was in 1918. At least 550 whales were taken over that period, although records before 1820 are incomplete and certainly underestimate the actual catch. The highest estimated catch in one year was 111 whales in 1707, and the total take over the entire period likely exceeded 2,000 animals. Right whales have been protected from commercial whaling since the first International Convention for the Regulation of Whaling was ratified in 1935 (Hain, 1975). Only six have been intentionally killed in the North Atlantic since that time (Moore, 1953; Brown, 1986; Mitchell et al., 1986).

Substantial anthropogenic mortality on North Atlantic right whales is continuing, and is suspected to be retarding recovery of the population (Kraus, 1990; Kenney and Kraus, 1993; IWC, 2001; Knowlton and Kraus, 2001; Laist et al., 2001; Kraus et al., 2005). The two most significant sources of mortality are collisions with ships and entanglement in commercial fishing gear. The average annual mortality in the western North Atlantic population during 2001–2005 was estimated as 1.4 killed by entanglement and 1.8 by ship strikes. A Take Reduction Plan is in effect to reduce fishery-related mortality, including closures and gear modification, with additional regulations due to take effect in April 2009 and others to be considered in the near future. A management regime to reduce mortalities from ship strikes, which includes limiting ship speed to 10 knots within 20 nautical miles of mid-Atlantic ports during right whale migration periods, took effect in December 2008. Other hypothesized anthropogenic impacts on right whales include toxic contaminants, habitat loss, and global climate change (Reeves et al., 2001a; Kenney, 2007).

Ecology and life history: Right whales in all oceans are strongly migratory, moving annually between high-latitude feeding grounds and low-latitude calving and breeding grounds (Cummings, 1985b; Kenney, 2009). The known feeding grounds in the North Atlantic are in the Gulf of Maine and adjacent waters, and the calving ground is in coastal waters off Florida and Georgia, but the location of breeding is unknown (Winn et al., 1986). Given the timing of births in winter and the 12–13 month gestation period, mating most likely occurs in November-January, when most adult males and non-calving adult females are absent from all known habitats (Winn et al. 1986, Brown et al. 2001).

Feeding by right whales is accomplished by “skimming” (Nemoto, 1970; Pivorunas, 1979), and the anatomy of the head, mouth, and baleen apparatus are all adapted to skim-feeding (Baumgartner et al., 2007). They feed by simply swimming forward with the mouth open. Water flows in through the opening at the front—below the rostrum, above and around the tongue, and between the two rows of baleen. Water then passes laterally through the baleen filter, straining prey organisms from the water and collecting them on the inside. The structure of the mouth appears to develop a pattern of pressure gradients that maintains smooth water flow through the baleen. Feeding can occur at or just below the surface (Watkins and Schevill, 1976, 1979; Mayo and Marx, 1990), where it can be observed easily, or more often at depth and out sight (Murison and Gaskin, 1989, Kenney et al., 1995; Nowacek et al., 2001; Baumgartner and Mate, 2003; Baumgartner et al., 2003a, 2003b, 2007). Typical feeding dives last for 10–20 minutes (Winn et al.; 1995).

Right whales are obligate planktivores, with the principal prey in the North Atlantic being large, late-stage juveniles and adults of the copepod *Calanus finmarchicus* (crustaceans approximately the size of a grain of rice). At times they also feed on other zooplankton, including smaller copepods, euphausiids ("krill"), barnacle larvae, and pteropods (Collett, 1909; Nemoto, 1970; Watkins and Schevill, 1976; Mayo and Marx, 1990). They can probably be somewhat opportunistic, feeding on any prey of a size that can be filtered efficiently by the baleen, which does not swim strongly enough to escape, and which is concentrated into sufficiently dense patches to trigger feeding behavior. On the other hand, they can also be considered as extremely specialized predators occupying a very narrow niche. The sizes of predator and prey differ by a factor of 50 billion, consequently right whales can feed successfully only in areas where their prey are aggregated into extremely dense concentrations (Kenney et al. 1986, 1995; Wishner et al. 1988, 1995; Kenney and Wishner 1995; Baumgartner et al., 2007). Studies of right whale feeding grounds have shown that prey aggregations result from a combination of bottom topography, water column structure and stratification, currents, and prey behavior (Kenney et al. 1986, 1995; Wishner et al. 1988, 1995; Murison and Gaskin, 1989; Kenney and Wishner, 1995; Beardsley et al., 1996). The sensory mechanisms involved in prey detection and foraging probably include at least sight and touch, if not also sound and possibly taste (Kenney et al., 2001).

Female right whales give birth to single calves in winter; most births are in December–February in the western North Atlantic, peaking in early January (Kraus et al., 1993, 2001; Knowlton et al., 1994). The gestation period of southern right whales is approximately 12–13 months (Best, 1994); mostly likely the same holds for North Atlantic and North Pacific right whales. Most calves are probably weaned toward the end of their first year of life (Hamilton et al., 1995, Burnell, 2001). Following weaning, the female typically takes a year to "rest"—feeding and rebuilding blubber stores before mating the following winter. The result is a 3-year interbirth interval under good conditions with adequate prey resources available. Calving intervals in southern right whales are generally 3–4 years (Best, 1990; R. Payne et al., 1990; Burnell, 2001, Cooke et al., 2001). The same was true of North Atlantic right whales until the early 1990s (Knowlton et al., 1994), but the average calving interval in the North Atlantic population increased to over 5 years by 2000 (Kraus et al., 2001), then returned to a predominance of 3-year intervals by 2004–2005 (Kraus et al., 2007). Environmentally driven interannual variability in prey resources appears to underlie the marked variability in calving success (Greene et al., 2003; Greene and Pershing, 2004; Kenney, 2007).

General distribution: North Atlantic right whales historically were widespread in continental shelf waters from subtropical to cold regions on both sides of the North Atlantic (Cummings, 1985b), but have been greatly reduced in number and range by centuries of whaling. Their original range extended from Florida and northwestern Africa north to the Gulf of Maine, Newfoundland, Labrador, Greenland, Iceland, the British Isles, and Norway (Kenney, 2009; Reeves and Kenney, 2003). The remnant population in the western North Atlantic occurs primarily between northeastern Florida and the Gulf of Maine region (Winn et al., 1986; Kenney et al., 2001). There is an annual migratory pattern from winter calving grounds in the nearshore waters off Florida and Georgia to feeding grounds in Cape Cod Bay (late winter-early spring), in the Great South Channel east of Cape Cod (late spring-early summer), and in the Bay of Fundy and Roseway Basin near Nova Scotia (late summer-fall). Other than the calving ground, habitat use during the winter is very poorly known. Migratory pathways between the calving/wintering and feeding areas are also poorly known. Other habitats in the Gulf of Maine also constitute feeding grounds in some years, and animals are occasionally observed in distant areas including deeper waters beyond the shelf edge, Gulf of Mexico, Gulf of St. Lawrence, Greenland, Iceland, Norway, and southwestern Europe (Reeves et al., 1978; Winn et al., 1986; Lien et al., 1989; Martin and Walker, 1997; Mate et al., 1997; Slay and Kraus, 1998; Knowlton et al., 1992; Jacobsen et al., 2004).

Historical occurrence: The Smithsonian data included four historical records from Rhode Island, three of which were extracted from Allen (1916). In February 1828, “a Right Whale forty-four feet long, and rated at about seventy barrels of oil, was killed in the waters off Providence, R.I., after having been seen for several days ‘sporting in our river’.” “1893.—Major E.A. Mearns furnishes me with a note of what was said to have been a Right Whale, about 50 feet in length, that was stranded on Ochre Point, Newport, R.I. The blubber had already been removed by one Mr. Church at Tiverton, where the whale had been killed. The carcass was finally sunk at sea by order of the City Council. The exact date is not available." Although this is an extreme example, it should be noted that there is some probability that any stranding during the whaling era was actually killed by whalers but not recovered ("struck and lost" in whaling statistics). "1894.—Major Mearns also sends me the record of a Right Whale that appeared off Beaver Tail, Conanicut Island, R.I., in this year. It finally was sighted off Fort Adams, where it was shot and killed (exact date unknown). He adds that Mr. Joshua P. Clark, formerly in charge of the Life Saving Station at Watch Hill, R.I., told him that Right Whales have been seen off Block Island in more recent years, although the most part of the whales seen in those waters are Finbacks." The single non-Allen record is a specimen record from the Academy of Natural Sciences of Philadelphia (ANSP3227)—right whale skull fragments from Rhode Island from November 1857. Cronan and Brooks (1968) reported the same three records as Allen, but knew of no others.

The records of the Long Island right whale fishery clearly reflect what is known about the migratory pattern of the population (Reeves and Mitchell, 1986). Both De Kay (1842) and Connor (1971) were very aware of the Long Island right whale fishery, and it was their principal source of information for the species. Most of the kills occurred in winter and early spring, from January through May with a peak in April, and included a high proportion of mothers and calves. The fishery was primarily targeting northbound animals during the spring migration. The Smithsonian dataset included more than 50 records from the whalers in eastern Long Island, dating back to 1707 (although no effort was expended to geolocate all of those old records for mapping). The AMNH has a mounted skeleton that was originally collected from Amagansett whalers on 22 February 1907 by Roy Chapman Andrews (Andrews, 1908, 1909, 1916). That individual, at 16.5 m, is the largest right whale known from the western North Atlantic and the second largest from the entire North Atlantic.

Allen (1916) also included large numbers of right whale records from Cape Cod, Nantucket, and Martha's Vineyard in Massachusetts, as well as Long Island, from 1620 to the early 20th Century. His summary of the annual cycle of right whale occurrence in Massachusetts waters closely mirrors the pattern seen in the last 40 years. Waters and Rivard (1962) tabulated sightings of "schools" of right whales in Cape Cod Bay in 1955, May 1958, May 1959, and May 1960, three off Martha's Vineyard in April 1956, one in the Cape Cod Canal in June 1957, and one in Plymouth Harbor "chasing herring" in May 1958, as well as a stranding of a right whale in Nantucket in June 1961—killed by a ship collision. Their description is a good example of their mix of recent observations and unsupported conjecture—"a herd of forty to fifty may be seen each May in Cape Cod Bay. From June to October they are in the waters off Labrador and Greenland, and the return to warm, southern waters, by way of the Gulf Stream without stopping off in Cape Cod Bay, takes place in October and November."

Recent occurrence: North Atlantic right whales have occurred in the Rhode Island study area in all seasons of the year (Fig. 3[7]). They are most common in spring (58.3%), less common in winter (19.2%) and summer (16.0%), and relatively scarce in fall (4.5%). There were only 14 sightings from the various whale-watch boats, so there is not a substantial bias in the seasonal patterns; without those data the respective percentages are 62.0% spring, 21.1% winter, 10.6% summer, and 4.2% fall. Right whale occurrence in the region is consistent with both the historical record from the Long Island fishery (Reeves and Mitchell, 1986) and their known annual migratory cycle (Winn et al., 1986). Animals in this region are mainly migrating between winter calving grounds in the southeastern U.S. and feeding grounds in and around the Gulf of Maine. Winn et al. (1986) hypothesized that the southbound migration in fall was more diffuse and farther offshore than the spring migration. Additionally, traveling whales are believed to have a reduced probability of detection (Hain et al., 1999), therefore their presence in the region may be greater than apparent from the full sighting record.

Sightings in the Rhode Island study area tend to be concentrated relatively close to shore. Knowlton et al. (2002) reported that 94% of all right whale sightings between South Carolina and Nantucket were within 55.6 km (30 nautical miles) of the coastline and 64% were within 18.5 km (10 nautical miles). Some of that pattern is caused by the concentration of observers closer to shore. The proportion of sightings close to shore is significantly higher south of Cape Hatteras, North Carolina than to the north. One might hypothesize that northward migrating right

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[7] Notes for all maps of this type: (1) the maps are Mercator projections with boundaries at: east = 70°00'W, west = 73°00'W, south = 39°30'N, north = 42°06'N; (2) records within Cape Cod Bay were excluded; (3) the pink outline shows the SAMP area and the yellow line shows the state waters boundary; (4) the same color code for seasons (winter = blue, spring = green, summer = red, fall = brown, unknown = black) is used whether the seasons are plotted on four separate maps or combined on one; (5) records with unknown season could not be classified because month was missing and are shown only for species with one combined map; (6) although the complete dataset may go back to the 17th or 18th Century for some species, the vast majority of records are from the 1970s and later.

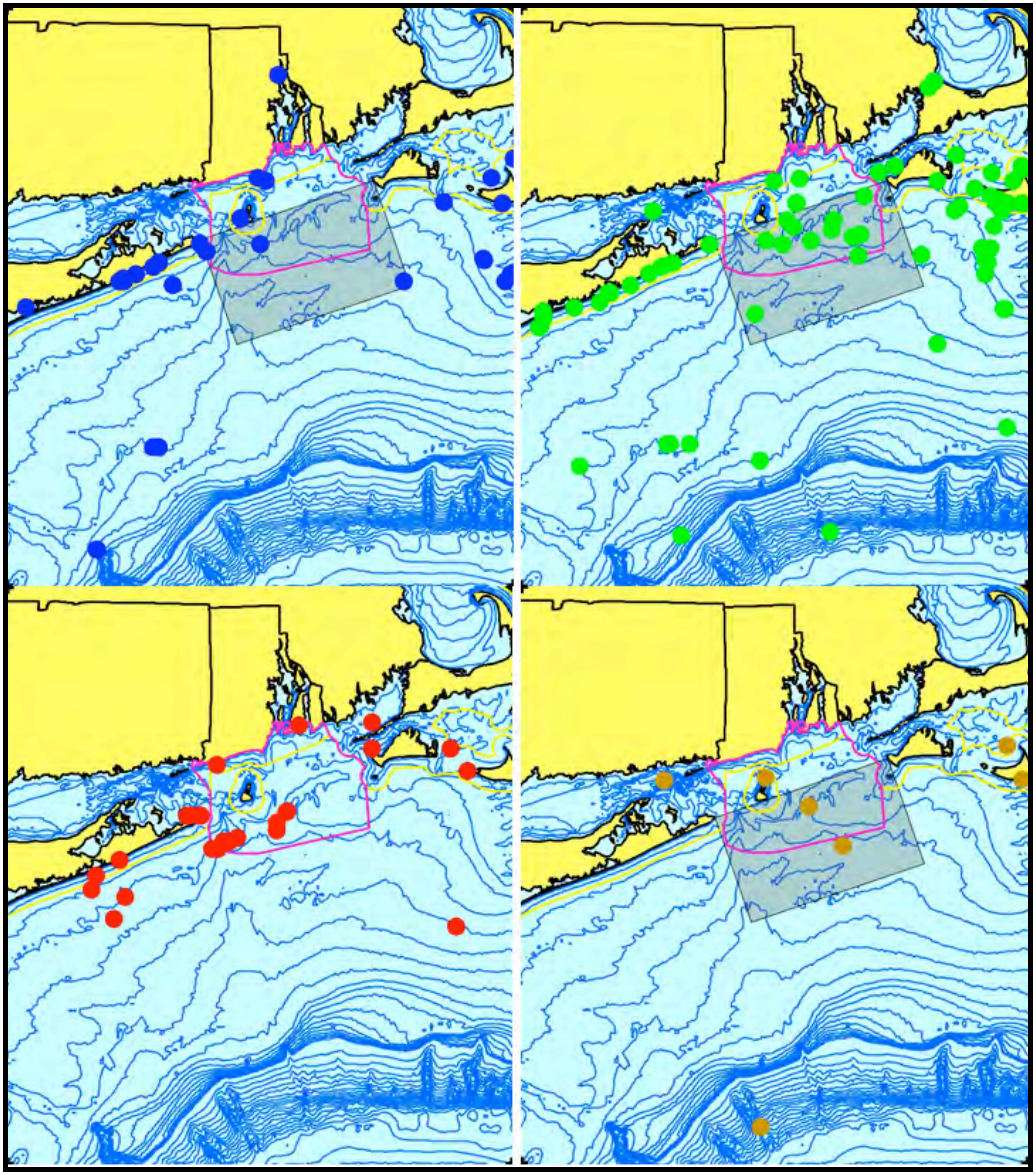

Figure 3. Aggregated sighting, stranding, and bycatch records of North Atlantic right whales in the Rhode Island study area, 1828–2007 (n = 156: winter = 30, spring = 91, summer = 25, fall = 7; unknown = 3). The gray-shaded box is the Block Island Sound Seasonal Management Area, in effect from November through April (see Conclusions).

whales in late winter and spring travel along shore until reaching Cape Hatteras, after which they spread out more, with some continuing to follow the coast while others take a more direct route towards Massachusetts. Right whales in the Rhode Island study area seem to show that pattern, with the majority of records in a band relatively close to shore, but others that are more offshore and may be on a migratory pathway between Cape Hatteras and the Great South Channel. Within the SAMP area, most right whales appear to remain in the offshore part of the area.

The relative abundance patterns resulting from kriging the 5-minute X 5-minute gridded SPUE data, corrected for survey effort, show right whales in or near the Rhode Island study area in all four seasons, but in the SAMP area only in spring and fall (Fig. 4). This is consistent with their known migratory cycle. Relative abundance in the SAMP area in both spring and fall is in the lowest class. The highest relative abundance of right whales in the area analyzed was in the Great South Channel east of Nantucket in spring and summer, which matches the known population distribution (Winn et al., 1986; Kenney et al., 1995, 2001). They were present at the lowest level of abundance south of Nantucket in winter and summer, and at the second-lowest level in spring.

Feeding by right whales is occasionally observed in the Rhode Island region, but is likely an opportunistic response to relatively rare occurrences of appropriate prey patches. An aggregation of feeding right whales that persisted for about two weeks was seen just east of Block Island in April 1998. The whales were first seen by fishermen, who reported their observations to the RI Division of Fish & Wildlife, who then passed on the reports to NMFS. NMFS directed their aerial surveys to investigate on 14, 19, and 21 April. On the 19th at least 16 whales were present and observed to be feeding at and just below the surface. To date 11 have been matched to the right whale catalog—mostly males (8) and ranging in age from 2-year-olds to adults. One other whale (an adult female) was identified from the photos (not dated) submitted by RIDFW. The NMFS crew photographed seven animals on the 14th and four have been identified—all different ones (3 adult males and 1 adult female). Five of the six whales they photographed on the 21st have been identified; three were resightings from the 19th and two were new—an adult male and a 2-year-old male. Eighteen different whales were identified in all, but the low rate of resightings suggests that substantially more than 18 whales were feeding in Rhode Island Sound in April 1998. (NOTE: This phenomenon occurred in the very first year of the NMFS aerial survey program, and they did not yet have complete and effective data collection protocols in

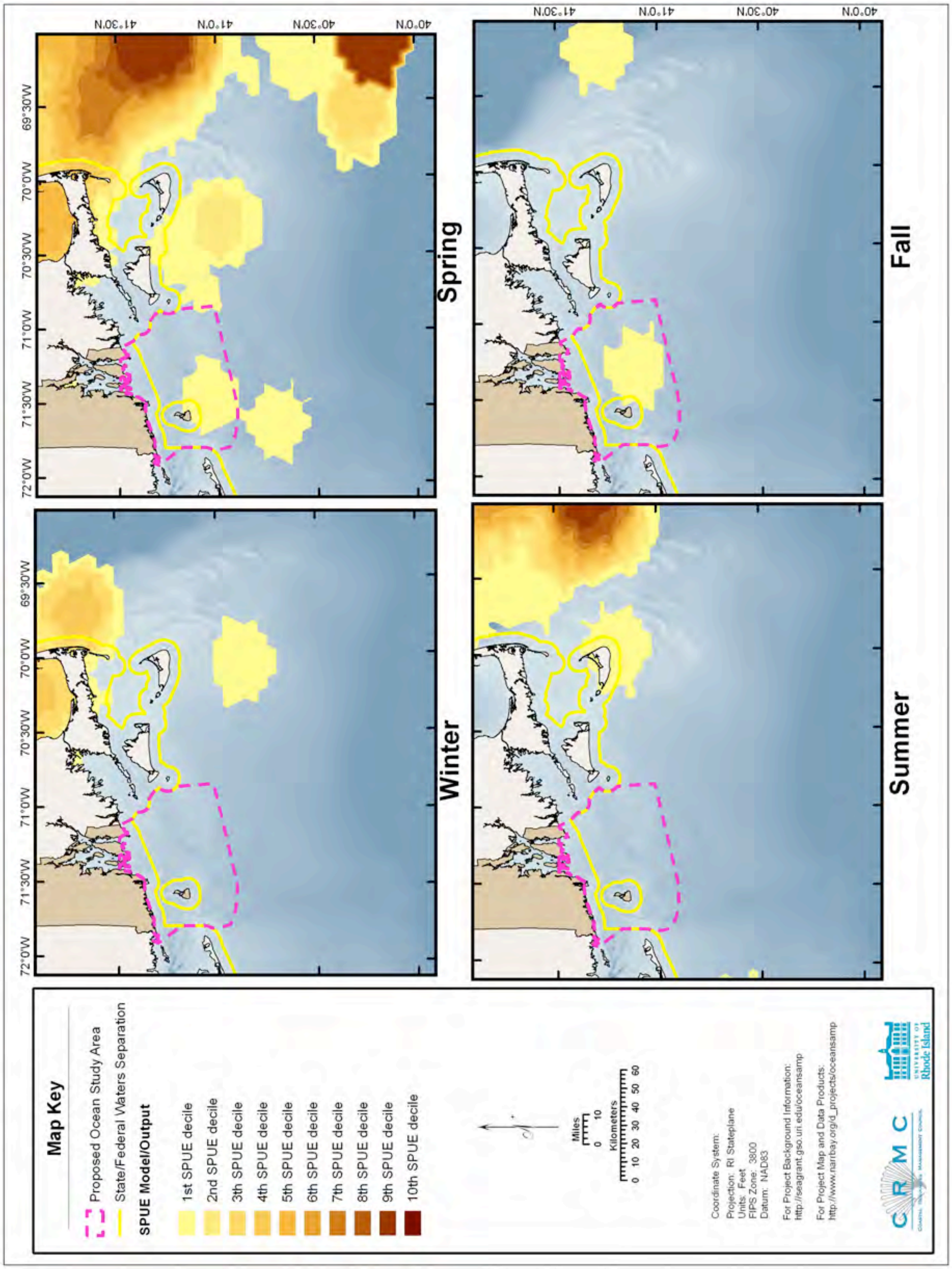

Figure 4. Modeled seasonal relative abundance patterns of North Atlantic right whales in the Rhode Island study area, corrected for uneven survey effort.

place. Therefore, the data are included in the sightings shown in Fig. 3, but could not be included in the analysis shown in Fig. 4.) (NOTE: On 20 April 2010, while this report was being finalized, 98 right whales, with many observed to be feeding at or near the surface, were reported in or near Rhode Island Sound by a NMFS aerial survey. These sightings have not been included in either Fig. 3 or Fig. 4).

There were five strandings in the Rhode Island study area in recent decades. A freshly dead animal washed ashore, with the tail severed by a ship collision, at Wainscott, New York on 5 March 1979; it was not identified as a known individual. A dead 10.0-m right whale stranded on Second Beach in Middletown on 17 July 1995 with multiple wraps of rope around one flipper, deeply embedded, even into the bone. It was eventually identified as a 2.5-year-old male (catalog #2366). It was first seen entangled as a 1-year-old off Georgia in December 1993. The entanglement appeared relatively benign, but as the whale grew the wraps became much tighter, eventually causing a massive systemic infection that led to the animal's death. A 3-year-old female (catalog #2701) was found floating dead 15–18 km southeast of Block Island on 19 January 2000. The carcass could not be retrieved and the cause of death was never determined, although there was fishing gear or rope on the animal. A 1-year-old female (#3107) washed ashore on Nantucket on 12 October 2002, but high surf prevented a necropsy until the 14th. It had first been seen entangled in what was probably inshore lobster gear near Brier Island, Nova Scotia, on 6 July. The gear was removed on a September in the Bay of Fundy, leaving severe lacerations on the tailstock. The whale likely succumbed to infection from the injuries. A NMFS aerial survey on 13 May 2005 sighted a dead right whale 39 km south of Martha's Vineyard, which was never recovered or identified. There was an additional record in 2006 that was not in the stranding data and has yet to be added to the NARWC database; a dead right whale was located on 21 May 2006 floating 56 km south of Block Island, after first having been reported by the Coast Guard three days previously. No cause of death could be determined; analysis of photos and genetic samples may eventually identify the individual.

Conclusions: Right whales are the marine mammal species of highest management concern in U.S. Atlantic waters because of their critically endangered status and known human impacts—most notably mortality from ship collisions but also entanglement in commercial fishing gear. They have the potential to occur in the SAMP area in any season, but would be most likely during the spring, when they are migrating northward, and secondarily in the fall during the southbound migration. In most years, the whales would be expected to transit through the SAMP area or pass by just offshore of the area, however there may be some years when right whales encounter suitable prey resources and linger for some time, as occurred in April 1998. Note again that the April 1998 event was not captured in the relative abundance pattern (Fig. 4) because the appropriate survey data were not collected during the relevant flights.

Potential impacts on right whiles must be considered for all construction activities or on-going operations for any alternative energy development. In addition, a Right Whale Ship Strike Reduction Rule (50 CFR 224.105) went into effect on 9 December 2008. Among other provisions, it established a Block Island Seasonal Management Area (BI-SMA; Fig. 3). Under the Rule, all vessels 65 ft (19.8 m) or longer transiting through the BI-SMA are required to travel at speeds of 10 knots or less from 1 November through 30 April.

3.2.2 Humpback Whale *Megaptera novaeangliae* (Borowski, 1781)

Balaenopteridae is the most diverse family of baleen whales, with two genera and six species long recognized (Jonsgård, 1966; Nowak, 1999) and three species recognized more recently (Rice, 1998; Wada et al., 2003). They are collectively referred to as “rorquals,” from the Norwegian meaning “furrow whale” in reference to the ventral grooves. Externally, the grooves look like long, parallel slits extending back from the tip of the lower jaw to as far as the umbilicus in some species, but are actually distensible pleats involved in feeding behavior. Rather than continuous, mouth-open skimming as in balaenids, rorquals are “gulpers” (Nemoto, 1970; Pivorunas, 1979; Lambertsen, 1983). The mouth is opened, engulfing a large volume of water and prey within the distended lower jaw and ventral pouch. Then the mouth is closed, the pouch contracted, and the water forced out through the baleen filter—retaining the prey on the inside. The baleen plates of rorquals are shorter and broader than in right whales, and the rostrum of the skull is flatter and broader. Rorquals have dorsal fins and retain only four digits in the forelimb (Bannister, 2002).

Description: Humpback whales are the easiest to identify of the rorquals and are clearly distinguished from *Balaenoptera* spp. based on morphology (Winn and Reichley, 1985; Jefferson et al., 1993; Wynne and Schwartz, 1999; Clapham, 2002), but genetic studies generally agree that they are not phylogenetically separate (Árnason and Best, 1991, Árnason et al., 1992, 1993; Árnason and Gullberg, 1994, 1996; Nikaido et al., 2001; Hatch et al., 2006; Sasaki et al., 2006). Adults typically range from 11 to 16 m in length. They have a more robust, stout body form than *Balaenoptera* spp., but are not as rotund as right whales. The body is black, often with some amount of white on the belly. The dorsal fin can be extremely variable in shape, from small and rounded to prominent to falcate or hooked. There is a prominent rounded hump in front of the dorsal, and a series of projections along the ridge from the dorsal fin to the tail. Their most distinctive features are their flippers, which are very long (about a third of the body length), with a relatively smooth trailing margin and a series of prominent bumps (the “knuckles”) on the leading margin. The flippers usually white in North Atlantic humpbacks. The rostrum is broad and flat with a somewhat rounded tip. There are rows of rounded knobs down the center and along the edges of the rostrum and on the lower jaw. Each knob has a 1–3-cm stiff sensory hair in the center. There is also a prominent knob on the chin, which is covered by a clump of barnacles—actually by acorn barnacles attached to the whale and stalked barnacles attached to the acorn barnacles. There are also barnacles on the “knuckles” of the flippers, the margins of the flukes, the edges of the head, and scattered in other areas. The flukes have a deep central notch and a concave trailing edge with a ragged or serrated margin, and their underside is patterned in black and white (from all black to all white, most often black in the center and white toward the ends). The patterns are unique and can be used to identify individual whales (Katona et al., 1979). The ventral grooves extend all the way to the navel, and are more widely spaced than in any other rorquals, numbering only 12–36.

Status: Humpback whales are listed as Endangered under the U.S. Endangered Species Act, are classified as Federally Endangered on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. A review of the status of North Atlantic humpback stocks under the Endangered Species Act is being contemplated (Waring et al., 2008), and could potentially result in a proposal to down-list the North Atlantic humpback population to Threatened or even to de-list it completely. The number of humpback whales in the North Atlantic was estimated at 11,570 in 1992–93 by applying mark-recapture methods on the collection of photographs of known individuals (Stevick et al., 2003). That estimate is known to be negatively biased from spatial heterogeneity in sampling. In addition, the population appears to be increasing at 3% to as much as 6.5% per year (Barlow and Clapham, 1997; Stevick et al., 2001). North Pacific and Southern Ocean populations also appear to be growing (Clapham, 2002). Recent estimates of abundance for only the Gulf of Maine feeding stock are 850–900 whales (Waring et al., 2008).

Humpback whaling in the North Atlantic began in the 1600s in Bermuda and continued into the 20th Century (reviews by Mitchell and Reeves, 1983; Reeves and Smith, 2002). Many thousands were killed by 19th and 20th Century whalers, seriously depleting populations. Most North Atlantic humpback whaling occurred in the 19th Century. Yankee whalers hunted humpbacks on the wintering grounds in the West Indies and Cape Verdes between sperm whaling seasons, leaving behind traditional whale fisheries in both locations. North Atlantic humpback whaling in the 20th century was mainly from shore stations in Canada, Greenland, Iceland, the Faroe Islands, the British Isles, and Norway. Humpback whaling ended world-wide in 1966 (Clapham, 2002). The only North Atlantic hunting since the International Whaling Commission (IWC) instituted a moratorium on commercial whaling in 1986 (see the fin whale account for more details) has been the occasional subsistence take in West Greenland (1 each in 1988 and 1990–1992, 2 in 1989) and 1 or 2 a year by a small, traditional fishery that has survived in Bequia, St. Vincent and the Grenadines, West Indies (see Table 21.3 in Reeves and Kenney, 2003 for a summary of all North Atlantic whaling in 1986–2000; for subsequent years see the annual reports of the IWC in the supplement to each volume of *Journal of Cetacean Research and Management*).

The 2001–2005 average annual human-related mortality from the Gulf of Maine humpback stock was estimated as 2.8 killed by fishery entanglements and 1.4 by ship collisions (Waring et al., 2008). Fisheries involved in humpback entanglements have included pelagic driftnets, sink gillnets, and lobster traps. Biotoxins have also been implicated in humpback whale mortalities. In 1987, 14 humpback whales died acutely near Cape Cod and Nantucket after eating mackerel containing saxitoxin produced by *Alexandrium tamarense*, the “red tide” organism that is responsible for paralytic shellfish poisoning in humans (Geraci et al. 1989). Domoic acid, produced by the diatom *Pseudo-nitzschia* sp., has been hypothesized as a cause of death of 12–15 humpbacks offshore on Georges Bank in 2003, but the data were sparse and results inconclusive (Waring et al. 2008).

Ecology and life history: Humpback whale habitat use patterns and distributions on their feeding grounds are not static, but change over time. Along with shifts in the relative abundance of herring and sand lance, the two principal forage fish species in the Gulf of Maine system, the distribution of humpback whales has similarly changed (P. M. Payne et al. 1986, 1990; Kenney et al., 1996; Weinrich et al., 1997). Herring and mackerel stocks were severely depleted by commercial fisheries in the 1960s and early 1970s, and sand lance populations expanded greatly in response. Humpback whales shifted from feeding mostly in the northern Gulf of Maine to concentrating in Cape Cod Bay and east of Cape Cod. In the early 1980s, sand lance populations declined and herring began to recover. Humpback and fin whales declined around Cape Cod, and were nearly absent in 1986. Similar shifts in humpback distribution that coincided with changes in prey populations have been observed in Newfoundland (Lien et al., 1979; Whitehead and Lien, 1983) and southeastern Alaska (Bryant et al., 1981).

Humpbacks are gulp-feeders like the other rorquals (Nemoto 1970, Pivorunas 1979), but they display a much wider variety of feeding behaviors (Ingebrigtsen, 1929; Jurasz and Jurasz, 1979; Hain et al., 1982, 1995; Hays et al., 1985; Weinrich et al., 1992; Swingle et al., 1993). They may lunge violently with the mouth open, or surface open-mouthed very slowly and smoothly. They also routinely use bubbles in feeding—either columns of large bubbles in lines or partial or complete circles ("bubble-nets") or large clouds of tiny bubbles that are apparently released from the mouth rather than exhaled through the blowholes ("bubble clouds"). Some whales add tail-slaps or other vigorous splashing to the feeding behaviors. There is evidence that feeding behaviors are learned from the mother (Weinrich et al., 1992).

Humpbacks feed on a variety of small, schooling prey, including krill and fish (Watkins and Schevill, 1979; Kenney et al., 1985a; Winn and Reichley, 1985; Clapham, 1996, 2002). The principal prey species in the Gulf of Maine are herring and sand lance (Overholtz and Nicolas, 1979; CETAP, 1982; Kenney and Winn, 1986; P. M. Payne et al. 1986, 1990; Kenney et al., 1985a, 1996; Weinrich et al., 1997). In the northern Gulf of Maine, euphausiids may also be important prey (Sutcliffe and Brodie, 1977; Paquet et al., 1997).

Sexual maturity in both male and female humpback whales is reached at about 5 years of age on average, ranging from 4 to 9 years (Clapham and Mayo 1987, 1990; Clapham 1992, 1996, 2002; Craig and Herman, 2000). Calving is strongly seasonal, with calves in the Northern Hemisphere born from January to March after a gestation period of about 11 or 12 months (Rice, 1967; Johnson and Wolman, 1984; Clapham 1996, 2002). Calves are born at about 4–5 m in length and reach 8–9 m by the time they are weaned (Winn and Reichley, 1985). Calves are fully weaned at about 1 year old, but begin to feed independently while still nursing at only 5 or 6 months old (Clapham, 1992). The intervals between calves are usually 2–3 years, although females occasionally give birth in successive years (Clapham and Mayo, 1990; Glockner-Ferrari and Ferrari, 1990; Clapham, 1996, Steiger and Calambokidis, 2000).

General distribution: Humpback whales occur in all of the world's oceans, making some of the longest migrations known for any mammal between high-latitude feeding grounds and low-latitude calving and breeding grounds (Kellogg, 1929; Jonsgård, 1966; Winn and Reichley, 1985; Rice, 1998; Clapham, 2002). North Atlantic humpbacks occur from the Caribbean Sea and Cape Verde Islands in the extreme south to as far north as Greenland, Iceland, Svalbard, and the Barents Sea (Jonsgård, 1966; Winn et al., 1975; Winn and Winn, 1978; Whitehead and Moore, 1982; Martin et al., 1984; Winn and Reichley, 1985; Katona and Beard, 1990; Clapham et al. 1992, 1993a, 1993b; Clapham, 1996; Palsbøll et al., 1997; Rice, 1998; Stevick et al., 1998; Smith et al., 1999). The vast majority of sightings in both the feeding and calving grounds are in nearshore and continental shelf waters, but the whales apparently migrate across deep oceanic regions. Reeves et al. (2004) mapped humpback whale sightings recorded in the logbooks of 18th and 19th Century sperm whalers. There were large numbers of sightings in the middle of the North Atlantic just west of the Mid-Atlantic Ridge, especially in April-July. The distribution confirmed migration routes far offshore, and also suggested that there might be offshore feeding grounds that are still unknown.

North Atlantic feeding grounds are occupied from spring through fall, and are located in continental shelf areas. The feeding range extends from southern New England and the British Isles north to Davis Strait, Greenland, Iceland, Svalbard, and Norway (Martin et al., 1984; Katona and Beard, 1990; Sigurjónsson and Gunnlaugsson, 1990; Clapham et al., 1992; Clapham, 1996; Palsbøll et al., 1997; Stevick et al., 1998). Humpbacks show strong matrilineal habitat fidelity (Baker et al. 1994). A calf learns the feeding grounds from its mother during its first year, and then tends to return to the same feeding areas each year (Clapham and Mayo, 1987). The result is genetically identifiable "feeding stocks," with very little interchange between stocks (Christensen et al., 1992; Palsbøll et al., 1995, 1997, 2001; Larsen et al., 1996). Separate feeding stocks have been recognized from the Gulf of Maine/Nova Scotia, Gulf of St. Lawrence, Newfoundland/Labrador, West Greenland, Iceland/Denmark Strait, and Norway. There is further subdivision on even finer scales. Clapham et al. (2003) showed that humpbacks in the Gulf of

Maine and on the Nova Scotian Shelf only partially overlap. Within feeding ranges, humpbacks tend to aggregate at specific locations where prey is most abundant.

During the winter, humpbacks from all North Atlantic feeding grounds migrate south to calving and breeding grounds on shallow banks in the West Indies/Caribbean region, where they mix together (Katona and Beard, 1990; Clapham et al., 1993b; Palsbøll et al., 1997; Stevick et al., 1998; Bérubé et al., 2004). The peak calving and breeding season is January–March, with some whales arriving as early as December and a few not leaving until June (Reeves et al., 2001b).

Historical occurrence: Historical occurrences of humpback whales in the southern New England region west of Massachusetts were very rare and were unknown to De Kay (1842), Linsley (1842), and Goodwin (1935). Allen (1916) reported only one from Rhode Island, in 1836—"A note in the Providence Courier makes mention of a whale that had been seen several times off Newport, R.I., during the last of June. It was finally captured in Newport Harbor, 'north of the asylum[8]; it measures fifty feet in length, and is of the Humpback species and is supposed to be the same which was seen off Pawtuxet on Wednesday morning last'." Cronan and Brooks (1968) reported that the only other humpback in Rhode Island was an 8.2-m calf stranded at Matunuck Beach in South Kingstown in June 1957, although the notes with the Smithsonian data record state that the photo showed an animal more likely 6 m long. Connor (1971) reported that the 1957 Rhode Island stranding was the only humpback known from southern New England, but he suspected that humpbacks had occasionally been taken by Long Island shore whalers hunting right whales.

There was one additional historical record of a humpback whale that was not included in the Smithsonian data. Both of us were graduate students of Professor Howard E. Winn (1926–1995) at GSO. It was common knowledge around the lab that a humpback had been seen in Mount Hope Bay at some time in the 1960s, but no record is in any database to our knowledge. However, in a box of photographs salvaged during the cleanout of Dr. Winn's files after his death was an envelope with ten black & white prints of a humpback whale, labeled "Humpback; Bristol, R.I., Nov. 4, 1968." One image clearly shows the Braga Bridge in Fall River in the

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[8] The Newport Asylum for the Poor was built in 1822 on Coasters Harbor Island, which was turned over to the Navy in 1882. The original asylum building is now the Naval War College Museum.

background. We also found an old newspaper clipping about the event ("A tape recorder may save Howie: Scientists want to 'talk' to whale"), but the date and source had been cut off.

Allen (1916) reported many humpbacks, mostly animals killed by whalers, from Massachusetts to Maine, beginning with one that stranded in the inner harbor at Nantucket in 1608 and was killed by a group of Indians. Waters and Rivard (1962) said that humpbacks were "unusual but not rare in New England coastal waters," but described an erroneous migratory pattern similar to what they had for right whales. They reported only two specific records—a stranding of an 18-m humpback in Barnstable in August 1941 and a sighting of a "school" in Cape Cod Bay off the canal entrance on 3 May 1951.

Recent occurrence: Humpback whales occur throughout the region in all four seasons, with many sightings from whale-watching boats concentrated south and east of Montauk in summer and spring (Fig. 5). Including those data, 71.2% of records are in the summer, 15.7% in the spring, 10.3% in the fall, and 2.6% in the winter. Without the whale-watching sightings, the seasonal differences are less dramatic and the peak season switches to the spring (45.8%), followed by summer (33.6%), fall (10.3%), and winter (9.7%). Sightings are distributed across the shelf, especially in the spring. Except for the summer concentration from the whale-watchers' data, the sightings tend to be more common in the eastern half of the study area.

The effort-corrected relative abundance patterns show that humpbacks are most abundant east of the Rhode Island study area in the Great South Channel (Fig. 6). Humpbacks are strongly concentrated there in spring, summer, and fall, and present at lower abundances in winter. Areas of low predicted humpback abundance extend into the SAMP area in spring and summer. Areas of slightly higher abundance are south and/or southeast of the SAMP area in winter, spring, and summer. Only in fall are humpbacks absent from the Rhode Island study area in the relative abundance model output.

Humpback distributions in the Gulf of Maine have fluctuated markedly over the years, largely tracking patterns of abundance of their principal prey species—Atlantic herring, sand lance, and krill (P.M. Payne et al., 1986, 1990; Kenney et al., 1996). In the years during the 1980s when humpbacks were scarce off Cape Cod, there were numerous humpback sightings between Long Island and Martha's Vineyard by Montauk and Galilee whale-watch boats. The peak year for sightings from the Montauk boat was 1987, with 63 sightings (compared with 2 in 1986 and 9 in

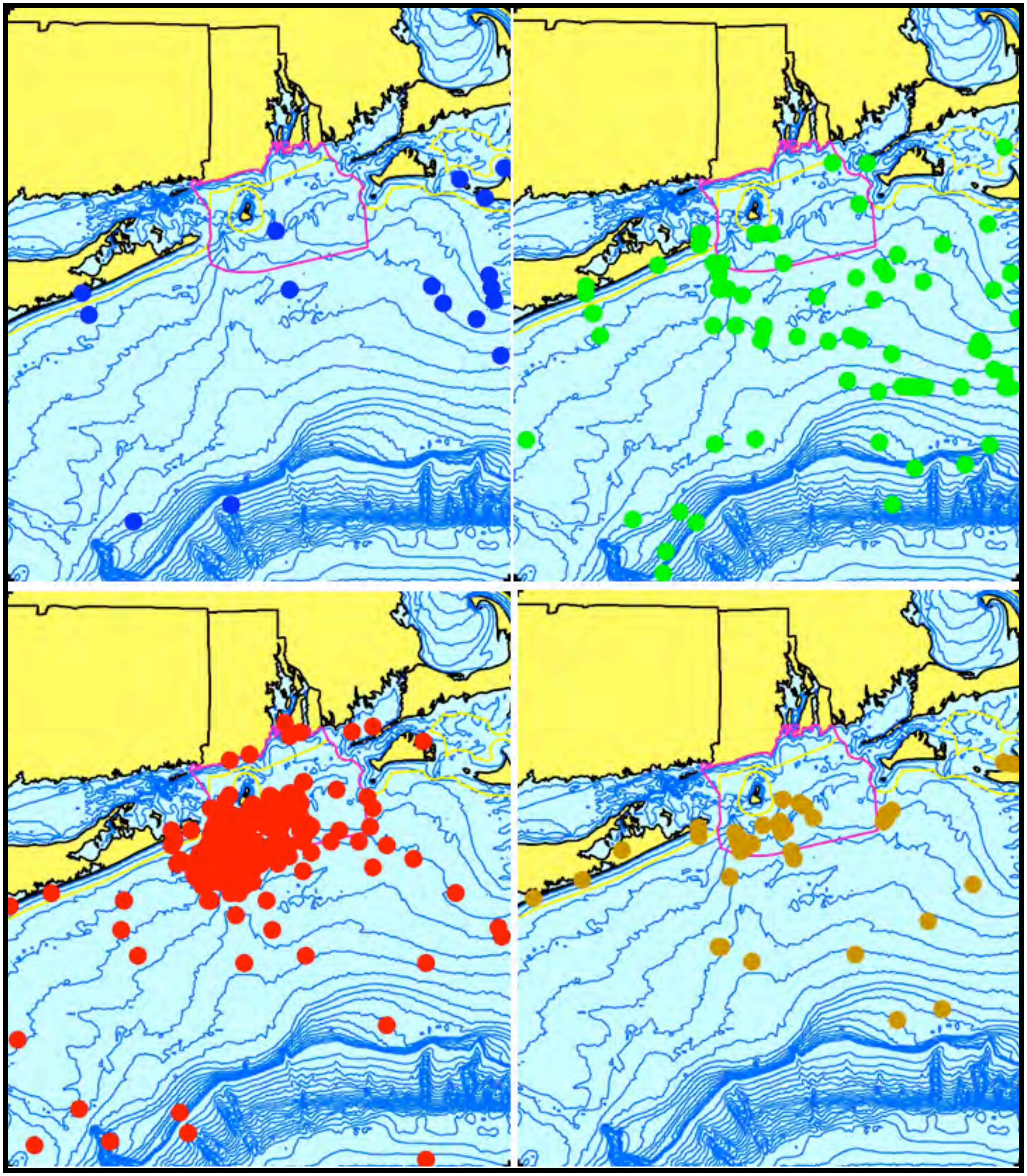

Figure 5. Aggregated sighting, stranding, and bycatch records of humpback whales in the Rhode Island study area, 1608–2007 (n = 611: winter = 16, spring = 96, summer = 435, fall = 63, unknown = 1).

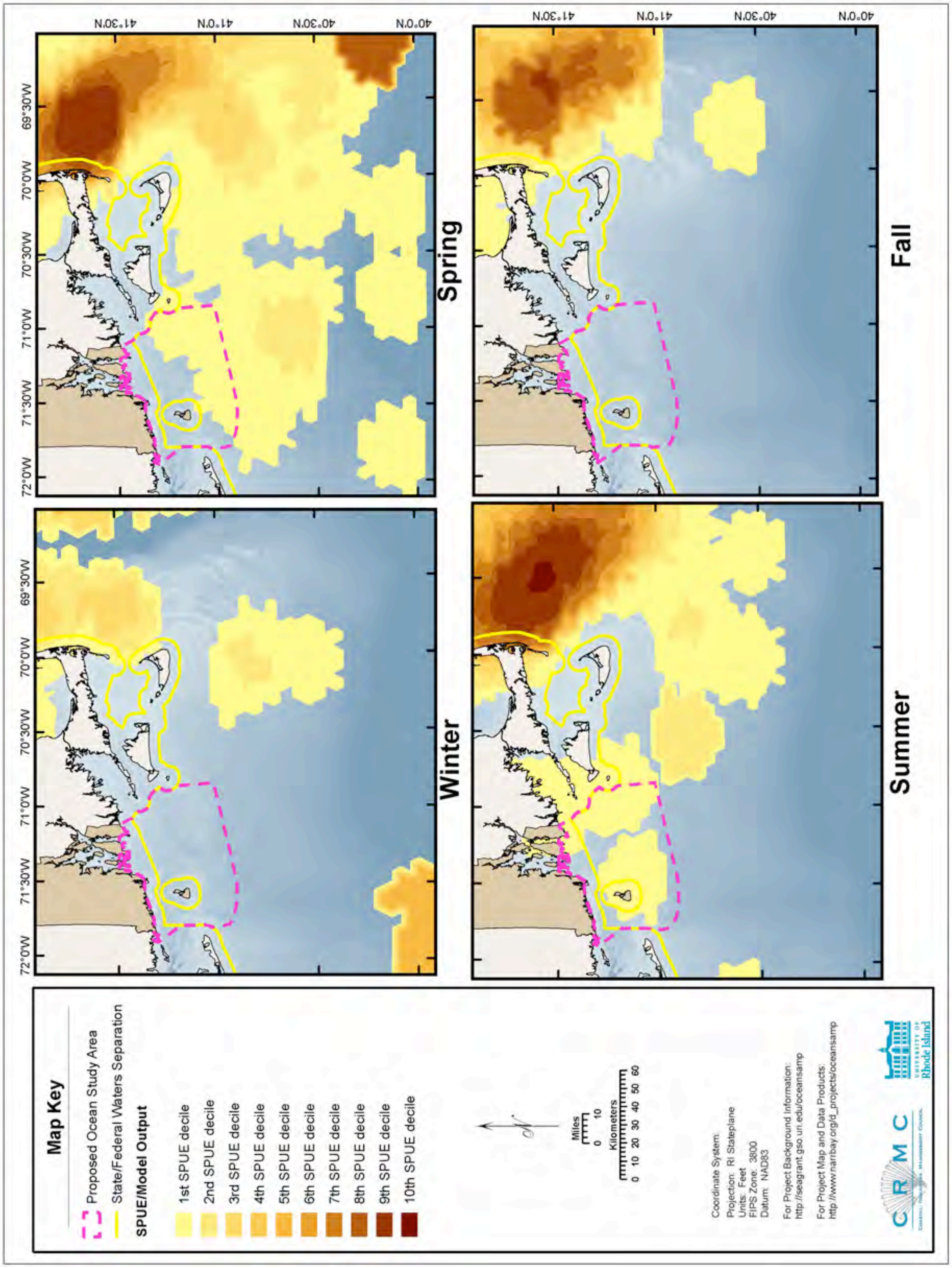

Figure 6. Modeled seasonal relative abundance patterns of humpback whales in the Rhode Island study area, corrected for uneven survey effort.

1988), and 1987 was also the best year for the Galilee boat. In 1987, the whales targeted by the whale-watching boats slowly shifted eastward over the course of the season—from the southwestern part of the SAMP area near Montauk and Block Island to the eastern part, near Noman's Land off the southwestern corner of Martha's Vineyard (G. O. Klein, pers. comm.). Sand lance populations in Cape Cod waters subsequently recovered, then went through another decline and recovery in the early 1990s, closely tracked again by whale sighting frequencies in the same area (Weinrich et al., 1997). There was similarly another increase in humpback sightings off Montauk in 1992 and 1993, and less dramatically in 1994 and 1991. The survey data, however, are far too sparse for an effective analysis of inter-annual trends in humpback abundances in the Rhode Island study area.

After an absence in the Rhode Island stranding record for more than 40 years, there were four humpback strandings in the state in 2001–2005: on 22 June 2001 behind "The Breakers" in Newport; on 10 August 2001 on the western side of Sachuest Point National Wildlife Refuge in Middletown; on 3 June 2004 on East Beach in the Ninigret Conservation Area in Charlestown; and on 6 July 2005 on Bailey's Beach in Newport. There were also four strandings around the Massachusetts Islands—in October 1987, November 1988, January 1991, and June 1992. There were also strandings on the south shore of eastern Long Island in February 1992, November 1992, October 1993, August 1997 (in Weesuck Creek off the northwestern part of Shinnecock Bay), and April 2004. Finally, there were two observations of a floating carcass on 20 May 2004—an opportunistic report to NMFS in western Vineyard Sound between Cuttyhunk and Nashawena and a sighting by the NMFS aerial survey team about 28 km west of there and 9 km southeast of Sakonnet Point. It is impossible to determine if both sightings were the same dead whale, or if that was the individual that washed up two weeks later in Charlestown. Although annual stranding frequencies of humpbacks in the Rhode Island study area are low, they do hint at a pattern of occasional peaks that may correspond to the years of peak occurrence in the area (Fig. 7). The first two peaks do match the peaks in sightings from the whale-watchers; unfortunately, we do not have sighting records from whale-watching boats in the region after 1996, so we are unable to check if sighting frequencies were also up in other years when strandings occurred.

Conclusions: Humpback whales have occurred in the Rhode Island study area and within the Ocean SAMP area in all four seasons of the year. Sightings are most frequent in spring, and the whales show up in the relative abundance maps in the SAMP area in spring and summer. Because they are listed as Endangered under the ESA, they must be considered carefully in any development planning. Humpback occurrence in significant numbers in southern New England is relatively unpredictable and likely to be highly dependent on prey availability, both locally and in their primary feeding grounds in the Gulf of Maine. They are likely to be relatively rare in most years in the SAMP area, but may be locally abundant in certain years.

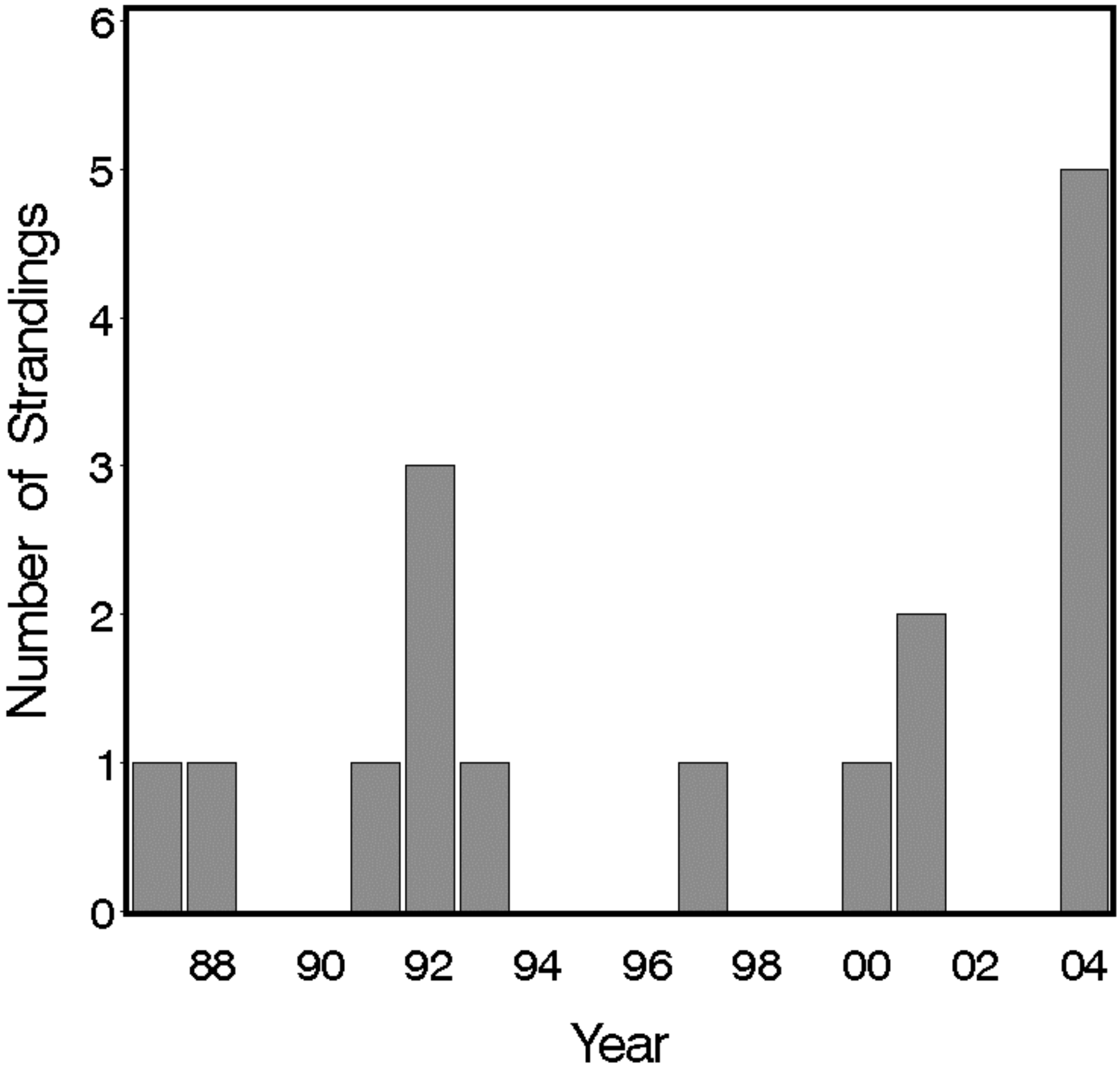

Figure 7. Annual stranding frequencies for humpback whales in the Rhode Island study area, 1987–2004.

3.2.3 Blue Whale *Balaenoptera musculus* (Linnaeus, 1758)

Description: Blue whales are the largest living animals, reaching lengths of 23–28 m and weights of 125,000 kg in the Northern Hemisphere, and over 30 m and 150,000 kg in the Southern Hemisphere (Yochem and Leatherwood 1985; Jefferson et al., 1993; Wynne and Schwartz, 1999; Sears, 2002). The rostrum is broad, U-shaped in dorsal view, and very flat. Coloration is blue-gray with distinctive light mottling. There are 55–88 ventral grooves that extend back to the umbilicus. There are 270–395 very broad baleen plates; they are black with coarse black fringes.

Status: Blue whales are classified as Endangered under the U.S. Endangered Species Act, but are not included on the Rhode Island state list. North Atlantic blue whales are classified as Vulnerable on the IUCN Red List, where the listing is noted as “needs updating.” Stocks world-wide were seriously depleted by modern industrial whaling, with hundreds of thousands taken in the Antarctic and about 11,000 in the North Atlantic (Yochem and Leatherwood, 1985; Reeves et al., 1998; Sears, 2002; Reeves and Kenney, 2003). There are no precise estimates of original abundance in the North Atlantic. Yochem and Leatherwood (1985) proposed an original population of about 15,000 in the North Atlantic, but Reeves et al. (1998) suggested that might be too high. Over 320 different individuals have been identified though photographs in the Gulf of St. Lawrence (Reeves et al., 1998), and there may be 1,500 at the present time in the North Atlantic (IUCN, 2008). There is no current estimate of the number of blue whales in U.S. Atlantic waters (Waring et al., 2008).

Ecology and life history: Blue whales feed almost exclusively on euphausiid crustaceans (“krill”). Females mature at 5–15 years of age, and calves are born in the winter (Mizroch et al., 1984; Yochem and Leatherwood, 1985; Sears, 2002). Calves are 7 or 8 m long at birth and grow to about 16 m by the time they are weaned in as little as 6 or 7 months. The typical calving interval is 2 years.

General distribution: Blue whales are distributed in all the world’s oceans; in the western North Atlantic, they are most commonly sighted from Nova Scotia north (Jonsgård, 1966; Yochem and Leatherwood, 1985; Sigurjónsson and Gunnlaugsson, 1990; Sears, 2002; Reeves and Kenney, 2003). There are occasional sightings and strandings along the U.S. east coast from the Gulf of Maine to the Gulf of Mexico (reviewed in Reeves et al., 1998). Acoustic detections of blue whales (Clark, 1995) show that they occur broadly in winter in the deeper central Atlantic as far south as the subtropics, supporting the hypothesis of an inshore-offshore annual migration and a deep-water winter range (Kellogg, 1929).

Historical occurrence: Historical blue whale records in southern New England are very rare. Allen (1916) reported a stranding at Narragansett Pier in 1882 (another report from Major E.A. Mearns). While he reported it as a large female fin whale, in the Smithsonian database it is listed as a probable blue whale because of its reported size at over 30 m long (even allowing for exaggeration, it was larger than would be likely for a fin whale). There were also strandings at Ocean City, New Jersey in October 1891 and Barnegat Inlet, New Jersey in December 1927. Edwards and Rattray (1932) reported an earlier stranding (date unknown) at Sagaponack, Long Island. Waters and Rivard (1962) said that blue whales were rare in New England and had occurred in Massachusetts Bay, but reported no specific records.

Recent occurrence: There are only four recent occurrences of blue whales in the Rhode Island study area (Fig. 8). On 3 March 1998, a dead 20-m blue whale was carried into Rhode Island coastal waters on the bow of the *Botany Triumph*, a 148-m tanker carrying a load of caustic soda from Belgium, bound for Providence. After drifting for a few days, the whale was towed ashore for necropsy on the 7th at Second Beach in Middletown. The location where the whale was first struck by the ship is not known and is believed to have been outside of U.S. jurisdiction (Waring et al., 2008). That animal’s skeleton has been mounted and is on display at the New Bedford Whaling Museum. Three blue whale sightings southeast of Montauk Point were recorded by whale-watchers over a one-week period—on 27 July, 31 July, and 3 August 1990. A single animal was seen each time, possibly the same one.

With no sightings from any surveys, a SPUE analysis for blue whales would result in zero values in all locations and all seasons.

Conclusions: Blue whale occurrence is very rare to accidental in southern New England. Consequently, blue whales pose no real concern for the Rhode Island Ocean SAMP.

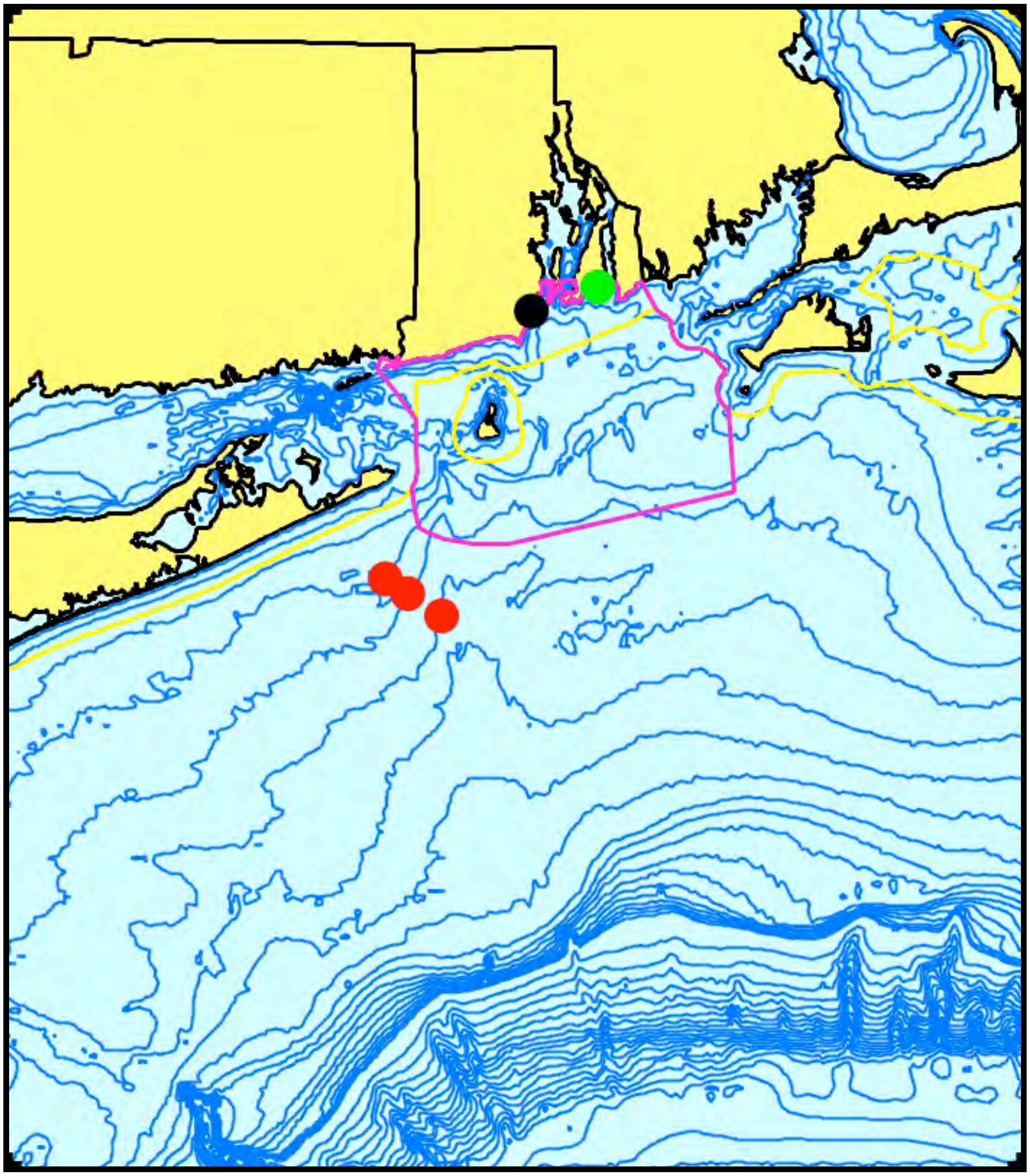

Figure 8. Aggregated sighting, stranding, and bycatch records of blue whales in the Rhode Island study area, 1882–1998 (n = 5: winter = 0, spring = 1, summer = 3, fall = 0, unknown = 1).

3.2.4 Fin Whale *Balaenoptera physalus* (Linnaeus, 1758)

Description: Fin whales are the second-largest species of living whale, with adults 17–24 m long (Gambell, 1985a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Aguilar, 2002). Females are slightly larger than males, with Northern Hemisphere adults averaging about 22.5 m for females and 21 m for males (Aguilar, 2002). There is evidence that the fin whales off the northeastern U.S. are smaller than animals from farther north (Hain et al., 1992). The mean adult length from animals measured from aerial photographs was 16.1 m, significantly smaller than fin whales taken in modern Icelandic whaling even after accounting for size selection by the whalers. Possible explanations suggested by Hain et al. (1992) included size differences between stocks or habitat segregation by age with the largest adults remaining farther offshore.

A fin whale has a very sleek, streamlined body with a flattened, tapered rostrum. The falcate dorsal fin is about 60 cm tall, set about two-thirds or even three-quarters of the way back on the body. There is a distinct ridge along the back from the dorsal fin to the tail. Fin whales are unique among mammals in being asymmetrically colored, with the lower jaw white on the right and dark on the left. The body color ranges from gray to brownish, with a much lighter belly. Above the flippers, there is a pale, forward-pointing V-shaped chevron on the back and swirls of lighter color on the sides, especially on the right side. There are 55–100 ventral grooves that extend back to the umbilicus.

Status: Fin whales are classified as Endangered under the U.S. Endangered Species Act, as Federally Endangered on the Rhode Island state list, and as Endangered on the IUCN Red List. There is no precise estimate of the total abundance of fin whales in the North Atlantic. Perry et al. (1999) estimated that there may be 50,000 to 60,000. Aguilar (2002) gave estimates of 3,500 in the western Mediterranean, 4,500 off northwestern Spain, 7,500 in the eastern temperate Atlantic, 700 around the Faeroe Islands, 1,850 off Norway, 15,600 in East Greenland and Iceland, 1,000 in West Greenland, and 10,800 off Nova Scotia, Newfoundland, and Labrador. Those estimates sum to 45,450. The most recent estimate for the U.S./Nova Scotia stock is 2,269, however that estimate did not include a correction factor for submerged animals that were missed during surveys. A more realistic estimate for the northeastern U.S. shelf in about 1979–1981, including a correction factor, would be on the order of 5,000–6,000 fin whales (CETAP, 1982; Hain et al., 1992; Kenney et al., 1997).

Fin whales began to be targeted after the depletion of blue whale stocks early in the modern whaling era, beginning off Norway in the 1870s (Tønnessen and Johnsen, 1982; Aguilar, 2002). The whaling stations in Norway closed by 1904 because nearby stocks were depleted, and the hunt expanded across the North Atlantic and into the Antarctic. Tens of thousands of Northern Hemisphere fin whales were taken during the 20th century. A total of 3,528 was taken from three shore whaling stations in eastern Canada in 1965–1971, with 1,402 at Blandford, Nova Scotia (Mitchell, 1974, Sutcliffe and Brodie, 1977). Fin whaling in U.S. Atlantic waters ended around the turn of the 20th Century (Allen, 1916).

In July 1982, the International Whaling Commission approved a measure setting whaling catch limits to zero for all stocks beginning in 1986 (IWC, 1983; Gambell, 1999), establishing a moratorium on all commercial whaling. Legal whaling since 1986 has been conducted only under (1) the exception for “aboriginal subsistence” whaling (Reeves, 2002), (2) scientific research permits, or (3) objection (under the terms of the Convention, nations that formally object to specific IWC regulations are not bound by them). After 1986, Iceland took 292 fin whales from 1986 to 1989 under a research permit, and subsequently withdrew from IWC membership (Reeves and Kenney, 2003). The subsistence hunt in West Greenland takes 10–15 fin whales per year (Aguilar, 2002). Iceland rejoined the IWC in 2002, and in October 2006 announced the intention to resume small-scale commercial whaling and issued licenses to take 9 fin whales in 2007. Seven were taken. No fin whale quota was set for 2008.

The average annual human-related mortality of fin whales from the U.S./Nova Scotia stock in 2001–2005 was 0.8 from fisheries entanglement and 1.6 from ship collisions. Ship-struck fin whale carcasses are sometimes discovered in New York harbor or nearby in New Jersey. Other serious conservation concerns are rare (Aguilar, 2002). There are detectible contaminant levels in fin whales from waters near industrialized coasts such as the Mediterranean and North Atlantic, but they appear to be relatively low. Feeding relatively low on the food chain makes them less likely to accumulate harmful concentrations.

Ecology and life history: Fin whales appear to be similar to humpback whales in exhibiting maternally-directed habitat fidelity. Agler et al. (1993) use photoidentification of individual whales to demonstrate that adult females showed preferences for either northern or southern Gulf of Maine feeding areas. They suggested that age and sex segregation occurred on local scales, similar to what Hain et al. (1992) suggested for broader geographic scales. Even though individual fin whales are more difficult to identify than humpbacks, both Seipt et al. (1990) and Clapham and Seipt (1991) were able to show relatively high resighting rates, concluding that females tend to return to the same feeding grounds consistently.

Habitat use patterns by fin whales off the northeastern U.S. have shifted significantly in some years. P. M. Payne et al. (1990) showed a decline in fin whale and humpback occurrence in the southern Gulf of Maine in 1985 and 1986, coinciding with a minimum in sand lance abundance. Kenney et al. (1996) hypothesized that changes in relative abundance of herring and sand lance in different portions of the Gulf of Maine, driven by past commercial fishery practices, led to changes in whale distribution. Fin whale sightings south of the Gulf of Maine from summer surveys during the 1990s were more concentrated along the shelf edge than they had been previously (Waring et al., 2008), which might suggest an additional habitat shift, however at least some of the difference is likely due to differences in survey design and timing. Coakes et al. (2005) reported unusual numbers of fin whales off Halifax, Nova Scotia in 1997, also correlated with unusually high local abundance of whale prey.

Fin whales are fast swimmers and capable of moving substantial distances in relatively short times. They normally swim at 5–8 knots (9–15 km/hr), but are capable of short bursts of 15 (28 km/hr) or even 20 knots (37 km/hr) (Gambell, 1985a; Aguilar, 2002). Watkins (1981) tracked a radio-tagged fin whale between Iceland and Greenland that traveled 2,095 km in ten days and covered 292 km in a single day.

Like the other rorquals, fin whales are gulp feeders (Nemoto, 1970; Pivorunas, 1979). They often roll onto their right sides during feeding. Mitchell (1972) speculated that their asymmetric coloration was related to feeding, maintaining counter-shading when rolled to the right. Tershy and Wiley (1992) did show quantitatively that fin whales rolled most often to the right (97% of the time in the North Pacific, 81% in the North Atlantic), but that symmetrically colored blue and Bryde’s whales also did. While Southern Hemisphere fin whales feed mainly on euphausiid crustaceans (krill), Northern Hemisphere whales prey upon a wide variety of small, schooling prey, including many small fishes (herring, sand lance, capelin, sardine, etc.), squids, and crustaceans such as krill and copepods (Gambell, 1985a; review in Kenney et al., 1985a; Hain et al., 1992; Kawamura, 1994; Aguilar, 2002).

Fin whale calves are born in the late fall and winter, probably offshore (Mitchell, 1974; Haug, 1981; Gambell, 1985a; Hain et al., 1992; Aguilar, 2002). Length at birth is about 6 m and weight is 1,000 kg or more, and the gestation period is about 11 months. Calves are weaned at 6–11 months old and about doubled in length to 11–13 m (Best, 1966; Haug, 1981; Gambell, 1985a;

Aguilar, 2002). Female fin whales mature at 7–8 years of age and males at 6–7, with the corresponding body lengths in the Northern Hemisphere around 17–18.5 m in females and somewhat smaller in males (Lockyer, 1972, 1984; Gambell, 1985a; Aguilar, 2002). Full physical maturity in both sexes might not be attained until around age 25. The inter-birth interval is usually 2 or 3 years (Christensen et al., 1992; Agler et al., 1993). The mean calving interval for identified individuals in the Gulf of Maine was 2.71 years, but may have been as low as 2.24 if potential missed calving years were taken into account.

General distribution: Fin whales are broadly distributed throughout the world's oceans, from the temperate regions poleward (Gambell, 1985a). Their range in the North Atlantic extends from the Gulf of Mexico, Caribbean Sea, and Mediterranean Sea in the south to Greenland, Iceland, and Norway in the north (Jonsgård, 1966; Gambell, 1985a). They are the most commonly sighted large whales in continental shelf waters from the Mid-Atlantic coast of the U.S. to Nova Scotia (Sergeant, 1977; Sutcliffe and Brodie, 1977; CETAP, 1982; Hain et al., 1992; Waring et al., 2008), which comprises the range of the U.S./Nova Scotia stock. Fin whales in other regions of the North Atlantic—Newfoundland/Labrador, West Greenland, East Greenland/Iceland, Norway, western Europe, and the Mediterranean—are believed to belong to different stocks (Donovan, 1991; Bérubé et al., 1998). Fin whales off the northeastern U.S. are most abundant from spring through fall, with smaller numbers of animals remaining through the winter (Hain et al., 1992). Most of the fin whales are believed to migrate offshore and south during the winter, which has been supported by passive acoustic tracking information developed in cooperation with the Navy (Clark, 1995).

Historical occurrence: Fin whales are the most common large whale in the Rhode Island region at the present time, and likely were common historically. Cronan and Brooks (1968) reported five 19th Century fin whale records from Rhode Island, all of which were included in Allen (1916), but stated that the last known occurrence was in 1884. The Smithsonian database included a larger number of records in or near Rhode Island from the late 19th Century, all also from Allen (1916), with the major difference probably being "definite" versus "probable" identifications. One whale was sighted off Point Judith on 28 October 1858. Allen quotes a newspaper account from 16 August 1873—"The skipper of the sloop *Annie*, of Saybrook, Conn., reports a large school of whales in close proximity to home. Monday, while midway between Southeast Point, Block Island, and Montauk, a school of whales, numbering probably thirty-five, was seen from the *Annie's* deck, gamboling near the Block Island shore where they had been lured, it is supposed, by the prospect of a good feeding-ground. In the school very few Finbacks or Humpback Whales were to be seen. The majority were large whales, some of them being not less than 70 feet in length." It was far more likely that those whales were fin whales than blue whales. Large schools of whales were seen around Noman's Land, Cuttyhunk, Gay Head, and Vineyard Sound in October 1874, chasing "great shoals of herring." A stranding of a very large fin whale was reported near the life-saving station in "Wakefield"[9] on 18 April 1880. Several whales were sighted off Block Island in early summer 1882. There were two sightings off Block Island in July of 1884—several whales on the tenth and about 20 at mid-month. A fin whale was sighted off Newport in 1885—"In the summer of this year a Finback was seen in Easton's Bay, R.I., by a number of people, including Mr. Philip Peckham, Jr., on whose authority Major E.A. Mearns reports the fact to me." An 1887 incident was included by Allen as a possible minke whale, but recorded in the Smithsonian data as more likely a fin whale—"Major E.A. Mearns sends me the account of a capture of a small whale that was supposed to have been a 'young Finback,' but was perhaps a Little Piked Whale. The incident occurred in Narragansett Bay, R.I., but the exact date is not available. By some curious accident, the whale in rising to the surface caught its head between the stern and the propellor blades of the government steamer *Munroe* as it lay at the South Dock. In its struggles to free itself the whale nearly lifted the stern of the vessel out of the water. The Captain, seeing that the whale was caught fast, turned on full steam in order to dislodge it. This had the desired result, but the swiftly revolving blades inflicted such injuries on the whale's head that it rushed upon a shoal at the head of Brenton's Cove and became stranded. It was finally killed there by soldiers from Fort Adams. ... It was said to have been a female, about thirty feet long." There were sightings of single whales off Newport on 2 June 1897 and 11 March 1899. Finally, a 15.5-m fin whale stranded at Point Judith on 28 August 1900.

Fin whales were not mentioned by De Kay (1842) or by Linsley (1842). Fin whales were commonly observed by the shore-based right whalers in eastern Long Island, but were rarely pursued because they were too fast and yielded less oil than right whales (Edwards and Rattray, 1932; Connor, 1971). Fin whales were not targeted by whaling in New England until the development of modern technology in the second half of the 19th Century, although the first

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[9] Narragansett was not established as a separate town from South Kingstown until 1901.

recorded attempt to kill fin whales, which was unsuccessful, was by Capt. John Smith in 1614, off Monhegan Island, Maine (Allen, 1916). Allen lists many sightings, strandings, and attempted captures (mostly unsuccessful) of fin whales off Massachusetts before the mid-19th Century. Waters and Rivard (1962) stated that fin whales were the most common whales in New England and very common in Cape Cod Bay. They tabulated 11 fin whale records between 1946 and 1958, including seven more or less typical strandings, one stranding with the tail severed by a ship propeller, two caught in fish weirs, and one entangled in the steel cable of a trawl net. Goodwin (1935) knew of only one record from the Connecticut coast, an 18-m whale killed in New Haven Harbor on 5 May 1834. Connor (1971) reported that fin whales were commonly sighted off Long Island, and he knew of strandings in 1916, 1936, and 1946.

Recent occurrence: Fin whales occur throughout continental shelf waters in the region in all four seasons (Fig. 9). Sightings are strongly concentrated in summer (80.9%) and spring (11.6%) and in the area between Block Island and Montauk Point, however both the spatial and temporal patterns are strongly biased by the whale-watching data, which generated 1,246 out of the 1,762 records (71%). Without those data, the seasonal differences are far less dramatic, with 52.7% of occurrences in summer, 29.8% in spring, 9.9% in fall, and 7.2% in winter, however the pattern of peak abundance is summer is still there. Strandings as a proportion of all records appear to be higher in the fall. It might be hypothesized that the observed seasonal increase in stranding frequency corresponds to the expected time of weaning.

After correcting for survey effort patterns (and including unidentified fin/sei sightings at 97.8% weighting), fin whales are present in the Rhode Island study area in all four seasons (Fig. 10). In spring, summer, and fall the main center of their distribution is in the Great South Channel area to the east of Cape Cod, which is a well-known feeding ground (Kenney and Winn, 1986). Winter is season of lowest overall abundance, but they do not depart the area entirely. In all four seasons, there are areas of higher fin whale occurrence both in inner shelf waters and near the shelf break. The highest occurrence within the SAMP area and nearby is in the outer half of the area from south of Montauk Point to south of Nantucket—in precisely the same area as the dense aggregations of sighting records from the whale-watching boats (Fig. 9). Therefore the pattern in the raw sighting data is not entirely due to bias in the data. That does make sense, since whale-watching would not be a viable operation if there were no whales, and they should be expected to focus their trips where they expect to find whales.

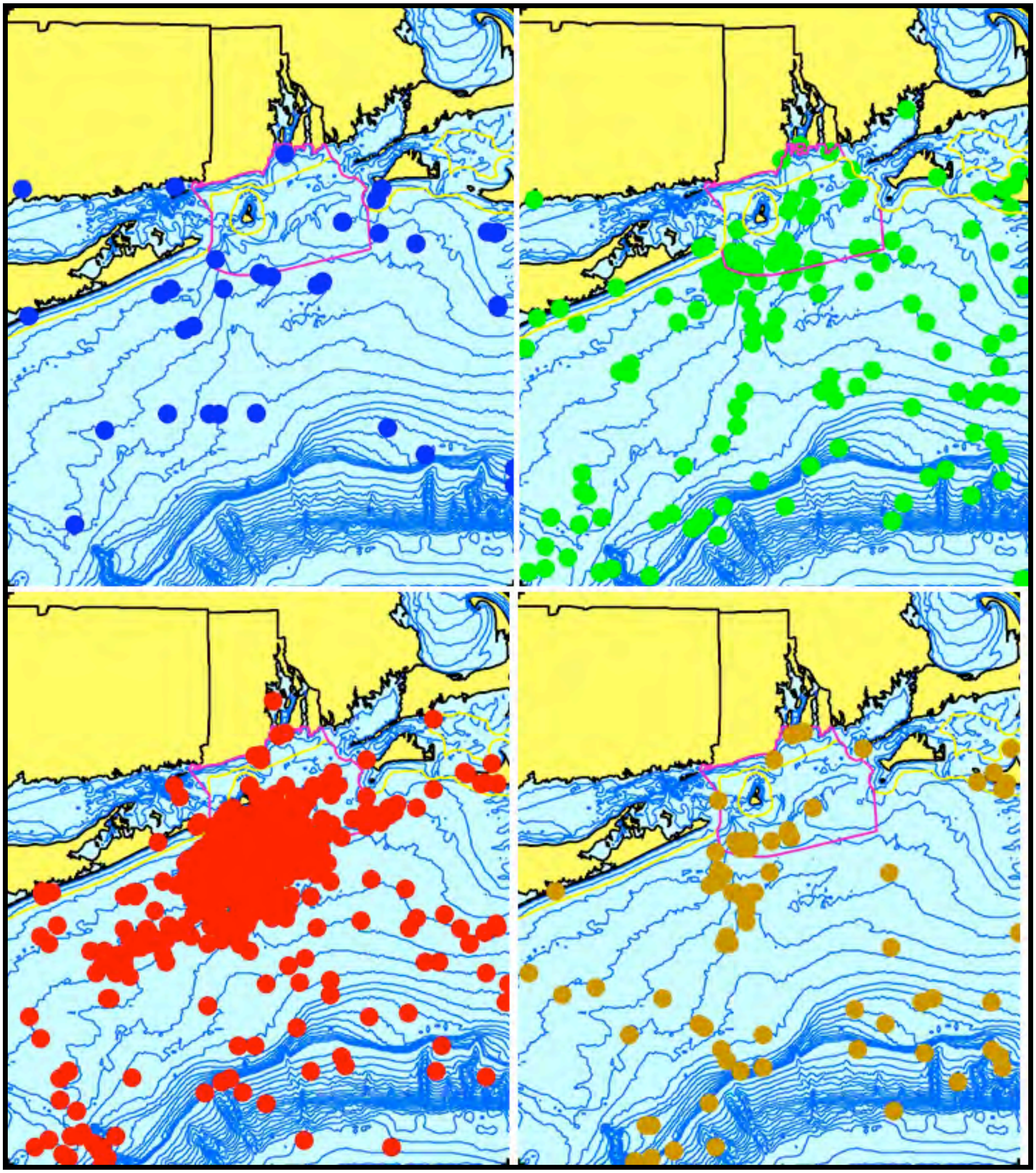

Figure 9. Aggregated sighting, stranding, and bycatch records of fin whales in the Rhode Island study area, 1834–2008 (n = 1,762: winter = 37, spring = 205, summer = 1,425, fall = 93, unknown = 2).

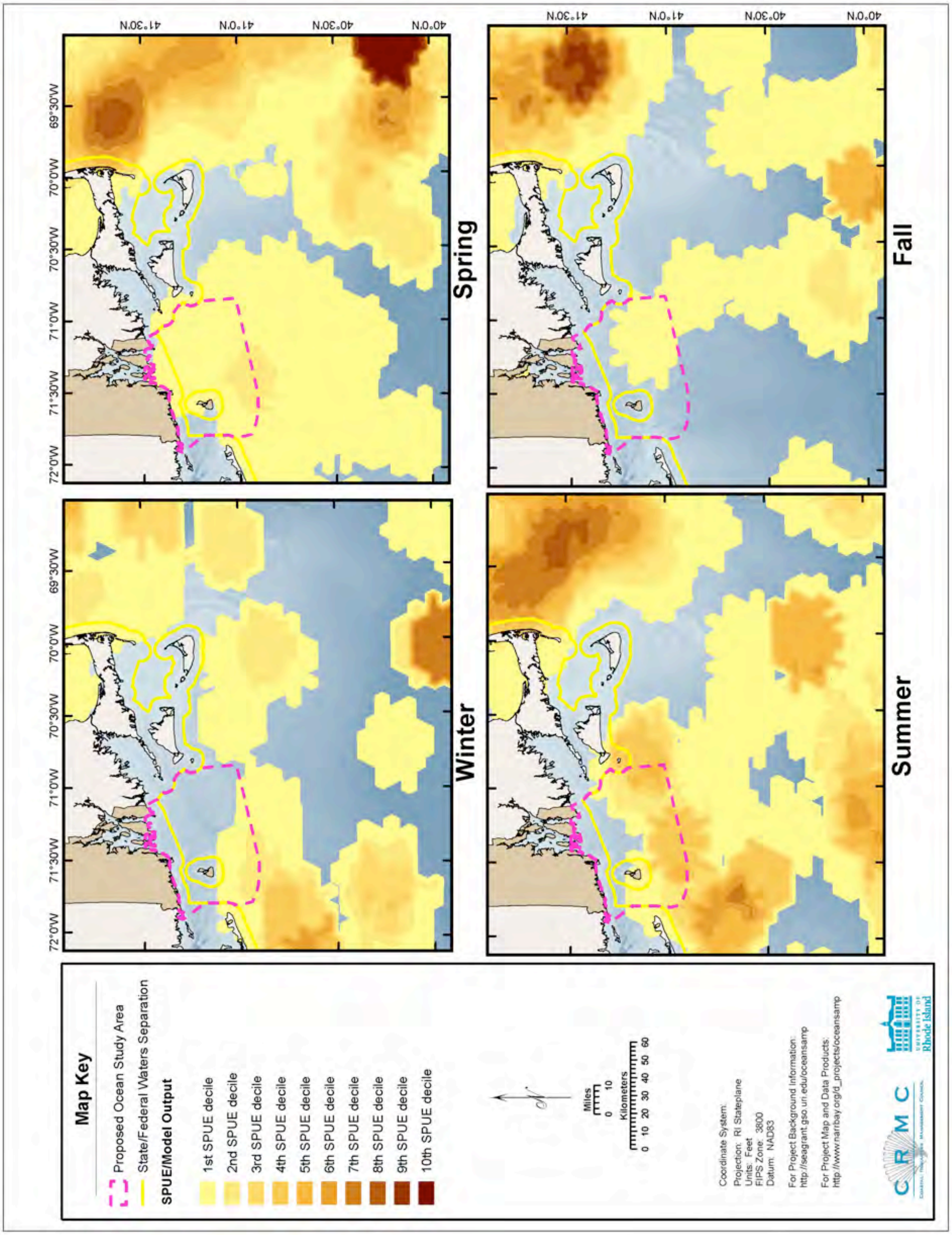

Figure 10. Modeled seasonal relative abundance patterns of fin whales in the Rhode Island study area, corrected for uneven survey effort.

Fin whales are the most commonly stranded large whale in the Rhode Island study area, with 28 records since 1970 (Table 2). One of the more interesting recent fin whale observations was in July 1983, when a headless carcass was seen drifting for several days. It was seen southwest of Block Island on the 27th and 5 km south of Point Judith on the 31st, with a number of great white sharks feeding on it. In August, as the dead whale continued drifting near Block Island, fishermen took the opportunity to target the feeding sharks (Casey and Pratt, 1985). Three very large male white sharks—480, 484, and 497 cm—were harpooned, two even larger animals (estimated at 518 and 610 cm) were tagged, and at least three others were seen. On 13 July 1989, a moderately decomposed immature female fin whale was found near Quonset Point; it was hauled up at Pier 2 in Davisville the following day. It had a fractured lower jaw and rope entangling the right flipper. On 27 July 1991, an 11-m whale was seen drifting near the south shore; it came ashore on East Matunuck State Beach on the 28th. On 30 April 1996, a 12.8-m fin whale stranded on Warren's Point in Little Compton. Three fin whales stranded this century in Newport—one in Castle Hill Cove on 25 November 2002, one at Fort Adams State Park on 13 June 2004, and one at Brenton Point State Park on 24 December 2004. There were also two strandings in Connecticut: on Long Point in Groton on 28 January 1976—a 13.5-m whale with injuries from a ship collision, and in New Haven harbor on 18 December 1983—a 12-m female that was stuck in an area of broken pilings for several hours before it died. Fin whale strandings are common in the Rhode Island study area both east and west of Rhode Island, as well as beyond the study area in New York, New Jersey, and Massachusetts. Shark scavenging on fin whale carcasses seems to be common from Rhode Island west. There are peaks in the stranding frequency in the study area in 1975–1985 and 2001–2005 (Fig. 11), which is a different pattern than what was shown for humpback whales (Fig. 7.) The underlying cause is not obvious. Plotting the annual stranding frequencies from 1987 to 2005 (Fig. 12) to match the humpback graph shows the fin whale stranding rate to be very consistent across years, with 0–2 strandings per year and no obvious clusters. However, plotting the previous 19-year period in the same format shows a very clear spike in 1983 at more than triple the maximum in any other year, which was also noted by Hain et al. (1992). The underlying reason is not known, but could potentially be fluctuations in prey resources, a disease event, a biotoxin event, other natural or anthropogenic impact, or simply random variability in mortality.

Conclusions: Fin whales are the most common large whale encountered in continental shelf waters south of New England and into the Gulf of Maine. They are the whales most often encountered by local whale-watching operations in most years, and are quite likely to occur in SAMP area. Despite their relative abundance, they are listed as Endangered under the ESA. Fin whales must be considered in construction and operational planning for any developments in the SAMP area.

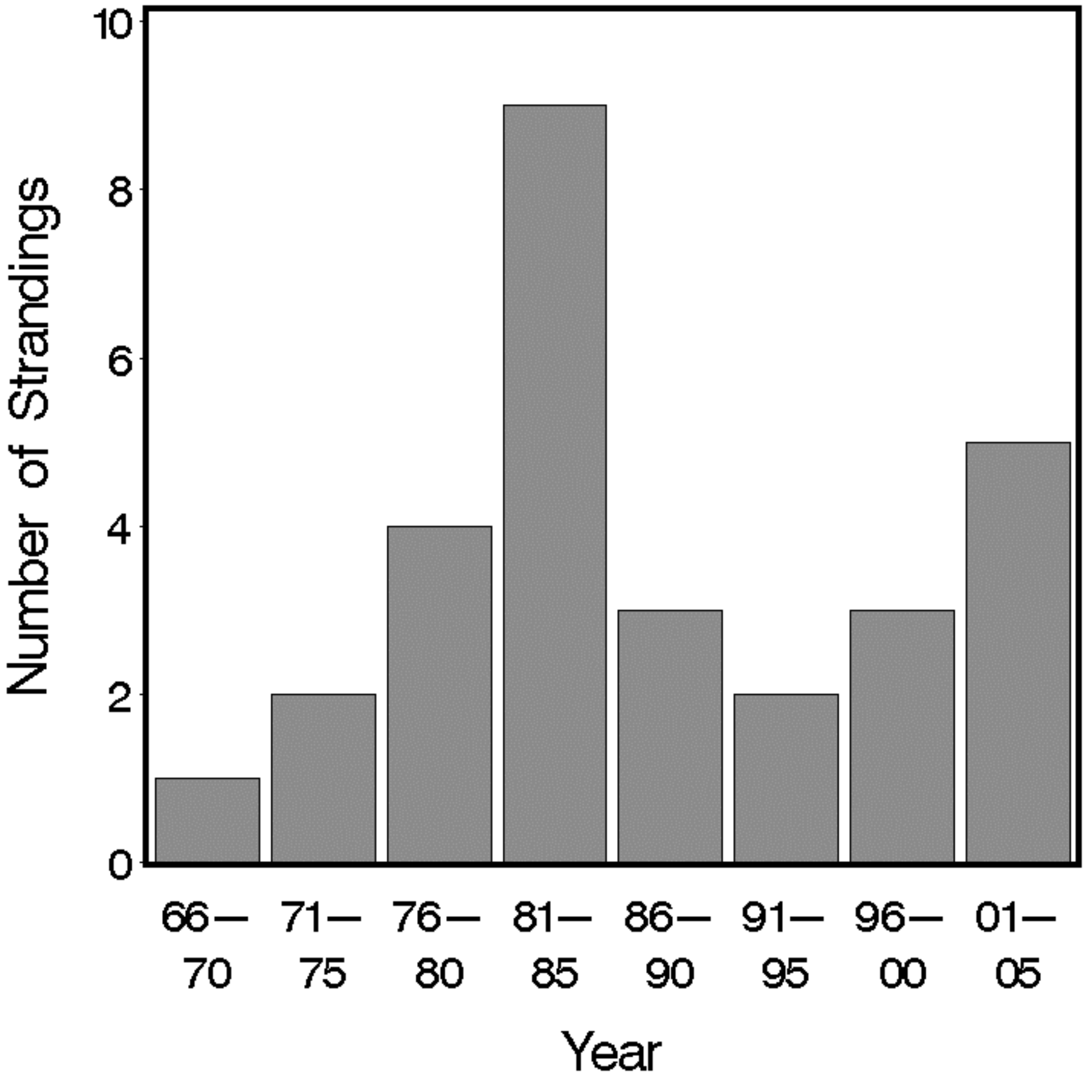

Figure 11. Five-year stranding frequencies for fin whales in the Rhode Island study area, 1966–2005.

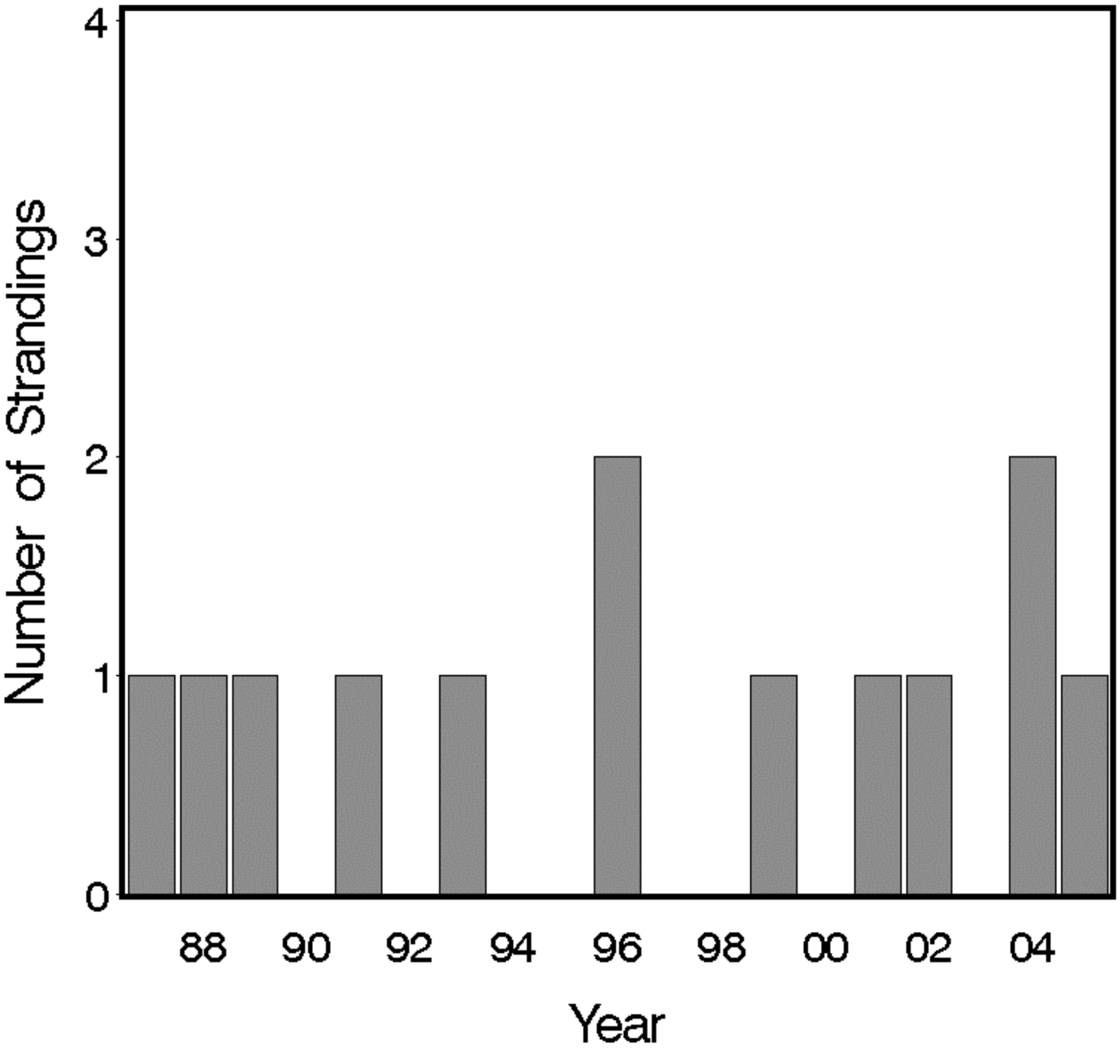

Figure 12. Annual stranding frequencies for fin whales in the Rhode Island study area, 1987–2005, for comparison with humpback whales (Fig. 7).

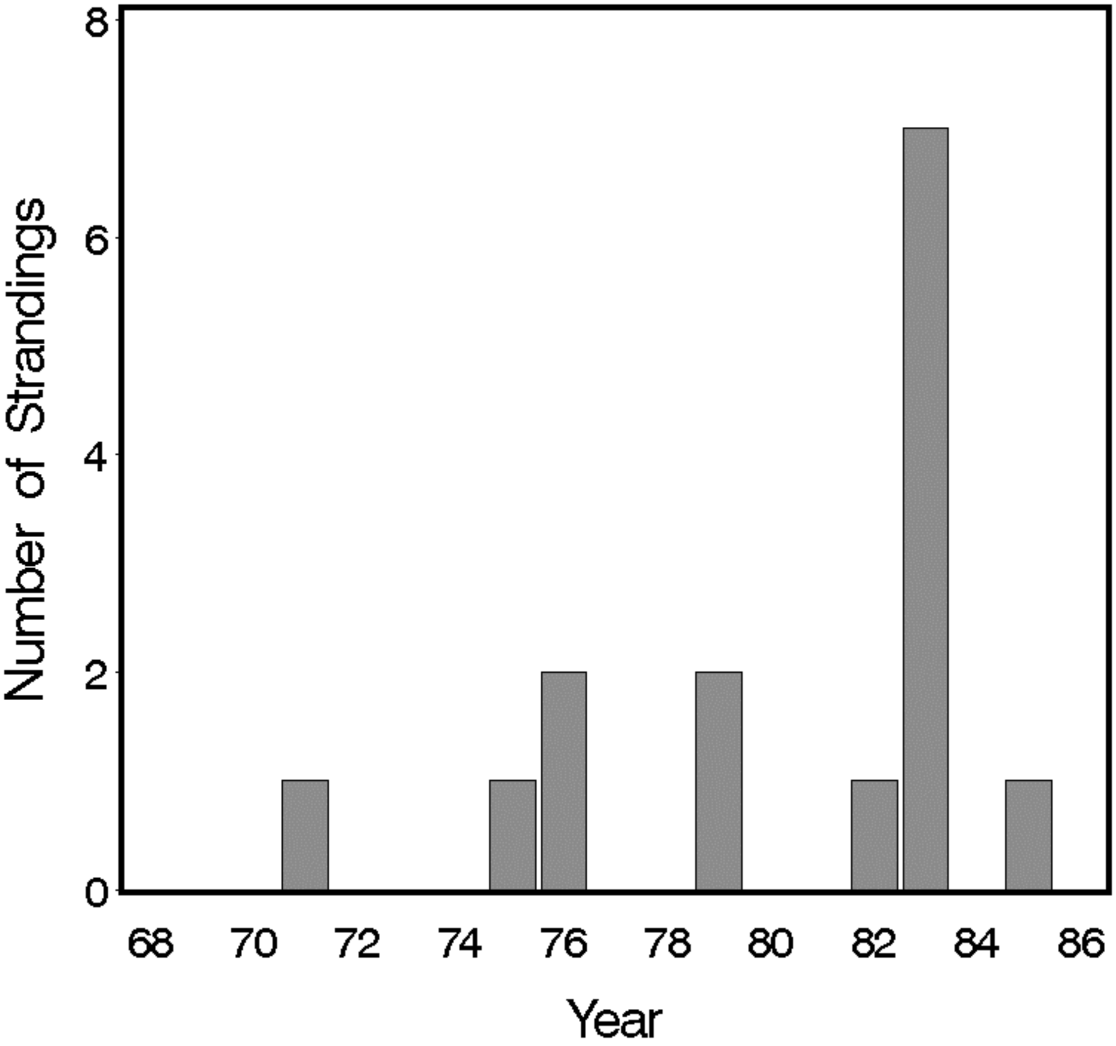

Figure 13. Annual stranding frequencies for fin whales in the Rhode Island study area, 1968–1986.

3.2.5 Sei Whale *Balaenoptera borealis* Lesson 1828

Description: Adult sei whales are 12–17 m in length, with a very sleek, slender, and streamlined appearance (Gambell, 1985b; Jefferson et al., 1993; Wynne and Schwartz, 1999). Typical maximum sizes in the whaling catches in Iceland were about 14 m in males and 15 m in females (Horwood, 1987). They are dark gray or brown to almost black in color, with a lighter belly, and frequently with pale mottling or scars. The rostrum is sharply pointed with a single longitudinal ridge, and curves noticeably downward towards the sides and tip. The dorsal fin is erect and very falcate, and is located about 2/3 of the way back on the animal. There are 40–55 ventral grooves, which end about mid-way between the flippers and the navel.

Status: Sei whales are classified as Endangered under the U.S. Endangered Species Act, and are not included on the Rhode Island state list. They are currently classified as Endangered on the IUCN Red List, however the classification was based mainly on depletion of Southern Hemisphere stocks by 20th Century whaling. There is no reliable estimate of the total abundance of sei whales in the North Atlantic (Perry et al., 1999). The IWC recognizes three more or less arbitrarily-defined stocks in the North Atlantic: Nova Scotia (the one occurring off the U.S. Atlantic coast); Iceland-Denmark Strait; and Eastern (Donovan, 1991). Recent surveys suggest that there are about 10,000 in the Iceland-Denmark Strait stock (Horwood, 2002), but they seem to remain very rare off Europe (IUCN, 2008). Recent summer surveys in the Gulf of Maine in 2004 and 2006 yielded estimates of 386 and 207 sei whales, respectively (Waring et al., 2008), however the estimates are not corrected for diving and the surveys may have been later in the year than the spring peak occurrence of the whales around Georges Bank. Mitchell and Chapman (1977) estimated the Nova Scotia stock at 1,400–2,200 whales, which is similar to the estimate of about 2,200 for the U.S. Atlantic from the CETAP (1982) survey data if corrected for diving using the same correction factor derived for fin whales (Kenney et al., 1997).

Commercial whaling on sei whales did not begin until modern technology allowed the capture of fast-swimming rorquals, beginning in the second half of the 19th Century. In the North Atlantic, sei whales have been hunted in the waters off mainland Europe, Norway, the British Isles, Iceland, Greenland, and Canada, with total takes of more than 14,000 whales (Horwood, 1987), plus an unknown proportion of the 30,000 whales taken that were not identified to species (IUCN, 2008). About 1,200 sei whales were taken off eastern Canada in the 1960s and 1970s (IUCN, 2008), including 825 by whalers operating from a station in Blandford, Nova Scotia (Mitchell, 1975b). Since the IWC moratorium began in 1986, the only North Atlantic sei whales killed have been 70 taken in Iceland in 1986–1988 under a scientific research permit, and the possibility of an occasional accidental take in subsistence hunting for fin whales in Greenland (Reeves and Kenney, 2003).

Other human-related mortalities of sei whales appear to be rare (Waring et al., 2008). There have been no known fishery entanglement mortalities in U.S. Atlantic waters. There have been three known ship-strike mortalities in the last two decades. A dead sei whale was found on the bow of a container ship in Boston on 17 November 1994, and a similar event happened on 2 May 2001 in New York Harbor. A dead sei whale with extensive injuries was found floating near the Navy base in Norfolk, Virginia on 19 February 2003.

Ecology and life history: Sei whales are normally observed alone or in groups of 2–5 animals. During the 1979–1981 surveys off the northeastern U.S., the most common sighting was a single whale, the average group size was the largest of all the baleen whales at 3.0, and the range was from 1 to 40 (CETAP, 1982). They are sometimes observed in feeding aggregations with other baleen whales, including fin, humpback, and right whales. Kenney and Winn (1987a) described a large whale feeding aggregation observed on 18 April 1980 in the vicinity of Hydrographer Canyon, which included 9 humpback whales, 10 right whales, at least 20 fin whales, and at least 40 sei whales, all feeding on probable euphausiid patches.

Sei whales are “switch-hitters” in their feeding behavior (Ingebrigtsen, 1929; Nemoto, 1970; Pivorunas, 1979; Watkins and Schevill, 1979; Gambell, 1985b). Sometimes they are gulp-feeders like blue, fin, or humpback whales—lunging forward with the mouth gaping widely, then closing the mouth and squeezing out the water. At other times sei whales skim-feed, opening the mouth only part-way, then swimming ahead with the mouth open for longer periods continuously filtering prey from the water. The feeding method is likely determined by prey type—skimming for smaller prey and gulping larger prey.

The principal prey species of sei whales are primarily copepods and secondarily euphausiids (Kawamura, 1974; Mitchell, 1975b; Jonsgård and Darling, 1977; Mitchell and Chapman, 1977; Christensen et al., 1992; Schilling et al., 1992). Their very fine baleen fringes allow them to filter out smaller prey than the other rorquals. It should be noted that the location of the sei whale sightings in the vicinity of the SAMP area, south of Montauk Point and Block Island (Fig. 14), is also a location where right whale sightings tend to be aggregated (Fig. 3), suggesting that dense copepod concentrations occasionally develop in that vicinity.

Sei whale calves are born in the winter at a length of 4.4–4.5 m and weight of about 650 kg (Mitchell and Chapman, 1977; Rice, 1977; Lockyer and Martin, 1983; Gambell, 1985b; Horwood, 1987, 2002; Boyd et al., 1999). The gestation period is believed to be 10.5–12 months, perhaps slightly longer in the Southern Ocean than in the North Atlantic and North Pacific, therefore mating also occurs in the winter. Calves are weaned at 6 to 9 months old and about 9 m long, following the typical mysticete pattern of doubling in body length by the time of weaning. Both sexes typically reach sexual maturity at 5–15 years of age, with a peak at 8–10 years, and at about 13 m long. Females give birth every 2–3 years.

General distribution: Sei whales occur in all of the world's oceans, migrating between feeding grounds in temperate and sub-polar latitudes and wintering grounds at lower latitudes (Gambell, 1985b; Horwood, 1987, 2002; Reeves and Kenney, 2003). Most North Atlantic sightings are along the continental shelf edge and slope (Mitchell, 1975b; CETAP, 1982; Martin, 1983; Hain et al., 1985). Sei whales that occur off the northeast U.S. have been hypothesized to migrate from spring feeding grounds around the southern and eastern edges of Georges Bank, to the Nova Scotian shelf in June and July, further eastward perhaps as far as Newfoundland and the Grand Banks in late summer, back to the Scotian Shelf in the fall, and possibly offshore during the winter (Mitchell, 1975b; Mitchell and Chapman, 1977; CETAP, 1982). The winter range is poorly known, but there are scattered records from the southeastern U.S., Gulf of Mexico, and Caribbean (Mead, 1977; Schmidly, 1981; Gambell, 1985b). Sei whales also are known for their unpredictable sporadic occurrences in areas where they are not regularly seen (Gambell, 1985b; Horwood, 1987; P. M. Payne et al., 1990; Schilling et al., 1992; Clapham et al., 1997).

Historical occurrence: Historical sei whale records from southern New England are extremely rare. Cronan and Brooks (1968) knew of no occurrences in Rhode Island. Allen (1916) reported a stranding from Chatham, Massachusetts in August 1910, which he believed to be the first record from the U.S. Waters and Rivard (1962) said they were rare in New England, and reported only one Massachusetts occurrence, a stranding of an emaciated, 11.9-m male in the Jones River in Kingston on 21 October 1948. De Kay (1842) wrote that Dr. Mitchill[10] told him of an 11.6-m whale that was captured in 1804 near Reedy Island at the mouth of the Delaware River and then exhibited in New York. He assigned the whale to "*Rorqualus borealis,* the northern rorqual" (i.e., sei whale). No specimen from that whale survives. Allen (1916) believed that it was most likely a humpback whale, but it is recorded in the Smithsonian data as *Balaenoptera* sp. based on De Kay's account and subsequent literature reports. De Kay reported

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[10] Presumably Samuel Latham Mitchill, 1764–1831, physician, naturalist, New York Assemblyman, U.S. Congressman and Senator, professor at Columbia, and co-founder of the Rutgers medical school.

no other sei whale occurrences, nor did Linsley (1842), Goodwin (1935), or Connor (1971).

Recent occurrence: Sei whales have occurred infrequently in the Rhode Island study area, with 35 records in total (Fig. 10) and a strong concentration in the spring (82.9%). The primary spring feeding area on Georges Bank shown by CETAP (1982) does not extend west of 70ºW longitude. Most of the sightings are more offshore—from the middle of the shelf to the shelf break and slope. The sightings do confirm the typical pattern of irregular occurrences by sei whales. The small cluster of five inshore sightings south of Montauk Point and Block Island included three on three different days in July 1981 (including the two inside the SAMP area—on 23 and 26 July), one in August 1982 (the only one from any whale-watching boat), and one in May 2003. All five were single individuals. The only other year with more than one sighting was 2001, when a NMFS aerial survey on 7 May recorded 23 sei whale sightings, totaling 112 individuals, within a relatively small area at mid-shelf south of Nantucket. There were single sightings in April 1983, May 1985, October 1987, April 2000, November 2004, April 2005, and April 2006.

For the sei whale SPUE estimates, we included 2.2% of the survey sightings identified as "unidentified fin/sei whale," based on the relative proportion of identified sightings of the two species. The resulting maps looked very similar to the fin whale model outputs. While it is quite probable that 2.2% of the fin/sei sightings in the study were sei whales (i.e., one or two of the 59 sightings), assuming that every sighting has the same probability of being a sei whale resulted in an obviously erroneous relative abundance model, which is not shown here. Since 60% of the identified sei whale sightings in the Rhode Island study area occurred on a single day in May 2001, and there were only six sightings in seasons other than spring, their occurrence in the region is too sparse to derive meaningful relative abundance patterns from the identified sightings alone.

There are no known strandings, either historical or recent, in the state or in the study area. The closest known stranding "as the crow flies" would be the 1948 incident in Kingston, Massachusetts mentioned above. The next two would be Allen's 1910 Chatham whale and one in September 2002 on the south shore of Long Island just west of Fire Island Inlet.

Conclusions: Although sei whales are sometimes known to occur unpredictably and irruptively, there have only been two sightings of single sei whales within the RI Ocean SAMP area—three days apart in July 1981. They are not expected to occur within the SAMP area except as a very rare visitor. Although sei whales are listed as Endangered under the ESA, they pose very little concern for any development with the SAMP area.

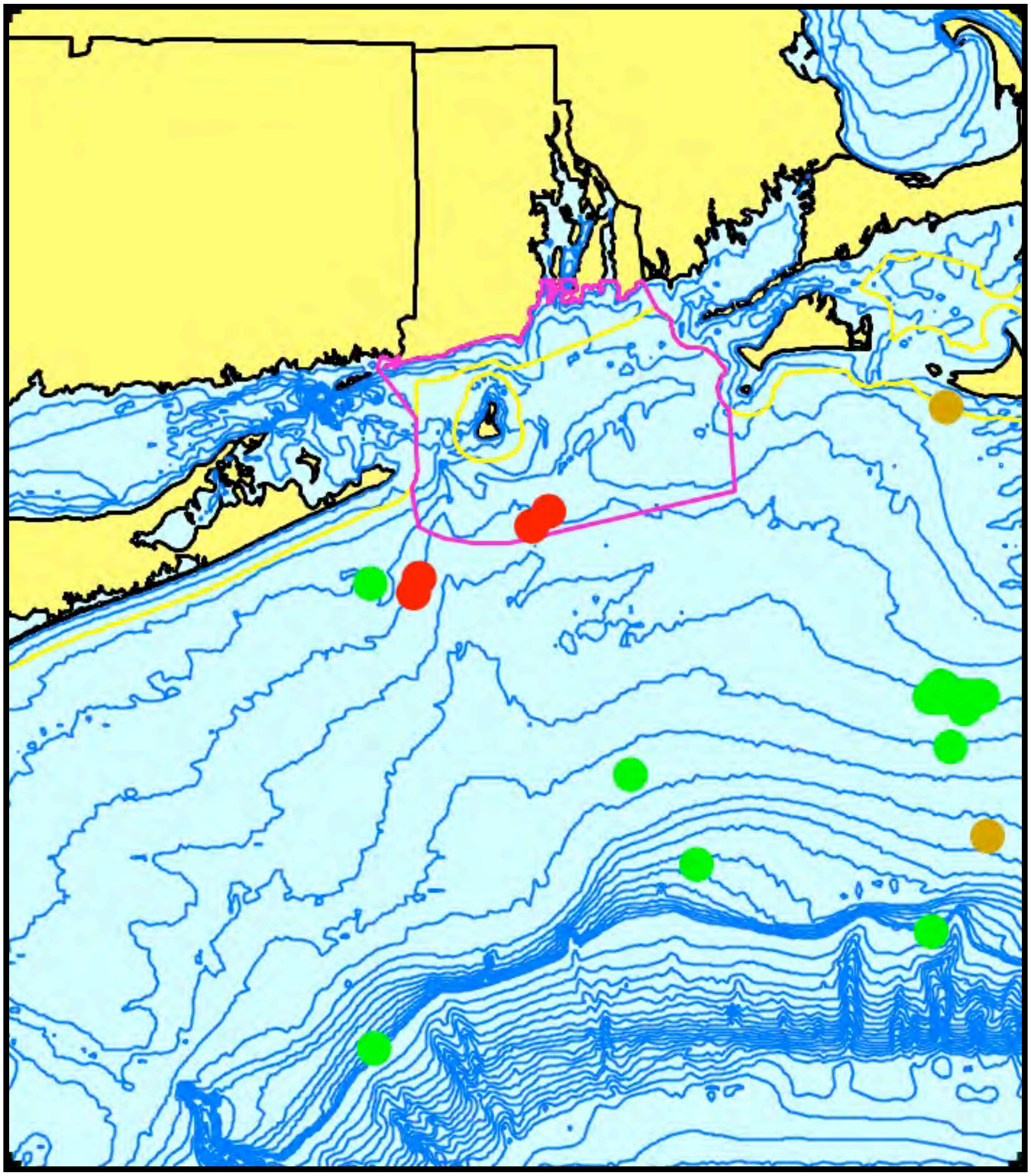

Figure 14. Aggregated sighting, stranding, and bycatch records of sei whales in the Rhode Island study area, 1981–2006 (n = 35: winter = 0, spring = 29, summer = 4, fall = 2).

3.2.6 Bryde’s Whale *Balaenoptera brydei* Olsen, 1913

Description: Bryde’s whales appear very similar to sei whales, but are slightly smaller, with adults up to 13–15.5 m in length (Cummings, 1985a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Kato, 2002). They are dark colored, lighter ventrally, with a pointed, slightly rounded rostrum and a prominent, falcate dorsal fin. The definitive distinguishing characteristic of Bryde’s whales is the presence of three longitudinal ridges on top of the rostrum—one down the middle and a parallel ridge on each side of it. There are 40–70 ventral grooves that extend to or past the navel. The baleen is dark gray with coarse, lighter gray fringes, and there are 250–350 plates on each side. The most anterior plates are sometimes lighter-colored or striped.

Status: Bryde’s whales are not listed under the U.S. Endangered Species Act, are not included on the Rhode Island state list, and are classified as Data Deficient on the IUCN Red List. There are no abundance estimates for the North Atlantic except for a small stock in the Gulf of Mexico. The most recent abundance estimate there is 15 (Waring et al., 2008), but there are previous estimates of 35–40.

In the North Pacific, Japan began taking Bryde’s whales under a scientific research permit in 2000, and currently takes 50 per year. North Atlantic Bryde’s whales have never been targets of commercial whaling, although traditional whalers in the West Indies very occasionally take one (Reeves and Kenney, 2003), and some may have been included in catch totals for sei whales prior to 1972 (IUCN, 2008).

Ecology and life history: Prey of Bryde’s whales include krill, other crustaceans, pelagic fish, and squid, with diets varying between regions (Best, 1977; Kawamura, 1980; Cummings, 1985a; Kato, 2002). Reproductive biology is not well known and is probably similar to other rorquals.

General distribution: Bryde’s whales are the most tropical rorquals and are found in all oceans (Cummings, 1985a; Kato, 2002; Rice, 1998), although the existing taxonomic questions and the fact that they were probably confused with sei whales in commercial whaling records for many years limits historical information on distribution.

Historical occurrence: There are no published records of Bryde’s whales in the region. There is a specimen of Bryde’s whale baleen in the Harvard Museum of Comparative Zoology (MCZ48537) that was dredged from the bottom in about 150 meters of water south of Nantucket, Massachusetts in 1952 (Fig. 15). The northernmost confirmed stranding record from the U.S. east coast is in Virginia (Mead, 1977).

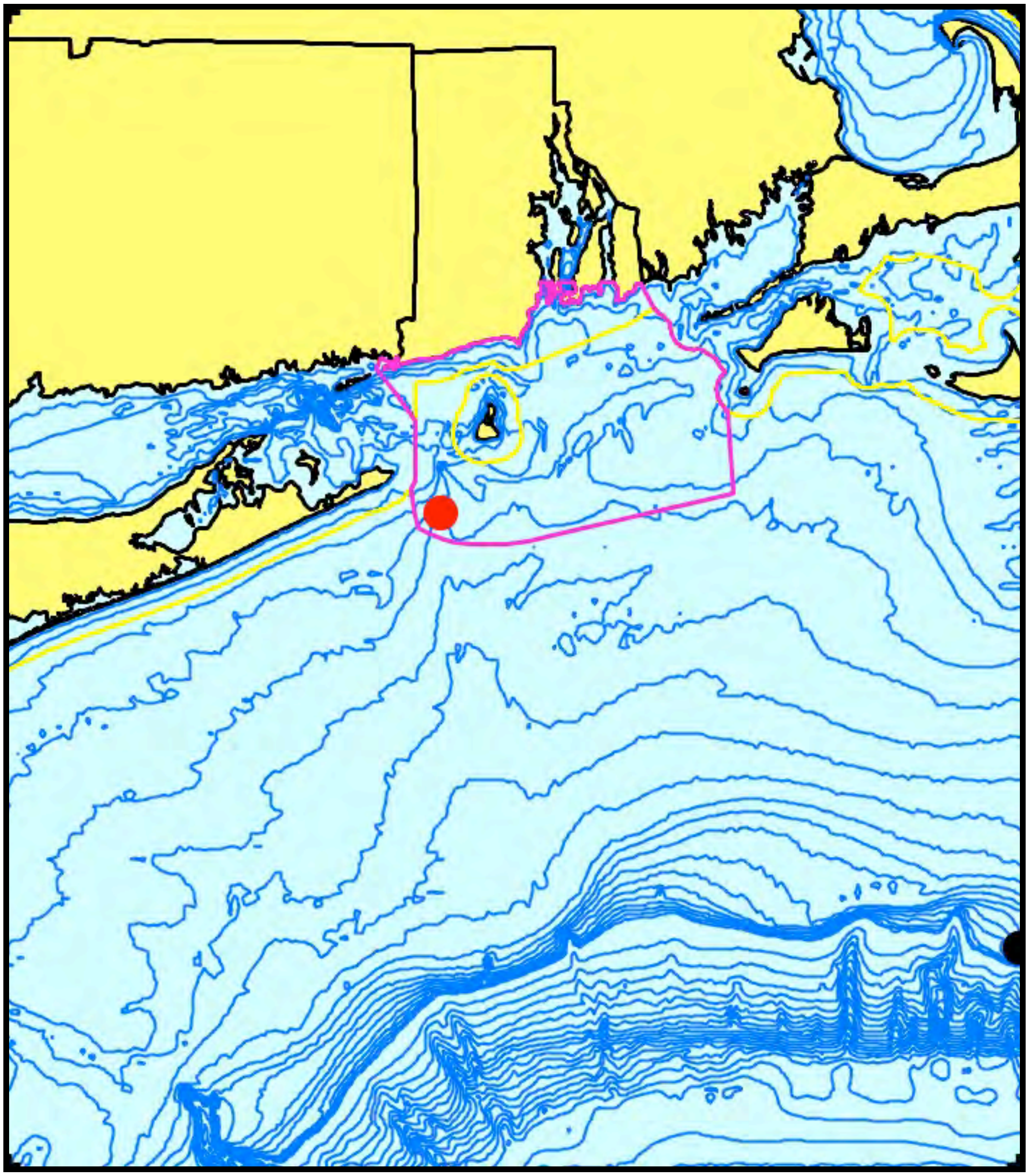

Figure 15. Aggregated sighting, stranding, and bycatch records of Bryde's whales in the Rhode Island study area, 1952 and 1982 (n = 2: winter = 0, spring = 0, summer = 1, fall = 0, unknown = 1).

Recent occurrence: There was one sighting of a single Bryde's whale southeast of Montauk from a whale-watch boat in August 1982 (Fig. 15).

Conclusions: Bryde's whales are clearly accidental off the northeastern U.S. and not a concern in the SAMP area.

3.2.7 Common Minke Whale *Balaenoptera acutorostrata* Lacépède 1804

Description: Common minke whales (There is a closely related species, the Antarctic minke whale *B. bonaerensis*, that has recently been accepted as a valid species, requiring the term "common" to designate this species.) are the smallest of the North Atlantic baleen whales, with adults generally 6–9 m long and reaching maximum lengths of 9–10 m (Stewart and Leatherwood, 1985; Jefferson et al., 1993; Wynne and Schwartz; 1999; Perrin and Brownell, 2002). The body is somewhat more robust than in the larger *Balaenoptera* species. The head is shorter relative to the body than in the other balaenopterids, and the rostrum is very sharply pointed with a prominent median ridge. The body is dark gray to black with a pale belly, and frequently shows pale areas on the sides that may extend up onto the back. The flippers are smooth and taper to a point, and the middle third of each flipper has a conspicuous bright white band. The dorsal fin is tall, prominent, and falcate, and is located about two-thirds of the way back along the body. The ventral grooves number 50–70, ending well forward of the navel. Minke whales were formerly known as little piked whales.

Status: Common minke whales are not listed under the U.S. Endangered Species Act or the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There are more than 180,000 minke whales in the North Atlantic (IUCN, 2008). The Northeast Atlantic stock is over 80,000 animals, the Central North Atlantic stock totals about 94,000, and the West Greenland stock is about 3,500. The Canadian East Coast stock includes the minke whales off the U.S. East Coast. The most recent estimate for a portion of the range from the Gulf of Maine to the Gulf of St. Lawrence is 3,312 (Waring et al., 2008), however that is likely to be a significant underestimate because minke whales tend to be under-sampled in most surveys. NMFS surveys in 1991 and 1992 designed specifically for harbor porpoises, also inconspicuous and difficult to detect, resulted in an estimate of 2,650 minke whales for just the northern Gulf of Maine and Bay of Fundy. Kenney et al. (1997) used those data in conjunction with CETAP

(1982) density estimates to suggest that a more likely range for minke whale abundance off the northeast U.S. was 10,000 to as many as 13,000 animals.

Minke whales are the smallest of the rorquals and did not have great commercial value until modern industrial whaling in the Southern Ocean decimated populations of the larger whales. Antarctic whalers started taking minke whales in the 1970s (Perrin and Brownell, 2002). In the North Atlantic, there is a long history of hunting for minke whales (reviews in Stewart and Leatherwood, 1985; Horwood, 1990; Reeves and Kenney, 2003). Small-scale minke whaling in Norway dates back to at least the Middle Ages, and modern whaling methods were first developed in Norway in the mid-19th Century. In the 20th Century, over 100,000 North Atlantic minke whales were killed by whalers, mostly Norwegians, on the high seas. Whalers from shore stations in Canada and West Greenland took about 1,000 and 8,000, respectively. Canada ceased whaling in 1972.

After the IWC moratorium began, Norway filed an objection and took 379 minke whales in 1986 and 375 in 1987 (Reeves and Kenney, 2003). In 1988–1992, catches ranged from 1 to 95 per year under a research permit. Norway resumed commercial minke whaling under objection in 1993, and presently takes several hundred each year. There is also an aboriginal subsistence hunt in Greenland that takes at least 150 minke whales per year. Iceland rejoined the IWC in 2002 and began taking small numbers of minke whales under a research permit beginning in 2003, with annual takes of 37, 25, 39, 60, and 39 through 2007. In October 2006, they announced the intention to resume small-scale commercial whaling and issued licenses to take 30 minke whales in 2007, but only 7 were taken. In 2008 they took 39 from a quota of 40.

Minke whales are occasionally entangled, with some killed and some released alive, in several east coast commercial fisheries, including the sink gillnet, pelagic driftnet, tuna purse seine, herring weir, and lobster trap fisheries, and there are occasional ship-strike mortalities. The average human-related mortality in 2001–2005 from the Canadian East Coast minke whale stock was estimated at 2.4 whales per year from entanglement and 0.4 per year from ship strikes (Waring et al., 2008).

Ecology and life history: Minke whales are typical baleen whales, most often seen as solitary individuals (Perrin and Brownell, 2002). The average group size sighted off the northeastern U.S. was 1.5 whales (CETAP, 1982). Large groups are occasionally observed, but those are temporary aggregations in areas of rich food supplies, often associated with other species that feed on the same prey, including fin whales, humpback whales, Atlantic white-sided dolphins, and harbor porpoises (CETAP, 1982).

Minke whales feed on a wide variety of prey types, including copepods, krill, pteropods, squid, and many kinds of small and medium-sized fishes (reviewed in Horwood, 1990). In the northeastern North Atlantic, where stomach contents have been studied extensively, krill and herring are the principal prey, followed by several gadoids (including cod, haddock, and pollack), and capelin (Folkow et al., 2000). Off the northeastern U.S., primary prey species are most likely clupeids, gadoids, sand lance, and mackerel. Feeding is by the typical rorqual gulp-feeding mode (Nemoto, 1970; Pivorunas, 1979). Minke whales can probably be more flexible in their prey choices than the larger rorquals, since they require smaller prey schools to feed efficiently.

Minke whales mature at about 7 years of age and 7.2 m long in females and 6 years and 6.8 m for males (Stewart and Leatherwood, 1985; Horwood, 1990; Perrin and Brownell, 2002). Mating has not been observed, but the timing has been inferred from fetal development curves derived from whaling data. In the North Atlantic, mating occurs from October to March. The gestation period is 10–11 months, therefore births are concentrated in winter. Calves are born at about 2.4–2.7 m long, and are weaned in only 4–6 months. Pregnancy rates in adult females taking in commercial whaling range from about 85% up to nearly 100%, therefore most females in good condition give birth on an annual cycle.

General distribution: Common minke whales are broadly distributed in the Northern Hemisphere from the edge of the ice to the tropics (Stewart and Leatherwood, 1985; Horwood, 1990; Rice, 1998; Perrin and Brownell, 2002). The distribution of the dwarf minke (a sub-species) in the Southern Hemisphere is less well known, and is perhaps more coastal than Antarctic minkes (a separate species). In the western North Atlantic, minkes are common from Virginia north to the ice edge, and they occur as far south as the West Indies and Gulf of Mexico. In continental shelf waters off the northeast U.S. and eastern Canada, minke whales are abundant in spring and summer, less abundant but still common in fall, and largely absent in winter (CETAP, 1982). There are stranding records from the southeast U.S. Atlantic coast and Gulf of Mexico, as well as sightings and strandings from the West Indies and Caribbean, all of which are concentrated mainly in the winter. This had led to the hypothesis that minke whales migrate offshore and south to wintering grounds in the West Indies and deep water south and east of Bermuda (Mitchell, 1991).

Historical occurrence: Cronan and Brooks (1968) reported five 19th Century minke whale records from Rhode Island, apparently from Allen (1916), but one is the whale injured by the ship propeller that was included above as a fin whale based on the species as recorded in the Smithsonian database. The others included: a 5.5–6.1-m whale killed near Point Judith on 15 May 1849, a 7.6-m whale killed (2 others were sighted) at the mouth of the Sakonnet River on 20 August 1867, a sighting off Newport in September 1887, and an 8.2-m whale killed near Fort Adams on 5 September 1889. Cronan and Brooks also reported a minke whale that drowned in a fish trap off Sakonnet Point on 11 June 1961 and a 4.6-m juvenile found in the Sakonnet River in July 1967.

The minke whale was included by De Kay (1842) as the "beaked rorqual (*Rorqualus rostratus*)", with "swimming paws white in the middle." He reported the capture of a 4.9–5.5-m animal in lower New York Bay in 1822 that was the basis for his description. Helmuth (1931) reported a specimen about 8 m long that was killed off Montauk Point and towed to shore on 16 August 1931. Connor (1971) knew of no additional New York records beyond those two, but said that minke whales were more frequent farther east in Rhode Island and Massachusetts. Allen (1916) said that, despite few previously published records, minke whales were common in New England, but Waters and Rivard (1962) erroneously concluded that they were rare. They knew only of a 6-m male that was caught in a fish trap off Barnstable and released alive, and the 1961 Rhode Island record.

Recent occurrence: Minke whales occur in the Rhode Island study area in all four seasons (Fig. 16). The largest proportion of records is in summer (74.6%) and spring (19.6%), however that is clearly biased by the large number of sightings from the whale-watching boats. Without the dense concentration of sightings between Block Island and Montauk Point in spring and summer, minke whales are still strongly seasonal—most widespread in the region during the spring (48.8%) and summer (41.7%), and relatively rare in the fall (7.1%) and winter (2.4%). Without the aggregation of records from the whale-watching boats, minke whales are distributed across the shelf from nearshore to the slope.

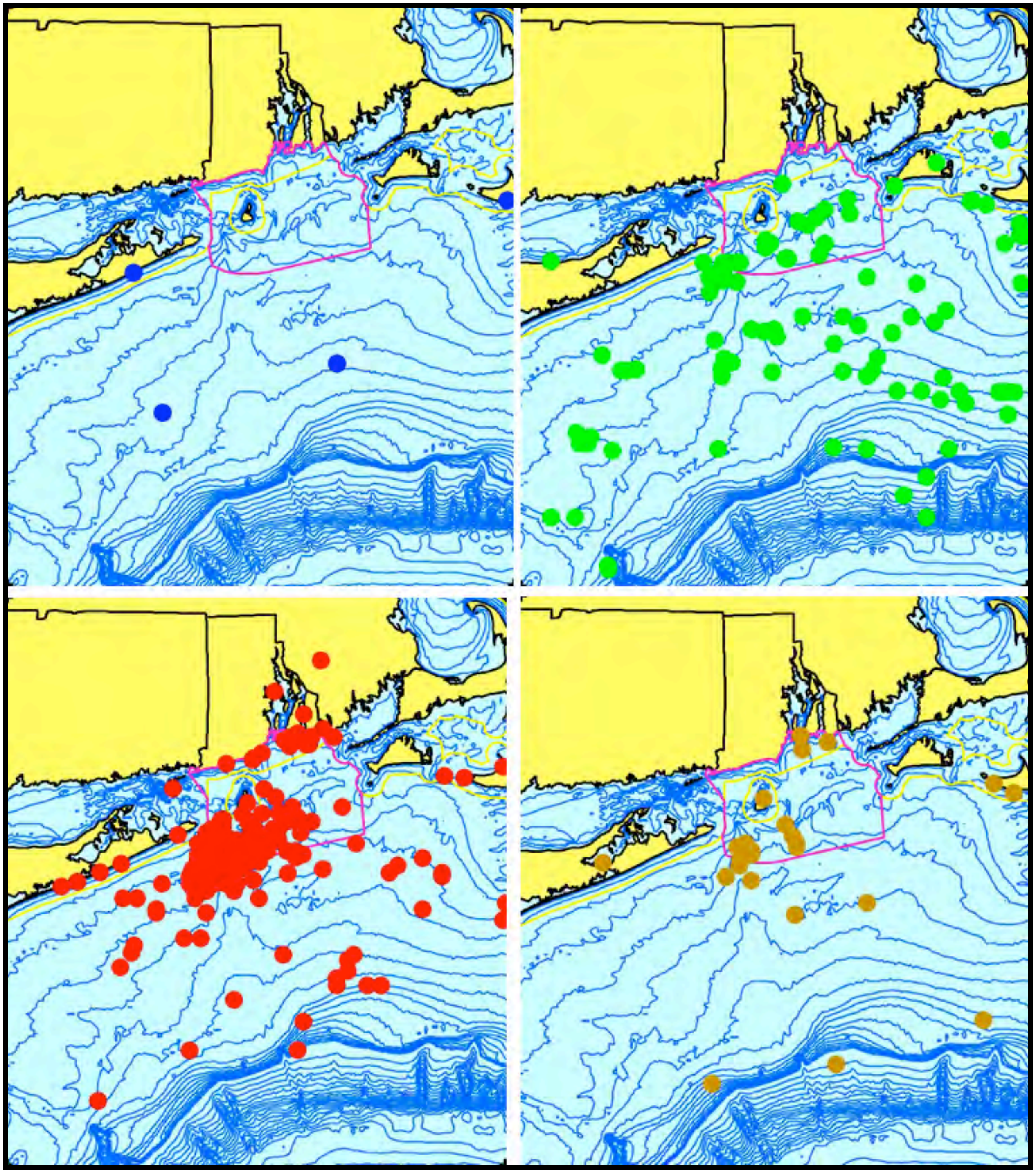

Figure 16. Aggregated sighting, stranding, and bycatch records of common minke whales in the Rhode Island study area, 1849–2008 (n = 504: winter = 4, spring = 99, summer = 376, fall = 25).

The effort-corrected relative abundance patterns of common minke whales (Fig. 17) show the same concentration in the Great South Channel east of Cape Cod and Nantucket as there was for humpback whales and fin whales (Figs. 6 & 10). Great South Channel minke whale abundance was highest in summer, followed in decreasing order by spring, fall, and winter. Kenney and Winn (1986) showed that the area in question was the most intensively utilized cetacean habitat off the northeastern U.S., primarily because of large stocks of sand lance. In the spring, there was also an area of high minke whale abundance on the outer shelf south of Nantucket, which extended west at lower levels as far as Montauk. Within the SAMP area, there is a widespread area of low minke abundance in spring, and another in summer that is only in the southwestern quadrant. There is also an area of moderate minke whale abundance on the outer shelf south of the SAMP area in summer.

Minke whales are the most commonly stranded baleen whale in the Rhode Island study area in recent decades, just nosing out fin whales with 29 strandings since 1970 (Table 2). There were 18 minke whale strandings in Rhode Island between 1976 and 2003: 31 July 1976—drowned in a fish trap off Sakonnet Point; 30 August 1981—stranded on First Beach, Newport, with possible rope marks; 26 November 1987—stranded on Mansion Beach, Block Island; 20 September 1988—stranded on Sakonnet Point; 5 July 1989—drowned in a fish trap off Point Judith; 18 August 1989—stranded in Newport; 19 July 1990—stranded in Newport, missing the tail but badly decomposed; 6 July 1991—stranded on Crescent Beach, Block Island, scavenged by sharks; 1 July 1992—stranded in Little Compton; 18 June 1995—stranded on Second Beach, Middletown; 10 July 1997—stranded in Little Compton; 3 July 1999—stranded in Tiverton; 2 August 1999—stranded in Jerusalem; 16 July 2000—stranded on East Beach, Charlestown; 30 July 2001—stranded at Black Point, Narragansett; 17 August 2001—stranded on Second Beach, Middletown; 12 August 2002—stranded near First Beach, Middletown; 22 June 2003—stranded near the Cliff Walk, Newport. There is a clearly obvious seasonality to the Rhode Island strandings, with two in June, nine in July, five in August, and one each in September and November. It is likely that many of the stranded minkes are recently weaned young of the year; their timing corresponds well with winter calving and a 4–6 month weaning time.

An interesting nearby minke whale occurrence was in Massachusetts in July 1994 (which at first glance looks like a mapping error in Fig. 16). A 405-cm female minke whale was seen in the

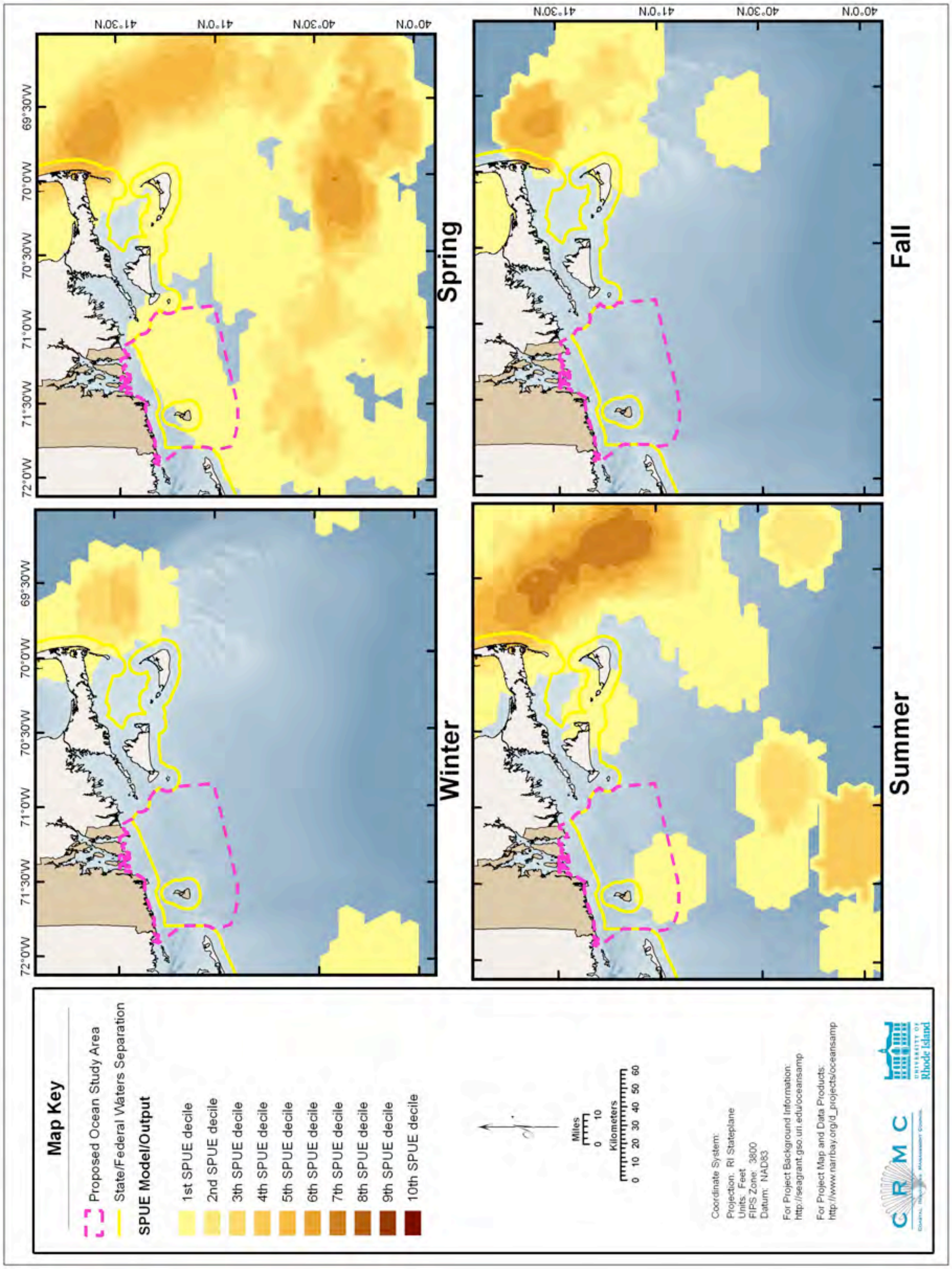

Figure 17. Modeled seasonal relative abundance patterns of common minke whales in the Rhode Island study area, corrected for uneven survey effort.

Taunton River in Dighton on the 23rd, about 13 km upstream from where the river empties into Mount Hope Bay at Fall River. The animal stranded in a marsh and was pushed off. It was found floating dead in the river two days later.

Five-year stranding frequencies in the Rhode Island study area (Fig. 18) show absence from 1966 to 1975, only one stranding in 1976–1980, then higher and relatively consistent strandings

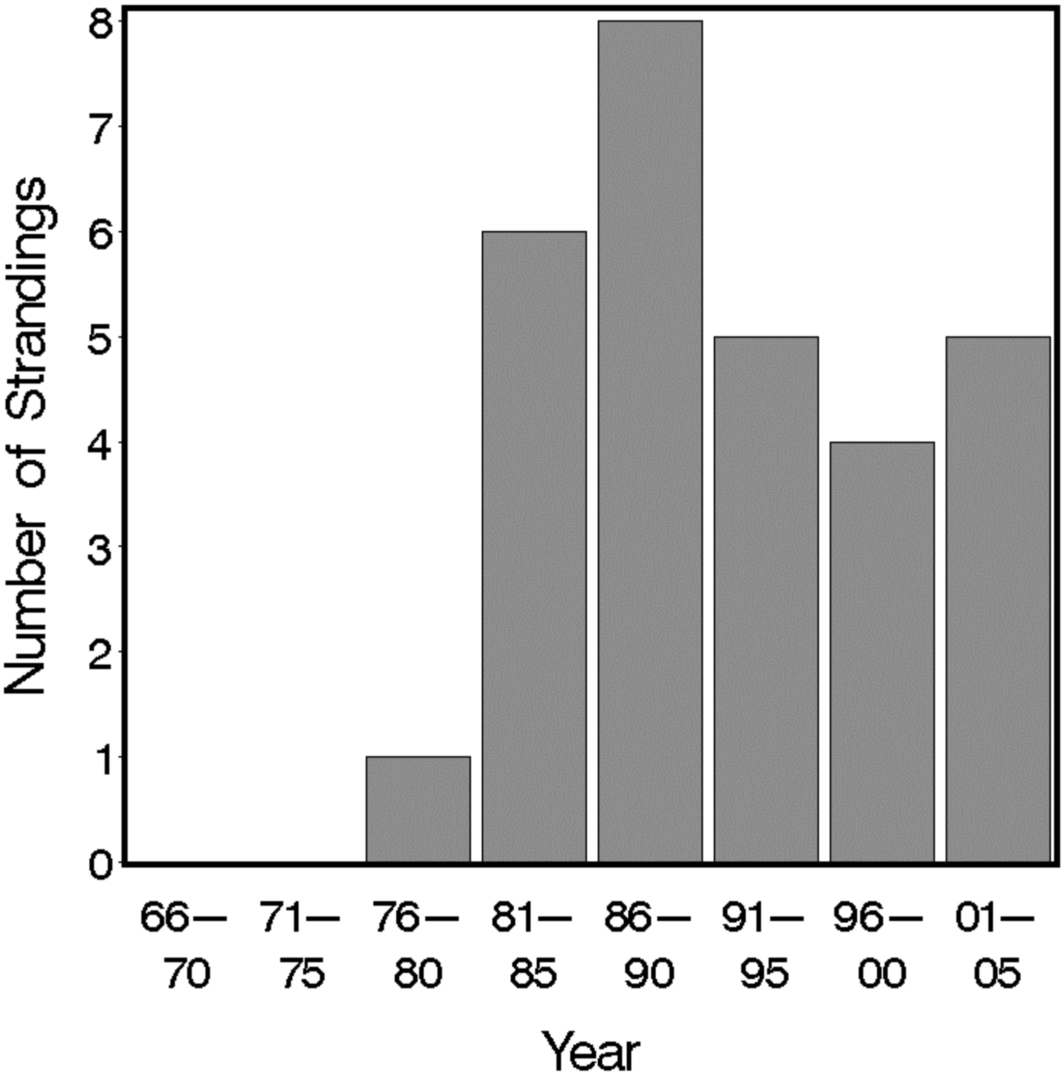

Figure 18. Five-year stranding frequencies for common minke whales in the Rhode Island study area, 1966–2005.

from 1981 to 2005. It is not known whether this pattern was caused by a lack of attention to minke whale strandings prior to the mid-1980s or a real increase in frequency afterwards.

Conclusions: The relative abundance models predict that common minke whales can be expected in the SAMP area in spring and summer, but not in fall or winter. There are some sighting records within the SAMP area in fall, but they were not during surveys, and the absence of minke whales in that season in the SPUE data is probably related to a combination of low abundance and low survey effort. Minke whales are not listed under the ESA, and should be considered a mid-level conservation priority relative to the SAMP.

3.2.8. Gray Whale *Eschrichtius robustus* (Lilljeborg, 1861)

Description: A gray whale is more robust in form than any of the *Balaenoptera* spp., but less so than a humpback (Wolman, 1985; Jefferson et al., 1993). Calves are born at 4.6–5 m, and adults reach 11–15 m. The head is relatively short, with a moderately curved and tapered rostrum. There is no dorsal fin; there is low hump followed by a series of “knuckles”—similar to the form in the sperm whale. There are 2–5 short, deep creases on the ventral surface in the throat region. The flippers are relatively broad and tapered to points, containing only four digits as in the rorquals. The color of the body is gray to brownish gray, lighter in adults and darker in calves, with extensive irregular mottling and patches of barnacles and whale lice. There are 130–180 short, yellowish baleen plates on each side of the mouth, with very coarse fringes.

Status: Gray whales were extirpated in the North Atlantic in early historical times, by the late 17th or 18th Century (Mead and Mitchell, 1984; Lindquist, 2000; Jones and Swartz, 2002), apparently persisting long enough to have been hunted by early whalers on both sides of the basin. The youngest specimen from the eastern North Atlantic dates to 1655 ± 260 years (Bryant, 1995). If, in fact, whaling were the cause of their disappearance, North Atlantic gray whales would be the only whale population hunted to extinction by commercial whaling.

Ecology and life history: Gray whales are primarily benthic feeders, specializing on ampeliscid amphipods, which live in mats of tubes in the sediment (Nemoto, 1970; Johnson and Nelson, 1984; Nerini, 1984; Kvitek and Oliver, 1986; Nelson and Johnson, 1987). A foraging gray whale swims to the bottom; rolls onto its side; sucks up a mouthful of sediment, water, amphipods, and their tubes; then forces a cloud of muddy water back out through the baleen filter. Gray whales can also feed on prey up in the water column, including krill, small schooling fishes, and squid, with a total of over 80 prey species recorded (Jones and Swartz, 2002).

General distribution: Gray whales occurred only in the Northern Hemisphere, and today survive in two separate populations on the eastern (the “California” stock) and western (the “Korean” stock) sides of the North Pacific (Wolman, 1985; Swartz, 1986; Jones and Swartz, 2002; Reeves and Kenney, 2003). Extant gray whales have a primarily coastal distribution, so it seems reasonable to presume that North Atlantic gray whales were similarly coastal animals. Gray whales undertake some of the longest migrations known for any mammal. Very little is known of the distribution and migration of the former North Atlantic population. Subfossil remains have been found at scattered sites in northern Europe and along the east coast of the U.S. (Jones and Swartz, 2002). Mead and Mitchell (1984) speculated that early American colonial reports of whales using Delaware Bay as a calving ground, generally presumed to have been right whales, may have actually represented North Atlantic gray whales.

Historical occurrence: The Smithsonian dataset includes one record of a gray whale bone from the Rhode Island study area—a mandible carbon-dated to the very early 18th Century (± 35 years) found in Southampton, New York in 1977 (Mead and Mitchell, 1984). There is a second record from New Jersey—a mandible dated to the 16th Century found in Tom’s River in 1855. Interestingly, Block Island Sound is known to have dense populations of ampeliscid amphipods (Steimle, 1982), and one might speculate that it was historically a gray whale feeding ground.

Conclusions: North Atlantic gray whales are extinct, therefore they pose no conservation issues relative to the Rhode Island Ocean SAMP.

3.2.9. *Physeter macrocephalus* Linnaeus 1758: Sperm Whale

Odontoceti includes a variety of species known as whales, dolphins, and porpoises. They are characterized by having teeth in one or both jaws (although in some species teeth only erupt in adult males) and a single blowhole (Hooker, 2002). They use echolocation for navigation and foraging, producing mid- to high-frequency sounds and listening to the echoes. Many of the unique characters of the skull, lower jaw, and facial region of odontocetes are related to echolocation (Au, 2002). Odontocete species vary widely with respect to sexual dimorphism—some species are strongly dimorphic with males much larger than females, while others are slightly dimorphic, slightly reverse dimorphic (i.e., females larger), or monomorphic. Most odontocete species are highly social, living in more or less permanent groups of closely related individuals (Tyack, 1986). Twenty-four odontocete species in six families have been recorded from the waters or beaches of Rhode Island and adjacent areas, five other species are hypothetical (Table 1).

A number of authors consider the living sperm whale (*Physeter*) and two species of *Kogia* to be in the same family, but in separate subfamilies (e.g., Mead and Brownell, 2005). Fordyce and Barnes (1994) and Rice (1998) maintained Physeteridae and Kogiidae as two separate but closely related families. Characters shared by both families include (Nowak, 1999): a skull with a broad, flat rostrum and a large concavity in the facial region; a spermaceti organ in the forehead; and a narrow lower jaw that is significantly shorter than the rostrum. Sperm whales differ from pygmy and dwarf sperm whales in several characters (Caldwell and Caldwell, 1989; Rice, 1989; Nowak, 1999; McAlpine, 2002; Whitehead, 2002). Physeterids are much larger than kogiids (although there is a 5-m fossil physeterid: Mchedlidze, 2002). The head in *Physeter* is also much larger, comprising a quarter to a third of total body length, compared with only an eighth to a sixth in *Kogia*. Among other skull characters, *Kogia* has the shortest rostrum of any odontocete at less than half of the total skull length, while the rostrum of a sperm whale makes up two-thirds to three-quarters of the total length of the skull. Finally, the blowhole of a sperm whale is S-shaped and located on the left anterior corner of the head, while *Kogia* has a C-shaped blowhole on top of the head and slightly left of center.

Sperm whales are the only odontocetes large enough to be included with the baleen whales among the so-called “great whales.” They were the basis of Yankee whaling in the 18th and 19th Centuries, as memorialized in Melville’s classic *Moby Dick*.

Description: Sperm whales are the largest of the toothed whales and the most sexually dimorphic of all cetaceans (Rice, 1989; Jefferson et al., 1993; Wynne and Schwartz, 1999; Whitehead, 2002; Reeves and Read, 2003). Adult males may reach 18.3 m in length, and Tomilin (1967) reported males from the North Pacific of 19 or 20 m, while the maximum size for adult females is only 12.5 m. More typical adult sizes are 12–16 m in males and 8.5–11 m in females. The head is large and squarish, comprising up to a third of the body length, with a very narrow, underslung lower jaw. The body color is from medium to dark gray-brown, often with light areas on the belly and around the mouth. The skin on the head is smooth, but forms longitudinal wrinkles or corrugations on the rest of the body. The flippers are relatively short, rounded, paddle-like, and set relatively high on the body so they do not project down below the belly when viewed from the side. The dorsal fin is low, blunt, and triangular—so low that some sources say that a dorsal fin is absent (e.g., Leatherwood et al., 1976; Nowak, 1999). There are distinct "knuckles" on the ridge between the dorsal fin and the tail. The trailing edge of the flukes is generally very straight across with a deep notch in the center, although they may become damaged and irregular in older animals.

Status: Sperm whales are listed as Endangered under the U.S. Endangered Species Act, are not included on the Rhode Island state list, and are classified as Vulnerable on the IUCN Red List, although the analysis concluded that a Near Threatened classification was almost as well-supported. There are statistically reliable estimates of abundance of sperm whales only for rather limited portions of their entire range, and a wide variety of extrapolations to global populations. Rice (1989) summarized the extrapolated estimates available at that time as 190,000 in the North Atlantic, 930,000 in the North Pacific, and 780,000 in the Southern Ocean. The worldwide total of 1.9 million represents a reduction from a pre-whaling population of 2.8–3 million. Whitehead's (2002) range of estimates for current stocks is substantially lower at 200,000 to 1.5 million, and stocks in some areas like the eastern South Pacific appear to be still severely impacted by past whaling. The most recent abundance estimate for sperm whales off the east coast of the U.S. from Florida to Maine is 4,804, with an additional 1,665 in the Gulf of Mexico (Waring et al., 2008). Those estimates are minimum values because they are not adjusted for whales missed due to diving.

Hundreds of thousands of sperm whales have been killed worldwide since the beginning of Yankee whaling in the early 18th Century. The total take in 1800–1910 was over 700,000, with an additional 600,000 or more killed since 1910 (Reeves and Read, 2003). Commercial hunting of sperm whales ended worldwide with the IWC moratorium in 1986. There is presently no hunting at all for any purpose in the North Atlantic, and a few are taken each year in the North Pacific under scientific research permits by the Japanese.

Sperm whales are occasionally entangled in fishing gear off the east coast of the U.S. or struck and killed by ships, but the level of mortality is not believed to be biologically significant (Waring et al., 2008). Sperm whales feed relatively high on the food chain and could potentially accumulate high levels of toxic contaminants, however they appear to have lower levels than odontocetes from more coastal waters (Whitehead, 2002). There is also concern that sperm whales could be subject to negative impacts from increasing levels of noise in the oceans, from sources including shipping, naval sonar, and seismic exploration for oil and gas (Reeves and Read, 2003).

Ecology and life history: Like most odontocetes, sperm whales are very social and live in permanent matrilineal groups (Caldwell et al., 1966; Best, 1979; Rice, 1989; Whitehead et al., 1991; Christal et al., 1998; Whitehead and Weilgart, 2000; Whitehead, 2002; Reeves and Read, 2003). Off the northeastern U.S., the average number of animals at a sighting was 3 (CETAP, 1982), and group sizes ranged as high as 100 whales. More than half of all sightings were solitary individuals, and typical group sizes were 2–10 whales. The basic unit of sperm whale social organization is the “mixed school” consisting of females of all ages and immature males (Best, 1979). Mixed schools are predominantly female, 70% or more. Adult females in the school are closely related, and the calves and immatures of both sexes are their offspring. Females in the mixed schools remain associated for their entire lives. Males leave the mixed schools as early as ages 4–5 and completely by age 15, forming bachelor schools. Whalers measured the size of a whale based on the oil yield. A New Bedford whaling captain quoted by Best (1979) indicated that the largest adult females or bulls in mixed schools yielded 35 barrels of oil. Bachelor bulls were caught in schools of same-sized animals, which decreased in number as the whales got larger. The largest bachelor schools were the 40-barrel bulls, and the next largest the 50-barrel bulls. Schools of 60-barrel bulls were generally 8–10 whales, 70-barrel bulls were in schools of 4–5 whales, and larger bulls were solitary or in pairs or trios. The whalers believed that mixed schools were “harems” controlled by a dominant bull, but mature males actually rove between mixed schools (Whitehead and Weilgart, 2000).

Sperm whales tend to remain relatively motionless at the surface or to swim ahead slowly during surface sequences, often tightly grouped. Surface sequences are generally much longer than in baleen whales, usually about 8–10 minutes but sometimes 15–60 minutes. Yankee whalers believed that a sperm whale needed to blow once for each minute spent submerged during the previous dive. Sperm whales are positively buoyant, and raise the flukes above the surface on the final dive in a surfacing sequence (Kenney and Winn, 1987b). Sperm whales are known to breach on rare occasions.

Sperm whales are prodigious divers (Watkins et al., 1985, 1993, 1999, 2002; Papastavrou et al., 1989; Rice, 1989; Whitehead, 2002; Amano and Yoshioka, 2003; Reeves and Read, 2003; Watwood et al., 2006). Dives are typically 30–40 minutes, but dives lasting an hour or more are relatively common, and Watkins et al. (1985) recorded one dive of 2 hours and 18 minutes. Dive depths depend on the depth of the water, as they are capable of diving to the bottom. Average dives are to about 400 m, but dives deeper than 2000 m are known. Descents and ascents may be nearly vertical. Watkins et al. (1999) tracked three sperm whales in the Caribbean using radio tags. Whales made relatively short surfacings of 7–10.5 minutes, both day and night, for respiration between long dives and for extended periods of rest and socializing during the day. They spent about 27% of their time surfaced during daylight and 15–17% during the night. Watkins et al. (2002) tracked a tagged 12-m sperm whale in the Caribbean for 4.6 days in April–May 1995. During that time it traveled 295 km and made 158 dives longer than 3 minutes. There were 65 relatively shallow dives (< 200 m) and 93 deeper dives that averaged 990 m (range = 420–1330) and 44.4 min (18.2–65.3). The whale spent 23% of its time at or near the surface, 23% in shallow dives, and 54% in deep dives.

An important characteristic that separates mysticetes and odontocetes is the use of echolocation (“sonar”) for foraging (Tyack, 1986, 1999; Au, 2002). Probably all cetaceans use sound for communication, but only odontocetes are known to echolocate. Echolocation involves the production of short-duration, high-amplitude, broadband pulses (“clicks”) and listening for echoes returning from objects in the environment. Clicks are produced in the nasal complex of air sacs and associated structures in the facial region and focused into a relatively narrow beam by the melon or spermaceti organ, and the echoes are received at the posterior portion of the mandibles (Norris, 1968, Norris and Harvey, 1974; Cranford et al., 1996; Møhl et al., 1999; Cranford, 2000; Au, 2002; Frankel, 2002). Click duration, frequency range, bandwidth, repetition rate, and amplitude vary among species. Many odontocetes, but not all, also produce tonal sounds (“whistles,” etc.) that are used for communication but have no role in echolocation. Sperm whales do not whistle, but use clicks for both echolocation and communication (Rice, 1989; Whitehead, 2002; Reeves and Read, 2003). Diving sperm whales click regularly once or twice per second as they search for prey. The whales in the school can certainly hear each other as they spread out during foraging dives, and they may be using clicks at the same time as contact calls. There are occasionally accelerating series of clicks (“creaks” or “buzzes”) as a whale homes in on a prey item (Miller et al., 2004; Watwood et al., 2006). Socially interacting whales also produced patterned sequences of 3 to about 20 clicks called “codas” (Watkins and Schevill, 1977). Codas vary by region and between schools and are probably passed on culturally within matrilineal groups. There are also very loud and slow (6–8 seconds apart) clicks called “clangs” that appear to be produced by large males; their function is not clear.

The primary prey of sperm whales is squid (Rice, 1989; Whitehead, 2002; Reeves and Read, 2003). Many species of mesopelagic and demersal squid are consumed, including very large ones up to the size of giant squid. The majority of the diet consists of medium-sized squids with mantle lengths of 20 cm to 1 m. Males feed on larger prey than do females and juveniles. Medium to large demersal fishes, including rays, sharks, and a variety of bony fishes, comprise small portions of the diet in most regions, but may be the predominant prey in certain areas, especially in high latitudes where only male sperm whales tend to occur. Other prey items include benthic octopus, crabs, and other crustaceans. Sperm whales consume a wider variety of squid than do northern bottlenose whales or Cuvier’s beaked whales, which correlates with range of movements within each species (Whitehead et al., 2003).

Feeding occurs at depth, apparently all the way to the bottom at times, since stomach contents sometime include stones, sediment, shells, and other non-food items from the sea floor. Feeding behavior has not been observed and can only be inferred or hypothesized (reviewed in Rice, 1989). Suction feeding is probably used. There are paired, expansible throat grooves that would allow rapid expansion of the buccal cavity. The teeth are apparently not necessary for feeding—stomachs often contain completely intact and unmarked prey items, and juveniles with no erupted teeth and adults with badly injured and useless lower jaws are able to feed effectively. Sperm whales may simply scan for prey using echolocation. An alternative suggestion is that the whale hangs motionless at depth with the mouth wide open, waiting for prey to be attracted to the white lips or the luminescent squid mucus on the jaw and teeth. The so-called “big bang” hypothesis is that a sperm whale (or smaller odontocete) can produce clicks of high enough intensity to stun prey items. Fristrup and Harbison (2002) suggested that sperm whale simply may use vision in feeding, either by searching upward for prey silhouetted against the brighter background or by searching for bioluminescence produced by prey species directly or indirectly by swimming through other bioluminescent organisms.

Sperm whales are at the extreme end of the mysticete-odontocete dichotomy in life histories (Caldwell et al., 1966; Best, 1974, 1979; Rice, 1989; Whitehead et al., 1991; Whitehead and Weilgart, 2000; Whitehead, 2002; Reeves and Read, 2003). Single calves are born at 4 m long following a 14–18-month gestation. In the Northern Hemisphere, mating occurs from December to August with a peak in March–May. Large mature bulls rove from one mixed school to the next. Adult females in a mixed school tend to come into estrus synchronously, and a bull’s stay with a particular school might only be a few hours. Calves nurse for at least two years, but begin feeding on solid food at about a year old. Some calves may continue nursing much longer, past age 7 in females and 13 in males. Females reach sexual maturity at age 7–13 and at about 9 m long. Growth then slows until they reach maximum size at about age 30. Maturation in males is a prolonged process, beginning at about age 10 and lasting for 10 years. They continue to grow at a more rapid rate than females, and do not reach their full size and complete physical maturity until about age 50. Males generally do not begin breeding successfully until their late twenties. The interval between calves for prime-age females is about 5 years.

General distribution: Sperm whales are found from tropical to subpolar waters in all oceans of the world (Rice, 1989, 1998; Whitehead, 2002; Reeves and Read, 2003). In the western North Atlantic, they occur from the edge of the pack ice south to the Gulf of Mexico and Caribbean. Mature males penetrate farther into high-latitude waters than females or immatures (Best, 1974; 1979). The northern distributional limit of female/immature schools in the western North Atlantic is probably around Georges Bank and the Nova Scotian shelf (CETAP, 1982; Whitehead et al., 1992). Sperm whales are very wide-ranging and migratory, and it is likely that all sperm whales in the North Atlantic belong to a single population (Reeves and Whitehead, 1997; Dufault et al., 1999). A whale tagged off Nova Scotia in 1966 was captured off Spain in 1973 (Mitchell, 1975c). Even on a global scale, sperm whales show very low genetic variability (Lyrholm and Gyllensten, 1998; Lyrholm et al., 1999).

Most sperm whale sightings around the world are in waters deeper than 200 m, however significant numbers of sightings have occurred in shallow continental shelf waters south of New England and on the Nova Scotian shelf (CETAP, 1982; Whitehead et al., 1992; Scott and

Sadove, 1997). Most sightings have been along the shelf break and the edge of the Gulf Stream, but there has been little or no survey effort farther seaward, and sperm whales can probably occur almost anywhere in the deep ocean.

Sperm whales occur year-round off the northeastern U.S., but with some seasonal variability (CETAP, 1982). They occur in highest numbers in spring and summer all the way from Cape Hatteras to Nova Scotia. In fall there are fewer whales, and the distribution contracts south and west of Georges Bank. The smallest numbers of sperm whales are in winter, and the sightings tend to be aggregated east of Cape Hatteras. There are few sightings south of Cape Hatteras, but that is more likely a result of little survey effort except relatively near shore (Waring et al., 2008). There are scattered strandings from North Carolina to Florida, and a few recent sightings far offshore south of Cape Hatteras. However the area east of South Carolina was very well known to the Yankee whalers (the “Charleston Grounds”). Sperm whales were taken there year-round, a few nearshore but very large numbers offshore (Townsend, 1935).

Historical occurrence: Given that sperm whales are primarily offshore animals and rarely seen near shore, the historical record is dominated by whaling takes. Cronan and Brooks (1968) reported only one stranding in Rhode Island, a 4.4-m animal (i.e., a calf) in Charlestown on 20 February 1967 (which is rumored to be buried somewhere on the URI Bay Campus). They added that sperm whales had “also been found within a few miles of Rhode Island with records from Stonington, Connecticut, and New Bedford and Nantucket, Massachusetts.” This seems to be a common issue in the literature—interpreting earlier reports of whaling captures as having been killed at the reported location rather than having been landed there—although it is not clear whether Cronan and Brooks did the misinterpreting or simply repeated it from someone else. For example, Linsley (1842) listed sperm whales for Stonington, by which he surely meant landed at Stonington but taken somewhere more offshore, however Goodwin (1935) seemed to interpret it otherwise: “The sperm whale was recorded by Linsley (1842) at Stonington, Conn.” Goodwin seems to have been a primary source for Cronan and Brooks, as well as for Waters and Rivard (1962), who said that the sperm whales had occurred “from the Gulf of Maine to Long Island Sound.” Note also that Stonington, New Bedford, and Nantucket were all major whaling ports.

Sperm whales were probably rarely, if ever, taken or even seen by the shore-based Long Island right whalers. The tale, likely apocryphal, is that Yankee sperm whaling began in about

1712, when Capt. Christopher Hussey, while hunting right whales from Nantucket, was blown offshore in a storm and took the first sperm whale. The sperm whale fishery expanded greatly, with voyages from a number of southern New England ports including Sag Harbor, Long Island; New London and Stonington, Connecticut; several localities in Rhode Island; and Nantucket, Woods Hole, and New Bedford, Massachusetts (Starbuck, 1878; Clark, 1887).

De Kay (1842) claimed that sperm whales were formerly abundant near Long Island, but provided very little specific information. Connor (1971) gave the oldest New York record as a 12-m whale captured in Fishers Island Sound in December 1894, and knew of a stranding on Fire Island in February 1918. There was one earlier stranding from Long Island, a 4.8-m animal at East Hampton on 19 March 1891, extracted for the Smithsonian dataset from an account published in the *East Hampton Star*. Waters and Rivard (1962) tabulated two strandings, one at West Yarmouth on 15 June 1954 and one at Nantucket in September 1961.

Recent occurrence: The distribution of sperm whales in the Rhode Island study area is concentrated along the edge of the shelf, with 57.3% of the records in the summer, 18.5% in fall, 16.5% in spring, and 7.8% in winter (Fig. 19). Southern New England is one of the rare locations in the world where sperm whales occur frequently well inshore of the shelf break (CETAP, 1982; Scott and Sadove, 1997). Sightings on the shelf in waters shallower than 200 m occurred in all four seasons, including seven sightings in summer, three in spring, and one in fall from the whale-watching boats. Many of them are aggregated in a relatively narrow band extending north-south along the shelf valley offshore of Montauk Point and Block Island. It is often speculated that sperm whale occurrence in shelf waters corresponds with inshore movements of spawning squid.

The effort-corrected relative abundance patterns show that sperm whales are generally not predicted to occur in the SAMP area (Fig. 20). Only in summer does one area of low abundance slightly intersect the SAMP area. Sperm whales are predicted to be present in all four seasons, but scattered and in low abundance. All of the high-abundance areas are offshore and beyond the boundaries mapped in Figure 20. The area of sperm whale occurrence in shallow water over the shelf valley between Block Island/Montauk and Block Canyon does not show up in the relative abundance outputs. This suggests that the phenomenon is sufficiently rare that it takes intensive searching, like repeated trips by whale-watching boats, to detect it.

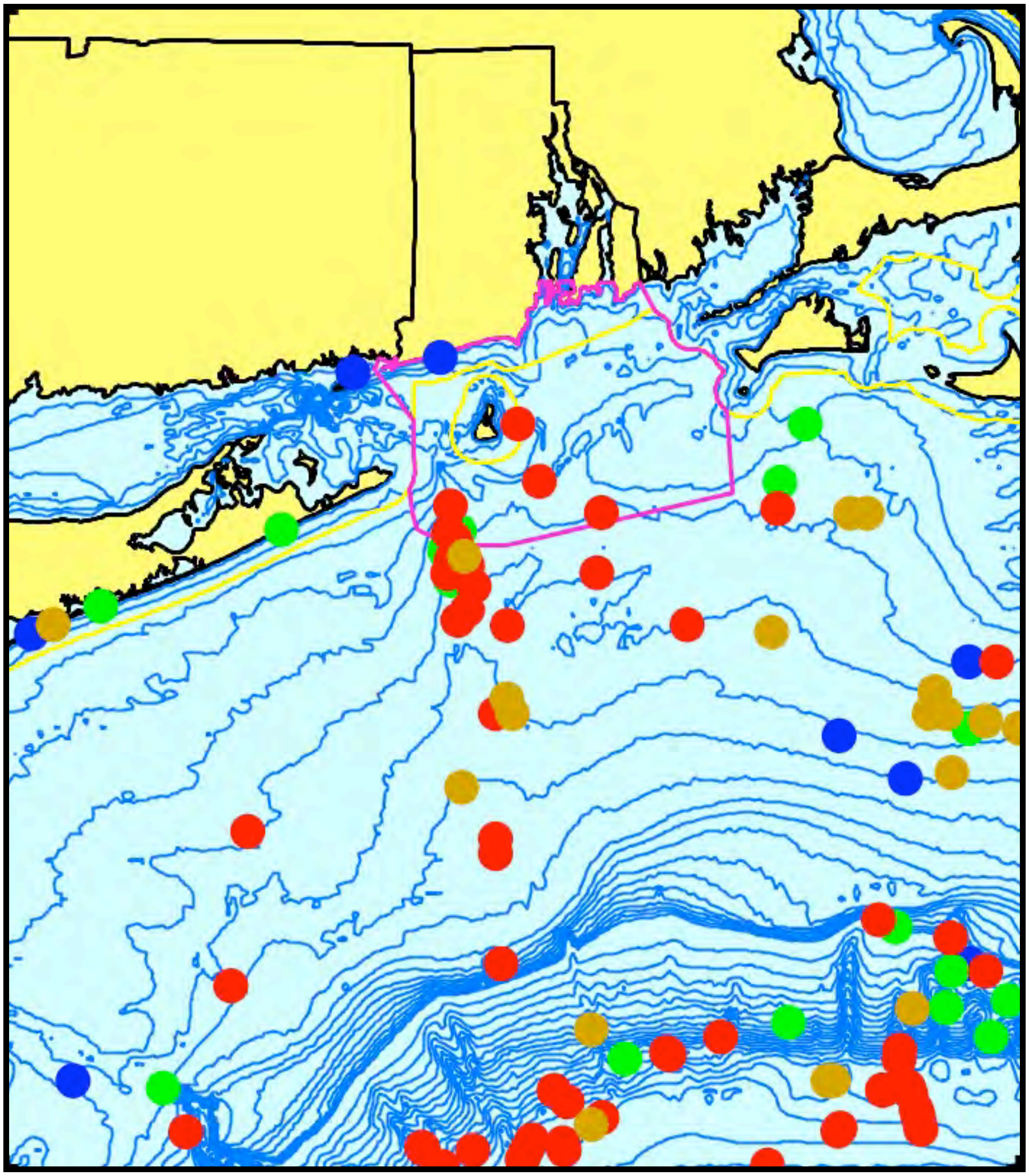

Figure 19. Aggregated sighting, stranding, and bycatch records of sperm whales in the Rhode Island study area, 1891–2004 (n = 103: winter = 8, spring = 17, summer = 59, fall = 19).

There have been no sperm whale strandings in Rhode Island since 1967. There have been occasional strandings in both Massachusetts and Long Island. The most publicized Long Island sperm whale stranding was in April 1981. On the 15th, a live, 732-cm, juvenile male sperm whale stranded at Coney Island and was pushed off the beach. The following day, it stranded again about 55 km east at Oak Beach near Fire Island Inlet. It was towed to a boat basin at a state

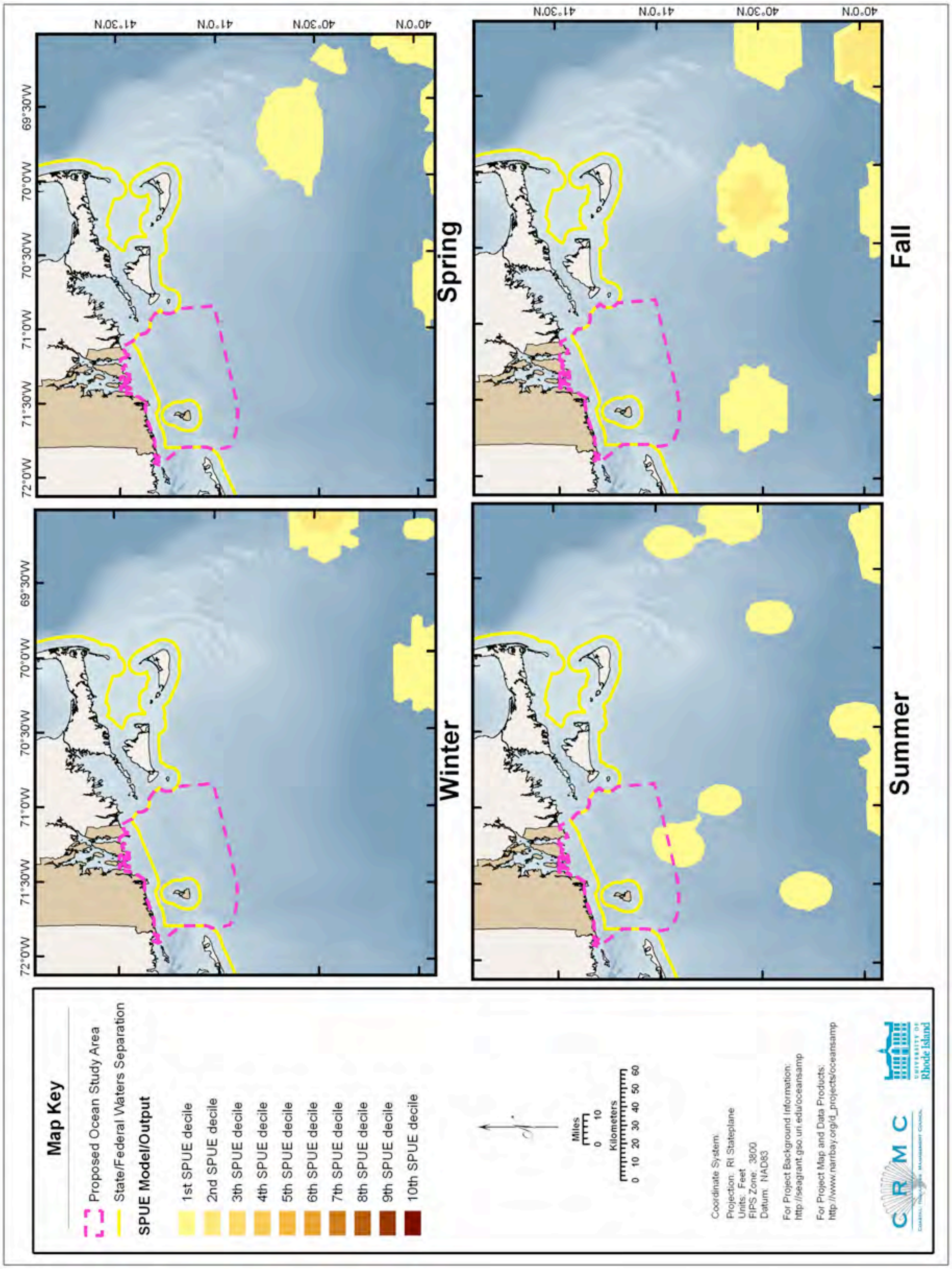

Figure 20. Modeled seasonal relative abundance patterns of sperm whales in the Rhode Island study area, corrected for uneven survey effort.

park 2–3 km away, where it was diagnosed with pneumonia and nick-named “Physty.” Eventually, divers coaxed him into eating squid, so he could be treated for the pneumonia by being fed squid containing antibiotic tablets. On 25 April the whale was herded by small boats out of the boat basin and through the inlet back into the Atlantic.

Conclusions: Sperm whales are primarily offshore animals, and are not predicted to occur within the SAMP area. However, they are known to regularly enter shallower waters over the shelf south of New England. They may occur within the southwestern quadrant of the SAMP area, most likely during the summer. Sperm whales are listed as Endangered under the ESA. Because they are toothed whales, they are highly dependent on sound for navigation, foraging, and communication. Planning for any development activities in the SAMP area, particularly activities that produce loud sounds, must consider the possible presence of sperm whales.

3.2.10. Pygmy Sperm Whale *Kogia breviceps* (Blainville, 1838)
Dwarf Sperm Whale *Kogia sima* (Owen, 1866)

The two *Kogia* species are rarely seen except as strandings, and are difficult to distinguish at sea or even with intact specimens on the beach. Many mammalogists considered them to be conspecific as late as the mid-20th Century (see Rice, 1998 for a review); identifications of stranded specimens before that time (and even since then) may be questionable. The two species are often pooled in reporting and analyses. They are considered together here for those reasons.

Description: Pygmy and dwarf sperm whales are very similar in appearance and nearly identical in body form (Caldwell and Caldwell, 1989; Jefferson et al., 1993; Wynne and Schwartz, 1999; McAlpine, 2002). Pygmy sperm whales are larger at 3–3.7 m in adult length. They are dark gray in color with a lighter belly and a pale, crescent-shaped mark between the eye and flipper that resembles the gill opening of a fish. The head is square or conical, broad, and blunt, often appearing shark-like, with a tiny underslung lower jaw. The single C-shaped blowhole is located on top of the head, but offset slightly left of center. The flippers are short, rounded, and placed very close to the head. The dorsal fin is very small and falcate, placed well behind the midpoint of the body, and rises off the back at a relatively low angle. The head is slightly longer and more rounded than in the dwarf species.

Dwarf sperm whales are smaller at 2.1–2.7 m. The dorsal fin is relatively tall, pointed, dolphin-like, falcate, placed about in the middle of the animal, and rises off the back at a relatively steep angle. The head is slightly shorter and more pointed than in the pygmy sperm whale, and they have a pair of inconspicuous throat creases.

Status: The pygmy sperm whale is not listed under the U.S. Endangered Species Act, is not included on the Rhode Island state list, and is classified as Data Deficient on the IUCN Red List. Dwarf sperm whales are not listed under the U.S. Endangered Species Act, are not included on the Rhode Island state list, and are classified as Data Deficient on the IUCN Red List. There are no estimates of the populations worldwide of either *Kogia* species, but both may be relatively common. In the NMFS SAR (Waring et al., 2008) abundance is estimated for both species combined because of the identification difficulty. Off the east coast of the U.S. and Canada, the abundance of *Kogia* spp. was estimated as 695 in 1998 (Florida to the Gulf of St. Lawrence) and 395 in 2004 (Florida to the Bay of Fundy); the estimates of the Gulf of Mexico were 742 in 1996–2001 and 453 in 2003–2004 (the differences are not statistically significant).

There is no significant hunting of pygmy or dwarf sperm whales beyond very small numbers taken in traditional fisheries in the Caribbean, Sri Lanka, Japan, and Indonesia (Caldwell and Caldwell, 1989). Fisheries-related mortalities of both species have been documented in U.S. Atlantic waters. One *K. breviceps* was released alive but seriously injured in the pelagic longline (swordfish) fishery off Florida in 2000. Stranded animals are sometimes recorded with evidence of entanglement in fishing gear, propeller marks, or with plastic in their stomachs (though not necessarily determined as the cause of death). One *K. sima* was killed in the pelagic swordfish driftnet fishery in 1995 (Waring et al., 2008).

Ecology and life history: Pygmy and dwarf sperm whales are very poorly known, with most information coming from stranded animals (Nagorsen, 1985; Caldwell and Caldwell, 1989; McAlpine, 2002). Most strandings are single individuals, or occasionally mother-calf pairs. Sightings at sea may be small groups, up to about 6 animals. They seem to spend long periods relatively motionless at the surface. Diving animals tend to sink without rolling forward, and both are believed to be capable of deep and long dives. Both species exhibit a unique response to being startled—defecating a dark reddish-brown liquid into the water, producing a dense cloud in the water that might screen an animal from a predator or other danger as it dives away. Both species have an expanded, balloon-like section of the lower intestine that is filled with up to 12 liters of liquid described by Caldwell and Caldwell (1989) as having the color and consistency of chocolate syrup.

Stomach contents of stranded pygmy and dwarf sperm whales are dominated by squid of a wide variety of species, sometimes with small amounts of fish or crustaceans (Nagorsen, 1985; Caldwell and Caldwell, 1989; McAlpine, 2002). Their anatomy (small jaw, reduced teeth, well-developed hyoid apparatus) also predicts a diet based on suction-feeding upon cephalopods. Most feeding appears to be at or near the bottom. Santos et al. (2006) analyzed stomach contents of 14 *K. breviceps* stranded in 1984–2002 in Europe (5 in Spain, 7 in France, and 2 in Scotland. Thirteen stomachs had almost entirely squid with some small amounts of crustaceans and fish, and one animal contained mainly crabs.

Little is known about reproduction, with nearly all information coming from strandings (Caldwell and Caldwell, 1989; McAlpine, 2002). Dwarf sperm whale calves appear to be born in spring at 1–1.2 m long. Gestation may be as short as 9 to as long as 11 months, and lactation lasts about a year. Females reach sexual maturity at about 2.7 m. Males probably attain maturity at similar sizes. Female pygmy sperm whales have been recorded that were simultaneously pregnant and lactating, indicating that a reproductive cycle with calving every year is possible. Female dwarf sperm whales reach sexual maturity at about 2.1 m, and newborn calves are under 1 m in length.

In addition to the usual range of diseases and parasites seen in stranded cetaceans, stranded adults in both species of *Kogia* frequently present with cardiomyopathy and other symptoms associated with heart failure (Bossart et al., 1985). The hearts in those animals are characterized grossly by pale, flabby ventricular muscle and by lesions that can be detected by detailed histopathology. The underlying cause is not known.

General distribution: Both pygmy and dwarf sperm whales are apparently broadly distributed in warm temperate, subtropical, and tropical waters around world (Caldwell and Caldwell, 1989; Rice, 1998; McAlpine, 2002). In the western North Atlantic, their distributions are entirely in deeper water offshore of the continental shelf edge. There was only one sighting of a single *Kogia* sp. off the northeastern U.S. during the CETAP surveys in 1979–1981, east of Delaware Bay in continental slope waters deeper than 2500 m in June 1981 (CETAP, 1982). The more recent NMFS stock assessment surveys in the summers of 1998 and 2004 extended much farther offshore, resulting in at least 25 sightings between the shelf break and very deep pelagic waters from Georges Bank to Florida. Survey sightings are all in summer, and strandings are scattered throughout the year, so there is no information on seasonal patterns of distribution or migration. There are no data on stock separation, so it is unknown whether pygmy or dwarf sperm whales off the Atlantic coast of the U.S. belong to the same populations as those in the Gulf of Mexico and Caribbean. Barros et al. (1998) speculated from stable-isotope data that pygmy sperm whales may the more inshore of the two species, although prey data from stomach contents suggests the opposite (Caldwell and Caldwell, 1989; McAlpine, 2002).

Historical occurrence: Cronan and Brooks (1968) knew of no records of either species of *Kogia* in Rhode Island, but said that *K. breviceps* was likely to be present based on occurrences in Massachusetts and Long Island. They did not even mention *K. sima*. Strandings of both species are relatively common along the southeastern coast of the U.S. (Handley, 1966; Waring et al., 2008), outnumbered only by bottlenose dolphins. Connor (1971) reported at least eight records in New York between 1914 and 1968. The Smithsonian and American Museum datasets include more than 90 records from New York, New Jersey, and Rhode Island, dating back to 1883. All records prior to 1970 are identified as *Kogia breviceps*, or in a few cases as *Kogia* sp., however the prudent course at this time would be to consider all records without a thorough review of specimens, data, and photographic documentation to be *Kogia* sp.

Recent occurrence: Strandings strongly dominate the occurrence record for *Kogia* in the Rhode Island study area (Fig. 21), with only a few scattered sightings. This is likely due to a combination of factors including rarity, low sightability, occurrence far offshore where survey effort is lowest, and difficulty in identification at sea. There are strandings all along the shore of Long Island, and a few in Rhode Island, and no occurrences within Long Island Sound. There is some evidence of seasonality, with 25.8% of records in both winter and spring, 45.2% in summer, and only 3.2% in fall. Sightings were far too few to derive SPUE estimates or produce relative abundance maps.

There were four recent strandings of pygmy sperm whales in Rhode Island: at Lloyd’s Beach, Sakonnet Point, on 19 January 1976; near Providence on 21 January 1976 (given the close proximity in time, one might speculate whether the two animals came in together, however they

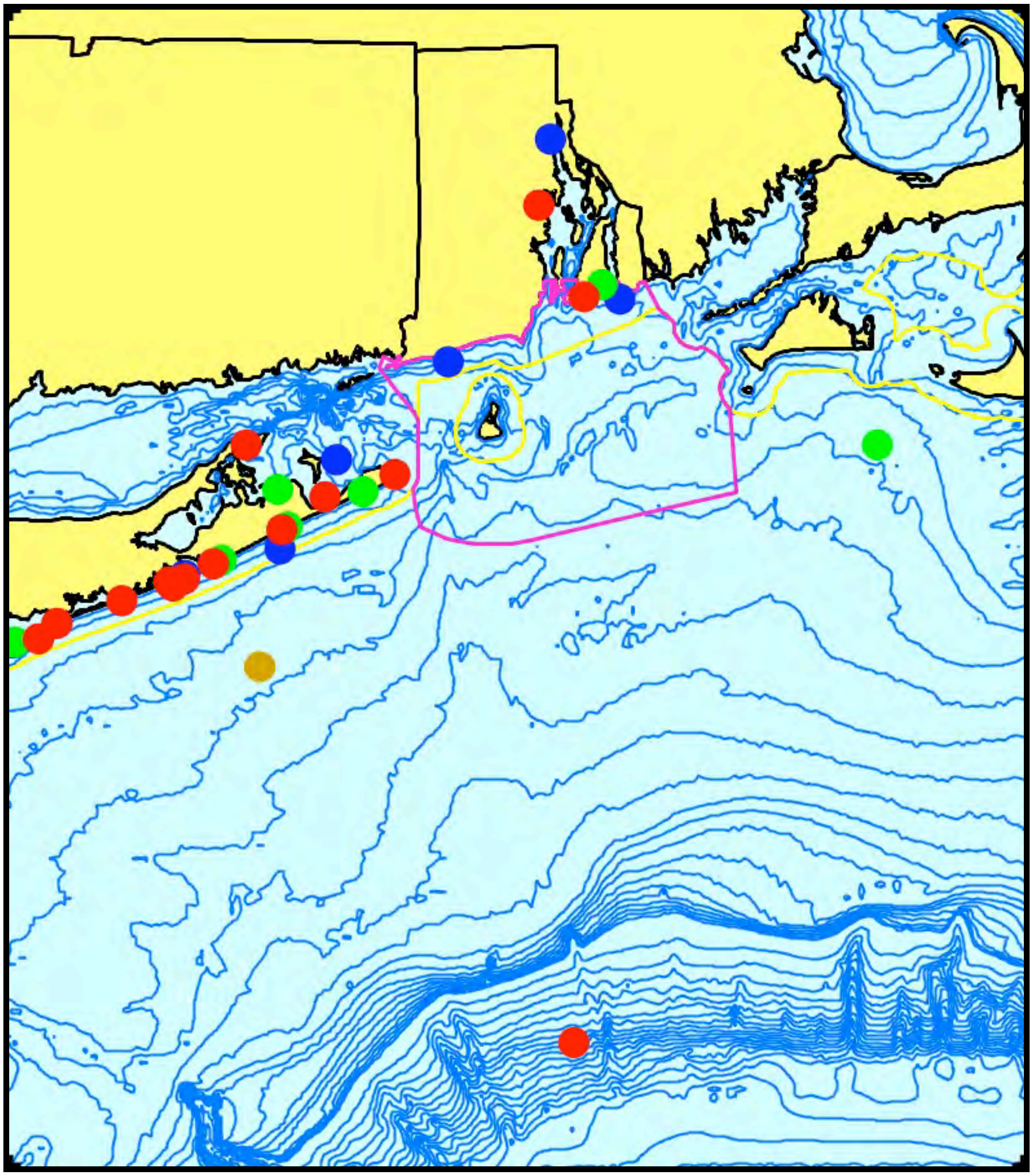

Figure 21. Aggregated sighting, stranding, and bycatch records of pygmy sperm whales, dwarf sperm whales, and unidentified *Kogia* sp. in the Rhode Island study area, 1941–2004 (n = 31: winter = 8, spring = 8, summer = 14, fall = 1).

were both adult-sized at 289 cm and 376 cm, respectively, therefore were not a mother-calf pair); on Third Beach, Middletown, on 22 March 2001; and near “Rosecliff” in Newport on 18 August 2003. There were also two strandings identified as dwarf sperm whales—one at the Quonochontaug Breachway in Charlestown on 29 December 1990 and one on the Goddard

Memorial State Park beach in Warwick on 10 June 1995. Based only on those records, the relative abundance of the two species in the region is 2:1. On the other hand, along the entire length of Long Island, there were 27 strandings between 1972 and 2005, but they were all recorded as *K. breviceps*.

It appears relatively clear from the post-1970 stranding record that *K. breviceps* is the more common species in the Rhode Island study area (Fig. 22). *K. breviceps* is known from strandings

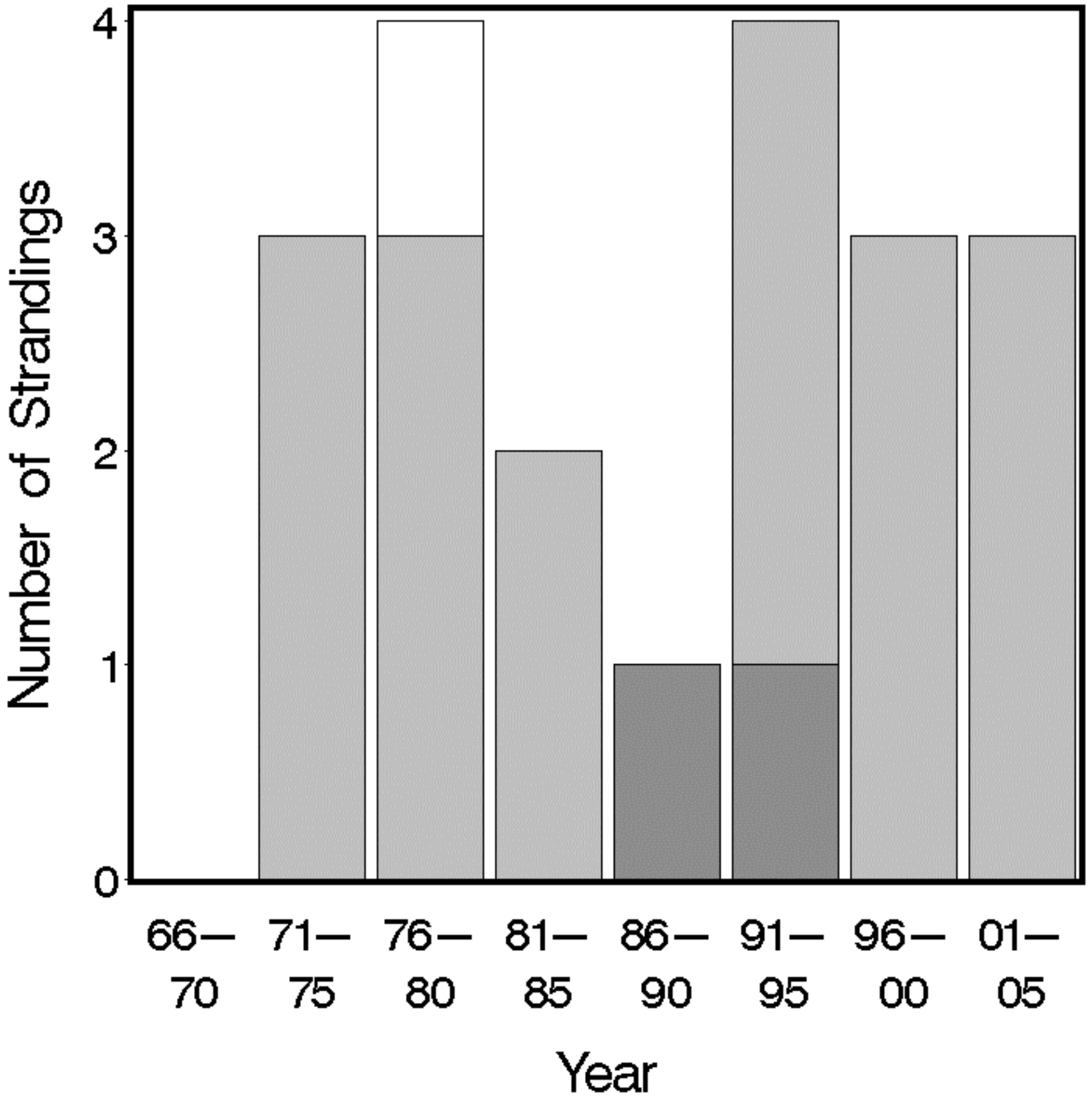

Figure 22. Five-year stranding frequencies for pygmy sperm whales (light gray bars), dwarf sperm whales (dark gray), and unidentified *Kogia* sp. (white) in the Rhode Island study area, 1966–2005.

in eastern Canada (Baird et al., 1996). The northernmost confirmed records of *K. sima* are the two strandings from Rhode Island, and *K. sima* has never been recorded from Canada (Willis and Baird, 1998). From 1999 through 2005, there were 260 *Kogia* strandings, identified to species, between Florida and Nova Scotia, including 200 *K. breviceps* and 60 *K. sima* (Waring et al., 2008). From Virginia north, 89.5% were *K. breviceps*; while from North Carolina south the strandings were 75.9% *K. breviceps*, indicating that pygmy sperm whales have a somewhat more northerly distribution. The level of expertise is not entirely consistent across all stranding groups, so it is impossible to conclude with certainty from the present data whether those differences represent true differences in species occurrence.

Conclusions: Both pygmy sperm whales and dwarf sperm whales are offshore species with main centers of distribution in relatively warm waters. There has never been a sighting of either in the SAMP area. Both species can safely be ignored for any development planning.

3.2.11. Beaked Whales: Northern Bottlenose Whale *Hyperoodon ampullatus* (Forster, 1770)
Cuvier's Beaked Whale *Ziphius cavirostris* G. Cuvier, 1823
Blainville's Beaked Whale *Mesoplodon densirostris* (Blainville, 1817)
Gervais' Beaked Whale *Mesoplodon europaeus* (Gervais, 1855)
Sowerby's Beaked Whale *Mesoplodon bidens* (Sowerby, 1804)
True's Beaked Whale *Mesoplodon mirus* True, 1913

Ziphiidae constitutes the second most speciose family of Cetacea, with 6 genera and 21 species (most in *Mesoplodon*) now recognized, second only to Delphinidae (Mead, 2002). Some species are still known only from stranded specimens and have never been seen alive (or even as a completely intact carcass). Ziphiids are collectively known as beaked whales. They all occur in deep water, far offshore. Six species are known from the North Atlantic, and all six have occurred in the Rhode Island study area. Many beaked whale species are difficult to differentiate with intact specimens at hand and nearly impossible to identify at sea, and sightings identified to species were extremely rare before the late 20th Century. All six species are considered together here.

Description: Except for a few larger species, including only *Hyperoodon ampullatus* in the North Atlantic, all of the beaked whales are medium-sized animals (adult lengths of 4–7 m) that share a number of distinctive characters (Mead, 1989a, 1989b, 2002; Heyning, 1989, 2002; Gowans, 2002; Pitman, 2002). They have tail flukes that lack a central notch and small triangular dorsal fins located in the rear third of the body. The flippers are relatively small, with relatively long arm bones and short digits. On the ventral surface of the lower jaw there are two so-called throat grooves, which likely are involved in expansion of the oral cavity for suction feeding. The head has a pronounced, elongated rostrum that is continuous with the forehead without a distinct break or crease. In most species there is only one more or less tusk-like tooth in each mandible, which erupts only in adult males.

Northern bottlenose whales are the largest of the Atlantic beaked whales, with males reaching a maximum length of 9.8 m and females reaching 8.7 m (Mead, 1989b; Jefferson et al., 1993; Wynne and Schwartz, 1999; Gowans, 2002). The body is robust with a relatively wide back. The head is rounded and bulbous, which becomes increasingly pronounced in older, larger animals and nearly square with a flattened, vertical forehead in adult males. The blowhole is located in a shallow depression on top of the head, and the blow is short and bushy, and may be angled slightly forward. There is a pronounced, elongate, dolphin-like beak. They are tan to dark chocolate brown in color, with a lighter belly and often with lighter blotches, scratches, and scars. The head and neck are whitish on large adults. The dorsal fin is prominent, falcate, darker in color than the body, and located about two-thirds of the way back along the body.

Adult Cuvier's beaked whales reach 7–7.5 m long (Heyning, 1989, 2002; Jefferson et al., 1993; Wynne and Schwartz, 1999). They have relatively robust, cigar-shaped bodies with small conical heads and short, tapered flippers. There is often a visible concavity or depression at the top of the forehead. There is little or no distinct beak, and the line of the mouth is relatively short and curved upward toward the rear. The teeth of adult males may be visible at the tip of the lower jaw, and are sometimes covered by clumps of stalked barnacles. The body is tan to reddish brown to dark gray, often mottled and covered with circular white scars and parallel pairs of scratches. The head and neck are often white, especially in adults, with a dark patch around the eye. Much of the back may be whitish in older males.

Beaked whales in the genus *Mesoplodon* are much smaller than northern bottlenose whales and smaller than Cuvier's beaked whales. In addition, they have elongate, tapered beaks which differ from both the very short conical head of Cuvier's beaked whales and the bulbous head with a dolphin-like beak of bottlenose whales. Identifying individuals to species becomes much more difficult. All species are about the same size and have the same general shape, show indistinct blows, have relatively small triangular to falcate dorsal fins located about 2/3 back on the body, and have flippers that fit into shallow depressions on the side of the body (Mead, 1989a).

Blainville's beaked whales may be the easiest of the four North Atlantic *Mesoplodon* species to differentiate, assuming a close look under optimum conditions (Mead, 1989a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Pitman, 2002). They are up to 4.7 m long. The body is relative robust and spindle-shaped, with a relatively thick beak. The forehead appears flattened in front of the blowhole, and there is little or no obvious indentation at the blowhole. The rear half of the lower jaw has an obvious upward arch, which enlarges and extends higher than the top of the upper jaw in adult males. Adult males have two massive, flattened, triangular, forward-tilting teeth growing from the top of the arch in the lower jaw that are clearly visible when the mouth is closed. The color is dark gray to black on the back with lighter sides and a white belly. There may be a dark circular patch around the eye, and large oval scars and scratches are common.

Female Gervais' beaked whales are up to 5.2 m long, while males only reach 4.6 m (Mead, 1989a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Norman and Mead, 2001; Pitman, 2002). The body is slender and laterally compressed, with an elongate, tapered beak and a prominent melon with a small indentation behind it at the blowhole. Gervais' and True's beaked whales are very similar, with the beak in the former having relatively flattened sides. The flippers are set very low on the body. The color is dark gray on the back and sides with irregular white patches and a lighter belly.

Sowerby's beaked whales are up to 5 m long (Mead, 1989a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Pitman, 2002). The body is slender and spindle-shaped, with an elongate, tapered beak and a very prominent melon with a pronounced indentation behind it at the blowhole. The color is dark gray to brown on the back with somewhat lighter sides and an even lighter belly.

True's beaked whales are up to 5.2 m long (Mead, 1989a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Pitman, 2002). The body is relatively robust and tapers noticeably toward the tail. There is an elongate, tapered, somewhat dolphin-like beak with rounded sides and a prominent melon with a small indentation behind it at the blowhole. There is a sharp ridge from dorsal fin to the flukes. The color is gray to brown, gradually paling from a dark back to lighter sides to a whitish belly, with a darker band down the center of the back. The dorsal fin, lips, and a circular eye patch are black.

Status: None of the North Atlantic beaked whales are listed under the U.S. Endangered Species Act and none are included on the Rhode Island state list. Northern bottlenose whales and all four *Mesoplodon* species are classified as Data Deficient on the IUCN Red List, but Cuvier's beaked whale is classified as Least Concern. Under the Species at Risk Act in Canada, the Scotian Shelf population of *Hyperoodon* is classified as Endangered and Sowerby's beaked whale is classified as Special Concern (CWS, 2006).

The original population of northern bottlenose whales prior to whaling may have been as many as 90,000, and the current number may be 40–50,000 (Mead, 1989b; Gowans, 2002; IUCN, 2008). The most recent estimate of the northern bottlenose whale population in the Gully, based on photoidentification of individual whales, is 163 animals (Whitehead and Wimmer, 2005). Genetic studies show that the populations in the Gully, Davis Strait, and Iceland are distinct, suggesting little interchange between the areas (Dalebout et al., 2006). There is no abundance estimate for U.S. waters in the SAR because they occur so rarely. There are no North Atlantic ocean-wide estimates of abundance for any of the other beaked whales, although the global abundance of *Ziphius* is believed to be over 100,000 animals. They are pooled in abundance estimates in U.S. Atlantic waters because of species identification issues; the most recent pooled abundance estimate for all five species combined is 3,513 whales from Florida to Georges Bank in summer 2004 (Waring et al., 2008). For the Gulf of Mexico, there are separate abundance estimates for *Ziphius*—95 in 1996–2001 and 65 in 2003–2004, *Mesoplodon* spp.—106 in 1996–2001 and 57 in 2003–2004, and unidentified beaked whales—146 in 1996–2001 and 337 in 2003–2004. None of those estimates are corrected for diving and beaked whales tend to be long divers, therefore the actual numbers are likely to be substantially greater. It is possible that some beaked whales are rather abundant and that their apparent rarity is due more to their offshore distribution, low detectability, and tendency to avoid ships.

Commercial whaling for northern bottlenose whales began in the second half of the 19th Century and lasted until 1973 (Mead, 1989b; Gowans, 2002). At least 80,000 were killed over that time, with peak catches in the 1890s. During 1962–1967, 87 were killed in the Gully by whalers from Nova Scotia (Mitchell, 1974). They are occasionally killed by small-scale whalers in the Faroe Islands, two in 2001 and six in 2002 (IWC, 2005, 2006). *Ziphius* was taken opportunistically in the Japanese fishery for North Pacific bottlenose whales, up to 35 in a single year (Heyning, 1989), and was occasionally taken by traditional whalers in the West Indies (Caldwell and Caldwell, 1971). There have been no directed hunts for *Mesoplodon* spp. (Mead, 1989a), although there have been occasional opportunistic takes in small cetacean fisheries, e.g. *M. bidens* in Newfoundland (Sergeant and Fisher, 1957).

Before it was shut down due to excessive marine mammal bycatch rates, the pelagic driftnet fishery for swordfish off the northeastern U.S. had a relatively high rate of beaked whale bycatch. Forty-six mortalities were recorded by NMFS fishery observers from 1989 to 1998, including 24 Sowerby's, 4 True's, and 1 Cuvier's, with 17 not identified to species (Waring et al., 2008). The extrapolated total annual average mortality from that fishery was 23 beaked whales killed per year. More recently, an average of 1.0 beaked whale per year strands along the U.S. Atlantic coast from human-caused mortality (ship collisions or entanglement in fishing gear), which is not thought to represent a serious impact on any of the species present.

There has been concern in recent years that very loud mid-frequency sounds, most notably naval active sonar and seismic exploration for oil and gas, could have serious impacts on beaked whales (Frantzis, 1998; Balcomb and Claridge, 2001; Evans and England, 2001). There have been several mass stranding events that have coincided with naval exercises—in the Bahamas, Canary Islands, and Mediterranean. Cuvier's beaked whales are most often affected, but some events have included Blainville's or Gervais' beaked whales. One hypothesis is that the loud sounds cause the whales to panic and surface very rapidly from depth, releasing nitrogen bubbles and causing the equivalent of the "bends" (Jepsen et al., 2003). The debilitated whales then strand, and eventually die from the physiological stresses associated with stranding (Cox et al., 2006). There may be other, more subtle impacts of anthropogenic sound. Aguilar Soto et al. (2006) suggested from their tagging study that intense ship noise might impact foraging behavior. On one of the dives by the tagged *Ziphius*, the animal made significantly fewer "buzzes" when the tag was receiving a high level of ship noise.

Ecology and life history: Northern bottlenose whales are usually encountered in small groups of up to four whales (Mead, 1989b). Short-lived aggregations of up to 20 animals are observed (Gowans, 2002). Associations between adult females tend to be short-lived, but some male associations persist for years, suggesting a fission-fusion social structure with male coalitions, similar to that of bottlenose dolphins (Gowans et al., 2001; Gowans, 2002). They typically spend 10 minutes or more on the surface before dives that may last 1–2 hours. The median dive depth is 1000 m, and they are likely diving to the bottom for foraging (Hooker and Baird, 1999).

Northern bottlenose whales specialize mostly on one genus of deep-water squid, *Gonatus* sp., especially *G. fabricii* (Mead, 1989b; Hooker et al., 2001), although they feed on other species of squid and deep-water fishes. Whitehead et al. (2003) concluded that northern bottlenose whales have a much narrower feeding niche (measured as number of genera of squid eaten) than either sperm whales or *Ziphius*. Their dietary specialization is probably related to their restricted distribution and movement patterns, foraging primarily along the 1000-m isobath.

Reproduction in *Hyperoodon* is the best known of the North Atlantic ziphiids from data collected during 20th Century commercial whaling (Mead, 1989b). Sexual maturity in females occurs at a minimum length of 6.0 m and average length and age of 6.9 m and 11 years. In males the minimum length at maturity is 7.3 m, and the averages are 7.5 m and 7–11 years. Gestation lasts about 12 months, and lactation lasts at least 1 year and is possibly prolonged. Calves average 3.5 m at birth. The mean calving interval is 2 years, although some females have been observed accompanied by newborns and yearlings simultaneously.

Given that observations of living animals are rare and that most species are believed to actively avoid close approaches by vessels, the behavior of most beaked whale species is very poorly known (Heyning, 1989, Mead, 1989a). Adult male beaked whales often bear multiple scars that match the spacing of the tusks in that species, indicating that the scars are inflicted during aggressive encounters between males (Mead, 1989a). Heyning (1984) concluded from the scarring that the blows were struck with the mouth closed, and that the dense, fused bones of the rostrum in adult males were adapted for intraspecific aggression. Cuvier’s beaked whales are typically observed in groups of 1–7 animals, with most groups of four or fewer (Heyning, 1989, 2002). *Mesoplodon* spp. tend to occur in small groups (1–6 whales, usually 2 or 3) of mixed large and small animals and probably have a social system like many other toothed whales (Mead, 1989a; Pitman, 2002). Groups at the surface tend to stay tightly clustered, no more than a body length or two apart (Pitman, 2002).

All beaked whales are probably capable of long and deep dives. *Ziphius* dive durations are generally 20–40 minutes (Heyning, 1989). *Mesoplodon* spp. dives are typically 20 to over 45 minutes, with groups of animals generally surfacing and diving simultaneously (Pitman, 2002). Recent telemetry tagging studies on *Ziphius cavirostris* and *Mesoplodon densirostris* show their use of echolocation during foraging dives is similar to that in sperm whales, with regular clicks produced continuously at depth and short series of closely spaced clicks ("buzzes") when closing in on targeted prey items (Johnson et al., 2004; Madsen et al., 2005; Zimmer et al., 2005).

All species of beaked whales are squid specialists (Heyning, 1989, 2002; Mead, 1989a, 1989b; Gowans, 2002; Pitman, 2002). Data on stomach contents of *Mesoplodon* spp. are very sparse, but also show a predominance of deep-water squid and occasionally fish (Mead, 1989a), with some of the fish remains probably introduced secondarily in the stomach contents of squids consumed by the whale.

Data from Japanese whaling indicated mean lengths at maturity for *Ziphius* as 5.8 m in females and 5.5 m in males (Heyning, 1989). The data for females may have been biased, since a 5.1-m pregnant female stranded in Florida. Calves average 2.7 m at birth. Reproductive data for *Mesoplodon* spp. are extremely sparse (Mead, 1989a; Pitman, 2002). One stranded female *M. densirostris* was observed with 9 growth layers in the teeth and one corpus albicans in an ovary, indicating recent sexual maturity. *M. europaeus* is the only species with enough data to estimate mean size at maturity—4.5 m in females.

General distribution: Northern bottlenose whales occur only in the North Atlantic, from Nova Scotia and the British Isles in the south to Baffin Island, Greenland, Iceland, Jan Mayen, and Svalbard in the subarctic north (Mead, 1989b; Gowans, 2002). There are six known areas of aggregation—two near Norway, west of Svalbard, north of Iceland, in Davis Strait west of Greenland, and in the Gully, a large submarine canyon east of Sable Island off Nova Scotia. They occasionally occur south to the edge of Georges Bank, where sightings were recorded near the shelf break in 1980, 1993, and 1996, all in late spring or summer (CETAP, 1982; Waring et al., 2008). Seasonality is poorly known, however the known strandings in eastern Canada and New England are scattered throughout the year (Reeves et al., 1993). Bottlenose whales occur in the Gully year-round, and some individuals have been sighted in other canyons along the edge of the Nova Scotian shelf (Gowans et al., 2000; Hooker et al., 2002; Wimmer and Whitehead, 2004).

Cuvier's beaked whale is the most cosmopolitan of all beaked whales, occurring in cold temperate to tropical waters world-wide (Heyning, 1989, 2002). There were six identified sightings in 1979 and 1980 off the northeastern U.S. (CETAP, 1982), and a number of additional sightings in more recent surveys off the Northeast and in the Gulf of Mexico (Waring et al., 2008). Sightings have been in spring and summer, and concentrated in deeper waters from the shelf break to further offshore. They are also known from strandings along the east coast from Nova Scotia to Florida to the West Indies.

Blainville's beaked whale has the widest distribution of any *Mesoplodon* species, occurring world-wide in warm temperate to tropical waters (Moore, 1966; Mead, 1989a). In the North Atlantic, they are more common in North America than in Europe. Strandings in the western North Atlantic are known from Nova Scotia south to Florida, the Gulf of Mexico, the Bahamas, and the Caribbean.

Gervais's beaked whales were once thought to occur only in the North Atlantic, but there were three strandings on Ascension Island in the tropical South Atlantic in 1980. They are the most common beaked whale in the stranding record from the east coast of the U.S. (Moore, 1966; Mead, 1989a; Norman and Mead, 2001). Fisher's Island, New York is the northernmost occurrence. Strandings occur south to Florida, the Gulf of Mexico, the West Indies, and the Caribbean. Occurrences on the eastern side of the North Atlantic are rare and scattered, occurring in France, Spain, the Canary Islands, Mauritania, and Guinea-Bissau.

Sowerby's beaked whales are known from cold temperate waters on both sides of the North Atlantic, but are much more common on the European side than on the North American side (Moore, 1966; Mead, 1989a). In the western North Atlantic, strandings are known from southern New England north to Newfoundland and Labrador. There is one stranding record from the Gulf of Mexico coast of Florida, however that is believed to be a stray far outside the normal range of the species.

As with Gervais' beaked whale, True's beaked whales were believed to occur only in temperate North Atlantic waters, but recently specimens have been identified from strandings on the Indian Ocean coasts of South Africa and Australia. Strandings are known from the northeast

Atlantic (Scotland, Ireland, and France) and in the western North Atlantic from Nova Scotia south to Florida and the Bahamas (Moore, 1966; Mead, 1989a).

Historical occurrence: The only documented historical records of northern bottlenose whale in southern New England were in Rhode Island in 1867—an 8.2-m animal was killed off Newport in February and a second was seen but escaped, and two 7.5-m animals stranded near the Stone Bridge in Tiverton on an unknown date. Mitchell and Kozicki (1975) concluded that there was only one occurrence that was inadvertently confused and repeated by various authors, however the specificity of the locality descriptions would seem to argue otherwise, and they are included in the Smithsonian database as separate records. There was also a stranding within Cape Cod Bay at North Dennis, Massachusetts in January 1869 (Mitchell and Kozicki, 1975). These were the southernmost known occurrences for the species in the western North Atlantic (Mead, 1989b) until a sighting of two animals near the shelf break east of Cape May, New Jersey in June 1981 (CETAP, 1982). Connor (1971) concluded that all earlier published reports for Long Island were in error. For example, Goodwin (1935) wrote “Linsley (1842) reported a whale of this species at Stonington, Conn.” He clearly mistook Linsley’s account of a minke whale (“*Rorqualus costatus* [sic] Dekay, Beaked Whale”) for *Balaena rostrata*, a once-commonly used junior synonym for bottlenose whale. Waters and Rivard (1962) perpetuated the error, saying that bottlenose whales had been “recorded from the Gulf of Maine to Long Island Sound,” but they included no specific occurrence records from Massachusetts.

There are two historical stranding records for Cuvier’s beaked whale in Rhode Island, both described in Cronan and Brooks (1968). A 564-cm animal stranded in Newport in October 1901. A 580-cm, 2,535-kg animal stranded alive in Newport on 13 March 1961 and died the next day. The photo in Cronan and Brooks shows visible teeth, so it was an adult male. There were no stranding records in the study area in New York, although there were several farther west in Long Island and others in New Jersey. Waters and Rivard (1962) stated that there had been many strandings over the years in Massachusetts, mainly in spring, and reported three recent records—two in Falmouth in March 1958 and one on Nauset Beach in August 1961, killed by a ship collision.

There are no historical stranding records for any of the *Mesoplodon* species in Rhode Island, and few in the study area. There is one record of Blainville’s beaked whale in eastern Long

Island, on 12 May 1925 in Southampton. There was one stranding of True's beaked whale on Mason's Island in Mystic, Connecticut on 19 November 1937, the only Connecticut occurrence for any beaked whale. There are multiple historical records of Blainville's, Gervais', and True's beaked whales in western Long Island and New Jersey. Goodwin (1935) suggested that a stranding at Southampton, New York was probably a Sowerby's but gave no evidence or even a date. Waters and Rivard (1962) reported that Blainville's, Sowerby's, and True's beaked whales were all known from strandings in Massachusetts.

Recent occurrence: The general pattern for beaked whales in the Rhode Island study area is strandings on the beaches and sightings at the shelf break and farther offshore, with a few scattered occurrences in between (Fig. 23). Most records that are identified to species are strandings; conversely, very few sightings are identified to species. There were two identified Cuvier's beaked whale sightings in the study area—one animal from a whale-watching boat in August 1986 in relatively shallow water near the 60-m isobath southeast of Montauk Point and a pair from a NOAA ship in deep water over the slope about 175 km offshore in August 1995. There were also two identified sightings of Sowerby's beaked whales in deep slope waters from a NOAA ship in 2004—three animals on 11 July and two animals on 2 August. Sowerby's was the most common beaked whale species taken incidentally by the swordfish driftnet fishery (see Status, above), which operated on the southern edge of Georges Bank just to the east. There are no identified sightings of Blainville's, Gervais', or True's beaked whales in the Rhode Island study area. There are few data for any species on migration or seasonality; sightings have tended to be mostly in the summer, but that may reflect more on patterns of survey effort and good weather than presence of whales (Table 3). Blainville's beaked whale is the only species that does not occur most often in summer, with two spring records and one in winter.

A stranding on Fishers Island (part of New York, but physically closer to Connecticut than to Long Island) on 17 July 1999 was originally identified as Sowerby's beaked whale and reported as such to the stranding network. It would have been the first documented occurrence of the species in the Rhode Island study area and the only record for New York. Subsequently, the skull was cleaned and photographs were sent to J. G. Mead at the Smithsonian, who identified it as Gervais' beaked whale (R. Nawojchik, Mystic Aquarium, pers. comm.), the sole record of that species in the Rhode Island study area. To balance the ledger, there was a stranding on Block

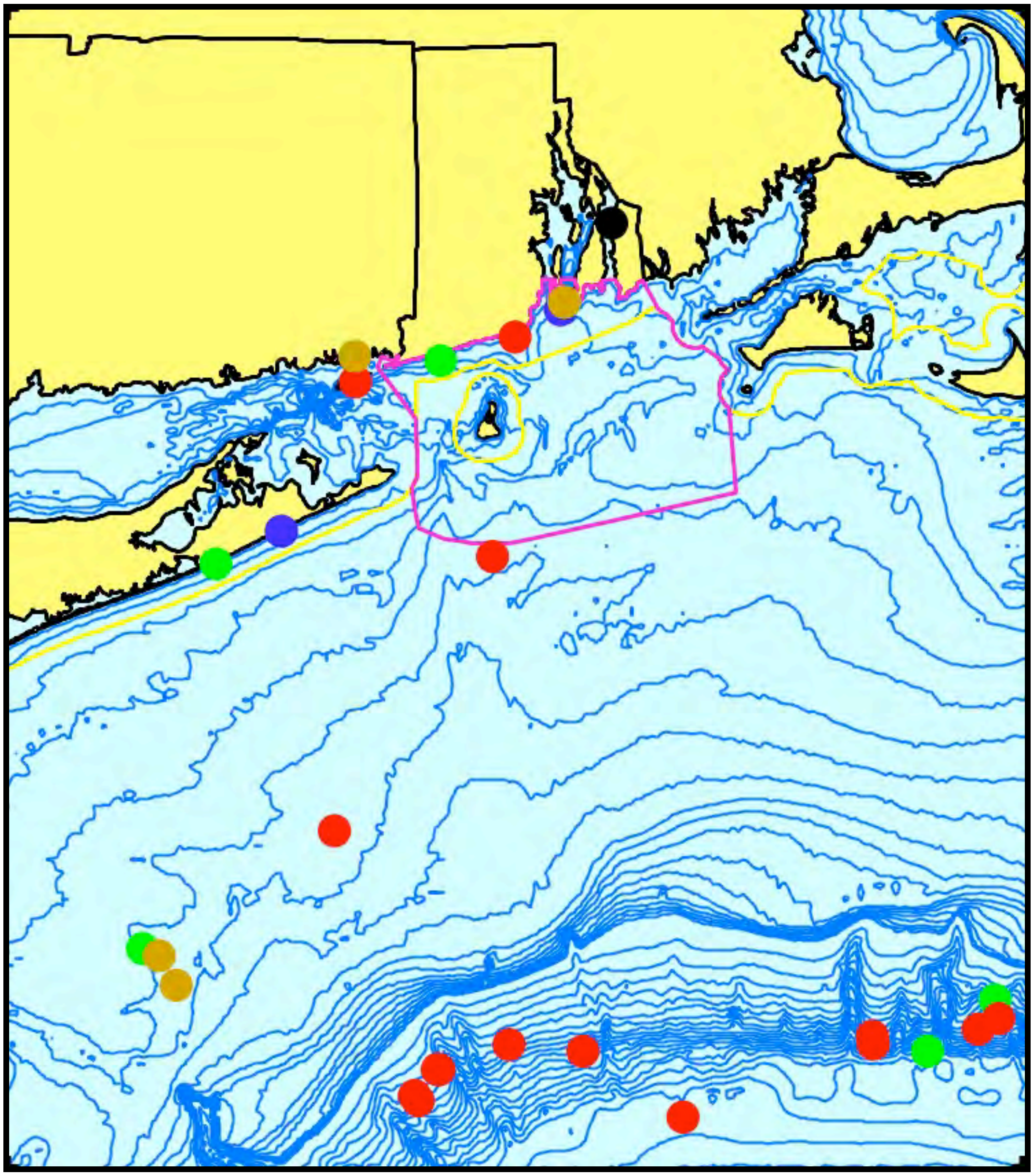

Figure 23. Aggregated sighting, stranding, and bycatch records of northern bottlenose whales, Cuvier's beaked whales, Blainville's beaked whales, Gervais' beaked whales, Sowerby's beaked whales, True's beaked whales, unidentified *Mesoplodon* sp., and unidentified beaked whales in the Rhode Island study area, 1867–2005 (n = 29: winter = 2, spring = 6, summer = 16, fall = 4, unknown = 1).

Table 3. Seasonal frequencies of all beaked whale records in the database (except for one 1857 northern bottlenose whale stranding where the date was not known).

Species	Winter	Spring	Summer	Fall
Northern bottlenose whale	1	0	0	0
Cuvier's beaked whale	0	1	2	1
Blainville's beaked whale	1	2	0	0
Gervais' beaked whale	0	0	1	0
Sowerby's beaked whale	0	0	2	0
True's beaked whale	0	0	1	1
Mesoplodon sp.	0	0	4	0
Unidentified beaked whale	0	3	6	2
Total	2	6	16	4

Island on 22 February 2007 (it occurred after obtaining the stranding database, so is not included on Fig. 23). It was identified at first by a local volunteer as a "dolphin," but photos were sent to Mystic Aquarium and then eventually forwarded to the Smithsonian. Dee Allen at the Smithsonian identified it as definitely a *Mesoplodon* and most likely Sowerby's beaked whale (*M. bidens*), but in the interim a storm washed the carcass back out to sea so no specimen could be collected to document the identification.

A 420-cm, 781-kg Blainville's live-stranded at East Hampton, New York on 14 February 1986. It died soon after stranding. On 21 March 1991, a 404-cm female Blainville's beaked whale stranded just west of the Quonochontaug Breachway in Charlestown, Rhode Island (Nawojchik, 1994). It was lactating, but there was no sign of the calf.

There was only one recent stranding of a True's beaked whale in the Rhode Island study area. A badly decomposed 463-cm carcass washed up on 2 August 1983 at Sand Hill Cove in Narragansett.

There have been no recent strandings of northern bottlenose whale, Cuvier's beaked whale, or

Sowerby's beaked whale (except for possibly the 2007 Block Island stranding discussed above) in the Rhode Island study area. Taking into account all of the historical and recent information, the general conclusion would be that the study area is situated well beyond the normal range of northern bottlenose whales, near the southwestern edge of the range of Sowerby's beaked whale, near the northeastern edge of the range of Gervais' beaked whale, and well within the range of the other three species.

Conclusions: At least three species of beaked whales probably occur regularly within the Rhode Island study area, and two others may occur. Beaked whales normally occur far offshore at the shelf break and beyond, and so would not be expected within the SAMP area.

3.2.12. Beluga Whale *Delphinapterus leucas* (Pallas, 1776)

Monodontidae includes two species of Arctic endemics, the narwhal (*Monodon monoceros*) and the beluga. The two living species are relicts of a family that was formerly more widespread in Northern Hemisphere temperate latitudes (Barnes, 2002b). Belugas are also known as white whales; the word "beluga" or "belukha" is the Russian word for "white."

Description: Beluga whales may be the easiest cetaceans to identify (Brodie, 1989; Jefferson et al., 1993; O'Corry-Crowe, 2002). Adult females are up to 4 m long. The maximum recorded size for a male was 6 m, but they usually do not reach more than about 4.5 m. Belugas have stocky bodies with no dorsal fin, instead there is a low dorsal ridge about 50 cm long but only 1–3 cm high along the mid-back. There may be thick folds of blubber, especially along the ventral surface. There is an obvious neck, which is much more flexible and mobile than in other cetaceans. The head is rounded and tapered in calves, with only the slightest indication of a beak. The melon expands with age, creating a bulbous forehead and a more obvious short, broad beak. The flippers are broad, blunt, and flat, but develop a distinct upward curve on the lateral edge in adult males that can be used to differentiate sexes in the field. The flukes have convex trailing edges. Belugas' most conspicuous character is their color—adults are completely snow-white. Calves are born dark slaty gray and gradually become lighter with age, becoming all white at the time of sexual maturity. Adults sometimes appear yellow, however that seems to be associated with molt.

Status: Belugas are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Near Threatened on the IUCN Red List. The St. Lawrence Estuary stock is listed as Threatened under the Species At Risk Act in Canada (CWS, 2006). It had been classified as Endangered by COSEWIC (Committee on the Status of Endangered Wildlife in Canada), but their role is advisory only, with the SARA listing made by the federal government. The total abundance of beluga whales worldwide is estimated to be at least 150,000, spread across 29 separate identified regional populations (IUCN, 2008). The St. Lawrence Estuary stock was estimated at 1,221 whales in 1997, with the number of calves observed suggesting a slow recovery (CWS, 2006). There is no estimate of the number in U.S. Atlantic waters (Waring et al., 2008).

Belugas are taken by subsistence hunters in many parts of the species' range. Statistics collated by the International Whaling Commission's Scientific Committee summarize the 2000–2004 annual subsistence takes in Greenland (610, 398, 399, 430, 196), Russia (22, 7, 20, 66, unknown), and Alaska (240, 463, 394, 271, 262) (IWC, 2005, 2006). Canada reported a subsistence take of 375 in 2001, but takes in other years are not known (IWC, 2006; Canada is not an IWC member). In the St. Lawrence estuary, they were hunted for over 400 years until the hunt was prohibited in 1979 (CWS, 2006). The peaks years of the St. Lawrence beluga hunt were 1880–1950, when as many as 15,000 whales were killed. Béland (1996) estimated that the St. Lawrence beluga population was about 5,000–10,000 at the beginning of the 20th Century, declining to only about 350 individuals in the 1970s.

A serious concern with St. Lawrence estuary beluga whales is the issue of toxic contamination and associated health effects (Béland et al., 1993; Martineau et al., 1994, 1999; De Guise et al., 1994, 1998; Measures et al., 1995; Béland, 1996; Mathieu et al., 1997; Gauthier et al., 1999; Hickie et al., 2000). The St. Lawrence River is the outlet from the Great Lakes and a substantial watershed in the industrial center of North America. There are contaminants in the water and sediments, accumulating up the food chain to the belugas at the top. St. Lawrence belugas have much higher loads of contaminants than Arctic belugas, including lead, mercury, selenium, PCB's, DDT, dioxins, furans, Mirex, and PAH's. The effects of these contaminants include direct toxicity, suppression of the immune system, effects on the reproductive system, mutation, and cancer. There is evidence for higher rates of disease and parasitism in St. Lawrence beluga whales. One beluga with both testes and ovaries was recorded in 1994, and many females appear to cease reproduction after reaching about age 21, which is not known from other beluga populations. Finally, over a third of all known tumors recorded from cetaceans have been in St. Lawrence River belugas.

Ecology and life history: Beluga whales are highly social and gregarious (Brodie, 1989; O'Corry-Crowe, 2002). They generally are seen in small groups of 2–10 animals, however they often occur in aggregations of over 1,000 animals in their summer habitats. Sightings off the northeastern U.S. are usually single individuals, although there was one group of six animals seen for two months in the vicinity of Portland, Maine in August–September 1927 (Reeves and Katona, 1980). Reeves and Katona reviewed hypotheses for why belugas have not expanded their range south of the St. Lawrence while at the same time there were so many extralimital records off the northeastern U.S. The possible explanations were temperature, avoidance of predators, competition, and prey abundance including the effects of commercial fishing, of which they considered competition the most likely. It is more likely that matrilineal habitat fidelity plays an important role, but that research was not available in 1980.

Belugas follow a distinct annual movement pattern (Brodie, 1989; O'Corry-Crowe, 2002). After the spring break-up of the sea ice, they move into summering areas in near-shore waters and in river mouths and estuaries. They frequently occur in extremely shallow water, sometimes barely deep enough to swim. They are apparently capable of swimming backwards, which may help them avoid being stranded by the out-going tide. At times they have been observed getting stuck on an out-going tide and simply waiting for the next high tide to re-float them. One hypothesis for using shallow waters in summer is that water temperatures may warm more quickly, providing a thermoregulatory benefit to young calves. In addition, belugas are the only cetacean known to undergo an annual molt in summer (St. Aubin et al., 1990). The entire outer layer of the skin turns yellow and is sloughed off. During the molt, belugas are known to rub themselves on gravel bottoms in shallow water to help scrape off the old skin (Smith et al., 1992). In winter, belugas are thought to mainly move offshore with the ice edge, however satellite tracked radio-tagging has shown them traveling long distances to as far as 1100 km offshore and as much as 700 km deep in the ice pack (Suydam et al., 2001).

Beluga whales are capable of diving to the sea floor in much of their habitat (Martin and Smith, 1992; Martin et al., 1998; Suydam et al., 2001). Satellite-linked time-depth-recorder tags show that they routinely dive to 300–600 m and are capable of dives to more than 1000 m with durations up to 25 minutes.

The diet of beluga whales is extremely broad, although little is known for the winter season (Brodie, 1989; Stewart and Stewart, 1989; Measures et al., 1995; Béland, 1996; O'Corry-Crowe, 2002). Prey species include benthic and demersal fishes such as flounders, gadids, and sand lance; pelagic fish such as capelin, herring, and smelt; migratory fishes like salmonids and eels; squid; octopus; shrimp; and benthic worms, clams, and crabs. Evidence for bottom feeding includes occasional seaweed, sand, and gravel in stomach contents.

Calving takes place in a relatively short period in the summer, with the timing differing slightly between different stocks (Brodie, 1989; Stewart and Stewart, 1989; O'Corry-Crowe, 2002). Calving peaks in July in the St. Lawrence population. Calves average 1.6 m at birth. Mating takes place in the spring, and the gestation period is 14–14.5 months. Males attain sexual maturity at about age 8, and females around 5–6. Lactation lasts 20–24 months, with the calf beginning to feed on easily captured prey like crabs, worms, and mollusks during its second year. The inter-birth interval for most females is 3 years.

General distribution: The beluga is primarily an Arctic species, occurring in high latitudes around the Northern Hemisphere (Brodie, 1989; Stewart and Stewart, 1989; Nowak, 1999; O'Corry-Crowe, 2002). They are found along Alaska (south into the Bering Sea), Arctic Canada (south to Labrador and Hudson Bay), east and west Greenland, Svalbard, northern Norway, and Arctic Russia (south into the Sea of Okhotsk in the northwest Pacific). Stock divisions are maintained by very strong matrilineal fidelity to summering sites, even where there are few barriers between sites. Genetic studies have been used to elucidate stock structuring in belugas. Nuclear DNA markers show that North American belugas partition into two groups, eastern and western, suggestive that they occupied two separate refugia during the Pleistocene Ice Age (Brown Gladden et al., 1999b). Mitochondrial DNA shows the finer structure indicative of matrilineal habitat fidelity (Brennin et al., 1997; Brown Gladden et al., 1997). There are isolated relict populations in Cook Inlet in southern Alaska and in the Gulf of St. Lawrence and adjacent bays and rivers in eastern Canada. There have been occasional occurrences of belugas along the Atlantic coast from Nova Scotia to New Jersey (Reeves and Katona, 1980), which are believed to be individuals from the St. Lawrence population. Brown Gladden et al. (1999a) confirmed via genetic sampling that a beluga stranded in Nova Scotia did come from the St. Lawrence population.

Historical occurrence: Cronan and Brooks (1968) knew of no occurrences of belugas in Rhode Island, but stated that “there are records from New Hampshire; Cape Cod, Massachusetts; and Atlantic City, New Jersey; it therefore seems likely that the white whale may someday be seen off Rhode Island.” The occurrence of belugas at Atlantic City is one of those errors that get passed down through the literature based a previous misinterpretation and then a series of repeated citations. Reeves and Katona (1980) concluded that the error traced back to someone’s mis-reading of True (1910), who reported behavioral observations of two captive belugas that were held in a tank in Atlantic City in 1908. Reeves examined the skull of one of those animals in the Smithsonian collection (USNM238104), and it did have a tag labeled “from Atlantic City,” but the curatorial records show that it was captured in the St. Lawrence River. Connor (1971) knew of no confirmed records of belugas in or near Long Island. He said that Roy Latham had reported a 3–4-m white cetacean that he concluded was a beluga in Long Island Sound between Orient Point and Mattituck for four days in June 1942. Connor judged the report to be reliable, and there is a record in the Smithsonian database based on Connor’s publication, the only mid-Atlantic beluga record in the Smithsonian database older than 1978. Reeves and Katona (1980) also accepted Latham’s report as likely in their review of extralimital beluga occurrences off the northeastern U.S.

Recent occurrence: Belugas are rare in the Rhode Island study area, with only four records (Fig. 24; note that the numbers of sightings can be misleading, because an animal seen repeatedly for up to several months is typically represented in the data by only one or two records). Somewhat surprisingly, they occur more frequently in western Long Island and New Jersey (including one seen in Delaware Bay and the Delaware River in April 2005, as far upstream as Trenton). Individuals that do occur south of Cape Cod commonly stay for extended periods, usually very near the coast (Reeves and Katona, 1980). The study area records include the June 1942 sighting off Orient Point reported in Connor (1971). A single beluga was seen off Moriches Inlet on the south shore of Long Island on 22 June 1980. In February 1985, a beluga was seen in the harbor at New Haven, Connecticut. It was sighted repeatedly over the succeeding months. On 13 May 1986 it was found dead and entangled in fishing gear in Long Island Sound south of New Haven, however the cause of death was determined at necropsy to be from a gunshot wound.

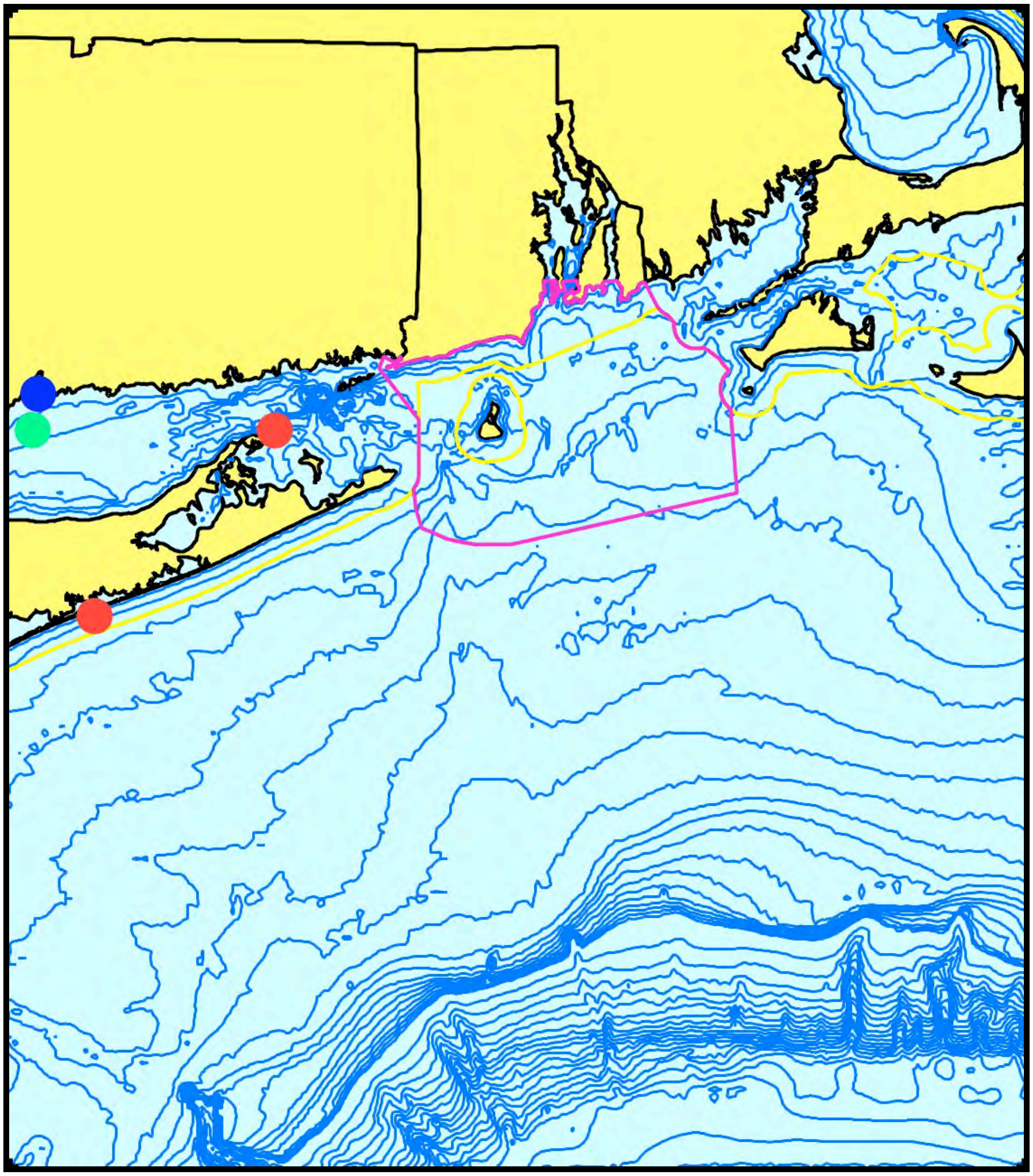

Figure 24. Aggregated sighting, stranding, and bycatch records of beluga whales in the Rhode Island study area, 1942–1986 (n = 4: winter = 1, spring = 1, summer = 2, fall = 0).

Conclusions: Belugas clearly occur only accidentally on rare occasions in the Rhode Island study area and are not expected in the SAMP area.

3.2.13. Harbor Porpoise *Phocoena phocoena* (Linnaeus 1758):

Phocoenidae includes three genera and six species of small toothed whales known as the porpoises, which are the smallest of the living cetaceans (Read, 2002). They are sometimes referred to as the "true" porpoises, most likely because the term "porpoise" has frequently been used in the U.S. as equivalent to "dolphin." Porpoises are closely related to the dolphins, and were long included in the Delphinidae. They are now recognized as a separate family, but are included with Delphinidae and Monodontidae in the superfamily Delphinoidea (Rice, 1998).

Porpoises are easily differentiated from dolphins by having spatulate rather than conical teeth (Read, 2002). The exposed portion of a porpoise tooth is flattened, somewhat wider than the base diameter, and slightly curved. A porpoise has a conical head without a beak. Their skulls resemble the skulls of very young dolphins, with delayed fusion of cranial sutures. The rostrum of the skull is much shorter than in small dolphins, and there are paired rounded protuberances on the premaxillae just in front of the braincase, which is relatively large and rounded. Porpoises have small but robust bodies, with relatively small flippers and dorsal fins (the dorsal fin is absent in the finless porpoise), which is likely related to conservation of heat for a relatively small animal living in cold water. Most species have epidermal tubercles on the leading edge of the dorsal fin. Porpoise life histories are more like those of mysticetes than like other odontocetes', with early maturation, rapid growth, short inter-birth intervals, and a low degree of sociality (Read and Hohn, 1995).

Description: Harbor porpoises are the smallest cetaceans occurring in the North Atlantic, reaching only 1.4–1.9 meters. They exhibit reverse sexual dimorphism; an average female is 160 cm and 60 kg, an average male is 145 cm and 50 kg, and the largest individual known was a 200-cm, 70-kg female (Bjørge and Tolley, 2002). The size ranges of mature porpoises from the Bay of Fundy were: females—131–168 cm (mean = 157, n = 32), 42–76 kg (mean = 62); males—129–157 cm (mean = 144, n = 62), 36–61 kg (mean = 49) (Read, 1999). The body is stocky, dark gray to black on the back and white on the belly with little or no distinctive patterning (Gaskin et al., 1974; Jefferson et al., 1993; Read, 1999; Wynne and Schwartz, 1999; Bjørge and Tolley, 2002). The sides may be mottled or simply transition gradually from dark to light. There are often one or more dark stripes from the corner of the mouth to the flipper. Individuals may show darker eye, chin, and lip patches. The head is bluntly conical with no distinct beak. The flippers are small and pointed, and the dorsal fin is small, triangular (sometimes slightly falcate), and located slightly behind the middle of the back.

Status: Harbor porpoises are not listed under the U.S. Endangered Species Act. A proposal made in 1993 to list the Gulf of Maine/Bay of Fundy stock as Threatened because of excessive bycatch mortality in the sink gillnet fishery was withdrawn in 1999 after an extensive review (NMFS, 1999) and the species was removed from the Candidate list in 2001 (NMFS, 2001). Harbor porpoises are not included on the Rhode Island state list and are classified as Least Concern on the IUCN Red List. Northwest Atlantic harbor porpoises are listed as Special Concern under the Species at Risk Act in Canada (CWS, 2006). The total number of harbor porpoises in the North Atlantic is likely to be over 500,000 (IUCN, 2008). The current estimate for the Gulf of Maine/Bay of Fundy stock is 89,054 (Waring et al., 2008).

Harbor porpoises were the subject of an organized hunt in Denmark for oil and meat from at least the 14th Century until World War II, and had probably been hunted in that area since the Stone Age (Kinze, 1995). Average annual catches probably exceeded 1,000 animals. Inuit subsistence hunters in Greenland took 1,607 porpoises in 2000, 1,946 in 2001, 1,373 in 2002, 2,320 in 2003, and 2,238 in 2004 (IWC, 2005, 2006). Micmac and Passamaquoddy Indians in the Bay of Fundy and along the coast of Maine hunted porpoises for both meat and oil in the 19th and 20th Centuries (reviewed by Reeves and Read, 2003). They hunted from canoes using shotguns, but there is no archeological evidence that hunting occurred before the introduction of firearms. The blubber was rendered down to 2–3 gallons of oil that was used for lighting and lubrication. Much more valuable was the “jaw oil” from the mandibular fat, which was used for lubricating clocks, watches, and other precision instruments. Jaw oil was obtained by hanging the lower jaw over a can and allowing the oil to drip out, producing about a half-pint per animal. Total takes were likely several hundred per year.

Mortality of harbor porpoises and other phocoenids as bycatch in commercial fisheries is a global concern (Perrin et al., 1994b; D’Agrosa et al., 1995; Read and Wade, 2000). The most significant fishery bycatch occurs in sink gillnet fisheries. As pointedly noted by Reeves and Read (2003), the first U.S. government fisheries report in 1886 detailing the efficiency of gillnet fishing for cod also reported incidental captures of harbor porpoises. The stock assessment for Gulf of Maine/Bay of Fundy harbor porpoise stock (Waring et al., 2008) reported annual average mortality of 725 porpoises in gillnet fisheries during 2001–2005—475 in the northeastern U.S., 177 in the mid-Atlantic, and 73 in Canada. There are also lower levels of mortality in other fisheries. A Take Reduction Plan is in effect in U.S. Atlantic waters, involving fishery closures in specific areas at times when the probability of porpoise bycatch is high, plus a requirement for the use of acoustic alarms (“pingers”) to alert porpoises to the presence of gear. Bycatch mortality did decline for a time, however then began to increase, perhaps due to declining compliance with the Take Reduction Plan.

Harbor porpoises are the most common stranded cetacean in the Rhode Island study area (Table 2). Fishery-related mortality is likely to be a significant component of the stranding record. Of those strandings where a cause of death could be determined, over a quarter showed evidence of fishery interactions (Waring et al., 2006b). In another 18%, the animals were judged to be emaciated and most likely were newly weaned calves that were unsuccessful at feeding independently.

Given that harbor porpoises live in coastal waters adjacent to areas with high human population densities and industrial development, the potential effects of toxic pollution are of concern. In some areas harbor porpoises do have high levels of organochlorines and heavy metals in their body tissues, but no correlations have been shown with adverse health effects or body condition (Read, 1999).

Ecology and life history: The most common harbor porpoise sighting off the northeastern U.S. is a single individual, with pairs and trios common (CETAP, 1982). This is consistent with observations in other areas (Read, 1999; Bjørge and Tolley, 2002). Groups of 6–10 are often observed, or even larger groups on rare occasions, however these are not stable social groupings as in many other toothed whales. Harbor porpoise groupings are fluid, short-term associations in a “fission-fusion” social structure (Reeves and Read, 2003). The largest reported groups are most likely aggregations of un-associated animals in areas of abundant prey.

Harbor porpoises exhibit a clear seasonal pattern of distribution and movement, however there is little evidence for a coordinated annual migration (Reeves and Reed, 2003). Off the northeastern U.S., porpoise abundance declines in the Gulf of Maine in winter, coincident with the peak occurrence in the mid-Atlantic region. However, evidence from genetic sampling of stranded and bycaught individuals shows that some proportion of the animals in the mid-Atlantic region do not come from the Gulf of Maine/Bay of Fundy stock (Rosel et al., 1999). In addition, the majority of stranded and bycaught porpoises in the mid-Atlantic are juveniles. Although juvenile mortality rates can be expected to be higher, there also may be age differences in seasonal movements, perhaps with younger animals wintering in more inshore areas than older animals.

Most dives by harbor porpoises are just about a minute or a little longer, but they are capable of diving for 5 minutes to depths exceeding 200 m (Westgate et al. 1995). Their surfacings are very brief. Read and Westgate (1997) studied movements of Gulf of Maine harbor porpoises using satellite-tracked radio tags. Average daily movements were 14–58 km. Tagged animals commonly remained resident in small, localized areas for extended periods, then made relatively rapid, directed movements lasting hours or days to different areas. Tagged porpoises ranged over the entire Bay of Fundy and Gulf of Maine area.

Harbor porpoises primarily feed on fish and secondarily on squid and crustaceans (Gaskin et al., 1974; Read, 1999; Bjørge and Tolley, 2002; Reeves and Read, 2003). They preferentially feed on non-spiny fishes with relatively high fat content that are less than 40 cm long (usually 10–30 cm). Clupeids and gadoids dominate. Their primary prey species in the Bay of Fundy are herring and silver hake. Other commonly eaten species include anchovies, sprat, sardines, and capelin, and calves apparently begin feeding on small crustaceans. Stomach contents of stranded porpoises in the Rhode Island study area frequently include herring and squid (Sadove and Cardinale, 1993). Harbor porpoises do not forage cooperatively, and often feed near the bottom (Read, 1999). Their daily ration ranges from 5% to 14% of body weight, and is highest in immatures and in pregnant and lactating females.

Harbor porpoise reproduction is strongly seasonal, with the timing varying between regions (Read, 1999; Reeves and Read, 2003). In the Gulf of Maine/Bay of Fundy population, ovulation occurs within a few weeks in late spring and early summer (Read, 1990a). Only the left ovary matures. There is also marked reproductive seasonality in the males, with testis mass and sperm production varying on an annual cycle and peaking at the same time as ovulation (Reeves and Read, 2003). At the peak of the breeding season, the testes in an adult male comprise about 4% of total body mass. The mating system is probably promiscuous with sperm competition occurring. Gestation is 10–11 months, with most calves born in May in the Gulf of Maine, and

June-July in Europe.

Calves are about 75 cm long and weigh about 6 kg at birth, and triple their weight in about 3 months (Read, 1999; Reeves and Read, 2003). Lactation lasts at least 8 months and possibly as long as a year, but weaning is gradual and calves begin feeding independently well before being completely weaned. Post-partum estrus and mating is common in harbor porpoise females, resulting in simultaneous pregnancy and lactation and 1-year intervals between calves. Most females give birth annually in the Gulf of Maine and European populations, but every other year in the California population (Read, 1990b; Read and Hohn, 1995).

Harbor porpoises typically reach sexual maturity in their third or fourth years, but are not physically mature until about age 5 in males and 7 in females (Read, 1999). The mean age at sexual maturity for Gulf of Maine/Bay of Fundy females is 3.44 years, at an average length of 143 cm (Read, 1990b).

Some harbor porpoises from the Bay of Fundy have tested positive for antibodies to morbillivirus (Duignan et al., 1995). A few porpoises died during the 1988 PDV epizootic in the North Sea harbor seals. Van Bressem et al. (2001) reported 16.7% morbillivirus seropositives in mature porpoises from the British Isles, but no positive tests in immatures from the British Isles or in either immatures or adults from the North Sea.

General distribution: Harbor porpoises are known from cool temperate to subpolar waters around both the North Atlantic and North Pacific (Gaskin et al., 1974; Read, 1999; Bjørge and Tolley, 2002; Reeves and Read, 2003). They occur most often in relatively shallow continental shelf and coastal waters. The sightings from the 1978–1981 CETAP surveys showed porpoises in spring most concentrated in the southwestern Gulf of Maine around Nantucket Shoals and western Georges Bank but also occurring throughout the Gulf of Maine and southern New England shelf, followed by a marked concentration into the northern Gulf of Maine and Bay of Fundy in the summer (CETAP, 1982). Sightings were much less frequent and extremely scattered in fall and winter, and it was hypothesized that many individuals migrated to the mid-Atlantic or offshore waters. Strandings are widespread from Maine to North Carolina. There are two stranding records for Florida in the 1980s and one in 2003 (Waring et al., 2008), however they are considered to be extralimital, since there are no other records south of North Carolina.

Historical occurrence: Cronan and Brooks (1968) knew of no records of harbor porpoises in

Rhode Island, but did mention occurrences nearby in Mount Hope Bay in July 1931 and September 1934 that “would have to go through Rhode Island waters to arrive in or leave Mount Hope Bay.” In the Smithsonian database there is a record of a stranding at Brenton’s Point in Newport on 5 July 1901, collected by E. A. Mearns, plus another undated specimen record from Newport, also collected by Major Mearns. There are also records of a 119-cm, 26-kg porpoise stranded at Narragansett Pier in February 1972, and 139-cm animal stranded on First Beach in Newport in March 1976.

There are historical stranding and capture records in the Smithsonian data for eastern Long Island, and quite a few more for western Long Island and New Jersey. The earliest harbor porpoise record in those data was a report of a porpoise taken more than 30 km up the Connecticut River in Middletown, Connecticut in 1850. One of the Smithsonian records is a sighting of 25 porpoises off Orient Point on 7 December 1921 extracted from Connor (1971), which might be suspect (see below). There is also a record of a live-stranding of a 120-cm, 20-kg porpoise in Niantic, Connecticut that was collected and survived for a short time at Mystic Aquarium. Waters and Rivard (1962) said that harbor porpoises occurred all along the coasts of New England, but were not very common in Cape Cod Bay. They presented only one recent record—a stranding up a river in Annisquam on Cape Ann in 1955.

Historical accounts of harbor porpoises in southern New England study area must be treated with some level of skepticism because of the common use of the word “porpoise” to also refer to dolphins, as pointed out by Connor (1971) with regard to sighting reports for Long Island during summers in the 1950s and 1960s. In addition, the recent data show harbor porpoises to be relatively rare in summer (see below). Also somewhat suspect are the accounts of porpoises in large schools, sometimes up to hundreds of animals (e.g., Miller, 1899; Rowley, 1902; Turrell, 1939: as cited by Conner, 1971; Cronan and Brooks, 1968). De Kay (1842) reported that porpoises were “formerly so abundant on the shores of Long Island as to have induced the inhabitants to form establishments for their capture.” His account was derived from a 1792 report by E. L’Hommedieu in *Transactions of the Society in the State of New-York for the Promotion of Agriculture, Arts, and Manufactures*, which described a net fishery in eastern Long Island taking small cetaceans for oil and leather. Mead (1975) concluded that the fishery was not for harbor porpoises, but was most likely for bottlenose dolphins, in part because the average oil yield reported (6 gallons) was too high for *Phocoena* but matched that from the Cape Hatteras

Tursiops fishery. In addition, the capture method described matched what was used at Cape Hatteras. Linsley's (1842) report that "Numbers of the common porpoise are taken in this town for the sake of the oil, which is usually from three to seven gallons" suffers from the same weakness.

Recent occurrence: Harbor porpoise occurrence in the Rhode Island study area is strongly seasonal, with 69.5% of all records in spring, followed by winter (19.5%), summer (7.8%), and fall (2.7%) (Fig. 25). Sightings are widespread across the shelf. Strandings have occurred all along the south shore of Long Island and in parts of coastal Rhode Island. There were also strandings along both sides of Long Island Sound and occasional occurrences in bays, estuaries, and rivers. Seasonal stranding frequencies partly mirror the sighting frequencies—highest in winter and second-highest in spring. Harbor porpoises are relatively common in the winter in eastern Long Island Sound, Gardiner's Bay, and Peconic Bay (Sadove and Cardinale, 1993), however bays and sounds are excluded from survey areas so there are few documented sighting records. They probably also occur in winter in Narragansett Bay, although we have only second- and third-hand anecdotal reports for evidence.

The effort-corrected relative abundance patterns show that harbor porpoises occurred within the SAMP area in all four seasons of the year (Fig. 26). The data probably under-represent occurrence, because of their relatively low detectability during surveys. In winter, they were present at low to moderate abundances in the eastern part of the SAMP area, as well as south of Martha's Vineyard and Nantucket and offshore along the entire study area. In spring, porpoises occurred throughout the SAMP area, at relative high abundances in the offshore portion. They also occurred at relatively high abundance throughout much of the study area, and in highest abundance over Nantucket Shoals and eastward. Spring is when harbor porpoises are known to be migrating from wintering areas in the mid-Atlantic and offshore toward their spring and summer feeding grounds in the Gulf of Maine (CETAP, 1982; Read, 1999; Waring et al., 2008). In summer, porpoises were present in lower numbers in the eastern half of the SAMP area, and still in high abundance in the Nantucket Shoals area. Their abundance was lowest in fall—in the western half of the SAMP area around Block Island, plus relatively limited areas offshore, at Nantucket Shoals, and near Cape Cod and Nantucket.

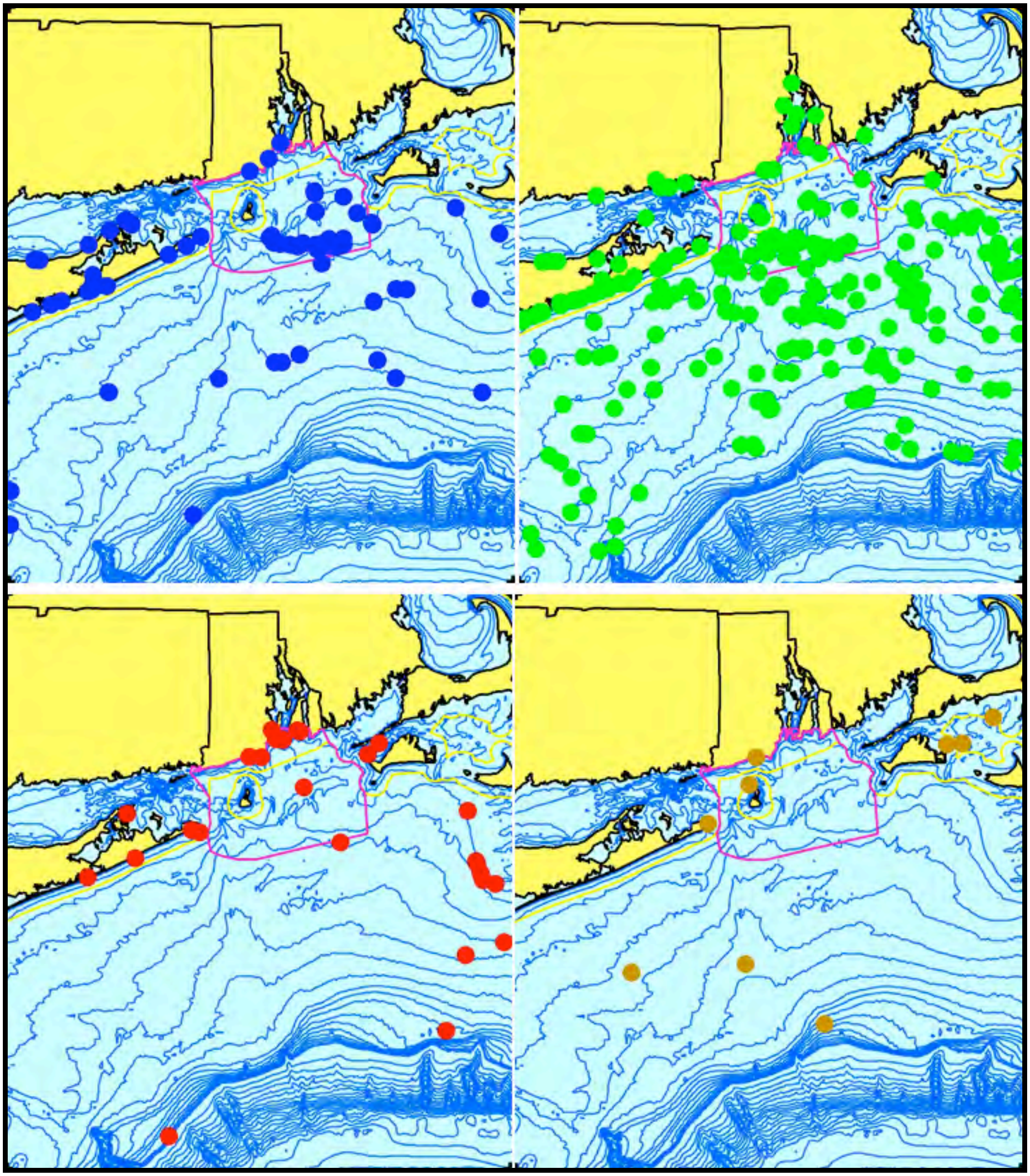

Figure 25. Aggregated sighting, stranding, and bycatch records of harbor porpoises in the Rhode Island study area, 1850–2007 (n = 376: winter = 73, spring = 262, summer = 29, fall = 10, unknown = 2).

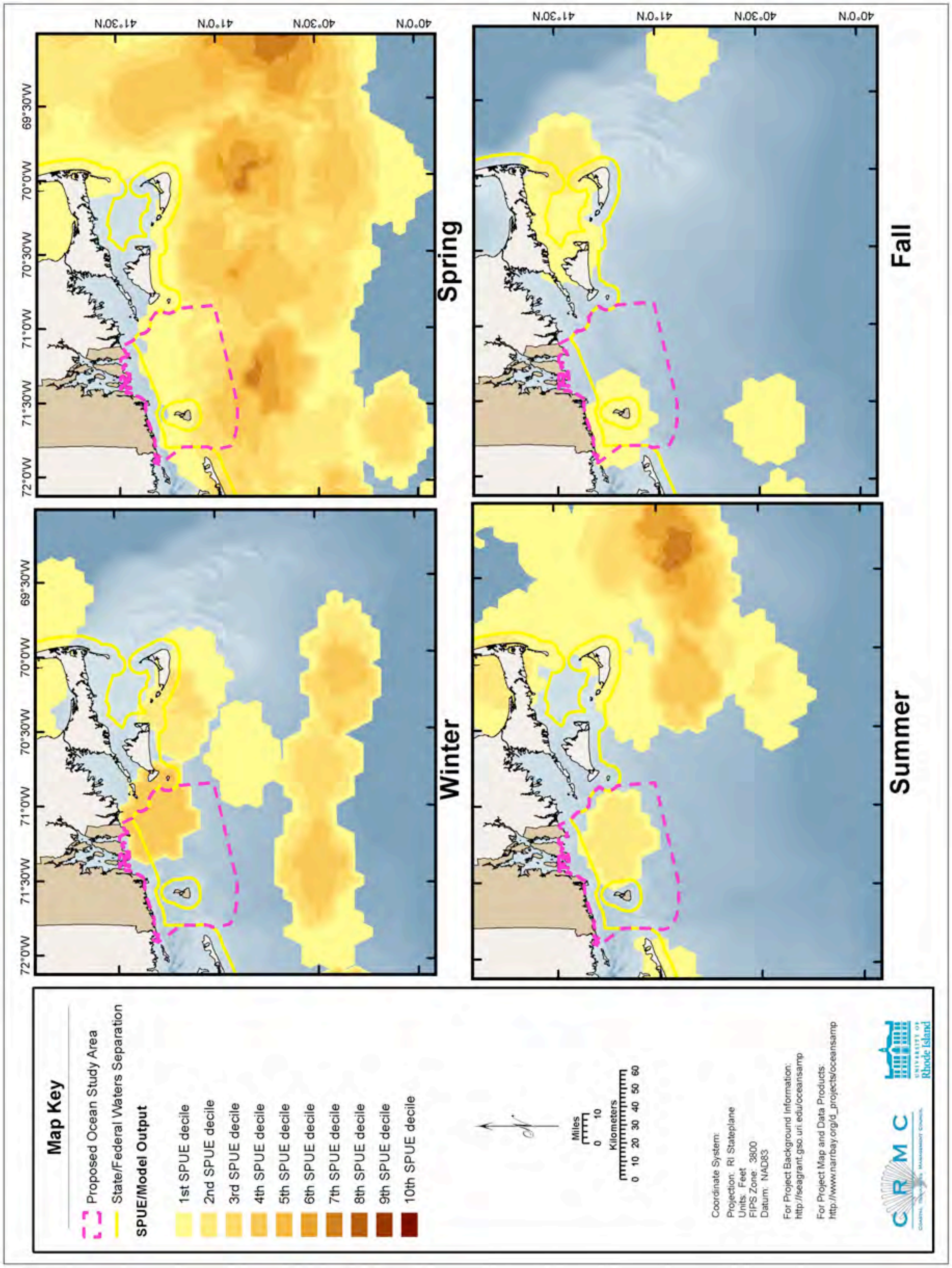

Figure 26. Modeled seasonal relative abundance patterns of harbor porpoises in the Rhode Island study area, corrected for uneven survey effort.

Stranding frequencies show a clear increasing trend beginning in the late 1980s (Fig. 27). One can only speculate about underlying causes. A high proportion of stranded porpoises have thin blubber, with starvation a contributing factor to their deaths (Nawojchik, 2002). Increased strandings could be related to increasing porpoise abundance in the region or to declines in prey availability. Some proportion of stranded porpoises also shows evidence of interaction with fisheries, primarily sink gillnets (Waring et al., 2008). Increasing strandings may reflect changes in fisheries—perhaps expansion of gillnet fishing for monkfish and dogfish. Landings of both increased sharply beginning about 1990.

The current Harbor Porpoise Take Reduction Plan (http://www.nero.noaa.gov/prot_res/porptrp) includes measures that recognize the high levels of mortality of harbor porpoises in gillnet fisheries off Rhode Island. The TRP established a Cape Cod South closure area to protect harbor porpoises. The closure area extends from 71°45' W (approximately the longitude of Weekapaug) east to 70°30' W (eastern Martha’s Vineyard), and from the shoreline to 40°40' N. Gillnet fishing is prohibited completely in March. In December–February and April–May, gillnet fishing is allowed only using nets equipped with acoustic alarms (“pingers”) that alert porpoises to the presence of the nets.

Conclusions: Harbor porpoises can occur in the SAMP area at any time of year, but are most abundant in spring, when they are moving inshore and northeastward. They are among the most abundant cetacean species in the SAMP area or the Rhode Island study area. Although they are not listed under the ESA, their abundance increases the likelihood of effects from development. In addition, seasonal restrictions on activities to mitigate potential impacts on right whales and other endangered species would mean that those activities would occur at times when harbor porpoises were likely to be abundant. This combination of factors suggests that harbor porpoise should be included in the second tier of conservation priorities for the SAMP (see Recommendations).

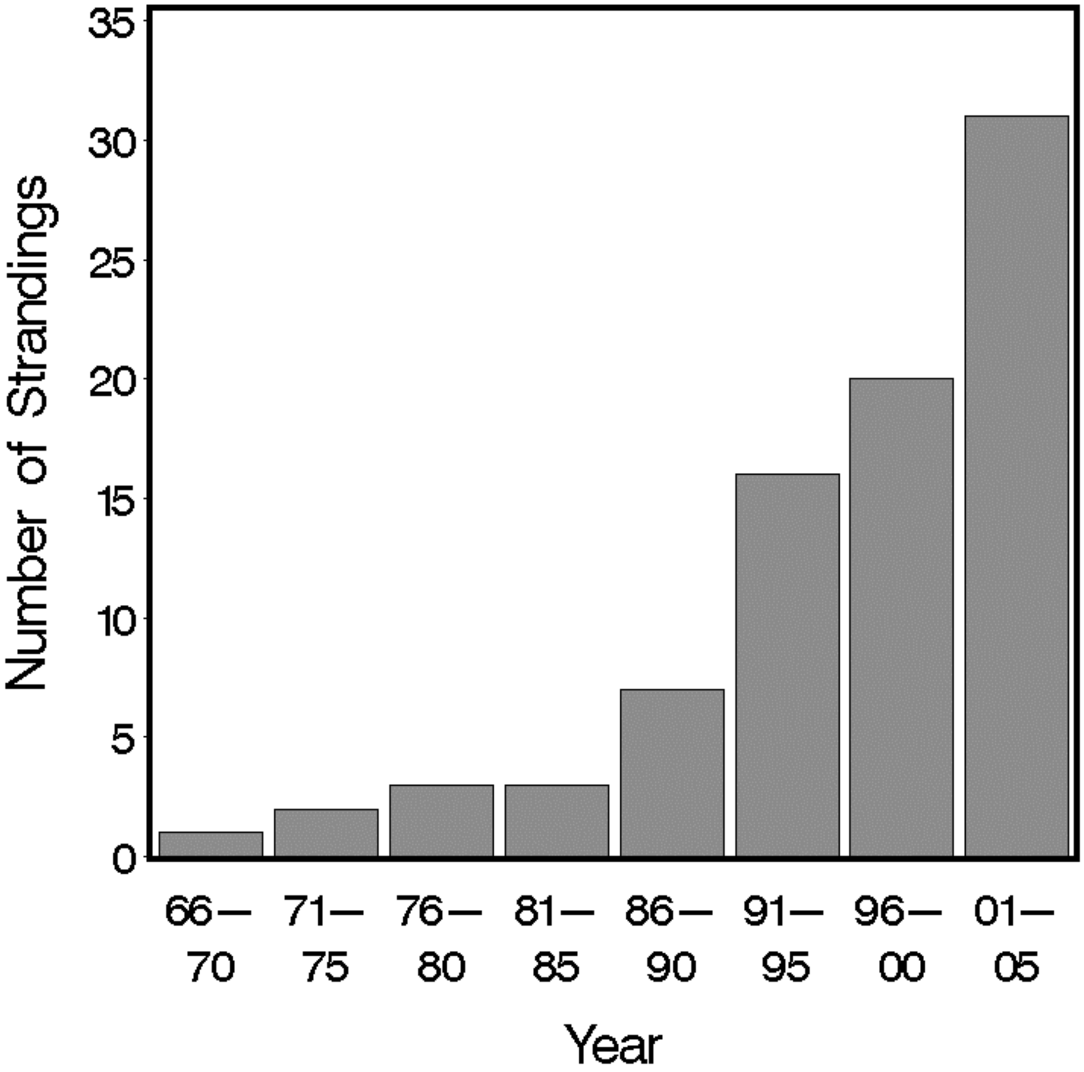

Figure 27. Five-year stranding frequencies for harbor porpoises in the Rhode Island study area, 1966–2005.

3.2.14. Long-finned Pilot Whale *Globicephala melas* (Traill, 1809)

Short-finned Pilot Whale *Globicephala macrorhynchus* Gray, 1846

Delphinidae is the most diverse and speciose family of cetaceans, with 17 currently accepted genera. Smaller delphinids are generally called “dolphins” and the larger ones “whales,” perhaps somewhat arbitrarily. In the recent past, the term "porpoise" was often used instead of "dolphin," especially in the U.S. The latter term could be confusing, because it also refers to tropical game and food fish in the genus *Coryphaena*. "Dolphin" is now used less often to refer to the fish in favor of the Hawaiian or Spanish name (mahi mahi or dorado, respectively).

All of the large, black, blunt-headed delphinids are sometimes collectively referred as blackfish, an old whalers' and fishermen's term. Pilot whales are sometimes also called potheads. The two species of pilot whales are well-defined and mostly parapatric, however, their ranges overlap in the waters off the mid-Atlantic coast of the U.S. They are also extremely difficult to differentiate in the field, so much of the information below refers to the two species combined.

Description: Pilot whales are easy to identify, but differentiating the long-finned and short-finned species in the field is exceedingly difficult (Jefferson et al., 1993; Bernard and Reilly, 1999; Wynne and Schwartz, 1999; Olson and Reilly, 2002). Both species are large, robust animals with a distinct "barrel-chested" appearance. Both are sexually dimorphic, with males larger than females. The head is rounded and bulbous with a very prominent melon, a slight beak, and an upturned mouth. The tailstock has prominent dorsal and ventral keels. The flippers are curved, tapered, and pointed. The dorsal fin is low, rounded to somewhat falcate, broad-based, and located well in front of the middle of the body. The color is black, dark gray, or brown overall, except for a whitish "anchor" mark on the chest, lighter gray "eyebrow" streaks from the eyes to the back, and a light gray "saddle" behind the dorsal fin.

Long-finned males may be as long as 7.6 m, while females reach a maximum of only 5.7 m. Their flippers are longer at about one-fifth of body length, with an obvious "elbow," but the length ranges overlap, making the difference in flipper length nearly useless as a field character for sightings of live animals. Short-finned pilot whales are somewhat smaller, and possibly slightly more thick-bodied, with males up to 6 m and females up to 5.5 m. The flippers in short-fins are shorter (about one-sixth of body length) and more curved, but the length ranges overlap, making the difference in flipper length nearly useless as a field character for sightings of live animals. In both species, dorsal fin shape changes in older adult males, with a tendency to become more broad-based in long-fins and more broad-based and hooked in short-fins. Additionally, in at least some short-fins, the saddle and lighter streaks on the head may be more distinct, and the overall color more brown than black. Range may be helpful, but should not be relied upon for identification.

Status: Both long-finned and short-finned pilot whales are not listed under the U.S. Endangered Species Act and are classified as Data Deficient on the IUCN Red List. On the Rhode Island state list, long-finned pilot whales are classified as Unprotected, while short-finned pilots are not included.

The total abundance of either species of pilot whale in the North Atlantic is not well known, although the long-finned species is better known. Early estimates of the total size of the population impacted by directed harvests in eastern Canada concluded that there were 50,000–60,000 long-finned pilot whales in the western North Atlantic (Mitchell, 1974; Mercer, 1975). Hay (1982) estimated the abundance of long-finned pilot whales off Newfoundland and Labrador at 6,731–19,603; Kingsley and Reeves (1998) estimated 1,600 in the Gulf of St. Lawrence in late summer 1995; and Buckland et al. (1993) estimated 778,000 in the eastern and central North Atlantic. Because of the difficulty in identifying pilot whales at sea, off the eastern U.S. the two species currently must be combined for estimating abundance. Based on a 2004 summer survey, the combined stocks of both species between Florida and the Bay of Fundy were estimated at 31,139 animals (Waring et al., 2008). Efforts are underway to use a combination of genetic data from biopsy sampling, spatial modeling, color differences, and morphometrics to partition the estimates by species. In the Gulf of Mexico only short-finned pilot whales occur; recent abundance estimates for parts of the Gulf are 2,388 in 1996–2001 and 716 in 2003–2004.

Directed pilot whale fisheries on both species have occurred in many places around the world (reviewed in Bernard and Reilly, 1999). A drive fishery in Newfoundland took almost 10,000 pilot whales in 1956 but declined during the 1960s and eventually ended. Small-scale pilot whale fisheries formerly took place in Norway, Greenland, Iceland, Ireland, and Cape Cod, and Inuit subsistence hunters in Greenland took 5 in 2000, 45 in 2001, 24 in 2002, 195 in 2003, and 208 in 2004 (IWC, 2005, 2006). The drive fishery for long-finned pilot whales in the Faroe Islands is the only substantial hunt still continuing in the North Atlantic. It dates back to at least the 16th Century. Catches were about 1,500 per year in the 1970s and 2,500 per year in the 1980s, with little evidence for any negative impacts on overall pilot whale stocks in the northeastern Atlantic. Annual catches in 2000–2003 were 588, 918, 626, and 503 (IWC, 2005, 2006). Short-finned pilot whales were hunted for centuries in Japan, and there are still catches of a few hundred per year (304 in 2000, 389 in 2001, 176 in 2002, 160 in 2003: IWC, 2005, 2006). In the North Atlantic, Yankee whalers left behind traditional fisheries in both the West Indies and the Azores that persisted into the 1980s.

Pilot whales are also impacted by bycatch in commercial fisheries. In U.S. Atlantic waters, average annual fishery-related mortality of both species combined in 2001–2005 was 163 animals. The predominant source of mortality is the pelagic long-line fishery for swordfish (86 per year), and pilot whales are also taken in bottom and mid-water trawl fisheries for squid, groundfish, and herring. Pilot whales were formerly taken in the pelagic swordfish driftnet and tuna pair-trawl fisheries, both now closed.

Ecology and life history: Pilot whales live in permanent social groups of about 10–50 animals, but at times pods join to form aggregations of hundreds of animals (Bernard and Reilly, 1999; Olson and Reilly, 2002). Off the northeastern U.S., group sizes observed ranged from 1 to 500, with a mode of 10 and mean of 20 (CETAP, 1982). In this region they commonly associate with other cetaceans. The most frequently observed mixed-species herds in the shelf-edge habitat off the northeastern U.S. were pilot whales and offshore bottlenose dolphins. They also have been observed associated with Risso’s, common, and spotted dolphins and sperm whales, as well as in the same areas as fin and humpback whales in more inshore waters.

Short-finned pilot whales that were trained by the U.S. Navy routinely dived to 300 m and were capable of dives of 15 minutes and to at least 500 m and probably over 600 m (Bernard and Reilly, 1999).

In the North Pacific, there are differences in northern and southern stocks of short-finned pilot whales off Japan in size, markings, and life history (Kasuya and Tai, 1993; Bernard and Reilly, 1999). In the southern stock, mating is mostly in April–May and births are in July–August, but some births occur year round. In the northern stock calving is more strictly seasonal, with breeding in September and calving in December. Calves are about 1.7 m long at birth. The age at weaning is longer than in long-fins at 3.5–5.5 years. An older female might nurse her last calf for as long as 15 years (Marsh and Kasuya, 1991). Females reach sexual maturity at 9 years on average and males at about 16 years. A significant proportion of females become senescent, ceasing reproduction during or after their 30s.

Details of the social structure of long-finned pilot whale herds have been examined by genetic sampling from groups killed in a fishery in the Faroe Islands (located in the northeastern North Atlantic between Scotland and Iceland) (Amos et al., 1993). Entire herds are driven into a fjord or bay and killed, providing a complete picture of the inter-relationships among group members. All of the adults in a pod are related to one another. The calves and juveniles are offspring of the adult females in the pod, but the pod's adult males are not their fathers. Both males and females remain with their mothers for their entire lives, similar to the situation in killer whales. It is believed that mating occurs in large temporary aggregations, when the adult males are able to breed with females in other pods. Pilot whales also are one of the only non-human mammals with evidence of reproductive senescence, with post-reproductive individuals contributing to the survival of the young. In this system, the long-term benefits of group-living, social facilitation, and learning are maximized while still avoiding inbreeding.

Both species of pilot whales are known to strand commonly in large groups (Geraci and Lounsbury, 1993; Bernard and Reilly, 1999; Perrin, 2002f). Mass stranding is a phenomenon that occurs only in social odontocetes, including sperm whales, pilot whales, false killer whales, and some dolphin species. The causes of mass strandings are not well understood, and there are numerous hypotheses, including disease, parasites, geomagnetic anomalies interfering with navigation, social cohesiveness, and others. It is likely that there is no single cause, and that multiple causes interact. A common site for long-finned pilot whale mass strandings is on the inside of Cape Cod. In fact, a tidal creek in Wellfleet is called Blackfish Creek for the pilot whale strandings that have happened in that area at least since colonial times. Stranding events there tend to happen in winter, after storms when the water is murky and visibility limited. The bottom slope is nearly flat, so that echolocation provides no cue as to which direction is offshore, which also means that very wide mud flats are exposed at low tide. There is a known area of geomagnetic anomalies. It also may be possible that the usual direction to safety offshore for western North Atlantic pilot whales is south and east, which does not hold true inside Cape Cod Bay. In some strandings, rescue attempts are unsuccessful as animals seem to intentionally beach themselves again. Sometimes it appears that one or more individuals may be debilitated by disease or other cause, and the rest of the herd is trying to stay together. The adaptive value of social cohesion may be maladaptive under those circumstances.

On two occasions long-finned finned pilot whales that stranded in New England were rehabilitated and then released with satellite-tracked radio tags that provided information on movements and diving. Mate et al. (2005) tagged a 3-m, 2-year-old male in a group of three juveniles released after 7 months in captivity. They were released together on 29 June 1987 on the outer edge of Georges Bank about 160 km southeast of Cape Cod. The tagged whale was tracked for 94.5 days and a minimum distance traveled of 3144 km. It spent 10 days on Georges Bank, then moved offshore beyond the shelf edge for 9 days, then traveled 2 days north into the central Gulf of Maine, where it remained for the next 67 days. On day 20 it was observed in a group of pilot whales. The percent of time spent at the surface per day ranged from 5 to 47%. The average dive time was only about 40 seconds, but the average included short respiratory dives between breaths at the surface. The overall range of dive times was 6 seconds to almost 28 minutes, with a higher probability of short dives during the daytime and longer dives at night.

Nawojchik et al. (2003) released two juvenile males on 20 October 17 km south of Montauk Point (they had stranded on 28 June). They first headed west along the Long Island shore, then turned east and traveled to Nantucket. At that point they moved offshore to the outer part of Georges Bank and around the eastern end of the back into the basins to its north in November–December, then made a clockwise loop around the northern Gulf of Maine in January and ended up in the Great South Channel area east of Cape Cod in February. Most dives were less than 2 minutes and shallower than 15 m. Both whales made dives exceeding 26 minutes. Their deepest dives were 312 and 320 m, which is approximately the depth to the bottom in the area where they were at the time.

The preferred prey of both pilot whale species is squid, although at least long-finned pilot whales have been observed to feed on fish in the North Atlantic (Sergeant, 1962; Mercer, 1975; Kenney et al., 1985a; Desportes and Mauritsen, 1993; Bernard and Reilly, 1999; Olson and Reilly, 2002). Pilot whales were commonly taken in foreign fishing activities that were conducted in December–May 1977–1991 along the shelf edge off the northeastern U.S., with 391 taken in the mackerel fishery and 41 taken in the squid fishery (Waring et al., 1990; Fairfield et al., 1993). It is unclear whether mackerel is an important prey item in winter in our region, or whether the whales were simply feeding opportunistically on mackerel scavenged from the trawl nets.

Based on samples from fisheries in Newfoundland and the Faroe Islands, long-finned pilot whale calves in the North Atlantic are born in July–October (Bernard and Reilly, 1999). Calves are about 1.7 m long at birth (Wynne and Schwartz, 1999). Estimates of gestation period range from 12 months to as long as 15–16 months. Calves are weaned at about 22 months, and females that are simultaneously pregnant and lactating are rare. The average inter-birth interval is about 40 months. Females reach sexual maturity at 6–8 years (3.6–3.8 m) and males at about 12–17 years (4.8 m) (Desportes et al., 1993; Martin and Rothery, 1993). The occurrence of reproductive senescence seems to be less common than in short-finned pilot whales; a pregnant 55-year-old was observed in the Faroes, though ovulations appear to be spaced further apart in older females.

General distribution: Long-finned and short-finned pilot whales have mostly parapatric distributions, but they overlap in several areas of the world (Rice, 1998; Bernard and Reilly, 1999; Olson and Reilly, 2002). Long-finned pilot whales occur in the entire Southern Ocean south of 40ºS and in the North Atlantic north of about 30ºN, overlapping with short-fins (see below) from Australia to South America in the South Pacific, on the Atlantic coast of South America, and around South Africa. The broadest overlap is in the North Atlantic, from the east coast of the U.S. across to the eastern North Atlantic from France to northwestern Africa. Long-finned pilot whales range from North Carolina north to Newfoundland, Greenland, and Iceland, with possibly extralimital occurrences represented by strandings in South Carolina and Georgia. Fullard et al. (2000) proposed that there were two stocks of long-finned pilot whale in the North Atlantic—a cold-water population distributed north and west of the Gulf Stream, and a warm-water population associated with the Gulf Stream across the basin from North America to Europe.

Short-fins are found world-wide in warm-temperate to tropical waters on both sides of the equator, primarily in deeper offshore areas. Their southern limit is about 40ºS latitude around the entire Southern Ocean, to about 50ºN in the North Pacific and 42ºN in the North Atlantic. In the western North Atlantic, the range of short-finned pilot whales includes the southern U.S., Gulf of Mexico, Caribbean, West Indies, and the coast of South America. The northern limit of the range off the Atlantic coast is not well known, but believed to be between Virginia and New Jersey, probably varying seasonally.

Off the northeastern U.S., pilot whales (both species combined) are found primarily along the shelf edge and around the edges of Georges Bank in all four seasons, most scattered in the winter (CETAP, 1982). Pilot whales occupied the most inshore depth zone of the shelf-edge cetaceans, along with common dolphins and offshore bottlenose dolphins (CETAP, 1982; Kenney, 1990). The patterns of seasonal distributions seen in the CETAP surveys and gaps in those patterns were suggestive of spatial partitioning between the species. In the winter, the densest concentration of sightings was offshore of New Jersey and southern New England, with scattered sightings along the edge of Georges Bank. South of New Jersey there were very few sightings except for a small cluster just off Cape Hatteras, North Carolina. In the spring, pilot whales were widespread from Maryland north to Georges Bank, and into shallower water on the shelf. There was a larger group of sightings off North Carolina than in winter, and still a hiatus in sightings east of Virginia. During the summer, there was a distinct concentration of pilot whales along the outer shelf from North Carolina to Delaware Bay, then a distinct gap south of Long Island and Cape Cod, and then sightings all around Georges Bank and into the central Gulf of Maine. Payne and Heinemann (1993) also noted the tendency for pilot whales to move into the deeper basins north of Georges Bank in late spring and summer. The pattern in fall was similar, except the gap in the middle was somewhat wider and extended farther south. More recent summer stock assessment surveys in 1998 and 2004 also showed a gap in pilot whale sightings approximately between the longitudes of eastern Long Island and Cape Cod (Waring et al., 2008). Those surveys also resulted in pilot whale sightings much farther offshore, mainly associated with the edge of the Gulf Stream.

Historical occurrence: The earliest pilot whale records for the Rhode Island study area were reported by De Kay (1842), who described a stranding at Fairfield Beach, Connecticut in October 1832 and two animals captured at the eastern end of Long Island in 1834. Cronan and Brooks (1968) reported three records from Rhode Island. One stranded in Middletown on 1 September 1959 and a 197-cm calf was caught in a fish trawl on 19 March 1961 about 50 km south of Narragansett Bay. The third was “the famous ‘Willy the Whale’ that cavorted about in the upper Providence River in July 1962. ‘Willy,’ who was actually a female, was over 18 feet in length.” Connor (1971) mentioned several 20th Century stranding records from New York plus reports of frequent sightings. Waters and Rivard (1962) said that long-finned pilot whales were the most common whale in Cape Cod Bay, usually occurring in herds of up to 300, but that a large group of 1,975 had been seen off Blackfish Creek in Wellfleet in 1895. They also said that pilot whales occurred year-round, but were most abundant in July and August. However, they did not list any recent records.

Recent occurrence: Pilot whales occur in the Rhode Island study area in all four seasons (Fig. 28), with a very strong peak in the spring (70.7%), and roughly equivalent proportions in the other seasons (winter – 8.1%, summer – 13.3%, fall – 7.4%). There are 43 records identified as long-finned pilot whales, only 1 as short-finned pilot whale, and 226 as only *Globicephala* sp. The seasonal proportions are nearly identical for long-finned pilot whales and *Globicephala* sp. There were only 12 sightings from the whale-watching data, 9 in summer and 3 in spring. Sightings were across the entire study area from the inner shelf to the slope, with more in shallow water in the spring, mirroring the pattern seen in CETAP (1982). In the Rhode Island to New Jersey stranding data, the ratio of long-finned to short-finned pilot whale is 9:1, but with the exception of the single Rhode Island record, short-finned pilot whale strandings have occurred only in New Jersey, and mainly in the southern part of that state. While there is a likelihood that some strandings might be misidentified, it is probably justifiable to conclude that pilot whales in the Rhode Island study area are usually the long-finned species, with short-fins occurring relatively rarely. A substantial proportion of the 226 unidentified pilot whale records in the combined data are more likely to have been long-finned pilot whales, consequently they were classified as “common” (Table 2) even though there were far fewer than 100 identified records.

The pattern in the effort-corrected relative abundance data (Fig. 29) is quite similar to that seen in the total occurrence data. Pilot whales occur in the Rhode Island study area year-round, but are most abundant in spring, most likely related to the inshore spawning of long-fin squid (*Loligo pealei*). Spring is also the only season when the relative abundance output predicts that pilot whales might occur in the SAMP area—in the southwestern corner of the area. In winter, there is an area of low abundance just offshore of the SAMP area and somewhat higher abundances farther offshore near the shelf edge. In summer, the abundances are maximum, but mainly east of the study area and offshore. The pattern in fall is similar to summer, however at lower abundance.

There was a mass stranding of 11 long-finned pilot whales in Cow Cove on Block Island, Rhode Island on 22 December 1983. The following day only five remained, all dead, but it is unclear from the Smithsonian data record whether the others were pushed off, left on their own,

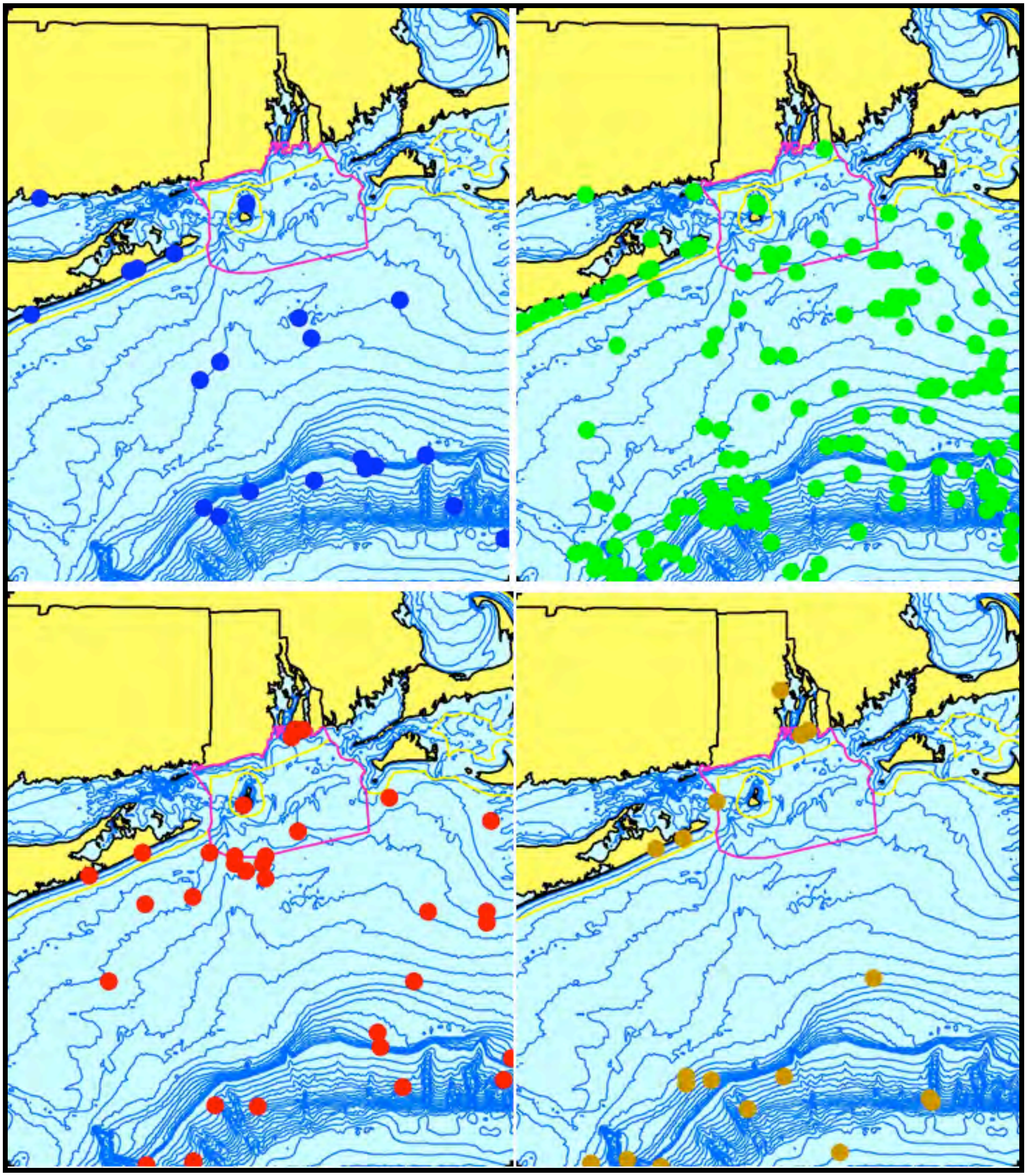

Figure 28. Aggregated sighting, stranding, and bycatch records of long-finned, short-finned, and unidentified pilot whales in the Rhode Island study area, 1834–2006 (n = 270: winter = 22, spring = 191, summer = 36, fall = 20, unknown = 1).

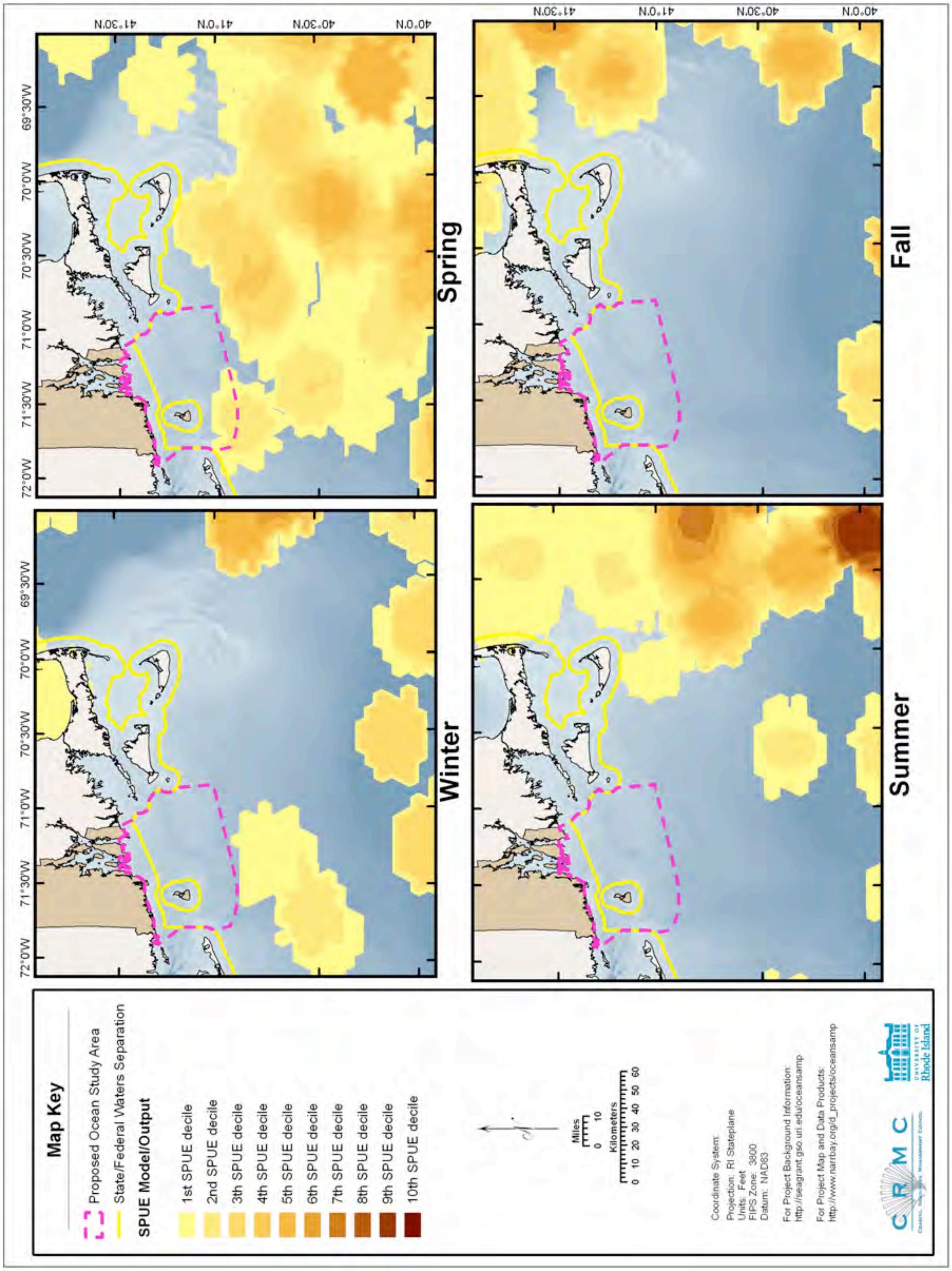

Figure 29. Modeled seasonal relative abundance patterns of pilot whales in the Rhode Island study area, corrected for uneven survey effort.

or died and washed out with the tide and waves. From necropsies of the five carcasses, the 1983 Block Island event was not a typical pilot whale mass stranding with a cross-section of ages and sexes (Nawojchik, 2002). All five were adult females of about the same size (442–457 cm) that all had some sort of medical problems (missing or broken teeth, thin blubber, kidney abnormality, abdominal fluid build-up).

Pilot whale stranding frequencies spiked in the late 1980s, and then declined but to a somewhat higher level than observed prior to 1985 (Fig. 30). The years 1987–1991 comprised a period of increased standings, with two in 1987, five in 1988, four in 1989, two in 1990, and three in 1991. Nearly all were in the spring, except for one in winter 1987, one in fall 1989, and one in winter 1991. Long-finned pilot whale strandings in Rhode Island occurred in Newport on 5 May 1974, in Newport on 28 November 1989 (a 192-cm calf), in Little Compton on 27 April 1990, at Clay Head on Block Island on 19 April 1994, near Goddard Park in Warwick on 8 October 1998, at Third Beach in Middletown on 2 June 2002, at Easton's Beach in Newport on 28 July 2003, and at Sandy Point on Block Island on 18 May 2004. There were also two strandings in Connecticut—in Madison on 5 April 1989 and in Branford on 9 February 1991. The latter animal had been reported alive along the Connecticut shore for five days before it washed up dead.

The only short-finned pilot whale record in the state or in the study area was a single animal stranded on 6 June 2001 at Snake Hole Beach on Block Island.

There were four strandings in the state of unidentified pilot whales: 18 December 1981 at Apponaug Cove in Warwick, 27 December 1985 at Brenton Cove in Newport, 18 February 1987 in Newport, and 17 March 1987 in Newport.

Conclusions: Although pilot whales (most likely long-finned pilot whales) are relatively abundant in the Rhode Island study area, they are not likely to occur within the SAMP area. The highest likelihood of occurrence would be in spring, and intensive whale-watching trips occasionally recorded pilot whale sightings southwest of Block Island. Pilot whales are not a significant concern for the SAMP.

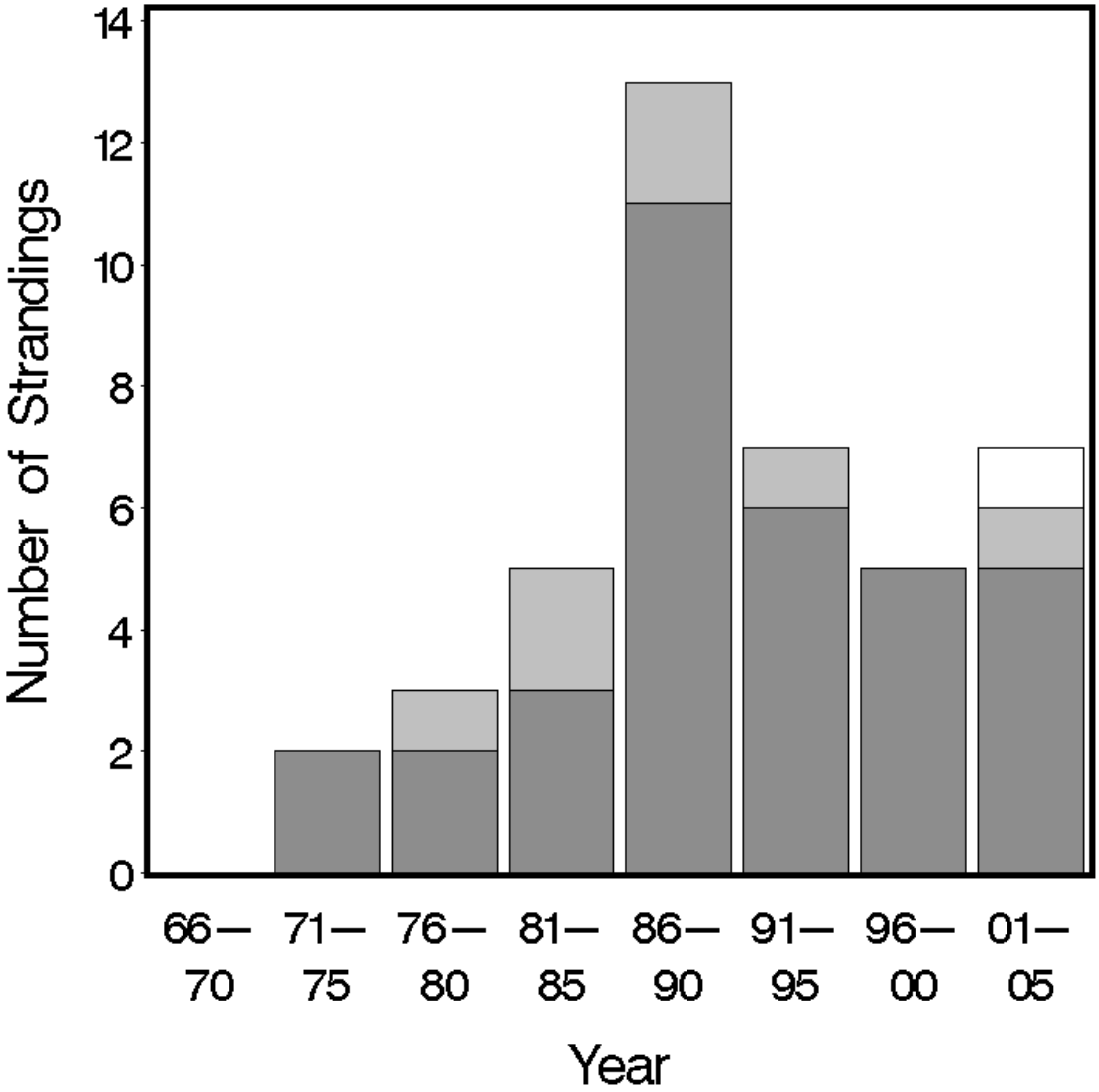

Figure 30. Five-year stranding frequencies for long-finned pilot whales (dark gray bars), short-finned pilot whales (white), and unidentified pilot whales (light gray) in the Rhode Island study area, 1965–2005.

3.2.15. Killer Whale *Orcinus orca* (Linnaeus, 1758)

Description: Killer whales, or orcas, are the largest of all delphinids. They are sexually dimorphic, with males up to 9.8 m and females up to 7–8.5 m (Jefferson et al., 1993; Wynne and Schwartz, 1999). They are very distinctive and easily recognized. The body is robust with a rounded head and very large, rounded flippers. The dorsal fin is about 1 m tall and falcate in females and juveniles, and 2 m high and erect in adult males. The color pattern is strikingly distinct, with a black back, dorsal fin, flukes, and flippers clearly contrasting with white under the belly, chin, and flukes. The white belly extends in a narrow lobe up and back on both sides behind the dorsal fin, and there is an oval white patch behind and above each eye. There is also a gray saddle patch behind the dorsal fin. Killer whales have 10–12 large, slightly curved teeth on each side of both upper and lower jaws.

Status: Killer whales are not listed under the U.S. Endangered Species Act, although the Southern Resident stock in the eastern North Pacific has recently been listed as Endangered (NMFS, 2005). They are not included on the Rhode Island state list, and are classified as Data Deficient on the IUCN Red List. There are no abundance estimates for the entire North Atlantic, although there are estimates based on photoidentification or similar methods for limited areas (Dahlheim and Heyning, 1999), including 500–1500 off Norway and 143 off Iceland. There is also no estimate for U.S. Atlantic waters, and an estimate of 133 for the northern Gulf of Mexico (Waring et al., 2008). Killer whales were formerly taken by small-scale coastal whaling in a number of locations; 13 were killed by subsistence hunters in Greenland in 2002 (IWC, 2006).

Ecology and life history: Killer whales are extensively studied, and are known to live in permanent pods of up to 50 individuals (reviews in Dahlheim and Heyning, 1999 and Ford, 2002). Pods are matrilineal social groups that are formed of females, their sons and daughters, and the offspring of the daughters. Unlike most mammals, both females and males remain in their natal pods for life. The maximum life span of orcas may be 80 or 90 years, which results in pods containing as many as four generations together.

General distribution: Killer whales are cosmopolitan, and may be the most broadly distributed of all cetaceans (Heyning and Dahlheim, 1988; Dahlheim and Heyning, 1999; Ford, 2002). They occur in all oceans of the world from the tropics to the edge of the polar ice, and from estuaries and shallow coastal waters to deep, offshore waters. They appear to be most common in colder, nearshore waters. In the western North Atlantic, they are known from the Arctic to the tropics, but are not common anywhere. There were only 12 sightings off the northeastern U.S. during the CETAP study (CETAP, 1982) and none during the more recent NMFS assessment surveys (Waring et al., 2008), although over a longer term they appear to be regular visitors to the Gulf of Maine (Gormley, 1990; M. Lutcavage, University of New Hampshire, pers. comm.).

Historical occurrence: Cronan and Brooks (1968) said they had one record of a killer whale stranding in Rhode Island, but provided no details, however Waters and Rivard (1962) included in their table a stranding of a 5.5-m animal in Narragansett in December of 1956. Waters and Rivard said that killer whales were fairly common in Massachusetts waters, and also cited records of one killed in Lewis Bay in Hyannis in March 1949, a pod seen off Provincetown in August 1949, and a stranding of a 5.2-m whale on Waquoit Beach in Falmouth in 1956. De Kay (1842) reported several sightings of killer whales off Long Island, and suggested without documentation that they were formerly more numerous. Connor (1971) described a live-stranded 730-cm orca at Orient, Long Island in January 1944 and a large male that followed a fishing boat for more than 30 km on its way back to Montauk in July 1958 (both records were in the Smithsonian data).

Recent occurrence: There are five additional killer whale records in the more recent data (Fig. 31). One or more orcas were reported by fishermen in Long Island Sound off Mattituck in August 1977. A group of 20 was sighted about 16 km southeast of Block Island on 22 September 1981. There were also three sightings in deep water south of Cape Cod—a group of 6 on 25 July 1979, a single animal on 5 October 1981, and a group of 19 on 13 September 1991.

Conclusions: Killer whales are sufficiently rare in the Rhode Island study area as to be ignored relative to development in the SAMP area.

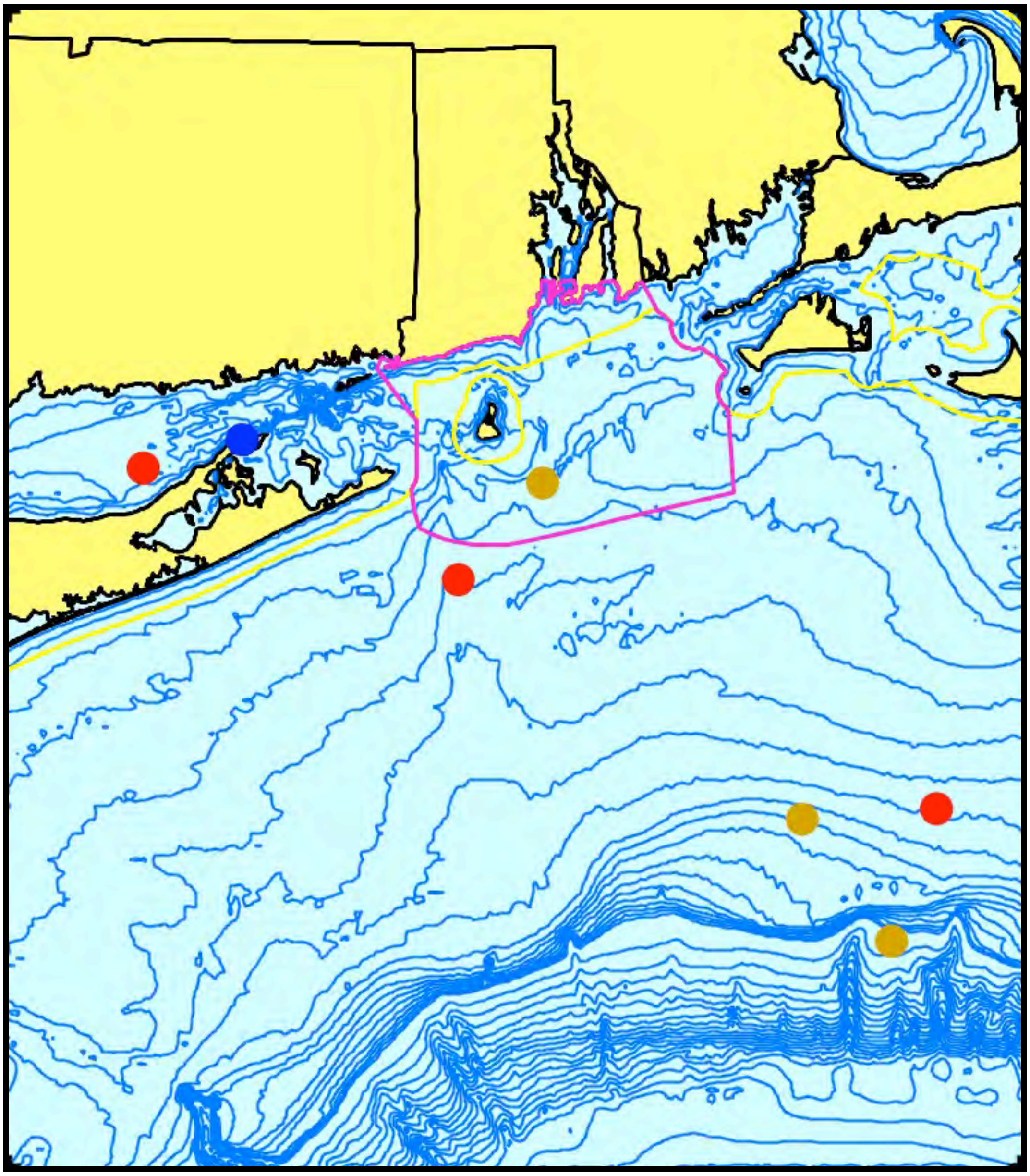

Figure 31. Aggregated sighting, stranding, and bycatch records of killer whales in the Rhode Island study area, 1944–1991 (n = 7: winter = 1, spring = 0, summer = 3, fall = 3).

3.2.16. False Killer Whale *Pseudorca crassidens* (Owen, 1846)

Description: False killer whales were so named because of the resemblance of the skull to that of a killer whale, not because of similar appearances (Odell and McClune, 1999). In fact, they look more like slimmed-down pilot whales, with which they are included as the larger "blackfish" (Jefferson et al., 1993; Wynne and Schwartz, 1999). They are long and slender, uniformly black with a pale anchor mark on the chest, no cape, and no white markings visible anywhere on the head or back. Total length is up to 5.5 m in males and 4.8 m in females. The head is narrow and tapered, with no beak and a small, rounded melon that overhangs the lower jaw. The flippers have a distinctive hump on the leading edge, which makes them look permanently bent. The dorsal fin is dolphin-like, narrow-based, located at mid-back, falcate, and often rounded at the tip. There are 7–12 large (up to 1.8 cm in basal diameter) teeth in each side of both jaws.

Status: False killer whales are not listed under the U.S. Endangered Species Act, are not included on the Rhode Island state list, and are classified as Data Deficient on the IUCN Red List. There are no estimates of the total number of false killer whales in the North Atlantic, none have been sighted from any stock assessment surveys off the U.S. Atlantic, and the number in the northern Gulf of Mexico is estimated as 1,038 (Waring et al., 2008). False killer whales are taken in low numbers (5–26 in a year in 2000–2004) in coastal small-cetacean fisheries in Japan (IWC, 2005, 2006).

Ecology and life history: False killer whales are believed to feed primarily on deep-sea squid and fishes, but have been seen to attack smaller dolphins escaping from tuna nets (Odell and McClune, 1999; Baird, 2002a). There was one observation each of an attack on a humpback whale calf and on a group of sperm whales. They appear to be very gregarious, but their social organization and life history are very poorly known.

General distribution: False killer whales are found in pelagic tropical, subtropical, and warm temperate seas in all oceans of the world (Stacey et al., 1994; Odell and McClune, 1999; Baird, 2002a). In the western Atlantic, they occur from Maryland south to the Gulf of Mexico, Caribbean Sea, West Indies, and off mainland South America to the tip of Tierra del Fuego. Sightings are typically in deep water beyond the shelf break. Little is known of seasonality of occurrence.

Historical occurrence: There are no historical records of false killer whales in the Rhode Island study area, and they were not mentioned by Cronan and Brooks (1968) or any of the other regional sources consulted.

Recent occurrence: There have been no false killer whale strandings in the Rhode Island study area. There were nine sightings in the whale-watching data over a four-year period in

1990–1993, all in the same general vicinity south of Block Island and Montauk Point between the 50- and 70-m isobaths (Fig. 32). The sightings occurred during very short periods each year: 22–29 May 1990, 31 May–13 June 1992, and 3 May 1993. The largest group seen at any one time was five, and on the only day with two sightings (28 May 1990), there were groups of two and three whales seen. One could speculate that a small group of five false killer whales returned to the same vicinity at the same time of year for several years in a row. From other sighting records in the NARWC database, the pattern of occasional occurrences in unusual locations seems to be characteristic of false killer whales. Although most sightings have been off the southeastern U.S., there are records far to the east in the mid-ocean, a sighting in Cape Cod Bay in March 1978, and sightings on Georges Bank in 1980 and 1987.

Conclusions: Although false killer whales may occur on very rare occasions in the SAMP area, they may safely be ignored.

3.2.17. Risso’s Dolphin *Grampus griseus* (G. Cuvier, 1812)

Description: Risso’s dolphins are large, robust animals, 3–4 m in length, which are relatively easy to identify (Jefferson et al., 1993; Kruse et al., 1999; Wynne and Schwartz, 1999; Baird, 2002b). The body is thick and robust from the dorsal fin forward and relatively slender behind. The impression is that of a shorter, more barrel-chested pilot whale. The head is blunt with a squarish profile and a slight but distinctive vertical crease down the forehead. The mouth curves noticeably upward, and there is no beak. The flippers are very long and pointed but broader than in pilot whales, and the dorsal fin is very tall, slender, and falcate. The color pattern is distinctive and unique. Calves are uniformly light gray, and gradually darken to dark gray or brown with a white belly and white “anchor” mark on the chest as juveniles. Older animals get gradually whiter, mainly from scars and scratches, especially on the head. Old adults may be entirely white except for the dorsal fin, flippers, and flukes.

Status: Risso’s dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There are no estimates of the total number of Risso’s dolphins in the North Atlantic, and no information on stock separation. The most recent estimate of abundance of Risso’s dolphins along the U.S.

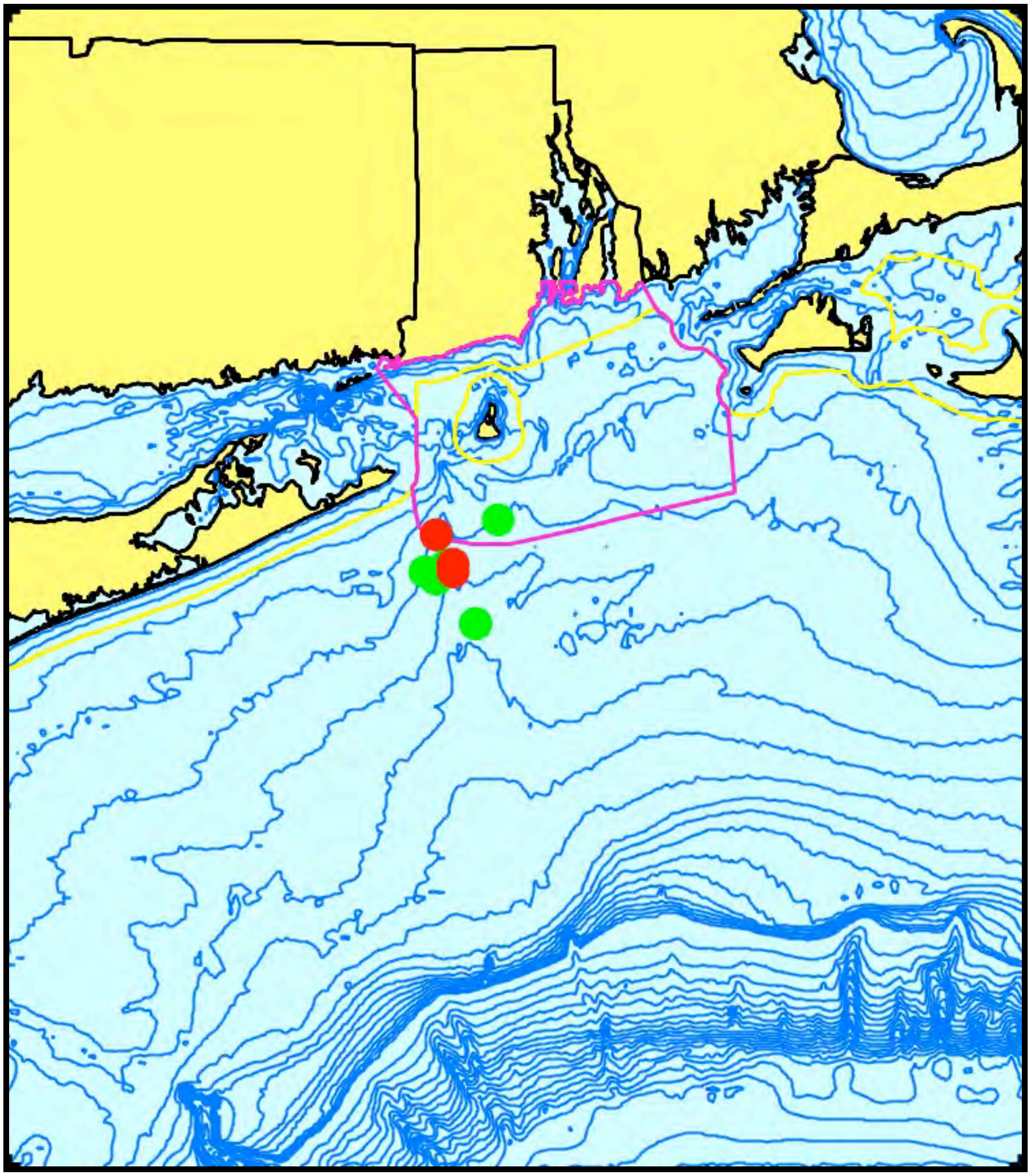

Figure 32. Aggregated sighting, stranding, and bycatch records of false killer whales in the Rhode Island study area, 1990–1993 (n = 9: winter = 0, spring = 6, summer = 3, fall = 0).

Atlantic coast was 20,479, with an additional 1,589 in the northern Gulf of Mexico (Waring et al., 2008). Surveys in 1998 estimated the Atlantic stock at 28,164.

Risso's dolphins have been taken in a number of small-cetacean fisheries around the world, but have never been the focus of a large-scale fishery (Kruse et al., 1999). They have been taken in Europe, Canada, the West Indies, the Azores, Peru, and Japan. Recent takes in Japanese small-cetacean fisheries were 506 in 2000, 474 in 2001, 386 in 2002, 373 in 2003, and 6 in 2004 (IWC, 2005, 2006). They are also subject to incidental take in variety of commercial fisheries (Read, 1996). The average annual fishery-related mortality of Risso's dolphins in U.S. Atlantic fisheries in 2001–2005 was 40 (Waring et al., 2008). Most mortality (37 per year on average) was in the pelagic swordfish long-line fishery, with the remainder in the sink gillnet fishery. There was formerly mortality in the pelagic swordfish driftnet and tuna pair-trawl fisheries, both of which are now closed.

Ecology and life history: Risso's dolphins generally occur in small groups of 10–50 animals, but may be sighted as single individuals and in herds of several hundred or more (Kruse et al., 1999; Baird, 2002b). Off the northeastern U.S. the mean group size was 17, with a range from 1 to 400 (CETAP, 1982). They frequently perform aerial behaviors such as breaching, spy-hopping, and lob-tailing, but rarely bow-ride. They were sighted at times in association with pilot whales, offshore bottlenose dolphins, and other species (CETAP, 1982). In the North Pacific they associate with many other species in mixed groups (Kruse et al., 1999).

There are almost no data on diving capabilities. They appear to be capable of dives up to 30 minutes (Kruse et al., 1999).

Risso's dolphins are believed to feed exclusively or almost exclusively on squid (Kruse et al., 1999; Baird, 2002b). Reduction in the number of teeth is believed to be an adaptation to the squid-feeding habit (Clarke, 1986). Based on observations of activity patterns off Santa Catalina Island, California, Risso's dolphins are mainly nocturnal feeders (Shane, 1995).

Life history data for Risso's dolphins are sparse (Kruse et al., 1999; Baird, 2002b). Calves are born at 110–150 cm, and calving may peak in the winter. Size at sexual maturity is 2.6–2.8 m in females and 2.6–3.0 m in males. There is no information on gestation or lactation periods or inter-birth intervals.

Amano and Miyazaki (2004) reported on a school of 79 killed in a drive fishery in Japan. There were 49 females and 30 males, for a sex ratio of 1.63:1. Of the females, 2 were pregnant, 9 lactating, 2 both pregnant and lactating, 14 resting, 14 immature, and 8 unknown (66% mature). Their age at maturity was probably 8–10 years, and the oldest was 34.5. Of the males, 23 were immature, 4 were maturing, 1 was mature, and 2 were unknown (18% mature). The estimated age at maturity was 10–12, but the sample size was very small. The oldest male was 16.5. The sex and age structure of the school suggests a life history pattern where males leave their natal groups when mature and remain segregated from schools of females and immatures.

General distribution: Risso's dolphins are found in tropical and temperate waters world-wide (Rice, 1998; Kruse et al., 1999; Baird, 2002b). In the Atlantic, they occur from Newfoundland and the British Isles south to the southern tips of Africa and South America, although the distribution is poorly known along the coasts of east-central South America and western Africa. Their distribution is primarily in deeper pelagic waters, and is poorly known in the central ocean regions. In the western North Atlantic they are found primarily along the shelf break, but are also sighted commonly in shallower waters to about mid-shelf, as well as much farther offshore. Off the northeastern U.S., Risso's dolphins occurred along the entire shelf in spring and summer, with dense concentrations from about Virginia to Cape Cod in spring and from Virginia to Georges Bank in summer (CETAP, 1982). In the fall, the number of sightings declined and the distribution contracted to Virginia–Long Island. There were many fewer sightings in winter, mostly east of Maryland and Virginia. Summer surveys in 1998, 1999, and 2004 extended farther offshore and resulted in numerous sightings, often associated with edges of the Gulf Stream and warm-core rings (Waring et al., 2008). The recent surveys also resulted in sightings offshore of the 100-m isobath off the southeastern U.S.

Historical occurrence: Cronan and Brooks (1968) were aware of no Risso's dolphin occurrences in Rhode Island. Neither De Kay (1842) nor Linsley (1842) mentioned the species. Schevill (1954) reported a sighting of more than 60 Risso's dolphins on 20 August 1952 about 140 km due south of Block Island near the shelf break. That record seemed to be the basis for conjectures about occurrence by Cronan and Brooks (1968), Waters and Rivard (1962), and Connor (1971). In their table of records from the 1940s and 1950s, Waters and Rivard included only Schevill's 1952 sighting (however giving the number of animals as one) and a sighting of three 350 km east of Cape Cod. Of course, none of those authors had the benefit of seeing the results of CETAP and subsequent surveys to know that Risso's dolphins are quite common in the area of Schevill's sighting. There are no historical strandings in the Rhode Island study area, although they are relatively common in New Jersey and less so in western Long Island. The only historical sighting in the study area was a group of 3 near Hudson Canyon on 29 May 1960 reported by Ulmer (1980) and included in the Smithsonian data.

Recent occurrence: Risso's dolphins are present year-round, but with strong seasonality (Fig. 33). They are most common in summer with 56.3% of the records, followed by 25.0% in fall, 15.9% in spring, and only 2.9% in winter. The sighting distribution is primarily along the shelf break and slope, with a few sightings in waters shallower than 100 m. There was only one spring sighting in the SAMP area, although there were strandings in or nearby in every season. Even with very intensive whale-watching over more than 15 years, they recorded only one sighting of Risso's dolphin—a group of 15 on 28 July 1992, which was on an offshore trip.

The patterns in the relative abundance data (Fig. 34) show the same thing as the total data. Abundance is lowest in winter and spring and highest in summer and fall. In addition, the species' distribution is centered far offshore in all seasons, with no areas of predicted occurrence in or near the SAMP area.

In the recent stranding record for the Rhode Island study area, Risso's dolphins have been relatively scarce. The first known stranding in the area was a 288-cm "old" adult on 17 July 1987 at Schooner Point on Block Island. A 192-cm immature male stranded at Newport on 28 November 1989. On 14 December 1991 a live Risso's dolphin was seen in a cove on the west side of Hog Island, but it was found dead the next day. A 250-cm adult stranded on Cooneymus Beach on Block Island on 3 March 1994. Risso's dolphins stranded in South Kingstown on 1 August 2004 and at Mackerel Cove in Jamestown on 25 August 2005. There were also strandings on the south shore of eastern Long Island in January 1995, March 2002, June and July 2004, and July, August, and September 2005. There is a very clear recent spike in the stranding record—of 13 total strandings during 1987–2005, 7 (53.8%) were in the last two years. To see whether that trend was more widespread and if it continued beyond the end of the stranding database we used, we reviewed the 2007 (Waring et al., 2008), 2008 (Waring et al., 2009), and draft 2009 stock assessments (NMFS, unpublished). The total numbers of Risso's dolphin strandings from Maine to Virginia were: 3 in 2001, 7 in 2002 (5 in Massachusetts), 13 in 2003 (10 in Mass.), 13 in 2004, 25 in 2005, 5 in 2006, and 7 in 2007. The 2004–05 spike seen in strandings in the study area was also present in the entire Northeast; it appeared to begin a year earlier in Massachusetts, and it did not continue beyond 2005.

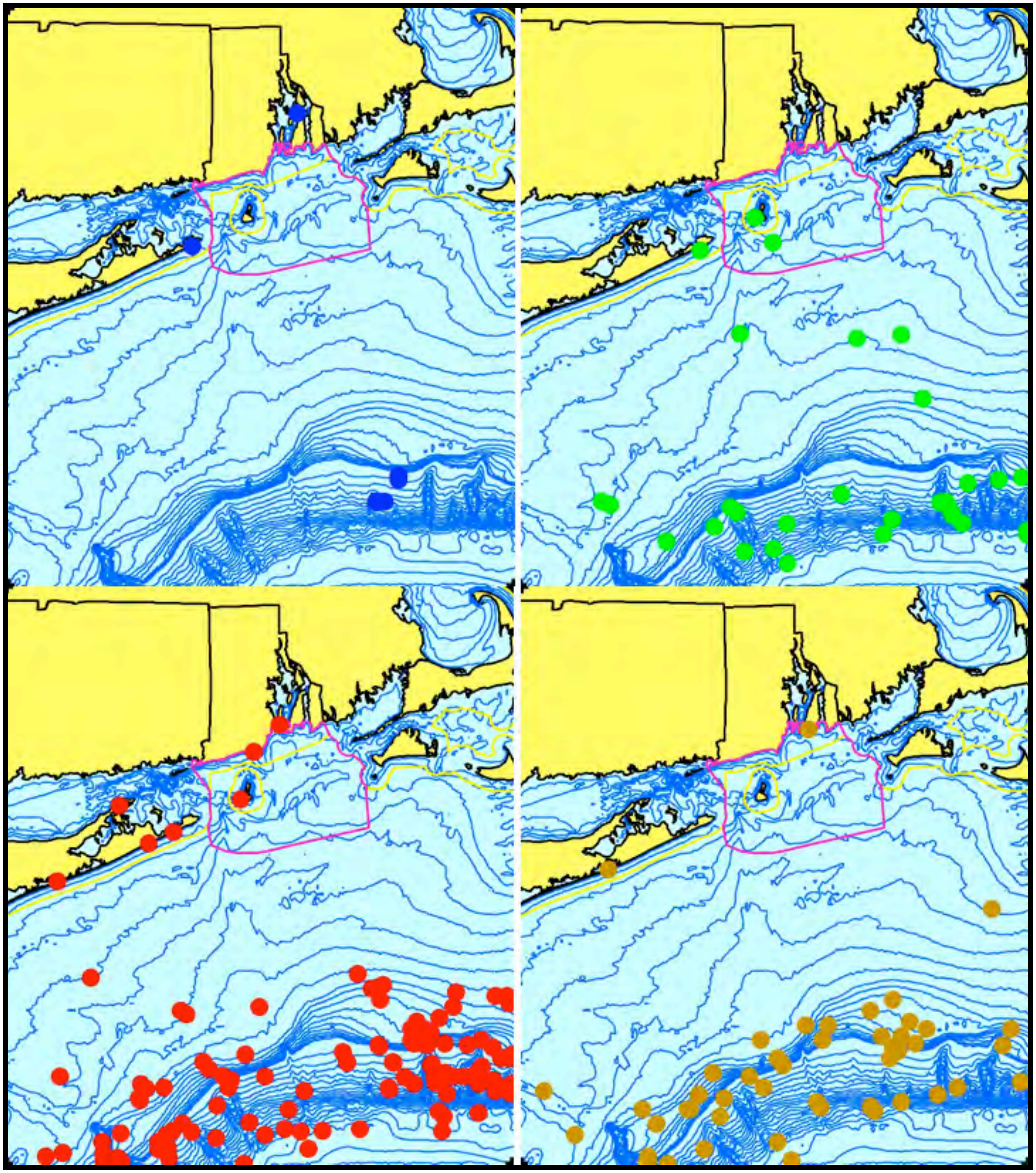

Figure 33. Aggregated sighting, stranding, and bycatch records of Risso's dolphins in the Rhode Island study area, 1960–2005 (n = 208: winter = 6, spring = 33, summer = 117, fall = 52).

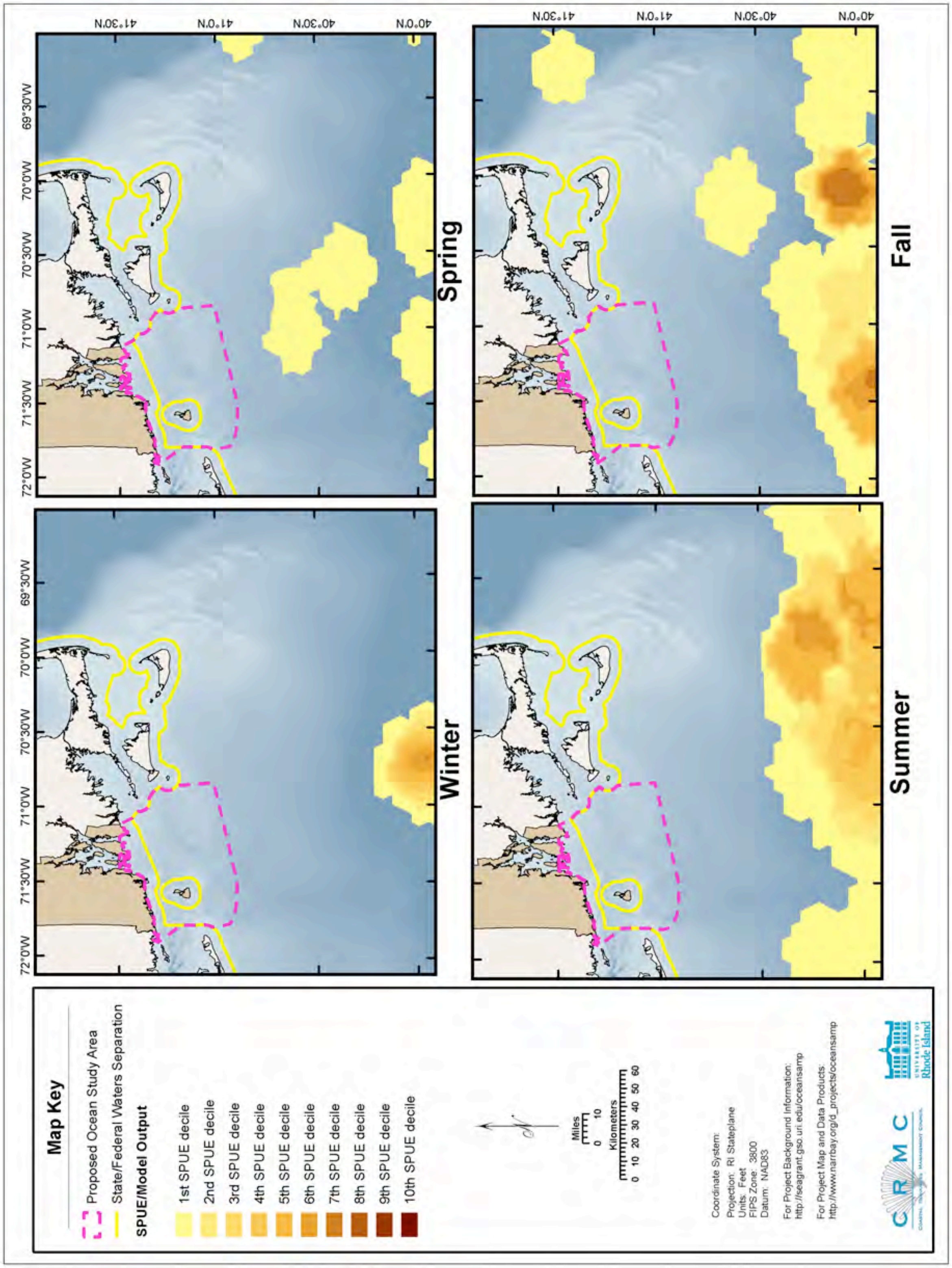

Figure 34. Modeled seasonal relative abundance patterns of Risso's dolphins in the Rhode Island study area, corrected for uneven survey effort.

Conclusions: Risso's dolphins are offshore animals and are not expected to occur in the SAMP area. They are clearly much more common in the study area than the previous species, false killer whale, and easier to identify, however the respective numbers of sightings of the two species from the whale-watching boats were one and nine. That confirms just how unlikely Risso's dolphins are to occur in the SAMP area.

3.2.18. Atlantic White-sided Dolphin *Lagenorhynchus (Leucopleurus) acutus* (Gray, 1828)

The six species of dolphins that have been included in the genus *Lagenorhynchus* appear very similar; all have robust bodies with tall falcate dorsal fins, very short beaks, and bold, distinctive color patterns (Jefferson et al., 1993; Folkens et al., 2002). LeDuc et al. (1999) and Cipriano (1997) both showed that the two North Atlantic species are genetically very divergent from the other four species and from each other. *L. albirostris* is the designated type species of the genus, and therefore should maintain the current name. The available generic name would *Leucopleurus* Gray, 1866 for the Atlantic white-sided dolphin. A detailed genetic analysis by May-Collado and Agnarsson (2006) supported the recognition of Atlantic white-sided dolphin as *Leucopleurus acutus*.

Description: Atlantic white-sided dolphins have robust bodies about 2.5–2.8 m in length; prominent sharp keels on the top and bottom of the tailstock; short, thick beaks; and very prominent, tall, falcate, pointed, broad-based dorsal fins (Jefferson et al., 1993; Reeves et al., 1999a; Wynne and Schwartz, 1999; Cipriano, 2002). Females are about 20 cm shorter than males. The basic color pattern is three-banded, with a black cape, a gray band along the side, and a white belly, all with clear, distinct, relatively horizontal margins. On the flank, below and slightly behind the dorsal fin, there is a brilliant white patch or band below the edge of the cape, which extends up and back into the cape as a yellowish-tan band. The cape extends all the way back from the dorsal fin to the tail, though from above and behind it may look like a narrow black stripe along the dorsal keel between the two yellow bands on the sides. On the beak, the upper jaw is black and the lower is white. The eye is surrounded by a round black patch, which is connected by a narrow black stripe to the upper jaw. There may also be a narrow, less distinct gray stripe from the eye to the black flipper, and there is a black patch around the genital slit.

Status: Atlantic white-sided dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There are no precise estimates of the number of white-sided dolphins inhabiting the North Atlantic, though the number is roughly estimated as a few hundred thousand (Cipriano, 2002). They were one of the two most abundant dolphins observed during the CETAP studies (the other was the common dolphin), with seasonal abundances off the northeastern U.S. in spring through fall of 38,000 to 42,000 (CETAP, 1982; Kenney et al., 1997). The most recent estimates for the Gulf of Maine and surrounding area have been extremely variable—51,640 in 1999, 109,141 in 2002, 2,330 in 2004, and 17,594 in 2006 (Waring et al., 2008). Kingsley and Reeves (1998) estimated the number in the Gulf of St. Lawrence in 1995 at 11,740.

A directed fishery for Atlantic white-sided dolphins formerly occurred in Norway, and small numbers are taken by subsistence hunters in Greenland (Reeves et al., 1999a). Large numbers were taken in some years in the former pilot whale drive fishery in Newfoundland (Sergeant and Fisher, 1957). In the Faroe Islands, white-sided dolphins continue to be taken in their pilot whale drive fishery, with total takes of 255 in 2000, 546 in 2001, 714 in 2002, and 186 in 2003 (IWC, 2005, 2006).

White-sided dolphins are also taken as bycatch in commercial fisheries (Addink et al., 1997; Couperus, 1997; Palka et al., 1997; Reeves et al., 1999a). The 2001–2005 average annual mortality from incidental take in U.S. Atlantic commercial fisheries was 357, including 31 in sink gillnet fishery, 221 in bottom trawls, 103 in mid-water trawls, and 2 in herring trawls (Waring et al., 2008). There were earlier takes known in swordfish driftnets (fishery now closed), Canadian sink gillnets, and Spanish deepwater trawlers off the Grand Banks.

Ecology and life history: White-sided dolphins generally occur in groups of a few to 50 or 60 animals, with some differences between areas (Reeves et al., 1999a; Cipriano, 2002). In the Gulf of Maine, they appear to travel in tight groups of 6–10 animals that are sometimes loosely associated in larger herds. In the CETAP (1982) data, group sizes ranged from 1 to 800, with a mean of 54.3, but the most frequently observed group size was 8 dolphins. White-sided dolphins are very active, fast-swimming animals, and are known to breach and tail-slap, as well as to bow-ride in front of vessels and surf in their wakes. They have been observed swimming directly in front of large whales, which is thought to be the same bow-riding behavior seen in front of vessels.

White-sided dolphins have been observed in mixed-species aggregations with long-finned pilot whales in eastern Canadian waters, with white-beaked dolphins in the North Sea, and with white-beaked, bottlenose, and common dolphins off Ireland (Reeves et al., 1999a). In the Gulf of Maine, white-sided dolphins are frequently (i.e., at about a quarter of all sightings) sighted in association with other species known to feed on sand lance and other small fishes, including fin, humpback, and minke whales (CETAP, 1982). This was the most commonly observed multi-species association during the CETAP surveys. The association in this case is fundamentally different from the mixed schools of pilot whales, bottlenose dolphins, and other delphinids seen in offshore waters. In mixed schools of shelf-edge delphinids, they clearly are swimming together in a coordinated group, and the group sizes of each species were not significantly different between associated and non-associated sightings (i.e., a mixed school of, e.g., *Globicephala* and *Tursiops* is simply a typical school of each that have joined together). In the baleen whale/white-sided dolphin associations, group sizes for each species are significantly larger when associated with other species than when not associated, suggested that the multi-species sightings are adventitious groups of animals that occur when each species individually aggregates to feed on the same patchy prey resource, but there is no true interaction.

Mass strandings of white-sided dolphins are relatively common. Such strandings have been known since antiquity, and are probably a naturally occurring phenomenon (Gaskin, 1992). Such occurrences show a clear spatial pattern, with about 85–90% of all stranded white-sided dolphins between North Carolina and Nova Scotia occurring in Massachusetts.

White-sided dolphins do not appear to be deep divers. A satellite-tracked tagged animal made no dive longer than 4 minutes and most of its dives were less than 1 minute (Mate et al., 1994).

White-sided dolphins feed on a wide variety of small fishes and squid, with differences in the species consumed between areas and seasons (reviewed by Reeves et al., 1999a). Sand lance is an important prey in the spring in the Gulf of Maine. Other fish prey include herring, smelt, mackerel, silver hake, and a variety of other gadoids.

Sergeant et al. (1980) and Perrin and Reilly (1994) summarized the available information on life history in white-sided dolphins. Calves are born at around 110 cm long in May to early August, peaking in June–July, however the calving period may be more prolonged in the northeastern Atlantic. The gestation period is 10–12 months. Lactation lasts about 18 months, and about a quarter of mature females are simultaneously pregnant and lactating. The resulting average inter-birth interval is 2–3 years. Sexual maturity in males is at 230–240 cm and 8–9 years of age; females mature at 201–222 cm and 6–8 years old.

General distribution: Atlantic white-sided dolphins and white-beaked dolphins are both found only in the North Atlantic, with broadly overlapping distributions (Rice, 1998; Reeves et al. 1999a, 1999b; Cipriano, 2002; Kinze, 2002). White-sided dolphins are found in temperate to subarctic waters on both sides of the basin, with the northern limits of the range not very clear, but probably very similar to the white-beaked dolphin's—to Newfoundland, Greenland, Iceland, Svalbard, and the North Cape of Norway. The southern distributional limit of white-sided dolphins is further south, at least on the western side of the North Atlantic, where they occur to the mid-Atlantic. Both species occur south to the Bay of Biscay on the eastern side of the basin. In the western North Atlantic, their range extends from the U.S. mid-Atlantic to Greenland. They are common in the Gulf of Maine and Gulf of St. Lawrence, but seem to be relatively rare along the Atlantic coast of Nova Scotia. Palka et al. (1997) suggested that there were separate stocks in the Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea.

Off the northeastern U.S., white-sided dolphins occur regularly from Hudson Canyon east to Georges Bank and north to the Bay of Fundy (CETAP, 1982; Selzer and Payne, 1988; Waring et al., 2008). They are the most common and abundant dolphin in the Gulf of Maine. They occur throughout the Gulf, but are most concentrated in the western portions from the Great South Channel east of Cape Cod to the Maine coast. During the CETAP surveys in 1979–1981, the annual pattern showed strong aggregation between Cape Cod and Georges Bank in the spring, dispersal throughout the Gulf of Maine in summer, a weaker aggregation in the central Gulf in fall, and a near-absence in the winter. The distribution in those years may have been driven by the distribution of sand lance, which were extremely abundant at that time. Strandings in the mid-Atlantic were mainly in the winter, leading to an hypothesis for a winter migration offshore and to the south.

Prior to the 1970s, however, white-sided dolphins were very rarely seen within the Gulf of Maine. A sighting of a small group of about 12 east of Cape Cod was worthy of publication in the *Journal of Mammalogy* (Schevill, 1956), and their range was believed to be centered along the outer edge of the shelf, as is apparently the case off Newfoundland and Europe (Reeves et al., 1999a; Northridge et al., 1997). During the 1970s, white-beaked dolphins were more commonly observed in the Gulf of Maine. Kenney et al. (1996) hypothesized that white-sided and white-beaked dolphins in the Gulf of Maine shifted distributions after drastic changes in the stocks of small pelagic forage fishes caused by commercial fisheries. Intense fishing by foreign fleets in the 1960s and early 1970s caused a major decline in herring stocks, which were replaced by an explosion of sand lance (Sherman et al., 1981). The hypothesis was that white-beaked dolphins preferred herring, and moved east on the Nova Scotian shelf, and white-beaked dolphins shifted from an offshore to inshore habitat to fill the vacated niche. White-sided dolphins appeared in the stranding record in the mid-Atlantic during the 1970s and gradually expanded to the south, which seems to fit that same pattern of an offshore-to-inshore habitat shift, perhaps accompanied by growth of the population.

Historical occurrence: Cronan and Brooks (1968) reported only one known occurrence of white-sided dolphin in Rhode Island—a stranding at Monahan's Dock in Narragansett Pier on 22 July 1967. Neither De Kay (1842) nor Linsley (1842) included white-sided dolphin as a species occurring in New York or Connecticut. Goodwin (1935) stated that the nearest record to Connecticut was from Cape Cod, Massachusetts. The nearest record Connor (1971) knew of was the stranding reported by Cronan and Brooks. Waters and Rivard (1962) reported that the species "may range south to Cape Cod, but it does so rarely. There are only a few recorded sightings in the area of Cape Cod." They reported strandings in Wellfleet in March 1949 and May 1960, and a mass stranding of 12 animals on Monomoy Island in September 1954. There were no other records in the Rhode Island study area prior to 1973.

Recent occurrence: The first recent record of Atlantic white-sided dolphin in the Rhode Island study area was a stranding at Bellport, Long Island in December 1973. The first Rhode Island stranding after the 1967 event was a 202-cm dolphin on First Beach in Newport on 1 May 1976. Later that same year, on 17 August, came the first live sighting record—a group of 200 dolphins seen in the southwestern end of Buzzard's Bay. Since then, the species has become common in the study area, and is the third most frequently recorded small cetacean (Table 1). There are occasional unconfirmed opportunistic reports of white-sided dolphins in Narragansett Bay, typically in fall and winter. Atlantic white-sided dolphins in the Rhode Island study area are inhabitants of the continental shelf, with a slight tendency to occur in shallower water in the spring (Fig. 35). They are most common in spring, with 61.4% of all records, evident in both sightings and strandings, followed by summer (21.0%), winter (10.0%), and fall (7.6%). There is an obvious aggregation of sightings southeast of Montauk Point, in that area where deeper water comes closest to shore—in spring and secondarily in summer. In the data from the whale-watching boats, there were 16 spring sightings and 7 summer sightings; their removal has almost no effect on the pattern of seasonality and little effect on the spatial pattern. The spring-summer concentration southeast of Montauk is not caused by bias from the whale-watch sightings. It is likely that the same prey resources that draw fin whales to that area also attract white-sided dolphins. There was one stranding in the spring on the Connecticut shore of Long Island Sound; there was one more in Connecticut and one in Long Island west of the study area boundary.

The effort-corrected patterns of relative abundance show that Atlantic white-sided dolphins occur in the Ocean SAMP area in all four seasons (Fig. 36). In winter, they occur at low abundance in the offshore half of the SAMP area, but more abundantly in deeper water on the outer part of the shelf. In spring they occur throughout the SAMP area in low numbers. The area of highest abundance is offshore of the southeastern corner of the SAMP area, and the distribution is in somewhat shallower water than in winter. There is also an area of relatively high abundance in the Great South Channel region east of Cape Cod. In summer, there is an area of moderate abundance in the eastern half of the SAMP area, the zone of abundance south of the SAMP has moved a little farther offshore, and the highest abundance is in the Great South Channel. The pattern in fall is similar to spring, but at lower abundances.

Atlantic white-sided dolphin strandings in the Rhode Island study area have been relatively rare (Fig. 37). There was a spike in 2001–2005, but the annual average was still low at only 1.2 per year. Four of the six strandings in that 5-year period were in Rhode Island—two in 2002 and 2 in 2005 (Waring et al., 2008), but the stranding rate is minimal in comparison with Massachusetts. Of 285 white-sided dolphins stranded from North Carolina to Nova Scotia in 2001–2005, 222 (78%) were in Massachusetts, mostly in mass strandings. Strandings in the study area were less strongly seasonal than sightings, with six in winter (29%), ten in spring (48%), and five in summer (24%).

After the first two Rhode Island strandings in 1967 and 1976, the next was on 21 February 1997 at Snug Harbor, when a 140-cm, 50-kg juvenile that was disoriented in Point Judith Pond was live-captured, then released alive after blood samples tested normal. Two dolphins stranded

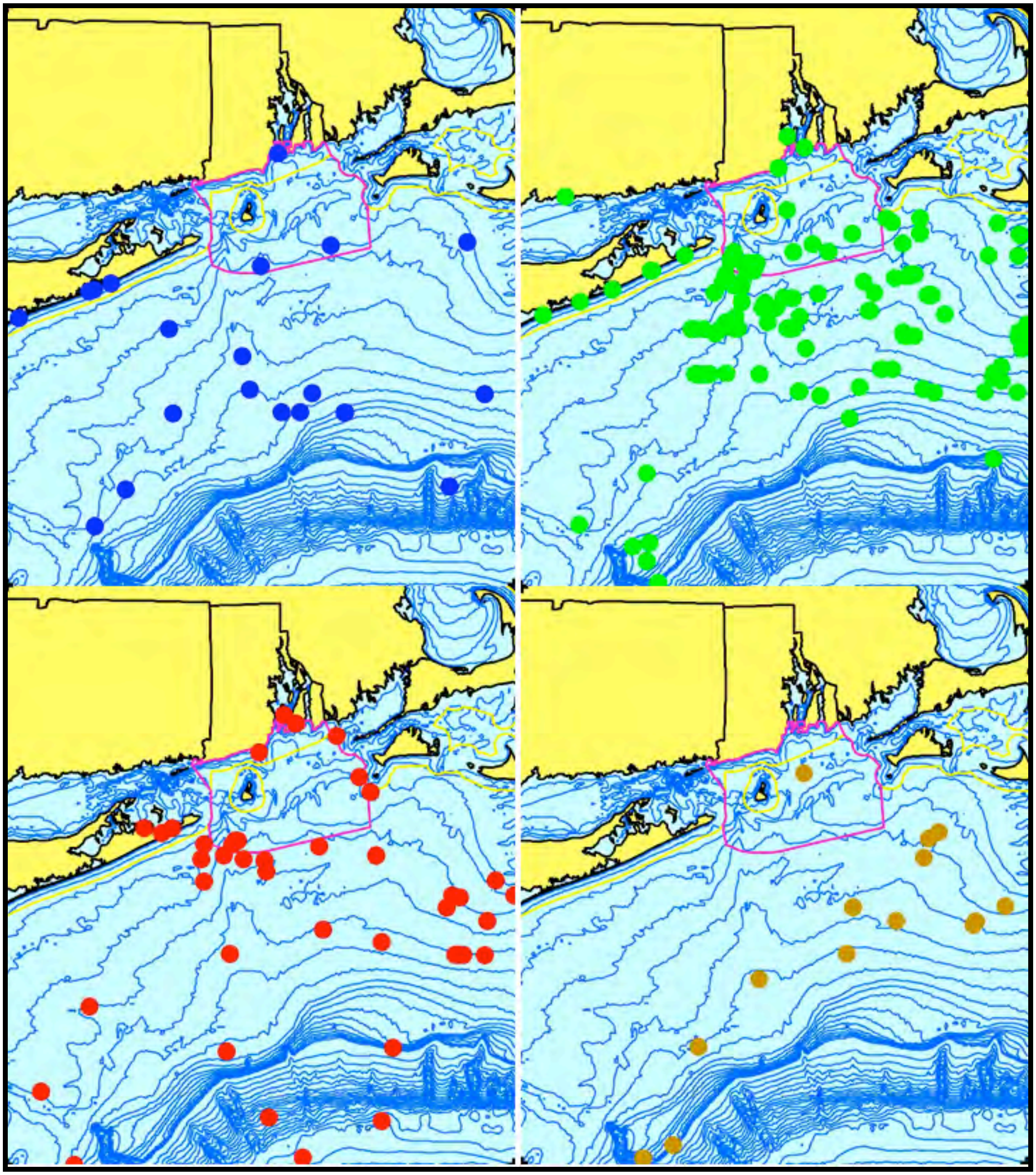

Figure 35. Aggregated sighting, stranding, and bycatch records of Atlantic white-sided dolphins in the Rhode Island study area, 1973–2006 (n = 210: winter = 21, spring = 129, summer = 44, fall = 16).

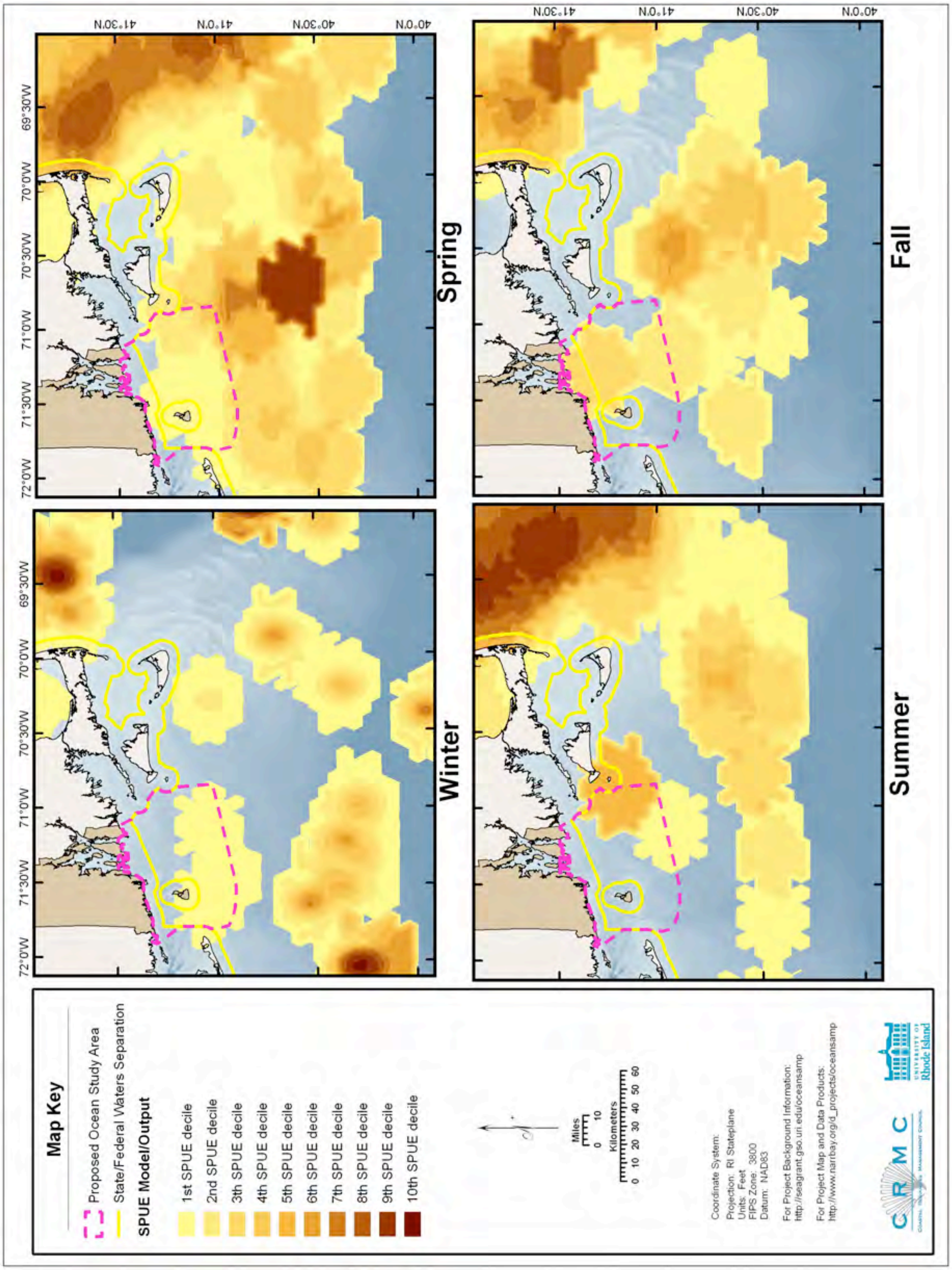

Figure 36. Modeled seasonal relative abundance patterns of Atlantic white-sided dolphins in the Rhode Island study area, corrected for uneven survey effort.

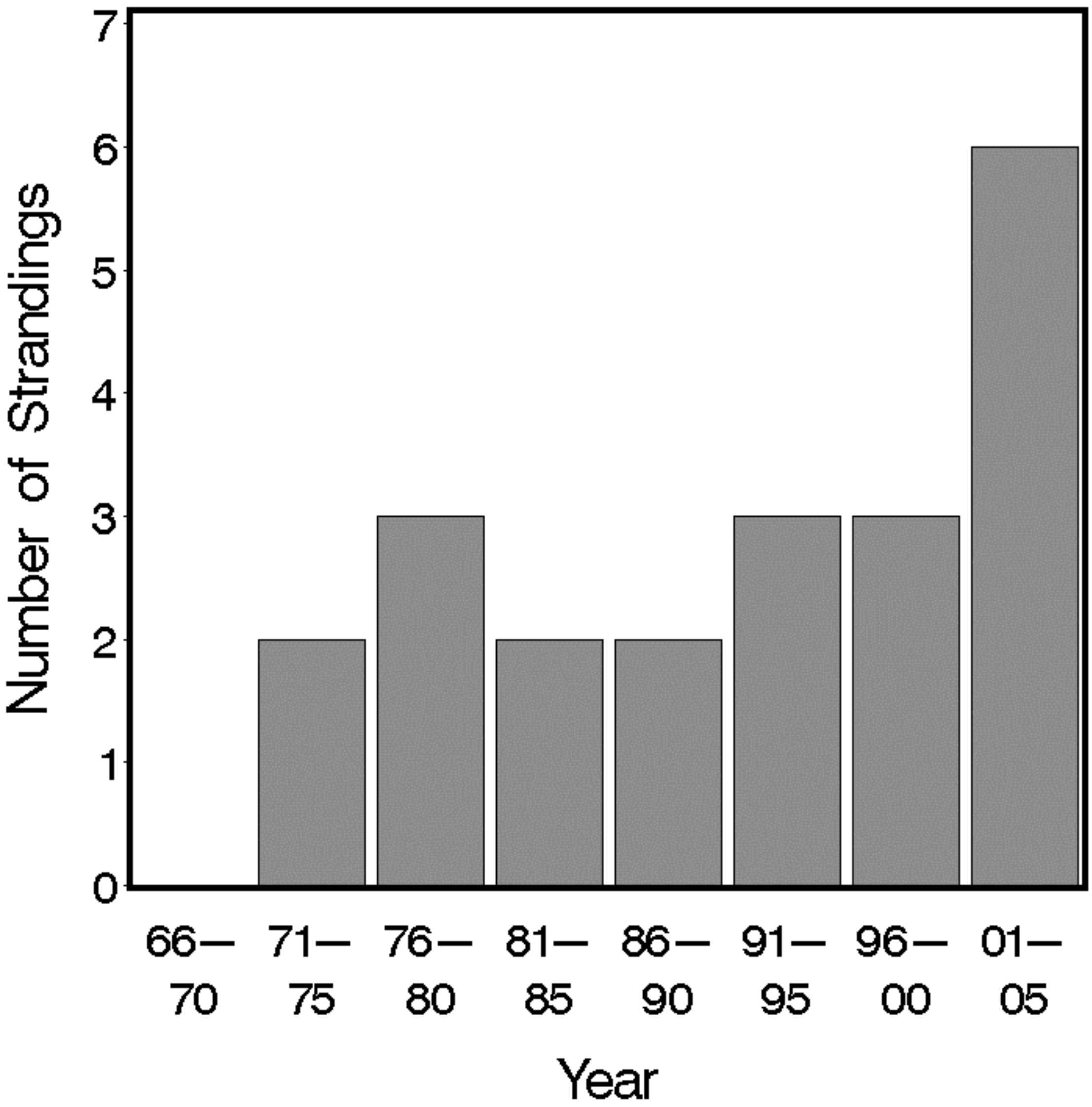

Figure 37. Five-year stranding frequencies for Atlantic white-sided dolphins in the Rhode Island study area, 1966–2005.

on Scarborough Beach in Narragansett on 31 March 2002, one stranded on First Beach in Newport on 8 June 2002, one stranded at Plum Point in North Kingstown on 6 March 2005, and one stranded on the eastern side of Jamestown on 7 July 2005. There was one stranding in Connecticut—at Branford in May 2003. The other 14 white-sided dolphin strandings in the study area were all in eastern Long Island, in 1973 (mentioned above), 1974, 1978, 1979, 1981, 1985, 1987, 1988, 1991, 1995 (two), 1996, 1997, and 2004. The strandings are rare and localized: 1997, 2002, and 2005 were the only years with two strandings, and only in 1997 were there strandings in more than one state.

Conclusions: Atlantic white-sided dolphins are not ESA-listed, but they are probably the cetacean species that occurs seasonally in the highest numbers in the SAMP area. As such, they would be in the second tier of species that need to be considered carefully relative to the SAMP (see section 4, Recommendations).

3.2.19. White-beaked Dolphin *Lagenorhynchus albirostris* (Gray, 1846)

Description: White-beaked dolphins are very similar in overall body form to Atlantic white-sided dolphins, with robust bodies; prominent keels on the top and bottom of the tailstock; short, thick beaks; and very prominent, tall, falcate dorsal fins (Jefferson et al., 1993; Reeves et al., 1999b; Wynne and Schwartz, 1999; Kinze, 2002). White-beaked dolphins are slightly larger, reaching 3–3.2 m in length. Both species are counter-shaded with black backs and white bellies, but remaining details of their color patterns are distinctively different. In white-beaks, as their common name indicates, the white belly area includes both the upper and lower jaws and a little of the melon, though a close look is necessary to see this well in free-swimming animals. In front of the dorsal fin, there is a black cape, a white or pale gray patch below, and a dark gray to black patch below that. The cape and the darker patch on the side blend together at the head. Behind the dorsal fin, most of the animal is medium to very pale gray to nearly white, without distinct edges between different colors.

Status: White-beaked dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There are no synoptic estimates of the number of white-beaked dolphins across the Atlantic, though from estimates in separate smaller areas it is possible that the number is in the highs tens to low hundreds of thousands (Reeves et al., 1999b). Individual estimates from eastern Canadian waters range up to several thousand. None were sighted during the CETAP census surveys, although a single estimate of 573 was calculated from a special right whale survey east of Cape Cod in May 1980 (CETAP, 1982). An aerial survey in the Gulf of Maine in August 2006 resulted in the first available estimate from any of the NMFS stock assessment surveys—2003 white-beaked dolphins (Waring et al., 2008).

White-beaked dolphins were at times the subject of small-scale opportunistic hunting in Norway, Iceland, Greenland, Newfoundland, and Nova Scotia. Some of the dolphins taken in the Faroe Islands pilot whale fishery may be white-beaked rather than white-sided dolphins. They were formerly hunted for food in Newfoundland and Labrador, with up to several hundred killed per year (Alling and Whitehead, 1987). Present takes in that region are apparently limited to only the most remote regions of Labrador (Lien et al., 2001). There are no records of human-related mortality in U.S. waters (Waring et al., 2008), although they are known to be killed by entanglement in fixed fishing gear in eastern Canadian waters (Alling and Whitehead, 1987; Read, 1994; Hai et al., 1996) and also in Europe (Kinze et al., 1997).

Ecology and life history: White-beaked dolphins typically are sighted in groups a few to 50 animals, most commonly in small groups of fewer than 10, but may at time aggregate in herds of hundreds (Reeves et al., 1999b; Kinze, 2002). There is a suggestion that juveniles segregate into separate groups from adults and calves, but the data are very sparse. They are very active, and are known to leap and breach, as well as bow-ride in front of vessels. They are very fast swimmers, and may create a rooster-tail of spray when surfacing.

White-beaked dolphins appear to feed primarily on fish and secondarily on squid, and also on octopus and benthic crustaceans (Reeves et al., 1999b; Kinze, 2002). The major types of fish eaten are herring and other clupeids, cod and other gadids, hake, capelin, mackerel, flounders, and sand lance.

There are very few available life-history data for white-beaked dolphins (Reeves et al., 1999b; Kinze, 2002). Calves are born at 110–120 cm over an extended period, probably from May to August or September. The gestation period is 10–11 months, but the length of lactation is not known. Information on maturity is based on very small samples. The smallest mature male known was 251 cm, and the largest immature male was 257 cm. In females the range is much wider—the smallest known mature individual was 174 cm and the largest immature was 246 cm. Physical maturity appears to be at an average length and age of 281 cm and 13 years in males and 261 cm and 16 years in females.

General distribution: Atlantic white-sided dolphins and white-beaked dolphins are both found only in the North Atlantic, with broadly overlapping distributions (Rice, 1998; Reeves et al. 1999a, 1999b; Cipriano, 2002; Kinze, 2002). White-beaked dolphins are found in temperate to subarctic waters on both sides of the basin, with the northern limits around Newfoundland, Greenland, Iceland, Svalbard, the North Cape of Norway, and the White Sea. The southern distributional limit is about the same as white-sided dolphins on the European side of the ocean, to about the Bay of Biscay, but on the North American side they are common only to the Nova Scotian shelf currently, and formerly to the Gulf of Maine, with occasional occurrences as far south as North Carolina and Portugal. In the northeastern Atlantic, white-sided dolphins typically occur farther offshore than white-beaked dolphins. In the western North Atlantic, their range extends from southeastern New England and Nova Scotia to Greenland, although there was one sighting of 15 “probable” white-beaked dolphins on the outer shelf east of northern North Carolina border in May 1979 (CETAP, 1982). Prior to the 1970s, they were the most common species of dolphin occurring within the Gulf of Maine, with sightings concentrated around Massachusetts in April through June or July. Since then, however, they have been very rare in the Gulf of Maine (Waring et al., 2008), though still common off Nova Scotia and farther north (see discussion under white-sided dolphin).

Historical occurrence: There are no historical records of white-beaked dolphins in the Rhode Island study area. They were not mentioned at all by Cronan and Brooks (1968), nor by De Kay (1842), Linsley (1842), Goodwin (1935), or Connor (1971). Waters and Rivard (1962) wrote that the species “very rarely enters New England coastal waters. A sighting on 27 April 1961, thirty miles north of Cape Cod, is said to be the first specimen record from New England.” They also reported a stranding on Nauset Beach on the outer Cape on 29 April 1961. The first known occurrence in the study area was the sighting in February 1975 (see below).

Recent occurrence: There were only 11 scattered occurrences of white-beaked dolphins in the Rhode Island study area (Fig. 38), all but one in spring or summer. The first was a sighting of six dolphins at the shelf break near Hudson Canyon on 15 February 1975. The sightings are concentrated in a few years. There were sightings in Vineyard Sound in August 1977 and March 1979, a sighting south of Martha’s Vineyard in June 1979, one over the slope east of Hudson Canyon in August 1979, one animal seen from a whale-watching boat about 2 km off Montauk Point on 4 July 1981, and another sighting of one dolphin just south of Block Island on 5 August 1981. Then there were no sightings for 17 years. There were two strandings, quite possibly

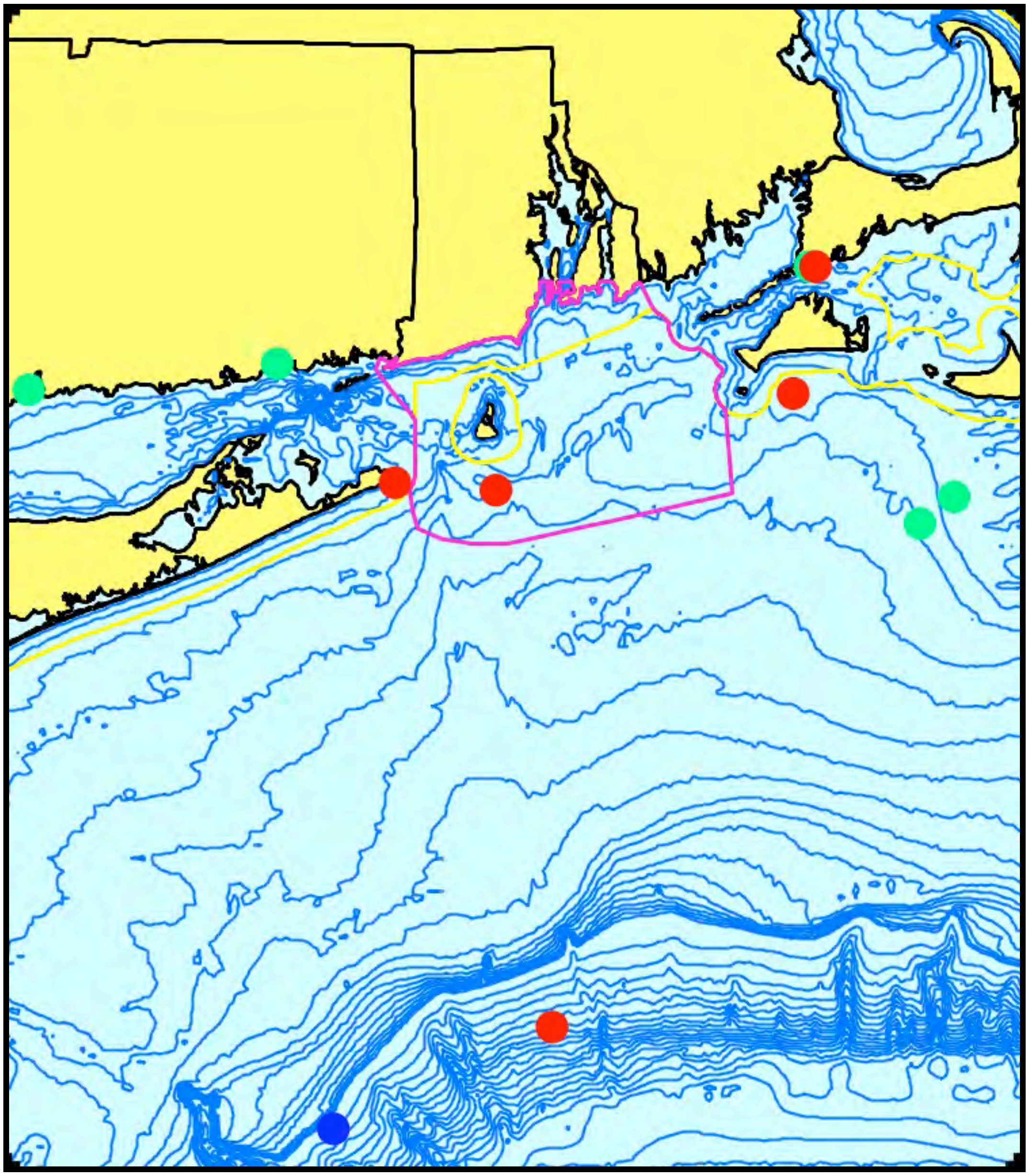

Figure 38. Aggregated sighting, stranding, and bycatch records of white-beaked dolphins in the Rhode Island study area, 1975–1998 (n = 11: winter = 1, spring = 5, summer = 5, fall = 0).

related, in Connecticut in May 1986—in West Haven (the westernmost) on the 22nd and in Niantic on the 25th. The last two sightings were from an aerial survey south of Nantucket on 22 May 1998—one group of 40 dolphins and another group of 2.

Conclusions: White-beaked dolphins occur in the study area only rarely, and are probably less likely now than they may have been 40 years ago. Despite the intensive whale-watching, only one sighting was recorded in 1981. White-beaked dolphins can reliably be assigned to the lowest priority group of species relative to the SAMP.

3.2.20. Common Bottlenose Dolphin *Tursiops truncatus* (Montagu, 1821)

At least one other species of bottlenose dolphin is recognized—the Indian Ocean bottlenose dolphin, *Tursiops aduncus*, and other species are likely to be (Rice, 1998). In addition, in many areas of the world including the western North Atlantic, there are diagnosable inshore and offshore populations (Mead and Potter, 1990, 1995; Rice, 1998). Off the eastern U.S. the inshore and offshore populations are currently considered to be “ecotypes” or “morphotypes” of a single species for management purposes (Waring et al., 2008). Recent genetic results, however, show them to be sufficiently distinct to be considered separate species (Kingston and Rosel, 2004). The type specimen of *T. truncatus* matches the characteristics of the offshore population; available names for a separate inshore species include *T. erebennus* (Cope, 1865) and *T. subridens* (Flower, 1884) (Mead and Potter, 1995).

Description: Bottlenose dolphins are the “plainest” and least distinctively marked of all of the beaked dolphins in the North Atlantic (Jefferson et al., 1993; Wells and Scott, 1999, 2002; Wynne and Schwartz, 2002). Body size is extremely variable between populations; adults may be 2–3.8 m long. Offshore animals average about 15% larger than inshore animals along the U.S. Atlantic coast (Mead and Potter, 1995). The body is relatively thick and robust (especially in offshore animals), with a tall, falcate dorsal fin. The beak is well-defined and prominent, of moderate length (shorter than in *Stenella* and *Delphinus*, but significantly longer than in *Lagenorhynchus*), and stout. The body is basically gray to brownish, darkest on the back and lightest on the belly. There may be a clearly visible darker cape, or the color may simply fade gradually from the back to the belly. There may be indistinct stripes on the head or spots, and some animals may have a faint version of the spinal blaze that is seen prominently in striped and Atlantic spotted dolphins. In addition to consistent genetic and biochemical differences, inshore bottlenose dolphins in the western North Atlantic are significantly smaller than offshore animals, are usually lighter-colored, have flippers and beaks that are larger relative to body length, as well as narrower skulls and rostrums, feed on different types of prey, and carry different types of parasites (Hersh and Duffield, 1990; Mead and Potter, 1990, 1995; Hoelzel et al., 1998).

Status: Common bottlenose dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. Coastal bottlenose dolphins along the U.S. Atlantic coast were designated as Depleted under the Marine Mammal Protection Act in 1993 (NMFS, 1993) because of high mortality in a 1987 epizootic (Scott et al., 1988). However, the impact of that event was seriously overestimated because the mortality occurred from Florida to New Jersey, but the only available estimate of abundance was for Cape Hatteras to New Jersey. In addition, no subsequent surveys have been able to detect a decrease in the abundance of coastal dolphins. A review of the depleted designation that is presently applied to all coastal stocks is needed (Waring et al., 2008). There are no reliable estimates of the total abundance of bottlenose dolphins in the North Atlantic. The existence of inshore and offshore populations (or species) and multiple stocks within populations makes it difficult to synoptically survey the entire region or to estimate the abundance of individual components. Mitchell (1975a) estimated the size of the stock subject to the North Carolina dolphin fishery in the 1880s at around 14,000. The CETAP data suggested that there were 11,000–13,000 bottlenose dolphins north of Cape Hatteras in spring and summer, with probably only 1,000 or fewer in the inshore stock (CETAP, 1982; Kenney, 1990). Subsequent surveys have been conducted in both inshore and offshore waters along the entire east coast (Waring et al., 2008). The Atlantic offshore population was estimated at 81,588 dolphins in 2002–2004 from Florida to Georges Bank. The total of all coastal stocks along the Atlantic coast was estimated at about 44,000 animals, including 17,466 in northern migratory stock—the only one that occurs in the mid-Atlantic. Additional bottlenose dolphin stocks occur in the Gulf of Mexico.

Bottlenose dolphins have been the targets of directed fisheries in several areas of the world (Wells and Scott, 1999, 2002; Reeves and Read, 2003). A fishery once existed in several countries around the Black Sea that took both bottlenose dolphins and harbor porpoises for oil, meat, and leather. Dolphin fisheries also exist in Peru, Sri Lanka, and Japan, taking dolphins for food, for bait in other fisheries, and to eliminate perceived competition for declining fish stocks. Recent takes of bottlenose dolphins in coastal small-cetacean fisheries in Japan have been 1,426 in 2000, 247 in 2001, 729 in 2002, 164 in 2003, and 16 in 2004 (IWC, 2005, 2006). There was a bottlenose dolphin fishery in operation at Cape Hatteras, North Carolina at least sporadically from 1797 to 1929 (Mead, 1975). A similar fishery was prosecuted at Cape May, New Jersey in 1884–1885, and one may have operated in the 18th Century or earlier in Long Island, depending on what De Kay (1842) and earlier writers were referring to regarding “porpoise” fisheries. Reeves and Read (2003) provide a good review of the fishery methods. Catches at Cape Hatteras were mostly in spring and fall, with very few in summer; so they were apparently targeting migrating animals moving north or south and not residents.

Another directed effort has been the live-capture dolphin fishery for public display and other purposes (including research and military use) (Reeves and Leatherwood, 1984; Reeves and Mead, 1999; Wells and Scott, 1999, 2002). Over 1,500 were captured between the late 1930s and early 1980s, mostly in the southeastern U.S. A May 2000 inventory by NMFS showed 392 captive bottlenose dolphins in 35 facilities in the U.S. alone, with at least several hundred more in at least 16 other countries.

Bottlenose dolphins are taken incidentally as bycatch in a number of different commercial fisheries around the world (Northridge, 1991; Perrin et al., 1994b; Wells and Scott, 2002). The average annual mortalities in 2001–2005 in U.S. Atlantic waters are summarized in Waring et al. (2008). One observed take of an offshore dolphin in 1991 in the New England sink gillnet fishery extrapolated to an annual average of 26 individuals. Previous takes included an annual average in the swordfish driftnet fishery in 1989–1998 of 31.7 (that fishery is now closed), an average of 38.4 in the pelagic tuna pair-trawl fishery in 1991–1995 (also now closed), and one animal taken in a bottom trawl in 1991 (extrapolated to a total estimated take that year of 91). There was one take in the mid-Atlantic coastal gillnet fishery in 1998 that was probably an offshore animal, and one take in 2001 in the coastal-offshore overlap zone that was not included in the extrapolated estimate for the fishery due to uncertainty as to the stock identity. Annual average takes of coastal bottlenose in the mid-Atlantic coastal gillnet fishery were 233 per year in 1996–2000 and 61 per year in 2001–2005, with all takes in North Carolina and north and most in North Carolina in the winter. Bottlenose dolphins are probably also killed or injured by recreational fishing gear, but it is not well quantified (Gorzelany, 1998; Wells et al, 1998).

Bottlenose dolphins are the most frequently stranded cetacean on the U.S. Atlantic coast—292 in 2003, 359 in 2004, and 284 in 2005 (Waring et al., 2008), occasionally in mass strandings and primarily from New Jersey south. Some proportion of stranded animals bear marks of netting or ropes and were probably killed by entanglement in fishing gear.

Ecology and life history: Bottlenose dolphins are gregarious, usually occurring in small groups of around 2–15 animals, but groups larger than 1000 have been reported (Wells et al., 1999; Wells and Scott, 1999, 2002). They generally are seen in smaller groups in bays and sounds than offshore, but group size is not a linear function of distance from shore. Off the northeastern U.S., the average group size was 14.8, with a mode of 2 and a range of 1–350 (CETAP, 1982), but that combined inshore and offshore sightings.

Group membership is dynamic, with sex, age, reproductive status, kinship, and affiliation history all involved (Wells et al., 1987; Scott et al., 1990; Wells and Scott, 1999, 2002; Connor et al., 2000; Reeves and Read, 2003). The social structure has been called a "fission-fusion" society. Some subgroups are stable for long terms, some may be repeated over periods of years, and others are more ephemeral. The basic social units are nursery schools of adult females and their calves, mixed-sex juvenile schools, and adult males, either solitary or in strongly bonded pairs and trios. Male-male bonds may last for decades, probably to enhance mating success and predator defense (Wells et al., 1987, 1990; Connor et al., 1992). There is no evidence for male coalitions in Moray Firth, Scotland, although those animals would be the same as the U.S. Atlantic offshore stock where there is very little information. Dominance hierarchies are observed in captivity—maintained by aggressive behaviors, including posturing, loud jaw claps, and physical contact.

Bottlenose dolphins commonly occur in mixed-species schools with other cetaceans. Scott and Chivers (1990) reported that bottlenose in the offshore eastern tropical Pacific were seen 16% of the time with one other species and 4% with two or more other species. They associated mostly with short-finned pilot whales, and pantropical spotted dolphins, and also with Risso's, rough-toothed, and spinner dolphins, sperm whales, and others. Norris and Prescott (1961) and Norris and Dohl (1980) similarly reported a common association of bottlenose dolphins and pilot whales in the North Pacific. Offshore bottlenose dolphins off the northeastern U.S. occur in mixed herds at 10% of all sightings, mostly with pilot whales, and also with Risso's, common, and striped dolphins (CETAP, 1982). Mixed delphinid schools often included calves and juveniles of one or both species.

There many reports on the prey of bottlenose dolphins, including observational studies and analyses of stomach contents, mostly dealing with inshore animals (Leatherwood, 1975; Leatherwood et al., 1978; Barros and Odell, 1990; Shane, 1990; Mead and Potter 1990, 1995;

Barros and Wells, 1998; Walker et al., 1999; Wells and Scott, 1999, 2002; Reeves and Read, 2003). The dominant prey are fishes, primarily from three families—sciaenids (weakfish, croaker, spot, etc.), scombrids (mackerels), and mugilids (mullets). Mead and Potter (1990) reported 40 different families of bony fishes, plus skates, rays, sharks, squid, shrimp, and isopods in the stomachs of *Tursiops* from the U.S. Atlantic coast. The four principal prey species were all sciaenids, including weakfish (also known as spotted sea trout), Atlantic croaker, spot, and silver perch. Stomachs of offshore animals were dominated by myctophids and squid.

Female bottlenose dolphins give birth after a 1-year gestation to a single calf that is 84–140 cm at birth, with substantial differences between populations (Wells and Scott, 1999, 2002; Reeves and Read, 2003). In Gulf of Mexico coastal dolphins, calves average 110 cm at birth (Fernandez and Hohn, 1998). Calving seasonality varies between populations (Scott et al., 1990; Urian et al., 1996; Fernandez and Hohn, 1998; Connor et al., 2000). In the long-term stranding data, Mead and Potter (1990) recorded neonates of 106–132 cm, and estimated a mean size at birth of 117 cm and 20.4 kg. They reported a mode in neonate strandings in March, and suggested a prolonged calving season with a peak in spring, with no evidence of a fall peak. During the CETAP (1982) study off the northeastern U.S., bottlenose calves were seen all year, recorded at 12% of sightings in spring, 12% in summer, 16% in fall, and 5% in winter. Thayer et al. (2003) reported that neonate strandings in North Carolina peaked in April–May and were lowest in fall and winter, but that births to known females were in May–June with one in fall. They speculated that the differences could be because of the presence of multiple stocks, or due to bias because out of season births may be more likely to lead to neonate mortality.

Mothers and calves rarely separate during the first few months (Mann and Smuts, 1998). A calf may nurse for several years, but begins foraging independently during its first or second year, maybe as young as four months (Wells et al., 1987; Wells and Scott, 2002). A calf is generally weaned completely at around the time the mother gives birth to the next calf, with overall duration a function of the age, nutritional condition, and social status of the mother (Wells et al., 1987; Mann et al., 2000; Whitehead and Mann, 2000; Wells and Scott, 2002). The typical inter-birth interval is 3–6 years (Scott et al., 1990; Wells and Scott, 2002).

The mating system in both species of bottlenose dolphins appears to be promiscuous with "roving" males (Wells et al., 1987, 1999; Scott et al., 1990; Connor et al., 1992; 2000; Wells and

Scott, 1999, 2002). Associations between males and females are extremely short-term. Coalitions of males travel more widely than any other groups, fighting for access to receptive females. Older males tend to be heavily scarred from fighting. In Australia, *T. aduncus* male coalitions aggressively separate receptive females from their bands and herd them away, which has not been observed in other populations.

In 1987–1988, there was a mass mortality of bottlenose dolphins along the U.S. Atlantic coast between New Jersey and Florida, which killed at least 740 animals (Scott et al., 1988). It was estimated at the time that the event killed 50% of the coastal migratory stock of *Tursiops*, however the only available abundance estimate (from CETAP, 1982) was for a much smaller area than that impacted by the epizootic. The dolphins died acutely from a wide variety of opportunistic viral and bacterial infections, but the underlying cause was first attributed to immune suppression caused by ingestion of prey containing a “red tide” toxin—brevitoxin produced by the dinoflagellate *Karenia* (formerly *Ptychodiscus*) *brevis* (Geraci, 1989). That finding was never widely accepted, particularly since there was no published literature showing a chronic immuno-suppressive effect of brevitoxin. In addition, bottlenose dolphins feed high on the food chain and could be subject to bioaccumulation of toxic contaminants. Animals in U.S. Atlantic waters have high concentrations of PCB’s and PBB’s (Kuehl et al., 1991; Lahvis et al., 1995). Organochlorines, even at relatively low levels, have the potential to affect immune response and may play a part in the apparent in increase in disease outbreaks (O’Shea et al., 1999; Wells and Scott, 2002). Males tend to accumulate higher loads than females, who reduce their own levels by transfer in milk lipids to their calves. In South African bottlenose dolphins, it was estimated that first-born calves received 80% of the mother’s body burden of PCB’s and dieldrin (Cockcroft et al., 1989). Subsequent reanalysis of archived tissue samples has suggested that morbillivirus may have played a role in the 1987–88 epizootic (Lipscomb et al., 1994). Morbillivirus has also been implicated in other bottlenose dolphin epizootics in the Gulf of Mexico (Duignan et al., 1996; Lipscomb et al., 1996).

General distribution: Bottlenose dolphins occur in temperate and tropical waters of all oceans of the world, as well as in the Mediterranean, Black, and Red Seas (Rice, 1998; Wells and Scott, 1999, 2002; Reeves and Read, 2003). The limit of the distribution in the Southern Hemisphere is around 40ºS. The distribution in the North Pacific extends north to the Sea of Okhotsk and Kuril Islands in the west and to central California in the east. Because of very extensive surveys undertaken to assess the stocks of dolphins impacted by the tuna purse-seine fishery, there are substantial numbers of sightings of bottlenose dolphins across an immense area of the eastern tropical Pacific—as far as 3,000 km and more offshore (Scott and Chivers, 1990). In the North Atlantic their range extends north to southern Greenland, Iceland, and northern Norway. In the western North Atlantic, bottlenose dolphins occur from the equator north to at least Nova Scotia, with some records to Newfoundland.

Within that overall distribution, the picture is complicated by the existence of multiple species, populations, and/or stocks. Surveys in 1979–1981 showed clearly separated inshore and offshore bottlenose dolphins off the northeastern U.S. (CETAP, 1982; Kenney, 1990). There was one band of sightings very close to shore from Cape Hatteras to Delaware Bay and southern New Jersey, and a second band along the shelf break from Cape Hatteras to the Nova Scotian shelf, with scattered sightings far offshore in deep water. In the vicinity of Cape Hatteras, where the continental shelf becomes quite narrow, the two areas of sightings overlapped. South of Cape Hatteras the presence of coastal bottlenose dolphins was well known, but the continuous distribution of the offshore stock was not clear until NMFS conducted marine mammal stock assessment surveys beginning in the 1990s (Waring et al., 2008). The inshore and offshore dolphins are distinct, and possibly represent two different species (reviewed above). Kenney (1990) suggested that inshore and offshore dolphins could be split spatially by partitioning sightings into classes in waters deeper or shallower than 25 m, however no simple scheme has been successful. Torres et al. (2003) analyzed *Tursiops* skin biopsies collected both inshore and offshore from Florida to Georges Bank by incorporating the genetic results into a spatial model. Within 7.5 km from shore, only inshore animals were sampled. In areas more than 34 km offshore and in water deeper than 34 m, only offshore animals were sampled. In between was the “gray zone” where both types can occur, and there were three locations where both types were biopsied within the same school.

On top of the inshore-offshore pattern there is also a definite seasonal pattern to bottlenose distribution off the northeastern U.S. (CETAP, 1982; Kenney, 1990). Offshore dolphins occurred on the outer shelf along the entire study area from Hatteras to southern Nova Scotia in spring and summer. In the fall the distribution became sparser in the northern half of that range. In winter, sightings of offshore dolphins were very sparse, but still scattered along the entire shelf break. The seasonality was much more dramatic in the inshore distribution, which extended to

Delaware Bay in spring and summer, contracted to Virginia and south in fall, and contracted completely to south of Hatteras in winter.

Historical occurrence: Cronan and Brooks (1968) reported two bottlenose dolphin records from Rhode Island, a 315-cm male stranded at Sand Hill Cove in Narragansett on17 September 1967 and one previously at Newport on an unknown date. That is likely to refer to the specimen from Newport in the Smithsonian, collected by Major E. A. Mearns on 13 December 1899—the oldest bottlenose record in the Rhode Island study area. The species was not included by De Kay (1842) as part of New York's marine mammal fauna, unless it had been confused or inadvertently combined with the "common porpoise." Neither Linsley (1842) nor Goodwin (1935) knew of occurrences in Connecticut. Connor (1971) summarized a number of published and anecdotal records of bottlenose dolphins along the shores of Long Island and nearby, indicating that the species was rather common. The Smithsonian data include stranding and sighting records around eastern Long Island between 1921 and 1960, plus several non-dated sightings, all extracted from Connor's review. There were two other relevant records—a sighting in 1936 "off Block Island" but with no more specifics, reported by Remington Kellogg in a 1940 *National Geographic* article; and a specimen collected during the Atlantis Expedition in May 1939 "100 miles south of Montauk" (beyond the study area). Waters and Rivard (1962) said that bottlenose dolphins were uncommon migrants in Massachusetts waters, and cited only one specific record, a stranding in Plymouth in December 1947.

Recent occurrence: The spatial and temporal distribution of bottlenose dolphins in the Rhode Island study area essentially mirrors what was described above from the CETAP data (Fig. 39). Sightings of offshore dolphins occurred year-round in waters of the outer shelf, shelf break, and upper slope. Summer was the peak season (45.6%), followed by spring (31.3%), fall (18.1%), and winter (4.4%). There were a number of more inshore sightings in summer, but they were in waters deeper than 40–50 m, so there is no clear sighting or distributional evidence for the occurrence of coastal bottlenose dolphins in the study area. (Note, however, that detailed analyses of skull morphometrics, blood profiles, genetics, etc. of stranded specimens would be necessary to say anything about the population origins of individual stranded animals). Fourteen sightings came from the whale-watching boats, about equally in summer and fall, however the fall sightings were all on offshore trips. There were no sightings within the SAMP area, although there were several close by in summer.

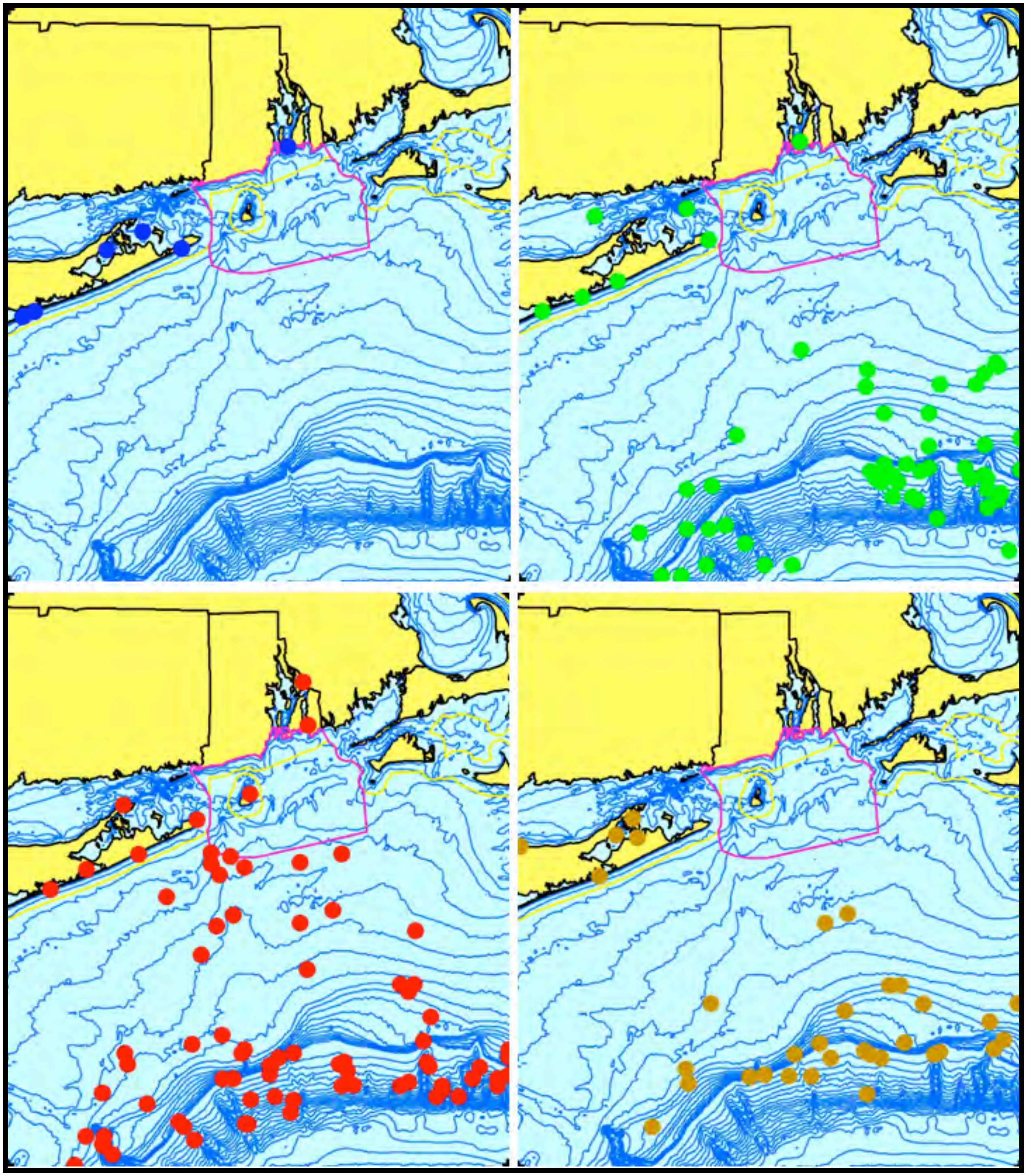

Figure 39. Aggregated sighting, stranding, and bycatch records of common bottlenose dolphins in the Rhode Island study area, 1899–2006 (n = 182: winter = 8, spring = 57, summer = 83, fall = 33, unknown = 1).

The first true offshore bottlenose dolphin sightings in the study area were in the 1970s. On 16 May 1974, a group of fifty dolphins was sighted from a U.S. Coast Guard cutter near the shelf break about 150 km south of Montauk Point. On 8 October 1978 a group of thirty was seen in the vicinity of Block Canyon. That sighting was extracted as an opportunistic sighting record in the early phase of CETAP from the Smithsonian's Scientific Event Alert Network bulletin, so it is also included in the Smithsonian data (among the many duplicates across datasets that needed to be identified and removed). The dolphins were originally seen by Paul Connor and the sighting published by Ulmer (1980).

The effort-corrected relative abundance patterns (Fig. 40) reinforce the suggestion that bottlenose dolphins in the Rhode Island study area are from the offshore population. There were no areas of predicted occurrence in the nearshore zone in the study area. There are areas of predicted bottlenose dolphin occurrence in all four seasons—always offshore. Overall relative abundance is lowest in the winter and highest in the summer, and the areas of highest abundance are outside the study area. Summer was the only season when the analysis showed that bottlenose might be expected within the SAMP area—in the most offshore portion and at the lowest level of abundance.

Bottlenose dolphins are the eighth most frequently stranded cetaceans in the Rhode Island study area (Table 2), which is much lower than the ranking in New York (third) or in New Jersey and states to the south (first). This is certainly due to the northern extent of the range of the inshore population. The seasonality in the strandings is different than seen in the total records, with about equal numbers in winter through summer (6, 6, and 7, respectively) and lower in the fall (3), which is more like the known temporal pattern of the offshore stock off southern New England than the inshore stock. There was a long gap in the stranding record for the study area between 1960 and 1983. Beginning in 1983, there have been four bottlenose strandings in Rhode Island, one on Fisher's Island, and thirteen in eastern Long Island (Fig. 41). There are two spikes in the time series. Of the five strandings in 1986–1990, four were in 1988, and may have been related to the epizootic. The second spike was six during 1996–2000, but those were more spread out, with three in 2000 and one each in 1996, 1998, and 1999.

On 16 August 1983, a 265-cm bottlenose dolphin live-stranded on the shore of Mount Hope Bay in Warren. It was taken to New England Aquarium in Boston, but its fate was not noted in

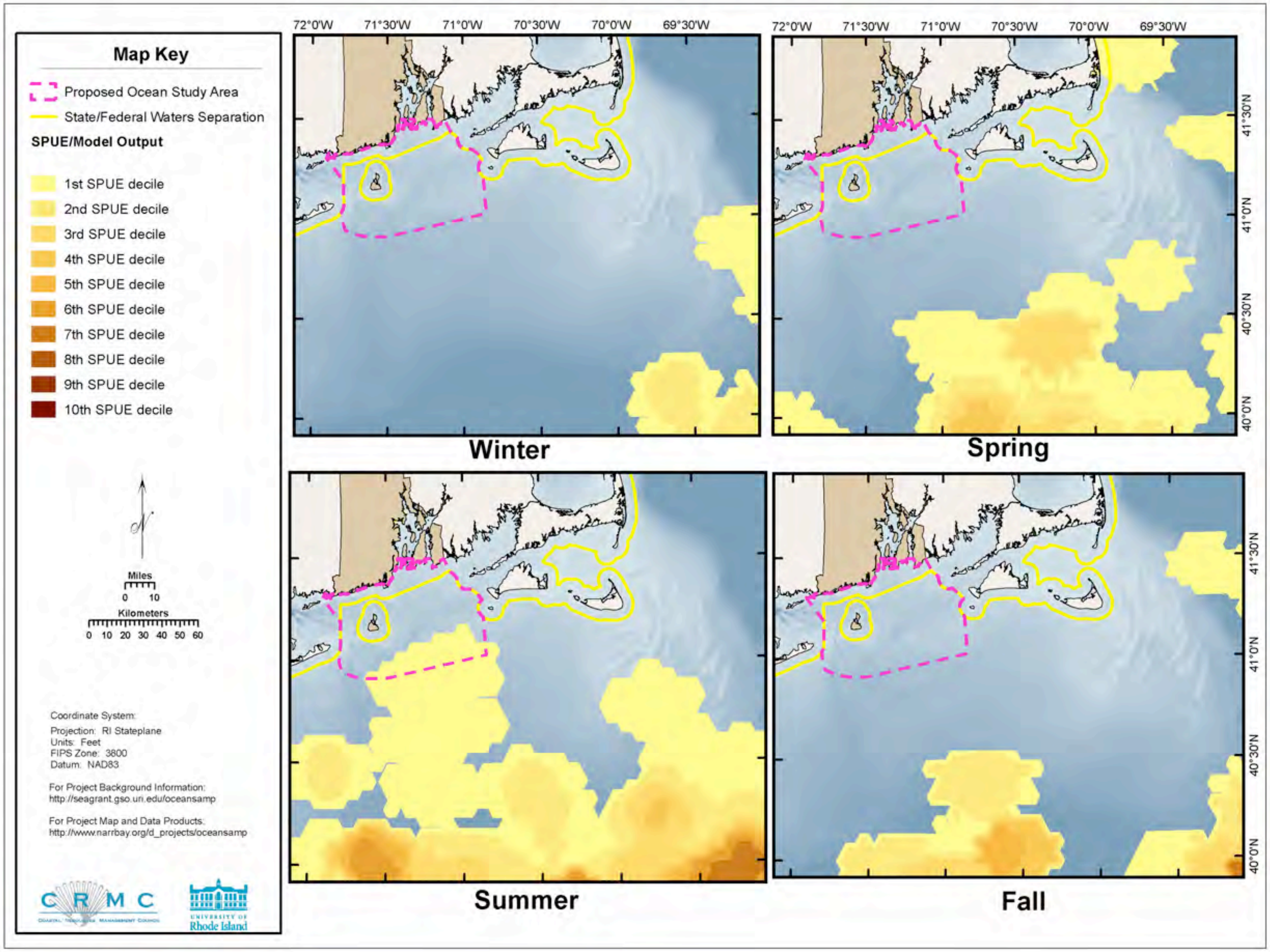

Figure 40. Modeled seasonal relative abundance patterns of common bottlenose dolphins in the Rhode Island study area, corrected for uneven survey effort.

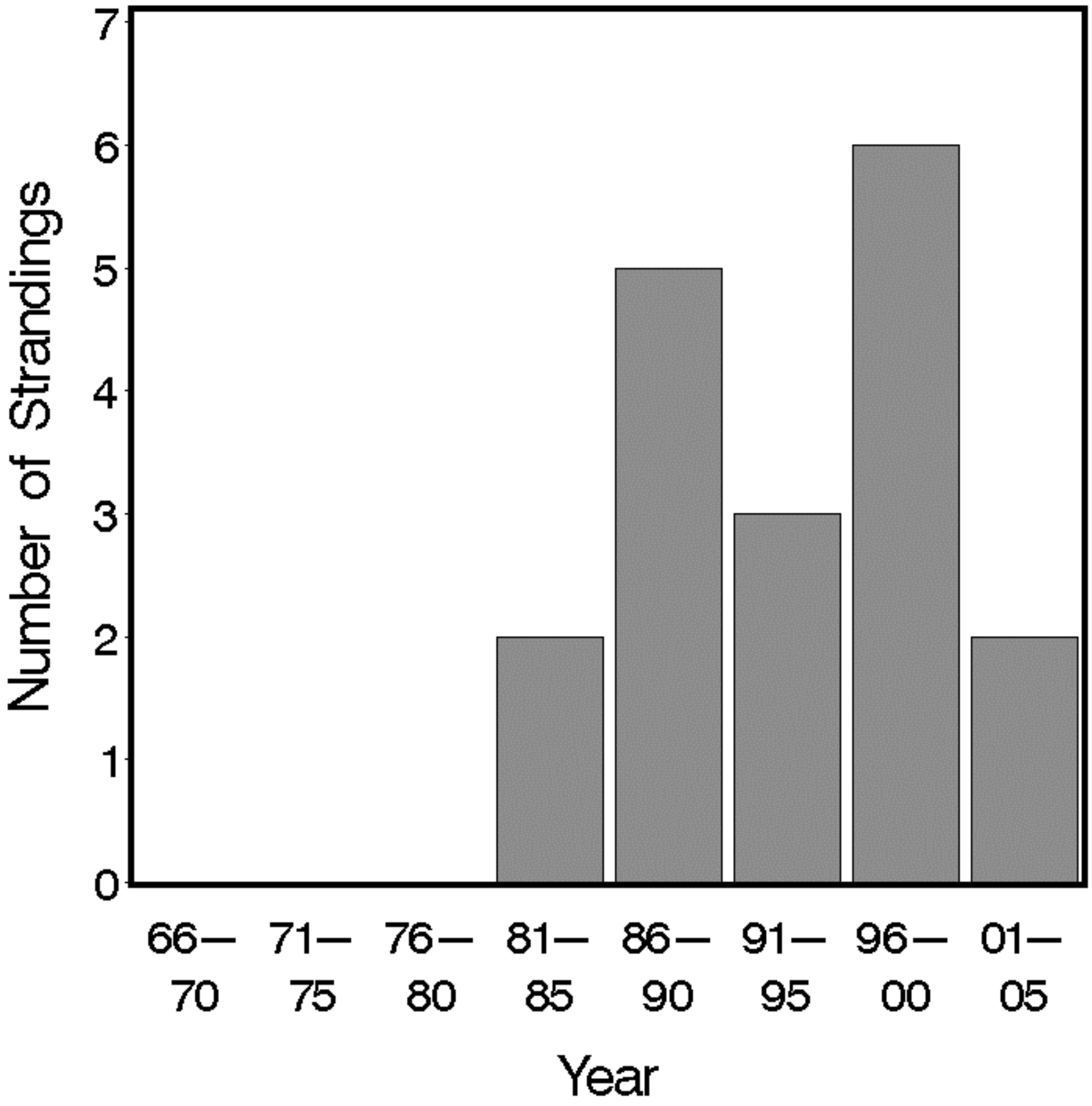

Figure 41. Five-year stranding frequencies for common bottlenose dolphins in the Rhode Island study area, 1966–2005.

the data record. On 31 August 1992, a 310-cm dolphin stranded on the east side of the Sakonnet River in Little Compton, which was noted as most likely from the offshore population. The last two Rhode Island strandings were both in 2004. One was on the Navy base in Newport on 7 March and the other was on Block Island on 12 July. The Fisher's Island stranding was in

August 1984. It was a very large male, 310 cm long and weighing 496 kg. A stranding on Montauk December 1988 was also a large animal at 311 cm; the record notes that analysis of a blood sample showed it to be an offshore bottlenose.

Conclusions: The sparse data suggest that bottlenose dolphins in the Rhode Island study area are more likely to come from the offshore population than from the coastal stock complex, which still is designated as “depleted” under the MMPA. Therefore the level of management concern is somewhat lower. Bottlenose dolphins are relatively abundant in the Rhode Island study area, but not in the SAMP area.

3.2.21. Short-beaked Common Dolphin *Delphinus delphis* Linnaeus 1758

Rice (1998) recognized three different species of *Delphinus*—the short-beaked common dolphin (*D. delphis*), the long-beaked common dolphin (*D. capensis*), and the Indian Ocean common dolphin (*D. tropicalis*), which may actually be a longer-beaked subspecies of *D. capensis* endemic to the Indian Ocean (Heyning and Perrin, 1994; Jefferson and Van Waerebeek, 2002). Only *D. delphis* is known from the North Atlantic (Heyning and Perrin 1994; Perrin 2002c).

Description: Common dolphins have the typical form of oceanic dolphins, with a streamlined fusiform body, a distinct beak that is separated from the melon by a crease, and a prominent dorsal fin (Jefferson et al., 1993; Evans, 1994; Wynne and Schwartz, 1999; Perrin, 2002c). Short-beaked common dolphins are slender, and range up to 2.3–2.6 m in length, with males slightly larger than females. Their color pattern is striking and distinctive. William Perrin developed a scheme for systematically classifying the pigmentation patterns of small cetaceans (summarized in Perrin, 2002b). There are two areas of dorsal pigmentation—the “cape,” which is generally smaller and more anterior, and the “dorsal overlay,” which is larger and extends farther posteriorly. The overlap of the two results in the typical pattern for a particular species. In common dolphins the cape is yellowish-tan, with a lower margin that runs back from the forehead crease, just below the eye, slightly downward to a lowest point between the flippers and the dorsal fin, then curves up to the back midway between the dorsal fin and the tail. The dorsal overlay is light gray; its lower margin starts on the forehead, curves upward over the eye to its highest point in front of the dorsal fin, then curves back downward to the belly in the area of the genital slit. Where the two areas overlap, the color is dark gray to black, resulting in a dorsal field that is a rather narrow band from the head back that widens to a sharp point directly below the dorsal fin (the “saddle,” where the margins of the cape and the dorsal overlay cross), then narrows to a point on the mid-back behind the dorsal fin. Anterior to the saddle the color on the side is yellowish tan (the cape alone), posterior to it and onto the back near the tail the color is gray (dorsal overlay alone). The belly is white. There is a prominent black blaze extending upward and forward from the genital slit to near the point of the saddle, which is thinner and paler in females. The complex pattern on the side of the animal gives rise to the alternative common names saddleback, hourglass, and criss-cross dolphin. The dorsal fin is tall, falcate, in the middle of the back, and black, often with a paler gray center. The lips, flippers, flukes, and a small circle around the eye are black. There are thin black stripes from the upper beak to the eye, and from chin to the flipper.

Status: Short-beaked common dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There is no estimate for the total abundance of short-beaked common dolphins in the North Atlantic. The CETAP (1982) survey results showed that common dolphins were one of the most abundant cetaceans off the northeastern U.S., with about 45,000 present in winter. More recent surveys (all in the summer) estimated a smaller population, until a summer shipboard survey from Florida to the Bay of Fundy in 2004 resulted in an estimate of 120,743 common dolphins (Waring et al., 2008).

There was a directed fishery (for human consumption) on common dolphins, bottlenose dolphins, and harbor porpoises in the Black Sea (Evans, 1994). The fishery began in the late 19th Century, and was conducted by Turkey, the Soviet Union, Romania, and Bulgaria. Tens of thousands of animals were taken annually, with peak kills perhaps as high as 200,000. The fishery ended in 1966, except in Turkey where it continued to 1983.

Common dolphins are taken incidentally in a number of commercial fisheries worldwide, in particular in gillnets (Perrin et al., 1994b) and in the eastern tropical Pacific tuna purse-seine fishery (Allen, 1985; NRC, 1992; Gosliner, 1999; Gerrodette, 2002). In the western North Atlantic, common dolphin bycatch mortalities occur in a number of different fisheries (Waring et al., 2008). The pelagic swordfish driftnet fishery killed an average of 303 annually in 1989–

1998, but has since been shut down. An experimental mid-water pair-trawl fishery for tuna killed 16 per year in 1991–1995, but it has also been closed. The most recent five-year average fishery-related mortality of common dolphins for U.S. Atlantic waters was 151 per year for 2001–2005, primarily in trawl fisheries, with a few in sink gillnets.

Ecology and life history: Common dolphins are known to aggregate into extremely large herds at times, however those schools are composed of smaller groups of 20–30 related individuals (Evans, 1994; Perrin, 2002c). Large herds chased during tuna fishing operations would break up into successively smaller groups, but the smallest groups of 20–30 animals remained tightly aggregated and never separated. Offshore fishermen tell of seeing herds of common dolphins on Georges Bank that take hours to pass by. Off the northeastern U.S. in 1979–1981, the average group size sighted was 54.8 dolphins, but the average was skewed by a few sightings of groups as large as 2000 individuals (CETAP, 1982). The modal group size was 8 animals. Off the northeastern U.S. they were sighted in mixed groups less often than a number of other species (CETAP, 1982). Other cetaceans with which they were associated on four or five occasions included fin whales, pilot whales, striped dolphins, and Risso’s dolphins.

Common dolphins do not appear to be deep divers. Tagging studies show that most dives are to less than 50 m, with a few dives to as deep as 200 m.

Common dolphins feed on small fishes and squids, including species that school in near-surface waters and mesopelagic species that occur near the surface at night (Evans, 1994; Perrin, 2002c). Tagging studies in the North Pacific showed that foraging dives commenced at dusk and continued all night long. They were apparently feeding on deep-scattering layer fishes (dominated by myctophids or “lanternfishes”) that migrate upwards at dusk and return to mid-depths at dawn, as well as on the squid that were also feeding on the small fishes. Hassani et al. (1997) looked at the stomach contents of common and striped dolphins taken as bycatch in a pelagic driftnet fishery in the northeastern Atlantic. Both species fed primarily on squid (50% or more of the prey items). Secondary prey in common dolphins, about equal in occurrence, were crustaceans (shrimp and krill) and fish (especially myctophids). Major (1986) reported a school of common dolphins on the southern edge of Georges Bank attacking and feeding on squid that had been lured near a research vessel at night by bright lights.

Most information about reproduction and life history comes from populations where large numbers were taken in directed fisheries, as in the Black Sea, or as bycatch in commercial fisheries, as in the eastern tropical Pacific (Evans, 1994; Perrin, 2002c). Sexual maturity occurs at 6–7 years and 195–208 cm in females, and 7–12 years and about 200 cm in males. Ages at maturity appear to be significantly lower in the Black Sea, possibly a density-dependent response to high exploitation rates. Gestation is 10–11 months. Calves are born at about 80–90 cm in length, and wean in about 5 or 6 months, but begin feeding on solid food as young as 2–3 months. In the Pacific, there are two peaks in calving, in the spring and fall. At any one time, about 10% of adult females off California are "resting" (i.e., neither pregnant nor lactating); in the eastern tropical Pacific the proportion of resting females is about 17% in fall and winter and 30% in spring and summer.

General distribution: Common dolphins occur in tropical to temperate waters around the world, although understanding of distributional details is somewhat muddied by questions of species identity in the older data (Evans, 1994; Rice, 1998; Perrin, 2002c). Evans (1994) shows the Atlantic distribution as continuous from Norway to equatorial west Africa on the east and in Iceland, Greenland, Labrador, and Newfoundland, then continuous to Argentina in the west, but that includes both *D. delphis* and *D. capensis*. In the western North Atlantic, common dolphins occur from Iceland south, but the southern limit of the distribution is unclear and appears to vary between years. Older reports of common dolphins off Florida or in the Gulf of Mexico and Caribbean are likely to be misidentifications of Clymene dolphins (Jefferson et al., 1992; Jefferson, 1997; Jefferson and Curry, 2003). Off the northeast U.S., common dolphin sightings occur over the outer half of the continental shelf and continental slope from North Carolina to Nova Scotia, with occasional sightings in shallower waters in the Gulf of Maine (CETAP, 1982; Waring et al., 2008). Of all of the shelf-edge odontocetes of the region, common dolphins occurred in the zone closest to shore, a habitat they shared with pilot whales and offshore bottlenose dolphins (CETAP, 1982; Kenney, 1990). In the overall record for the broader mid-Atlantic, common dolphins are the most frequently stranded delphinid in Rhode Island and New York; while in New Jersey and south bottlenose dolphins are much more common.

Common dolphins have an atypical seasonal pattern off the northeastern U.S., with peak abundance in winter—very different from all other dolphin species (CETAP, 1982; Selzer and Payne, 1988). In spring during 1979–1981, intermediate densities of common dolphins occurred along the entire outer shelf from Virginia to Georges Bank. Sightings were widely scattered in summer, with very low densities. The animals were thought to move north and east along the Nova Scotian shelf, however recent surveys did not observe substantial numbers of common dolphins there (Waring et al., 2008). Perhaps they move even farther north and east, or more offshore. In the fall, they were concentrated on Georges Bank in very high densities, extending west to about the longitude of Montauk Point. They reached their peak abundance in the winter, when they were again distributed all along the outer shelf from Virginia north.

Historical occurrence: Cronan and Brooks (1968) reported two historical records of common dolphins in Rhode Island—a specimen from Block Island with no date given and one captured alive in Point Judith Pond on 12 August 1966. The former most likely refers to the oldest known record in the study area in the Smithsonian dataset—a 203-cm dolphin captured “off Block Island” on 7 August 1882. Waters and Rivard (1962) said that common dolphins were relatively common in Cape Cod Bay, but made the counter-intuitive (and incorrect) conclusion that “even though most strandings take place in the winter, it is probably more abundant there in the warmer months.” They reported two specific Massachusetts records—a mass stranding of eleven in Wellfleet in February 1949 and a stranding in Dennis in January 1950. De Kay (1842) listed common dolphins as part of the New York fauna, but said they rarely came into shallow water. Linsley (1842) reported that they occurred in Long Island Sound, which Goodwin (1935) extrapolated to “it is probably not an uncommon visitor to the shores of this state [i.e., Connecticut].” Connor (1971) summarized a number of sighting, stranding, and capture records for New York from a variety of sources. Of note was the occurrence of a herd of 30–40 common dolphins seen in the Hudson River in October 1936, almost as far upriver as Albany (Stoner, 1938). There are seven stranding records in the Smithsonian dataset from eastern Long Island between 1923 and 1951, all taken from Connor (1971), but none in Rhode Island.

Recent occurrence: Common dolphins occur in the Rhode Island study area year-round, across much of the shelf but most commonly in waters deeper than about 60 m (Fig. 42). Seasonality is not particularly strong, with 33.6% of records in spring, 26.2% in summer, 18.2% in fall, and 21.8% in winter. Sightings are somewhat more common in the spring. Strandings also occur year-round. A concentration of sightings in summer southeast of Montauk Point is evident, in the area where the 60-m isobath comes closer to shore. Without the sightings from the whale-watching boats (2 in spring, 39 in summer, and 5 in fall), the spring peak is slightly stronger, but

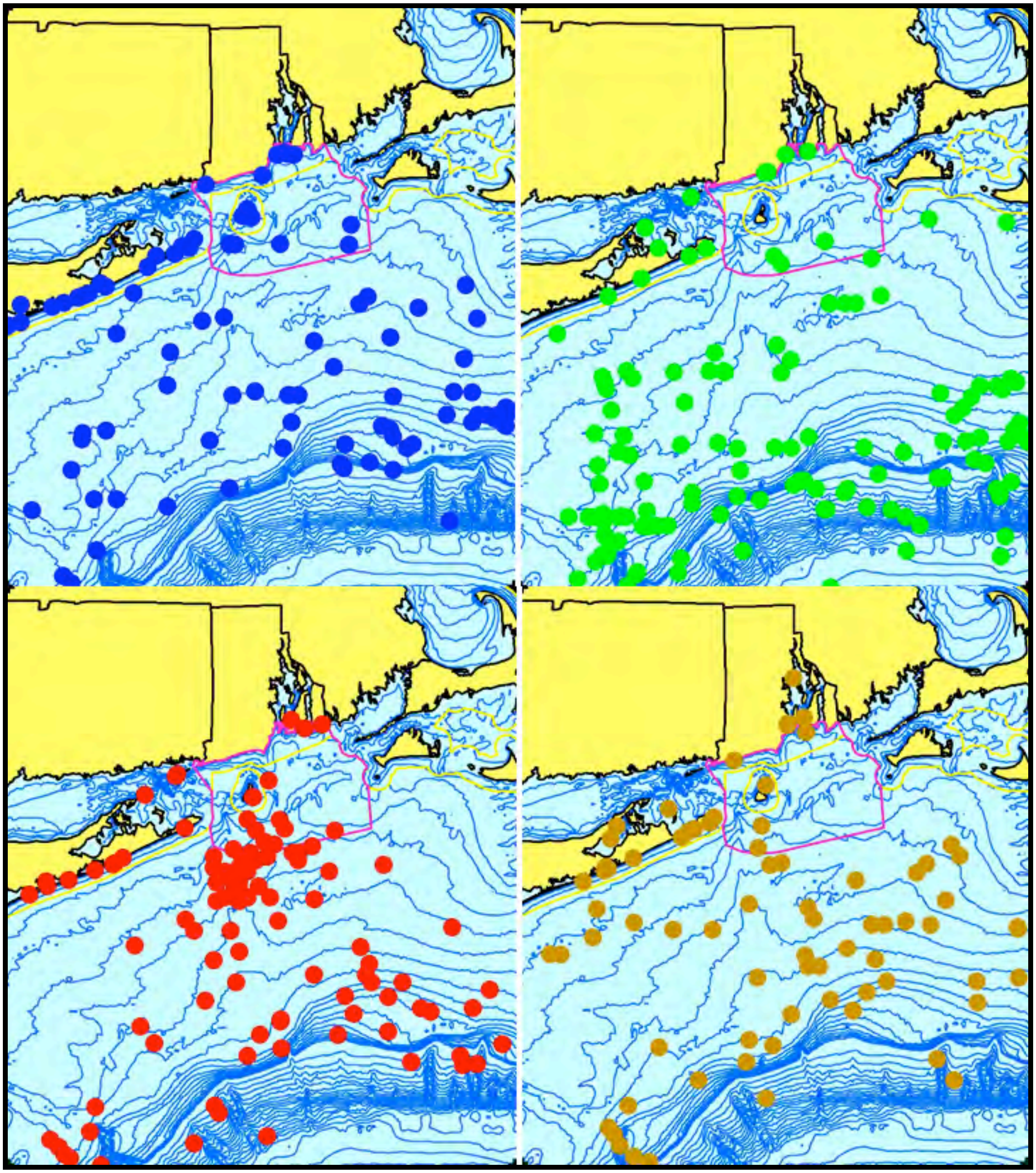

Figure 42. Aggregated sighting, stranding, and bycatch records of short-beaked common dolphins in the Rhode Island study area, 1882–2007 (n = 435: winter = 95, spring = 146, summer = 114, fall = 79, unknown = 1).

the seasonality during the rest of the year flattens out even more (24.4% winter, 37.0% spring, 19.3% summer, and 19.0% fall).

There are no recent records of common dolphins far up rivers, however such occurrences would only show up in the stranding database if the stranding network responded, and there is no centralized clearinghouse for opportunistic sightings of that type. In Rhode Island, there are occasional opportunistic reports of common dolphins in Narragansett Bay up as far as the Providence River, usually in winter.

The patterns of relative abundance show that short-beaked common dolphins are present in the Rhode Island study area in all four seasons (Fig. 43). They are consistently found on the outer half of the shelf, but do occur within the SAMP area in all seasons. Peak abundance in the study area is in the winter; peak abundance in the SAMP area is in the fall.

In the stranding record for the Rhode Island study area, common dolphins are the second most frequently stranded cetacean (exceeded only by harbor porpoises) and the most common delphinid (Table 2). There were 68 strandings in the study area between 1972 and 2005, including 23 in Rhode Island alone (Table 4). The rest were all in New York, including three on Fisher’s Island—one in May 1981 and two in August 1995, six days apart. The first 1995 Fisher’s Island animal was a 115-cm, 24-kg juvenile that was live-stranded, collected, and rehabilitated at Mystic Aquarium. The second was a dead 192-cm female, which may have been the juvenile’s mother. There was one stranding in Connecticut during the period, but it was west of the study area in Fairfield. Strandings are even more frequent in Massachusetts, with 148 in 2001–2005 (Waring et al., 2008), but those are almost all on Cape Cod and include several mass strandings (e.g., 41 dolphins in four events in 2005). Stranding frequency spiked in 1996–2000, and was somewhat lower but still elevated in 2001–2005 (Fig. 44). The underlying reason for the increase is not known. There is also a clear seasonal pattern in the strandings, with a peak in the winter, a minimum in spring, and a smaller peak in summer (Fig. 45). Seasonal percentages were 40% in winter, 13% in spring, and 24% in both summer and fall.

Conclusions: Short-beaked common dolphins are very likely the most abundant marine mammal in the Rhode Island study area. They are also likely to occur in the SAMP area in all four seasons of the years. Although there are few serious management concerns about the

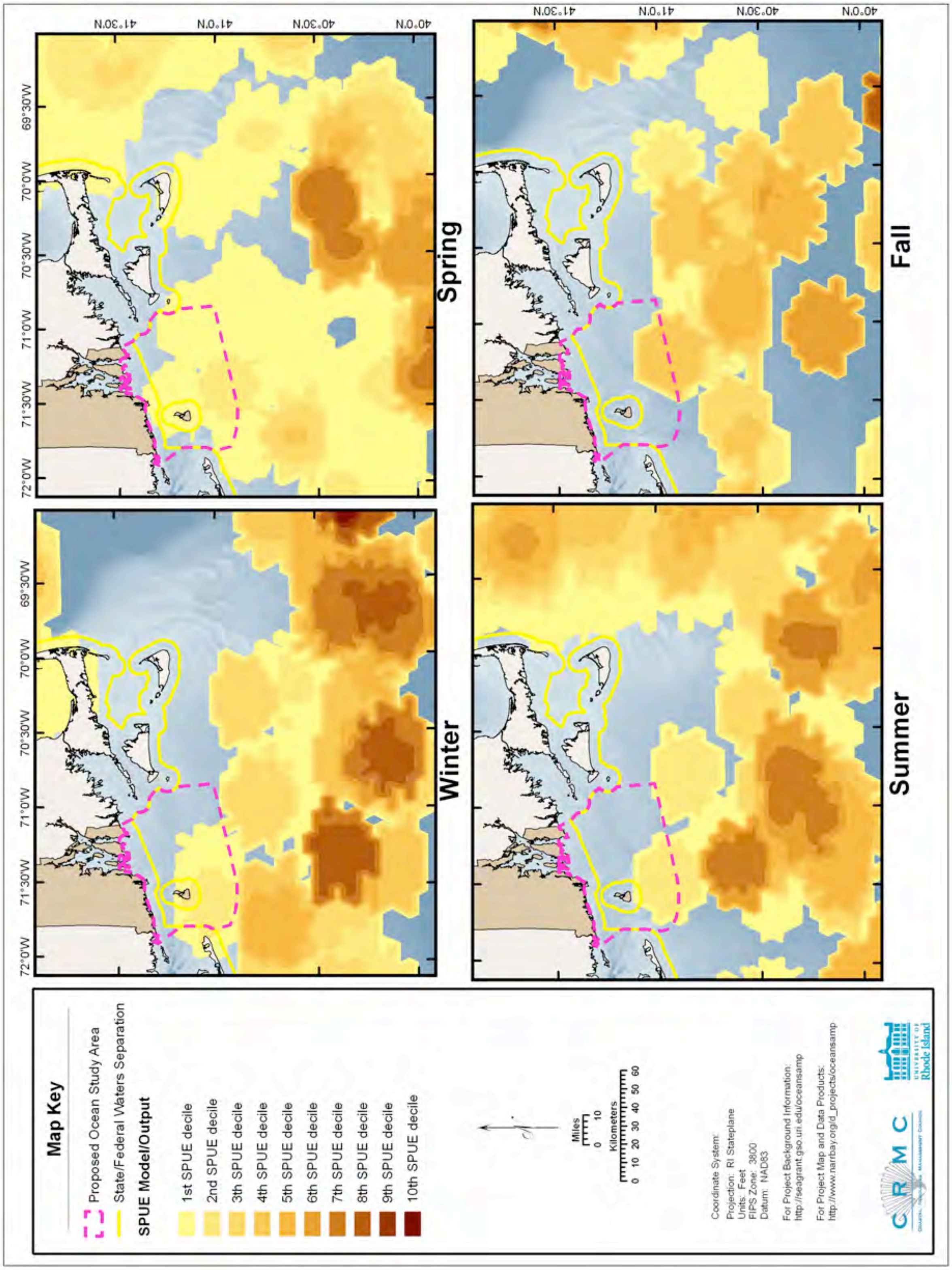

Figure 43. Modeled seasonal relative abundance patterns of short-beaked common dolphins in the Rhode Island study area, corrected for uneven survey effort.

Table 4. Rhode Island strandings of short-beaked common dolphins

Date	Locality	Notes
21 Nov 1983	Block Island, N of state beach	225-cm female
31 May 1986	Newport, near the mansions	live-stranded, was pushed off
25 Jun 1990	Newport, Coasters Harbor	205-cm female, alive, died 2 days later
02 Dec 1991	Newport, Bailey’s Beach	181-cm male
26 Feb 1996	Point Judith, just inside east wall	206-cm, 78-kg male; both mandibles fractured, undigested food in stomach
14 Mar 1996	Narragansett, near Ft. Varnum	216-cm male
05 Dec 1996	Block Island, near Dories Cove	219-cm male
14 Feb 1997	Block Island, SW corner	176-cm male, propeller wounds
19 Jan 1998	Newport, Price’s Cove	
15 Jul 1998	Middletown, Sachuest Point	
01 Jun 1999	Little Compton	
04 Nov 1999	Newport, Bailey’s Beach	
05 Nov 1999	Westerly, Weekapaug Beach	
06 Dec 1999	Jamestown, Beavertail Point	
31 Dec 1999	Block Island	
30 Mar 2000	South Kingstown, Matunuck	
05 Apr 2000	South Kingstown, Town Beach	
09 Jun 2000	Block Island, Old Harbor	
14 Dec 2000	Westerly, Misquamicut Beach	
22 Dec 2002	Block Island, Old Harbor	
05 Jan 2003	Portsmouth, Island Park	
27 Oct 2003	Narragansett, Bonnet Shores	198-cm female, lactating, probably the mother of the calf seen earlier that day swimming alone off the Bay Campus; very worn teeth and thin blubber
05 Sep 2004	Warwick	

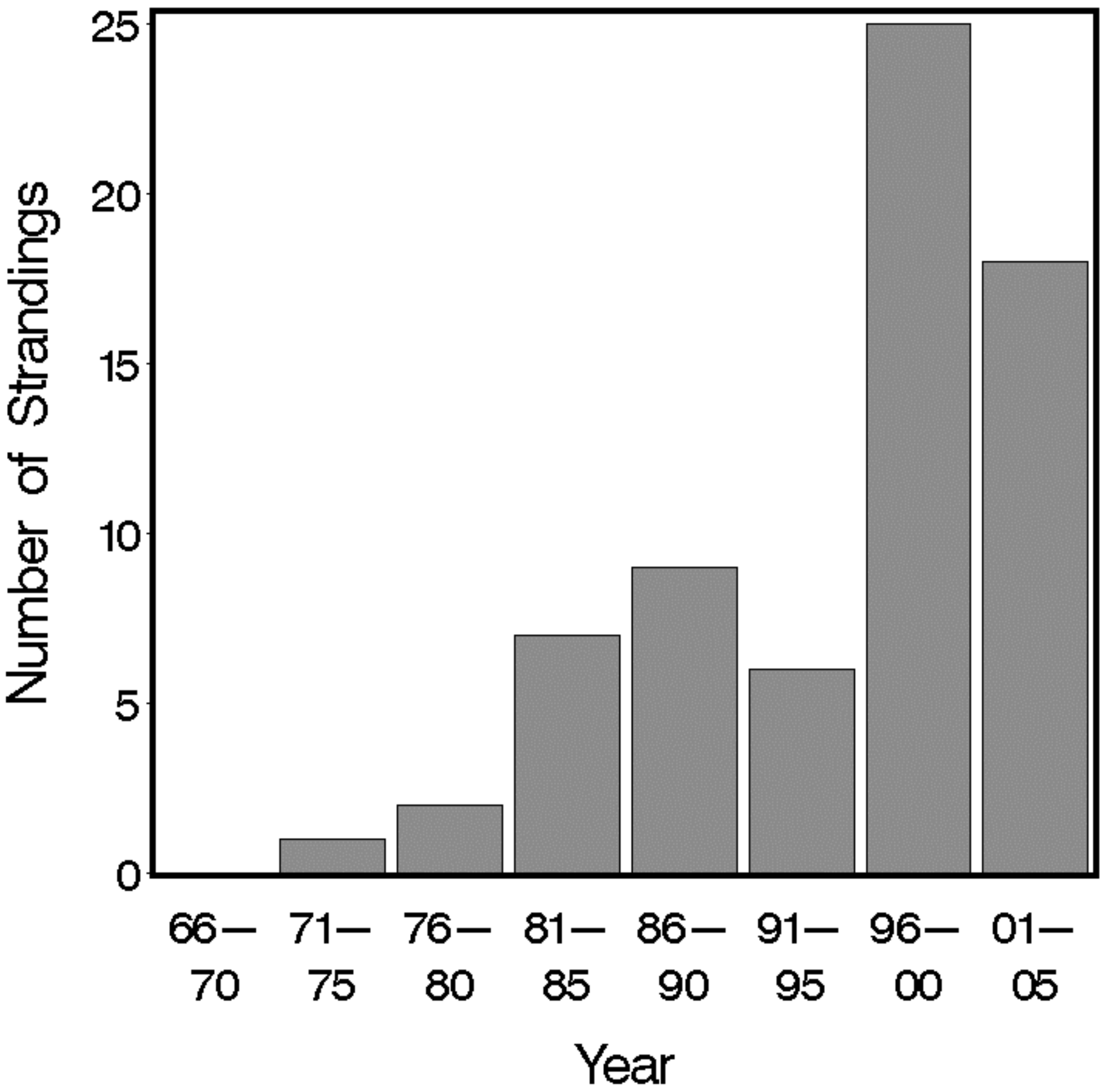

Figure 44. Five-year stranding frequencies for short-beaked common dolphins in the Rhode Island study area, 1966–2005.

population, their relative abundance would put them in the second tier of priority species relative to the SAMP.

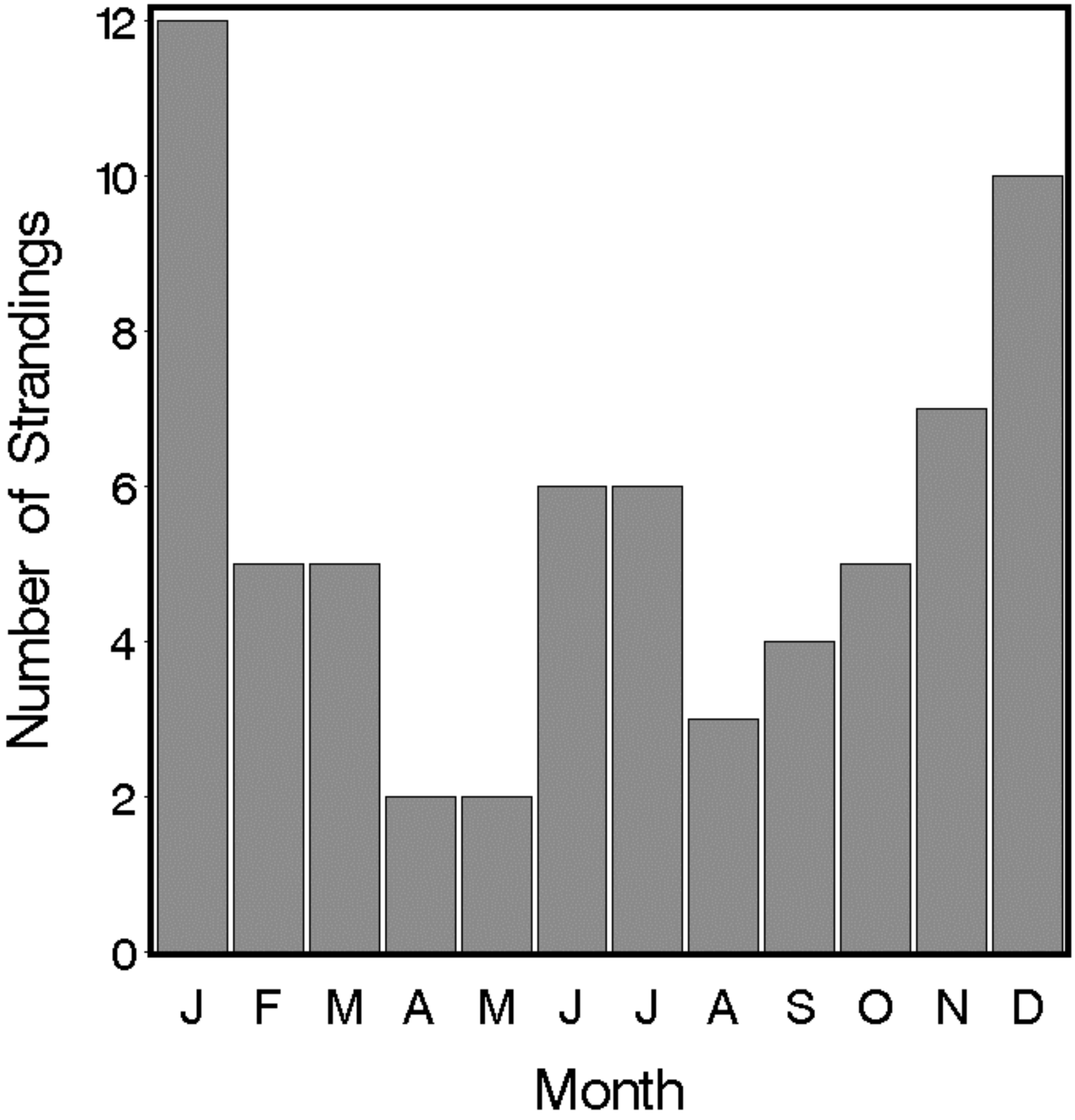

Figure 45. Monthly stranding frequencies of short-beaked common dolphins in the Rhode Island study area.

3.2.22. Striped Dolphin *Stenella coeruleoalba* (Meyen, 1833)

Description: Striped dolphins are typical of all the *Stenella* species in size and shape, and are very distinctively patterned (Jefferson et al., 1993; Perrin et al., 1994c; Archer and Perrin, 1999;

Wynne and Schwartz, 1999; Archer, 2002). They are slender and long-beaked, with tall falcate dorsal fins. Adults are up to 1.5–2.5 m long, with the largest animal known at 256 cm. Animals in the Mediterranean may be somewhat smaller than those in the North Atlantic. The cape is dark blue-gray, very narrow above the eye and widest in front of the dorsal fin (at about the midpoint of the flipper), and ends less than halfway back from the dorsal fin to the tail. There is a prominent pale band (the spinal blaze) extending from just above the flipper upward and backward into the cape toward the dorsal fin. Below and behind the cape, the sides and back are lighter gray, fading into a whitish (sometimes pink) belly. The upper beak is black, and the lower is gray to black. There is a bold black stripe from the upper jaw to the eye, where it divides into one stripe to the flipper, often a short thin stripe ending above the flipper, and a very bold stripe extending the length of the body back to the anus.

Status: Striped dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list and are classified as Least Concern the IUCN Red List. There are no reliable estimates of the total abundance of striped dolphins in the North Atlantic. The first abundance estimate off the U.S. Atlantic coast was from the CETAP (1982) surveys, which estimated that there were 4,300 striped dolphins in the spring. That number was negatively biased for two reasons. The CETAP study used only aerial surveys for estimating abundances, and many aerial sightings could only be identified to *Stenella* sp. Secondarily, the aerial surveys were almost entirely limited to continental shelf waters, and the majority of the striped dolphin sightings during the program were beyond the shelf (by shipboard observers). Kenney et al. (1997) attempted to address the first of those negative biases by partitioning the estimated abundances of unidentified *Stenella* sp. based on the proportions of identified sightings of striped, spotted, and spinner dolphins, which derived striped dolphin estimates of 6,491 in winter, 12,025 in spring, 16,320 in summer, and 13,482 in fall. More recent NMFS surveys for marine mammal stock assessments (Waring et al., 2008), using shipboard surveys that extended well beyond the edge of the shelf, produced estimates of striped dolphin abundance off the U.S. east coast of 49,945 in 1998 and 94,462 in 2004, with an additional 6,505 in the Gulf of Mexico.

There has been a directed small-cetacean fishery in a number of coastal villages in Japan, with records back to the mid-19th Century but probably dating back to at least the early 15th Century (Perrin et al., 1994c; Archer and Perrin, 1999). Takes averaged 8,000–9,000 annually along one section of the coast, and overall takes were about 14,000 per year, during the 1940s and 1950s, with peak catches of over 21,000 in 1942 and 1959 (Kishiro and Kasuya, 1993). Recent takes of striped dolphins in coastal small-cetacean fisheries in Japan were 300 in 2000, 484 in 2001, 642 in 2002, and 450 in 2003 (IWC, 2005, 2006). There have also been directed harvests in the Lesser Antilles and in the Mediterranean (Archer, 2002).

Mortality of striped dolphins as bycatch in commercial fisheries has been observed in a number of locations around the world (Archer and Perrin, 1999; Archer, 2002), including the Pacific tuna purse-seine fishery. There was no known bycatch mortality of striped dolphins in U.S. Atlantic commercial fisheries in 2001–2005 (Waring et al., 2008). In previous years, there was bycatch estimated in two fisheries. Two striped dolphins were killed in the bottom trawl fishery in 1991, which extrapolated to an estimated mortality for the entire fishery of 181 animals. The average annual striped dolphin mortality in the pelagic swordfish driftnet fishery in 1989–1998 (now closed) was 17.

A dolphin morbillivirus epizootic in the western Mediterranean Sea killed over 1,100 striped dolphins in 1990–1992 (Aguilar and Raga, 1993; Perrin et al., 1994c). A later survey estimated the Mediterranean population of striped dolphins at 225,000, which would suggest that the mortality rate from the epizootic was relatively insignificant (less than 0.5%). Toxic contaminants, particularly organochlorines, were suspected to have played a role, acting as an immunosuppressant that then allowed a naturally occurring virus to cause disease (Aguilar and Raga, 1993; Aguilar and Borrell, 1994). Blubber PCB levels as high as 2,500 ppm were measured in the stranded striped dolphins during that event, which were among the highest levels ever recorded in a cetacean.

Ecology and life history: Striped dolphins are gregarious and may be observed in very large herds. In the eastern tropical Pacific average school size was 28–83 animals (Wade and Gerrodette, 1992). The mean school size in Japan is about 100, while in the eastern North Atlantic it is only 10–30 (Perrin et al., 1994c; Archer and Perrin, 1999). The average school size observed off the northeastern U.S. was 64.9 (CETAP, 1982), with a range 1 to 500. This was the largest average school size of all species observed, nevertheless the modal group size was still relatively small at 20.

Striped dolphins are known to segregate into juvenile, adult, and mixed schools, and adult and mixed schools can be either breeding or non-breeding (Miyazaki and Nishiwaki, 1978; Perrin et al., 1994c; Archer and Perrin, 1999). Calves leave the mixed schools 1–2 years after weaning and join juvenile schools. Within breeding schools there are structured subgroups of only adult males or adult females.

Striped dolphins are very active and acrobatic, with frequent leaps, spins, and somersaults, and they may bow-ride (Perrin et al., 1994c; Archer and Perrin, 1999; Archer, 2002). They are known for an aerial behavior called “roto-tailing,” which involves making a high jump while rapidly rotating the tail.

Striped dolphins sometimes associate with yellowfin tuna in the eastern tropical Pacific, but less than short-beaked common dolphins and much less than spinner or pan-tropical spotted dolphins (Archer and Perrin, 1999). They are known to occur commonly in mixed schools with short-beaked common dolphins off Japan and in the Mediterranean. Off the northeastern U.S. they were observed to be associated with other species only on a few occasions, usually with common dolphins (CETAP, 1982). Globally, striped and short-beaked common dolphins tend to occur in areas where spinner and pan-tropical spotted dolphins do not (Perrin et al., 1994c).

Mass strandings are rarely observed in striped dolphins (Archer, 2002). There was a stranding of a group of 12 striped dolphins in North Carolina in 2005 (Waring et al., 2008).

Striped dolphins overall feed on a very wide variety of fish and squid, including both pelagic and benthic species, with sharp differences among geographic regions (Perrin et al., 1994c; Archer and Perrin, 1999; Archer, 2002). The dominant prey items off Japan are mesopelagic myctophids (“lanternfishes”). In the northeastern Atlantic their main prey is cod, and in the Mediterranean they primarily eat squid. Extrapolating from prey species, they may commonly dive to 200–700 m for foraging. Stomachs of all stranded specimens examined in Long Island have contained squid beaks, suggesting a preference for squid in the Rhode Island study area (S. S. Sadove, pers. comm.).

Hassani et al. (1997) looked at the stomach contents of common and striped dolphins taken as bycatch in a pelagic driftnet fishery in the northeastern Atlantic. Both species fed primarily on squid, which comprised nearly 60% of the prey items in striped dolphins. Secondary prey in striped dolphins were crustaceans (shrimp and krill, about a third of diet), and fish were a relatively minor component.

The majority of the life-history data are derived from animals taken in the directed fishery in Japan, with additional data from animals caught in the tuna fishery (Perrin et al., 1994c; Archer and Perrin, 1999; Archer, 2002). Calves are born at 93–100 cm in length after a gestation period of 12–13 months. Calving may occur at almost any time of year with one or two diffuse peaks—winter and summer off Japan, spring or spring and fall in other areas. Lactation lasts for 1–1.5 years. Off Japan, calves grow to an average length of 166 cm at age 1, and to 180 cm at age 2. Between 2 and 3 years of age, males and females diverge in body size, with males growing larger and typically exceeding females by 10–15 cm as adults. Mean length at sexual maturity in females is 2.1–2.2 m. Maturity in females occurs at 5–13 years of age and in males at 7–15. Fecundity in females declines markedly at around age 30, but reproduction does not stop completely. In striped dolphins in Japan, the female age at maturity declined from 9.7 to 7.2 years, and the inter-birth interval dropped from 4 to 3 years, with both believed to be density-dependent responses to population declines caused by the small-cetacean fishery.

General distribution: Striped dolphins are distributed world-wide in temperate to tropical waters, although the distribution is poorly known in the South Atlantic where research has been sparse (Perrin et al., 1994c; Rice, 1998; Archer and Perrin, 1999; Archer, 2002). In the North Atlantic, they have the most temperate distribution of the five *Stenella* species, extending from northern South America to New England and Nova Scotia and from the Mediterranean to the British Isles. They are the most commonly sighted cetacean in the Mediterranean. There are a few sightings from Newfoundland, southern Greenland, Iceland, and the Faroe Islands, which may be extralimital. Striped dolphins are frequently sighted off the northeastern U.S. and Nova Scotia (CETAP, 1982; Gowans and Whitehead, 1995; Waring et al., 2008). Their distribution off the northeastern U.S. during the CETAP surveys was primarily along the outer shelf and into deeper waters, despite the very strong bias of the sampling to the shelf. Unlike all other cetaceans of the region, there was very little seasonal pattern to their distribution. In addition, their depth distribution in the CETAP data was significantly deeper than any other species, with an average sighting depth of 2,076 m and with 90% of the sightings between 101 and 3,749 m. There have been no sightings south of Cape Hatteras during any of the recent NMFS surveys, although there are strandings in Florida to North Carolina and striped dolphins do occur in the Gulf of Mexico (Waring et al. 2008). Nothing is known of stock structure, e.g., whether the animals seen in the Gulf of Mexico and off the northeastern U.S. come from the same or separate stocks.

Historical occurrence: Cronan and Brooks (1968) reported a stranding of an “old,” 241-cm male on the town beach in Narragansett on 5 December 1966. They also indicated that there was a previous record for Woods Hole, Massachusetts. Waters and Rivard (1962) said that the species was very rare in New England and cited no recent Massachusetts records. Striped dolphins were not mentioned in De Kay (1842), Linsley (1842), or Goodwin (1935). Connor (1971) reported two historical stranding records for Long Island, but only one was within the Rhode Island study area—in May 1929 at Bellport. That is the oldest striped dolphin record in the study area. Other than the 1929 Bellport and 1966 Narragansett strandings, there is only one other pre-1970 striped dolphin record from the study area. The Harvard Museum of Comparative Zoology has a specimen from a 62-kg animal collected about 150 km south of Block Island on 27 July 1961 by M. R. Bartlett (MCZ51071).

Recent occurrence: Striped dolphins in the Rhode Island study area are observed either stranded on a beach or very far offshore, with few observations in between (Fig. 46). The records occur in approximately equivalent numbers in all four seasons, with 31.7% in the winter, 29.3% in summer, 18.5% in fall, and 19.5% in spring. That pattern may be misleading, however, since the sightings and strandings follow opposite trends. Striped dolphins are the sixth most common stranded cetacean in the region (Table 2). Strandings are primarily in fall (8, 29%) and winter (11, 39%), followed by spring (5, 18%) and summer (4, 14%). There are fewer than half as many sightings (13, including captures) as strandings (28), and they are mainly in the summer (8, 73%), with 3 (23%) in spring, 2 (15%) in fall, and none in winter. The seasonality in the sightings is surely due to sampling effort, especially from shipboard surveys beyond the shelf break. The survey data included too few sightings within our analysis area to develop SPUE estimates or produce relative abundance maps.

Stranding frequency has been relatively constant over time (Fig. 47). The small spike in the early 1990s may not be anything more than random interannual variability. Eleven of 26 strandings in the study area since 1966 have been in Rhode Island, which is a higher proportion than any for other cetacean. On 10 December 1978, a 174-cm striped dolphin stranded in Charlestown. A 147-cm juvenile stranded on First Beach in Middletown on 3 October 1980. A 121-cm calf stranded on the south shore of Little Compton on 26 June 1985. Later that year, on 7 September, a 241-cm adult live-stranded near the Stone Bridge in Portsmouth, but it died later that same day. A 235-cm adult male washed ashore on Matunuck Beach on 10 February with

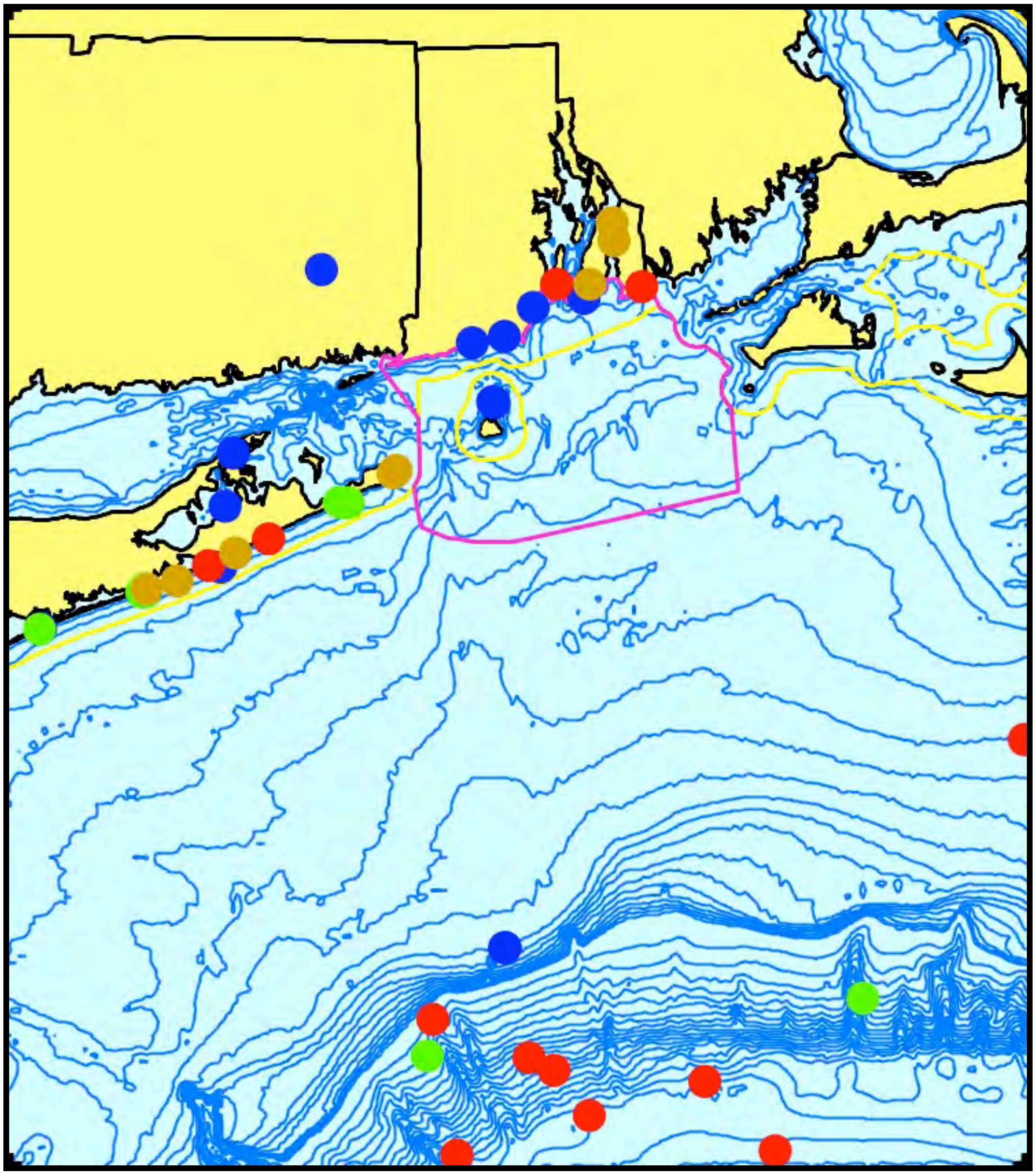

Figure 46. Aggregated sighting, stranding, and bycatch records of striped dolphins in the Rhode Island study area, 1929–2004 (n = 41: winter = 13, spring = 8, summer = 12, fall = 8).

both jaws severely fractured; the trauma was judged to be evidence of some sort of collision. A 136-cm, 27-kg juvenile female was seen swimming near Seapowet Beach in Tiverton on the morning of 20 November 1995; it died and stranded that afternoon. Striped dolphins stranded in Cow Cove at the northern end of Block Island on 10 January 1997 and 22 January 2000. On 4 June 2001 at 15:30, Jamestown police reported that a dolphin was seen swimming erratically and

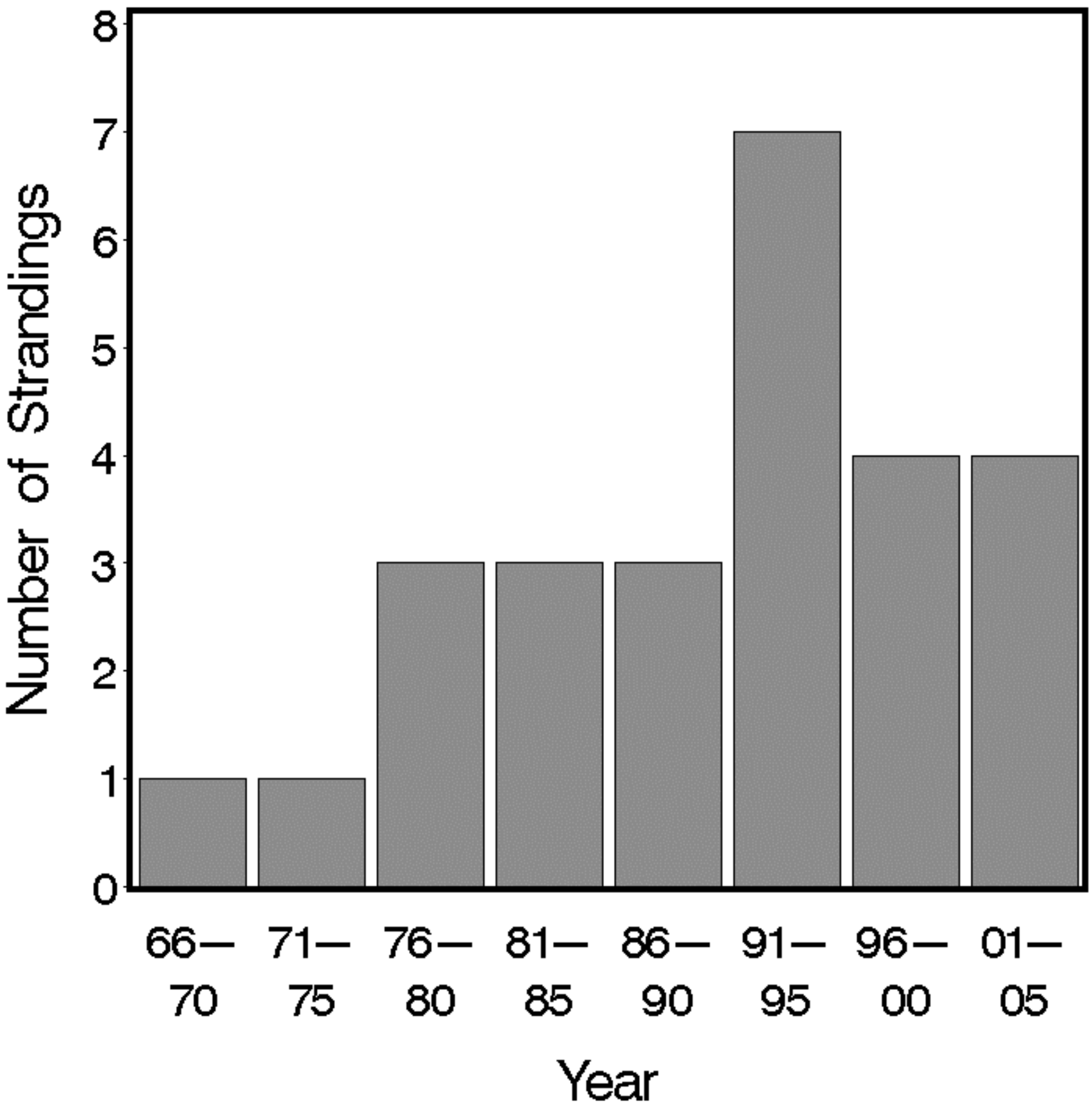

Figure 47. Five-year stranding frequencies for striped dolphins in the Rhode Island study area, 1966–2005.

seemingly in distress just off the beach at Mackerel Cove. It died and stranded by 17:15, when the carcass was recovered from the beach. It was a 201-cm adult or sub-adult male, and there was no discernible cause of death. Finally, a striped dolphin stranded near Sheep Point on the east side of Newport on 11 January 2002.

Conclusions: While striped dolphins are one of the most abundant cetaceans off the northeastern U.S., their distribution is very far offshore. They have never been sighted in or near the SAMP area, and do not pose any concern relative to the SAMP.

3.2.23. Atlantic Spotted Dolphin *Stenella frontalis* (G. Cuvier, 1829)

Pan-tropical Spotted Dolphin *Stenella attenuata* (Gray, 1846)

The two species of spotted dolphins are broadly sympatric in the North Atlantic, are difficult to distinguish at sea, and have been frequently combined in survey and bycatch data, sometimes even in stranding data. It was not until the paper by Perrin et al. (1987) that the taxonomy of the spotted dolphins was sorted out. Prior to that, a variety of different common and scientific names were used, so it is not always clear which species may be referred to in particular instances. For example, Leatherwood et al. (1976) used the binomial *Stenella plagiodon* for the Atlantic spotted dolphin (*Stenella frontalis*), and used the common name bridled dolphin and binomial *Stenella frontalis* for the pan-tropical spotted dolphin (*Stenella attenuata*). Both are known from the Rhode Island study area, and they are combined here.

Description: Atlantic spotted dolphins are the most robust-bodied of the *Stenella* species, enough so that a young, unspotted animal may be mistaken for a young bottlenose dolphin. Adults are 1.7–2.3 m in length, with a tall, falcate dorsal fin, long but relatively thick beak, and moderately developed keels (Perrin et al., 1987, 1994a; Jefferson et al., 1993; Wynne and Schwartz, 1999; Perrin, 2002a, 2002e). They have a three-toned color pattern, with a dark gray cape that is widest below the dorsal fin, lighter gray sides, and a white belly. The tailstock is almost uniformly gray top and bottom. There is a pale gray “spinal blaze” that starts in the “shoulder” area above the flipper and extends upwards and backwards into the cape towards the dorsal fin, which may not be clearly visible on all individuals. The combination of spinal blaze and spots is diagnostic for *S. frontalis*. Calves are born without spots. Dark ventral spots begin to appear at about the time of weaning. Around puberty, the ventral spotting increases and pale dorsal spots begin to appear. The spotting intensifies, such that it can largely obscure the margins of the cape and lateral gray bands, but the ventral spots remain distinct in adults and do not fuse together. The tip of the beak is often distinctly white, there may be thin white borders along the lips, and there is a dark stripe from the corner of the mouth to the eye and then to the flipper. This latter character is variable, with some specimens having the mouth-to-flipper stripe passing below the eye. Along the eastern U.S., there are relatively distinct inshore and offshore forms, with the offshore animals smaller, lighter, and less heavily spotted than the inshore animals, i.e., more similar in appearance to pan-tropical spotted dolphins. The larger, more spotted inshore animals represent the stock that may be a separate subspecies referable to *Stenella frontalis plagiodon*. Some offshore animals may be nearly unspotted, even as adults.

Pan-tropical spotted dolphins are very similar in body form to spinner dolphins, with a slender body, long thin beak, and prominent keels on the tailstock (Perrin et al., 1987; Jefferson et al., 1993; Perrin and Hohn, 1994; Wynne and Schwartz, 1999; Perrin, 2001, 2002d). The beak is shorter and the dorsal fin is more falcate than in spinners. Body size in adults is 1.6–2.6 m, with averages of 187 cm for females and 200 cm for males. They are more slender than Atlantic spotted dolphins, averaging 10–30 kg less at the same body length. The basic body pattern appears essentially two-toned. The dark gray cape is very narrow at the head, curving up well above the eye, and dips low on the side in front of the dorsal fin. There is no pale spinal blaze in the cape as in *S. frontalis* and *S. coeruleoalba*. Behind the dorsal fin the cape margin rises to the back and behind it the tailstock is clearly two-toned, lighter gray dorsally and white ventrally. The tip of the beak is often white, and there may be thin white borders along the lips. There is a black stripe from the upper jaw to the eye, and one from the corner of the mouth to the flipper. Overlaid on top of the basic pattern is the spotting. Calves are born without spots—dark gray above and ivory white below. The belly gradually turns light gray. Spotting begins with dark gray spots on the throat and abdomen, followed by pale dorsal spots. The ventral spots gradually increase in number and size, first touching each other and causing a mottled ventral appearance, then fusing and fading to a slightly mottled to uniform pale gray. The spotting does not obscure the margin of the cape. The flippers, flukes, and dorsal fins are smaller than in Atlantic spotted dolphins.

Status: Atlantic spotted dolphins are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Data Deficient on the IUCN Red List. Pan-tropical spotted dolphins are not listed under the U.S. Endangered Species Act, are not included on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There are no estimates of the total North Atlantic abundance number of either species of spotted dolphin. For continental shelf waters between Cape Hatteras and the Gulf of Maine, CETAP (1982) estimated only a few hundred undifferentiated spotted dolphins, however those estimates were exclusively from aerial surveys, and a large proportion of aerial sighting could be identified only to *Stenella* sp. Kenney et al. (1997) partitioned the abundance estimates of "unidentified *Stenella*" into striped dolphin, spotted dolphin, and spinner dolphin based on the proportions of identified sightings—with estimates of spotted dolphins (both species combined) of 589 in winter, 1,689 in fall, 1,975 in spring, and 2,441 in summer. The estimated abundances from the more recent NMFS stock assessment surveys are substantially greater, since the surveys included the area from Florida to the Nova Scotian shelf and extended much farther offshore (Waring et al., 2008). Atlantic spotted dolphins were estimated at 46,481 in 1998 and 50,978 in 2004. There is also an estimate of 30,947 in the Gulf of Mexico. Pantropical spotted dolphins were estimated at 13,090 in 1998 and 4,439 in 2004, with 91,321 in the Gulf of Mexico.

Atlantic spotted dolphins are intentionally taken in small numbers by traditional fisheries in St. Vincent in the Lesser Antilles and maybe at some of the other islands (Perrin, 2002e). They are also taken as bycatch in tuna purse seines off West Africa. Offshore stocks of pan-tropical spotted dolphins and spinner dolphins were most seriously impacted by bycatch mortality in the Pacific tuna purse-seine fishery. There is also a directed fishery for small cetaceans in some coastal villages in Japan. Takes of pan-tropical spotted dolphins in Japan totaled 39 in 2000, 10 in 2001, 418 in 2002, and 132 in 2003 (IWC, 2005, 2006). There are also similar small-cetacean fisheries in the southwestern Pacific (Perrin, 2002d).

The average annual mortality of spotted dolphins in U.S. Atlantic commercial fisheries in 2001–2005 was 6, all in the swordfish longline fishery (Waring et al., 2008). From 1989 to 1998, the average annual mortality of spotted dolphins (not differentiated to species) in the pelagic swordfish driftnet fishery was 16 animals per year, ranging from 0 to 51. That fishery was shut down after the 1998 season for excessive marine mammal bycatch. Six spotted dolphins from the driftnet bycatch were sent to the Smithsonian for examination and identification, and all six were the pantropical species.

Ecology and life history: Atlantic spotted dolphins tend to occur in groups of fewer than 50, most often 1–15, although schools of 100 or more may occur offshore (Perrin et al., 1994a; Perrin, 2002a, 2002e). They are very active, acrobatic, and frequent bow-riders, and commonly break the surface with the tip of the beak when surfacing. Long-term studies in the Bahamas by Herzing (1997) show very fluid groupings of individuals, with some evidence of segregation by age and sex. In the Bahamas, Atlantic spotted dolphins frequently associate with bottlenose dolphins (Herzing and Johnson, 1997). A tagged individual in the Gulf of Mexico made dives up to 40–60 m deep and 6 minutes in duration, but the majority of dives were shallower than 10 m (Davis et al., 1996).

Stenella frontalis feeds on small to large epipelagic and mesopelagic fishes and squid, and sometimes on benthic invertebrates (Perrin et al., 1994a; Perrin, 2002a, 2002e). It is probable that the diet differs between the inshore and offshore forms.

The available data for Atlantic spotted dolphins are more limited than for pan-tropical spotters, since there are not large samples of by-caught animals (Perrin et al., 1994a; Perrin, 2002a, 2002e). Calves are probably born at 90–100 cm. Females mature at about 190 cm along the U.S. Atlantic and 180 cm in St. Vincent in the West Indies. Males mature at 170–180 cm. The age at maturity in females in the Bahamas is estimated to be 9–15 years old (Herzing, 1997). The inter-birth interval is 1–5 years, averaging about 3.

Pan-tropical spotted dolphins may occur in schools from a few animals to several thousand (Perrin and Hohn, 1994; Perrin, 2001, 2002d). Within a large school there are distinct subgroups separated by age and sex—mother and calves, adult males, and juveniles—which tend to remain stable. There is evidence for an annual cycle of migration, inshore in spring and summer and offshore in fall and winter. They are very active, acrobatic, and frequent bow-riders. Dive data are limited, with dives known only up to 3.4 minutes in duration. In the Pacific, they commonly associate with spinner dolphins, short-beaked common dolphins, and yellowfin tuna.

Stenella attenuata in offshore Pacific waters feeds primarily on small epipelagic fishes, squid, and crustaceans, with some mesopelagic species (Perrin et al., 1973; Robertson and Chivers, 1997; Perrin and Hohn, 1994; Perrin, 2001, 2002d). Flying fish appear to be important prey, at least at times. The large inshore Pacific form may feed on larger benthic fishes. Archer and Robertson (2004) analyzed 203 stomachs from dolphins killed in the tuna fishery. Calves began to feed on myctophids at about 6 months of age while still nursing, then shifted their diet more to squid during weaning.

Pan-tropical spotted dolphins are born at 80–85 cm, and reach body lengths of 129–142 cm by 1 year of age (Perrin and Hohn, 1994; Perrin, 2001, 2002d). Calving is spread out over an extended period, with peaks in spring and fall, and maybe also in summer. Both males and females begin to mature at about 160 cm, at which time males have a secondary growth spurt. Females mature at 9–11 years old, males at 12–15. The gestation period is 11.2–11.5 months. Lactation lasts is 1.4–2.1 years; the mean age and size at weaning in the Pacific bycatch sample analyzed by Archer and Robertson (2004) was 9 months and 122 cm. The inter-birth interval is 2–3 years. Both lactation period and inter-birth interval appear to vary in a density-dependent fashion with population status.

General distribution: Atlantic spotted dolphins are found only in subtropical and tropical waters of both the North and South Atlantic Oceans, between about 50ºN and 25ºS (Perrin et al., 1994a; Rice, 1998, Perrin, 2002a, 2002e). They appear to be more common on the western side of the basin—along the U.S. east coast to the Gulf of Mexico, Caribbean, and West Indies. There are scattered records from the South Atlantic near South America and Africa, and offshore, but there has been little research in those areas so they could be more common than the current data show. They are also known from the Azores, Canaries, and Cape Verdes, but not from Europe. There are numerous stranding records and older sighting records from the southeast U.S. for this species, and a few strandings along the northeast U.S. coast to Massachusetts.

Pan-tropical spotted dolphins are found in subtropical and tropical waters on both sides of the equator in all oceans between approximately 30–40ºN and 20–40ºS, a distribution nearly identical to that of the spinner dolphin (Perrin and Hohn, 1994; Rice, 1998; Perrin, 2001, 2002d). In the Atlantic the distribution seems to be mainly offshore and around oceanic islands. There are stranding records from Florida, and a scattering of strandings from North Carolina to Massachusetts.

In the western North Atlantic, distributional information about spotted dolphins has been confused by the occurrence of two similar species with overlapping ranges, confounded by the previous uncertainty regarding common and scientific names. Sightings of spotted dolphins were relatively numerous north of Cape Hatteras during the CETAP (1982) surveys, comprising about 40% of the identified *Stenella* sightings, but they were not differentiated to species, principally because the majority of the sightings came from aerial surveys. (Striped dolphin was the most frequently sighted *Stenella*, at 57% of the identified sightings, with a few spinner dolphin sightings and one Clymene sighting). The spotted dolphin sightings ranged from the middle of the shelf out into very deep water, were most common off North Carolina and Virginia, and were rare north and east of Hudson Canyon. There were a few sightings identified to species, which were about three-quarters Atlantic and one-quarter pan-tropical spotters.

There have been additional sightings during the more recent NMFS assessment surveys, which have included a much larger shipboard component and have been able to identify a higher proportion of spotted dolphins to species (Waring et al, 2008). Spotted dolphins now make up 48% of the total *Stenella* sightings (with striped dolphins down to 49%), and pan-tropical spotters are less than 10% of the identified spotted dolphins. Sightings identified to pan-tropical spotters are almost all very far offshore, and mostly south of Cape Hatteras, but there were three sightings on the edge of Georges Bank. Pan-tropical spotted dolphins are the most commonly observed offshore cetacean species in the Gulf of Mexico, and are relatively common in the West Indies.

Historical occurrence: There are no historical records of either spotted dolphin from the Rhode Island study area. Cronan and Brooks (1968) did not mention either species for Rhode Island. The same is true for Waters and River (1962) for Massachusetts. Neither De Kay (1842) nor Linsley (1842) reported either species of spotted dolphins from New York or Long Island Sound, but both species were poorly known at that time, if at all. Goodwin (1935) mentioned Atlantic spotted dolphin (as *Prodelphinus plagiodon*) and said that the nearest known specimen was from New Jersey. Connor (1971) stated that *Stenella* "*plagiodon*" was a southern species reported from southern New Jersey.

Recent occurrence: There have been only nine scattered occurrences of spotted dolphins in the Rhode Island study area (Fig. 48). The first two confirmed spotted dolphin records for the Rhode Island study area were only two weeks apart in 1979. A shipboard observer sighted a pair of unidentified spotted dolphins offshore of the shelf break in the southeastern part of the Rhode Island study area on 16 August. On 1 September a CETAP aerial survey sighted a group of 100 unidentified spotters was sighted over the slope west of the August sighting. Another CETAP survey sighted a group of 40 on 22 August 1981 in the mid-shelf area south of Block Island. The other three sightings, all far offshore near or beyond the shelf break, came from an opportunistic sighting database originally created to map seabird distributions (PIROP, Programme Intégré des Recherches sur les Oiseaux Pélagiques)—two sightings of Atlantic spotters in July and October 1982 and one sighting of pan-tropical spotters in July 1984. All spotted dolphin sightings from

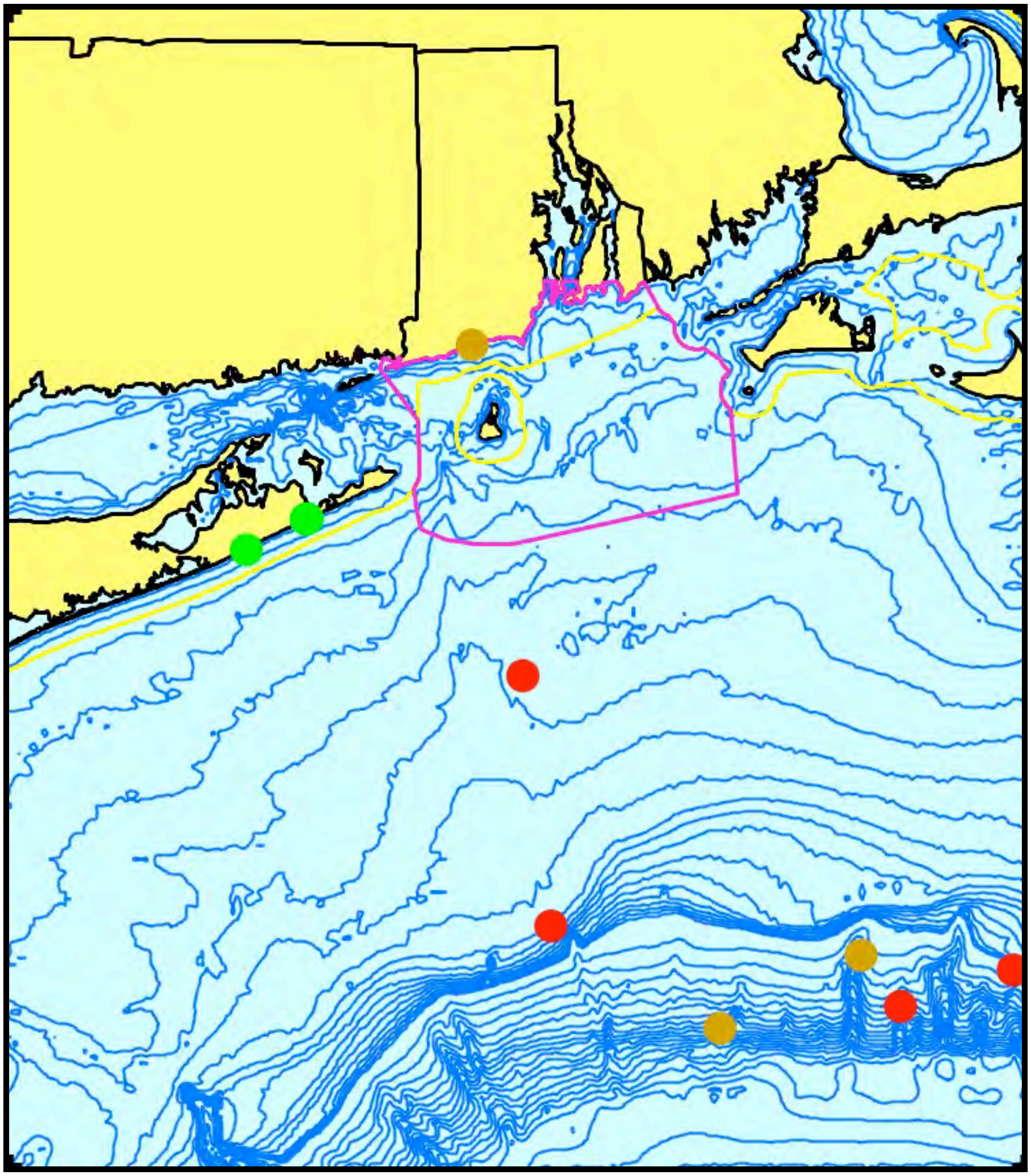

Figure 48. Aggregated sighting, stranding, and bycatch records of Atlantic, pan-tropical, and unidentified spotted dolphins in the Rhode Island study area, 1979–1988 (n = 9: winter = 0, spring = 3, summer = 3, fall = 3).

the NMFS cruises beginning in the 1990s have been farther offshore and beyond the study area. Based on the overall sighting record now available from those surveys (Waring et al., 2008), it is most likely that spotted dolphins encountered in the Rhode Island study area would be *Stenella frontalis*, but *Stenella attenuata* is possible.

In addition to the six sightings, there have been three spotted dolphin strandings in the Rhode Island study area. There was a live-stranding of a 216-cm, 47-kg pan-tropical spotted dolphin in Charlestown, Rhode Island on 11 October 1983. It died at Mystic Aquarium three days later. A 203-cm, 107-kg, pan-tropical spotter stranded in Amagansett, New York on 7 May 1983. The only confirmed Atlantic spotted dolphin stranding in the study area was a 209-cm animal stranded at Bridgehampton, Long Island on 23 May 1988.

Conclusions: Both spotted dolphin species have more subtropical and offshore distributions, and are not likely to occur in the SAMP area. Neither poses any conservation concern relative to the SAMP.

3.2.24. Harbor Seal *Phoca vitulina* Linnaeus, 1758

Pinnipedia includes three families of marine carnivores that are characterized by retention of all four limbs as flattened, simplified flippers—Phocidae (seals), Otariidae (sea lions and fur seals), and Odobenidae (walrus). Pinnipeds are not as completely adapted to the marine habitat as are cetaceans or sirenians, since all species must leave the water to give birth, either to a terrestrial habitat or onto sea ice. Recent morphological and molecular studies have concluded that Pinnipedia belongs within Order Carnivora, Suborder Caniformia (Rice 1998; Wozencraft 2005).

Phocids are sometimes referred to as “hair seals,” “earless seals,” or “true seals.” Phocids and otariids differ in a number of anatomical and life-history characteristics, with the walrus often intermediate (see Table 4 in Riedman, 1990 for a more detailed review). Otariids possess external ear pinnae, which are absent in seals and walrus. Seal flippers are completely furred with well-developed terminal claws. The hind-flippers are oriented directly backwards with opposed soles, and cannot be rotated underneath the body for locomotion on land, which is accomplished by caterpillar-like wriggling. In water, seals swim via alternating, lateral strokes of the hind-flippers, while using the fore-flippers mainly for maneuvering. Sea lions and fur seals have at least partially furless flippers with more rudimentary, subterminal claws. The pelvis and hind limbs can rotate underneath the body for walking on land. In water, they swim by simultaneous flapping of the long fore-flippers and use the hind limbs more as rudders. Seal coats have little underfur, and a seal is insulated by a thick layer of blubber. Fur seals have dense underfur for thermal insulation and the least developed blubber layer, while sea lions have less dense underfur and moderately thick blubber. The walrus moves on land like a sea lion and in the water like a seal. It is essentially hairless with thick blubber. Seal pups grow extremely fast and wean quickly. The mother fasts completely during lactation in almost all species. In otariids and walrus, lactation can last two years or more, pup growth is slower, and the mother feeds during lactation.

There are no sea lions or fur seals in the North Atlantic. Pinnipeds of the North Atlantic and adjacent waters include the walrus and nine species of Phocidae. Only five seal species are confirmed as occurring in the Rhode Island study area. Three seal species have (or had) very restricted distributions—the Caspian seal (*Pusa caspica*), Mediterranean monk seal (*Monachus monachus*), and Caribbean monk seal (*Monachus tropicalis*, extinct since the mid-20th Century). The walrus (*Odobenus rosmarus*) and bearded seal (*Erignathus barbatus*) have Arctic distributions and occur rarely in U.S. waters but not south of Cape Cod. Although De Kay (1842) wrote that walrus "were formerly numerous on our coast, but are now scarcely ever found south of Cape Sable," there is no evidence to support his conjecture. There are no confirmed records in the Rhode Island study area. Historical walrus breeding populations in the Gulf of St. Lawrence and on Sable Island off Nova Scotia were extirpated in the early 18th Century (Lavigne and Kovacs, 1988). The nearest recorded walrus occurrences to New York were in Massachusetts in 1734 and 1937 (Cardoza et al., 2006). Similarly, there is a bearded seal stranding record in Massachusetts in 2002 (Sardi and Merigo, 2006), but none in the mid-Atlantic.

Description: Harbor seals are relatively small animals, with adults 1.7–1.9 m long (Jefferson et al., 1993; Wynne and Schwartz, 1999). Males are slightly larger than females. Harbor seals vary in color from very light gray or tan to brown to almost black, with extensive spotting. The basic spotting pattern is light with dark spots. In some individuals the spots coalesce, particularly on the back, giving the appearance of a dark color with sparse, light mottling. In general the belly is lighter than the back. Whether an individual is wet or dry will greatly change its appearance, with completely dry individuals often light-colored. Pups shed their white fetal coat (lanugo) in utero and are born with the same spotted coat pattern as adults. A harbor seal has a rounded head with a concave puppy-like face and only a short distance from eyes to nose. Nostrils are close together at the bottom and look like the letter "V" when seen from head-on.

Status: Harbor seals are not listed under the U. S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List.

A peak count of 271 harbor seals between the Massachusetts-Rhode Island border and eastern Long Island Sound was reported for March 1987 (Payne and Selzer, 1989). They suggested an upper bound of 374 based on their highest counts at each haul-out. Only Fishers Island, New York consistently had more than 50 animals, with a peak of 101 in March 1986. Schroeder (2000) estimated that the total number present in Narragansett Bay in 1999 was between 825 and 1,047. Ronald and Gots (2003) reported that the total seal count in southern New England in the spring of 1999 was nearly 6,100 animals.

The increase in harbor seals south of Cape Cod parallels that observed in the population's breeding range along the Maine coast. Gilbert et al. (2005) used aerial surveys to count seals hauled out on ledges along the entire Maine coast, and used radio-tagging data to correct for the proportion of seals hauled out at any given time. Between 1981 and 2001, seal counts increased from 10,543 to 38,014 (6.6% per year). Counts of pups increased at an even higher annual rate of 14.4%. The corrected estimate of the total abundance of harbor seals in Maine in late May and June of 2001 was 99,340 (95% CI = 83,118–121,397). The number of ledges used as haul-out sites also increased over that span of years, from 336 to 556, with the number used as pupping sites growing from 186 to 496.

Harbor seals were hunted by Native Americans for subsistence, then by early European settlers for oil, meat, and leather (Lavigne and Kovacs, 1988). In recent times, commercial hunting has never been of any great importance. Seals are commonly perceived as competitors for commercially valuable fish stocks. Bounties were paid on harbor (and gray) seals in both Maine and Massachusetts into the 1960s, resulting in depletion of the population overall and its extirpation from pupping sites in Massachusetts (Katona et al., 1993). Bounty payments in New Brunswick, Canada persisted until 1976 and were re-instituted in at least two years in the 1980s (Terhune, 1985). Harbor seals were also hunted for sport in the U.S. prior to passage of the Marine Mammal Protection Act in 1972, as reported for eastern Long Island by Connor (1971).

Harbor seals are taken as by-catch in a variety of U.S. and Canadian commercial fisheries, including gillnets, drift nets, long-lines, bottom trawls, midwater trawls, purse seines, trammel nets, fish traps, herring weirs, and even lobster traps (Woodley and Lavigne, 1991; Waring et al., 2008). The 2001–2005 estimate of average numbers of harbor seals killed annually in the northeastern U.S. sink gillnet fishery was 882, plus an undetermined number in the bottom trawl fishery. It is as yet unclear how much of the U.S. fishery-related mortality represents seals from breeding sites in the U.S. versus Canada. Other known sources of human-related mortality in the northeastern U.S. and Canada include boat strikes, entrainment in power plant intakes, entanglement in aquaculture facilities, and intentional shooting.

More is known about disease as a population impact for harbor seals than for other marine mammals (Bigg, 1981). A relatively large number of diseases are known, and there have been several significant epizootics. Epizootics where the underlying cause was never determined were reported in Iceland in 1918 (Dietz et al., 1989b) and in the Shetland Islands in the 1920s (Bonner, 1972). There have also been several recent epizootics where the cause has been determined.

At least 500 harbor seals died in New England in 1979–80 (Geraci et al., 1982). The epizootic began in Cape Cod Bay in December 1979 and spread north along the Maine coast. The animals died from bacterial pneumonia caused by *Mycoplasma* spp. These bacteria are normally present in healthy seals, and can cause an infection known as “seal finger” in humans who have been bitten by a seal (Hartley and Pitcher, 2002; Mazet et al., 2004). At least three different species have been isolated from harbor seals or humans bitten by harbor seals (Geibel et al., 1991; Ruhnke and Madoff, 1992; Baker et al., 1998). The seals that contracted pneumonia were also infected with a strain of influenza A, and the hypothesized explanation was that the influenza lowered their immune response to the *Mycoplasma*.

There was a second, smaller epizootic in New England harbor seals in 1982 that killed only about 60 animals (Hinshaw et al., 1984). It was first recognized in Narragansett Bay. In that case, the underlying cause was a different strain of influenza A virus that normally is found in birds.

The most significant epizootic to date in harbor seals occurred in the North Sea in 1988, killing about 18,000 seals (Dietz et al., 1989b; Heide-Jørgensen et al. 1992). It began in April on Anholt Island in the Kattegat between Denmark and Sweden. It spread from there to the north along the coast of Norway and west to the Netherlands, Great Britain, and Ireland. Seal counts declined by 60% in the Kattegat and Skagerrak. Some areas experienced 90% mortality in 40–60 days, and in the Wadden Sea the number of carcasses recovered exceeded the highest previous aerial survey count. The highest incidences occurred in areas where seals had congregated for pupping or molting, with less severe outbreaks where first introduced in the fall. The immediate cause of mortality was acute bacterial pneumonia, with *Bordetella bronchisepta* an important cause. There were secondary infections by herpes and picorna viruses, but the underlying cause appeared to be a morbillivirus. It was first identified as canine distemper virus (CDV) (Dickson, 1988; Osterhaus et al., 1988). Eventually the infectious agent was identified as a closely related morbillivirus now called phocine distemper virus (PDV) (Cosby et al., 1988; Osterhaus and Vedder, 1988). Dietz et al. (1989a) tested samples from 40 harp seals and 90 ringed seals collected in Greenland in 1985, prior to the 1988 epizootic, for the presence of antibodies to CDV, and found 30% positive in the harp seals and 4% in the ringed seals. It is now hypothesized that the virus was introduced to North Sea harbor seals from harp seals in a year when the harp seals dispersed unusually far southward (Heide-Jørgensen et al., 1992; Markussen and Have, 1992). A smaller PDV outbreak in the North Sea in 2002 killed hundreds of seals (Jensen et al., 2002).

Duignan et al. (1993) reported PDV in harbor seals from Long Island, New York. In an expanded study, Duignan et al. (1995) detected PDV antibodies in 37% of harbor seals and 73% of gray seals from New England, but not at all in Pacific harbor seals. There was usually little or no evidence of disease. In the winter of 1991–92, strandings increased in New England, and the PDV antibody detection rate increased to 83%. Morbillivirus lesions were observed in six animals, and a case of morbilliviral encephalitis was detected in archived tissue from an animal stranded in 1988. The authors hypothesized that high levels of PDV without disease outbreaks in gray seals are maintained by their large population size, high recruitment rate, and innate resistance, while infection is maintained in the smaller harbor seal population through contact with gray seals.

Dunn and Wolke (1976) reported seal heartworm infestation in harbor seals from New England. They found pulmonary, vascular, and hepatic lesions caused by both adult worms and microfilariae. The 1988 PDV epizootic in the North Sea provided very large sample sizes for parasite studies, and North Sea harbor seals carried a variety of nematodes, cestodes, trematodes, and acanthocephalans (Claussen et al., 1991a, 1991b). Five species of nematodes were very common. Seal heartworm was present in 32% of individuals. The lungworms *Otostrongylus* and *Parafilaroides* were present in 26% and 27%, respectively. The presence of heartworm and lungworm was inverse to age, with *Parafilaroides* and heartworms absent in adults. The two common gut nematodes, *Contracecum* and *Pseudoterranova* (sealworm), present in 10% and 88% of animals, increased in occurrence with age.

Ecology and life history: Harbor seals are generally solitary when in the water, but gregarious when hauled out (Bigg, 1981; Burns, 2002; Ronald and Gots, 2003). Unlike many other pinnipeds that haul out only for reproduction and molting, harbor seals regularly haul out for resting. When hauled out, seals are observed sleeping for short periods with intervals of scratching, vocalization, yawning, jostling for position, or scanning for predators or other disturbance. Sometimes there are gray seals mixed in at harbor seal haul-outs, especially from Massachusetts north. In the Rhode Island study area, however, gray seals are most often juveniles and are difficult to identify except by experienced observers. Groups of seals on haul-outs show no evidence of sociality or structuring, but are simply aggregations of individuals that come together in order to utilize a limited resource. In addition, hauling out in groups is believed to be an anti-predator strategy. Terhune (1985) showed that as the number of seals in the group increased, the duration of time spent scanning decreased and the intervals between scans increased.

Hauling-out behavior is a function of tide stage, wind, temperature, precipitation, and time of day (Pauli and Terhune, 1987a, 1987b; Schneider and Payne, 1983; Burns, 2002; Ronald and Gots, 2003). The largest numbers of seals are likely to be hauled out at low tide in late afternoon on a calm, sunny day. Haul-out use also drops off when air temperatures get very cold. The seals are also extremely sensitive to disturbance when hauled out, and they may retreat to the water with only slight provocation—by humans, boats, aircraft, or potential predators.

What appears to be a relatively simple behavior pattern of hauling out at low tide each day and returning to the water between haul-out periods, presumably for foraging, can actually be quite complex. Individual harbor seals have been rehabilitated after stranding and released with satellite-linked radio tags. Single individuals have been recorded as using multiple haul-outs between Cape Cod, Massachusetts and Downeast Maine, interspersed with apparent foraging trips to one or more consistent locations tens of kilometers offshore in the Gulf of Maine. (see the WhaleNet satellite tagging program page at http://whale.wheelock.edu/whalenetstuff/stop_cover.html for both currently active tags on a variety of marine vertebrates and archived data and maps from previous tags.)

Harbor seals are relatively flexible in their selection of haul-outs, and can be found on rocky ledges and reefs, islets, mudflats, sand bars, gravel bars, sandy beaches, cobble beaches, glacial icebergs, sea ice, and man-made objects such as floating rafts and docks (Boulva and McLaren, 1979; Burns, 2002; Ronald and Gots, 2003). Important characteristics include protected locations that are relatively inaccessible from the land side and that have unobstructed access to water. Since harbor seals do not maintain breathing holes in the ice, when bays, inlets, and other nearshore waters freeze, the seals are pushed offshore where the ice edge provides water access (Ronald and Gots, 2003).

Annual molt occurs over two or three months from midsummer through early fall, after pupping (Bigg, 1981; Burns, 2002). Haul-out frequency increases somewhat during the molt. Yearlings molt first, followed by subadults, adult females, and then adult males. During molt there is an overlapping progression of age and sex classes.

Typical harbor seal dives last 3–4 minutes, but they are capable of diving for 30 minutes and to depths of 500 meters (Bigg, 1981; Burns, 2002). Frost et al. (2006) reported a study of Alaskan harbor seal pups using satellite-linked telemetry tags. Tagged pups increased their amount of time in the water and maximum dive depths during their first 3–6 months. Then time in the water and maximum dive depth both decreased, suggesting foraging seasonality. Percent time in the water was lowest in July (68%) and highest in November (89%). Tagged pups spent 50% of their swimming time diving in the upper third of the water column and only 5% in the deepest third, evidence that pups do not feed on or near the bottom during their first year.

Harbor seals are flexible in their prey selection (Bigg, 1981; Nowak, 1999; Burns, 2002; Ronald and Gots, 2003). Small to medium-sized fishes are the dominant prey, followed by squid and octopus, and then by crabs and shrimp. Types of fish eaten include a number of economically important commercial species. Among these are cods, hakes, mackerel, herring, sardines, anchovy, smelt, shad, capelin, sand lance, trout, salmon, rockfish, sculpins, and flounders. Shrimp may be particularly important prey for pups after weaning. Seals appear to feed on what is most abundant. Payne and Selzer (1989) collected scats from haul-outs in Maine and Massachusetts to look at prey preferences. They found clear geographic differences. Sand lance was the dominant prey at all three Cape Cod, Massachusetts sites: 87% of the diet at Race Point (tip of Cape Cod), 85% at Monomoy Island (at the “elbow”), and 50% at Jeremy Point (on the west side in the middle of the “forearm”). Squid comprised the next most abundant food item (22%) and then gadids, herring, and flounders in decreasing importance. Mackerel and skate were also eaten. At the Isles of Shoals off southern Maine (about 100 km from Race Point), there was no dominant prey type. Gadids and rockfishes were about equal at 22% each, flounders and herring both were >10% of the diet, and cunner, sand lance, and skate were also eaten. The diet of harbor seals along Long Island, based on stomach contents of stranded animals and some observations of feeding, includes herring, mackerel, squid, flounder, green crabs, mussels, cod, and silver hake (S. S. Sadove, pers. comm.).

Harbor seal pupping in the Gulf of Maine takes place in late May and June (Katona et al. 1993). Pupping occurs from the Isles of Shoals at the Maine/New Hampshire boundary northward into Canada. Pupping formerly occurred south to Cape Cod (Katona et al., 1993), and recent evidence indicates that pupping has resumed at Manomet, Massachusetts on the west side of Cape Cod Bay. Single pups are born approximately 70 cm long and weighing about 10 kg (Wynne and Schwartz, 1999). The white lanugo is shed in utero, and the pup is born in a spotted juvenile coat, essentially the same as the adult pattern.

Harbor seals are unique among phocids. In most other seals, pups remain at the birth site until after weaning, and the mother tends to remain with or close by the pup for the entire lactation period, feeding little or not at all (Riedman, 1990). Harbor seal pups are precocial, swimming and following the mother within hours of birth (Bigg, 1981; Riedman, 1990; Burns, 2002; Ronald and Gots, 2003). At many pupping sites the pup has no other option, since the location is submerged at high tide. After the mother and pup leave the birth site, the pup follows the mother closely, sometimes riding on her back during the first week. They haul out at intervals, when nursing takes place. Adult females spend a larger proportion of their time hauled out during lactation (Thompson et al., 1989), but are able to feed throughout lactation (Burns, 2002). Pups are weaned at 3–6 weeks of age (Bigg, 1981; Burns, 2002). Harbor seal pups may continue to remain with and follow their mothers for 2–4 weeks after weaning.

Ovulation and mating occur very soon after weaning (Bigg, 1981; Thompson, 1988; Riedman, 1990; Burns, 2002). Mating takes place in the water. Males are largely unable to defend breeding sites or females, resulting in a promiscuous or slightly polygynous mating system (Riedman, 1990). Implantation of the embryo is delayed for 1.5 to 3 months.

Female harbor seals become sexually mature at 2–5 years of age, most at age 3 or 4, and reach physical maturity at age 6 or 7 (Bigg, 1981; Burns, 2002). Males take about a year longer. Most (85–92%) mature females give birth each year. First-year mortality rate is 20–60%, after which it is 5–20% (Boulva and McLaren, 1979), and the mortality rate in males is higher than in females after sexual maturity. It is commonly assumed that a large proportion or even a majority of the harbor seals in southern New England are juveniles, and there is some published support for this (Payne and Schneider, 1984; Whitman and Payne, 1990; Katona et al., 1993). Waring et al. (2006a) captured and radio-tagged 21 harbor seals and estimated age for 17 near Cape Cod, Massachusetts in March 2001. Fourteen (82%) were adults, one (6%) was a subadult, and two (12%) were juveniles. It is still possible that the proportion of juveniles is higher in the Rhode Island study area. Alternatively, perhaps perceptions of the age structure in the region are somewhat biased by the reliance on strandings for data. Adults, sub-adults, and juveniles cannot be easily differentiated except by close examination, and mortality and stranding rates can be expected to be higher for younger animals. Gilbert and Wynne (1987) reported that all of the harbor seals taken in the gillnet fishery in the Gulf of Maine were young of the year.

In harbor seals, predation impacts pups to a larger extent than adults. Predators of pups include polar bears, red foxes, Arctic foxes, Steller’s sea lions, eagles, ravens, and gulls (Burns, 2002; Ronald and Gots, 2003). In eastern Canada, the three major sources of mortality in the pups are stillbirth, abandonment after birth, and sharks (Boulva and McLaren, 1979). Stobo and Lucas (2000) reported that the rate of shark predation (with Greenland shark an important predator) on harbor seal pups at Sable Island increased markedly, from 20% of pups in 1980–1993 to about 25% in 1994 and 1995 to 45% in 1996. Shark attacks on adult seals seem to be directed preferentially towards females. In recent years white shark occurrence near Cape Cod seems to have increased, presumed to be related to the increased summer abundance of both harbor seals and gray seals (G. Skomal, Massachusetts Div. of Marine Fisheries, pers. comm.).

General distribution: Harbor seals occur in coastal waters of both the North Atlantic and North Pacific (Bigg, 1981; Riedman, 1990; Burns, 2002; Ronald and Gots, 2003). In the western North Atlantic, they are common from southern New England north to Labrador, Greenland, and

Iceland. They are mainly seen hauled out or relatively close to the shore. North of Cape Cod harbor seals can occur year-round. However, south of Cape Cod (Rhode Island to New Jersey) seals occur only during winter migration (October to early May) (Payne and Selzer, 1989). There are occasional records from as far south as Florida (Caldwell and Golley, 1965; Caldwell and Caldwell, 1969; Caldwell et al., 1971; Waring et al., 2008). As with pinnipeds in general, records of in-water observations are much less common than records of stranded animals or seals on haul-out sites. Harbor seal sighting and bycatch records away from shore are concentrated in relatively shallow water. Lens (1997) reported seven individuals taken in a Spanish deep-water trawl fishery on the southern edge of the Grand Banks, showing that harbor seals are capable of long-distance foraging movements and can occur far offshore.

The annual patterns of movement in the harbor seals of New England and Atlantic Canada are complex (Bigg, 1981; Riedman, 1990; Katona et al., 1993; Nowak, 1999; Burns, 2002; Ronald and Gots, 2003). Some sources call harbor seals migratory, while others say they are non-migratory, sometimes differentiating between migration and “seasonal movements.” In Maine and Atlantic Canada, harbor seals can be observed year-round (Boulva and McLaren, 1979; Katona et al., 1993; Baird, 2001), while in southern New England they are very clearly seasonal, occurring from September to late April–early May (Payne and Schneider, 1984; Payne and Selzer, 1989; Sadove and Cardinale, 1993; Schroeder, 2000). Only a minority of the population winters in the Rhode Island study area, and does not remain for pupping. However, since the 1990s, small numbers have been reported to remain around Long Island year-round and pupping has been observed on Great Gull Island and Fishers Island (S. S. Sadove, pers. comm.). One hypothesis for why harbor seals depart from the Rhode Island study area just prior to the time of pupping is the presence of predators. Many large predatory sharks are more common south of Cape Cod than to the north in the Gulf of Maine (Kenney et al., 1985b; Collette and Klein-MacPhee, 2002).

Historical occurrence: Harbor seals have long been recognized as common residents in the northeastern U.S. (De Kay 1842; Allen 1880). (The Smithsonian dataset we obtained included only cetacean records, so we had no historical data from that source.) Cronan and Brooks (1968) reported seven 20th Century records from Rhode Island or nearby between 1933 and 1967. Seals were seen in Mount Hope Bay in 1933, 1938, and 1941. One was sighted off the URI Bay Campus on 10 December 1956, and another was seen in the Sakonnet River in November 1957.

A dead seal was found floating in the Bay in the fall of 1957 and collected as a specimen for the survey conducted by Cronan and Brooks for their study. One seal was captured in a fish net off Newport in August 1967. Waters and Rivard (1962) wrote that harbor seals were usually seen in southeastern Massachusetts in late winter and early spring and had formerly been much more abundant, but were rare south of Massachusetts. All historical sources concur that harbor seals were relatively common around Long Island and Connecticut (De Kay, 1842; Linsley, 1842; Merriam, 1884; Goodwin, 1935; Connor, 1971).

Recent occurrence: Harbor seals are regularly observed around all coastal areas throughout the Rhode Island study area, and occasionally well inland up bays, rivers, and streams (Fig. 49). It should be noted for all the seals that the available data are strongly dominated by stranding records, which comprised 446 out of 507 total records for harbor seals (88%). Seals are very difficult to detect during surveys, since they tend to be solitary and the usual sighting cue is only the seal's head above the surface. In addition, seals were specifically excluded from data collection efforts during CETAP, and there is no centralized repository for opportunistic seal sighting information outside of small localized collections. Although the harbor seal is generally referred to as a winter resident in the region, their period of occurrence is significantly broader. Of the available records, 52.5% are in spring, 31.2% in winter, 9.5% in summer, and 6.9% in fall. In the Rhode Island study area, there are no records offshore of the 90-m isobath (Fig. 49). From counts on haul-outs in Narragansett Bay, Schroeder (2000) showed that seals usually start arriving in September, steadily increase in numbers until April, then depart relatively abruptly in May.

Payne and Selzer (1989) identified six haul-outs in Narragansett Bay in the 1980s. Their peak counts were 43 at the Dumplings off Jamestown and 36 at Rome Point in North Kingstown, and only one animal was ever seen at Block Island. The numbers of harbor seals in the Rhode Island study area have increased dramatically since then. Schroeder (2000) reported 21 haul-outs around Narragansett Bay and 6 at Block Island during 1994–1999 (Fig. 50). The largest haul-out was a clump of rocks located 230–370 m off Rome Point in North Kingstown, with a maximum count of 170 animals. However, some haul-outs used in the 1960s–1980s had apparently been abandoned or nearly abandoned. The maximum count at the Dumplings was 2. The peak counts at the two largest haul-outs in Block Island were 54 and 16 (see below). Her results indicated that

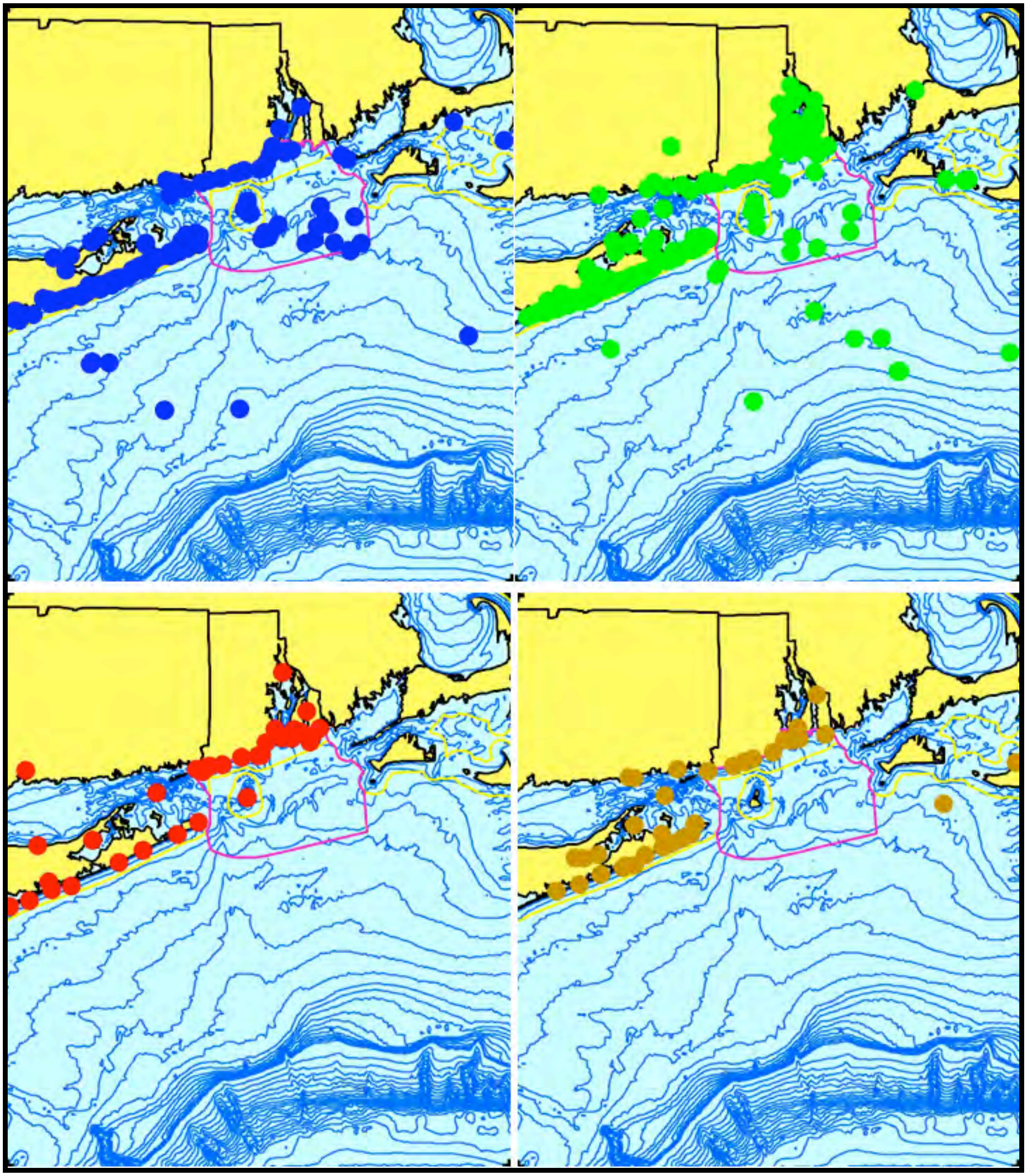

Figure 49. Aggregated sighting, stranding, and by-catch records of harbor seals in the Rhode Island study area, 1954–2005 (n = 507: winter = 158, spring = 266, summer = 48, fall = 35).

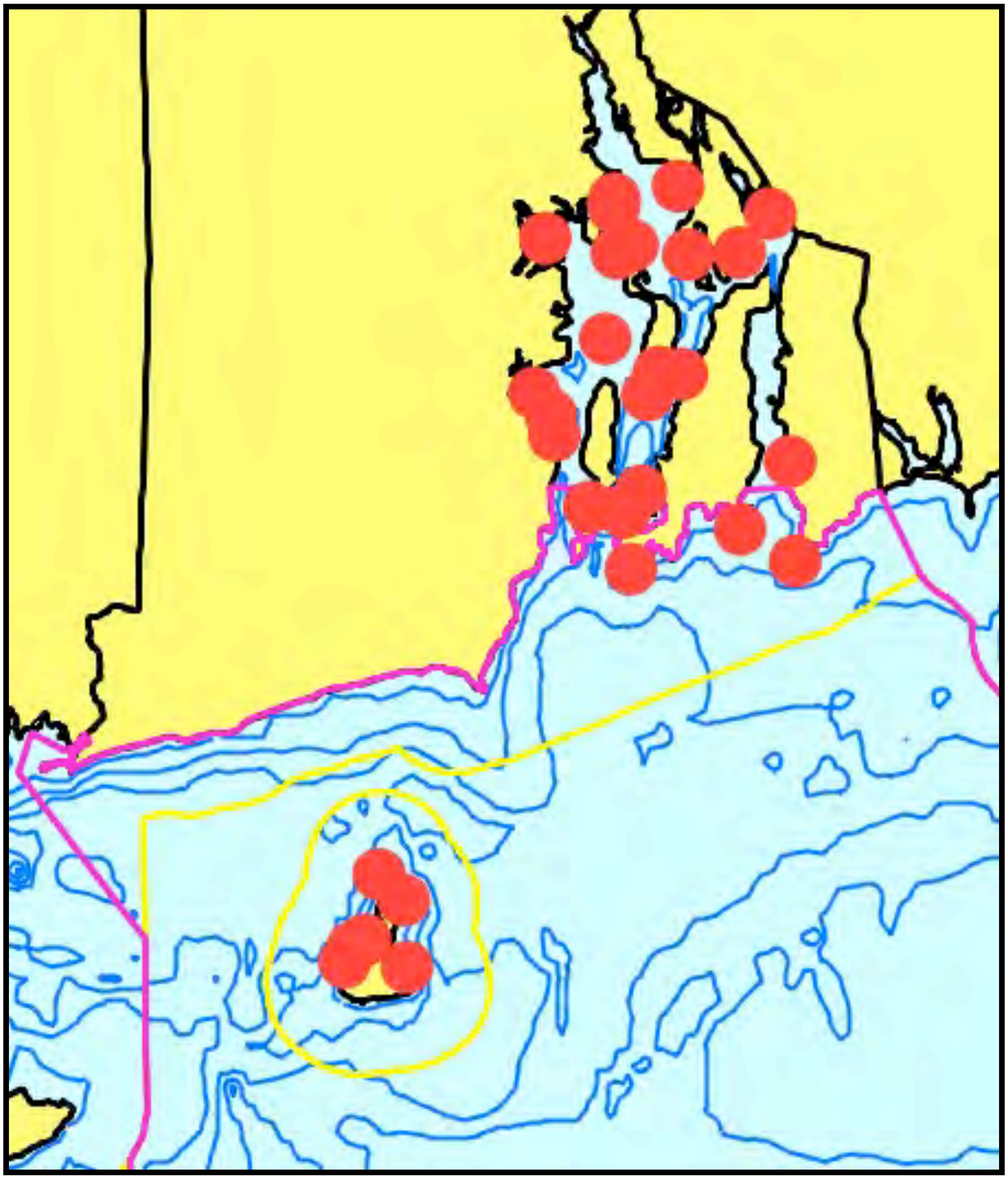

Figure 50. Harbor seal haul-outs in Rhode Island: 1966–1976, 1981, 1986–1987, and 1994–1999 (based on Schroeder, 2000).

the number of harbor seals in Rhode Island had increased by an order of magnitude from the 1960s to the late 1990s.

Schroeder (2000), collaborating with Scott Comings of The Nature Conservancy, identified six harbor seal haul-outs at Block Island (Table 5). The largest haul-out is at Cormorant Cove in the southwestern corner of Great Salt Pond (see below). The other five are around the periphery of the island. Pebble Beach is on the southeastern part of the island, near Old Harbor. Two haul-outs are at the northern end of the island, at Clay Head and Sandy Point. Finally, there are two haul-outs on the southwestern side, first identified during the final season of Schroeder's research—Dorie's Cove and Grace's Cove.

Table 5. Maximum monthly counts of harbor seals at the six Block Island haul-outs during the 1997–98 and 1998–99 seasons (Schroeder, 2000).

	Month					
Haul-out (season)	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Cormorant Cove (97–98)	–	–	47	52	22	0
Pebble Beach (97–98)	–	–	–	12	14	0
Clay Head (97–98)	–	–	–	8	0	0
Sandy Point (97–98)	–	–	–	0	2	0
Cormorant Cove (98–99)	52	52	54	53	43	0
Pebble Beach (98–99)	16	8	8	10	9	0
Clay Head (98–99)	3	5	4	6	10	0
Sandy Point (98–99)	2	3	0	6	0	0
Dorie's Cove (98–99)	0	1	2	3	3	0
Grace's Cove (98–99)	0	0	1	2	4	2

In Rhode Island, seals utilize different haul-out types around Narragansett Bay compared to those on Block Island (Schroeder, 2000). Nearly all of the haulouts around the Bay are rocky ledges and isolated rocks that are mostly submerged at high tide. The exception is Spar Island, which is a man-made dredge-spoil island in Mount Hope Bay. At Block Island, there are several haul-outs on cobble and sandy beaches around the island, but the haul-out used by the largest number of seals is a wooden raft moored in Cormorant Cove. Around the eastern end of Long Island, Payne and Selzer (1989) identified the most important haulouts in the 1980s, in order of decreasing counts, as Fishers Island, Great Gull Island, Montauk Point, Gardiners Island, Sag Harbor, and Falkner Island (CT). These continue to have the largest aggregations, and constitute locations where access is restricted by physical characteristics or by extensive private or government property holdings. There are other haul-outs all around the eastern end of Long Island and along both the Atlantic and Long Island Sound shores (Sadove and Cardinale, 1993). The numbers of individuals at Long Island haul-outs range from about 20 to 500 (S. S. Sadove, pers. comm.). There are also known haul-outs in Connecticut (A. Ferland, Maritime Aquarium, pers. comm., R. Nawojchik and H. Medic, Mystic Aquarium, pers. comm.).

The vast majority of seal sightings during surveys come from aerial surveys flown by the National Marine Fisheries Service or the Provincetown Center for Coastal, focused primarily on right whales and mainly around Cape Cod. In the survey data for the broader area used in the relative abundance modeling (Fig. 1), there were 976 seal sightings—including 16 identified as gray seals, 151 identified as harbor seals, and 809 recorded simply as unidentified seals. In addition to the difficulty in identifying seals at sea from an airplane, the survey crews very often do not take the time from their primary mission to identify hauled-out seals. The number of animals at a sighting averaged 39.6, and ranged from 1 to 3,000. Over half of all sightings were single animals, but about 20% were groups of 4 or more, mainly on or near haul-outs.

All of the survey sightings of harbor, gray, and unidentified seals were combined in calculating the SPUE values and in creating the relative abundance maps (Fig. 51). The pattern shows concentration around the major haul-outs near Cape Cod and Nantucket in all four seasons. In winter, there is also an area of moderate abundance near the coast from eastern Long Island to Buzzards Bay and Vineyard Sound. There are areas of occurrence offshore in three seasons of the year, but at much lower levels of abundance than near the haul-outs. There was no survey effort in Narragansett Bay or the Sakonnet River except for a little at the mouth of the Bay in summer, therefore the occurrences in the Bay/River in all four seasons result from the GIS kriging and extrapolation procedure.

Annual stranding frequencies since 1993 (the start of the NE regional stranding network dataset available from NERO) are shown in Figure 52. Strandings were highest in the early 1990s. The numbers of strandings were lower on average in 1997–2002, with one-year spikes in 1998 and 2001, then generally higher again.

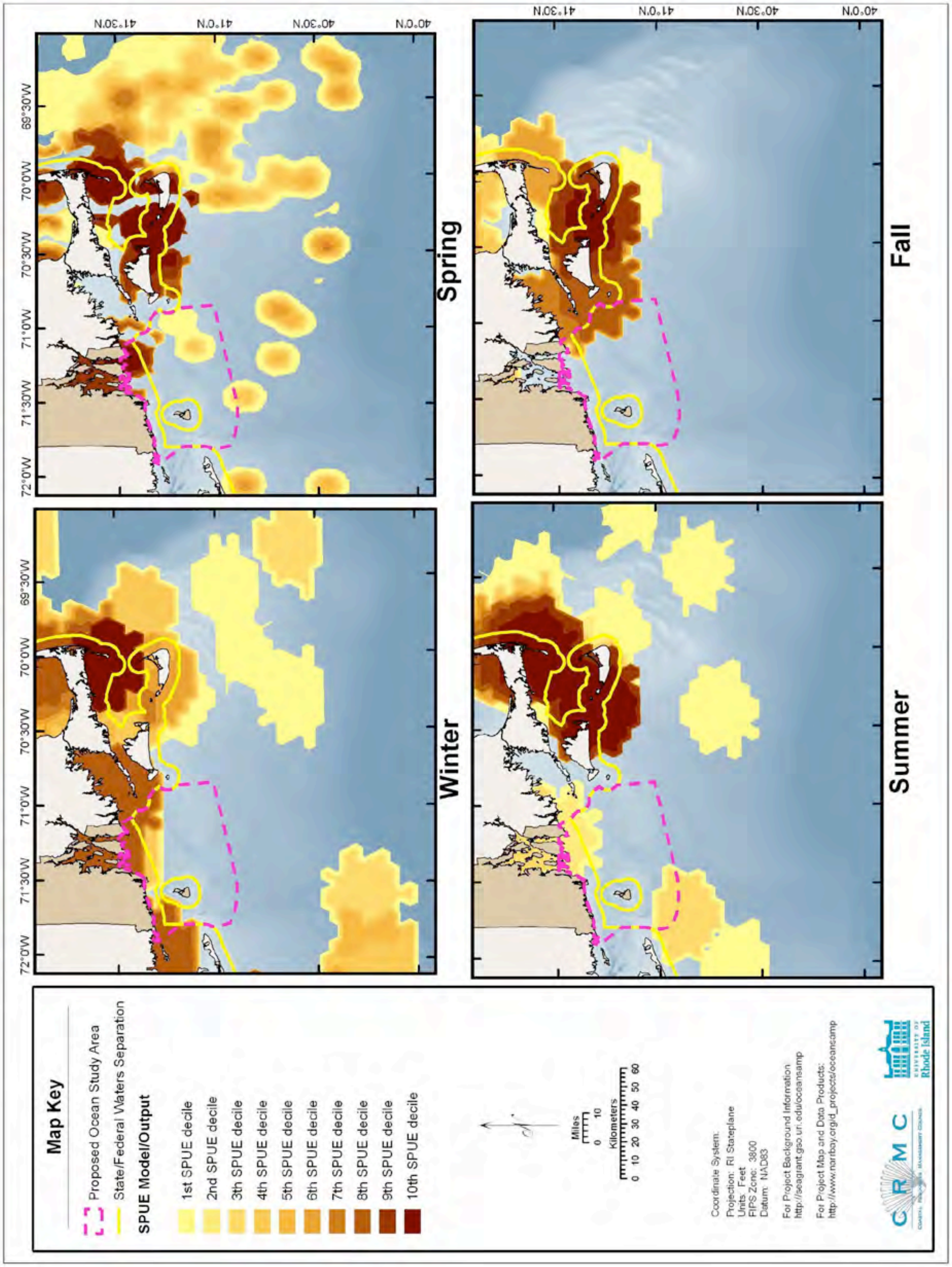

Figure 51. Modeled seasonal relative abundance patterns of seals (harbor seals, gray seals, and unidentified seals combined) in the Rhode Island study area, corrected for uneven survey effort.

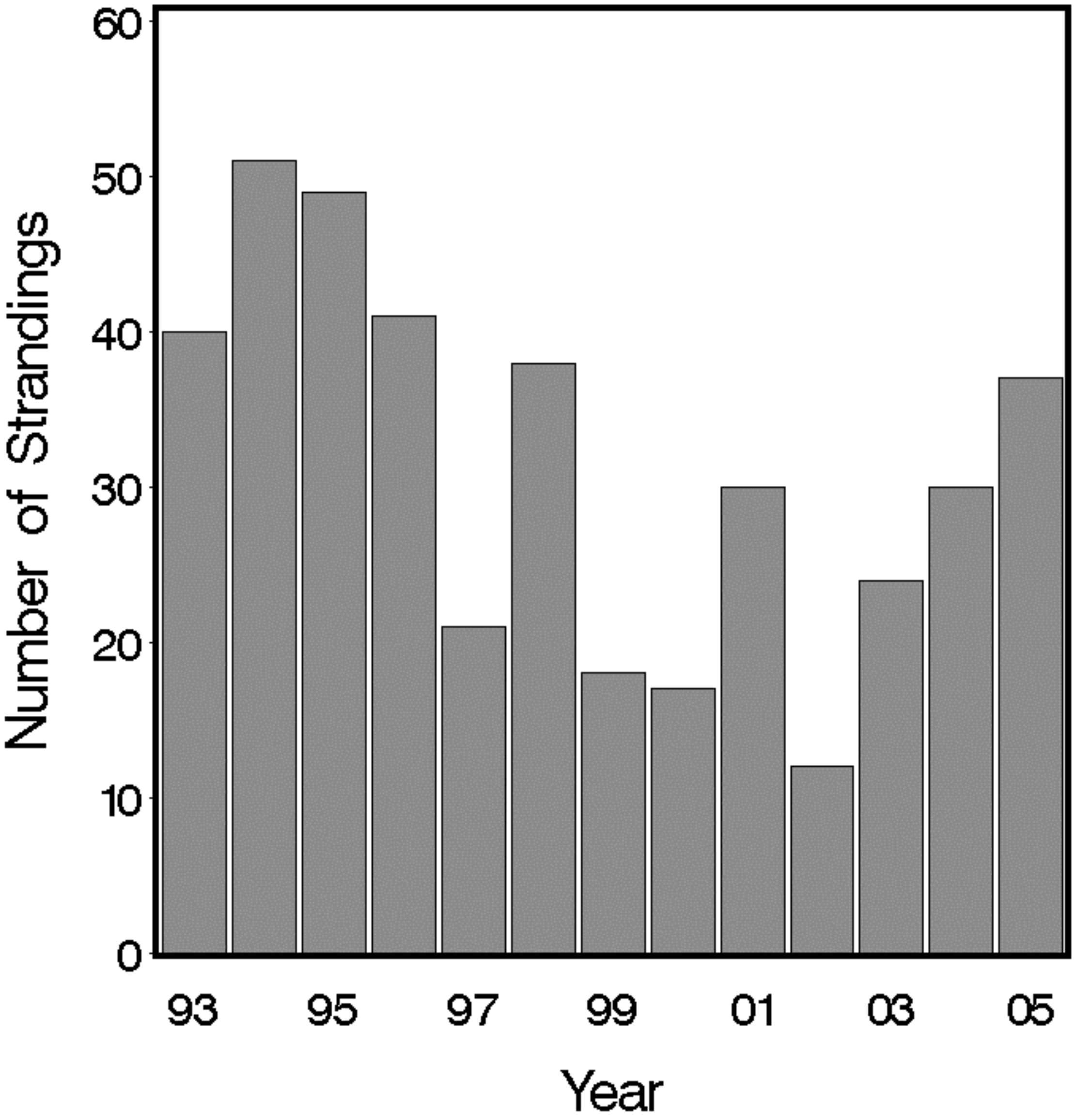

Figure 52. Annual stranding frequencies for harbor seals in the Rhode Island study area, 1993–2005.

Harbor seal strandings occur year-round in the study area, with a seasonal trend that closely mirrors the trends in counts on Rhode Island haul-outs shown by Schroeder (2000; Fig. 53). Strandings are least common in July and August and more frequent from November to June, with a peak in April and May. The stranding records from Mystic Aquarium included 44 harbor seal strandings in Rhode Island in 1976–1992. Combined with the Rhode Island records from the NERS data, there were strandings in Rhode Island every year beginning in 1985, and in significant numbers beginning in 1987 (Fig. 54). There is no evidence for an increase in 1991-92, during the regional PDV epizootic. The pattern is similar to that seen in the regional data, with higher numbers in 1987–1998, a lower rate in 1999-2002, and then a return to similar levels.

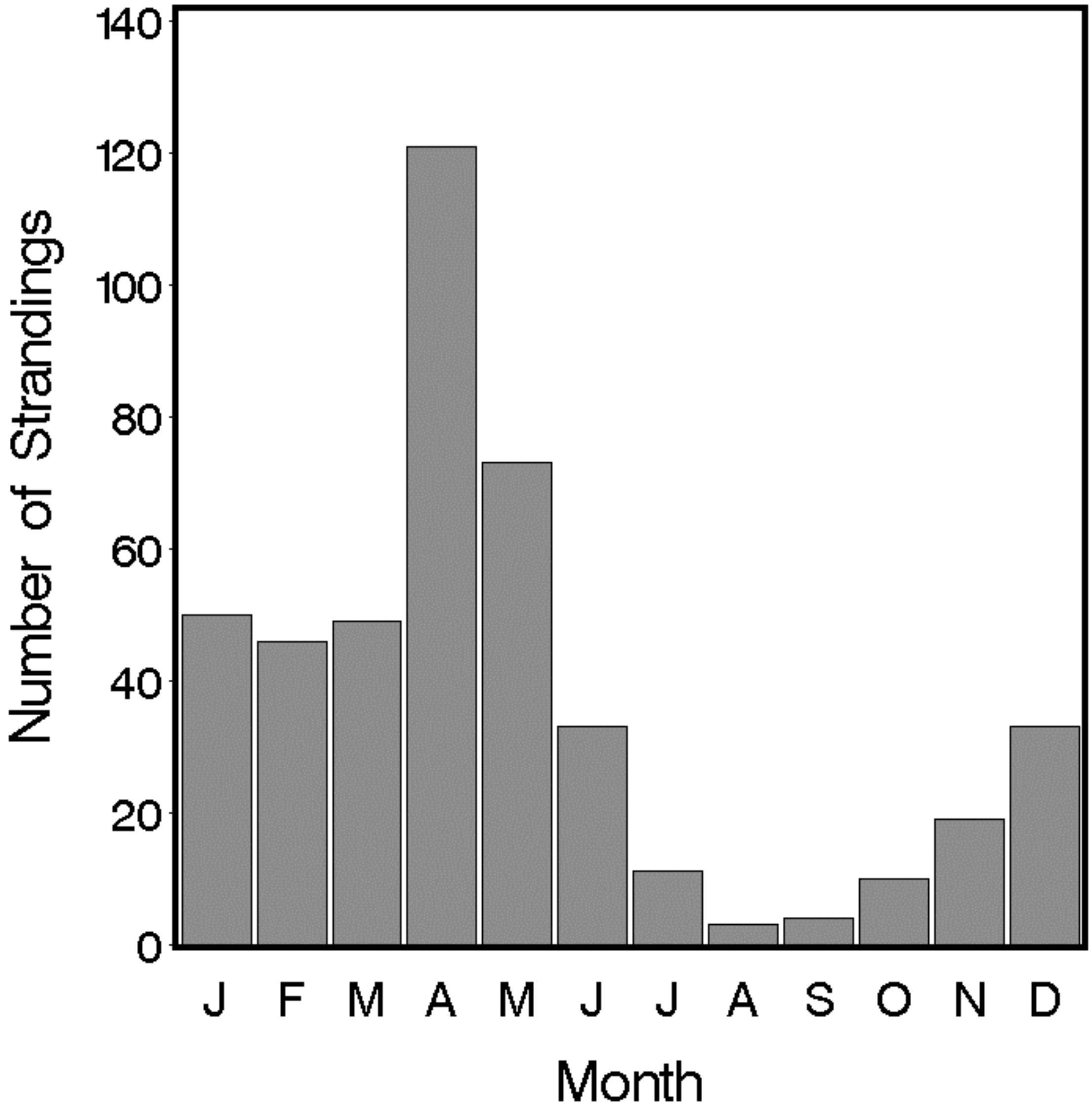

Figure 53. Monthly stranding frequencies of harbor seals in the Rhode Island study area.

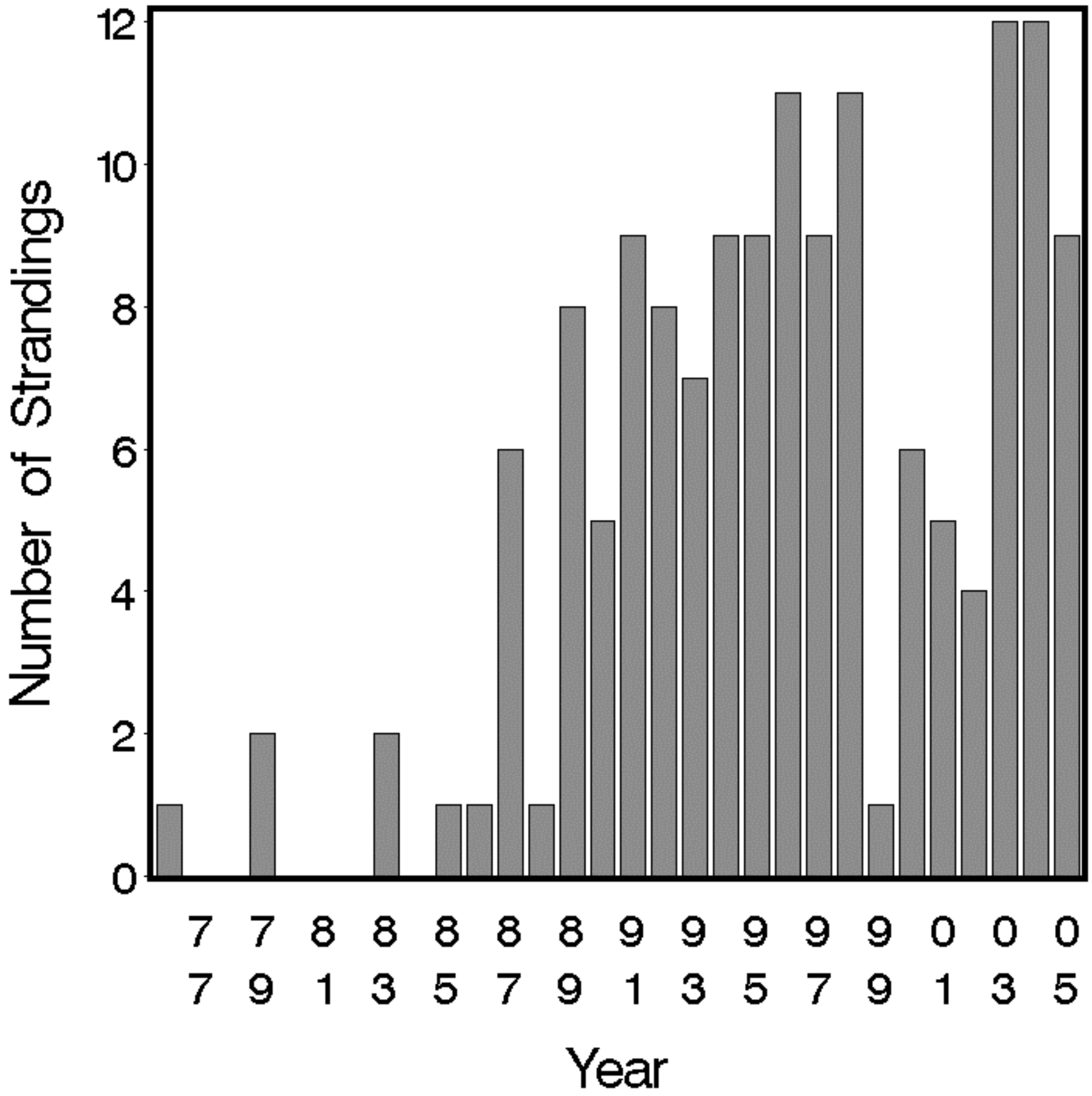

Figure 54. Annual stranding frequencies for harbor seals in Rhode Island alone, 1976–2005.

Conclusions: Harbor seals are really the only resident marine mammal within Rhode Island state waters, including Narragansett Bay and Block Island. If construction activities for a wind farm or other development project were to be restricted to winter in order to mitigate potential impacts on endangered whales and sea turtles, one effect would be to put those activities into a season of higher seal numbers. The proposed installation of wind turbines in state waters southeast of Block Island would be closest to the seal haul-out at Pebble Beach near Old Harbor, where there might be 15 or more seals at any one time (Table 5). That construction might require both an Incidental Harassment Authorization or specific mitigation elements.

3.2.25. Gray Seal *Halichoerus grypus* (Fabricius, 1791)

Description: Gray seals are sexually dimorphic, with adult males up to 2.3 m long and females up to 2.0 m (Jefferson et al., 1993; Wynne and Schwartz, 1999). Sexes also differ in color—males mainly dark with irregular light patches and females light with dark spots. Pups are born with a solid white or yellowish coat, and molt to a spotted coat in 2–4 weeks. Gray seals (including pups) are distinguished from harbor and harp seals by the distinctive shape of the head. Gray seals have an elongate snout with a flat or slightly convex profile. The distance between the eyes and nose is about twice the distance between the eyes and the ear openings. The neck and chest of males may be wrinkled, scarred, and often devoid of fur. The latter is believed to result from male-male fights over access to females. Females are sleeker and lack scarring (Hall, 2002). The nostrils are widely separated and from the front look like the letter "M" or "W."

Status: Gray seals are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. Gray seal populations in both the northeastern U.S. and eastern Canada have grown significantly since low points in the 1960s. Starting from a handful of animals and no pupping, the Massachusetts colony now has an annual pup production of over 1,000 and >5,600 seals total. There are >1,700 animals present in Maine (Waring et al., 2008). The eastern Canadian population was estimated at only 5,600 seals in the 1960s (Mansfield, 1966), but grew to 144,000 in 1993, 195,000 in 1997, and 209,000–223,000 in 2004 (Lesage and Hammill, 2001; Hammill, 2005).

Gray seals were hunted by Native Americans for subsistence. They were hunted by European settlers, for oil, meat, and leather, to the point where abundance was extremely low from the mid-19th to mid-20th centuries (Lavigne and Kovacs, 1988). In the modern era, commercial hunting has been relatively limited because of low abundance and relatively low pelt value. Most modern hunting has been primarily for population control to reduce sealworm infestation and minimize damage to commercial fishery gear and seal consumption of commercial fish stocks

(Bonner, 1981). Bounties paid by state authorities in both Maine and Massachusetts were one factor leading to the near extirpation in the 1960s of gray seals in the northeastern U.S. (Andrews and Mott, 1967; Rough, 1995). In Canada, gray seal stocks were also greatly reduced (Mansfield, 1966). There were culls at Sable Island averaging over 1,700 per year from the late 1960s to the early 1980s (Waring et al., 2008). At present there is a small commercial hunt in the Gulf of St Lawrence (few hundred per year), and hunting is not permitted at Sable Island (Waring et al., 2008). In addition, a personal hunting license in Canada allows killing up to six gray seals (Lesage and Hammill, 2001). The 2001–2005 annual average bycatch mortality of gray seals from entanglement in the northeastern and mid-Atlantic U.S. sink gillnet fisheries was 304 animals, with unknown levels of mortality in the bottom trawl fishery and some Canadian fisheries (Waring et al., 2008).

Ecology and life history: Like harbor seals, but unlike harp and hooded seals, gray seals haul out routinely for resting and not only for breeding or molting. They appear to be flexible in selection of haul-out substrates, utilizing rocky ledges, sandy beaches, and sea ice.

After the winter breeding season, there is a post-breeding pelagic feeding period in February–April. This is followed by a haul-out for molting in May or June, then another dispersed feeding period until the next winter’s pupping season begins (Lesage and Hammill, 2001). Juveniles disperse more widely than adults during feeding phases of the annual cycle (Ronald and Gots, 2003). Three gray seals were taken in 1996 by Spanish trawlers on southern edge of the Grand Banks (Lens, 1997), suggesting they are capable of moving long distances and far offshore during pelagic feeding. Recent satellite-linked tagging studies have confirmed that Canadian gray seals commonly travel long distances far from their breeding sites (Beck et al., 2002; Austin et al., 2003).

Gray seals feed on a variety of fish species and cephalopods, with no evidence for significant dietary differences between first-year juveniles and adults (Bonner, 1981). Scat samples from Muskeget Island, Massachusetts, included flounder, silver hake, sand lance, skates, and gadids (Rough, 1995). Species identified from scats collected from Sable Island, Grand Manan Island, and eastern Nova Scotia include sand lance, herring, silver hake, cod, pollack, capelin, flounders, mackerel, and squid (W. D. Bowen et al., 1993; Bowen and Harrison, 1994). In New York waters, stomach contents of stranded gray seals show herring to be the predominant prey, as well as mackerel, gadids, and flounders (S. S. Sadove, pers. comm.).

Gray seals give birth to single pups in January or February (Bonner, 1981; Riedman, 1990; Nowak, 1999; Hall, 2002). Adult females attend their pups continuously from birth to weaning and do not feed at all during that time. The breeding fast is even longer for adult males, since they arrive first to stake out and defend territories. Pups are weaned and abandoned in about 18 days, followed by a post-weaning fast of 10–28 days. Pups are born with a white lanugo coat that is molted around the time of weaning. Ovulation and mating take place late in lactation, and implantation is delayed for about 3.4 months.

Age at sexual maturity differs between sexes (Bonner, 1981; Hall, 2002). Most females mature at 4 or 5 years. Males mature at 6 years, but do not begin to breed until 8 years. Most breeding bulls are 12 to 18 years old.

Sharks prey on gray seals around Sable Island (Brodie and Beck, 1983; Stobo and Lucas, 2000). A variety of different shark species has been implicated, but Greenland sharks are suspected as a principal predator.

Bonner (1981) reviewed the occurrence of disease and parasites in gray seals. Most disease incidences are known from pups where the immune system has been compromised by starvation, rendering them subject to a variety of opportunistic infections. Common infections include pneumonia, conjunctivitis, and septicemia. External parasites include seal lice (*Echinophthirius horridus*) and nasal mites (*Halarachne halichoeri*). Internal parasites include a variety of nematodes, acanthocephalans, cestodes, and trematodes in the gut, lungs, liver, and kidneys. Of particular interest is the anisakine nematode *Pseudoterranova decipiens*, the sealworm or codworm (Templeman, 1990). The penultimate phase of the parasite's life cycle is as a large juvenile encysted in the muscle tissue of a fish like cod or haddock, greatly reducing the palatability and marketability of the fillets. Piscivorous seals are the final host in the life cycle of the worms, which mature and reproduce in the seal's gut. Sealworms infect other seal species, but are most commonly found in gray seals in most areas, which has led to seal reduction programs such as bounties or culls. Disease and parasites are better known in harbor seals, and it is likely that many of the same organisms affect gray seals.

General distribution: Gray seals are found only in the North Atlantic (Bonner 1981; Riedman 1990; Nowak 1999; Hall 2002; Ronald and Gots 2003). There are three separate populations: a

Canadian stock that occurs from Massachusetts to Labrador, a European stock that occurs from France north to Russia and west to Iceland, and a third stock in the Baltic Sea. There are two principal pupping concentrations of the Canadian stock: one in the Gulf of St. Lawrence and the other on Sable Island off the southern coast of Nova Scotia. The Massachusetts population has grown substantially, and at least two pupping colonies are now established in Maine (Waring et al. 2008).

Historical occurrence: Gray seals were largely absent from Rhode Island and nearby waters until recently. Cronan and Brooks (1968) reported that the species was unknown from Rhode Island, but said that there was one record to the south. That surely referred to Goodwin's (1933) report of a juvenile male taken in a net at Young's Million Dollar Pier in Atlantic City, New Jersey in 1931. Archaeological finds indicate that Native Americans utilized gray seals on Block Island and along the Connecticut coast (Waters, 1967), however, the number of individuals was apparently relatively small. It is quite possible that the Indians simply made opportunistic use of stranded animals at no greater frequency than current stranding rates. Neither De Kay (1842) nor Connor (1971) knew of any occurrences in New York. Similarly, Linsley (1842) did not mention gray seals for Connecticut, and Goodwin (1935) stated that the species had not been recorded in Connecticut.

Waters and Rivard (1962) said that gray seals might occur in low numbers in winter off Massachusetts to as far south as Block Island. There was a small breeding colony of gray seals in Massachusetts during the first half of the 20th Century (Andrews and Mott, 1967; Rough, 1995). They pupped on Muskeget Island, a low sandy island off the west end of Nantucket. They had been nearly extirpated by the 1960s due to hunting, primarily for bounties paid by state authorities in both Maine and Massachusetts. Annual pup production of the Massachusetts colony declined from 14–19 in the early 1950s to only 1 by the end of 1960s. No pups were observed and adults were scarce in 1971–1979, but the number of seals increased during the 1980s and pupping resumed by 1988 (Rough, 1995).

Recent occurrence: The recovery of the Massachusetts and Canadian populations led to an increased occurrence in southern New England and mid-Atlantic waters. There are gray seal specimens in the Smithsonian collection from strandings in New Jersey in 1973 and 1978. These were the first records west of Massachusetts after the 1931 Atlantic City animal. The three earliest strandings in Rhode Island, all from Block Island, were in 1980, 1986, and 1988 (Nawojchik, 2002), although the 1980 specimen was misidentified and labeled as a harbor seal and then lost in a freezer for 24 years (Kenney, 2005). The first sighting of a gray seal in eastern Long Island was in about 1980 (S. S. Sadove, pers. comm.). Strandings and occasional sightings throughout the region have become common beginning in the 1990s.

Gray seal occurrences in the Rhode Island study area are mostly represented by stranding records—155 of 193 total records (80%). Gray seal records in the region are primarily from the spring (87.1%), with much smaller numbers in all other seasons—5.7% in winter, 5.2% in summer, and 2.1% in fall. Strandings were broadly distributed along ocean-facing beaches in Long Island and Rhode Island, with a few spring records in Connecticut (Fig. 55). There were no strandings on the north shore of Long Island.

As with other seals, habitat use by gray seals in the Rhode Island study area is poorly known. They are seen mainly when stranded or hauled out and infrequently at sea. No definitive conclusions about habitat preferences should be drawn from strandings. Gray seals are frequently observed mixed in with groups of harbor seals at haul-out sites in Massachusetts and northward. There are very few observations of gray seals in Rhode Island other than strandings. In New York, apparently healthy gray seals are similarly seen at harbor seal haul-outs, usually only one or two animals but in larger numbers on a few occasions (S. S. Sadove, pers. comm.). The most regular occurrences are at the haul-outs on Great Gull Island and Fisher's Island.

The annual numbers of gray seal strandings in the Rhode Island study area since 1993 have fluctuated markedly, from a low of 1 in 1999 to a high of 23 in 2004 (Fig. 56). There is some suggestion of a 3-4 year periodicity, but any underlying factors are not understood.

The very strong seasonality observed in gray seal occurrence in the study area is clearly related to the timing of pupping in January–February. The majority of individuals in the study area appear to be post-weaning juveniles, and starved or starving juveniles are the most common stranded individuals encountered (Nawojchik, 2002; Kenney, 2005). The expected period of feeding dispersal by newly weaned pups that have just completed their post-weaning fast and molt would be in March and April. A peak in gray seal stranding frequency in the study area occurs in April (n = 82, 43%), followed by March (61, 32%) and May (25, 13%) (Fig. 57).

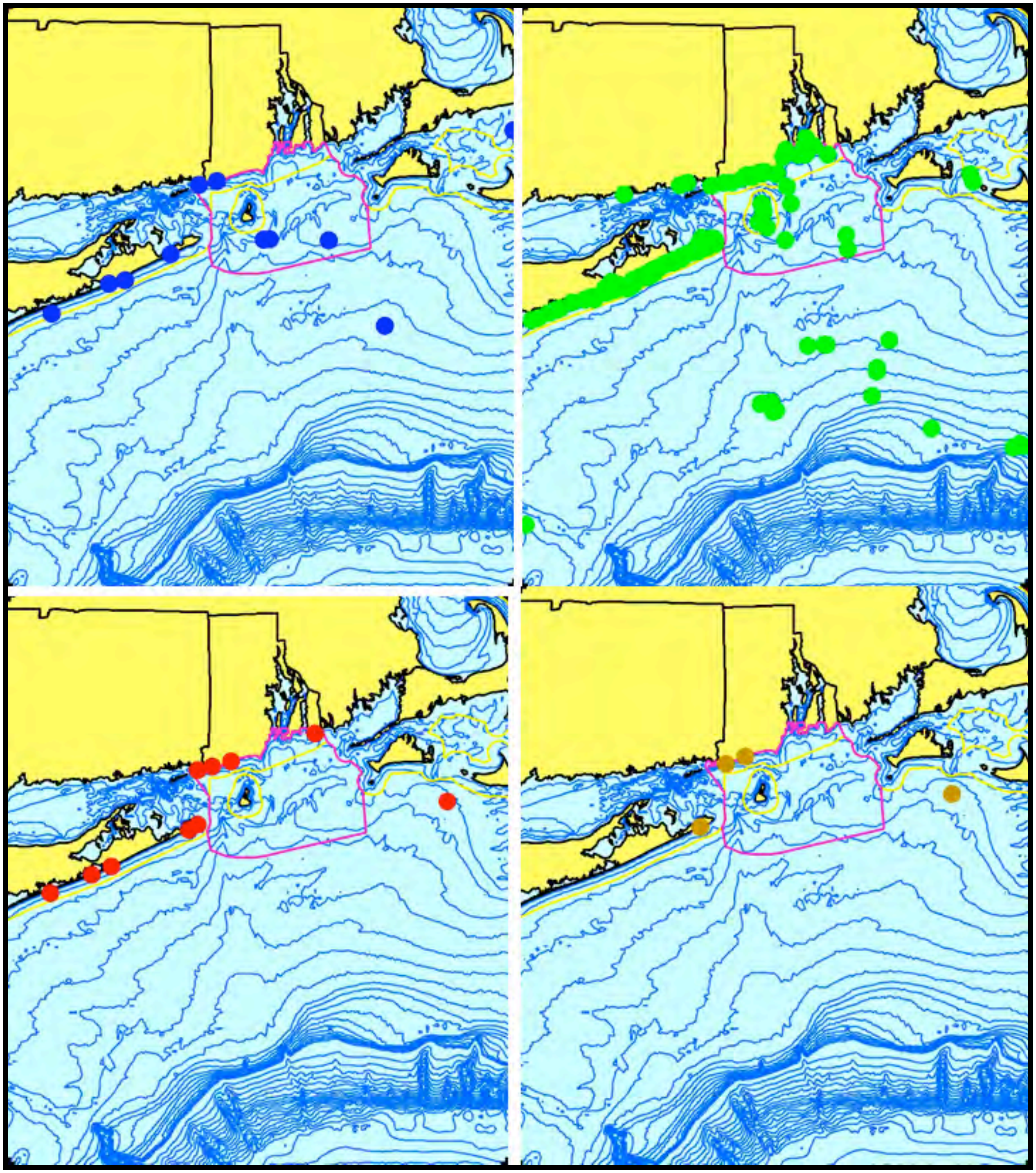

Figure 55. Aggregated sighting, stranding, and bycatch records of gray seals in the Rhode Island study area, 1986–2008 (n = 193: winter = 11, spring = 168, summer = 10, fall = 4).

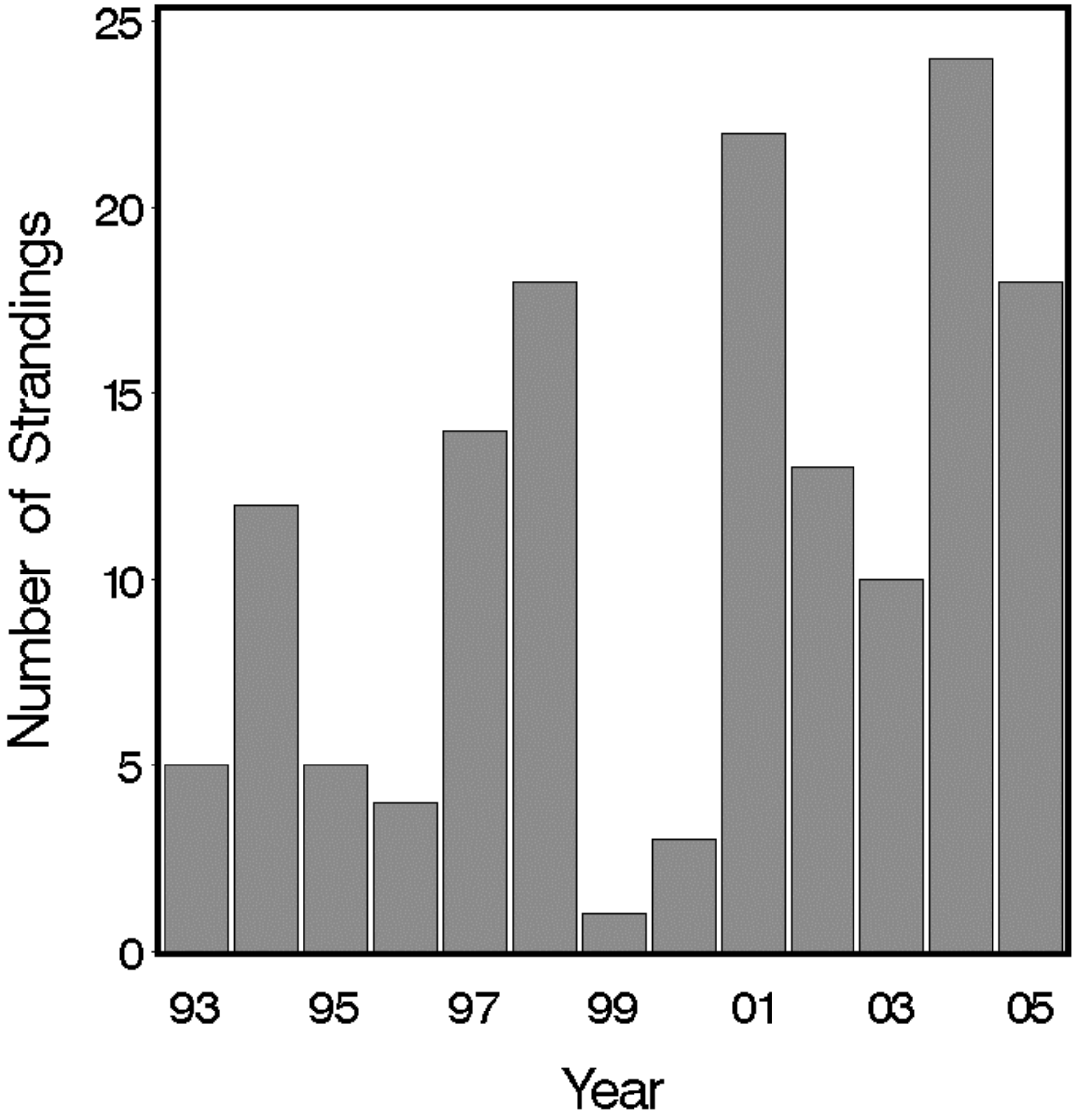

Figure 56. Annual stranding frequencies for gray seals in the Rhode Island study area, 1993–2005.

Including six pre-1993 stranding records provided by Mystic Aquarium, gray seal strandings in Rhode Island alone have been relatively uncommon (Fig. 58). Most years had 0–3 strandings, but there was a short-term spike with 7 in 2003 and 8 in 2004.

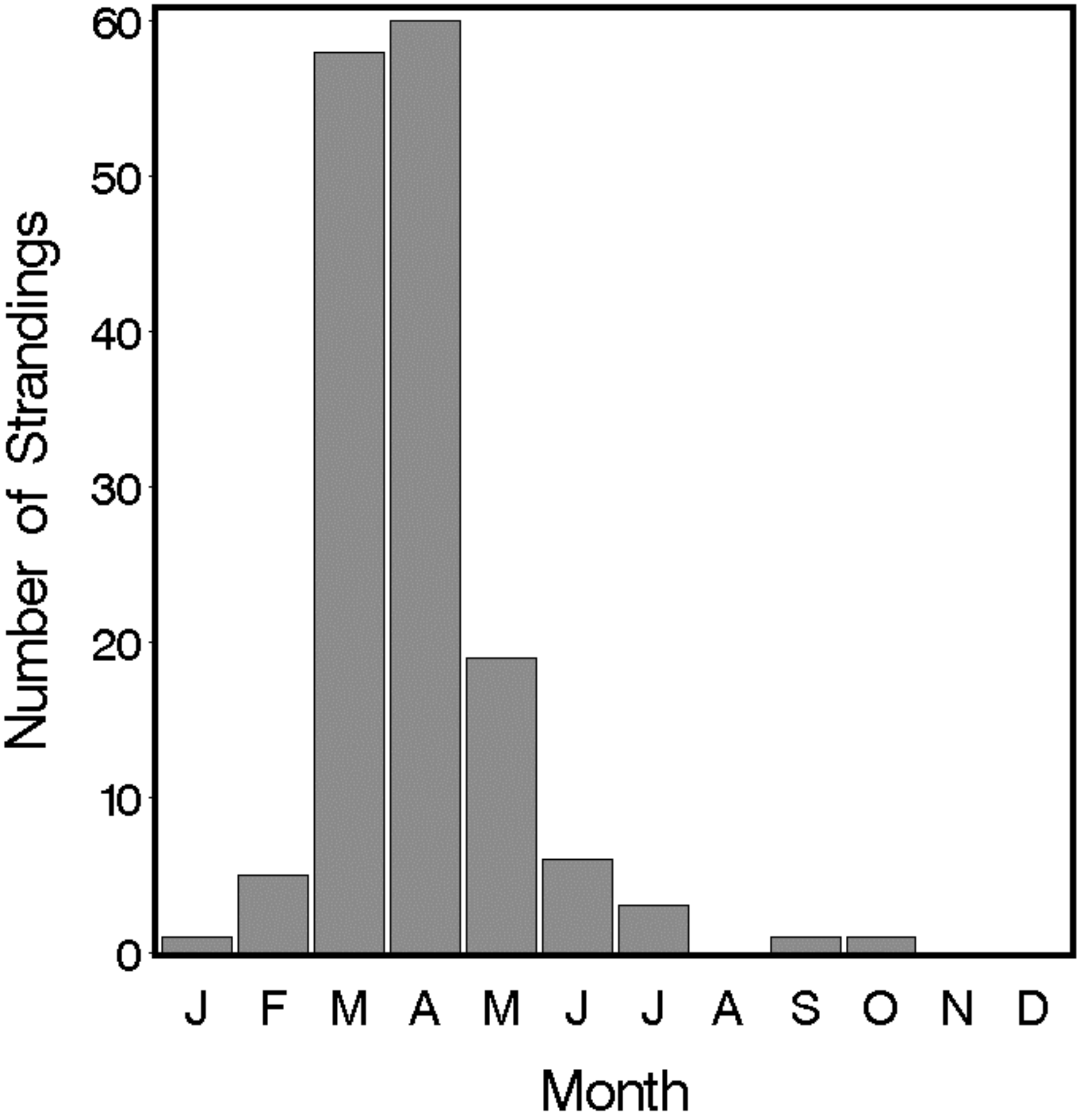

Figure 57. Monthly stranding frequencies for gray seals in the Rhode Island study area.

Conclusions: The occurrence of gray seals in the Rhode Island study area appears to be increasing over time, but the seals present are mostly dispersing juveniles in the spring. There are no consistent haul-out locations in the study area except for the sandy shoals around Nantucket and Monomoy in Massachusetts. Consequently, gray seals are not a significant concern relative to the SAMP. Over the longer term, one might speculate that continued expansion of the breeding colony in Massachusetts could lead to establishment of pupping at Sandy Point at the northern end of Block Island, which might have the right combination of habitat and low disturbance.

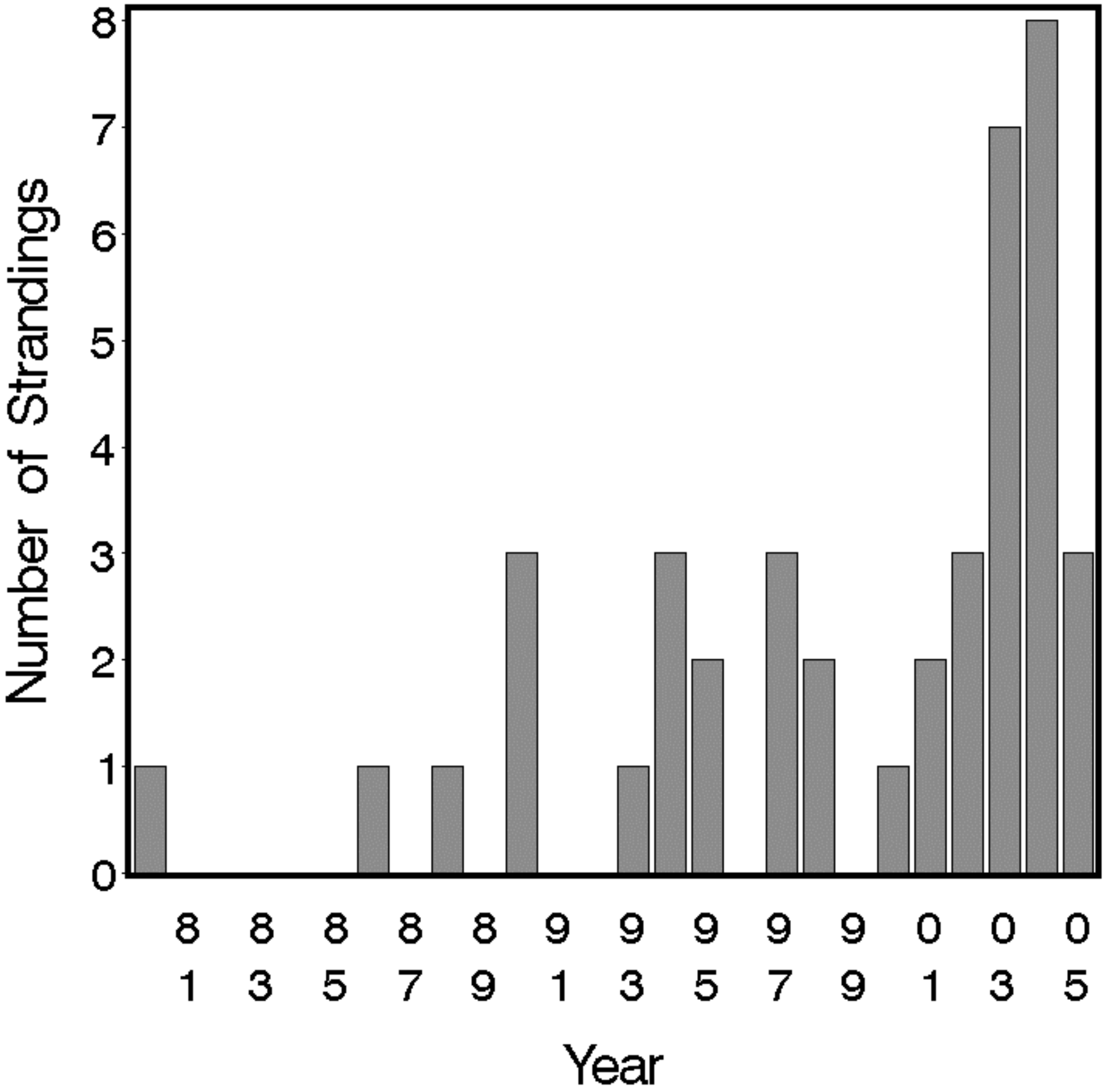

Figure 58. Annual stranding frequencies for gray seals in Rhode Island alone, 1980–2005.

3.2.26. Harp Seal *Pagophilus groenlandicus* (Erxleben, 1777)

Description: Adult harp seals are relatively distinctive and easily recognized. While they are roughly the same size (1.7–1.9 m) and shape as harbor seals, with heads that appear slightly smaller, their color pattern is distinctive (Jefferson et al., 1993; Wynne and Schwartz, 1999). An adult has a pale white to silvery-gray body with a black face and a black inverted V- or harp-shaped marking on the back. Juveniles are silvery gray with scattered large black blotches, and are much less spotted than similar-sized harbor seals. Harp seals go through a sequence of pelages from neonate to adult (Lavigne, 2002). Pups known as “thin white-coats” are born covered in a fine, white fetal fur or lanugo. They become “fat white-coats” as they gain weight during nursing. At weaning, the juvenile coat has filled in and is visible under the white lanugo. The pup is now known as a “gray-coat.” The lanugo is shed after weaning, and the pup then has a silvery juvenile coat with scattered dark blotches. At this stage young seals are referred to as “beaters” because of their awkward, splashing manner of swimming on the surface. The second molt occurs at 13 to 14 months into a similar “bedlamer” pelage, with somewhat more dark patches. Juvenile and adult seals molt annually, hauling out in dense aggregations on the pack ice north of the breeding areas in April and May (Ronald and Gots, 2003). Adult pelage is attained at the time of sexual maturity. The transition tends to be much quicker in males than females, with some females never completely developing the harp pattern. Adults with the intermediate pattern of both a partially developed harp marking and typical juvenile dark blotches are known as “spotted harps.”

Status: Harp seals are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. Despite substantial annual harvests by commercial and subsistence hunters, the abundance of harp seals in the eastern Canadian populations appears to have increased steadily (Waring et al., 2008). Abundance is estimated using production models based on pup counts. The total Canadian population was estimated at 3.1 million in 1990, 4.8 million in 1994, 5.2 million in 1999, 5.5 million in 2000, and 5.9 million in 2004. The other two populations are substantially smaller—0.3 million near Jan Mayen and 1.5–2.0 million in the White Sea (Lavigne, 2002). There are no estimates for the numbers of harp seals off the northeastern U.S. or in the Rhode Island study area.

Harp seals have traditionally been hunted for subsistence use by the Inuit in Greenland and eastern Canada (MacLean et al., 2002). They still are hunted in Greenland; one of the first returns of a flipper tag from a live-stranded harp seal that had been rehabilitated and released by Mystic Aquarium came from an Inuit hunter in Greenland (R. Nawojchik, pers. comm.). Lavigne and Kovacs (1988) extensively reviewed the history of the eastern Canadian seal hunt. Early European settlers did not immediately exploit harp seals, since other species were more accessible. The walrus was the first species hunted for ivory, oil, and leather, but it was extirpated in the Gulf of St. Lawrence and off Nova Scotia by the early 18th century. Hunters also took gray seals and, to a lesser extent, harbor seals for oil, meat, and skins. Winter harp seal hunting began in the St. Lawrence River in the mid-17th century. Hunting methods quickly shifted from shooting seals on the ice from boats to the use of nets, adopting the Inuit methods. By the mid-18th century, harp sealing spread throughout the Gulf and along the northeastern coast of Newfoundland. Total annual takes ranged from 7,000 to 128,000 seals. It was also in the 18th century that the early spring hunt for white-coat pups began. During those years whelping patches, on the pack ice, were easily accessible from shore. In the 19th century, technological advances such as steam-powered ships enabled additional expansion of the hunt. Annual takes ranged from more than 500,000 to 740,000 seals. Hooded seals were also taken. Oil rendered from the blubber layer was the main product of the seal hunt, until tanning methods (developed in the 1940s and 1950s) made the pelts of white-coat harp seals and, especially, blue-back hooded seals extremely valuable. Beginning in the 1960s, opposition to the white-coat hunt became a major campaign of environmental organizations. Because of widespread opposition and a European ban on importation of white-coat pelts, commercial hunting of seal pups was banned in Canada in 1987. Hunting is now restricted to non-breeding adults, juveniles, and independent, post-weaning pups. The harp seal hunt is currently managed under quotas set by the Canadian Dept. of Fisheries and Oceans (Waring et al., 2008). Total annual take in Canada and Greenland, by commercial and subsistence hunters, including animals struck and lost, is about 440,000 harp seals. There is also substantial mortality caused by entanglement in gillnets in the Canadian lumpfish fishery, varying between 5,000 and 19,000 annually. Entanglement mortality in U.S. fisheries is lower, averaging 73 per year in 2001–2005 in the sink gillnet fishery plus an undetermined number in the bottom trawl fishery.

Starvation is by far the most frequent cause of mortality and morbidity for harp seals in the

Rhode Island study area. The most common harp seal encountered is a stranded, starved or starving juvenile in winter or early spring. The timing coincides with the feeding transition period, when 1-year-olds must switch from near-surface feeding on krill to diving deeper for fish, and some proportion of animals simply do not seem to make that transition successfully. Lucas et al. (2003) reported the same phenomenon at Sable Island, where three-quarters of the harp and hooded seals encountered were starved or emaciated juveniles. They also reported on the prevalence of gravel in the stomachs, and concluded that juveniles were often unable to feed successful. Disease and parasites are much better known in harbor seals, and it is likely that many of the same organisms affect harp seals.

Ecology and life history: Harp seals are gregarious in their northern range, hauling out for pupping and molting in large aggregations. In the Rhode Island study area, however, they are most often solitary. Nearly all individuals observed are juveniles. Three adults (one stranded dead, one photographed alive but extremely emaciated, and one apparently healthy) have been reported in Rhode Island, and Sadove and Cardinale (1993) reported one stranded adult in New York. An adult was captured in 1945 in Virginia (McAlpine and Walker, 1990), and adult markings were described for a harp seal in New Jersey by Allen (1880) (see Historical Occurrence below).The increase in juvenile harp seal occurrences in the Rhode Island study area in the 1990s coincided with growth of the seal population in Canada and declines in fish stocks. One might speculate that juveniles are forced to disperse more widely because of competition for prey (McAlpine et al., 1999a). However, complicating factors such as changes in climatic and oceanographic conditions (Frank, 2003) prevent taking the idea much beyond speculation.

Harp seals in their usual range are associated with sea ice, with an annual migration following the annual cycle of pack ice, moving north in summer and south in winter (Ronald and Healey, 1981; Lavigne, 2002; Ronald and Gots, 2003). Off the northeastern U.S., almost nothing is known of their habitat preferences except for stranded individuals. Like hooded seals, they are most likely to occur on relatively flat, sandy beaches.

Adult harp seals feed on a wide variety of small pelagic and demersal fishes, squid, and crustaceans, especially on capelin and Arctic cod (Wallace and Lawson, 1997). Pups undergo a transition in prey type and feeding depth during their first year (Ronald and Healey, 1981). After the post-weaning fast, pups first feed mainly on euphausiid crustaceans (“krill”) in near-surface waters. At about one year of age, they make a transition to diving to intermediate depths and feeding on pelagic fishes. Stomach contents of harp seals stranded in New York sometimes include herring or similar fishes (S. S. Sadove, pers. comm.). Often, stomachs are empty, or at times filled with stones and shells, leading to serious medical complications or death (Medic, 2005). No reason for the pathologic ingestion of stones has been determined, but it is speculated that it is a consequence of their habit of eating ice as a source of fresh water. Stranding response protocols for harp and hooded seals have been modified in an attempt to recover starving juveniles as soon as possible before they have a chance to start eating stones.

Female harp seals give birth to single pups on the dense pack ice (Ronald and Healey, 1981; Lavigne and Kovacs, 1988; Lavigne, 2002; Ronald and Gots, 2003). Females select areas of thick, hummocky ice that provides protection for pups. These locations are some distance from the ice margin but where open water is still accessible. Females gather in aggregations separated only by a couple of meters from one another. The timing differs slightly among breeding populations. Most pups in the Gulf herd are born between 20 February and 10 March, while births are slightly later in the Front herd.

Pups average a meter in length, weigh 11–12 kg at birth, and have little blubber. They nurse for 10–12 days on milk that is up to 43% fat and 10% protein, gaining 2.2 kg per day. Females fast entirely, or feed little, during lactation. They abandon the pups immediately after weaning. At weaning the pups have a 5-cm thick layer of blubber and weigh ca. 36 kg. Pups then remain on the ice for a post-weaning fasting period as long as 6 weeks, during which they can lose up to half of their body mass.

Mating occurs just after the pup is weaned. It usually takes place in the water, though there have been observations of mating on the ice. Implantation of the embryo is delayed about three months. Adult females breed annually, and both males and females can remain reproductively active into their twenties (Ronald and Healey, 1981). Both males and females reach sexual maturity at an average age of 5.5 years, but males generally are not reproductively active and successful until age 8 (Ronald and Healey, 1981).

General distribution: Harp seals are found only in the North Atlantic and Arctic, from eastern Canada east to northwestern Siberia (Ronald and Healey, 1981; Lavigne and Kovacs, 1988; Riedman, 1990; Nowak, 1999; Lavigne, 2002; Ronald and Gots, 2003). There are three breeding populations—in the White Sea north of Russia, in the Greenland Sea near Jan Mayen, and in two locations near Newfoundland—the “Front herd” to the northeast and the “Gulf herd” to the west. Harp seal breeding patches are located somewhat inshore of those of hooded seals. Their distribution during the remainder of their annual cycle is poorly known.

Historical occurrence: Until recently harp seals were very rare in the Rhode Island study area and nearly as rare from Massachusetts to Maine (McAlpine and Walker, 1990). Cronan and Brooks (1968) cited one earlier report of a harp seal in Connecticut (but see the following), but knew of no records from Rhode Island. Waters and Rivard (1962) described harp seals as rare winter visitors to New England, but gave no specific records. Linsley (1842) reported a single occurrence in Connecticut: “The white seal, commonly called the harp seal, is very rare, and has been seen only at Stonington a few times on the rocks. During the past winter, attempts were made to take him, but unfortunately the hunters went to the windward side of him, and though they came so near as to shoot at him while sliding off, he escaped. I have information from J. H. Trumbull, Esq., of Stonington, who says ‘his color was a dusky white throughout.’ I conclude, therefore, it must be the *groenlandica*.” Given that (1) the identification was based only on color from a second-hand report, (2) the report said nothing about markings, (3) harp seals in southern New England are more likely to haul out on flat sand than rocks, and (4) some harbor seals, especially when dry, appear very pale-colored, it seems that Linsley’s seal was more likely a harbor seal. Goodwin (1935) and Connor (1971) repeated Linsley’s account, and Connor added an unsubstantiated report from Kieran (1959) of harp seals offshore at Coney Island in winter. Allen (1880) reported a harp seal at Trenton, New Jersey and did include reasonable identifying details, but it was a third-hand report without documentation. Goodwin (1954) reported an adult male captured at Cape Henry, Virginia, in March 1945, documented by a newspaper photograph that was reprinted by McAlpine and Walker (1990), making it the only well-documented historical record south of Massachusetts.

Recent occurrence: Harp seals in the Rhode Island study area are known almost exclusively from strandings (688 of 703 records = 98%). Strandings are widespread on ocean-facing beaches throughout Long Island and Rhode Island (Fig. 58). The apparent absence in Massachusetts is due only to the geographic scope of the stranding dataset we had acquired. The records are almost entirely from spring (68.3%) and winter (30.4%). Harp seals are nearly absent in summer

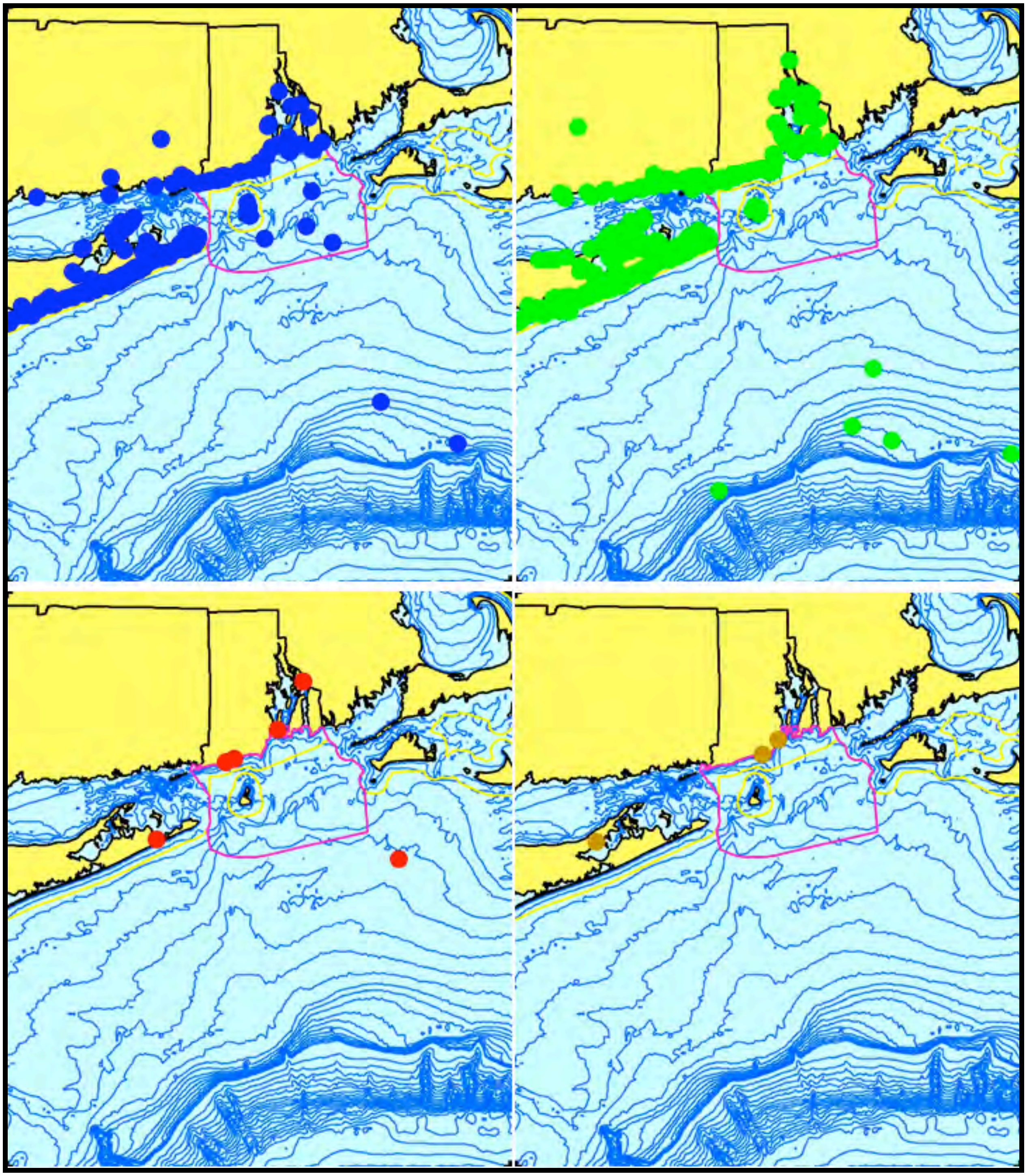

Figure 59. Aggregated stranding, sighting, and bycatch records of harp seals in the Rhode Island study area, 1989–2007 (n = 703: winter = 214, spring = 480, summer = 6, fall = 3).

and fall. Strandings are common on both sides of Long Island Sound, more than any other species of seal. Harp seals also make occasional appearances well inland up rivers.

Beginning in the late 1980s harp seal occurrences began to increase in the Gulf of Maine (McAlpine and Walker, 1990; Stevick and Fernald, 1998; McAlpine et al., 1999a; Harris et al., 2002). The available regional stranding dataset for the Rhode Island study area begins in 1993, when there were 9 harp seal strandings (Fig. 60). Harp seal records in the region more than quadrupled to 38 in 1994, then increased to 55 in 1995 and to a peak of 67 in 1996. In 1995, for the first time harp seals exceeded the total for harbor seals. They have been the most common stranded seal in the region since, with the exception of 2003. Strandings spiked sharply in 2001 at 150% higher than the average annual rate in the other years from 1994 to 2005.

Monthly stranding frequencies provide a clearer view of the trend in harp seal strandings over the year (Fig. 61). Strandings peak in late winter-early spring, with very few outside of January–May. Peak strandings are in March (42%), with 22% in both February and April. The timing is too late for the strandings to be pups born in late February–early March in Newfoundland, confirming that strandings in the region are primarily yearlings.

It appears from the study area stranding trend that harp seal occurrence increased sharply in 1994 (Fig. 60), but that dataset doesn’t quite capture the beginning of their presence in the region. There were three earlier strandings in Rhode Island—near the Quonochontaug Breachway in Charlestown in May 1989, on Napatree Point in Westerly in April 1990, and at Mackerel Cove in Jamestown in January 1992. There were also strandings before 1993 in New York (Sadove and Cardinale, 1993), but we don’t have those records. Looking only at Rhode Island (Fig. 62), the stranding trend closely matches that for the entire study area, confirming that 1994 was the year when their presence really began to increase. The spike in 2001 is even higher in Rhode Island, at 284% above the 1994–2005 average background rate.

Conclusions: While harp seals may be relatively abundant in the Rhode Island study area, they are predominantly juveniles dispersed from a population center far to the north in eastern Canada. They are not of concern relative to the SAMP.

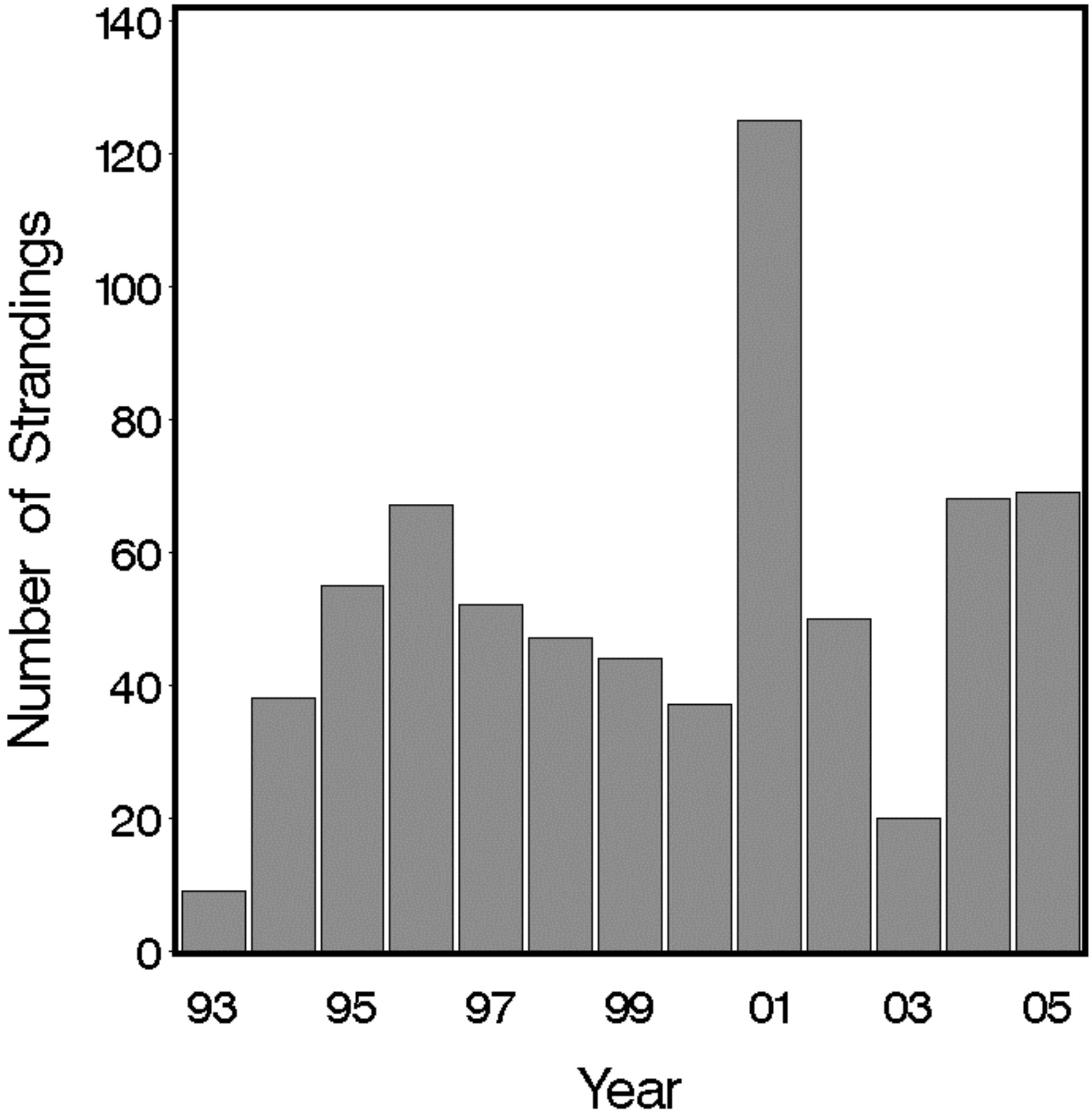

Figure 60. Annual stranding frequencies for harp seals in the Rhode Island study area, 1993–2005.

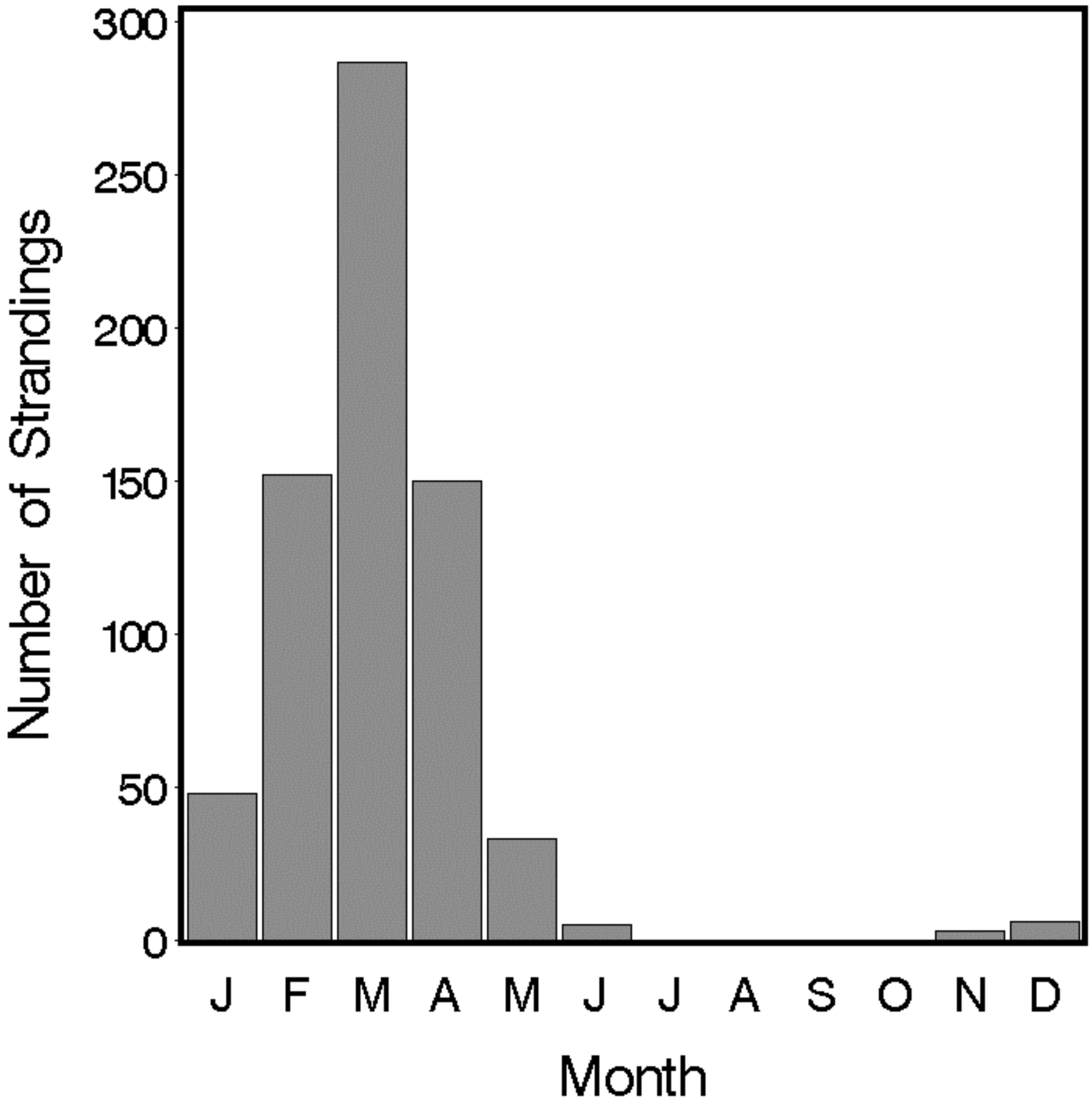

Figure 61. Monthly stranding frequencies of harp seals in the Rhode Island study area.

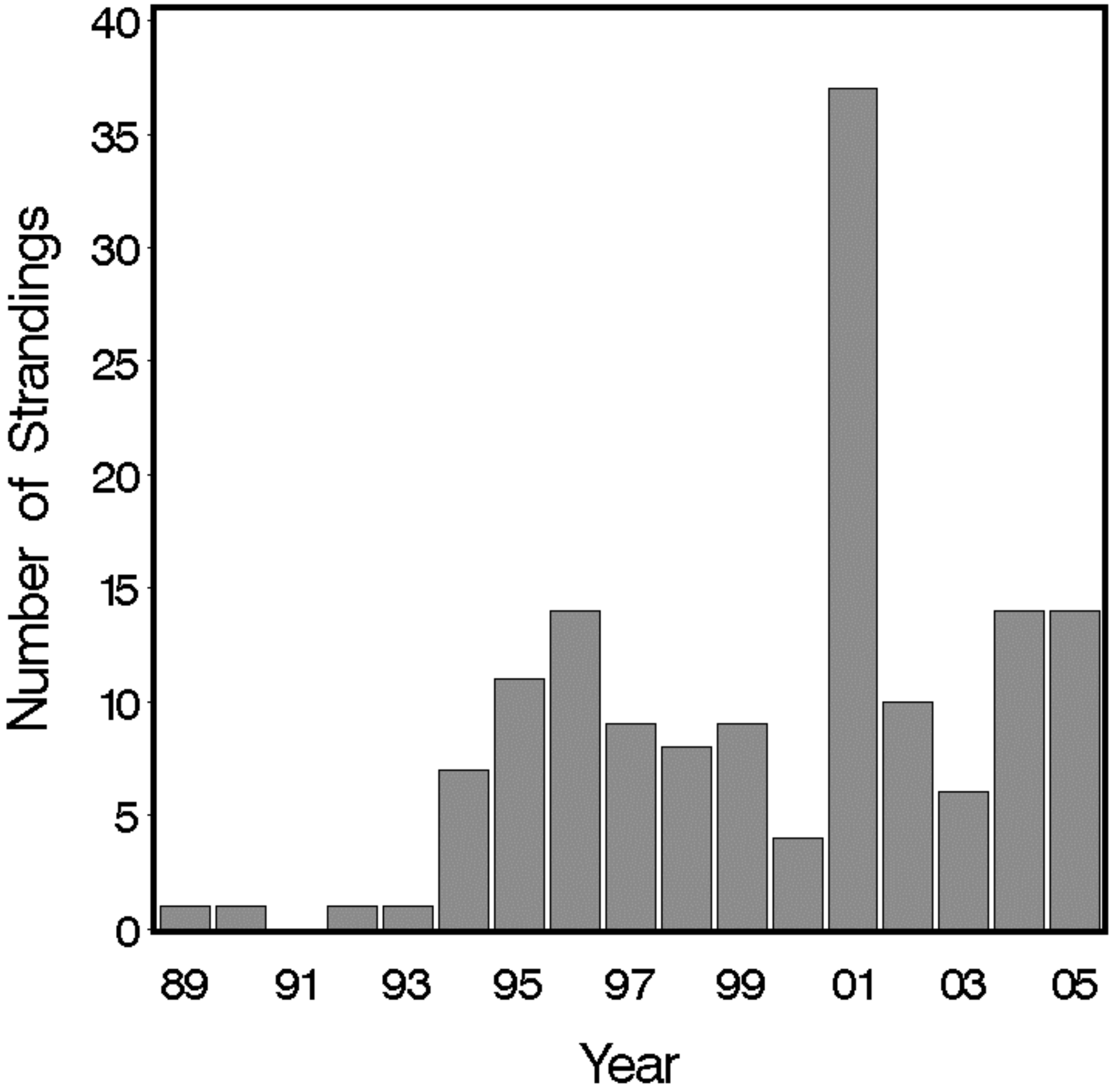

Figure 62. Annual stranding frequencies for harp seals in Rhode Island alone, 1989–2005.

3.2.27. Hooded Seal *Cystophora cristata* (Erxleben, 1777)

Description: Hooded seals are moderately sexually dimorphic, with males 2.3–2.7 m long and females 2.0–2.2 m (Jefferson et al. 1993; Wynne and Schwartz 1999). Adult males have a two-lobed, inflatable proboscis or hood on the top of the snout. They can also inflate the nasal septum out of one nostril like a red balloon. Adults are silvery blue-gray with a black face, irregular black blotches, and a lighter belly. Pups, known as "blue-backs," are solid dark blue-gray above, with a creamy whitish belly clearly demarcated from the dark back. The head is broader, flatter, and rounder, with noticeably larger eyes, than other Atlantic seals.

Status: Hooded seals are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Vulnerable on the IUCN Red List. There is no current, reliable estimate of abundance for the entire hooded seal population in the North Atlantic or for the animals within U.S. waters or in the Rhode Island study area (Waring et al., 2008). Breeding herd abundance estimates are extrapolated from pup counts assuming a ratio of 1:5 (pups:total population). The most recent estimates were from counts in 2005 (IUCN, 2008). The total abundance of the Northwest Atlantic stock (in eastern Canada and western Greenland) was estimated at 592,000, which represents a moderate increase since 1980. The West Ice stock (east of Greenland) was estimated at about 70,000, which is a decline of 85–90% in the last 60 years, and pup production declined from 24,000 in 1997 to 15,250 in 2005. The cause of the decline is not understood, but it is the reason for the Vulnerable classification on the Red List.

Hooded seals have long been hunted both by subsistence hunters (MacLean et al., 2002) and commercial sealers (Lavigne and Kovacs, 1988; Waring et al., 2008). There is no longer any hunting of blue-backs for their pelts. The annual commercial quota for the Front herd off eastern Newfoundland has been set at 10,000 since 1998, but recent catches have been low, and no commercial hunting is allowed in the Gulf of St. Lawrence or Davis Strait (Waring et al., 2008). The West Ice commercial hunt is jointly managed by Norway and Russia, with several thousand taken each year (NMFCA, 2006). An average of 16 hooded seals per year have been killed in recent years in U.S. waters by entanglement in the sink gillnet fishery, and others are taken as bycatch in Canadian fisheries (Waring et al., 2008). The total incidental take from all sources is believed to be low relative to the population's total abundance.

Ecology and life history: Hooded seals are solitary and aggressive (Kovacs, 2002). Most of the year they are widely dispersed and asocial. Even when aggregating during the breeding and molting season, they are aggressive with one another. Adult males fight for prime space near a mother and pup, but a female will keep a larger male at a distance from her pup. Even newly weaned pups have a reputation for aggressiveness.

Almost nothing is known of habitat use by healthy hooded seals in the Rhode Island study area. The species is known exclusively from strandings, which are nearly all recently weaned blue-back pups, many of which are under-nourished or even starving. A subadult male that live-stranded in Westerly in February 1999 was an exception. It was rehabilitated and released (see below). In their normal range, hooded seals are most often associated with sea ice. As with harp seals, the other ice seal that occurs in the Rhode Island study area, hooded seals are most often observed on relatively flat sandy beaches.

Outside of the breeding season, hooded seals are most likely highly pelagic. Scholander (1940) recorded a month-old hooded seal pup diving to a depth of 75 m on its first dive. Based on telemetry tagging, hooded seals are capable of dives deeper than 1000 m and lasting almost an hour (Folkow and Blix, 1995; Kovacs, 2002).

In their normal Arctic range, adult hooded seals feed on deepwater fish species such as Greenland halibut, redfish, and a variety of other fishes and squids (Reeves and Ling, 1981; Kovacs and Lavigne, 1986; Kovacs, 2002; Ronald and Gots, 2003), while pups feed more on crustaceans at shallower depths. Their prey preferences in the Rhode Island study area are poorly known. Stomachs of stranded animals contain a variety of prey items, probably reflecting local prey availability.

Hooded seal reproduction was reviewed by Reeves and Ling (1981), Kovacs and Lavigne (1986), Lavigne and Kovacs (1988), and Kovacs (2002). Single pups are born in late March, with pupping in all the stocks occurring synchronously. Pupping takes place on loose pack ice, with females at least 50 m apart. Hooded seals tend to pup farther offshore than harp seals in all areas except the Gulf of St. Lawrence. Pups are about 1 m in length and weigh 20–25 kg at birth. They shed the gray lanugo in utero and are born in a relatively advanced state in their juvenile blue-back coats. They are nursed on milk that averages 60% fat content, and weaned at 50–60 kg in only four days, the shortest known lactation period of any mammal (Bowen et al., 1985).

Each female-pup pair is usually guarded by a single male. Males compete vigorously for the opportunity via displays at first, but competition frequently escalates to violent, bloody fights. After weaning, the female abandons the pup and returns to the water, where mating takes place. At an earlier time, these mother-pup-male triads were anthropomorphically interpreted as families, and hooded seals were presumed to have a monogamous mating system. However, after mating with one female the male is free to move to another, resulting in a polygynous mating system (Boness et al., 1988). The most successful males may mate with up to 8 females in one breeding season. Implantation of the embryo is delayed for about four months, extending gestation to match a tightly synchronized annual cycle. Adults then disperse until aggregating, along with juveniles, for molting in June and July.

Pups remain alone on the ice for a post-weaning fast period of at least several days. They then disperse widely. They skip the molt during their first year and undergo the first post-natal molt at 14 months of age.

Females mature at age 3. Males mature at 4–6 years, but probably need to be older in order to successfully compete for mating opportunities (Lavigne and Kovacs, 1988).

General distribution: Like most pinnipeds, the distribution of hooded seals is well-known only for the portion of their annual cycle when they haul out for pupping (“whelping”). Hooded seals occur only in two separate breeding stocks in the North Atlantic (Reeves and Ling, 1981; Kovacs, 2002). The Northwest Atlantic stock pups in three areas, two in eastern Canada—the Gulf herd in the Gulf of St. Lawrence west of Newfoundland and the Front herd northeast of Newfoundland and east of Labrador, and in the Davis Strait between eastern Canada and Greenland. The West Ice stock pups in the Greenland Sea, east of Greenland and near Jan Mayen. After the breeding season, adults and pups disperse, then seals from all areas, except pups, re-aggregate in the Denmark Strait between Greenland and Iceland to molt, with a second molting area farther north off the east coast of Greenland for some of the West Ice animals (Nowak, 1999). Their distribution at sea is poorly known, but they apparently disperse widely through much of the northwestern North Atlantic and into the Arctic Ocean (Lavigne and Kovacs, 1988). A few hooded seals, particularly pups and juveniles, have been known to disperse surprisingly far from their breeding areas, including the Caribbean and the North Pacific. Strandings have recently increased in frequency in New England, primarily between January and May coinciding with the breeding season (McAlpine et al., 1999b; Harris et al., 2001).

Historical occurrence: Historical literature confirms both the presence and extreme rarity of hooded seals in the Rhode Island study area or in southern New England more generally. Cronan and Brooks (1968) reported a single record in the Providence River, but the date was unknown to them. Waters and Rivard (1962) also mentioned the Providence occurrence and one other at Newburyport on the Massachusetts north shore. De Kay (1824) reported that an adult male was killed in Westchester County, New York. Linsley (1842) and Goodwin (1935) stated that they were not known from Connecticut. Connor (1971) added a second New York record—an anecdotal report of a hooded seal in a New York Harbor tributary “within just the last few years.”

Recent occurrence: Hooded seal occurrences in the Rhode Island study area are almost entirely strandings (96 of 97 records, 99%). The first confirmed strandings were recorded in 1993, though there were scattered anecdotal reports earlier than that (Sadove and Cardinale, 1993). They have been relatively common since. Hooded seal strandings are broadly distributed across ocean-facing beaches in the region, with only rare occurrences in Long Island Sound (Fig. 63). Strandings are most common in spring and winter (45% and 36% of all records, respectively), and rare in summer and fall. They occasionally occur well up rivers—for example, in southeastern Connecticut in spring, but less often than harp seals.

The time-series of strandings in the study area showed a marked spike in 1998 (Fig. 64). The same pattern is seen if only Rhode Island strandings are considered, where the 1993–2005 background level was 0–2 strandings per year with 3 in 1996, but there were 9 in 1998 (Fig. 65). There were no hooded seal strandings in Rhode Island before 1993. The reason for the sharp short-term increase is not known, but it may be related to hydrographic patterns in the region. In 1998 a cold mass of Labrador Subarctic Slope Water just offshore of the continental shelf extended much farther south than normal, reaching the latitude of southern New Jersey by February (Greene et al., 2003). The phenomenon was linked to a sharp decrease in the North Atlantic Oscillation Index in 1996.

Monthly stranding frequencies show maximum values in February (31%) and March (29%), but the occurrence is more spread out than in either gray seals or harbor seals (Fig. 66). As with harp seals, the peak in strandings is too early in the year to be pups. Most strandings are therefore yearlings, although summer and fall blueback strandings may be pups of the year. There was one interesting stranding event in 1999. On the 8th of February there was a report from Block Island of a live seal, possibly in distress, that sounded from the description like an adult hooded seal. The next day a subadult male hooded seal stranded on Misquamicut Beach in

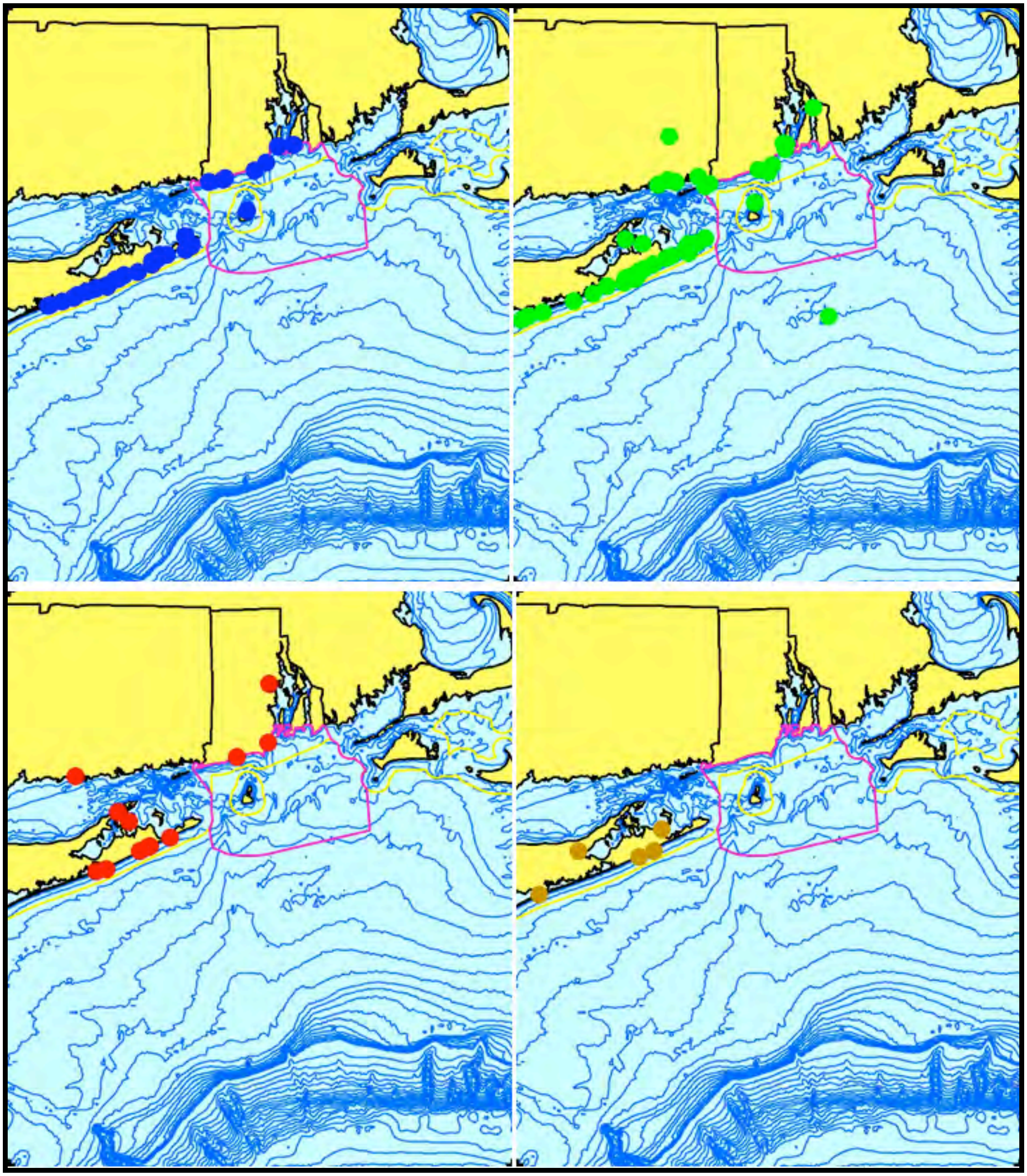

Figure 63. Aggregated sighting, stranding, and bycatch records of hooded seals in the Rhode Island study area, 1993–2005 (n = 97: winter = 36, spring = 43, summer = 13, fall = 5).

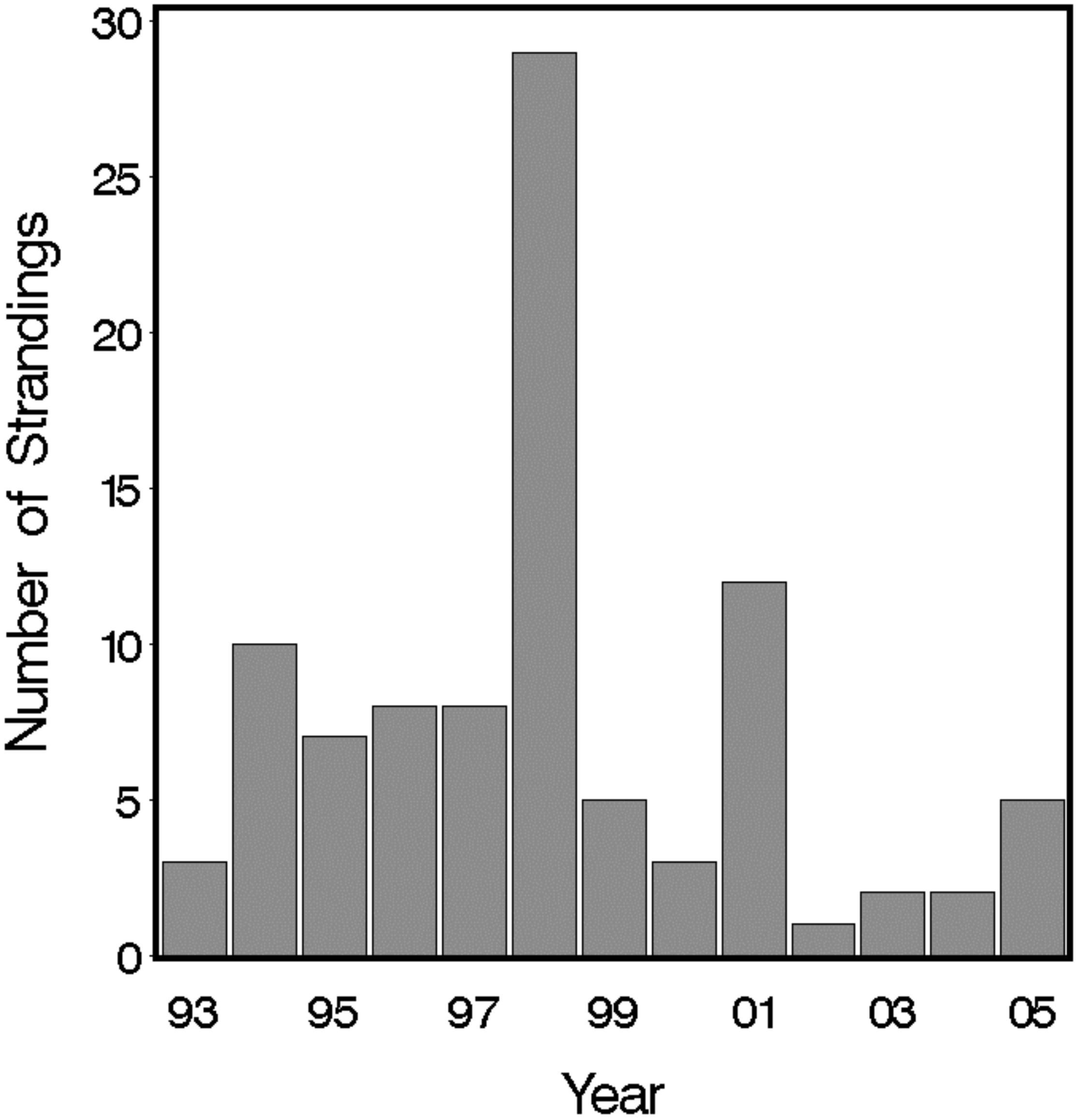

Figure 64. Annual stranding frequencies for hooded seals in the Rhode Island study area, 1993–2005.

Westerly. It was in very poor condition and was not expected to survive overnight (R. Nawojchik, pers. comm.). Contrary to expectations, it gained over 100 kg over the next month and was released at Monahan's Dock in Narragansett Pier.

Conclusions: As with harp seals, hooded seals in the Rhode Island study area are predominantly juveniles dispersed from a population center far to the north in eastern Canada. They are not of concern relative to the SAMP.

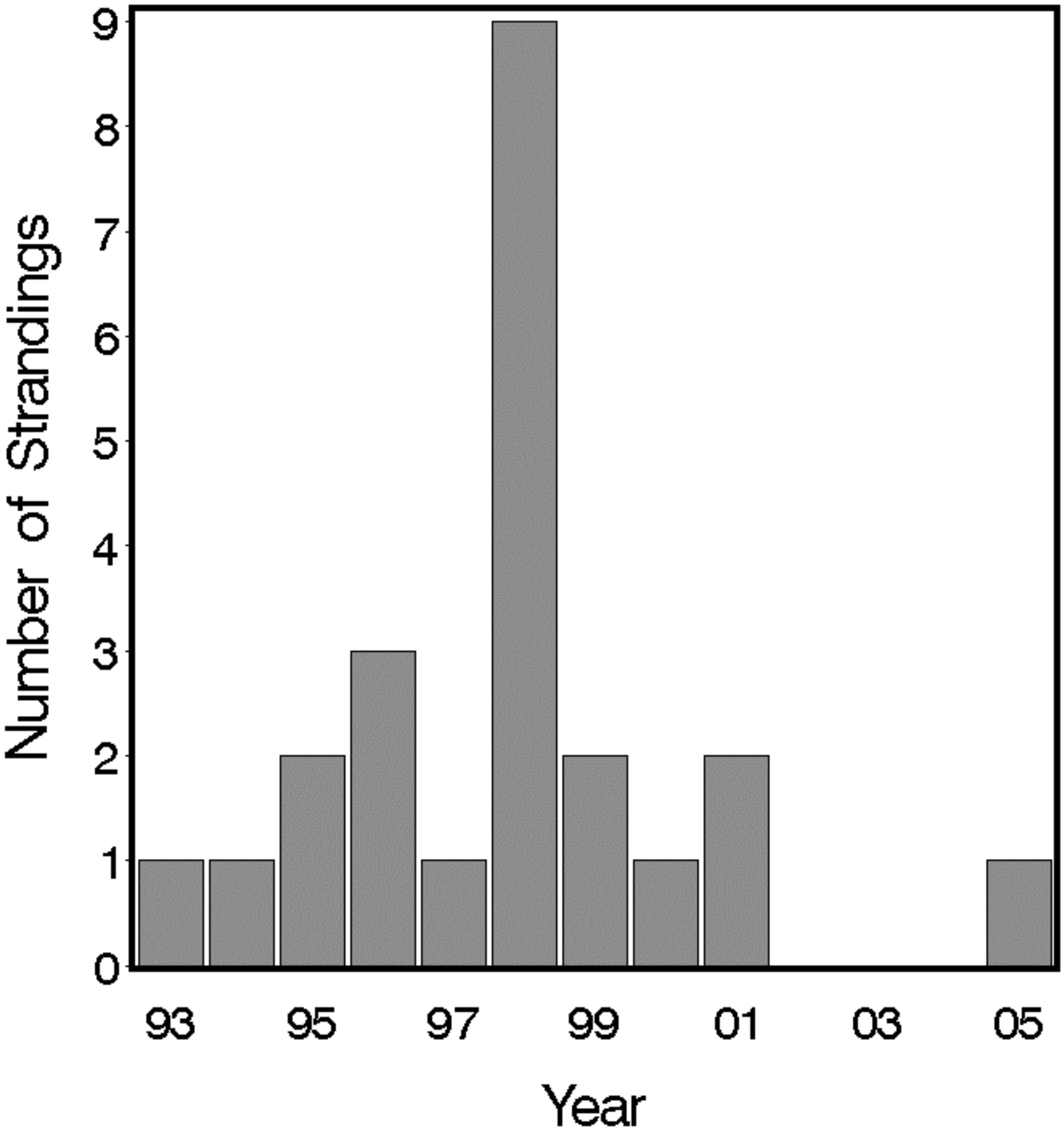

Figure 65. Annual stranding frequencies for hooded seals in Rhode Island alone, 1993–2005.

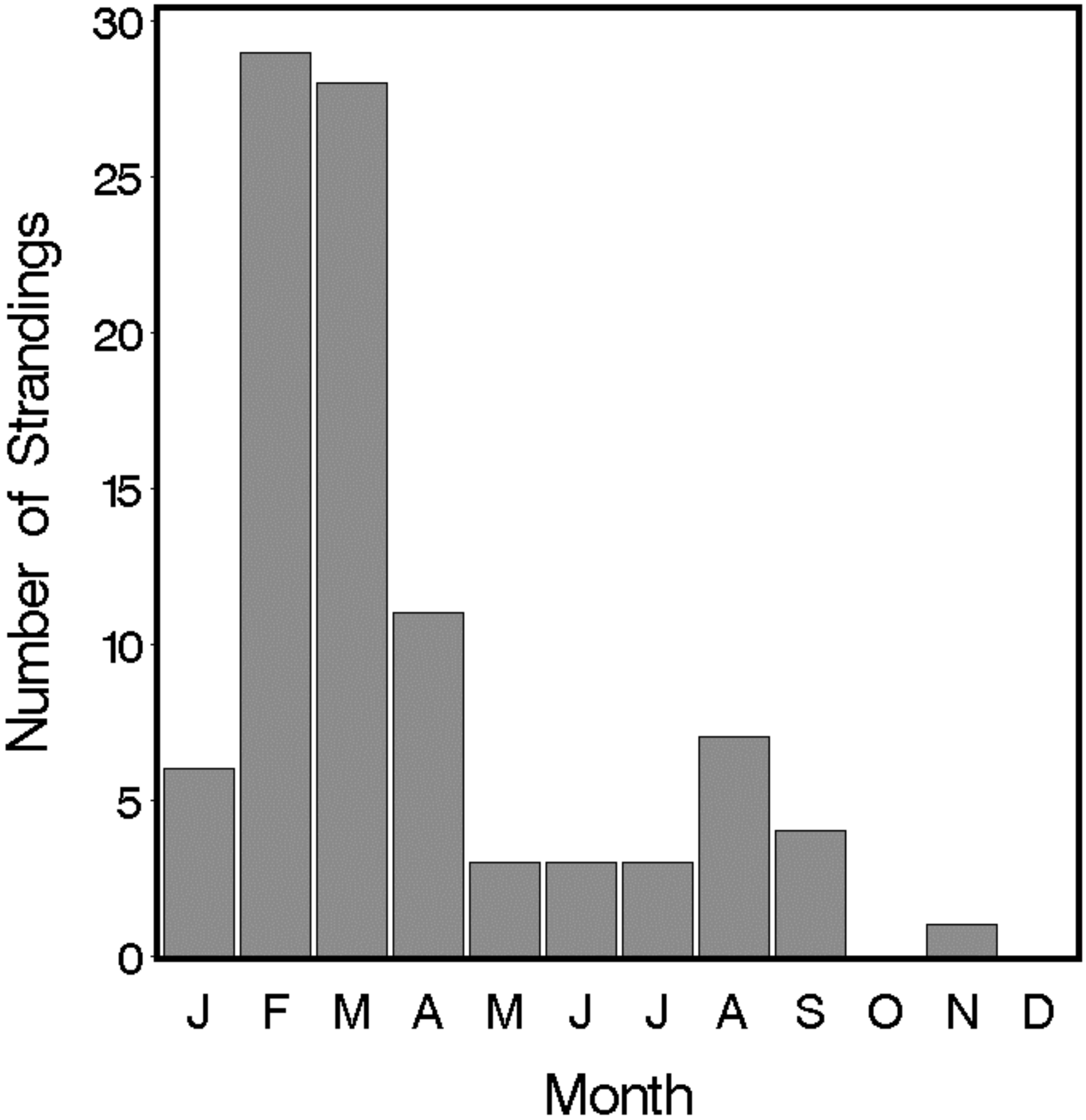

Figure 66. Monthly stranding frequencies of hooded seals in the Rhode Island study area.

3.2.28. Ringed Seal *Pusa hispida* (Schreber, 1775)

Description: Ringed seals are the smallest pinnipeds of the North Atlantic, with average adult lengths of 1.2–1.4 m (Frost and Lowry, 1981) and maximum length of about 1.6 m (Jefferson et al., 1993). They are plumper than harbor seals (maximum girth up to 80% of total length), with a shorter, almost cat-like snout. The ventral aspect of the adult coat is a solid light silver; dorsally it is dark gray with oval spots that are about the same or slightly darker than the background and surrounded by pale rings. Pups are born covered in a fine white lanugo that is shed between 2 and 8 weeks after birth; juveniles are colored like adults but without the spots.

Status: Ringed seals are not listed under the U.S. Endangered Species Act or on the Rhode Island state list, and are classified as Least Concern on the IUCN Red List. There is no reliable estimate of ringed seal abundance in the North Atlantic. World-wide abundance has been estimated as high as 7 million (Kelly, 1988) and is at least 2.5 million (Miyazaki, 2002). Ringed seals are taken in subsistence hunts by natives around the Arctic (MacLean et al., 2002), but are not hunted commercially.

Ecology and life history: Ringed seals feed on a variety of small fishes and crustaceans (Frost and Lowry, 1981; Miyazaki, 2002), and they are known to dive to depths of at least 90 m (Lavigne and Kovacs, 1988).

Ringed seal pups are born in late March or early April in birth lairs constructed under the snow on stable, shore-fast ice (Frost and Lowry, 1981; Miyazaki, 2002). Pups are weaned in 5–7 weeks and then abandoned, at just around the time of ice break-up. As is typical of all phocids, mating takes place just around weaning (Riedman, 1990), therefore in late April–early May in ringed seals. Implantation of the embryo is then delayed for some time, synchronizing pupping to a tight annual cycle. That delay varies with the length of lactation, and is about three and a half months in ringed seals. Both sexes mature at 5–7 years of age, and record longevity is 43 years (Frost and Lowry, 1981; Miyazaki, 2002).

General distribution: Ringed seals are widely distributed around the Arctic (Miyazaki, 2002). In the North Atlantic they occur from Labrador, Iceland, and Norway to the North Pole, with isolated populations (recognized as three separate subspecies) in the Baltic Sea, Lake Ladoga, and Lake Saimaa (Frost and Lowry, 1981). They are associated with sea ice most of the year. Their distribution both during the pupping season and in the remainder of the year is extremely dispersed, likely driven by polar bear predation.

Historical and recent occurrence: There are no ringed seal records in Rhode Island. In New York waters, ringed seals are known only from very rare strandings and opportunistic sightings. There is one confirmed ringed seal stranding record in the Northeast regional dataset—in Easthampton in eastern Long Island in February 1998, and several other earlier anecdotal observations (Sadove and Cardinale, 1993). There was also a live-stranded sub-adult male ringed seal on the north shore of Long Island in 2006, which was rehabilitated and released (RFMRP, 2006).

Conclusions: Ringed seals are clearly rare, accidental visitors to the Rhode Island study area and are not recorded from the SAMP area. They are not a concern relative to the SAMP.

3.2.29. West Indian manatee *Trichechus manatus* Linnaeus, 1758

Sirenia includes the marine and aquatic species known collectively as “sea cows” (Reynolds and Odell, 1991; Shoshani, 2005). There are four extant species in two families—three manatees of the tropical Atlantic (*Trichechus* spp.: Trichechidae) and the dugong (*Dugong dugon*: Dugongidae) of the tropical Indo-Pacific. A fifth species, Steller’s sea cow (*Hydrodamalis gigas*), a sub-Arctic dugongid found only around the Commander Islands in the western Bering Sea, was both discovered and extirpated in the 18th Century.

Sirenians are fully aquatic, with many adaptations similar to those seen in the cetaceans, including a more or less fusiform body, absence of hair except for well-developed vibrissae on the muzzle, loss of the hind limbs, forelimbs modified into paddle-like flippers, and swimming powered by a horizontally flattened tail. They were long considered to be herbivorous cetaceans (e.g., Hamilton, 1839) and De Kay (1842) included the “Manatidae” as family I in the Cetacea, but sirenians are not closely related to the other marine mammals in the Cetacea and Carnivora. All sirenians are obligate herbivores, feeding primarily on seagrasses and also on submerged and floating aquatic vegetation.

Description: West Indian manatees are large, rotund, docile, and slow-moving, ranging in length from 2.5 to 4.5 m (Jefferson et al., 1993; Wynne and Schwartz, 1999). The body is tapered and somewhat streamlined, with a relatively small head and a large, rounded tail. The skin is relatively smooth, hairless, and uniformly gray or gray-brown, often with distinctive scars from boat collisions. The eyes are small and deep-set, and the fleshy muzzle is covered with stiff vibrissae. The only teeth present, except for vestigial incisors that are resorbed soon after birth, are 5–7 molars in each upper and lower jaw, which are replaced from the rear and drop out at the front of the row when worn (Husar, 1978; Caldwell and Caldwell, 1985). The skull and postcranial bones are very dense, perhaps adapted to serve as internal "dive weights." The forelimbs are relatively long and flexible, with blunt, rounded ends and elephant-like nails. The forelimbs are often used in feeding, in conjunction with the nearly prehensile upper lips, for manipulating vegetation into the mouth.

Status: West Indian manatees are classified as Endangered under the U.S. Endangered Species Act, are not included on the Rhode Island state list, and are classified as Vulnerable on the IUCN Red List, although both the Florida population and the population in the West Indies are classified as Endangered. Florida manatee numbers have been assessed since 1991 by aerial surveys following winter cold fronts, which concentrate the animals into the available warm-water refuges (FFWCC, 2006). The highest count was 3,807 in January 2009, more than 500 higher than the previous high of 3,300 in 2001 (FFWCC, 2009). Mortality is high, averaging 183 deaths annually since 1974 and more than 300 per year in the last decade or so. About 30% of the mortality can be attributed as human-related mortalities, primarily collisions with watercraft (24%) but also including crushing in floodgates and canal locks, poaching, ingestion of persistent debris, and drowning or entanglement in fishing gear. Categories of natural mortalities include perinatal, cold stress, and biotoxins from "red tides."

Ecology and life history: Manatees feed on a wide variety of marine, estuarine, and aquatic vegetation, including seagrasses, algae, mangrove leaves and seedlings, floating aquatic plants, overhanging and streamside terrestrial plants, and even acorns (Reynolds and Odell, 1991). Manatees typically spend 6–8 hours a day feeding. They are not deep divers, but are capable of remaining submerged for as long as 20 minutes.

Manatees become sexually mature at 6–10 years old and about 2.7 m in length (Reynolds and Odell, 1991). Gestation is believed to be about 12–13 months. Calves are born at about 1.2 m and 60 kg. In Florida, births can occur at any time of year, most are in spring and summer. Lactation lasts for about a year, although a calf may remain with its mother for another year. Intervals between births range from 2 to 5 years.

General distribution: West Indian manatees occur in warm subtropical and tropical waters of the western North Atlantic (Husar, 1978; Caldwell and Caldwell, 1985; Reynolds and Powell, 2002). They are primarily found in freshwater systems, estuaries, and shallow, nearshore, coastal waters. The species ranges from the southeastern U.S. to Central and northern South America, the Caribbean, and the West Indies. Florida manatees disperse in summer to feeding grounds as far north as the Chesapeake (Reynolds and Odell, 1991; Reynolds and Powell, 2002).

Historical occurrence: There are no historical records of manatees in the Rhode Island study area.

Recent occurrence: One individual (an adult male known as “Chessie”) was the first manatee confirmed to occur in Rhode Island waters. He was captured in a Chesapeake tributary as winter approached in 1994 (ORG, 2003). He was transported to Florida, equipped with a radio transmitter that could be tracked by satellite, and released. When the weather warmed the following spring, he departed from Florida and headed north along the coast. Chessie did not make the expected left turn into Chesapeake Bay, but continued north past New Jersey into New York Harbor and then into Long Island Sound. He traveled the entire length of the Sound before finally reaching Point Judith on the 16th of August. Then he turned around and went back. He eventually lost the tag near New Haven, Connecticut, but was sighted in Virginia on 23 September and recognized back in his normal winter habitat in Florida in November. Chessie was re-sighted in August 2001 in Virginia (USGS, 2006).

Three other manatees have since visited the study area (Fig. 67)[11]. A manatee was seen in Montauk Harbor for about a week in late July of 1998 (Kimberly Durham, Riverhead Foundation, pers. comm.). Another wayward manatee visited southern New England in the summer of 2006, leaving an extensive trail of sighting reports (Hamilton and Puckett, 2006). It was first reported in Ocean City, Maryland on 11 July. It was then seen in Delaware Bay on 14 July and at Barnegat Inlet, New Jersey on 22–23 July. Next it lingered for about a week in the Hudson River, from the 1st to the 8th of August, and was sighted off Manhattan and Harlem and more than 40 km upriver north of the Tappan Zee Bridge in Westchester County. The next sighting was far to the east, in Quissett Harbor near Woods Hole, Massachusetts, on 17 August, before it turned around and started on the return trip. It was seen on the 19th in Westport, Massachusetts, and then caused a brief media furor in Rhode Island—drinking from a storm drain for the Channel 10 television cameras in a marina in Greenwich Bay on 20 August, and making brief appearances in Wickford harbor on the 22nd and Bristol harbor on the 27th or 28th.

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[11] Another manatee was sighted in 2009; it is not included on the figure.

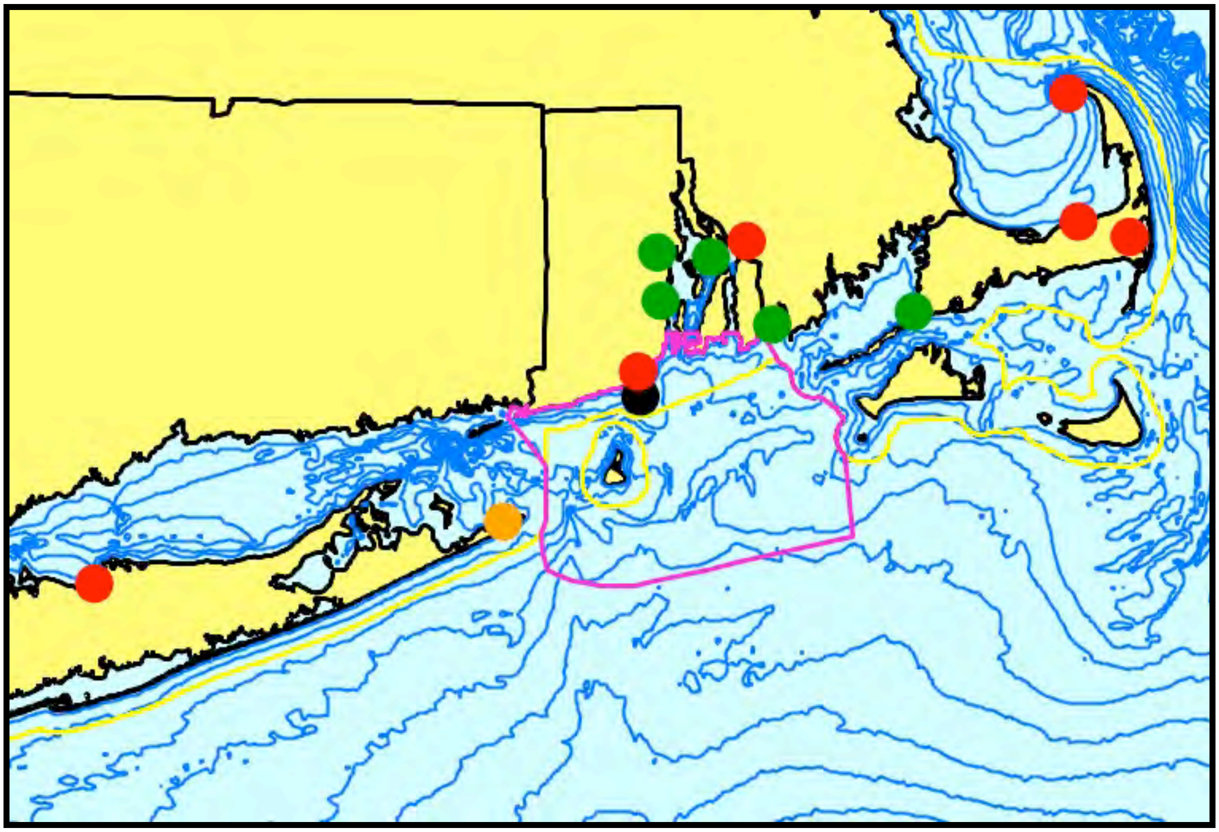

Figure 67. Sightings of four individual manatees in and near the Rhode Island study area, in 1995 (black), 1998 (orange), 2006 (green), and 2008 (red).

It has not been seen since (though there was an undocumented report of a manatee in Barnegat Bay, New Jersey in September), and is assumed to have returned home.

The last manatee to visit Rhode Island was in 2008; its locations and movements were extracted from a series of media reports. It first was seen on 11 August off Crown Point, on the South Kingstown side of Point Judith Pond and near Skip’s Dock in Snug Harbor. The next report, on 21 August, came from a family fishing from a dock in Stony Brook Harbor on the north shore of Long Island. Then it laid low for almost a month, until the Massachusetts Division of Marine Fisheries reported on 19 September that a manatee had been seen for a couple of days under the Braga Bridge in Fall River. It showed up five days later on the 24th in a cove off Pleasant Bay in Harwich, Massachusetts—on the outside of Cape Cod. It apparently then went around the outer Cape, showing up on the 29th near the whale-watching boats in Provincetown harbor. The next day it was seen in Sesuit Harbor in Dennis, in the southeast corner of Cape Cod

Bay, where it remained until 11 October. On that day it was captured for relocation to Florida, however it died in transit from cold stress.

Conclusions: Florida manatees are clearly accidental visitors to the SAMP study area, and are most likely to occur on those occasions in shallow waters very close to shore, where there are sea grass beds. They can safely be ignored in planning for any developments in the SAMP area.

3.2.30. Leatherback sea turtle *Dermochelys coriacea* (Vandelli, 1761)

A turtle, encased within its shell (comprised of an upper carapace and a lower plastron), is something that is instantly recognizable to most people. The sea turtles include seven or eight species in two closely related families. Sea turtles spend their entire lives at sea except for nesting; adult females deposit their eggs in nests dug above the high-tide mark on sandy beaches in the tropics and sub-tropics. Their limbs are adapted for swimming—modified into simplified, flattened flippers. Sexes are generally indistinguishable, except that adult males usually can be identified by their very long tails. Only five species typically occur in the North Atlantic, although one other may occur accidentally in the West Indies (Ernst et al., 1994; Spotila, 2004). Four species are known from the Rhode Island study area—leatherback, loggerhead, Kemp’s ridley, and green sea turtles (Table 1). The hawksbill sea turtle is known from single historical stranding records in Massachusetts in 1968 (Lazell, 1980; McAlpine et al. 2007) and New York in 1938 (Morreale et al., 1992), and is considered to be hypothetical for this analysis.

Description: The leatherback sea turtle is one of the largest living reptiles, and is the only living species in its family, Dermochelyidae (Ernst et al., 1994). Leatherbacks differ from all other sea turtles in lacking the outer layer of keratin plates or scutes on the shell. The bony shell, composed of a mosaic of thousands of tiny dermal bones, is covered by a layer of soft, leathery skin. Carapace lengths (the standard for measuring a turtle is to measure the length and width of the carapace without including the head, tail, or limbs) of adults are up to 1.8–2 m or more, and large leatherbacks can reach weights of 1,000 kg (Wynne and Schwartz, 1999). The carapace tapers from front to back, and there are seven longitudinal ridges. The overall color is black, and there are usually white or pinkish spots, especially underneath. The front flippers are very long and flexible; both front and rear flippers lack claws.

Status: Leatherback sea turtles are classified as Endangered under the U.S. Endangered Species Act, as Federally Endangered on the Rhode Island state list, and as Critically Endangered on the IUCN Red List. The status of populations in the North Atlantic does not seem to be as precarious as it is for those in the Pacific, where nesting populations have declined by more than 80%. Estimates of the total number of adult females in the world declined from 115,000 in 1982 to 20–30,000 in 1996 (IUCN, 2008).

Estimates of sea turtle population abundance for any region are rare or non-existent. Sea turtles are wide-ranging, difficult to detect at sea, and capable of long submergences; in addition, aerial surveys detect only individuals above a certain size threshold—about 75 cm carapace lengths (Shoop and Kenney, 1992). The northeastern U.S. is one of a few locations where there have been published estimates of abundance of pelagic sea turtle populations, based on line-transect aerial surveys (CETAP, 1982). Shoop and Kenney (1992) summarized the CETAP estimates, which showed that 100–900 leatherbacks occurred off the northeastern U.S. in the summer. Those numbers are minimum values, since they do not account for animals missed because they were below the surface and not visible when the survey aircraft passed.

Abundance is more typically indexed by counts of nesting adult females. There are seven known leatherback nesting populations in the Atlantic (reviewed in TEWG, 2007; NMFS & USFWS, 2007c), with the total number of adults estimated at 34,000–94,000. The Florida population grew from 98 nests in 1988 to 800–900 per year in the early 2000s, with a 17% increase rate on index beaches. The Northern Caribbean population nests on Puerto Rico and the Virgin Islands. Nests in Puerto Rico increased at 10% annually, from 9 in 1978 to 469–882 in 2000–2005. Nesting in the U.S. Virgin Islands increased at 10% from 1986 to 2004, and at 13% from 1994 to 2001. There were 143 nests in 1990 and 1008 in 2001. The number of nests in the British Virgin Islands increased from a few in the late 1980s to 35–65 in the 2000s, at a rate of 20% in 1994–2004. The Western Caribbean populations nests from Honduras to Colombia, especially in Costa Rica, Panama, and Colombia, and shows declining trends. At the major nesting beach in Tortuguero, Costa Rica, nesting declined by 68% between 1995 and 2006. The Southern Caribbean population nests in Guyana, Suriname, French Guiana, Trinidad, Dominica, and Venezuela, with perhaps 40% of the world’s leatherback nesting in Suriname and French Guyana. The trend is generally stable to a slight increase. The other three populations are in the South Atlantic—Brazil, West Africa, and South Africa.

All sea turtle species share a nearly identical suite of survival threats (reviews in NRC, 1990; Lutcavage et al., 1997; Spotila, 2004; NMFS & USFWS, 2007a, 2007b, 2007c, 2007d). Harvesting of adults and eggs depleted populations in many areas of the world, and continues in some places. Predators, both natural and introduced, take significant numbers of eggs, hatchlings, and juveniles. There are two additional significant anthropogenic impacts on sea turtles—loss or degradation of nesting habitat and incidental capture in fisheries. While there are natural sources of habitat loss (e.g., beach erosion, hurricanes), development of beachfronts for residences or tourism, beach armoring, disorientation of hatchlings by artificial lighting, sand mining, beach replenishment, and spread of non-native vegetation are much more serious. Sea turtles are captured frequently in many fisheries, including pelagic longlines, high-sea driftnets, sink gillnets, pound nets, trap and pots, and trawls; turtles can also be entangled in other types of persistent debris. Other anthropogenic impacts include boat strikes and plastic ingestion.

Lewison et al. (2004) estimated that 50,000 leatherbacks were killed in pelagic longline fisheries worldwide in 2005, mainly in the Pacific. About 3,000 a year were killed in the U.S. Atlantic and Gulf of Mexico shrimp fishery; leading NMFS to require a larger escape opening in Turtle Excluder Devices (TEDs) beginning in 2003 (NMFS & USFWS, 2007c). Morreale and Standora (1998) reported eight leatherback turtles that were entangled in fishing gear near Long Island during 1987–1992 and released after tagging. In Rhode Island waters, a leatherback entangled in buoy lines for lobster traps is the most common sea turtle entanglement.

Ecology and Life History: The basic picture of sea turtle life history has long been known, is very similar across all species, and has been well-described in the works of Archie Carr and his colleagues (Carr, 1967, 1980, 1986, 1987, 1995; Carr and Meylan, 1980; Hamner, 1988; Musick and Limpus, 1997). An adult female crawls up onto a sandy beach, digs a nest hole, deposits a clutch of eggs, covers it over, and returns to the sea. About two months later a batch of hatchlings emerges from the nest and scrambles down the beach and into the ocean. The hatchlings swim straight out to sea and disappear until they next show up as small juveniles—long termed the "lost year." Carr theorized, which was later confirmed, that hatchlings get passively carried in ocean current systems and collect in sargassum patches and other surface convergences, where they feed on a wide variety of plant parts and invertebrates. Pelagic post-hatchlings grow into small juveniles, who move into developmental habitats, usually in coastal waters, although leatherbacks and olive ridley remain pelagic during this phase. Larger juveniles move into the same foraging habitats as the adults.

Sea turtles are very difficult to age, so that the durations of the various life-stages were not known. For leatherbacks, growth seemed to be relatively fast, and the age at maturity had been estimated from as short as 2–3 years to as long as 13–14 years (Pritchard and Trebbau, 1984; Rhodin, 1985; Zug and Parham, 1996; Dutton et al., 2005). More recent work, however, suggests that the median age for first-time nesting females in the western North Atlantic is 24.5 to 29 years (Avens et al., 2009).

Adult leatherback sea turtles feed mainly on jellyfish and other gelatinous invertebrates, especially the lion’s mane jelly *Cyanea capillata* (Bleakney, 1965; Lazell, 1980; Bjorndal, 1985; Mortimer, 1995).

General distribution: The leatherback sea turtle has the widest distribution of any species of sea turtle, extending worldwide from tropical and subtropical at least into cold-temperate waters and sometimes even more poleward (Ernst et al., 1994; Spotila, 2004; NMFS & USFWS, 2007c). In the North Atlantic, leatherbacks have been observed in waters of the U.S., Nova Scotia, Europe, the eastern Mediterranean, Newfoundland and Labrador, Greenland, the North Sea, and the Barents Sea (Bleakney, 1965; Brongersma, 1972, 1995; Threlfall, 1978; Goff and Lein, 1988; Marquez, 1990; Casale et al., 2003; Hays et al., 2004, 2006; James et al., 2005; McAlpine et al., 2007). They are capable of maintaining a body temperature well above ambient through a combination of anatomy, physiology, and behavior (Frair et al., 1972; Greer et al., 1973).

Off the northeastern U.S., leatherbacks were sighted commonly in summer in shelf waters from North Carolina to Maine, and in much lower numbers in spring and fall (Shoop and Kenney, 1992). The densest aggregation of sightings was in the nearshore waters south of central Long Island. Despite being present in much lower numbers than loggerheads (less than 5% of the number of sightings) leatherbacks were far more likely to occur within the Gulf of Maine north of Cape Cod—consistent with their known tolerance for colder water.

Historical occurrence: Lazell (1980) reported that the first recorded occurrence of a leatherback turtle in New England was in 1886 by the Monomoy lighthouse keeper. However, Babcock (1919) reported that the first New England occurrence was in Massachusetts Bay in 1824, and that the specimen was in the collection of the Boston Society of Natural History. He reported two earlier records—in 1811 at an unknown locality and in 1816 at Sandy Hook, New Jersey. He listed a total of 31 known records between 1811 and 1917, ranging from New Jersey to Maine, including three from Rhode Island and seven others from the Rhode Island study area. The Rhode Island records included one in Narragansett Bay in 1878 and two off Southeast Point, Block Island around 30 July 1886. The plate illustrating leatherbacks in his monograph included two photos of one of the Block Island specimens. The other leatherback records in the study area included: 1826—Long Island Sound; 1875—one at Stonington, Connecticut, another between New London and Montauk; 1876—Stonington; 1879—Buzzards Bay at Marion, Massachusetts; 1891—caught in a fish trap in Buzzards Bay near Woods Hole; 1907—fouled in an anchor rope a few miles south of Noman's Land.

Lazell (1980) also mapped a number of leatherback sightings from Brongersma (1972) and Lazell (1976) along the New England coast from Rhode Island to Downeast Maine, concluding that "the greatest concentrations of non-nesting leatherback records in the Atlantic are around the Gulf of Maine."

Recent occurrence: Leatherback turtles occur relatively commonly in the Rhode Island study area (Fig. 68), and are almost entirely limited to summer (57.7%) and fall (41.6%). Leatherbacks occurred over much of the continental shelf in the study area. There is an aggregation of occurrences in the SAMP area, but 20 of those are strandings on Block Island extracted from Nawojchik (2002). There is also somewhat of an aggregation south of central Long Island, in the same area noted by Shoop and Kenney (1992) as a leatherback concentration area. There were 24 sightings in summer and 5 in fall from the whale-watching boats.

The relative abundance patterns (Fig. 69) show leatherbacks to be relatively dispersed and not particularly abundant. The areas of higher abundance are all beyond the boundary of the mapped area, and the model output does not predict occurrence within the SAMP area.

Leatherback strandings are relatively common in Rhode Island, however we did not have access to most of those records. Nawojchik and St. Aubin (2003) reported that, of the 146 sea turtle strandings responded to by Mystic Aquarium from 1987 to 2001, 124 (84.9%) were in Rhode Island, and 120 of the 146 were leatherbacks. All strandings occurred during June through November, with the biggest numbers in August and September. This is fully consistent with the sighting data. Leatherbacks were the only sea turtle species to strand on Block Island.

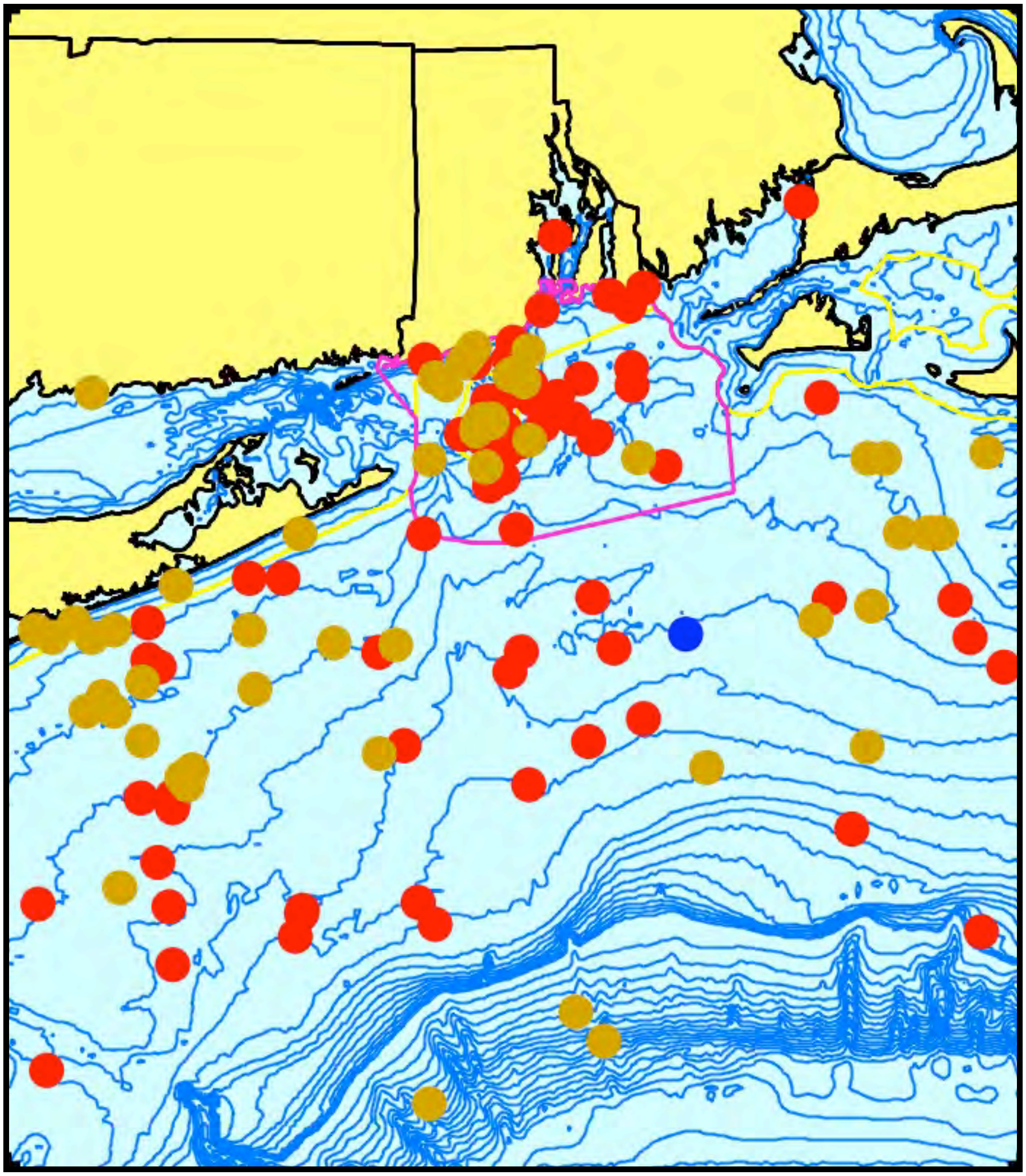

Figure 68. Aggregated sighting, stranding, and bycatch records of leatherback sea turtles in the Rhode Island study area, 1974–2008 (n = 142: winter = 1, spring = 0, summer = 82, fall = 59).

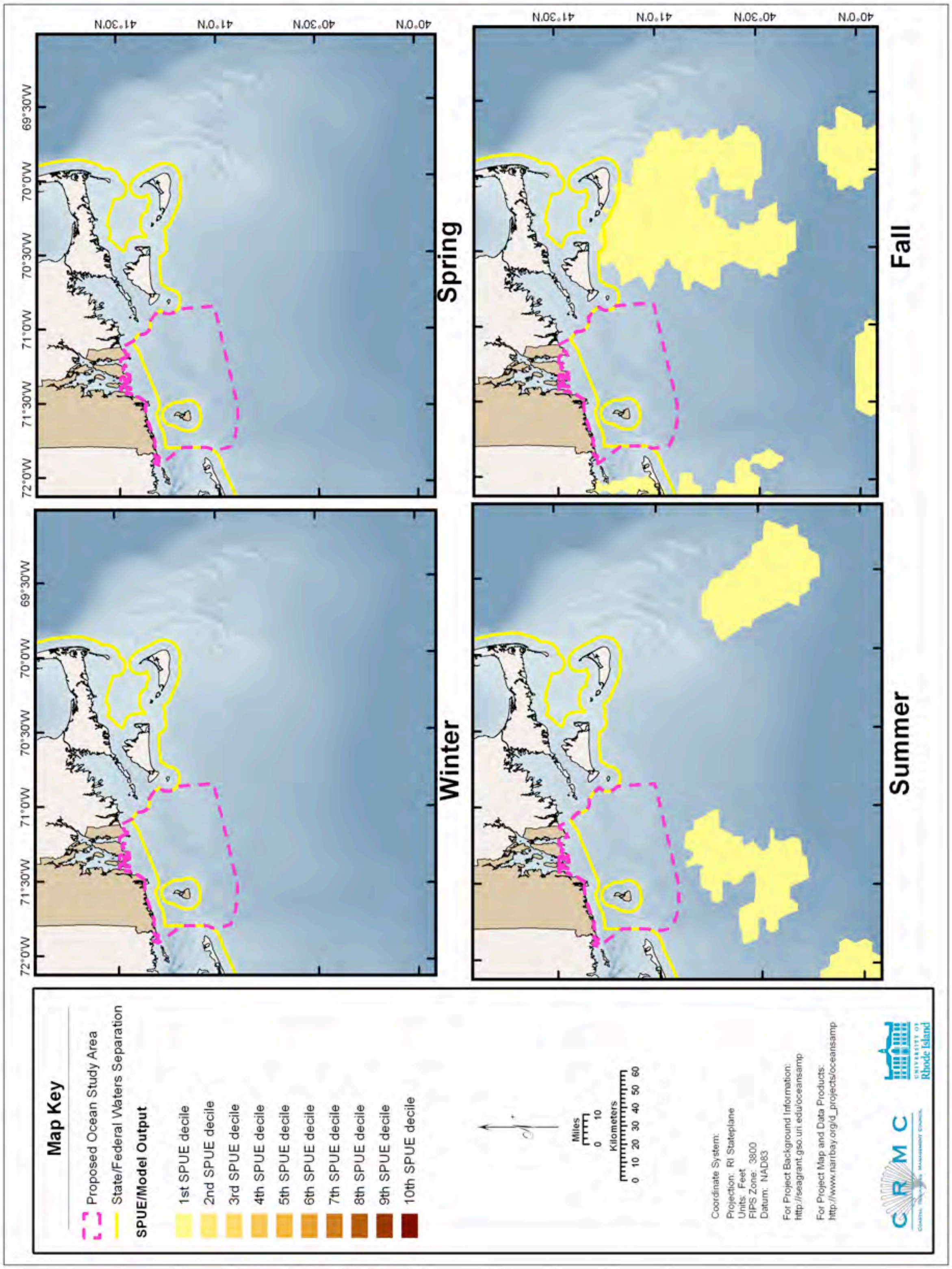

Figure 69. Modeled seasonal relative abundance patterns of leatherback sea turtles in the Rhode Island study area, corrected for uneven survey effort.

Conclusions: The relative abundance analysis does not predict that leatherback sea turtles will occur in the Ocean SAMP area (Fig. 69), however the more extensive data, including sightings from the whale-watching boats, show that leatherbacks do occur in the SAMP area. The lower survey effort in summer and fall may explain some of the difference. Given the leatherback's status as an Endangered species, they should be considered in any planning process.

3.2.31. Loggerhead sea turtle *Caretta caretta* (Linnaeus, 1758)

All of the sea turtles other than leatherbacks belong to a separate family—Cheloniidae, the so-called "shelled" sea turtles. The bony shell is much thicker and heavier than in leatherbacks, and it is covered by a layer of keratin plates or scutes. The arrangements and numbers of scutes are important characters used to identify species, especially small individuals or decomposed carcasses.

Description: The loggerhead sea turtle is one of the two species of larger shelled turtles found in the North Atlantic, with adult carapace lengths of 85-120 cm (Wynne and Schwartz, 1999), although the maximum known length was 213 cm (Ernst et al., 1994). The shell is shaped like a broad oval, tapering toward the rear. The head is much larger relative to body size than in the other sea turtle species, with broad crushing surfaces on both the upper and lower jaws. The color is a distinctive yellowish- to reddish-brown.

Status: Loggerhead sea turtles are classified as Threatened under the U.S. Endangered Species Act, as Federally Threatened on the Rhode Island state list, and as Endangered on the IUCN Red List. Shoop and Kenney (1992) estimated the summer pelagic population off the northeastern U.S. of large juveniles and adults detectable from aerial surveys at 2,200–11,000, not accounting for diving behavior, with less than half as many in spring and fall. There are no more recent comparable estimates.

TEWG (2000), Ehrhart et al. (2003), and NMFS & USFWS (2007d) reviewed the status of loggerhead nesting populations in the North Atlantic. The largest is in the southeastern U.S. and Gulf of Mexico, which is the second largest loggerhead nesting population in the world after the one in the eastern Indian state of Orissa. The total numbers of nests and nesting females per year are estimated at 53,000–92,000 and 32,000–56,000, respectively. The population is divided into five sub-populations. The Northern sub-population nests in Georgia and the Carolinas. The average number of nests per year is 5,151, with a 1.9% declining trend over 1989–2005. The largest sub-population is South Florida, with an average of 65,460 nests and 15,966 females and a declining trend of 22.3% in 1989–2005. That decline may be accelerating. The Dry Tortugas sub-population shows no detectable trend and has annual averages of 246 nests and 60 females. The averages for the Florida Panhandle sub-population in 1995–2005 were 910 nests, 222 females, and a declining trend of 6.8%. The Yucatan sub-population increased from 903 nests in 1987 to 2,331 in 2001, but may currently be decreasing.

Other western North Atlantic populations include the eastern Bahamas, with 500–600 nests per year, and Cuba, with 250–300. Loggerheads formerly nested on Jamaica, Haiti, the Dominican Republic, and Puerto Rico, but no longer do so. The nesting population in northeastern Brazil has shown a long-term increase, with 4,837 nests in 2004. The only nesting population in the eastern North Atlantic is in the Cape Verde islands, with several thousand nests per year. Loggerheads also nest in the eastern Mediterranean, where nest counts can exceed 7,000 per year, although monitoring is incomplete.

Impacts on loggerheads are the same as for other sea turtles. Lewison et al. (2004) estimated that 60,000–80,000 loggerheads were killed annually by incidental capture in Atlantic pelagic longline fisheries, primarily in the western Mediterranean, and 200,000 globally. NRC (1990) estimated that, prior to regulations requiring TEDs, 5,000–50,000 loggerheads were killed each year in the southeastern U.S. and Gulf of Mexico shrimp trawl fishery.

In southern New England, juvenile sea turtles sometimes strand dead, comatose, or seemingly paralyzed. The event happens in the fall of the year, when water temperatures decline, and is referred to as "cold-stunning." In 1985, 56 cold-stunned turtles stranded in eastern Long Island (Meylan, 1986), sparking the establishment of a monitoring, research, and rehabilitation program. A similar program exists in Cape Cod Bay.

Ecology and Life History: Loggerheads follow the typical sea turtle life history pattern. Post-hatchlings disperse and are entrained in ocean currents (Carr, 1986). Small juveniles are present in high abundance around the Azores (Bolten, 2003), where they remain resident for extended periods and feed on pelagic invertebrates such as siphonophores, jellies, salps, gastropods, barnacles, and isopods. Small juveniles may also congregate on the Grand Banks off

Newfoundland. In the Mediterranean, genetic profiling has shown that small and medium juvenile loggerheads come from both the eastern Mediterranean nesting population and from western North Atlantic populations (B. W. Bowen et al., 1993). Eventually juveniles reach the size where they return to coastal waters, first into shallower developmental habitats in bays and estuaries and then into adult foraging habitats. The diet of juveniles in developmental habitats is dominated by crabs (Burke et al., 1993). Adults feed on a wide variety of benthic prey, including bivalves, gastropods, crabs, sea pens, anemones, and seaweeds (reviewed by Bjorndal, 1997).

General distribution: Loggerhead sea turtles are distributed worldwide in subtropical and temperate waters (Ernst et al., 1994; Ehrhart et al., 2003). In the western North Atlantic, they are common off the southeastern U.S. and in the Gulf of Mexico. Off the northeastern U.S., there are few sightings north of the latitude of Long Island, and only one in the northern Gulf of Maine (CETAP, 1982; Shoop and Kenney, 1992), although there are inshore records from Nova Scotia and juveniles are commonly taken as bycatch in fisheries on the Newfoundland Grand Banks (Bleakney, 1965; Brongersma, 1972, 1995; Bolten, 2003; McAlpine et al., 2007).

From Long Island south to North Carolina, loggerhead occurrence is strongly seasonal (CETAP, 1982; Shoop and Kenney, 1992). They are nearly absent in winter. In spring they spread northward from south of Cape Hatteras. The distribution is most extensive in summer—from the shore to the mid-shelf area and also along the outer shelf. The distribution then contracts southward in the fall.

Historical occurrence: Babcock (1919) stated that loggerhead turtles “not uncommonly visit Long Island Sound and the Massachusetts coast.” He reported that “a number of specimens usually about two feet in length [were] taken every year” in fish traps in Menemsha Bight of the northwestern side of Martha’s Vineyard. He also included an interesting report that small loggerheads were “taken in Long Island Sound in a benumbed condition as late as December 4,” possibly one of the first reports of cold-stunning from the region.

Lazell (1980) wrote that loggerhead turtles were “common in New England waters and the Canadian portions of the Gulf of Maine.” However, McAlpine et al. (2007) suggested that Lazell was going beyond the limits of his available data in trying to make his point, and that loggerheads were rare north of Cape Cod.

Recent occurrence: The occurrence of loggerhead sea turtles in the Rhode Island study area (Fig. 70) is fully consistent with the reports of CETAP (1982) and Shoop and Kenney (1992). Sightings are strongly concentrated in the summer (73.4%), and then the fall (26.2%). The concentration of sightings is highest in the western half of the study area, and sightings in the eastern half are more on the outer part of the shelf. There is one cluster of sightings in the southwestern quarter of the SAMP area, which includes the majority of the 10 summer sightings and 1 fall sighting from the whale-watching boats.

As with leatherbacks, the areas of high relative abundance were to the west of the area mapped (Fig. 71). Within the study area, most areas of predicted loggerhead summer and fall occurrence were offshore of the SAMP area. One area of lowest abundance extended into the SAMP area’s southwest corner in the fall, and there was an area of moderate occurrence on the outer shelf southeast of Nantucket in summer.

We did not have access to sea turtle stranding data for the study area. Nawojchik and St. Aubin (2003) reported that 23 of the 146 sea turtle strandings in Rhode Island and Connecticut (15.8%) were loggerheads—many fewer than leatherbacks even though the population in shelf waters is estimated to be an order of magnitude larger.

Many of the loggerheads that occur in coastal embayments such as Peconic Bay in eastern Long Island or Cape Cod Bay are juveniles that are too small to be detected during surveys. Morreale et al. (1992) reported that 28 juvenile loggerheads collected in eastern Long Island in 1986–1988 ranged from 36.6 to 59.6 cm, with a mean of 49.5. Over a longer period from 1984 to 1998, the mean size of 298 juvenile loggerheads in Long Island was smaller at 45.5 cm (SD = 18.0; Saari et al., 2000). Shoop et al. (1999) considered that 45 cm was the lower end of the 45-85 cm size range of large, benthic-feeding juveniles found off Georgia. Assuming a normal distribution, that would suggest that loggerheads around Long Island are about half and half small juveniles <45 cm and large juveniles >45 cm.

The species proportions differ between areas and between collection methods (Table 6). Collecting turtles for measurement, sampling, and tagging from those caught in fishing gear should sample more across the available size range than collecting individuals debilitated by declining temperatures in the fall (“cold-stunned”), which

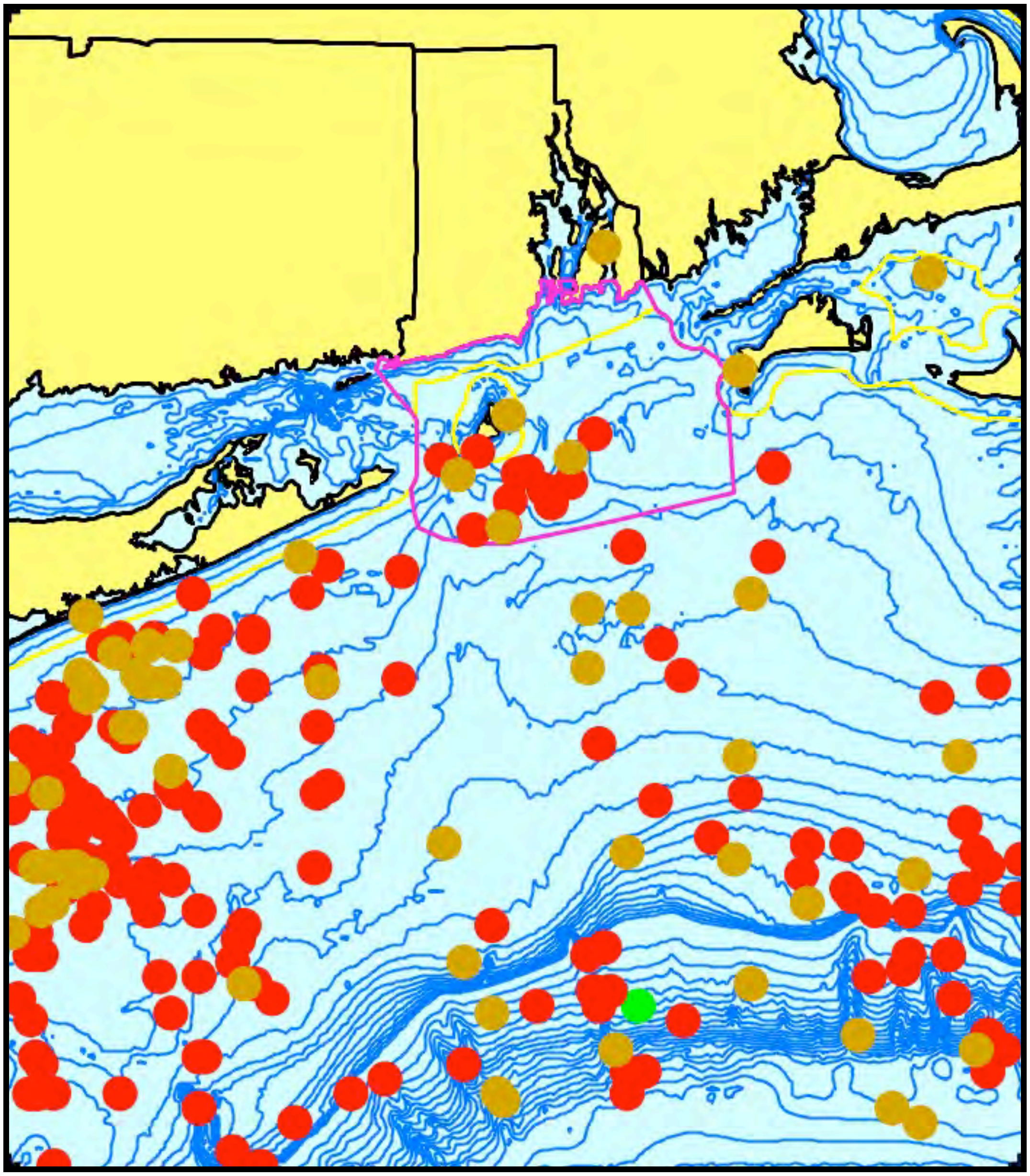

Figure 70. Aggregated sighting, stranding, and bycatch records of loggerhead sea turtles in the Rhode Island study area, 1963–2006 (n = 233: winter = 0, spring = 1, summer = 171, fall = 61).

affects juveniles more than adults. Of 519 turtles live-captured around eastern Long Island in 1984–1998, 298 (57.4%) were loggerheads (Saari et al., 2000). However, of 130 cold-stunned turtles in 1986–1988, only 28 (21.5%) were loggerheads (Morreale et al., 1992). In Rhode Island stranding records, loggerheads are far less frequent than leatherbacks (Nawojchik and St. Aubin, 2003).

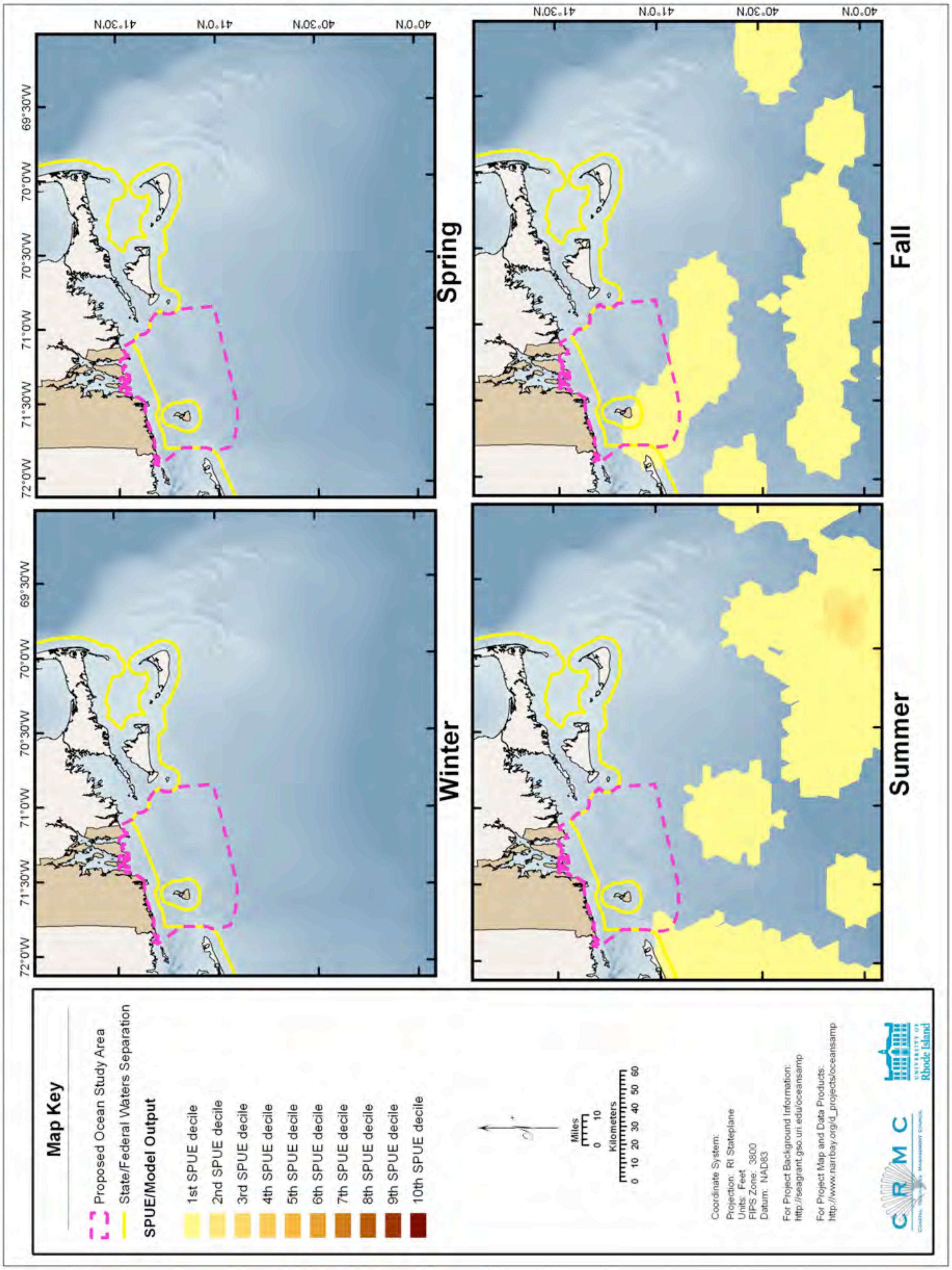

Figure 71. Modeled seasonal relative abundance patterns of loggerhead sea turtles in the Rhode Island study area, corrected for uneven survey effort.

Table 6. Comparisons of relative frequencies and percentages of leatherback (LeTu), loggerhead (LoTu), Kemps' ridley (KRTu) and green (GrTu) sea turtles in different collections from southern New England localities.

Collection and Source	LeTu	LoTu	KRTu	GrTu
RI (85%) & CT (15%) strandings, 1987–2001	120	23	1	2
(Nawojchik and St. Aubin, 2003)	82.2%	15.8%	0.7%	1.4%
Long Island live captures, 1984–1998	0	298	120	101
(Saari et al., 2000)	–	57.4%	23.1%	19.5%
Long Island cold-stunned, 1986–1988	0	28	97	5
(Morreale et al., 1992)	–	21.5%	74.6%	3.8%
Peconic Bay live captures, 2002–2003	0	2	11	16
(Aguirre et al., 2008)	–	6.9%	37.9%	55.2%
Cape Cod Bay cold-stunned, 1979–2003	0	272	983	30
(Dodge et al., 2008)	–	21.1%	76.3%	2.3%

Conclusions: Although loggerhead turtles are much more abundant off southern New England than leatherbacks (about 20:1 in numbers of sightings), they are less likely to occur in nearshore waters or in the SAMP area (1:6 in stranding frequency, also compare Figs. 69 and 71). Even though they are listed as a Threatened species, they can probably be discounted in planning for any development in the SAMP area, since mitigation taken for leatherbacks will also benefit loggerheads.

3.2.32. Kemp's ridley sea turtle *Lepidochelys kempii* (Garman, 1880)

Description: Kemp's ridleys are smaller shelled sea turtles, with adult carapace lengths of 60-80 cm (Ernst et al., 1994; Wynne and Schwartz, 1999). Individuals encountered off the northeastern U.S. are mostly juveniles. The shell is slightly heart-shaped to nearly circular, and is usually gray.

Status: Kemp's ridley sea turtles are classified as Endangered under the U.S. Endangered

Species Act, are not included on the Rhode Island state list, and are classified as Critically Endangered on the IUCN Red List.

At least 60% of all Kemp’s ridley nesting takes place on one 40-km stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Ernst et al., 1994; TEWG, 2000; NMFS & USFWS, 2007b). As many as 40,000 females nested there on a single night in 1947 (Carr, 1963). By 1985, the total number of nests per year had declined to 740, and nesting females to about 250 (TEWG, 2000). Nesting increased through the 1990s. In 2002 there were over 4,000 nests at Rancho Nuevo and 6,000 in all of Mexico. In 2006 the respective counts were 7,866 and 12,143, with about 100 nests in the U.S., mainly at Padre Island, Texas. Given average estimates of nests per female per season and years between nesting years, the total number of adult females in the population is estimated at 7,000–8,000 (TEWG, 2000; NMFS & USFWS, 2007b).

There are no estimates of the number of Kemp’s ridleys off the northeastern U.S. (Shoop and Kenney, 1992). Even most adults are too small to be sighted during aerial surveys, so the numbers of sightings are far too few to calculate densities.

Ecology and Life History: Kemp’s ridley sea turtles follow the typical sea turtle life history pattern (reviewed in TEWG, 2000). Hatchlings are entrained in oceanic current patterns and passively drift about in the Gulf of Mexico and North Atlantic until they reach about 20 cm in carapace length (Collard and Ogren, 1990). At that point, which takes 1–4 years, they transition from a pelagic existence to a benthic-feeding juvenile stage and migrate into shallow developmental habitats. They reach sexual maturity at about 60 cm, by which time they have moved into typical adult foraging habitats and migratory patterns (Morreale et al., 2007). The total time from hatching to maturity is not well known, and is estimated to vary from 7 to 15 years (TEWG, 2000; Heppell et al., 2003, 2005). The typical re-migration interval for adult females (i.e., years between nesting years) is 2 years; 60% of females are on 2-year cycles, 20% on annual cycles, 15% on 3-year cycles, and 5% on 4-year cycles.

Pelagic post-hatchlings and small juveniles probably feed on the same types of prey as loggerheads of the same life-stage, but are poorly known (Bjorndal, 1997). Benthic juveniles and adults feed primarily on crabs (Shaver, 1991; Burke et al., 1994; Bjorndal, 1997; Morreale and Standora, 1998).

General distribution: Kemp’s ridley sea turtles occur only in the North Atlantic (Ernst et al., 1994; Spotila, 2004) and nearly all nesting is in the western Gulf of Mexico. Sighting and stranding records are concentrated heavily in the Gulf of Mexico and southeastern U.S. Atlantic (TEWG, 2000). Juveniles are dispersed about the Gulf of Mexico and North Atlantic. Brongersma (1972) pointed out the very interesting phenomenon that the smallest known Kemp's ridleys outside of hatchlings leaving the nesting beach were strandings in western Europe, and the second smallest were strandings in New England. Carr (1967) wrote that "The greatest concentration of positively identified Atlantic ridleys that I ever heard of (away from Tamaulipas) occurred in just about the most unlikely place that anybody could imagine. It was Martha's Vineyard, Massachusetts." Until relatively recently, it was often assumed that small ridleys in the temperate North Atlantic represented "waifs" that were lost to the population, however it now appears well established that they are a normal component of the species life history.

Historical occurrence: Babcock (1919) did not include Kemp's ridley sea turtles as occurring in New England, however Shoop et al. (1981) suggested that Babcock had incorrectly included many Kemp's ridley records as hawksbills. At that time, many did not accept that Kemp's ridleys were a valid species, and instead believed them to be hybrids of other species ("bastard turtles") (Carr, 1967). In addition, juvenile ridleys have a sharp, beak-like mouth similar to a hawksbill's. Babcock quoted several sources who said that small hawksbills were occasionally taken in fish traps in Massachusetts, and wrote that they were "reported to be more common in Buzzard's Bay than loggerheads." However only one or two specimens were ever collected.

Lazell (1980) summarized the substantial numbers of records of Kemp's ridley sea turtles in southern New England that had been collected to that time. He argued that New England waters constituted normal and important habitat for the species, and should be protected by designation as "Critical Habitat" under the ESA.

Recent occurrence: We had only 14 records of Kemp's ridley sea turtles in the Rhode Island study area—12 (85.7%) in summer and 2 (14.3%) in fall (Fig. 72). Four of the summer records came from whale-watching boats. Kemp's ridleys occurred either in the southwestern corner of the study area, or in or near the SAMP area. The sightings were far too few to generate relative abundances. There was one very recent stranding in Rhode Island—a live juvenile that was caught in a fisherman's net in Greenwich Bay in late October of 2004 (Wyman et al., 2004); its photo graced the front page of the Fall/Winter 2004 issue of *Narragansett Bay Journal*. Only one other Kemp's ridley stranding from Rhode Island and Connecticut was recorded in 1987–2001 (Nawojchik and St. Aubin, 2003), although the exact year and location are not known to us.

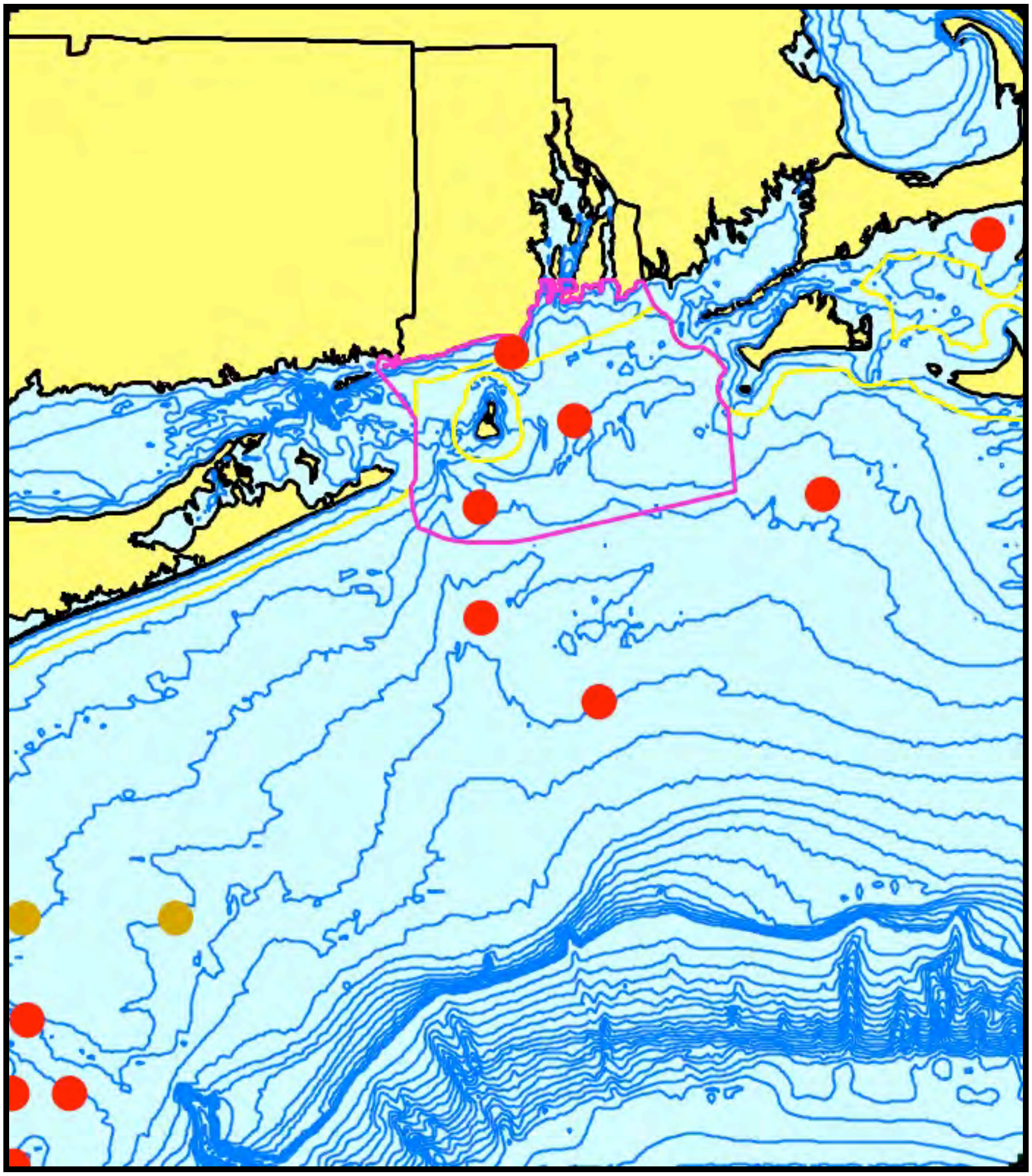

Figure 72. Aggregated sighting, stranding, and bycatch records of Kemp's ridley sea turtles in the Rhode Island study area, 1979–2002 (n = 14: winter = 0, spring = 0, summer [red] = 12, fall [brown] = 2).

The occurrence record for Kemp's ridleys in the study area is biased due to two factors. Most are simply too small to be detected from surveys. Morreale et al. (1992) reported that the carapace lengths of cold-stunned Kemp's ridleys in eastern Long Island in 1986–1988 ranged from 22.5 to 37.6 cm (N = 97, mean = 29.4). Dodge et al. (2008) reported that the typical cold-stunned Kemp's ridley in Cape Cod Bay was the size of a 2-year-old juvenile, based on sizes of some known-age individuals that had been tagged as hatchlings. The second factor is that the shallow bays and estuaries utilized by ridleys within the study area are usually excluded from survey designs. It is very clear that juvenile Kemp's ridleys are relatively common both around eastern Long Island and in Cape Cod Bay (Table 6). It is likely that Rhode Island simply does not have equivalent environments that would constitute good habitat for juvenile ridleys or other juvenile sea turtles. Given that they are common both east and west of Rhode Island, it is possible, however, that small ridleys regularly transit the Rhode Island and SAMP study areas.

Conclusions: Kemp's ridley sea turtles have occurred in the SAMP area, but they are much rarer in the study area than leatherbacks or loggerheads. There is some small concern that the small juvenile ridleys that are found around eastern Long Island or Cape Cod might transit through the SAMP area during their migrations. Any mitigation relative to the SAMP or development activities for leatherbacks would also benefit Kemp's ridleys, so it does not seem necessary to consider them separately.

3.2.33. Green sea turtle *Chelonia mydas* (Linnaeus, 1758)

Description: Green turtle adults are usually about the same size as or slightly larger than loggerheads, although the largest adults reach only about 150 cm (Ernst et al., 1994; Wynne and Schwartz, 1999). The shell is not as broad as in the loggerhead, and is more oval and less tapered. The color can be extremely variable, from pale olive to dark brown, with distinctive mottling or radiating patterns on the scutes. The head is much narrower than in loggerheads and lacks the broad crushing plates on the jaws.

Status: At the species level, green sea turtles are classified as Threatened under the U.S. Endangered Species Act, however the Florida nesting population is listed as Endangered. Since the population identity of any individual green turtle encountered off the northeastern U.S. is impossible to determine, the risk-averse strategy would be to consider them as Endangered.

Green turtles are not included on the Rhode Island state list, and are classified as Endangered on the IUCN Red List.

There are 46 identified nesting concentrations of green turtles in the world, including 13 in the Atlantic (reviewed in NMFS & USFWS, 2007a): five in the western North Atlantic, four in the eastern Mediterranean, one in Brazil, two in western Africa, and one on Ascension Island. The total number of nesting adult females worldwide is estimated between 110,000 and 150,000. The five western North Atlantic nesting populations include: Florida, with an average of 5,055 nests per year, mostly in Brevard and Palm Beach Counties, and with an increasing trend in 2001–2005; Yucatan, with 1,500 nests in the 2000s and an increasing trend; Costa Rica, with 17,402–37,290 nesting females in a year during 1999–2003, and with an increasing trend; Venezuela, with 335–443 nesting females and no detectable trend; and Suriname, with 1,803 nesting females in 1995 and an increasing trend.

There are no estimates of the number of green sea turtles off the northeastern U.S. (Shoop and Kenney, 1992). The numbers of sightings are far too few to calculate densities, and many individuals are too small to be sighted during aerial surveys.

Ecology and Life History: Green sea turtles follow the typical sea turtle life history pattern (reviewed in NMFS and USFWS, 2007a). Hatchlings are entrained in oceanic current patterns and passively drift about in association with sargassum patches (Carr, 1987). After 5–6 years of pelagic existence, they reach 20–25 cm in carapace length and move into developmental habitats in shallow coastal waters. They spend about 6 years in these habitats, then move into typical adult foraging habitats. The total time from hatching to maturity may be as long as 40 years (Limpus and Chaloupka, 1997). Adult females exhibit remigration intervals of 2–5 years, on average deposit three nests per breeding year, and have a reproductive lifetime of 17–23 years.

Green sea turtle adults and benthic feeding juveniles are herbivores, feeding on a variety of sea grasses and algae (Bjorndal, 1985, 1995, 1997; Mortimer, 1995). They also consume small amounts of animal material, including jellyfish, salps, and sponges (Bjorndal, 1997). Juvenile green turtles from Long Island were recorded as feeding on eel-grass, three species of green algae, and two species of brown algae (Burke et al., 1991). Pelagic post-hatchlings and small juveniles are not herbivorous, but are probably omnivores feeding more on animal food than on plant material (Bjorndal, 1985, 1997).

General distribution: Green sea turtles are globally distributed in tropical and sub-tropical regions, with some individuals occurring in cooler, temperate regions (Ernst et al., 1994; NMFS & USFWS, 2007a). In the western North Atlantic, they are most common in the Gulf of Mexico and Caribbean. Because of their herbivorous diet, green turtles are most likely to occur in shallow, nearshore habitats with extensive sea grass meadows.

Historical occurrence: Babcock (1919) wrote that green sea turtles were occasionally recorded in southern New England. He reported that one was captured in New Bedford harbor in September 1878, but that there were no other records from Buzzards Bay, where he expected they should occur. He also said that there were numerous records from Long Island Sound back to 1840, including two captured in the Housatonic River in Connecticut. Lazell (1980) recounted anecdotal evidence for a resident population of juvenile green turtles in Nantucket Sound, where they were regularly caught in pound nets and were often sold as exhibit specimens to commercial aquaria.

Recent occurrence: There has been only one confirmed green turtle sighting in the Rhode Island study area—on 25 March 2005 south of Long Island between the 40- and 50-m isobaths (Fig. 73). The sighting was made during an aerial survey for right whale monitoring, and was assigned an identification reliability of “probable.” Nawojchik and St. Aubin (2003) reported only two strandings in Connecticut and Rhode Island during 1987–2001, but the dates and locations are not known to us. However, like Kemp’s ridleys, juvenile green turtles are known to be present in shallow waters around eastern Long Island and Cape Cod (Table 6). Those data suggest that green turtles are relatively more common around Long Island than they are in Massachusetts.

Conclusions: Green sea turtles have never been recorded in the SAMP area, and they are much rarer in the study area than leatherbacks or loggerheads. There is some small concern that the juvenile green turtles that are found around eastern Long Island or Cape Cod might transit through the SAMP area during their migrations. Any mitigation relative to the SAMP or development activities for leatherbacks would also benefit green turtles, so it does not seem necessary to consider them separately.

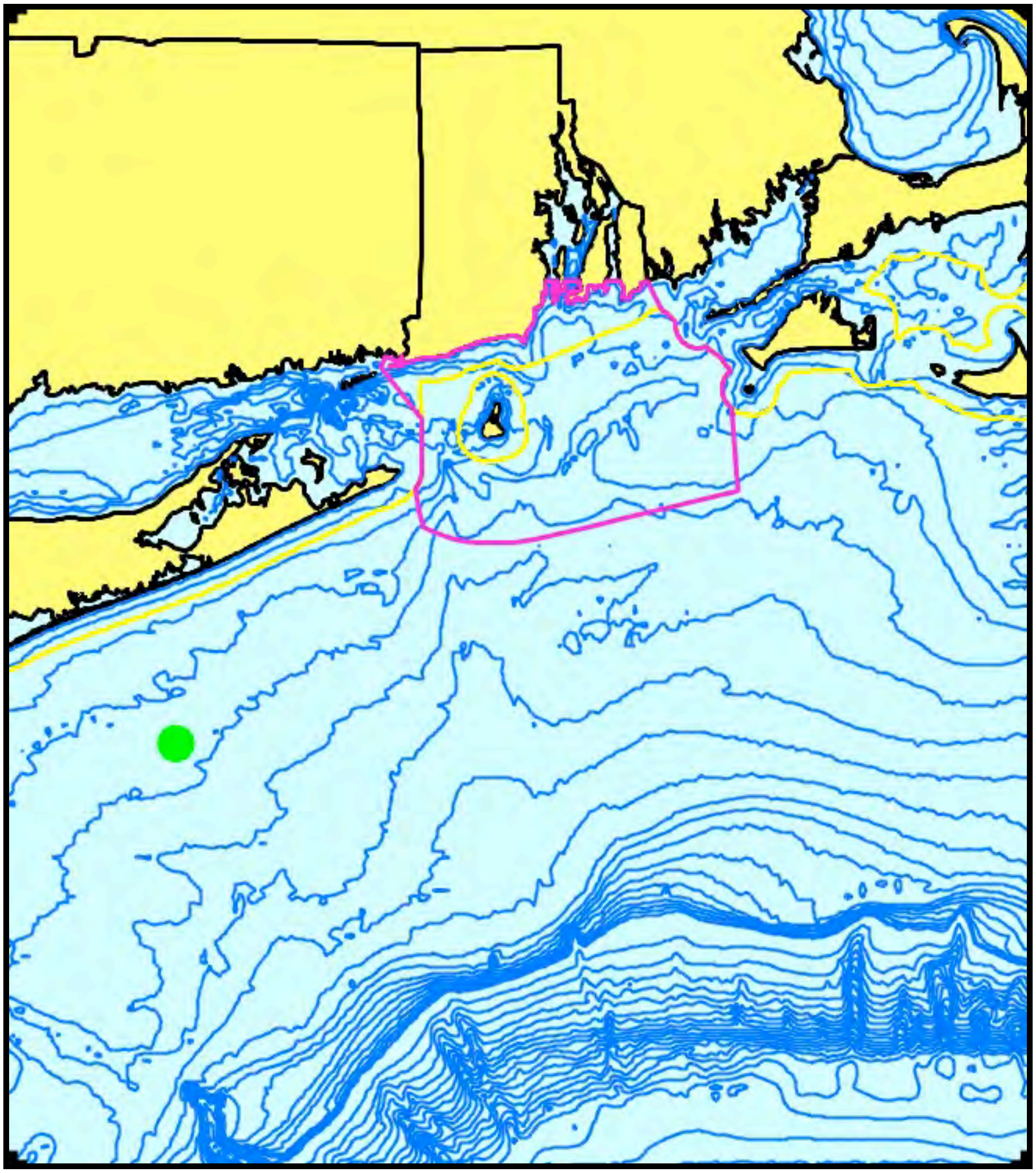

Figure 73. Aggregated sighting, stranding, and bycatch records of green sea turtles in the Rhode Island study area, 2005 (n = 1: winter = 0, spring [green] = 1, summer = 0, fall = 0).

4 Conclusions and Recommendations

Forty species of marine mammals and sea turtles are known to occur in the waters of the Rhode Island study area—encompassing Narragansett Bay, Block Island Sound, Rhode Island Sound, and nearby coastal and continental shelf areas. Sixteen are categorized as common to abundant, six as regular, and eighteen as rare to accidental. Eleven of those species—six whales, the manatee, and four sea turtles—are listed as Endangered or Threatened under the U.S. Endangered Species Act. One other species was present historically but is now extinct in the North Atlantic. Eight other species, including one Endangered sea turtle, are considered to be hypothetical in the study area—with one or more records nearby.

Every species does not pose the same level of conservation concern relative to the Rhode Island Ocean SAMP or to the development of alternative energy projects or other industrial/ commercial projects in our coastal waters. Factors that influence the level of concern include overall abundance of the population, abundance in the study area, seasonal distribution patterns and likelihood of occurrence in or near any area of development, ESA-listing status, sensitivity to specific anthropogenic activities, and existence of other known threats to the population.

The 40 marine mammal and sea turtle species known to occur in the study area have been ranked into five levels of conservation priority relative to the SAMP. The ranking has been done using the factors outlined above. The general characteristics of each priority level are summarized in Table 7, and the species included in each priority class are summarized in Table 8.

4.1 Priority 1

The highest priority level includes species that are common in the Rhode Island study area, that are known to occur in the SAMP area at least seasonally, and that are listed as Endangered under the U.S. Endangered Species Act. The North Atlantic right whale almost deserves to be in a category by itself. The species is one of the rarest mammals in the world, there is serious concern about long-term population viability, and there is known anthropogenic mortality from ship collisions, as well as from entanglement in commercial fishing gear. The populations of humpback whales and fin whales are at least an order of magnitude larger than the right whale’s, but they can be abundant in or near the SAMP area, and they are also subject to human-caused mortality from ship strikes and fishery entanglements. Leatherback sea turtles are a global conservation priority, and are the most likely sea turtle species to be encountered in the SAMP area. Leatherbacks are subject to anthropogenic mortality from fishery entanglements, vessel collisions, and debris ingestion. Other threats not relevant to the SAMP region are loss or degradation of nesting habitat and intentional harvest of eggs and/or adults.

Table 7. Summarized definitions of the five levels used to prioritize conservation rankings of marine mammals and sea turtles relative to the Rhode Island Ocean Special Area Management Plan.

Rank	Defining characteristics
1	Species common in the Rhode Island study area, known to occur in the SAMP area at least seasonally, and listed as Endangered under the ESA
2	(a) ESA-listed species that are common in the Rhode Island study area, but not likely to occur more than rarely to occasionally in the SAMP area; (b) very abundant species likely to occur in significant numbers within the SAMP area at least seasonally
3	(a) ESA-listed species that are not known to occur in the SAMP area, but might visit irregularly or pass through undetected as juveniles; (b) species common in the study area, but likely to occur in the SAMP area only infrequently
4	(a) ESA-listed species with accidental occurrences over an extended period; (b) rare species with offshore distributions at the shelf edge and beyond; (3) common pinniped species with main centers of the distribution elsewhere and present in the study area mainly as dispersing juveniles
5	Very rare or accidental species, including ESA-listed species only occurring very recently

4.2 Priority 2

The second level of priority includes species in two different classes. The first would include sperm whales and loggerhead sea turtles. Both are ESA-listed, sperm whales as Endangered and loggerheads as Threatened, and both are common in the Rhode Island study area. However, neither species is likely to occur more than rarely to occasionally in the SAMP area, with sperm whales more likely offshore and loggerheads more offshore and to the southwest on the shelf. The other group includes four very abundant marine mammals. Harbor porpoises, Atlantic white-sided dolphins, and short-beaked common dolphins are probably the most abundant marine mammals in the study area, and all are likely to occur in significant numbers within the SAMP area at least seasonally. Harbor seals are the most common seal species in the study area, and are the only marine mammal that can be considered as resident in Rhode Island. They are known to occupy haul-out sites on the periphery of Block Island, where they could be subject to disturbance from development activities.

Table 8. Prioritized conservation rankings of 49 species of marine mammals and sea turtles relative to the Rhode Island Ocean Special Area Management Plan. Species listed as Endangered or Threatened under the U.S. Endangered Species Act are identified by *E* or *T*, respectively.*

Rank	Species included
1a	North Atlantic right whale (*E*)
1b	humpback whale (*E*), fin whale (*E*), leatherback sea turtle (*E*)
2	sperm whale (*E*), harbor porpoise, white-sided dolphin, short-beaked common dolphin, harbor seal, loggerhead sea turtle (*T*)
3	sei whale (*E*), common minke whale, long-finned pilot whale, Risso's dolphin, bottlenose dolphin, Kemp's ridley sea turtle (*E*), green sea turtle (*T* & *E*)
4	blue whale (*E*), pygmy sperm whale, dwarf sperm whale, Cuvier's beaked whale, Blainville's beaked whale, Gervais' beaked whale, Sowerby's beaked whale, True's beaked whale, striped dolphin, gray seal, harp seal, hooded seal
5	Bryde's whale, northern bottlenose whale, beluga, short-finned pilot whale, killer whale, false killer whale, white-beaked dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, ringed seal, West Indian manatee (*E*)
na	Atlantic gray whale, pygmy killer whale, melon-headed whale, rough-toothed dolphin, spinner dolphin, Clymene dolphin, bearded seal, walrus, hawksbill sea turtle (*E*) [1 extirpated and 8 hypothetical species]

* the order of species within any ranking category does not imply any priority within that category; it is simply the order in which the species appear in this report.

4.3 Priority 3

The third level of priority includes five cetacean species and two sea turtles. Sei whales are considered regular in the Rhode Island study area and are ESA-listed as Endangered, however they are not likely to occur in the SAMP area, typically occur beyond the study area, and are only likely to visit the study area irregularly in a small number of years. Kemp's ridley and green sea turtles are ESA-listed, but have mainly tropical and sub-tropical distributions and are not known to occur in the SAMP area. However juveniles of both species are known to utilize shallow developmental habitats around eastern Long Island and Cape Cod and may well occur within or transit through the SAMP area. Minke whales, long-finned pilot whales, Risso's dolphins, and bottlenose dolphins are all common species in the study area, but likely to occur in the SAMP area only infrequently.

4.4 Priority 4

The fourth level of priority includes mostly rare species with known centers of occurrence outside of the SAMP area, or even beyond the Rhode Island study area. Blue whales are endangered, but occur accidentally in southern New England, and have a long historical record of doing so in the region. Pygmy sperm whales, dwarf sperm whales, Cuvier’s beaked whales, Blainville’s beaked whales, Gervais’ beaked whales, Sowerby’s beaked whales, True’s beaked whales, and striped dolphins are all regular or rare species in the study area with distributions that are primarily offshore—at the shelf edge and beyond. Gray seals, harp seals, and hooded seals are all common species in the study area and very frequently stranded. However, for all three species the majority of individuals in the study area appear to be dispersing juveniles, the main centers of the adult populations are elsewhere in the western North Atlantic, and the strandings appear to be simply a component of natural juvenile mortality.

4.5 Priority 5

The lowest level of priority includes all rare species, with many occurring only accidentally in the study area—Bryde’s whale, northern bottlenose whale, beluga whale, short-finned pilot whale, killer whale, false killer whale, white-beaked dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, ringed seal, and West Indian manatee. The manatee is the only ESA-listed species here, and it has a record of occurrence in the Northeast going back only to 1996.

4.6 Recommendations

In the event that a full EIS is required at some point in the future for a wind farm, other alternative energy project, or other commercial/industrial development, there could well be a need to estimate the levels of “take” of protected species. Calculating take estimates will require estimating the densities (animals per km^2) of each species present. The relative abundances generated in this technical report will not be sufficient, nor can statistically defensible density estimates be derived from the data that we used. Only line-transect or similar surveys can produce density estimates. There are old seasonal, stratified density estimates from CETAP based on aerial line-transect surveys in 1979–1981 (CETAP, 1982; Kenney et al., 1985a). The sampling design was year-round, and there were two survey strata that could approximate the SAMP area. However, the sampling coverage was relatively low and was reduced each year of the project. Later NMFS aerial and shipboard surveys were designed to estimate stock abundances for the annual stock assessment reports (e.g., Waring et al., 2008) that were required under the 1994 amendments to the MMPA. However, the surveys were almost all in summer, the coverage was low with one-off surveys spaced several years apart, many of the surveys concentrated on offshore waters coverage, the objective was to generate one abundance estimate and not densities by local sampling areas, and the actual densities are not published in the stock assessments. The most recent attempt to generate density estimates was for the Navy (DoN, 2007), done by Geo-Marine, Inc. with input from NMFS Science Center staff. That project tried to break down the estimates into smaller areas, however they were based on only a subset of the NMFS aerial surveys, and again were mainly from summer (exclusively so in the vicinity of the SAMP study area). In addition, it is possible that those estimates have never been externally reviewed outside of the agencies involved in generating them.

New appropriately designed line-transect surveys might be necessary to generate regionally specific seasonal density estimates of protected species. They could be either aerial or shipboard surveys, however a combination of both would be ideal to capture species that are best sampled by only one or the other. An ideal survey program would need to run year-round to adequately capture seasonal variability, for at least 2–3 years to capture interannual variability, and at sufficient intensity and sample sizes to generate reliable estimates with reasonably low CVs. A statistical review of the previous line-transect surveys in the region and a power analysis would be necessary to define the level of survey intensity and frequency needed to generate robust density estimates for the SAMP area, but the required survey program clearly would not be a simple or inexpensive undertaking.

Passive acoustic monitoring (PAM) would be a valuable addition to future studies for species that regularly produce underwater sounds (i.e., cetaceans). PAM studies have an advantage over visual boat- or aircraft-based surveys in not being restricted by reduced visibilities at night or during adverse weather conditions. For vocalizing animals, PAM can generate very good presence-absence information over extended periods on a continuous basis. Currently, however, it is not possible from PAM data alone to generate estimates of density or abundance, however that capability is an objective of on-going research. Tagging studies might provide additional data on habitat use and movement patterns of animals of concern for specific projects, for example small sea turtles or resident seals.

Relatively low-cost, long-term monitoring during the summer could be accomplished by supporting student interns who would ride on the whale-watching boat from Galilee and collect sighting records and associated effort data in standardized form. Such an intern could also assist the company in computerizing their previous logbooks for additional trend analyses. An additional, although lower-priority, project for such an intern would be incorporating any still-outstanding stranding data, including seal strandings from the Smithsonian for prior to 1993, Massachusetts marine mammal strandings, marine mammal strandings for 2006 and beyond, and full sea turtle stranding data.

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