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

Draft Technical Report

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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. Forty species of marine mammals and 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. 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 species that is very unlikely to occur in the SAMP area, and several other species that are common but mainly found outside of the SAMP area. In Priority 4 are three relatively rare to accidental ESA-listed species where there may be uncertainty about regional occurrence. There are 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. 21): 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. 37): 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 presense 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. 53): 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. 287): 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. 87): 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. 295): 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 Porpoises (Priority 2, Common, Unlisted, p. 129): 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. 171): 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. 201): 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. 229): 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. 67): 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.

Common Minke Whale (Priority 3, Common, Unlisted, p. 77): 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. 141): 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. 163): 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. 187): 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. 49): 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.

Kemp's Ridley Sea Turtle (Priority 4, Regular, Endangered, p. 303): 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 4, Rare, Threatened [species], Endangered [Florida nesting population], p. 309): 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.

Pygmy Sperm Whale (Priority 4, Regular, Unlisted, p. 99): 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. 99): 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. 107): 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. 107): 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. 107): 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. 107): 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. 107): 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. 213): 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. 247): 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. 257): 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. 269): 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. 281): 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. 73): 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. 107): 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. 121): 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. 141): 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. 155): 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. 159): False killer whales are primarily tropical and subtropical inhabitants. A few animals were was 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. 181): 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. 221): 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. 221): 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. 279): Ringed seals are very abundant residents of the high Arctic, which occur only accidentally in New England.

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" 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 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 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 mammal specific to Rhode Island were a summary by Cronan and Brooks (1968) and a checklist by August et al. (2000). 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 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 artefacts 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.

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

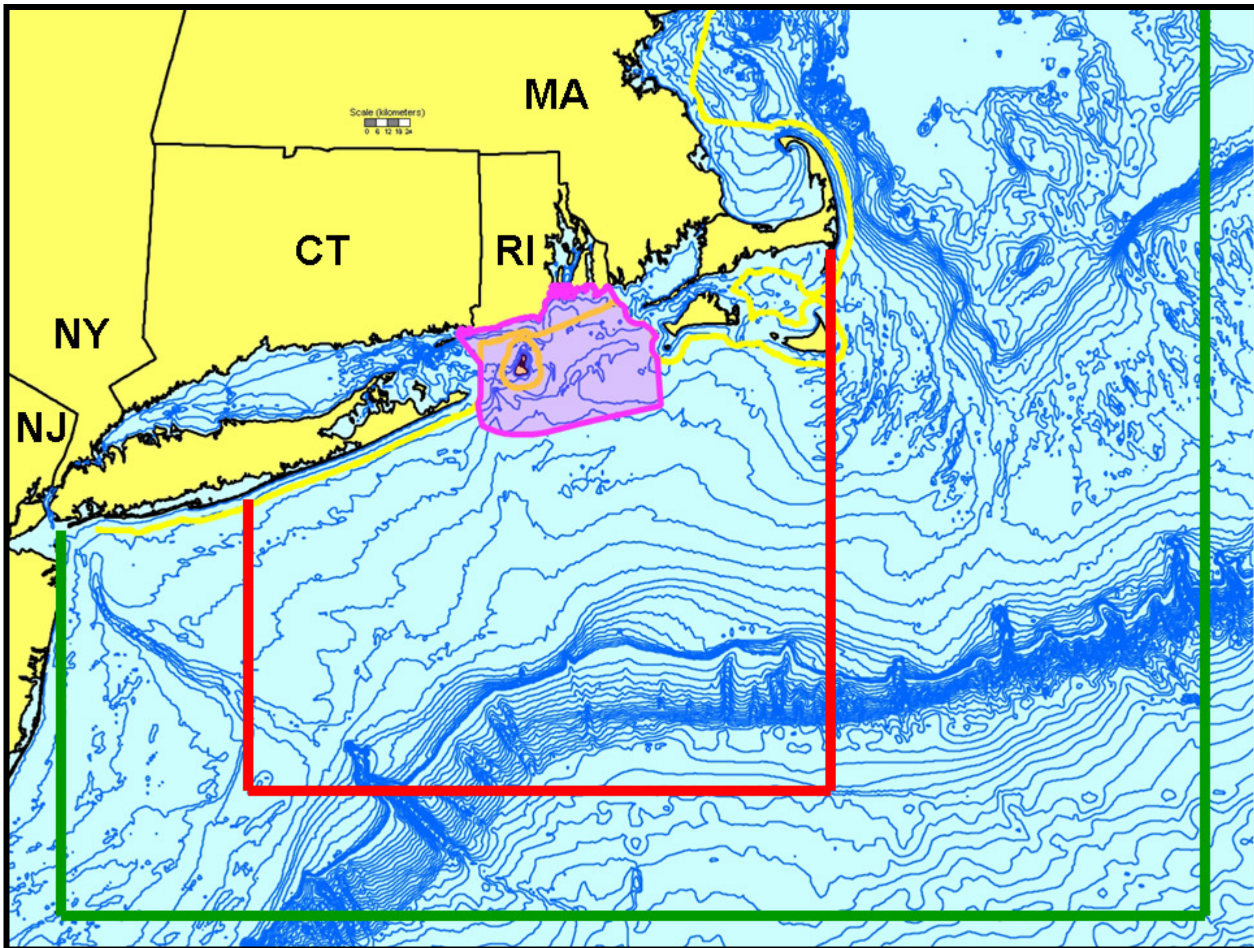

Figure 1. The study areas used in analyzing marine mammal and sea turtle occurrence for the Rhode Island Ocean SAMP. The broadest area outlined in green is the area used for extracting data for the relative abundance modeling procedure. The smaller area enclosed in the red line is the Rhode Island study 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.

(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 target species (and sometimes non-target species) sighted, survey data include detailed information on the track of the 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 1981–1994 (primarily the *Finback*). These sightings are heavily concentrated in late spring and summer in the area between eastern Long Island and Block Island, 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. Allison Seifter, an undergraduate work-study student, completed the task of deciphering Charles' hand-written log entries and entering the data into a computer spreadsheet. 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); 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 identifed 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. We have not seen that publication. 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[1] 1916 monograph—*The Whalebone Whales of New England*[2]. 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

[1] 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, and it is easy to get them confused. 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.

[2] 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.

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 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 18th and early 19th 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 occurrrence levels were defined as: "common" is more than 100 records, "regular" is 10–100 records, and "rare" 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"). In addition, strandings are not necessarily representative of the occurrence of healthy animals. 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 are limited to only a subset of the survey tracklines which meet defined criteria for "acceptability," which include 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 detectibility 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 sufficient numbers of sightings from both platform types, it is possible to incorporate a correction factor into the SPUE calculation for a single species or a few very similar species to account for inter-platform differences, as was done for a SPUE analysis of basking sharks (Campana et al., 2008). However, it would not be practical to do those corrections for a multi-species study with a relatively small area and small sample sizes, not least because it would introduce additional layers of uncertainty into the analysis.

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 previous work was that we used the elliptical search option instead of circular, because marine animal distributions are expected to be related to bathymetry, and in our restricted study area the bathymetric contours are consistently east-west.

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). 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 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 one exception. 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.

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 since 1979 except for several years in the1990s. Cape Cod Bay, another right whale habitat, had high effort in all

Table 1. Marine mammals and sea turtles of the Rhode Island region, showing the total numbers of records and occurrence classification.

Species	N	Occurrence
Class Mammalia		
Order Cetacea – whales, dolphins, and porpoises		
Suborder Mysticeti – baleen whales		
Family Balaenidae – right whales		
North Atlantic right whale	156	common
Family Eschrichtiidae – gray whales		
Gray whale	1	extinct
Family Balaenopteridae – rorquals		
Humpback whale	611	common
Blue whale	5	rare
Fin whale	1,762	common
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
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
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
Family Phocoenidae – porpoises		
Harbor porpoise	374	common
Family Delphinidae – dolphins		
Long-finned pilot whale	43	common*
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

Table 1. (continued)

Species	N	Occurrence
Atlantic white-sided dolphin	210	common
White-beaked dolphin	11	regular
Common bottlenose dolphin	182	common
Short-beaked common dolphin	435	common
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
Gray seal	193	common
Harp seal	703	common
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.

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.

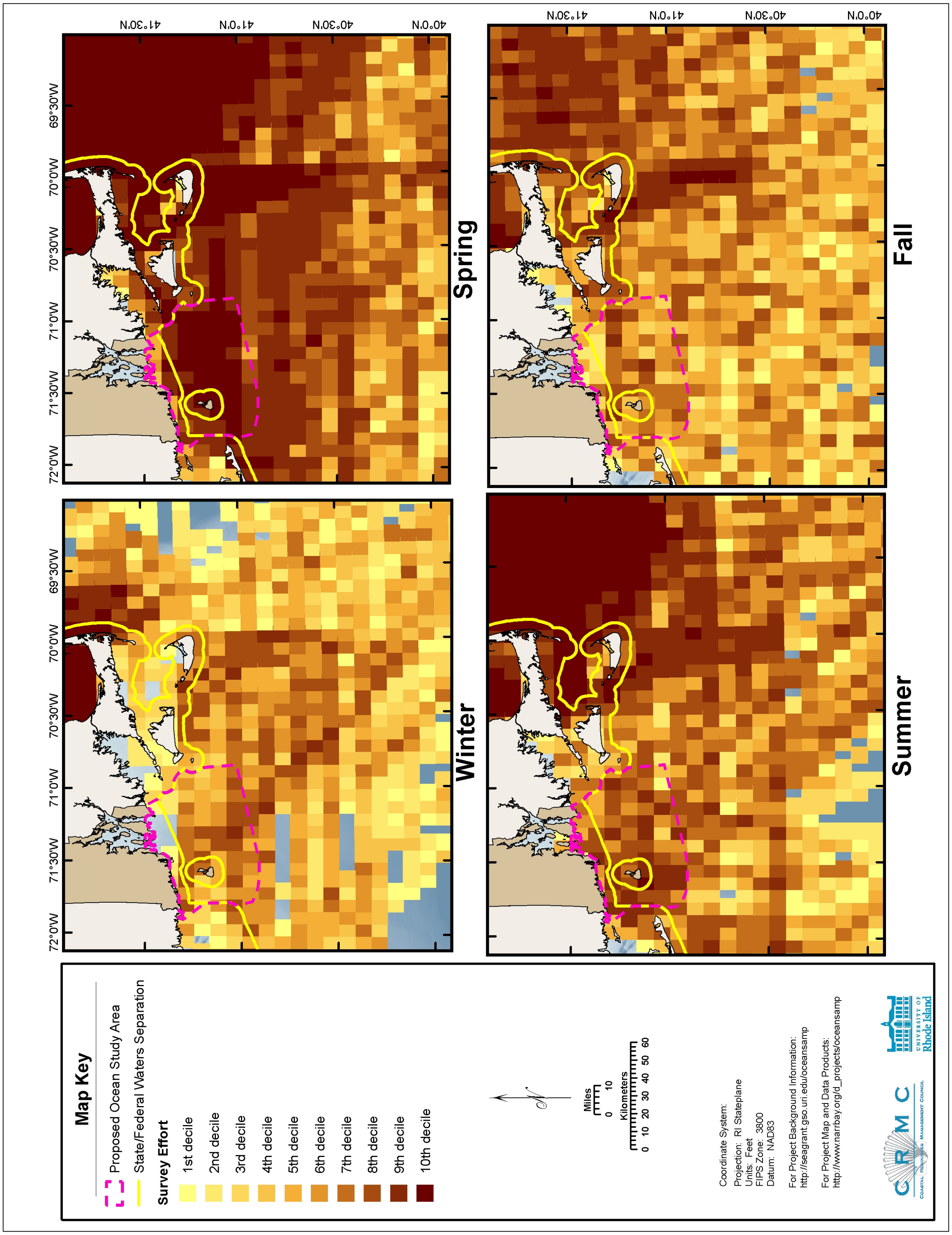

Figure 2. Seasonal summary maps of combined aerial and shipboard survey effort, in km of trackline per 5-minute grid cell.

Strandings, excluding intentional captures 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 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 stranding data also may be complicated by capture records, and strandings during the whaling era may actually be 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.

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 following six sections and primary sources. 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:

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

- ***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[3] was obtained from USFWS (2009). Rhode Island state status[4] is as shown in *Rare Native Animals of Rhode Island* (RIDEM, 2006). International status[5] 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 are based on the most recently published edition (2007) of the NMFS marine mammal stock assessment report (SAR: Waring et al., 2008). 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 citations in this report have not been updated). (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 (http://www.nmfs.noaa.gov/pr/sars/). (4) The SAR does not include sea turtles. The SAR is also the source for estimates of human-caused mortality to marine mammal population, 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

[3] Categories, in decreasing order, are Endangered, Threatened, or Candidate (i.e., proposed for listing).
[4] Categories are Federally Endangered, Federally Threatened, State Endangered, State Threatened, Concern, and State Historical (i.e., extirpated).
[5] Categories are Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, and Data Deficient.

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 particulary relevant to the Rhode Island Ocean SAMP. See also Section 4, Recommendations, for a ranked list of species in the area priotized by conservation concerns.

The species accounts are formatted so that each one begins at the top of a right-hand page, making it easier to copy or package individual accounts as stand-alone documents.

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[6]). 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 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.

[6] 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.

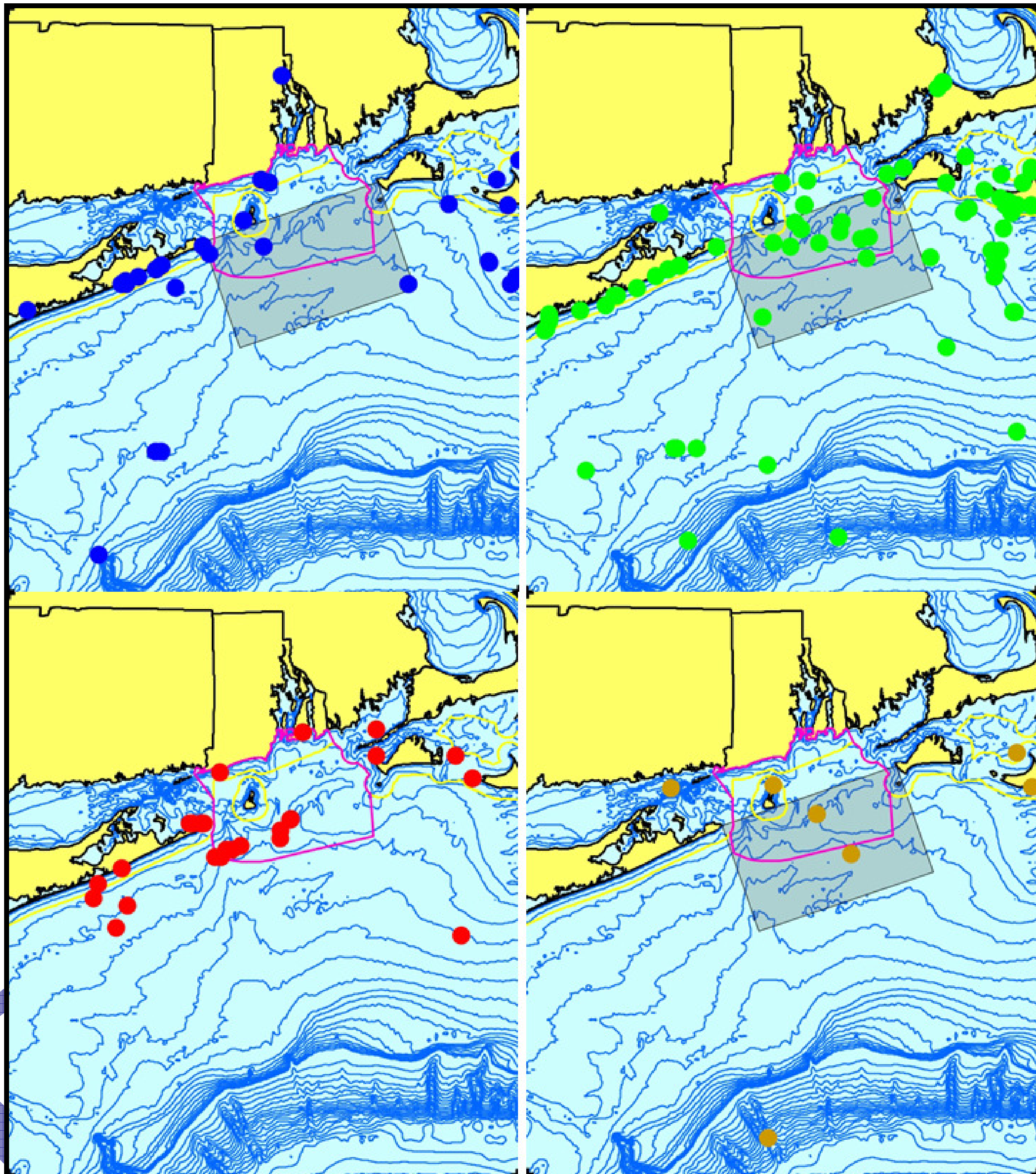

Figure 3. Aggregated sighting, stranding, and bycatch records of North Atlantic right whales in the Rhode Island study area, 1828–2007 (n = 156: winter = 30, spring = 91, summer = 25, fall = 7; unknown = 3). The gray-shaded box is the Block Island Sound Seasonal Management Area, in effect from November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

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 indentified—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 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.)

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

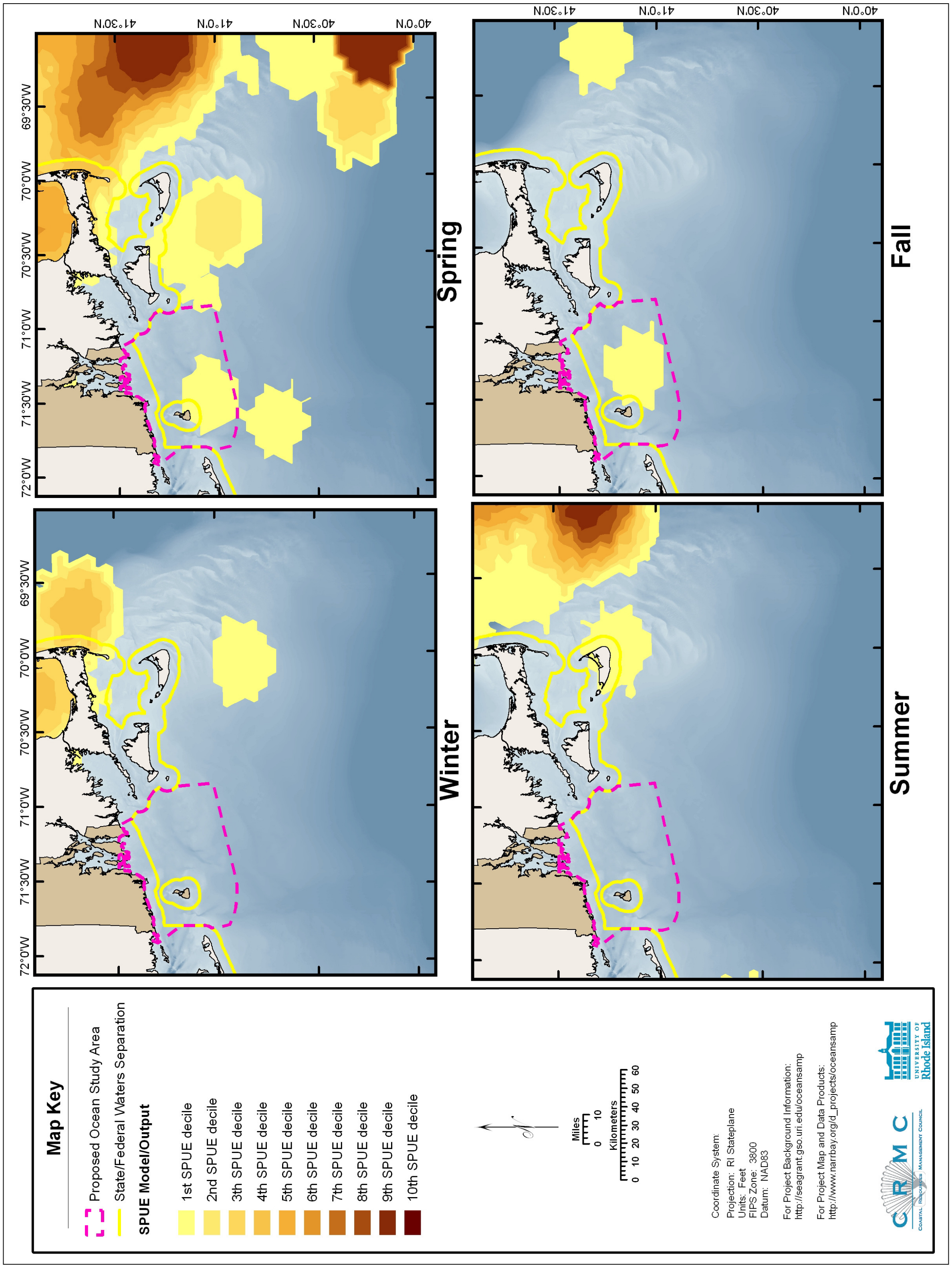

Figure 4. Modeled seasonal relative abundance patterns of North Atlantic right whales in the Rhode Island study area, corrected for uneven survey effort.

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 (see Recommendations, section 4, page 313). 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.

Would it be appropriate for this technical report to include some mention of potential mitigation measures here? These might include seasonal restrictions on pile-driving and/or other construction activities, clearance surveys prior to activities likely to affect whales, ramp-ups of activities creating loud sounds, other sound-reducing mitigation (e.g., bubble curtains around pile-driving), voluntary vessel speed restrictions inshore of the RI-SMA, MMOs on construction vessels (and servicing vessels?), continuous passive acoustic monitoring (maybe from hydrophones mounted on strategically selected towers).

It would then be possible to add a sentence to many or all other species to the effect that mitigation efforts to avoid or lessen potential impacts on right whales would also benefit that species, and to refer back to this page.

3.2.2. 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.

3.2.3. 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[7]; 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, labelled "Humpback; Bristol, R.I., Nov. 4, 1968." One image clearly shows the Braga Bridge in Fall River in the background.

[7] 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.

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

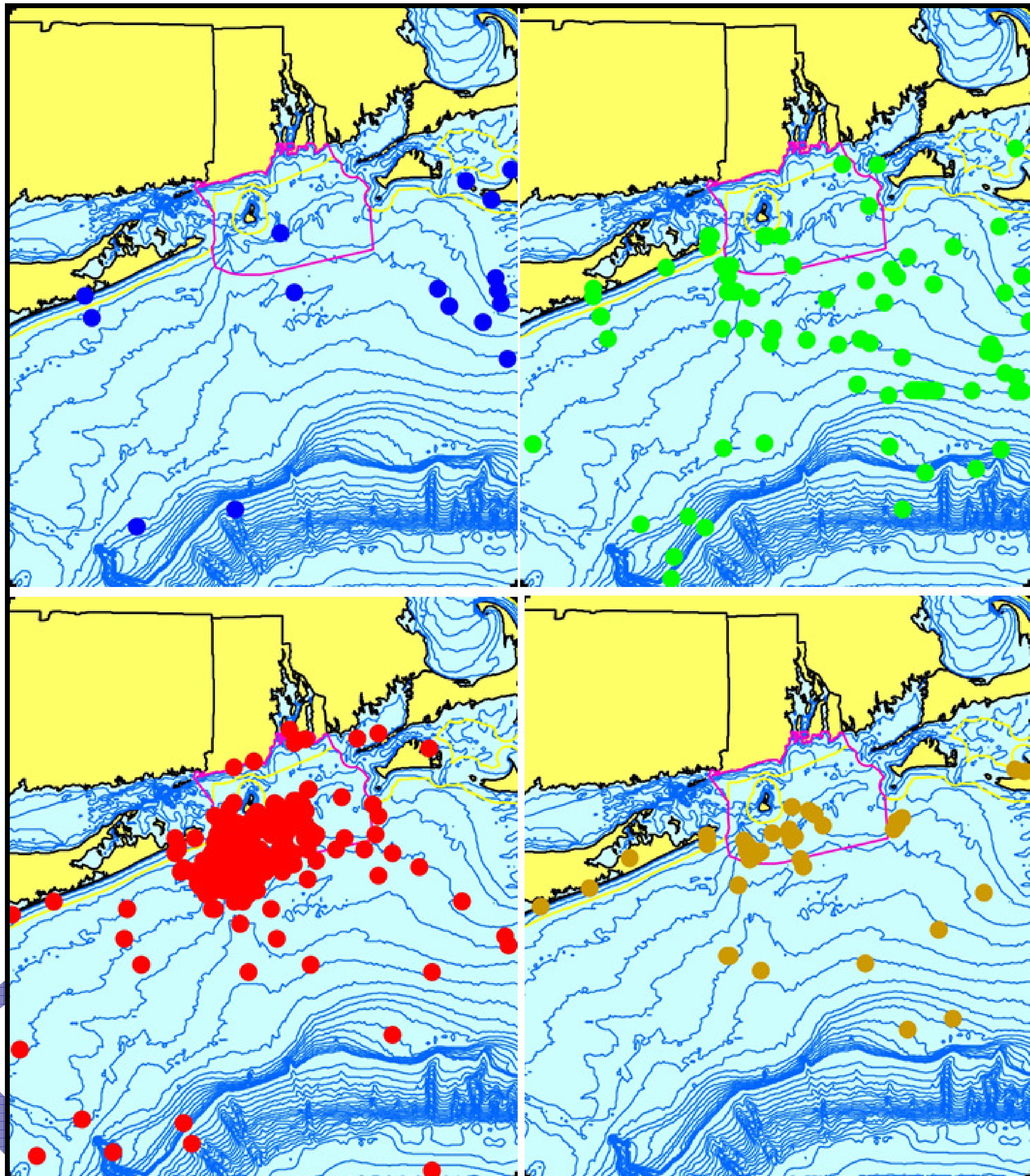

Figure 5. Aggregated sighting, stranding, and bycatch records of humpback whales in the Rhode Island study area, 1608–2007 (n = 611: winter = 16, spring = 96, summer = 435, fall = 63, unknown = 1).

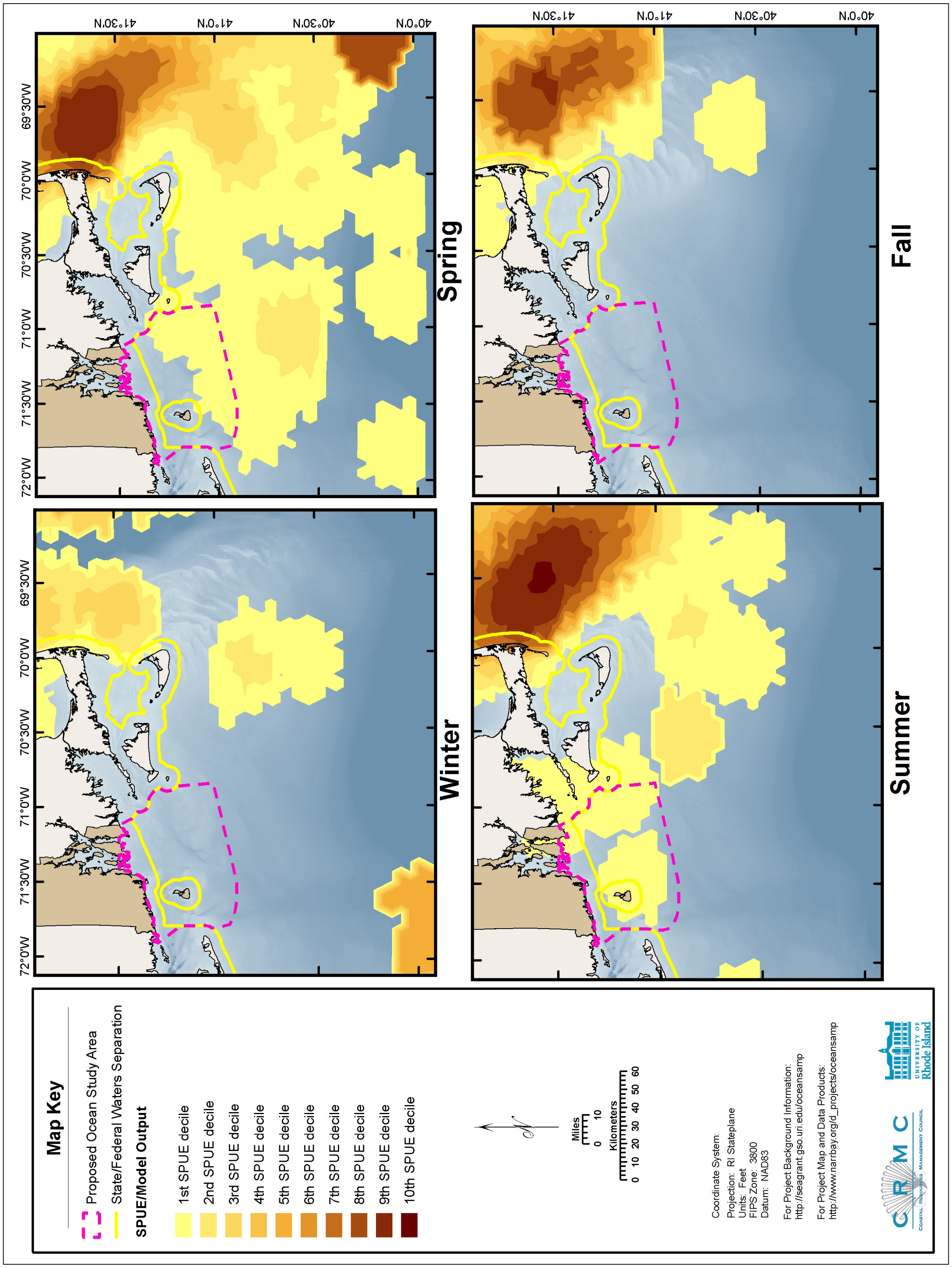

Figure 6. Modeled seasonal relative abundance patterns of humpback whales in the Rhode Island study area, corrected for uneven survey effort.

1986 and 9 in 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 southwestern part of the SAMP are 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.

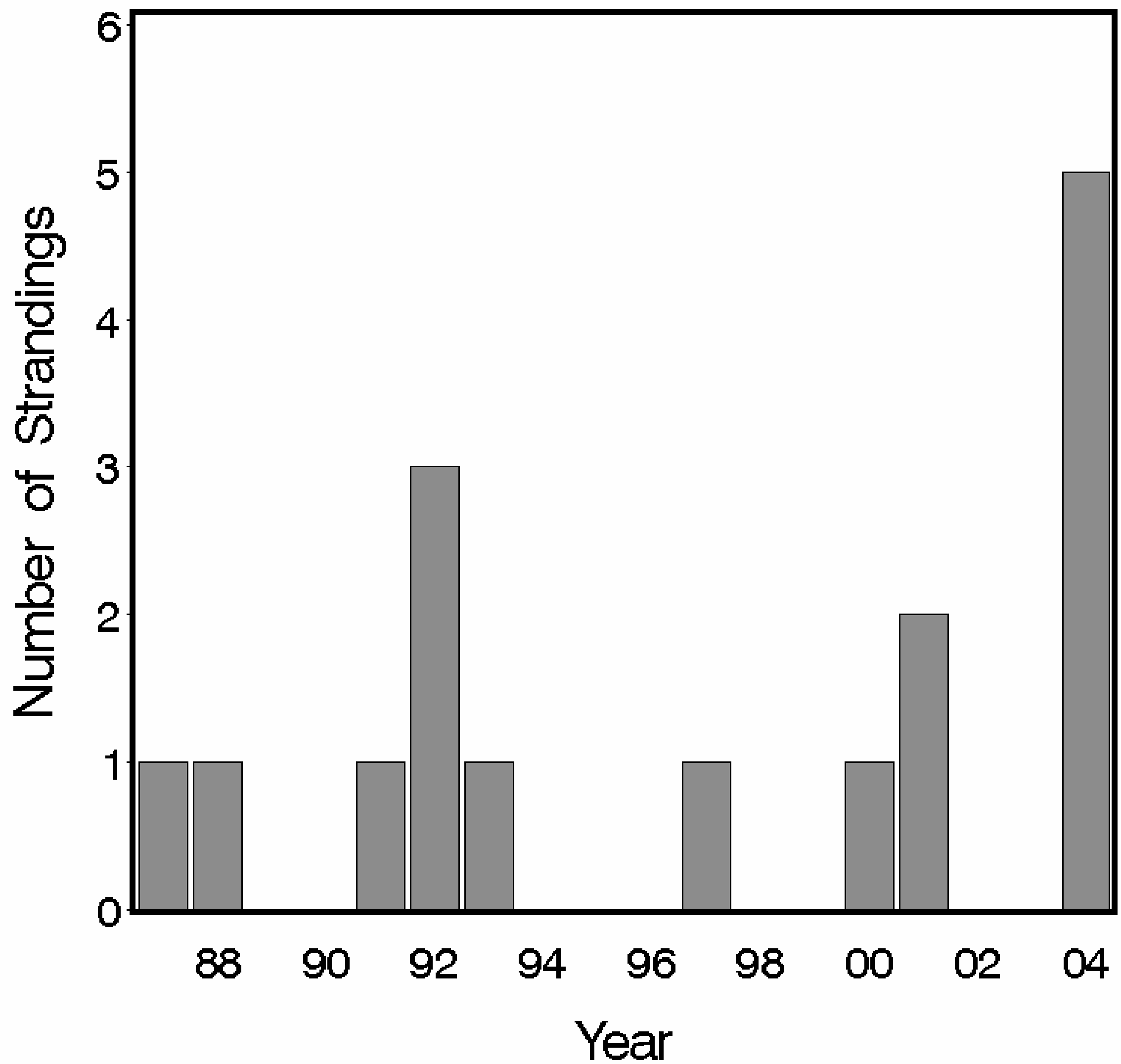

Figure 7. Annual stranding frequencies for humpback whales in the Rhode Island study area, 1987–2004.

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 cccurrence 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.

3.2.4. 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,

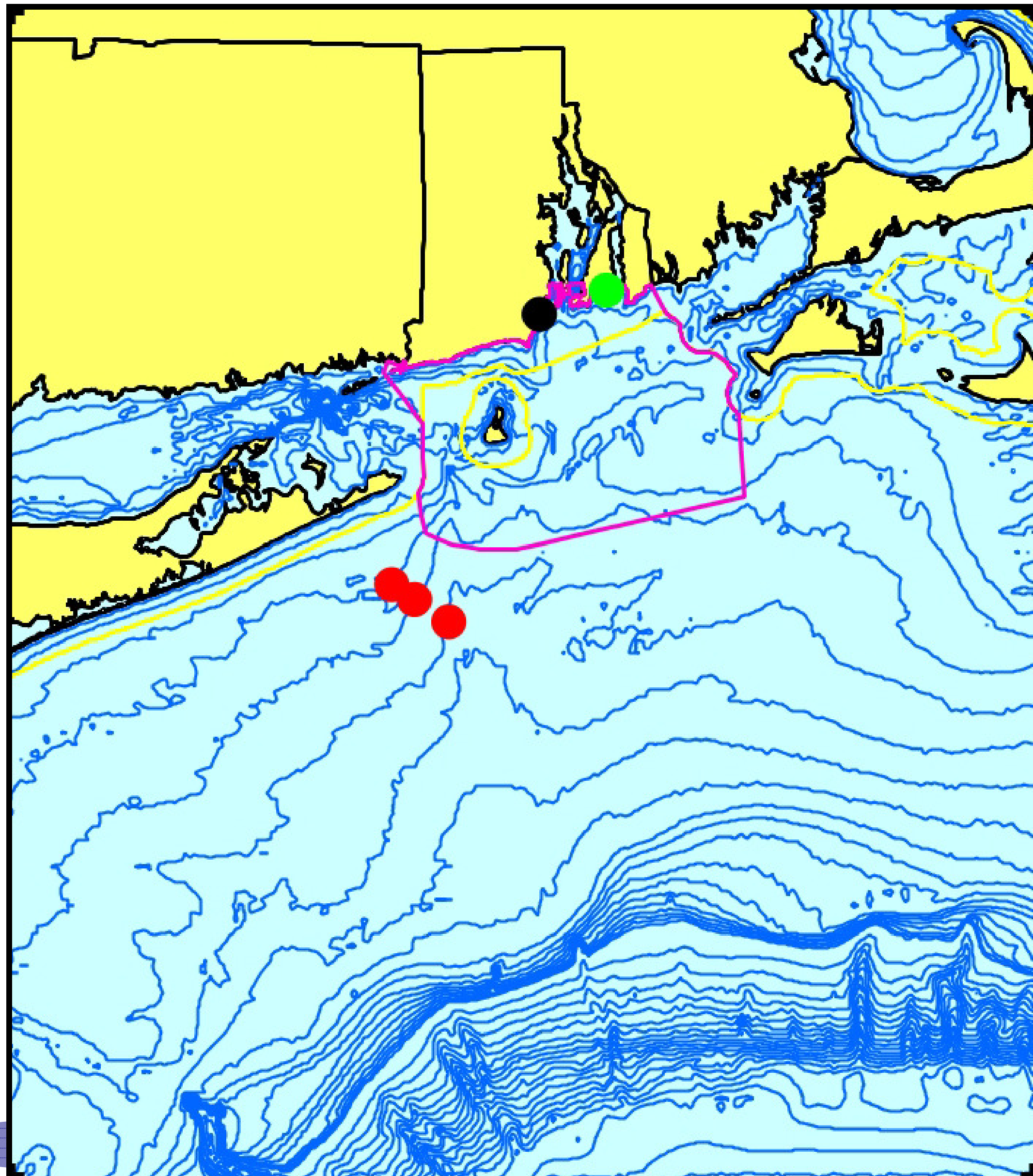

Figure 8. Aggregated sighting, stranding, and bycatch records of blue whales in the Rhode Island study area, 1882–1998 (n = 5: winter = 0, spring = 1, summer = 3, fall = 0, unknown = 1).

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.

3.2.5. 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"[8] 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

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

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 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

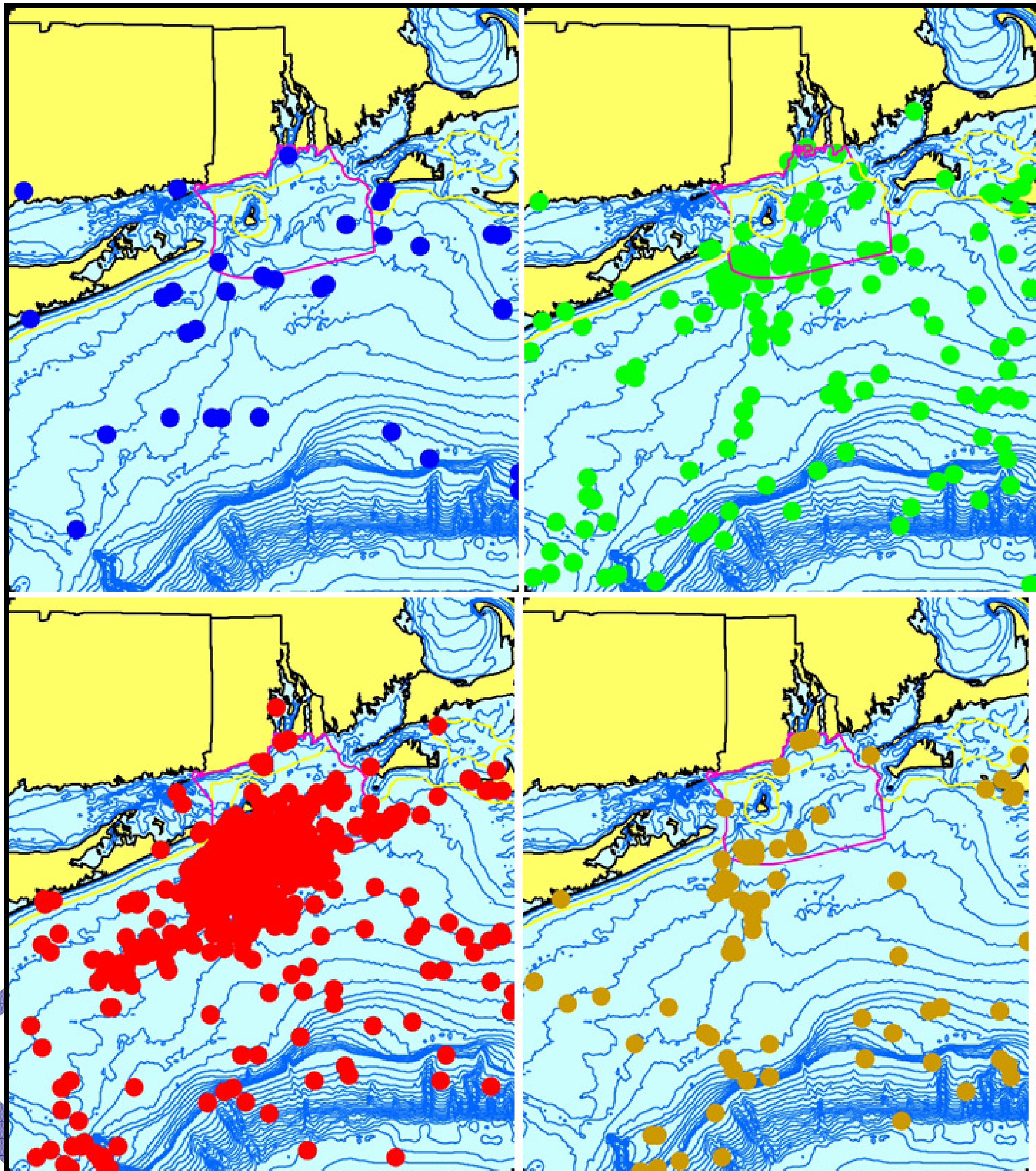

Figure 9. Aggregated sighting, stranding, and bycatch records of fin whales in the Rhode Island study area, 1834–2008 (n = 1,762: winter = 37, spring = 205, summer = 1,425, fall = 93, unknown = 2).

(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 is there were no whales, and they should be expected to focus their trips where they expect to find whales.

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

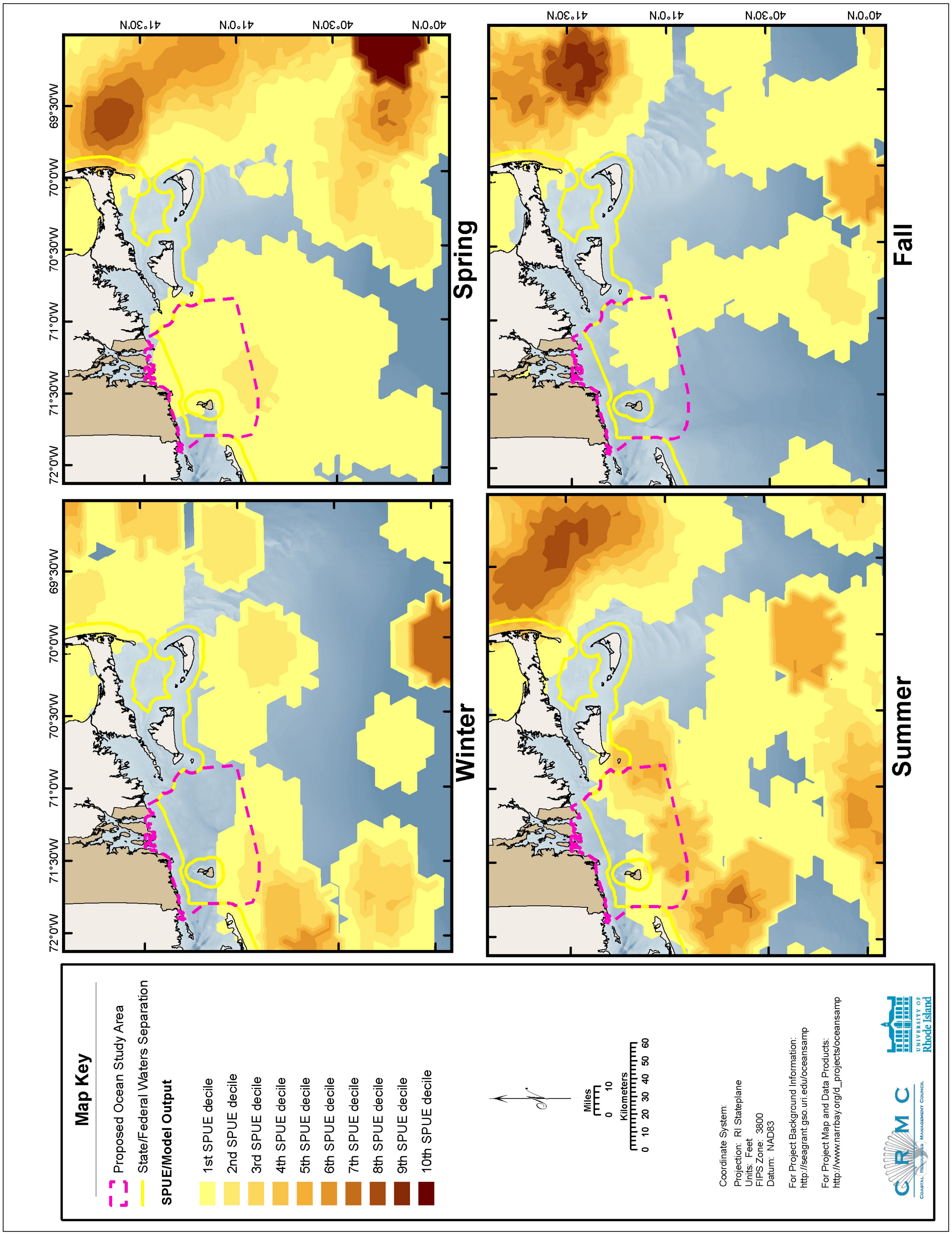

Figure 10. Modeled seasonal relative abundance patterns of fin whales in the Rhode Island study area, corrected for uneven survey effort.

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.

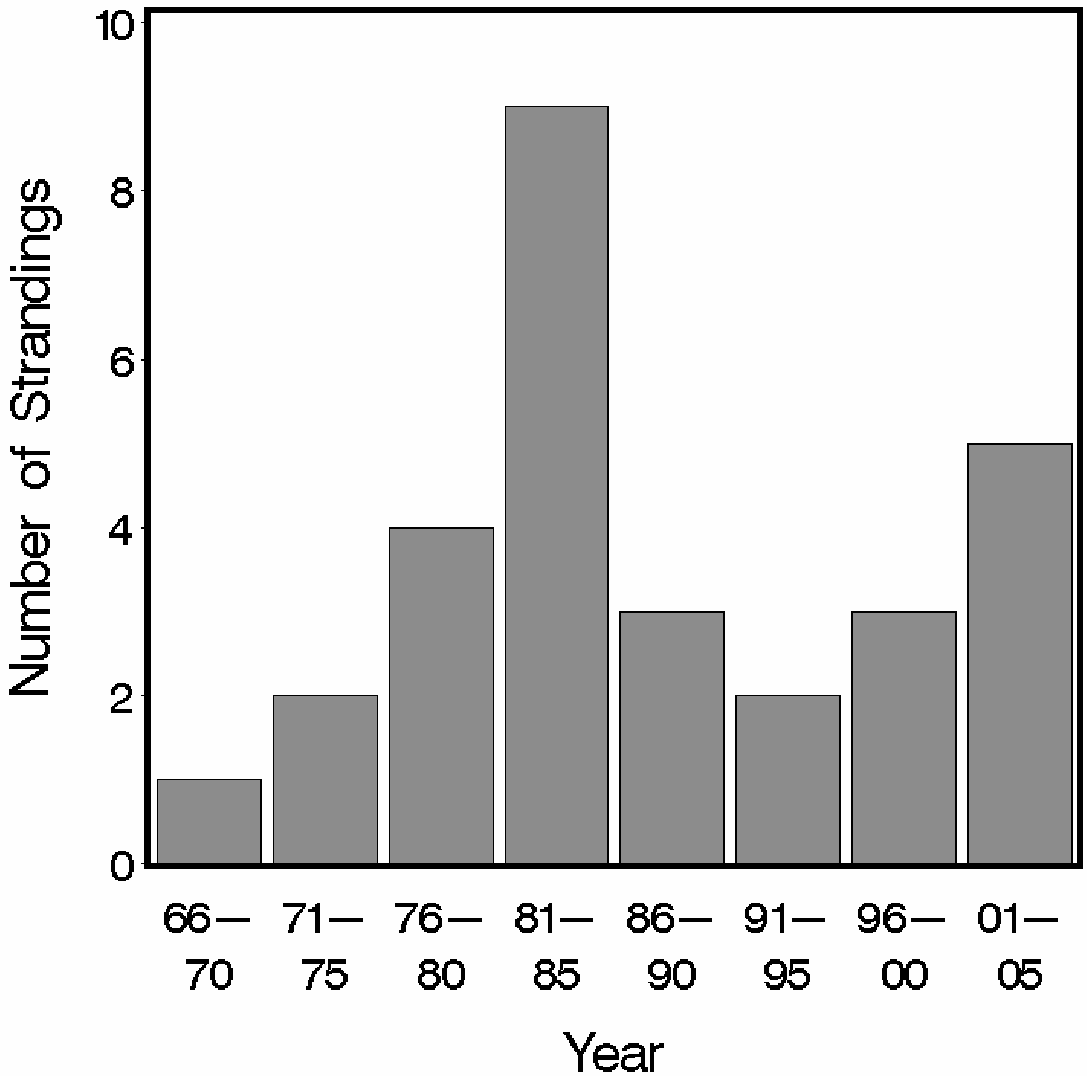

Figure 11. Five-year stranding frequencies for fin whales in the Rhode Island study area, 1966–2005.

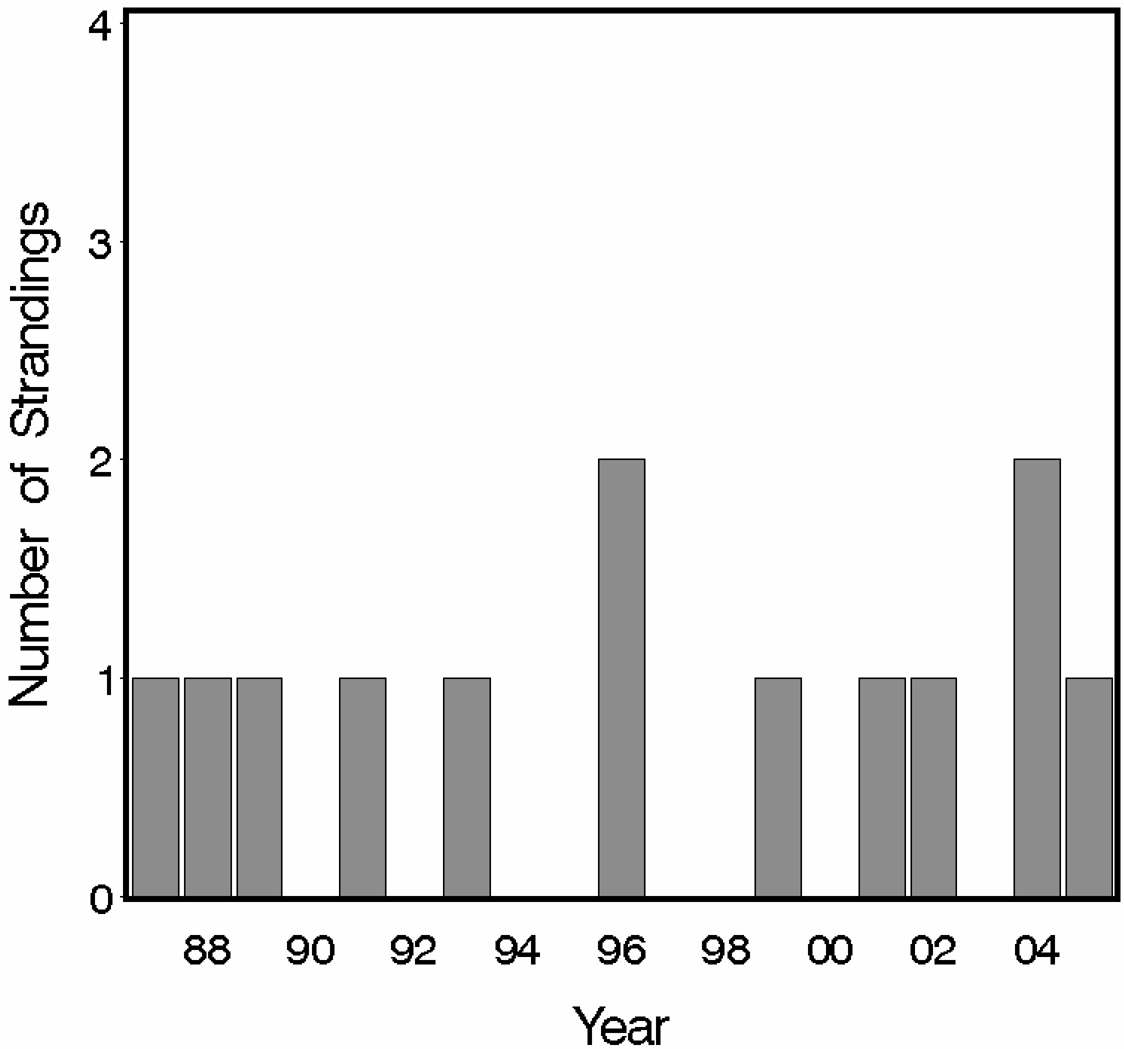

Figure 12. Annual stranding frequencies for fin whales in the Rhode Island study area, 1987–2005, for comparison with humpback whales (Fig. 7).

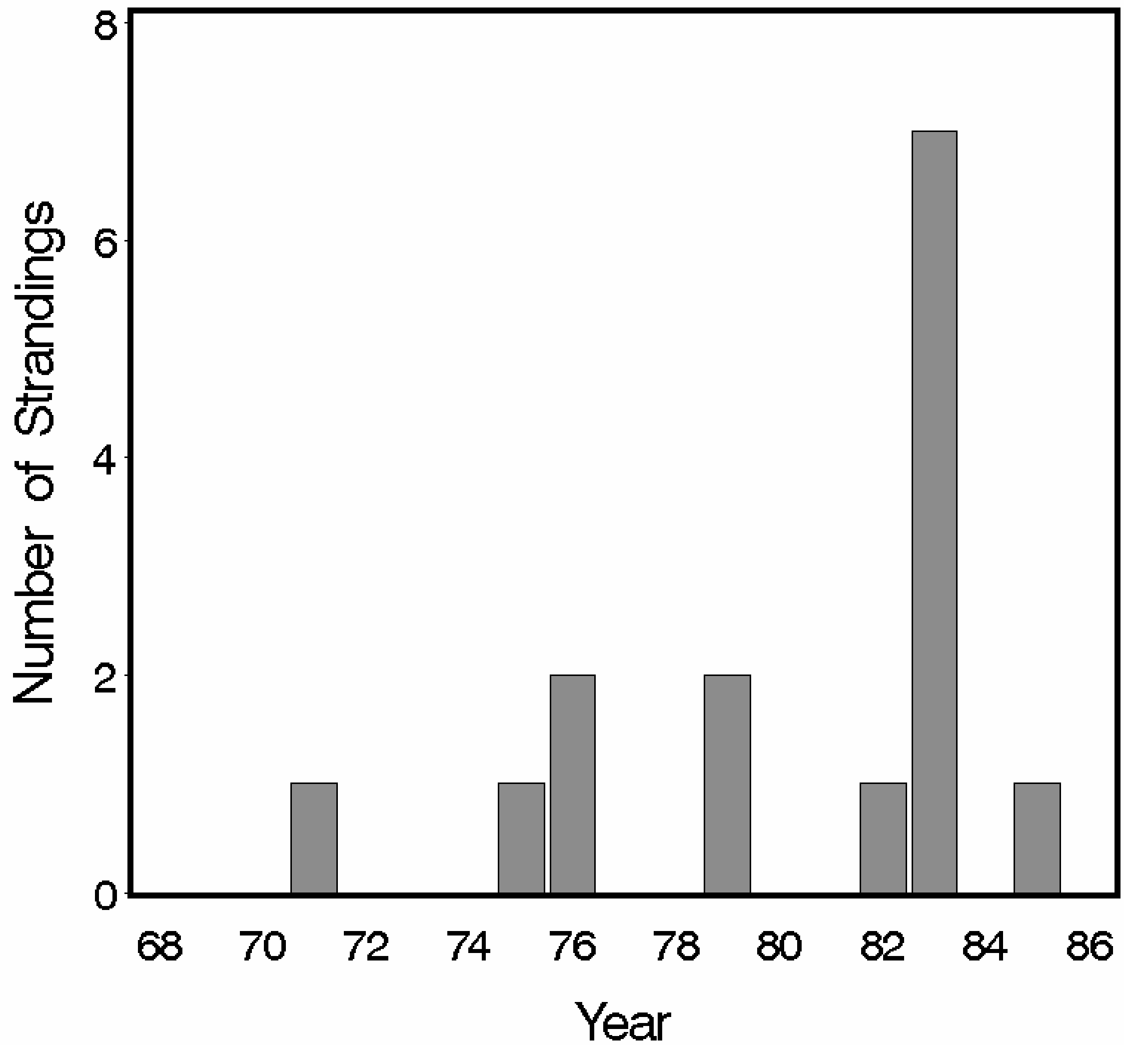

Figure 13. Annual stranding frequencies for fin whales in the Rhode Island study area, 1968–1986.

3.2.6. 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). Typcial 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[9] 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 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

[9] 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.

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.

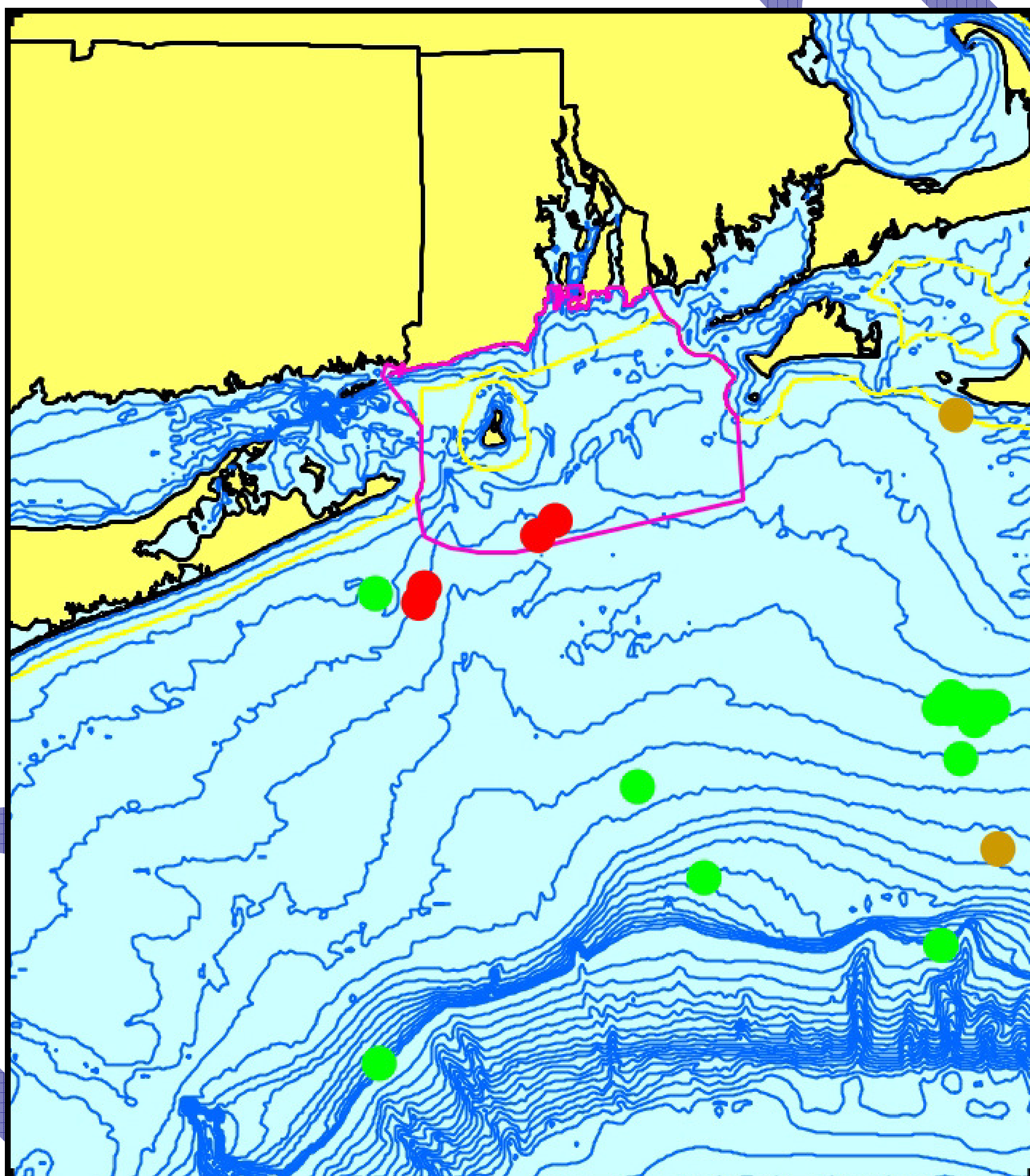

Figure 14. Aggregated sighting, stranding, and bycatch records of sei whales in the Rhode Island study area, 1981–2006 (n = 35: winter = 0, spring = 29, summer = 4, fall = 2).

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.

3.2.7. 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).

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.

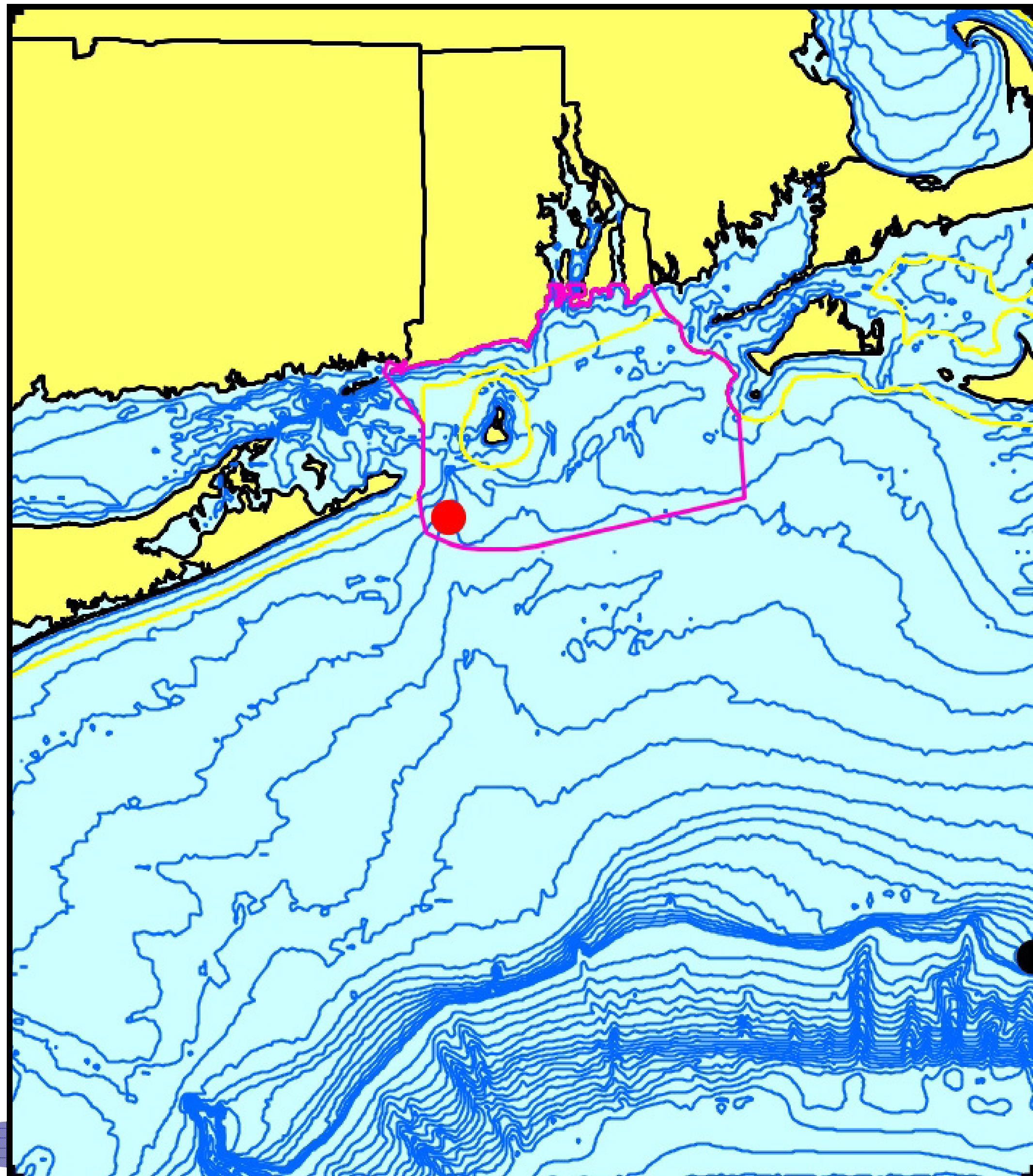

Figure 15. Aggregated sighting, stranding, and bycatch records of Bryde's whales in the Rhode Island study area, 1952 and 1982 (n = 2: winter = 0, spring = 0, summer = 1, fall = 0, unknown = 1).

3.2.8. 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.

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 larrge 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 a 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;

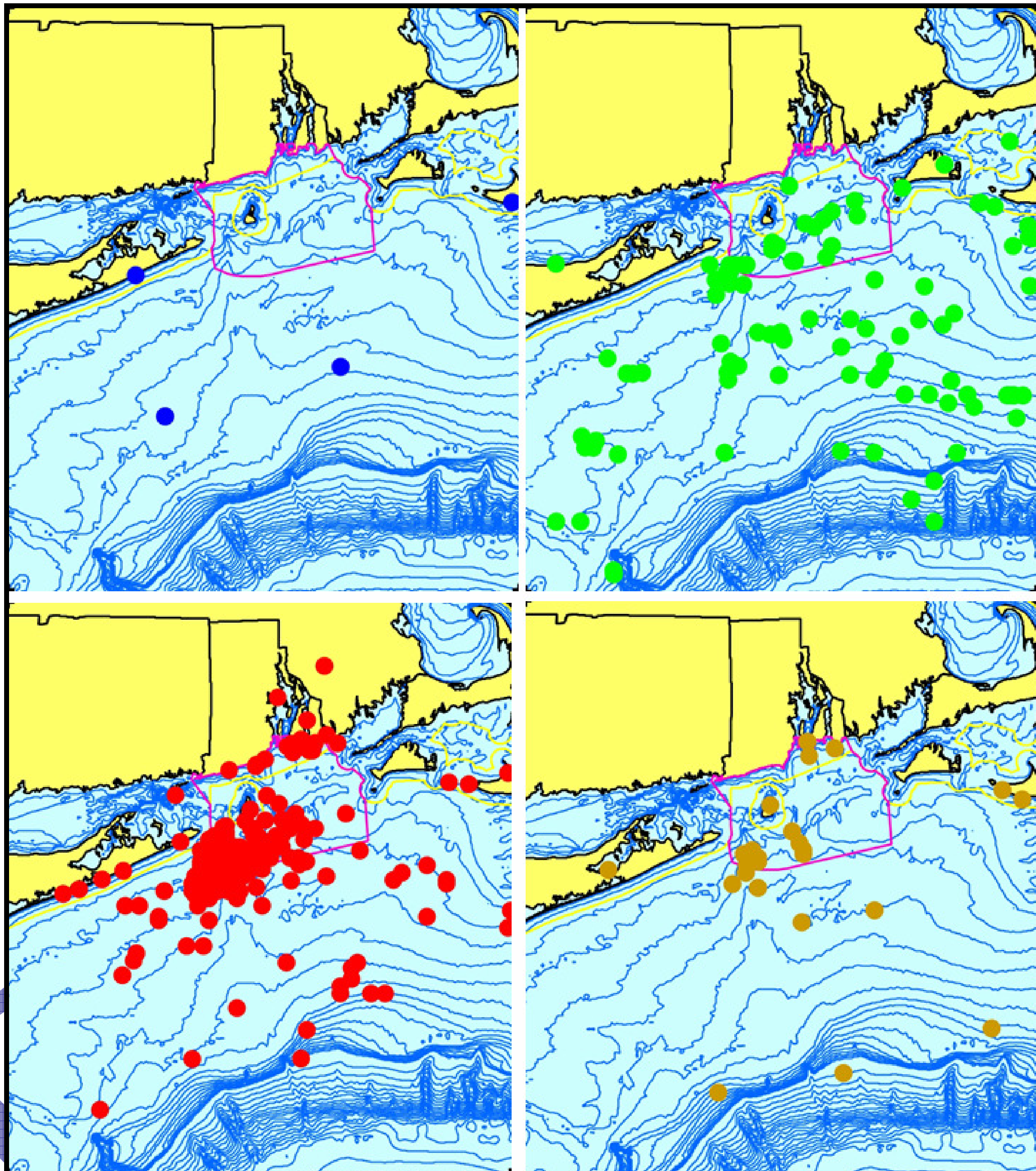

Figure 16. Aggregated sighting, stranding, and bycatch records of minke whales in the Rhode Island study area, 1849–2008 (n = 504: winter = 4, spring = 99, summer = 376, fall = 25).

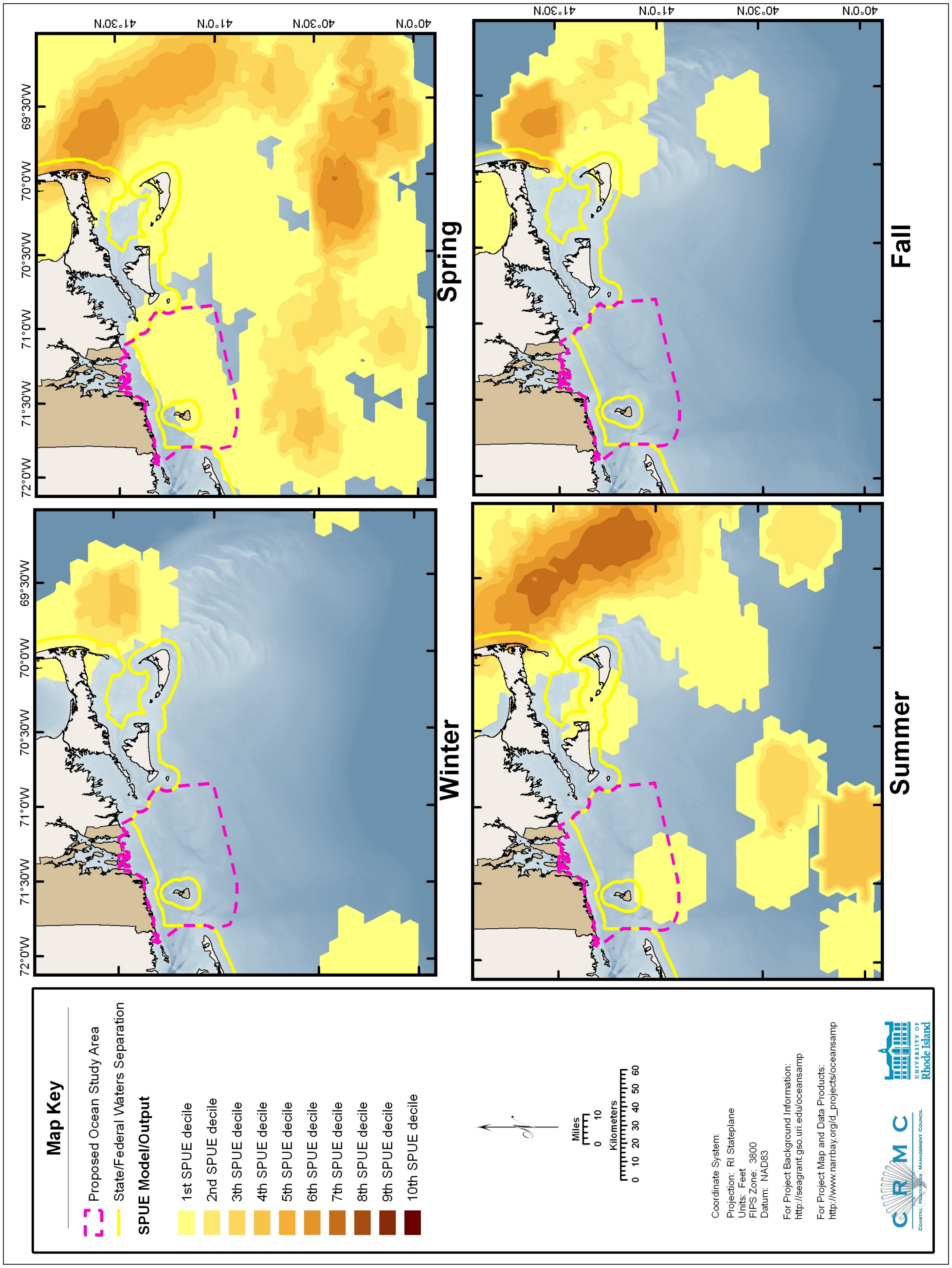

Figure 17. Modeled seasonal relative abundance patterns of common minke whales in the Rhode Island study area, corrected for uneven survey effort.

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 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 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.

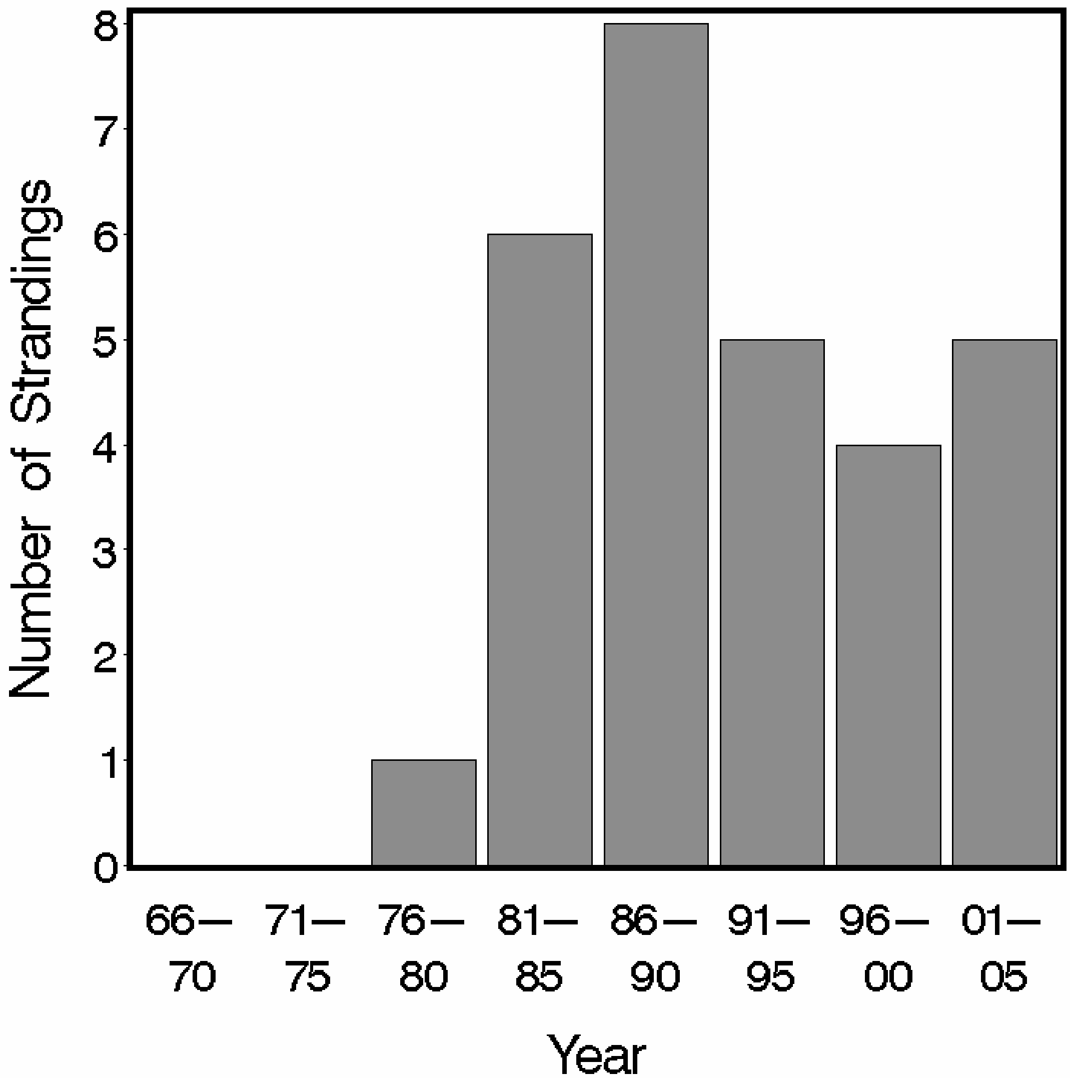

Figure 18. Five-year stranding frequencies for minke whales in the Rhode Island study area, 1966–2005.

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 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 biolumisence 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 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.

There have been no sperm whale strandings in Rhode Island since the one in 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, he stranded again about 55 km east at Oak Beach near Fire Island Inlet. He was towed to a boat basin at a state park 2–3 km away, where he 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 he was herded by small boats out of the boat basin and through the inlet back into the Atlantic.

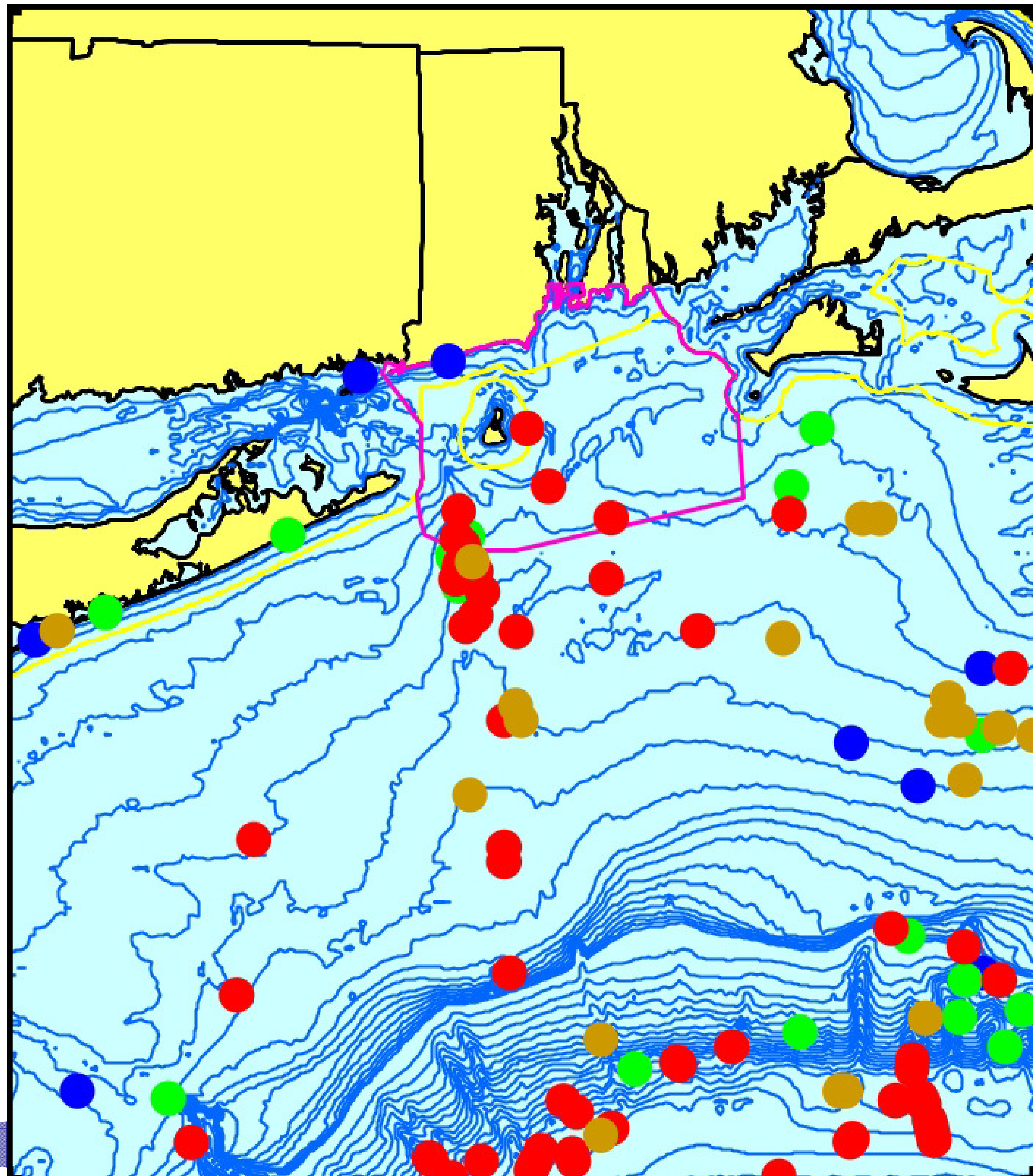

Figure 19. Aggregated sighting, stranding, and bycatch records of sperm whales in the Rhode Island study area, 1891–2004 (n = 103: winter = 8, spring = 17, summer = 59, fall = 19).

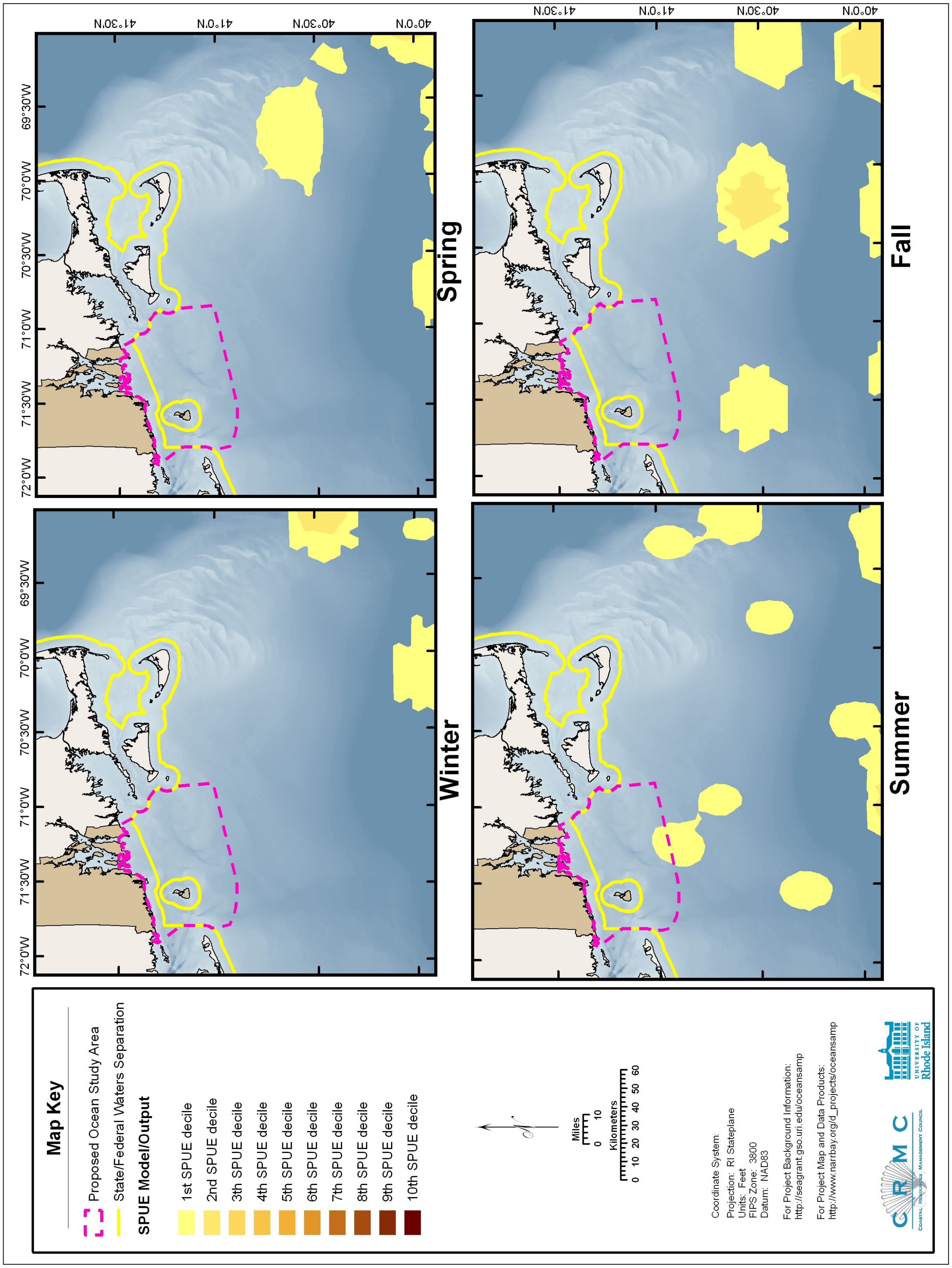

Figure 20. Modeled seasonal relative abundance patterns of sperm whales in the Rhode Island study area, corrected for uneven survey effort.

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, particulary 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 pymgy 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.

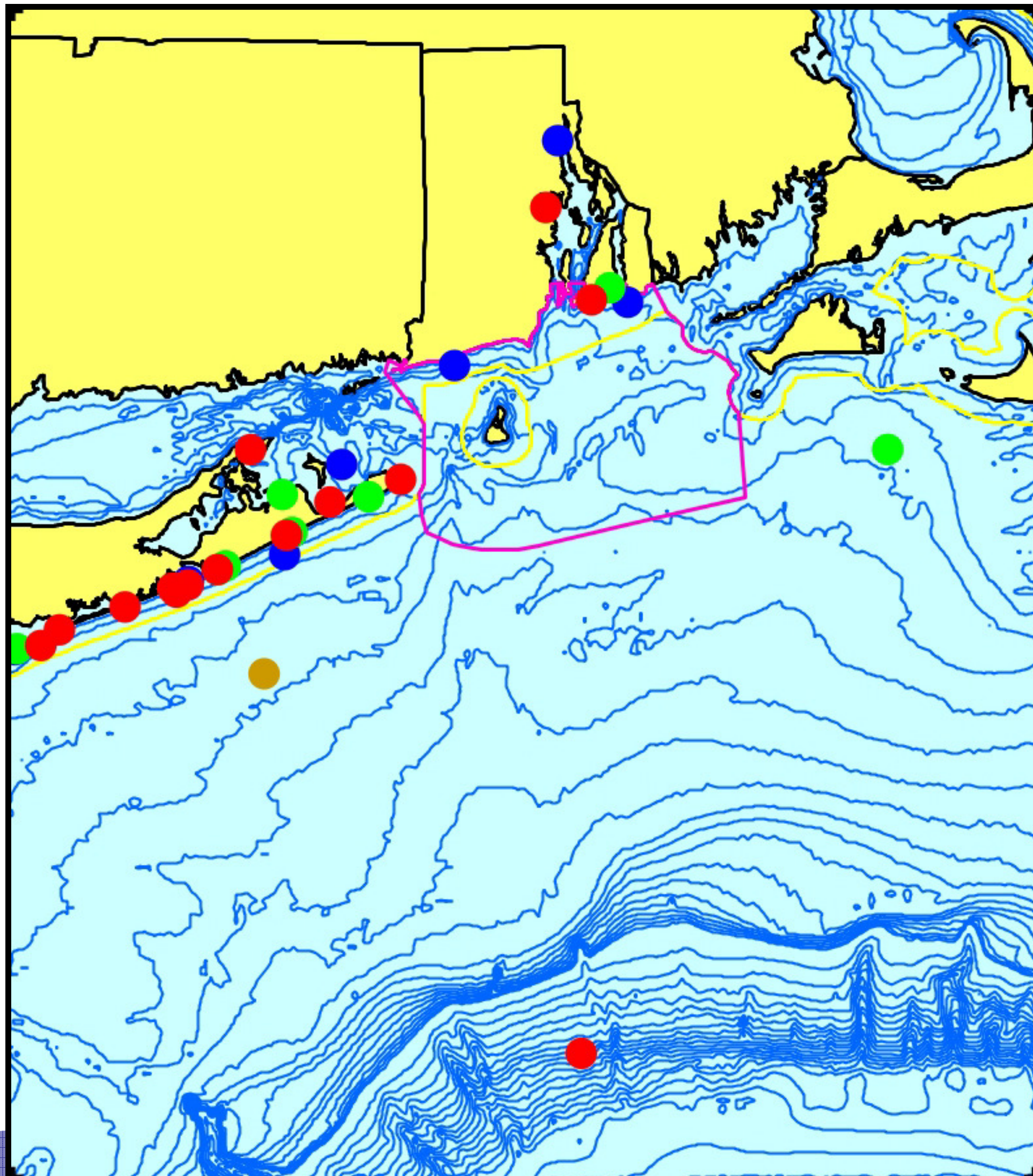

Figure 21. Aggregated sighting, stranding, and bycatch records of pygmy sperm whales, dwarf sperm whales, and unidentified *Kogia* sp. in the Rhode Island study area, 1941–2004 (n = 31: winter = 8, spring = 8, summer = 14, fall = 1).

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 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 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.

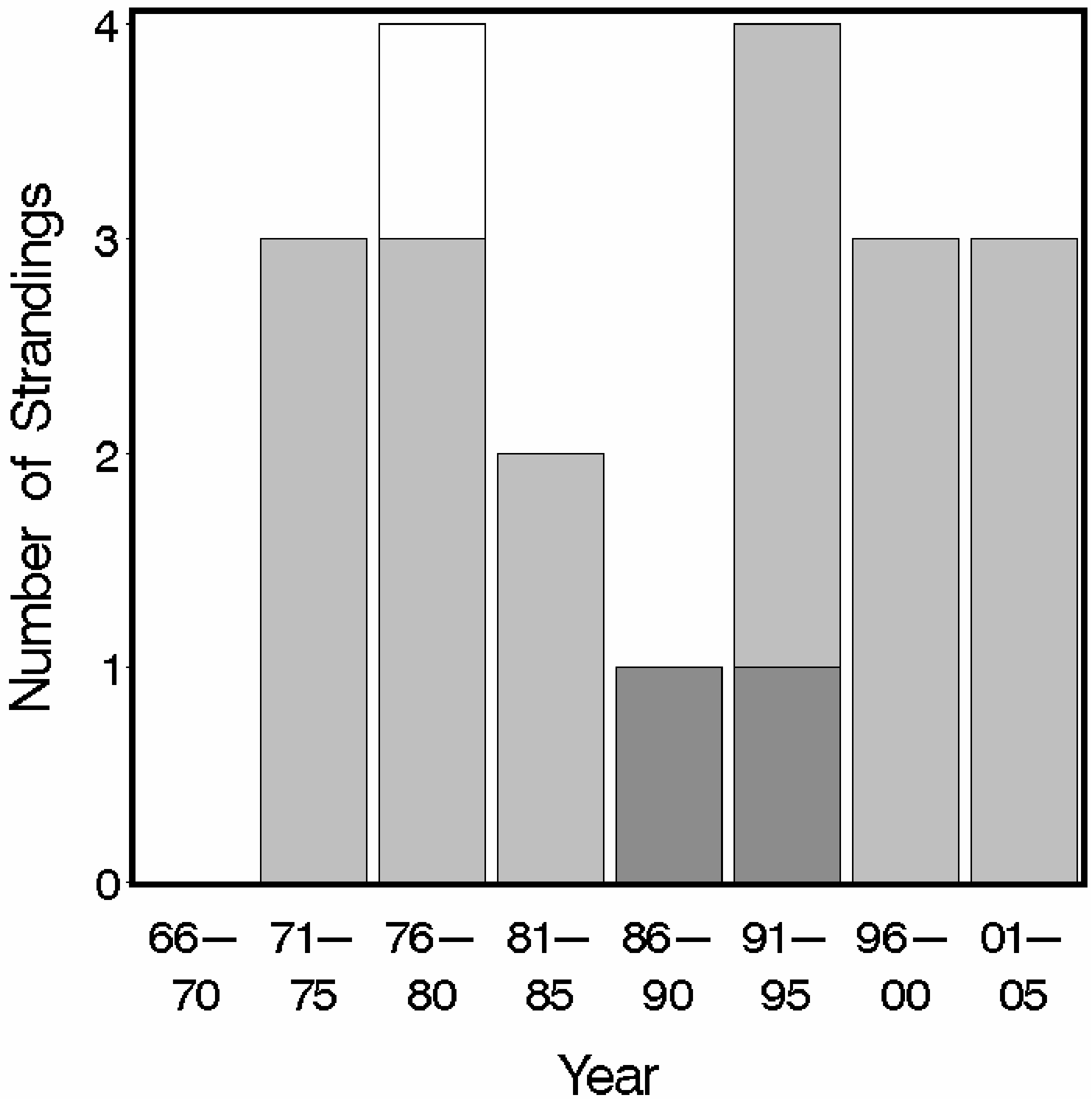

Figure 22. Five-year stranding frequencies for pygmy sperm whales (light gray bars), dwarf sperm whales (dark gray), and unidentified *Kogia* sp. (white) in the Rhode Island study area, 1966–2005.

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 a clump 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