5.0 SURVEY AND MONITORING RESULTS

5.1 AERIAL AND SHIPBOARD SURVEY RESULTS

5.1.1 Aerial Survey Effort

The total aerial survey covered 13,254 km (7,157 NM) of on-effort trackline between February 2008 and June 2009 (**Figure 5-1**). This total includes the 1,039 km (561 NM) of on-effort trackline that was covered during the shoreline surveys to record hauled out seals in February 2008 and January through March 2009. The aerial surveys were scheduled to begin in January 2008; however, poor weather conditions delayed the start of the surveys until February 2008. Aerial surveys were cancelled after the May 2008 plane crash and did not resume until January 2009. The BSS of all the aerial surveys ranged from 0 to 5. Survey days, effort, and BSS ranges are summarized in **Table 5-1**. The total amount of survey effort that met the criteria (i.e., BSS 0 to 5) for the abundance/density analyses for all species or groups except the harbor porpoise was as follows: winter (6,022 km [3,252 NM]), spring (4,038 km [2,180 NM]), and summer (1,927 km [1,040 NM]). No aerial surveys were conducted during the fall.

5.1.2 Shipboard Survey Effort

The total shipboard survey covered 13,123 km (7,086 NM) of on-effort trackline between January 2008 and December 2009 (**Figure 5-2**). The BSS ranged from 0 to 6. Survey effort was usually stopped when conditions reached a BSS of 6; however, effort was continued in some cases when the BSS was shifting between a 5 and 6. The majority of survey effort was conducted in a BSS between 2 and 4. Survey days, effort, and BSS ranges are summarized in **Table 5-2**. The total amount of survey effort that met the criteria (i.e., BSS 0 to 5) for the abundance/density analyses for all species or groups except the harbor porpoise was as follows: winter (3,424 km [1,849 NM]), spring (2,476 km [1,337 NM]), summer (3,629 km [1,960 NM]), and fall (2,546 km [1,375 NM]). The total survey effort included in the harbor porpoise analysis (BSS 0 to 2) for winter abundance/density was 1,056 km (570 NM). Note that there were not enough sightings data to model the abundance/density of this species during the other seasons or from the aerial surveys.

5.1.3 Sightings and Distribution

The following eight species of marine mammals were identified in the Study Area during the study period: North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), minke whale (*Balaenoptera acutorostrata*), fin whale (*B. physalus*), bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), harbor porpoise (*Phocoena phocoena*), and harbor seal (*Phoca vitulina*). All marine mammal species are protected under the Marine Mammal Protection Act (MMPA). North Atlantic right, humpback, and fin whales are listed as endangered under the Endangered Species Act (ESA).

The leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) were the only species of sea turtles identified in the Study Area during the study period. All sea turtles are protected under the ESA; leatherbacks are listed as endangered while loggerheads are currently listed as threatened.

During the aerial and shipboard surveys, a total of 615 sightings were recorded between January 2008 and December 2009 (**Figure 5-3**). A total of 486 of these sightings were recorded while the survey teams were on effort in the Study Area (i.e., observers were actively searching for marine mammals and turtles on the trackline). Seven cetacean species, one pinniped species, and two sea turtle species were sighted in the Study Area. In some cases, the animal(s) in a sighting could not be identified to the species level; therefore, a generalized taxonomic grouping, such as “small cetacean”, was used. The bottlenose dolphin was the most frequently sighted species (319 sightings), and most of these sightings were recorded in the summer months (22 June through 27 September). The loggerhead turtle was the second most frequently sighted species during the survey period and demonstrated a strong seasonal occurrence in the Study

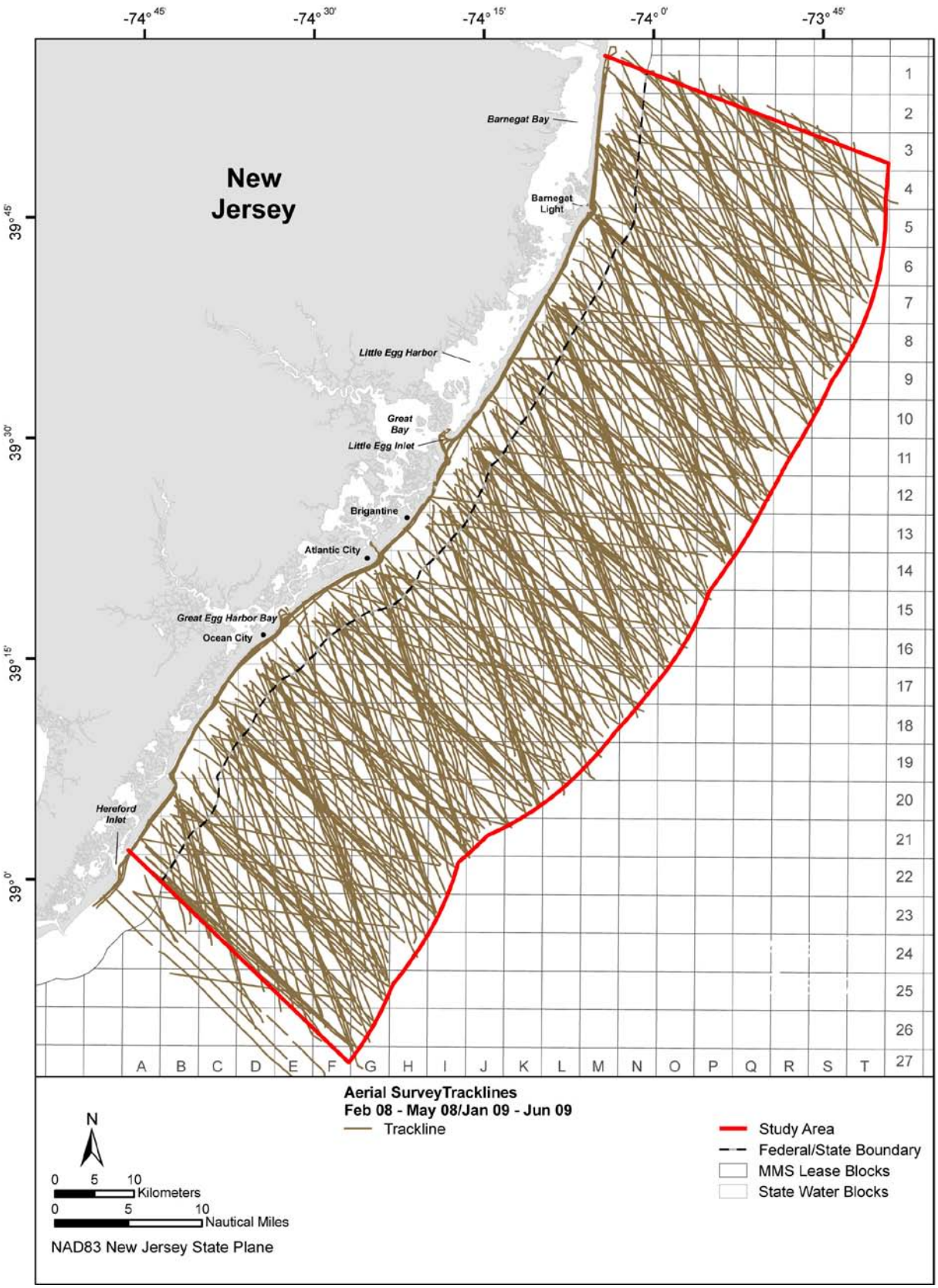

Figure 5-1. Marine mammal and sea turtle aerial survey tracklines in the Study Area for February-April 2008 and January-June 2009.

Table 5-1. Summary of dates, effort, and BSS range for the 2008 and 2009 aerial surveys for marine mammals and sea turtles.

Month	Dates	Survey Effort (km)	BSS Range
2008			
February	2/3-2/4	549	1-3
March	3/3, 3/6	729	2-4
April	4/18	850	0-5
May*	5/15, 5/17	N/A	N/A
2009			
January	1/24-1/26	1,982	1-3
February	2/11, 2/21	2,031	2-5
March	3/18, 3/20-3/21	1,925	1-5
April	4/13, 4/18	1,729	1-5
May	5/23-5/24	1,509	1-5
June	6/23-6/24	1,950	1-3

* The survey plane crashed on May 17; the data collected on May 15 could not be recovered. Aerial surveys did not resume until January 2009.

Area with the vast majority of sightings (67) recorded only during the summer. Three cetacean species – fin whale, humpback whale, and bottlenose dolphin – were sighted during all seasons. The only confirmed pinniped species recorded in the Study Area was the harbor seal; a single individual was sighted from the shipboard survey in June 2008.

Table 5-3 provides a summary of on-effort and off-effort sightings for each species or group. Note that one sighting may consist of one or multiple animals; therefore, the mean group size and range of group sizes for each species and taxonomic group are included in **Table 5-3**. Group size varied greatly among and within species; overall group sizes ranged from one to 112 animals.

More information on the distribution of observed marine mammal and sea turtle species and the sightings recorded during the shipboard and aerial surveys is provided in **Table 5-3**.

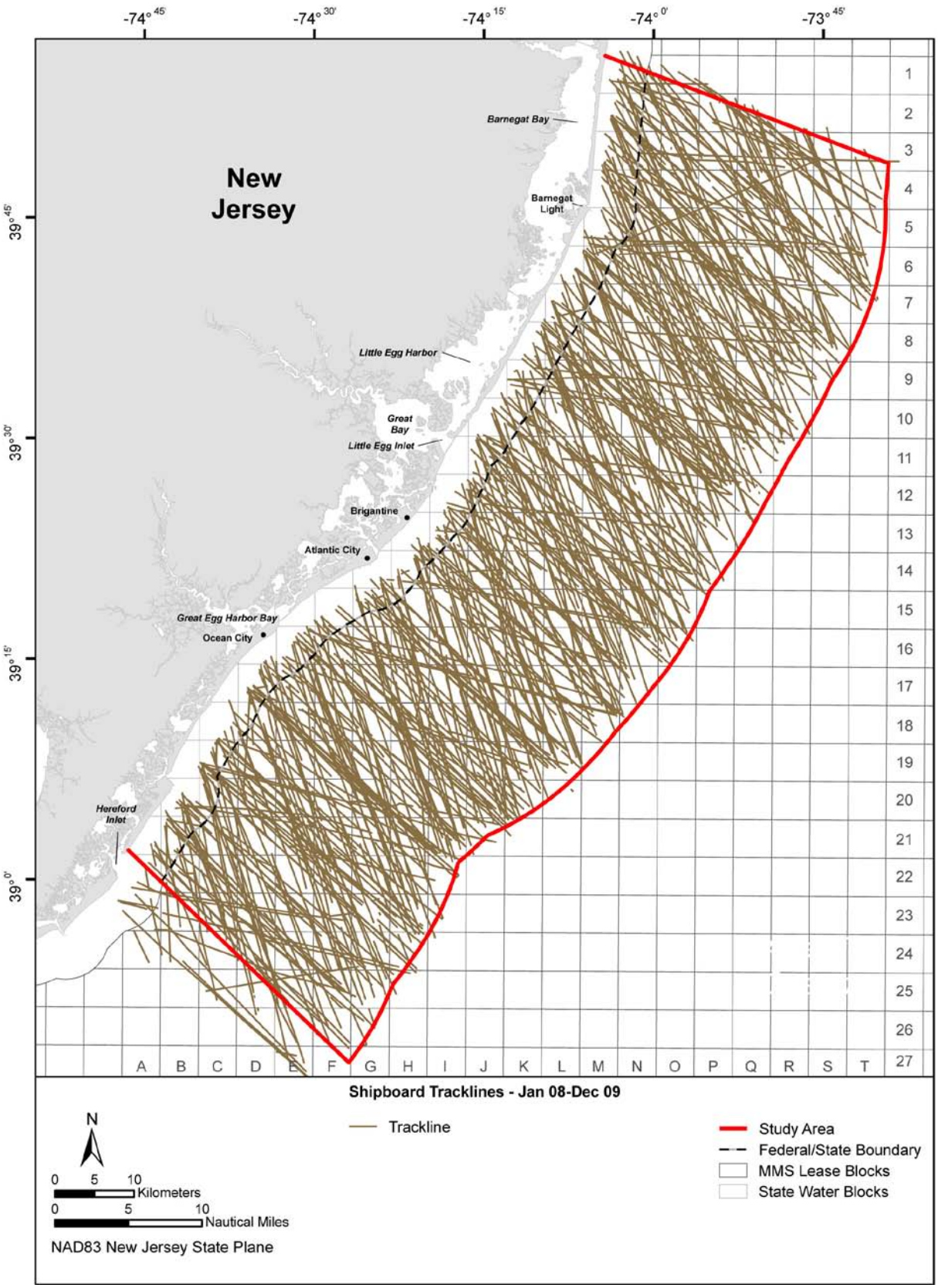

Figure 5-2. Marine mammal and sea turtle shipboard survey tracklines in the Study Area for January 2008-December 2009.

Table 5-2. Summary of dates, effort, and BSS range for the 2008 and 2009 shipboard surveys for marine mammals and sea turtles.

Month	Dates	Survey Effort (km)	BSS Range
2008			
January	1/15-1/18	408	2-6
February	2/12	109	1-4
March	3/7, 3/10-3/14	627	1-6
April	4/9-4/10, 4/12-4/14	501	2-6
May	5/7-5/8, 5/10-5/11	415	2-6
June	6/13-6/16	570	0-5
July	7/13-7/16	711	1-4
August	8/11-8/14	706	1-5
September	9/12-9/16	780	1-5
October	10/13-10/17	794	2-5
November	11/11-11/14, 11/17	479	1-4
December	12/9, 12/13-12/14	348	2-6
2009*			
January	1/6, 1/10, 1/12-1/14	591	1-6
February	2/8-2/11, 2/14-2/16	912	0-6
March	3/11-3/16	837	0-5
April	4/7-4/10	462	1-5
May	5/2-5/6	579	1-5
June	6/2-6/6	583	1-5
August	8/1-8/5	851	0-4
September	8/30-9/3	782	2-6
October	9/28, 9/30-10/2	395	2-6
November	11/19-11/22	516	2-6
December	12/07, 12/12-12/13	166	2-6

* Note that no survey effort was conducted during July 2009.

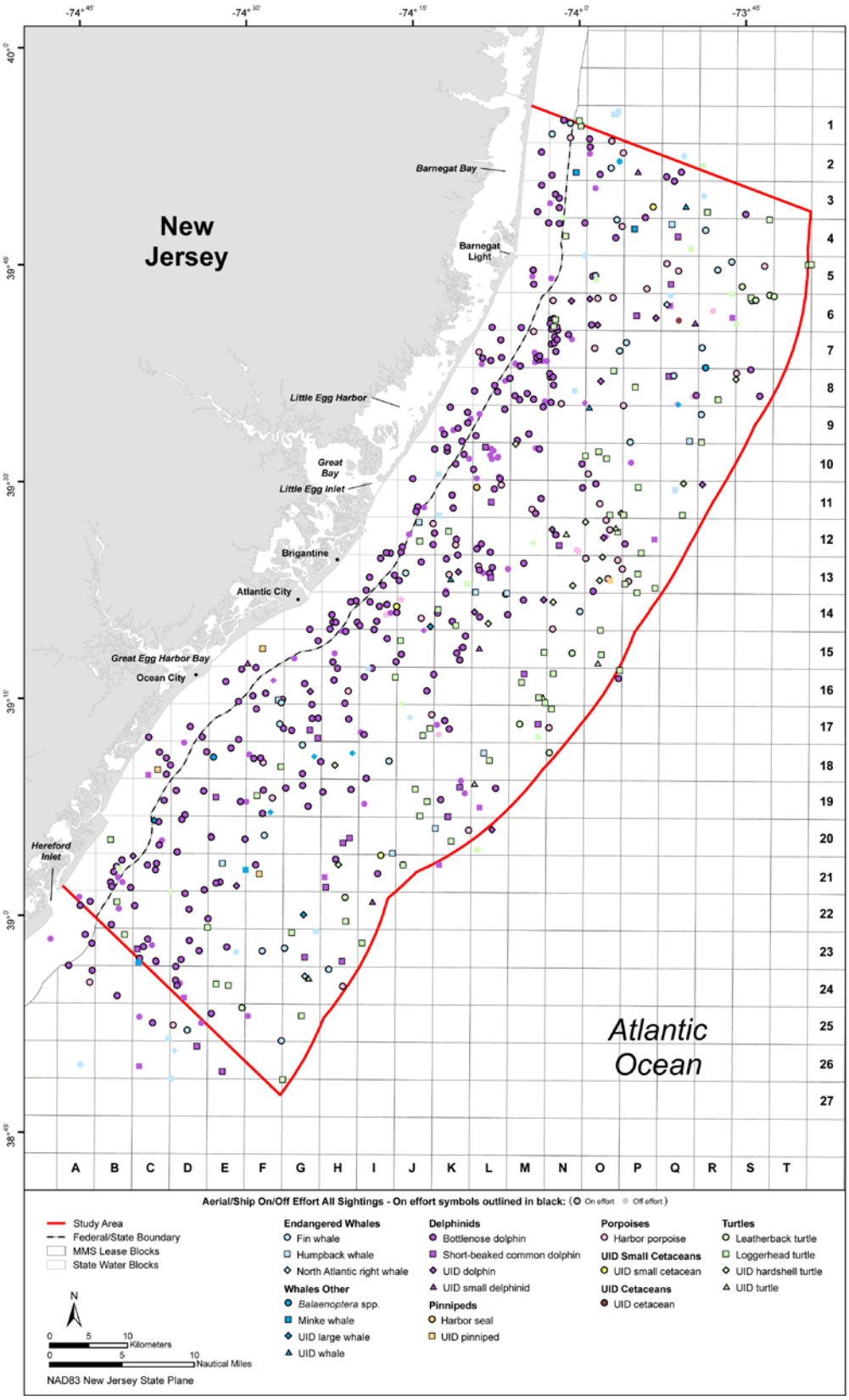

Figure 5-3. Marine mammal and sea turtle sightings (on-effort and off-effort) from shipboard and aerial surveys in the Study Area for January 2008-December 2009.

Table 5-3. Summary of sightings data (combined aerial and shipboard survey data) by species/group. The means and ranges of group size, water depth, distance from shore, and SST are also summarized.

Common Name	Sightings (# of schools)			Group Size (# of animals)		Water Depth (m)		Distance from Shore (km)		SST* (°C)	
	On-effort	Off-effort	Total	Mean	Range	Mean	Range	Mean	Range	Mean	Range
North Atlantic right whale *Eubalaena glacialis*	2	2	4**	1.5	1-2	22.5	17-26	23.7	19.9-31.9	10.0	5.5-12.2
Humpback whale *Megaptera novaeangliae*	10	7	17	1.2	1-2	20.5	12-29	18.4	4.8-33.2	10.1	4.7-19.5
Minke whale *Balaenoptera acutorostrata*	2	2	4	1	1	18	11-24	13.1	6.7-18.5	8.3	5.4-11.5
Fin whale *Balaenoptera physalus*	27	10	37	1.5	1-4	21.5	12-29	20.0	3.1-33.9	9.6	4.2-19.7
Bottlenose dolphin *Tursiops truncatus*	257	62	319	15.3	1-112	16.6	1-34	11.3	0.4-37.7	16.3	4.8-20.3
Short-beaked common dolphin *Delphinus delphis*	23	9	32	12.8	1-65	23.2	10-31	23.5	3.0-37.5	7.1	4.7-12.4
Harbor porpoise *Phocoena phocoena*	42	9	51	1.7	1-4	21.5	12-30	19.5	1.5-36.6	5.8	4.5-18.7
Harbor seal *Phoca vitulina*	1	0	1	1	1	18	18	9.9	9.9	11.4	11.4
Unidentified cetacean	0	1	1	3	3	28	28	22.0	22.0	5.2	5.2
Unidentified small cetacean	3	0	3	1	1	21	14-25	19.5	9.3-32.3	5.3	4.5-6.0
Unidentified dolphin	13	8	21	5	1-20	22.2	12-32	19.4	5.0-37.6	11.2	5.3-19.6
Unidentified small delphinid	5	0	5	2	1-4	22.6	10-29	19.6	3.2-35.3	5.6	5.1-6.4
Balaenoptera spp.	2	1	3	1	1	20.3	17-23	16.2	8.6-27.7	9.6	4.4-18.9

Table 5-3 (*continued*). Summary of sightings data (combined aerial and shipboard survey data) by species/group. The means and ranges of group size, water depth, distance from shore, and SST are also summarized.

Common Name	Sightings (# of schools)			Group Size (# of animals)		Water Depth (m)		Distance from Shore (km)		SST* (°C)	
	On-effort	Off-effort	Total	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Unidentified whale	3	0	3	1	1	22	17-25	17.0	12.7-21.1	13.9	11.3-18.9
Unidentified large whale	3	4	7	1	1	19.4	15-28	18.6	5.8-27.6	8.3	4.7-18.9
Unidentified pinniped	3	1	4	1.3	1-2	16	8-27	14.4	2.8-30.7	6.4	4.9-10.6
Leatherback turtle *Dermochelys coriacea*	9	3	12	1	1	24	18-30	28.6	10.3-36.2	19.0	18.1-20.3
Loggerhead turtle *Caretta caretta*	63	6	69	1.3	1-2	23.5	9-34	24.6	1.5-38.4	18.5	11.0-20.3
Unidentified turtle	6	1	7	1.1	1-2	25.7	16-32	26.5	5.4-34.3	17.6	9.4-20.2
Unidentified hardshell turtle	12	3	15	1	1	22.9	17-30	23.8	11.3-32.6	17.2	5.1-19.6

* SST data were remotely sensed because SSTs could not be recorded during the aerial surveys. See **Section 2.3.1** for more details.

** Two sightings of North Atlantic right whales were recorded close together in both time and space on 12 December 2009. These sightings were originally recorded as two separate sightings and appear as such in the final quarterly report for the NJDEP. Subsequent photo-identification analyses indicate that these sightings were of the same individual North Atlantic right whale. Therefore, the first sighting of this individual is considered the original sighting, and the second sighting is considered a re-sight of the individual and, thus, is not included in this table.

- **North Atlantic Right Whale (*Eubalaena glacialis*)**

Status—North Atlantic right whales are listed as endangered under the ESA (NMFS 2005). The North Atlantic right whales occurring in U.S. waters belong to the western Atlantic stock (Waring et al. 2009). The best available abundance estimate for this stock is 438 catalogued whales believed alive as of 2008; this number does not include individuals that are not in the North Atlantic Right Whale Consortium's (NARWC) photo-identification catalog which is managed by the New England Aquarium (NARWC 2009). In the western North Atlantic, right whales are subject to relatively high levels of injury and mortality from collisions with vessels and entanglement in fishing gear (Knowlton and Kraus 2001; Kraus et al. 2005; Glass et al. 2008).

General Distribution—Right whales are distributed throughout the northern and southern hemispheres in sub-polar to temperate waters (Jefferson et al. 2008). In the western North Atlantic, right whales occur in waters over the continental shelf off the east coast of North America between Florida and Nova Scotia (Winn et al. 1986). Most sightings of this species are recorded in well-known, frequently-used habitat areas, including the coastal waters of Georgia and Florida, within Cape Cod and Massachusetts bays in the northeastern U.S., east of Cape Cod in the Great South Channel, and in Canadian waters in the Bay of Fundy and over the Scotian Shelf (Winn et al. 1986; NMFS 2003). The feeding grounds of Cape Cod Bay, which have the greatest number of individuals from February through April (Hamilton and Mayo 1990; Nichols et al. 2008), and the Great South Channel east of Cape Cod, with most frequent use from April through June (Winn et al. 1986; Kenney et al. 1995), are designated as critical habitat for the North Atlantic right whale under the ESA (NMFS 1994; NMFS 2003). The waters off Georgia and northern Florida are the only known calving ground for North Atlantic right whales in the western North Atlantic basin and are designated critical habitat. North Atlantic right whale use in this area is concentrated from November through March (Winn et al. 1986).

North Atlantic right whales undertake a well-defined, strongly seasonal migration from their northeast habitats south along the U.S. east coast (Winn et al. 1986; Kenney et al. 2001); however, individuals are sighted often in these habitats outside the time of year they might be expected to occur there (Winn et al. 1986; Kenney et al. 2001; NOAA 2008). Aerial surveys conducted from 2004 through 2007 demonstrated that approximately half of the known population of right whales may be found in the Gulf of Maine between November and January (Cole et al. 2009). Calving has also been documented in the mid-Atlantic (i.e., outside of the known grounds off the southeastern U.S.; Pabst et al. 2009; Patrician et al. 2009). Surveys in the southeast Atlantic Bight (Virginia through South Carolina) recorded individuals from December through May, with more than a quarter of these sightings consisting of females with calves (Pabst et al. 2009). Knowlton et al. (2002) analyzed sightings data collected in the mid-Atlantic from northern Georgia to southern New England and found that the majority of right whale sightings occurred within approximately 56 km (30 NM) from shore; however, North Atlantic right whales do range widely; trans-Atlantic migrations of North Atlantic right whales between the eastern U.S. coast and Norway have been documented (Jacobsen et al. 2004), suggesting a possible offshore migration path.

North Atlantic right whales are known to occur off the coast of New Jersey. New Jersey waters are within the known migratory route taken by right whales as they travel between their feeding areas in the north and their breeding/calving grounds off the southeastern U.S. Right whales were detected acoustically during February through May and August through December in the New York Bight just north of the Study Area (Biedron et al. 2009). Previous research efforts have visually recorded right whales in nearshore waters off New Jersey in spring and fall (CETAP 1982). Few sightings near Delaware Bay have been recorded in October, December, May, and July (Knowlton et al. 2002). One satellite-tagged cow and her calf were tracked from the Bay of Fundy to New Jersey and back within a six-week period in September (Knowlton et al. 2002). Another satellite-tagged individual fed in the shelf waters east of the Study Area as it travelled south from the waters off Maine (Bowman et al. 2001). One right whale mortality incident due to entanglement was recorded off the coast of New Jersey in October (Knowlton et al. 2002).

Feeding/Fisheries—North Atlantic right whales feed on zooplankton, primarily copepods of the genus *Calanus* (Kenney et al. 1985; Beardsley et al. 1996; Baumgartner et al. 2007). The particular species upon which they prey may vary between their known primary feeding grounds (i.e., Great South Channel, Bay of Fundy, Cape Cod Bay; Mayo and Marx 1990; Jaquet et al. 2005). The movements and occurrence of right whales on their feeding grounds has been linked to concentrations of prey species (Pendleton et al. 2009). Two male North Atlantic right whales sighted in January, 2009, exhibited feeding behavior in the Study Area, but feeding was not confirmed.

The larvae of many species of fish are known to feed on zooplankton, including copepods. Refer to **Volume IV** for more information.

Baseline Study Occurrence—North Atlantic right whales are known to occur regularly throughout the year in the mid-Atlantic and occur in the Study Area year-round. While many right whales make annual long-distance movements to southern breeding and calving areas, not all individuals leave high latitudes. Right whales were sighted during the study period in all seasons except summer. Four sightings of North Atlantic right whales were recorded during the study period; two of these were off-effort and two were on-effort sightings and all were detected during the shipboard surveys (**Figure 5-4**). Photos were taken of each right whale sighted, and the New England Aquarium was able to match all of the photos to individuals from the NARW catalog. The location, time, date, physical description, and group size of all four right whale sightings were reported to the U.S. Coast Guard and NMFS immediately after the sighting was recorded in order to warn other mariners of the presence of right whales.

Right whales were seen as single animals or in pairs (mean group size=1.5). Sightings occurred in water depths ranging from 17 to 26 m (56 to 85 ft) with a mean value of 22.5 m (73.8 ft). Distances from shore ranged from 19.9 to 31.9 km (10.7 to 17.2 NM) with a mean of 23.7 km (12.8 NM). Right whales were seen in winter, spring, and fall in waters with SST ranging from 5.5 to 12.2 degrees Celsius (°C; 41.9 to 54.0 degrees Fahrenheit [°F]; mean 10.0°C [50.0°F]). Three sightings were recorded during November, December, and January when right whales are known to be on the breeding/calving grounds farther south (Winn et al. 1986) or in the Gulf of Maine (Cole et al. 2009). The November 2008 sighting just south of the Study Area boundary was of an adult female who must have been migrating through the Study Area on her way to the calving grounds because she was sighted in mid-December 2008 off the coast of Florida (Zani, M., New England Aquarium, pers. comm., 14 January 2009). The sighting recorded in December 2009 near the southern boundary of the Study Area (water depth of 25 m/82 ft) was also of a female that was later sighted off the coast of Georgia in early January 2010 (Zani, M., New England Aquarium, pers. comm., 11 January 2010). Initially, two sightings of right whales were recorded close together in both time and space. Subsequent photo-identification analyses indicate that these sightings were of the same individual North Atlantic right whale. Therefore, the first sighting of this individual is considered the original sighting, and the second sighting is considered a re-sight of the individual. The January 2009 sighting was of two adult males; these whales were sighted offshore of Barnegat Light in the northernmost portion of the Study Area. The whales exhibited feeding behavior (i.e., surface skimming with mouths open) in 26 m (85 ft) of water; however, actual feeding could not be confirmed. During May 2008, a cow-calf pair was recorded in waters near the 17 m (56 ft) isobath southeast of Atlantic City. The pair was sighted in the southeast U.S. in January and February prior to the May sighting, and they were sighted in the Bay of Fundy in August (Zani, M., New England Aquarium, pers. comm., 6 January 2010).

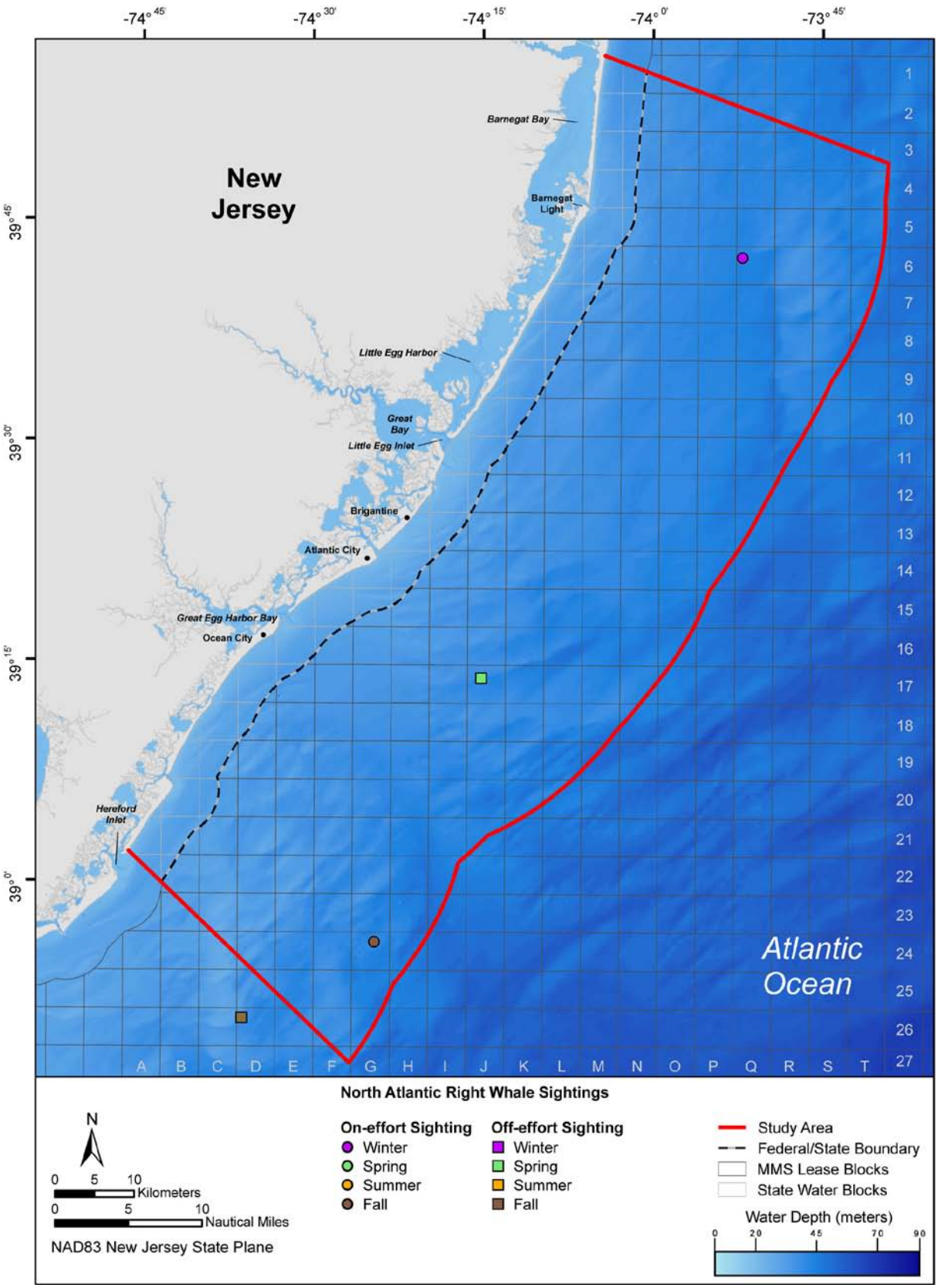

Figure 5-4. On-effort and off-effort sightings of the North Atlantic right whale in the Study Area and vicinity from the shipboard and aerial surveys.

- **Humpback Whale (*Megaptera novaeangliae*)**

Status—Humpback whales are listed as endangered under the ESA (NMFS 1991). Humpback whales occurring in U.S. North Atlantic waters belong primarily to the Gulf of Maine stock, although individuals from Canadian populations have also been sighted in U.S. waters. The best available population estimate for the Gulf of Maine stock is 849 individuals (Waring et al. 2009). An estimated 11,570 humpback whales occur in the entire North Atlantic, including the Gulf of Maine and Canadian stocks (Stevick et al. 2003a).

General Distribution—Humpback whales occur worldwide in all major oceans and most seas and are known to make long-distance, seasonal migrations (Jefferson et al. 2008). Humpback whales in the western North Atlantic are widely distributed and their occurrence is strongly seasonal. During spring and summer in U.S. waters, the largest numbers of humpback whales are found off the northeast and mid-Atlantic coasts (CETAP 1982; Whitehead 1982; Kenney and Winn 1986; Weinrich et al. 1997; Hamazaki 2002; Stevick et al. 2008). During the winter, many individuals migrate to calving grounds in the West Indies (Dawbin 1966; Whitehead and Moore 1982; Smith et al. 1999; Stevick et al. 2003b); however, significant numbers of humpbacks have been found at mid- and high latitudes during this time, suggesting that not all individuals in this stock undergo a seasonal migration (Dawbin 1966; Clapham et al. 1993; Swingle et al. 1993; Charif et al. 2001; Clapham 2009). Winter sightings of humpback whales, including juveniles, along the U.S. Atlantic coast from Florida to Virginia suggest that this area may be a supplemental winter feeding ground (Clapham et al. 1993; Swingle et al. 1993; Wiley et al. 1995; Laerm et al. 1997; Barco et al. 2002).

Humpback whales are known to occur throughout the mid-Atlantic, including in New Jersey waters. There are sightings of this species over the continental shelf within the Study Area (particularly during summer) and documented strandings from the coast of New Jersey (Barco et al. 2002). Humpbacks are known to feed in the Study Area and juveniles feed regularly during the summer off the coast of Virginia near the mouth of the Chesapeake Bay just south of the Study Area (Swingle et al. 1993). Humpback whales have been detected acoustically just north of the Study Area in the New York Bight south of Long Island, New York (Biedron et al. 2009).

Feeding/Fisheries—The prey species of humpback whales include euphausiids (krill) and small fishes such as herring (Clupeidae), sand lance (*Ammodyties* spp.), anchovies (Engraulidae), and capelin (*Mallotus villosus*; Clapham and Mead 1999). Prey species and foraging tactics may vary depending on geographic location (Clapham and Mead 1999; Hazen et al. 2009). A humpback whale sighted in the Study Area in September 2008 exhibited lunge-feeding behavior.

The larvae of many species of fish found in the Study Area are known to feed on zooplankton, including euphausiids. Capelin, and species of herring, mackerel (Scombridae), sand lance, and anchovies occur in the Study Area. In addition to being the known prey species of humpback whales, these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., black sea bass [*Centropristis striata*], monkfish/goosefish [*Lophius americanus*], and bluefin tuna [*Thunnus thynnus*]).

Prey species of humpback whales are also targeted by commercial fisheries in the Study Area. For example, Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) were two of the five most landed species in New Jersey between 2003 and 2007 in terms of total tonnage. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Humpback whales are known to occur regularly throughout the year in the mid-Atlantic and may occur in the Study Area year-round. Seventeen sightings of humpback whales were recorded during the study period; seven of these were off-effort and 10 were on-effort (**Figure 5-5**). Humpback whales were sighted during all seasons; the majority of sightings (nine) were recorded during winter. Humpback whales were sighted as single animals or in pairs (mean group size=1.2). Distance from shore ranged from 4.8 to 33.2 km (2.6 to 18.0 NM; mean=18.4 km/9.9 NM). In mid-September 2008, a mixed species aggregation of a fin and humpback whale was recorded

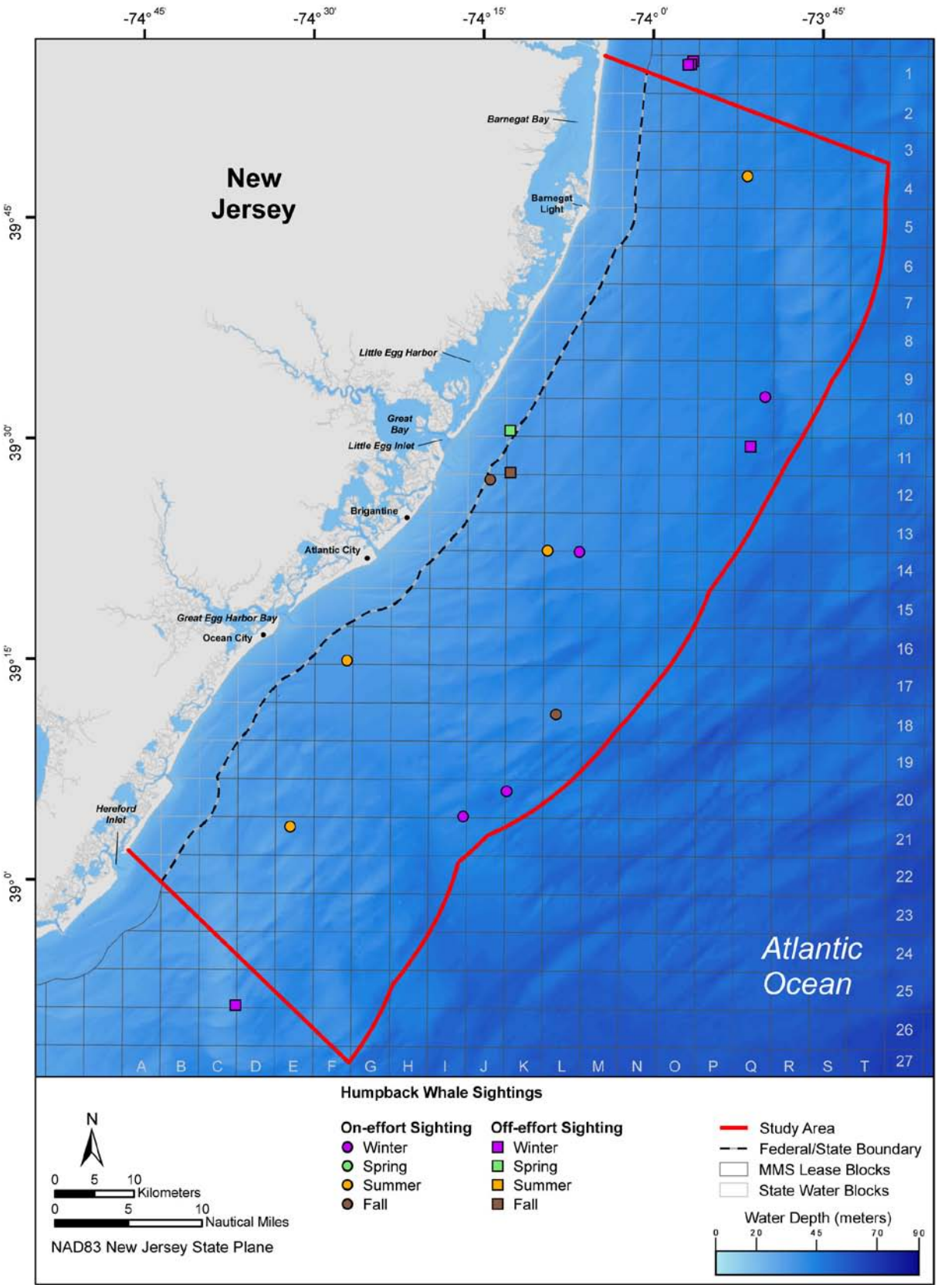

Figure 5-5. On-effort and off-effort sightings of the humpback whale in the Study Area from the shipboard and aerial surveys.

south of Atlantic City. The humpback whale was observed lunge feeding in the vicinity of the fin whale; the water depth of this sighting was 15 m (49 ft). Humpback whale sightings occurred at water depths ranging from 12 to 29 m (39 to 95 ft) with a mean depth of 20.5 m (67.3 ft). This species was sighted in waters with SST ranging from 4.7°C to 19.5°C (40.5 to 67.1°F; mean 10.1°C [50.2°F]). A cow-calf pair was recorded in February 2008 just north of the Study Area boundary in 20 m (66 ft) of water. This was the only sighting of a calf during the study period. Breaching behavior was observed during two sightings; the first was in May 2009 and the second was in October 2009. During the study period, photographs were taken whenever possible for photo-identification purposes. These photographs were compared to the College of the Atlantic's North Atlantic Humpback Whale Catalog. One individual sighted in the Study Area August 2009 was matched to the catalog and last observed in the Gulf of Maine in 2008 (Weinrich, M., Whale Center of New England, pers. comm., 11 January 2010).

- **Minke Whale (*Balaenoptera acutorostrata*)**

Status—Minke whales occurring in U.S. North Atlantic waters belong to the Canadian east coast stock. The best available population estimate for this stock is 3,312 individuals (Waring et al. 2009).

General Distribution—Minke whales have a worldwide distribution in polar, temperate, and tropical regions (Jefferson et al. 2008), though they are less common in the tropics than in temperate and polar regions. Minke whales are known to occur in shelf waters and in deep offshore waters of the North Atlantic (Slijper et al. 1964; Horwood 1990; Mitchell 1991; Nieukirk et al. 2004). Along the U.S. east coast, minke whales are sighted regularly off New England and in the mid-Atlantic, primarily over the continental shelf (Schmidly 1981; Hamazaki 2002; Calambokidis et al. 2004; Waring et al. 2009). Minke whale distribution in the western North Atlantic appears to be seasonal. Previous studies have noted that the number of minke whales present in New England waters peaks from July to September and decreases from fall into winter when visual and acoustic detections suggest that minke whales are largely absent (Murphy 1995; Risch et al. 2009; Waring et al. 2009). It is thought that many individuals from the Canadian east coast stock disperse from their spring and summer center of distribution in the Gulf of Maine. They appear to move offshore and southward in winter (November through March) where they are known to occur in the western North Atlantic from Bermuda to the West Indies (Mitchell 1991; Mellinger et al. 2000).

Minke whales occur throughout the mid-Atlantic and are documented over New Jersey's continental shelf and in surrounding waters (Schwartz 1962; Mead 1975; Potter 1979; Rowlett 1980; Potter 1984; Winn et al. 1985; DoN 2005). There are several known sightings of minke whales within the Study Area, including an opportunistic sighting in the winter of 1987 (Canadian Wildlife Service 2006). Minke whales have been detected acoustically in the New York Bight just north of the Study Area during winter (February through May) and late summer/fall (August through December; Biedron et al. 2009). Strandings of this species have been recorded along the coast of New Jersey, and a juvenile individual was sighted in New York Harbor just north of the Study Area in April 2007 (Hamazaki 2002).[4] Minke whales are most likely to occur in nearshore waters off New Jersey based on known habitat associations and predictive habitat models (Hamazaki 2002).

Feeding/Fisheries—Minke whales are opportunistic feeders so their prey species varies depending on what species are available in the area (Lindstrøm and Haug 2001). Along the U.S. and Canadian east coast, minke whales feed on zooplankton, including copepods and euphausiids, as well as schooling fishes such as capelin and species of sand lance, herring, and mackerel (Kenney et al. 1985; Horwood 1990).

The larvae of many species of fish found in the Study Area are known to feed on zooplankton, including euphausiids and copepods. Capelin and species of herring, mackerel, and sand lance occur in the Study Area. In addition to being the known prey species of minke whales, these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., black sea bass, monkfish/goosefish, and bluefin tuna.

Prey species of minke whales are also targeted by commercial fisheries in the Study Area. For example, Atlantic herring and Atlantic mackerel were two of the most landed species in New Jersey between 2003 and 2007 in terms of total tonnage. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Minke whales are most likely to occur in the mid-Atlantic region during winter, but this species is widespread in U.S. waters and may occur in the Study Area year-round. Four sightings of minke whales were recorded during the survey period; two of these were on-effort and two were off-effort (**Figure 5-6**). All sightings were of single individuals. Sightings of minke whales occurred during the winter and spring in water depths ranging from 11 to 24 m (36 to 79 ft) with a mean depth of 18 m (59 ft). SSTs associated with the minke whale sightings ranged from 5.4 to 11.5°C (41.7 to 52.7°F) with a mean of 8.3°C (47.0°F). The winter sightings were recorded in February in the northern portion of the Study Area northeast of Barnegat Light. The two spring sightings were recorded in June in the southern portion of the Study Area southeast of Sea Isle City and northeast of Wildwood. Minke whales were sighted within 6.7 and 18.5 km (3.6 and 10.0 NM) from shore with a mean distance of 13.1 km (7.1 NM).

- **Fin Whale (*Balaenoptera physalus*)**

Status—Fin whales are listed as endangered under the ESA (NMFS 2006). Fin whales occurring in U.S. North Atlantic waters are part of the western North Atlantic stock. The best available population estimate for this stock is 2,269 individuals (Waring et al. 2009).

General Distribution—Fin whales occur throughout the world in continental shelf and offshore waters (Jefferson et al. 2008). Along the U.S. east coast, fin whales are more common north of North Carolina (about 30ºN) than at subtropical and tropical latitudes (NMFS 1998). Fin whales are the most commonly sighted large whale in shelf waters of the U.S. and Canadian east coast, north of the mid-Atlantic region (CETAP 1982; Hain et al. 1992; Hamazaki 2002). Fin whales also are detected regularly by hydrophone arrays in the upper North Atlantic (Clark 1995; Boisseau et al. 2008).

Movement patterns and seasonality of fin whales in the western North Atlantic are poorly understood. Many individuals follow a traditional migration pattern, moving southward in the fall and northward in the spring (Clark 1995; Aguilar 2009). Acoustic detections indicate an offshore presence of fin whales during the winter (Clark 1995). Many individuals may move to lower latitudes south of Bermuda to the West Indies during winter, but it is certain that not all individuals in the western North Atlantic stock undergo this seasonal migration (Aguilar 2009). Sightings of fin whales are documented from all seasons in the mid-Atlantic region north to the Gulf of Maine (CETAP 1982; Hain et al. 1992).

Fin whales are sighted commonly in continental shelf waters throughout the mid-Atlantic and northeast. There are numerous sightings of this species in the Study Area and vicinity. Fin whales have been sighted or detected acoustically on New Jersey's continental shelf during all seasons (CETAP 1982; DoN 2005; Turgut and Lefler 2006). Fin whales were also recently detected acoustically north of the Study Area in the New York Bight on all recording days during winter/spring (February through May) and summer/fall (August through December) hydrophone deployments south of Long Island, New York (Biedron et al. 2009). There are several documented strandings of fin whales on the New Jersey coast north of and adjacent to the Study Area. These include one stranding each in July[5] and August[6] 2008 north of the Study Area and a dead fin whale found floating in the Delaware River in April 1996.[7] Habitat prediction models demonstrate that preferred fin whale habitat in the mid-Atlantic includes the nearshore and shelf waters from south of the Chesapeake Bay north to the Gulf of Maine, including all of the Study Area (Hamazaki 2002).

Feeding/Fisheries—Fin whales are known to feed on schooling fishes, particularly capelin and species of herring and sand lance. They also are known to feed on squid and zooplankton, such as euphausiids and copepods (Kenney et al. 1985; NMFS 2006).

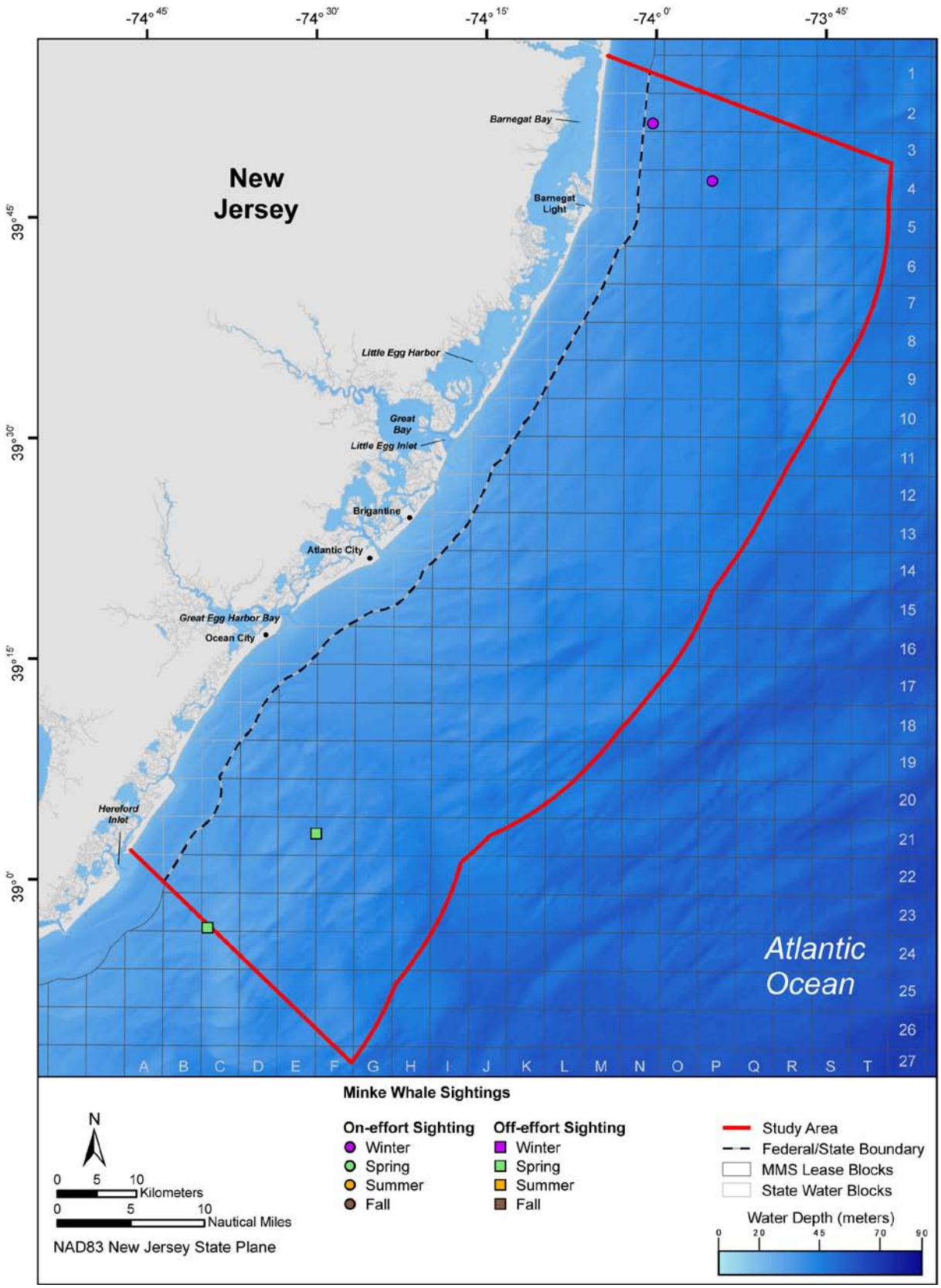

Figure 5-6. On-effort and off-effort sightings of the minke whale in the Study Area from the shipboard and aerial surveys.

The larvae of many species of fish found in the Study Area are known to feed on zooplankton, including euphausiids and copepods. Capelin and species of herring and sand lance occur in the Study Area. In addition to being the known prey species of fin whales, these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., black sea bass, monkfish/goosefish, and bluefin tuna).

Prey species of fin whales are also targeted by commercial fisheries in the Study Area. For example squid represented the sixth most valuable fishery in New Jersey between 2003 and 2007. Atlantic herring and Atlantic mackerel were two of the most landed species in New Jersey between 2003 and 2007 in terms of total tonnage. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Fin whales are common in U.S. mid-Atlantic waters and may occur in the Study Area year-round. Fin whales were the most frequently sighted large whale species during the survey period. There were a total of 37 fin whale sightings; the majority of these (27) were recorded on effort (**Figure 5-7**). Fin whale group size ranged from one to four animals (mean group size=1.5). Water depth for fin whale sightings ranged from 12 to 29 m (39 to 95 ft) with a mean depth of 21.5 m (70.5 ft). SSTs for these sightings ranged from 4.2 to 19.7°C (39.6 to 67.5°F) with a mean temperature of 9.6°C (49.3°F). Fin whales were sighted between 3.1 and 33.9 km (1.7 and 18.3 NM) from shore with a mean distance of 20.0 km (10.8 NM).

Fin whales were sighted during all seasons. Twenty-six sightings were recorded throughout the Study Area during the 2008 surveys. Most of these sightings were recorded during the winter and summer. One mixed-species aggregation of a fin and humpback whale was observed in September. While the humpback whale was lunge feeding, the fin whale surfaced multi-directionally but did not appear to be feeding. One calf was observed with an adult fin whale in August 2008. During the 2009 surveys, fin whales were again the most frequently sighted baleen whale species and were seen in every season except summer for a total of 11 sightings. Attempts were made to photograph all the fin whales sighted during the surveys. These photographs were compared to the North Atlantic Finback Whale Catalogue managed by Allied Whale for possible matches but no matches have been made to date.

- **Bottlenose Dolphin (*Tursiops truncatus*)**

Status—Bottlenose dolphins occurring in U.S. North Atlantic waters belong to multiple, genetically-distinct stocks (Hohn and Hansen 2009; Rosel et al. 2009; Waring et al. 2009). Bottlenose dolphins found in the Study Area or vicinity occur in two distinct stocks: the western North Atlantic offshore stock and the coastal northern migratory stock (Hohn and Hansen 2009; Waring et al. 2009). There are an estimated 70,775 individuals in the offshore stock and 7,789 individuals in the coastal northern migratory stock (Waring et al. 2009).

General Distribution—Individuals of the genus *Tursiops* occur worldwide in tropical and temperate waters. Their distribution is, with a few exceptions, limited to latitudes lower than about 45º (Jefferson et al. 2008). Bottlenose dolphins are found as far north as Nova Scotia in the western North Atlantic. They are distributed continuously southward as far as Venezuela and Brazil (Wells and Scott 1999). Bottlenose dolphins occur seasonally in estuaries and bays as far north as Delaware Bay (Kenney 1990) and in waters over the continental shelf and upper slope as far north as Georges Bank (CETAP 1982; Kenney 1990).

Off the U.S. east coast, the distribution of bottlenose dolphins varies amongst stocks. Although sympatric in U.S. shelf waters during part of the year, the two stocks that occur in the vicinity of the Study Area have differing habitat preferences that result in a dichotomous temporal and spatial distribution offshore of New Jersey. Individuals belonging to the offshore stock are distributed primarily along the outer continental shelf and continental slope (CETAP 1982; Kenney 1990; Garrison et al. 2003; Waring et al. 2009), although offshore individuals have been noted close to shore in some areas (Wiley et al. 1994; Garrison et al. 2003; Waring et al. 2009). The offshore stock occurs from as far north as Georges Bank south to Florida. The coastal northern migratory stock has a seasonal distribution in waters from Long Island, New York to Cape Lookout, North Carolina in the

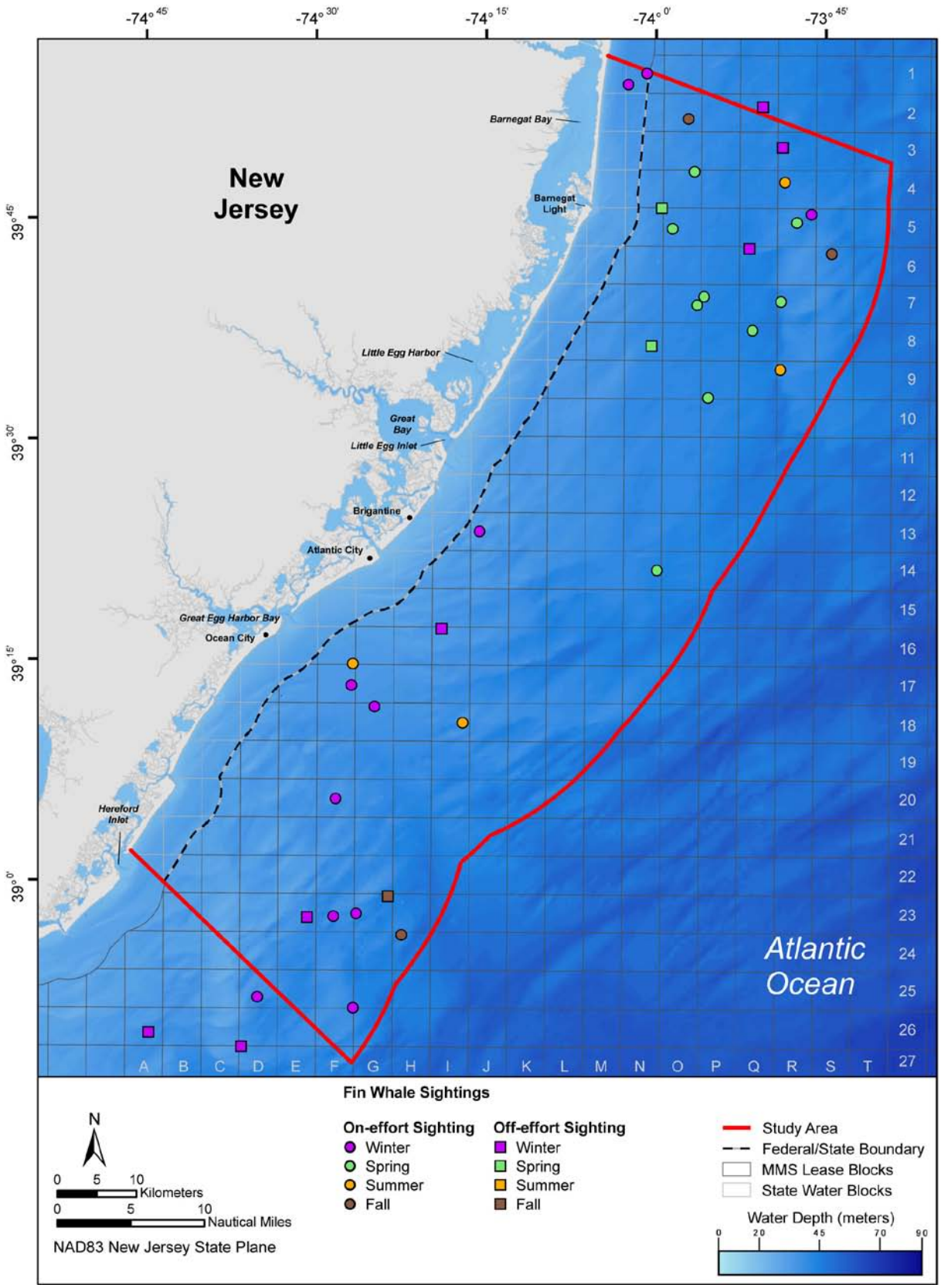

Figure 5-7. On-effort and off-effort sightings of the fin whale in the Study Area and vicinity from the shipboard and aerial surveys.

summer and from southern Virginia to Cape Lookout during the winter (CETAP 1982; Kenney 1990; Garrison et al. 2003; Hohn and Hansen 2009; Waring et al. 2009; Toth et al. in press). This stock does not appear to move south of North Carolina (Urian et al. 1999; NMFS-SEFSC 2001).

New Jersey and Long Island, New York represent the northernmost range of coastal bottlenose dolphins in U.S. waters, with the exception of a possible extralimital occurrence of two individuals in Cape Cod Bay in 1992 (Wang et al. 1994; Wiley et al. 1994; Toth et al. in press). This species has been documented in New Jersey from the 19th century (True 1885) and is sighted consistently both along the shore and farther offshore over the continental shelf and slope (CETAP 1982; Palka 2001; Hamazaki 2002). The bottlenose dolphins that occur off the coast of New Jersey are migratory, spending the summer and fall months (primarily May through October) off New Jersey (Toth et al. in press) and higher latitudes and moving southward during the winter and spring to waters off Virginia and North Carolina. In New Jersey waters, this seasonal occurrence is probably due to the presence of preferred prey species that also occur in the region seasonally (Able and Fahay 1998; Gannon and Waples 2004); however, not all bottlenose dolphins leave New Jersey waters during the colder months. There are documented sightings of bottlenose dolphins in the Study Area from all seasons, several of which occurred during winter (December and January; CETAP 1982). In summer 2008, a group of bottlenose dolphins traveled into the Shrewsbury and Navesink rivers[8] and remained there into the winter months.[9] In February 2010, a group of 8 to 15 animals, most likely bottlenose dolphins, was spotted in the Hackensack River far inland in northern New Jersey.[10]

Bottlenose dolphins appear to have a fine-scale distribution within the Study Area. Toth-Brown et al. (2007) documented a significant break in the habitat usage of bottlenose dolphins in New Jersey's nearshore waters (out to 6 km [3.2 NM] from shore), with one group using the waters within 2 km (1.1 NM) of the shore and the other occupying waters outside of 2 km (1.1 NM) of shore with very little overlap between the two groups. In general, bottlenose dolphins off New Jersey are not often found in estuarine habitats, but they are found in Delaware Bay off the southern end of New Jersey (Toth et al. in press). Despite the strong seasonal occurrence of individuals in New Jersey waters, photo-identification of coastal bottlenose dolphins have shown individual fidelity to specific areas both within and between years (Toth et al. in press). Toth et al. (in press) also identified higher levels of use and increased presence of young individuals in the very nearshore waters off Brigantine just north of Atlantic City, New Jersey.

Feeding/Fisheries—The presence of bottlenose dolphins along the east coasts of the U.S. has been linked to the presence of prey species (Barros and Odell 1990; Gannon and Waples 2004; Torres et al. 2005; Torres et al. 2008). Primary prey species for bottlenose dolphins can vary by area, season, and stock but is dominated by sciaenid fishes (e.g., Atlantic croaker [*Micropogonias undulates*], weakfish [*Cynoscion regalis*], spot [*Leiostomus xanthurus*]), squid (such as longfin inshore squid [*Loligo pealei*]), and shrimp (Barros and Odell 1990; Shane 1990; Wells and Scott 1999; Gannon and Waples 2004). Sciaenid fishes make seasonal movements into New Jersey waters in the spring (March and April) and may be found along the coast primarily during the summer months (June through August; Able and Fahay 1998). The vast majority of bottlenose dolphin sightings recorded during the environmental baseline study surveys occurred during the spring and summer months; this pattern is consistent with other studies that suggest that bottlenose dolphins and their primary prey species co-occur in New Jersey coastal waters during the spring and summer (Gannon and Waples 2004).

Sciaenid fishes (croaker, weakfish, and spot) and squids occur in the Study Area. In addition to being the known prey species of bottlenose dolphins, these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., Atlantic angel shark [*Squatina dumeril*], sand tiger shark [*Carcharias taurus*], and clearnose skate [*Raja eglanteria*]).

Many of the species that are known prey for bottlenose dolphins are targeted by commercial fisheries (Friedlaender et al. 2001), including fisheries operating in the Study Area. Trawl fisheries in the Study Area target several of the sciaenid fishes (Atlantic croaker, weakfish, and spot) and squid. These species are included in the ten most dominant species collected by the New Jersey Ocean Stock

Assessment (OSA) Program between 2003 and 2008 (NJDEP 2009). Bottlenose dolphins are known to interact with fishing gear and have been known to depredate fishing nets and to feed in the vicinity of shrimp trawlers (Fertl and Leatherwood 1997; Read et al. 2003; Zollet and Read 2006; Garrison 2007). Refer to **Volume IV** for more information.

Baseline Study Occurrence—Bottlenose dolphins may occur in the Study Area during any time of year. Bottlenose dolphins were the most frequently sighted species during the study period. A total of 319 bottlenose dolphin sightings were recorded; the majority of sightings (257) were on-effort (**Figure 5-8**). Although large groups of bottlenose dolphins were occasionally sighted (maximum group size=112), the mean group size of 15.3 animals is consistent with the typical group size of coastal bottlenose dolphins (Shane et al. 1986; Kerr et al. 2005). The presence of calves was confirmed in 24% of all sightings. The mean (16.6 m [54.5 ft]) and minimum water depth (1 m [3 ft]) for bottlenose dolphins were the most shallow of all identified cetacean species sighted during the survey and are indicative of bottlenose dolphins' primarily coastal distribution within New Jersey waters (see Toth et al. 2007; in press); however, a bottlenose dolphin sighting represents the deepest water depth at which a cetacean sighting was recorded during this study (34 m [112] ft), suggesting that their distribution within the Study Area is not limited to a particular depth or depth range. Bottlenose dolphin sightings ranged from 0.4 to 37.7 km (0.2 to 20.4 NM) from shore (mean=11.3 km/6.1 NM) which further supports this species' nearshore distribution in the Study Area but is also indicative of occurrence farther offshore in the Study Area. SSTs for bottlenose dolphins ranged from 4.8 to 20.3°C (40.6 to 68.5°F) with a mean of 16.3°C (61.3°F). The mean and maximum SST values represent the highest temperatures for all cetacean sightings; this supports the strong seasonality associated with bottlenose dolphin occurrence in the Study Area.

This species was sighted during all seasons; bottlenose dolphins were sighted as early as the beginning of March (winter), but the vast majority of sightings occurred during the spring and summer. The latest fall sighting of a bottlenose dolphin during the surveys was October; however, this species was sighted offshore of Ocean City, Maryland in November 2008 (J. Brandon and T. Ninke personal observation), 65 km (35 NM) from the southern boundary of the Study Area, indicating that bottlenose dolphins are present in the vicinity of the Study Area during late fall.

Attempts were made to photograph the dorsal fins of all individuals that were in camera range; however, the dorsal fins of many of the photographed individuals were at least partially covered with the barnacle *Xenobalanus globicipitis* which can make photo-based mark-recapture more difficult. Unfortunately, none of the photographs taken were of acceptable quality to be matched to the photographs taken during nearshore surveys of bottlenose dolphins off New Jersey between 2003 and 2005 (Toth et al. in press).

During the baseline study period, opportunistic sightings of marine mammals in the Study Area were recorded during monitoring efforts and avian surveys. Several monitoring efforts were conducted in the potential windfarm sites southeast of Atlantic City (GMI 2009a; GMI 2009b). These efforts were not dedicated marine mammal/sea turtle surveys; however, sightings of these animal groups were recorded during geophysical surveys. Experienced marine mammal observers recorded a sighting of two bottlenose dolphins during the geophysical surveys in August 2009 (GMI 2009b). Additional opportunistic sightings of bottlenose dolphins were recorded in the summer months during the coastal avian boat surveys which were part of this baseline study.

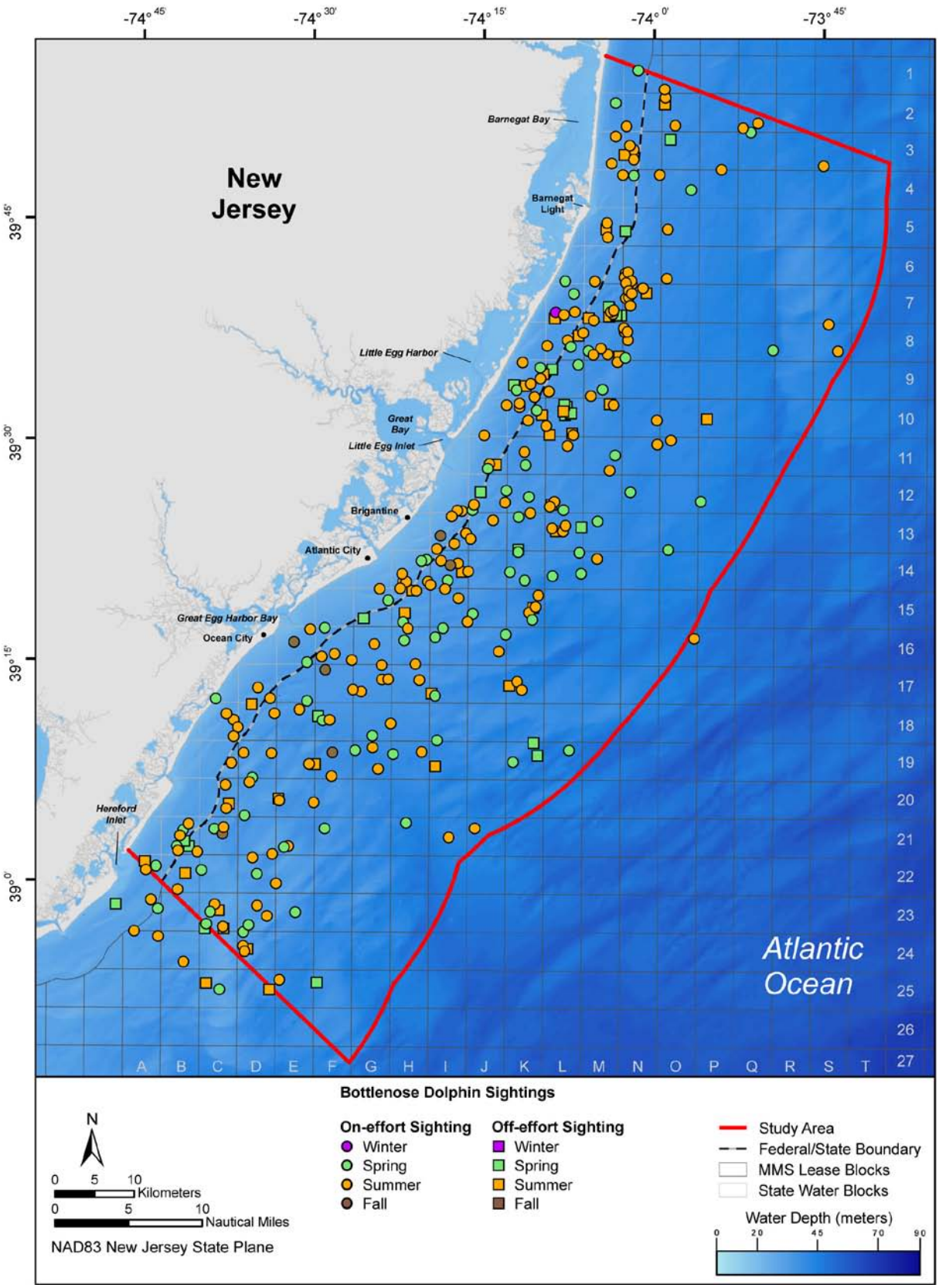

Figure 5-8. On-effort and off-effort sightings of the bottlenose dolphin in the Study Area and vicinity from the shipboard and aerial surveys.

- **Short-beaked Common Dolphin (*Delphinus delphis*)**

Status—Common dolphins occurring in U.S. North Atlantic waters are short-beaked common dolphins (Jefferson et al. 2009) that belong to the western North Atlantic stock. The best estimate of abundance for this stock is 120,743 individuals (Waring et al. 2009).

General Distribution—Common dolphins (*Delphinus* spp.) are distributed globally in temperate, subtropical, and tropical waters. In the North Atlantic, short-beaked common dolphins occur from southern Norway to West Africa in the eastern Atlantic and from Newfoundland to Florida in the western Atlantic (Perrin 2009), although this species more commonly occurs in cold-temperate waters in the western North Atlantic (Waring and Palka 2002; Jefferson et al. 2009).

Selzer and Payne (1988) described the distribution of short-beaked common dolphins along the northeastern U.S. This study noted the presence of short-beaked common dolphins in waters over the continental slope north of 35ºN to the northeast edge of Georges Bank (east of Cape Cod, Massachusetts). There is strong seasonality to short-beaked common dolphin distribution in the western North Atlantic, with sightings occurring primarily along the continental shelf break south of 40ºN in spring and north of this latitude in fall. During fall, this species is particularly abundant along the northern edge of Georges Bank (CETAP 1982) but less common south of Cape Hatteras (Gaskin 1992b). A recent review of short-beaked common dolphin distribution along the U.S. east coast showed that they occur primarily from Cape Hatteras, North Carolina to Canada and show a preference for waters ranging from 200 m to 2,000 m (656 to 6,562 ft) in depth (Jefferson et al. 2009); however, short-beaked common dolphins are known to occur in shallower waters offshore of the mid-Atlantic, including New Jersey waters, with their distribution in this area concentrated in the colder months (November through March; Payne et al. 1984; Waring et al. 2009).

Short-beaked common dolphins are known to occur within the Study Area and vicinity. There have been multiple sightings and strandings of this species along the New Jersey and Long Island, New York coasts (Ulmer 1981; Hamazaki 2002).[11] Sightings of this species from previous surveys were recorded in February, May, and July just east and north of the Study Area (CETAP 1982; Canadian Wildlife Service 2006). Sightings of short-beaked common dolphins tend to occur offshore (>37 km [20 NM]) in the vicinity of the shelf break (Ulmer 1981; CETAP 1982; Canadian Wildlife Service 2006). There are multiple strandings of short-beaked common dolphins along the New Jersey coast adjacent to the Study Area from all seasons (NOAA/NMFS 2004). Predictive habitat modeling of the waters of the western North Atlantic suggests that short-beaked common dolphins will occur over the shelf and at the shelf break in the vicinity of the Study Area (Hamazaki 2002).

Feeding/Fisheries—Prey species of short-beaked common dolphins include squid, herring, whiting/silver hake (*Merluccius bilinearis*), anchovies, and other species of schooling fishes (Waring et al. 1990; Overholtz and Waring 1991). In the waters of the northeast U.S., they are known to feed on longfin inshore squid) and Atlantic mackerel (Overholtz and Waring 1991).

Clupeid species (e.g., herring) and squid occur in the Study Area. In addition to being the known prey species of short-beaked common dolphin, these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., black sea bass, monkfish/goosefish, and winter skate [*Leucoraja ocellata*]).

Prey species of short-beaked common dolphins are also targeted by commercial fisheries in the Study Area. For example squid represented the sixth most valuable fishery in New Jersey between 2003 and 2007. Atlantic herring and Atlantic mackerel were two of the most landed species in New Jersey between 2003 and 2007 in terms of total tonnage. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Short-beaked common dolphins are more likely to occur in the Study Area during the fall and winter (November through March), but they may occur at any time of year. A total of 32 short-beaked common dolphin sightings were recorded during the survey period; 23 were on-effort and nine were off-effort (**Figure 5-9**). Total group size varied greatly with a minimum group

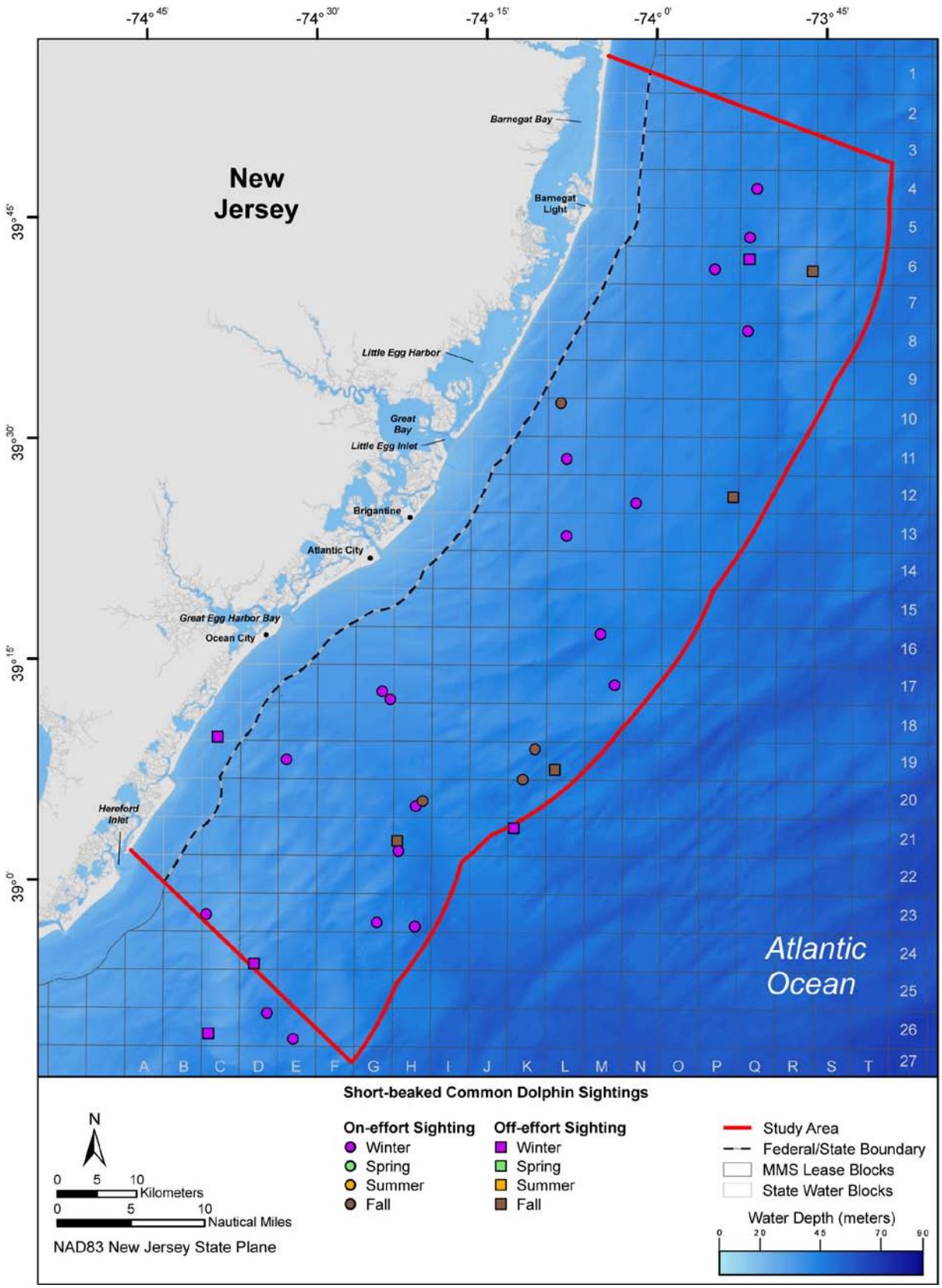

Figure 5-9. On-effort and off-effort sightings of the short-beaked common dolphin in the Study Area and vicinity from the shipboard and aerial surveys.

size of one animal and a maximum of 65 animals recorded. The mean group size was 12.8 animals. Water depth for short-beaked common dolphin sightings ranged from 10 to 31 m (33 to 102 ft). The mean water depth for sightings was 23.2 m (76.1 ft), which is the deepest mean depth for all identified cetacean sightings recorded during the survey period. This may indicate a preference for deeper waters or may be a construct of the fact that the distribution of sightings of short-beaked common dolphins during the study period was relatively far from shore. The mean distance from shore was 23.5 km (12.7 NM) although sightings ranged from 3.0 to 37.5 km (1.6 to 20.2 NM) from shore. SSTs associated with short-beaked common dolphin sightings ranged from 4.7 to 12.4°C (40.5 to 54.3°F) with a mean of 7.1°C (44.8°F). The low mean SST associated with sightings supports the strong seasonality of this species in the Study Area. Short-beaked common dolphins were only sighted during the study period in fall and winter (late November through mid-March). The presence of calves was confirmed in 26% of the shipboard sightings.

- **Harbor Porpoise (*Phocoena phocoena*)**

Status—Harbor porpoises found in U.S. North Atlantic waters belong primarily to the Gulf of Maine/Bay of Fundy stock; however, stranding and bycatch data suggest that individuals found in the mid-Atlantic region may come from other populations, as well. The best available population estimate for the Gulf of Maine/Bay of Fundy stock is 89,054 individuals (Waring et al. 2009).

General Distribution—Harbor porpoises are found in the North Pacific and North Atlantic oceans in sub-polar to temperate waters (Read 1999). Their distribution is associated closely with aggregations of prey, particularly Atlantic herring (*Clupea harengus*), and with cool SSTs (<17ºC) (Watts and Gaskin 1985; Gaskin 1992a; Read 1999). In U.S. North Atlantic waters, harbor porpoises are distributed primarily in the Gulf of Maine and south to Georges Bank, although they do occur commonly as far south as Virginia (CETAP 1982; Northridge 1996). They have been documented less commonly as far south as northern Florida, which probably represents the southern limit of their range in the western North Atlantic (Polacheck et al. 1995; Read 1999).

Harbor porpoise distribution in the western North Atlantic is seasonal. From July through September, harbor porpoises are concentrated in relatively shallow waters (<150 m [492 ft]) of the northern Gulf of Maine and southern Bay of Fundy (Palka 1995), with a few occurrences during this time period documented farther north and south of this area (Palka 2000). From October through December, the densest concentrations of harbor porpoises are farther south, primarily from New Jersey to Maine, with lower densities north and south of this region (NMFS 2001). Harbor porpoises occur mostly on the continental shelf but appear to have an offshore component to their distribution (Read et al. 1996; Westgate et al. 1998), particularly farther south in the Mid-Atlantic Bight in the fall and winter (Westgate et al. 1998). During the early winter, sightings occur primarily in the southwestern and northern Gulf of Maine, as well as in the Bay of Fundy (CETAP 1982). From January through March, individuals may be found from New Brunswick, Canada to North Carolina in the mid-Atlantic (NMFS 2001); however, not all harbor porpoises remain in shallow, nearshore waters during winter; harbor porpoise bycatch has been reported in pelagic fisheries in the U.S. northeast and mid- Atlantic (Read et al. 1996; Belden et al. 2006). The presence of bycaught individuals in pelagic fisheries lends credence to the proposed offshore distribution of harbor porpoises during the winter months and may explain the observed paucity of sightings in the Bay of Fundy and Gulf of Maine (CETAP 1982); bycatch data also support the seasonal movement of individuals along the mid-Atlantic coast, where harbor porpoises have been caught as far south as Virginia (Palka et al. 2009).

New Jersey waters and the waters of the New York Bight may represent an important winter (January to March) habitat for harbor porpoises (Westgate et al. 1998). Fisheries bycatch data indicate that harbor porpoises, particularly juveniles, are present in the nearshore waters of the mid-Atlantic during these months (Cox et al. 1998). Bycatch data acquired between 1999 and 2007 provide insight into the presence of harbor porpoises in New Jersey waters. During this time period, bycatch was recorded only during the months of January through April, with the majority of individuals caught in northern New Jersey waters near Hudson Canyon and in the “Mudhole”, a trench approximately 21 km (11 NM) off the New Jersey coast (Palka et al. 2009). The Harbor Porpoise Take Reduction Plan,

which went into effect in 1999, established two management areas to reduce harbor porpoise bycatch in the waters off New Jersey; the first of these areas encompasses the Mudhole north of the Study Area while the second area includes all the waters off New Jersey, excluding the Mudhole, out to 72°30'W. These management areas encompass the entire Study Area and prohibit use of certain types of gillnets during the winter (January through April) when harbor porpoises are most likely to be present. Based on data since 1999, bycatch of harbor porpoises in New Jersey waters has increased dramatically in recent years (Palka et al. 2009).

Other studies have documented harbor porpoise occurrence in the Study Area. One satellite-tagged individual was rehabilitated and released near Ocean City, Maryland, in the late spring; the individual remained in the nearshore waters of New Jersey and New York for four weeks before moving north towards Cape Cod in June (Westgate et al. 1998). There are sightings of this species in the Study Area during the winter and spring and strandings during the winter, spring, and summer (CETAP 1982; NMFS-NEFSC 1997; NOAA/NMFS 2004).

Feeding/Fisheries—Harbor porpoises feed on small schooling fishes such as herring, sardine (*Harengula*/*Sardinella* spp.), menhaden (*Brevoortia* spp.), Atlantic cod (*Gadus morhua*), whiting/silver hake, and pollock (*Pollachius virens*) (Read 1999). Prey species may vary depending on the geographic area; for example, in the Bay of Fundy, harbor porpoises prey primarily on Atlantic herring and whiting/silver hake while in the Gulf of Maine they are known to feed primarily on Atlantic herring (Recchia and Read 1989). First year calves may feed on euphausiids (krill) or young fishes (Smith and Read 1992; Gannon et al. 1998).

The larvae of many species of fish found in the Study Area are known to feed on zooplankton, including euphausiids. Many clupeid species (e.g., herring and menhaden) and anchovies occur in the Study Area. In addition to being the known prey species of harbor porpoises, these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., black sea bass, monkfish/goosefish, and bluefin tuna).

Prey species of harbor porpoises are also targeted by commercial fisheries in the Study Area. For example, Atlantic herring was one of the most landed species in New Jersey between 2003 and 2007 in terms of total tonnage. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Harbor porpoises occur in the nearshore waters of New Jersey, including the Study Area, primarily during the winter (January to March); however, they may also occur in this region during other times of the year. Harbor porpoises were the second most frequently sighted cetacean during the survey period. A total of 51 harbor porpoise sightings were recorded; 42 of these were on-effort and nine were off-effort (**Figure 5-10**). Total group size for the harbor porpoise was small, ranging from one to four individuals per sighting (mean group size=1.7). Sightings were recorded throughout the Study Area and ranged from 1.5 to 36.6 km (0.8 to 19.8 NM) from shore (mean=19.5 km/10.5 NM). Water depth of sightings ranged from 12 to 30 m (39 to 98 ft) with a mean value of 21.5 m (70.5 ft). SSTs for harbor porpoise ranged from 4.5 to 18.7°C (40.1 to 65.7°F) with a mean of 5.8°C (42.4°F), which is the lowest mean value for all identified cetacean species. The very low mean SST associated with these sightings supports the seasonality of harbor porpoise occurrence in the Study Area. Over 90% of harbor porpoise sightings during the study period were recorded during winter (mainly February and March). Three sightings occurred during spring (April and May), and one sighting was recorded during summer (July).

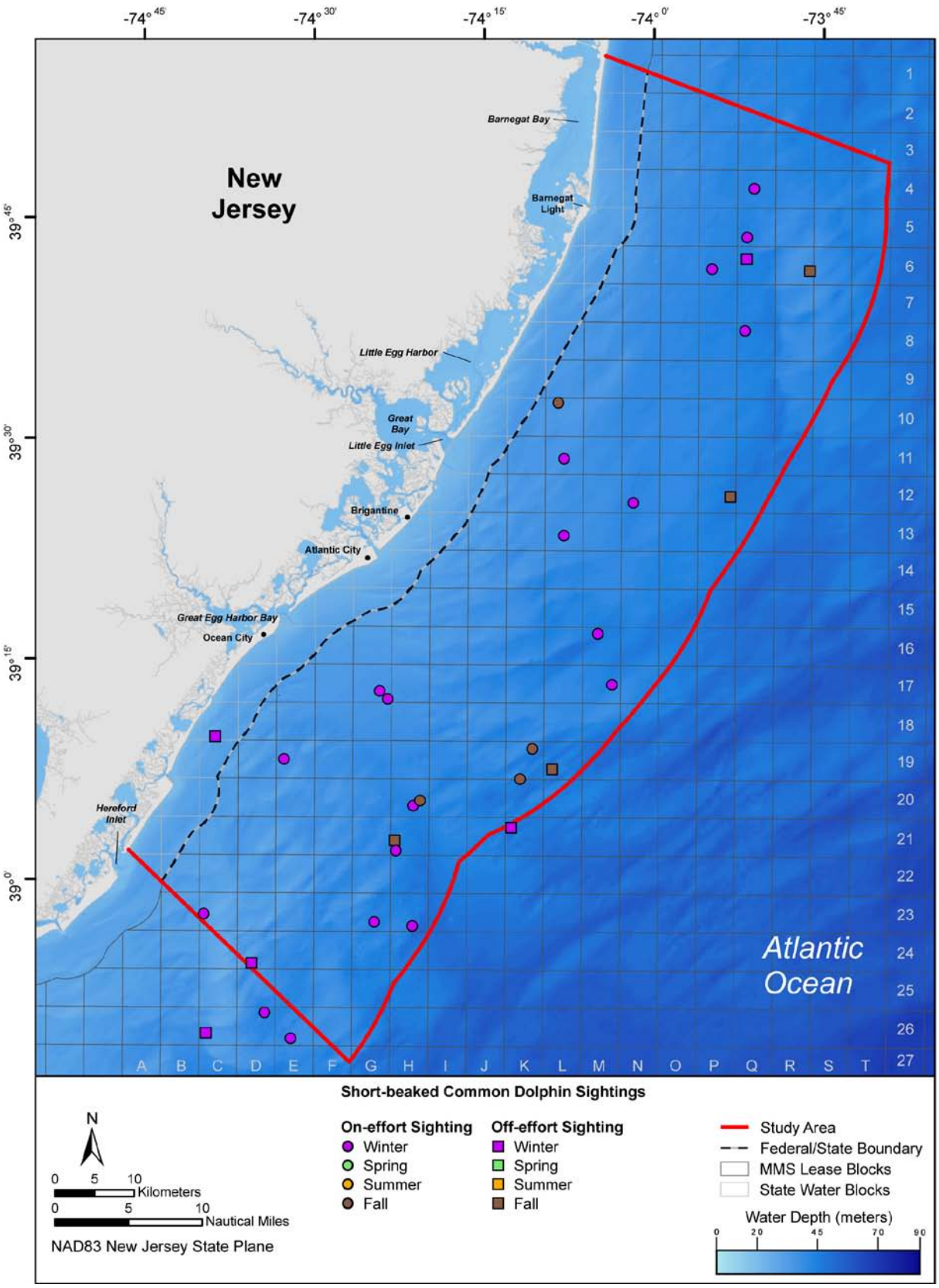

Figure 5-10. On-effort and off-effort sightings of the harbor porpoise in the Study Area and vicinity from the shipboard and aerial surveys.

- **Harbor Seal (*Phoca vitulina*)**

Status—Harbor seals in the western North Atlantic belong to the subspecies *Phoca vitulina concolor* (Jefferson et al. 2008). The best available population estimate for harbor seals occurring in U.S. North Atlantic waters is 99,340 individuals (Waring et al. 2009).

General Distribution—Harbor seals occur throughout the North Atlantic and North Pacific basins from temperate to subarctic latitudes (Bigg 1981). In the western North Atlantic, they are known to occur year-round along the coasts of eastern Canada and south into Maine (Boulva 1973; Katona et al. 1993; Gilbert and Guldager 1998; Baird 2001). The highest densities of harbor seals in U.S. waters occur in the Gulf of Maine, specifically in Machias and Penobscot bays (Katona et al. 1993).

Most harbor seals that occur in U.S. waters remain in northern New England, dispersing seasonally to areas south of Maine or farther offshore. From October through December, and perhaps earlier and later, the number of harbor seals present in Canadian waters declines while a corresponding increase occurs in the number of harbor seals south of Maine (Terhune 1985; Rosenfeld et al. 1988). This supports the general hypothesis that the population undergoes a general southward movement during this period (Rosenfeld et al. 1988). During late September through late May, harbor seals may be found south of Maine (Schneider and Payne 1983; Payne and Schneider 1984; Rosenfeld et al. 1988; Whitman and Payne 1990; Barlas 1999; Hoover et al. 1999; Schroeder 2000; Schroeder and Kenney 2001; Slocum et al. 2005). Many seals move offshore into the Gulf of Maine or into southern New England and occur in the mid-Atlantic region, particularly from late fall to spring. Harbor seals have been noted as a bycatch species in the mid-Atlantic coastal gillnet fishery during the winter (Belden et al. 2006); however, not all seals disperse; some individuals remain in the nearshore waters of Maine and Canada year-round (Baird 2001).

Individuals that make seasonal movements have been observed in New Jersey during the winter months (Slocum et al. 1999), and extralimital occurrences have been observed as far south as Florida (Caldwell and Caldwell 1969; NMFS unpublished data cited in Waring et al. 2009). Haulout sites are documented in Massachusetts on Cape Cod and Nantucket Island and in New York and New Jersey (Payne and Selzer 1989; Slocum et al. 1999; Di Giovanni et al. 2009; Slocum and Davenport 2009). Harbor seals have been taken as bycatch during the month of December in fisheries that operate offshore of New Jersey (Belden et al. 2006).

There are three well known, long-term haulout sites in New Jersey, including one in Great Bay adjacent to the Study Area (Slocum et al. 2005; Slocum and Davenport 2009). Harbor seal abundance at this haulout has increased since 1994 and shows strong seasonality (Slocum et al. 1999; Slocum et al. 2005). In addition to the haulout site at Great Bay, harbor seals are known from sighting, stranding, and bycatch records in the Study Area and vicinity (Slocum et al. 1999; Slocum and Schoelkopf 2001; Belden et al. 2006). North of the Study Area, harbor seals haul out regularly along the northern shore of the New York Bight, including on Sandy Hook and on islands and shores along the coasts of Rhode Island, Connecticut, and Massachusetts (Payne and Selzer 1989; Barlas 1999; Schroeder 2000; DeHart 2002; Di Giovanni et al. 2009; Antonucci et al. n.d.). It is likely that some of these individuals move into the Study Area, particularly during the winter months. The harbor seal is a nearshore species that occurs primarily within 20 km (11 NM) of the coast throughout its range; however, harbor seals have been documented as far offshore as the 100-m (328-ft) isobath off the northeast U.S. (Belden et al. 2009).

Feeding/Fisheries—Harbor seals prey on a variety of species depending on the geographic area and season (Payne and Selzer 1989; Baird 2001; Bjørge et al. 2002). Prey species include cephalopods (squid), crustaceans, and fishes such as sand lance, Atlantic herring, Atlantic cod, and winter flounder (*Pseudopleuronectes americanus*) (Payne and Selzer 1989; Wood et al. 2001).

Many species that are known prey species of harbor seals occur in the Study Area, including squid (longfin inshore squid), sand lance, Atlantic herring, and winter flounder. These species are also

forage species for several life stages of other fishes that occur in the Study Area (e.g., black sea bass, winter skate, and king mackerel [*Scomberomorous cavalla*]).

Prey species of harbor seals are also targeted by commercial fisheries in the Study Area. For example squid represented the sixth most valuable fishery in New Jersey between 2003 and 2007. Atlantic herring was one of the five most landed species in New Jersey between 2003 and 2007 in terms of total tonnage and winter flounder are targeted by the northeast multispecies groundfish fishery. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Harbor seals may occur in the Study Area during any time of the year. A single sighting of an individual harbor seal was recorded during the survey period. This seal was observed in shallow waters (18 m [59 ft]) 9.9 km (5.3 NM) east of Little Egg Inlet in June 2008 (**Figure 5-11**). The SST associated with this sighting was 11.4°C (52.5°F). The two unidentified pinnipeds recorded near Ocean City, New Jersey in April 2008 were probably harbor seals but species identification could not be confirmed. There were additional unidentified pinnipeds seen during the surveys but no supposition can be made regarding their probable identification.

- **Leatherback Turtle (*Dermochelys coriacea*)**

Status—Leatherback turtles are listed as endangered under the ESA (NMFS and USFWS 1992). Recent abundance estimates for adult leatherbacks range from 34,000 to 94,000 individuals in North Atlantic waters (NMFS 2007; TEWG 2007).

General Distribution—Late juvenile and adult leatherback turtles are distributed globally in both oceanic and nearshore waters (Schroeder and Thompson 1987; Shoop and Kenney 1992; Grant and Ferrell 1993). They may occur in tropical, subtropical, temperate, and cool-temperate latitudes (Frazier 2001; James et al. 2006a). General distribution trends are linked closely to their life history, including the seasonality of prey availability and the limitations imposed by their terrestrial reproductive requirements (Collard 1990; Davenport and Balazs 1991; Luschi et al. 2006). Critical habitat for leatherbacks is designated in the Caribbean at Sandy Point, St. Croix, U.S. Virgin Islands (NMFS 1979).

In the western North Atlantic, leatherback distribution and movement is strongly seasonal (Davenport and Balazs 1991; Luschi et al. 2006). Thompson et al. (2001) and James et al. (2006b) noted that leatherbacks foraging in the western North Atlantic preferred waters from 16 to 18ºC (61 to 64ºF), while Witt et al. (2007) found that the lower thermal limit for leatherbacks occurs in waters with SSTs ranging from 10 to 12°C (50 to 54ºF). Leatherbacks that frequent the waters of the northeast U.S. are typically subadult or adult individuals greater than 100 centimeters (cm; 39 inches [in.]) in curved carapace length (CCL).

A regular, seasonal occurrence of leatherbacks is known along the northeast U.S. Atlantic coast. In the late winter and early spring, leatherbacks are distributed primarily in tropical latitudes (Stewart and Johnson 2006); survey data show that around this time of year, individuals begin to move north along the North American Atlantic coast. By February and March, the majority of leatherbacks found in U.S. Atlantic waters are distributed off northeast Florida. This movement continues through April and May when leatherbacks begin to occur in large numbers off the coasts of Georgia and the Carolinas (NMFS 1995; 2000). Leatherbacks become more numerous off the mid-Atlantic and southern New England coasts in late spring and early summer, and by late summer and early fall, leatherbacks may be found in the waters off eastern Canada (CETAP 1982; Shoop and Kenney 1992; Thompson et al. 2001; James et al. 2006b). Leatherback sightings north of the mid-Atlantic typically occur between June and October with peak sightings occurring in August (Bleakney 1965; James and Herman 2001). Leatherbacks in this area may occur in deep, offshore waters (>2,000 m [6,562 ft]) but are noted mainly in coastal waters where gelatinous prey are abundant (Shoop and Kenney 1992; James and Herman 2001; James et al. 2006b).

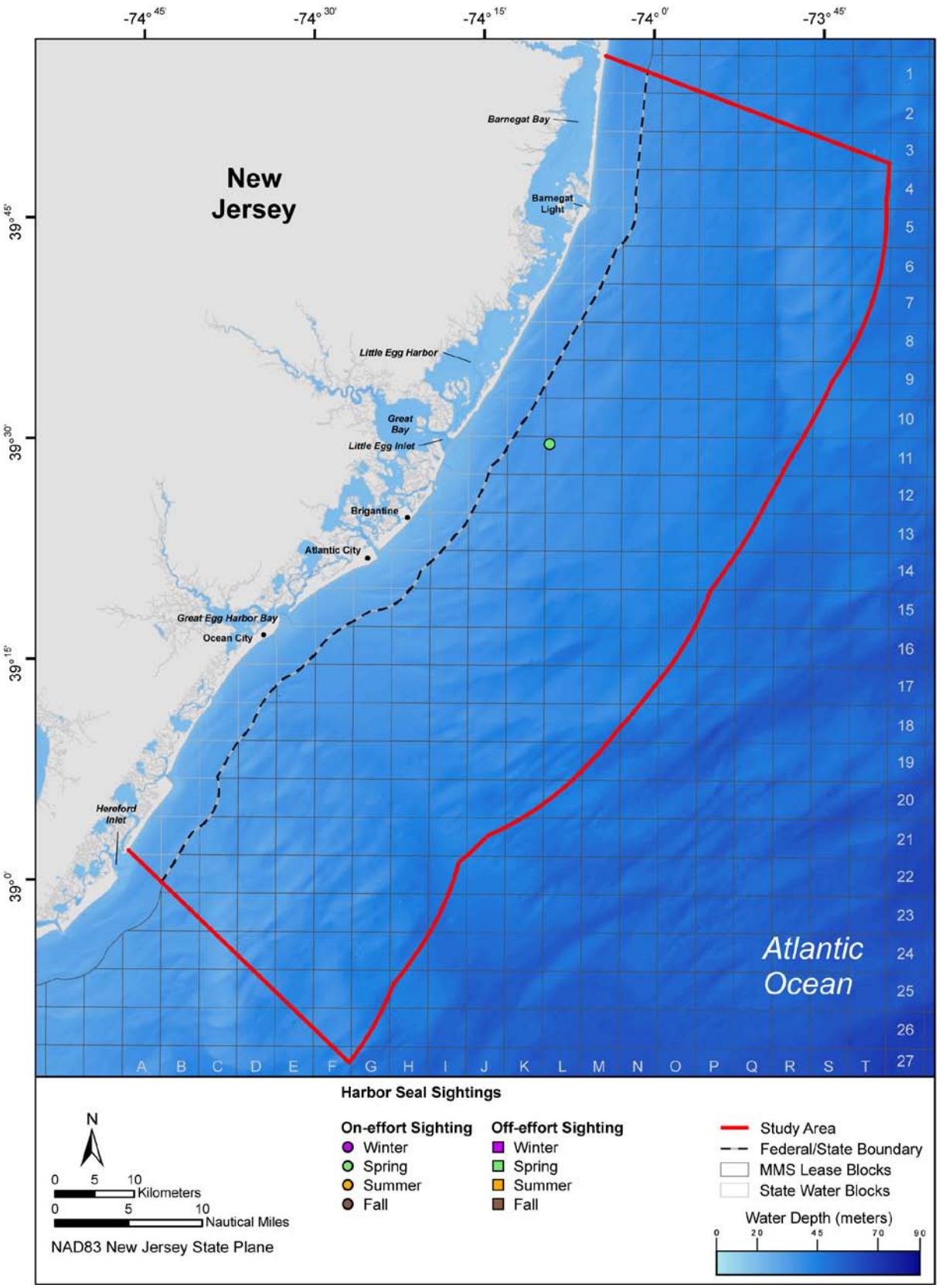

Figure 5-11. On-effort and off-effort sightings of the harbor seal in the Study Area from the shipboard and aerial surveys.

Feeding/Fisheries—Leatherbacks feed primarily on invertebrates and prefer gelatinous zooplankton, particularly of the family Scyphomedusae ("jellyfish"; Ernst et al. 1994). The primary preferred prey species of leatherbacks are not targeted by commercial fisheries in the Study Area. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Leatherback turtles are more common in mid-Atlantic waters during the summer and fall; however, this species may occur in the Study Area year-round. Twelve sightings of leatherback turtles were recorded during the surveys; nine of these were on-effort and three were off-effort (**Figure 5-12**). All leatherback turtle sightings were of single individuals; eight of the total 12 sightings were thought to be juveniles. Water depths of leatherback sightings ranged from 18 to 30 m (59 to 98 ft) with a mean depth of 24 m (79 ft). The SSTs associated with leatherback turtle sightings ranged from 18.1 to 20.3°C (64.6 to 68.5°F) with a mean of 19.0°C (66.2°F). This mean SST is the highest average value for any species or species group sighted during the survey period and is consistent with the seasonality of leatherback occurrence in the Study Area. Leatherback turtles were sighted only during the summer. The majority of sightings (seven) occurred in the far northern portion of the Study Area. Sightings were recorded from 10.3 to 36.2 km (5.6 to 19.5 NM) from shore with a mean distance of 28.6 km (15.4 NM).

- **Loggerhead Turtle (*Caretta caretta*)**

Status—Loggerhead turtles occurring in the U.S. North Atlantic may belong to one of five nesting groups or subpopulations: the Northern, Peninsular Florida, Dry Tortugas, Northern Gulf of Mexico, and Greater Caribbean (NMFS and USFWS 2008). There are no abundance estimates for individuals in the western North Atlantic. The Peninsular Florida subpopulation is the largest nesting population in the Atlantic Ocean, with an average annual nest production of 64,513 turtles between 1989 and 2007 (NMFS and USFWS 2008; Witherington et al. 2009); however, nesting for this subpopulation declined 41% between 1998 and 2008 (NMFS and USFWS 2008; Witherington et al. 2009). Loggerhead turtles are listed as threatened under the ESA (NMFS and USFWS 1991). The Northwest Atlantic population of loggerheads is currently proposed for listing as a distinct population segment and for reclassification to endangered status (USFWS 2010).

General Distribution—Loggerhead turtles are distributed globally in offshore, shelf, and nearshore waters (including estuaries and bays; Dodd 1988). Young loggerhead turtles (< approximately 14 years old) are distributed mainly in open ocean, pelagic waters. Juvenile loggerhead turtles from the western North Atlantic nesting populations have been documented as far north as Newfoundland in the western North Atlantic and in the eastern North Atlantic (Bolten et al. 1994; Bolten et al. 1998; Bowen et al. 2004). After about 14 years of age (i.e., >40 cm [16 in.] CCL), juvenile individuals begin to use nearshore areas in addition to the deep, offshore waters of the early juvenile lifestage (e.g., Musick and Limpus 1997; Laurent et al. 1998). Adult loggerhead turtles (about 25 to 30 years) occur primarily in nearshore waters where their preferred prey is found (Musick and Limpus 1997; Godley et al. 2003).

In the waters of the U.S. North Atlantic, loggerheads commonly occur in shelf waters as far north as the New York Bight (CETAP 1982; Shoop and Kenney 1992). Loggerhead distribution along the U.S. Atlantic coast is strongly seasonal and is dictated primarily by SSTs. Loggerheads prefer SSTs between 13 and 28°C (56 and 82°F; Mrosovsky 1980); they tend to become lethargic in SSTs below 15°C (59°F) and may become incapacitated ("cold-stunned") at temperatures below 10°C (50°F) (Schwartz 1978; Mrosovsky 1980). Loggerhead turtles occur north of Cape Hatteras primarily in late spring through early fall (May and October), with a peak occurrence in June; however, sightings are recorded in mid-Atlantic and northeast waters year-round (CETAP 1982; Lutcavage and Musick 1985; Shoop and Kenney 1992). During the summer, loggerheads may be found regularly in shelf waters from Delaware Bay to Hudson Canyon, including Long Island Sound and Cape Cod Bay (Burke et al. 1991; Shoop and Kenney 1992; Prescott 2000; UDSG 2000). As SSTs decline in the winter, most individuals move south of Cape Hatteras to overwinter (Epperly et al. 1995; Mitchell et al. 2002).

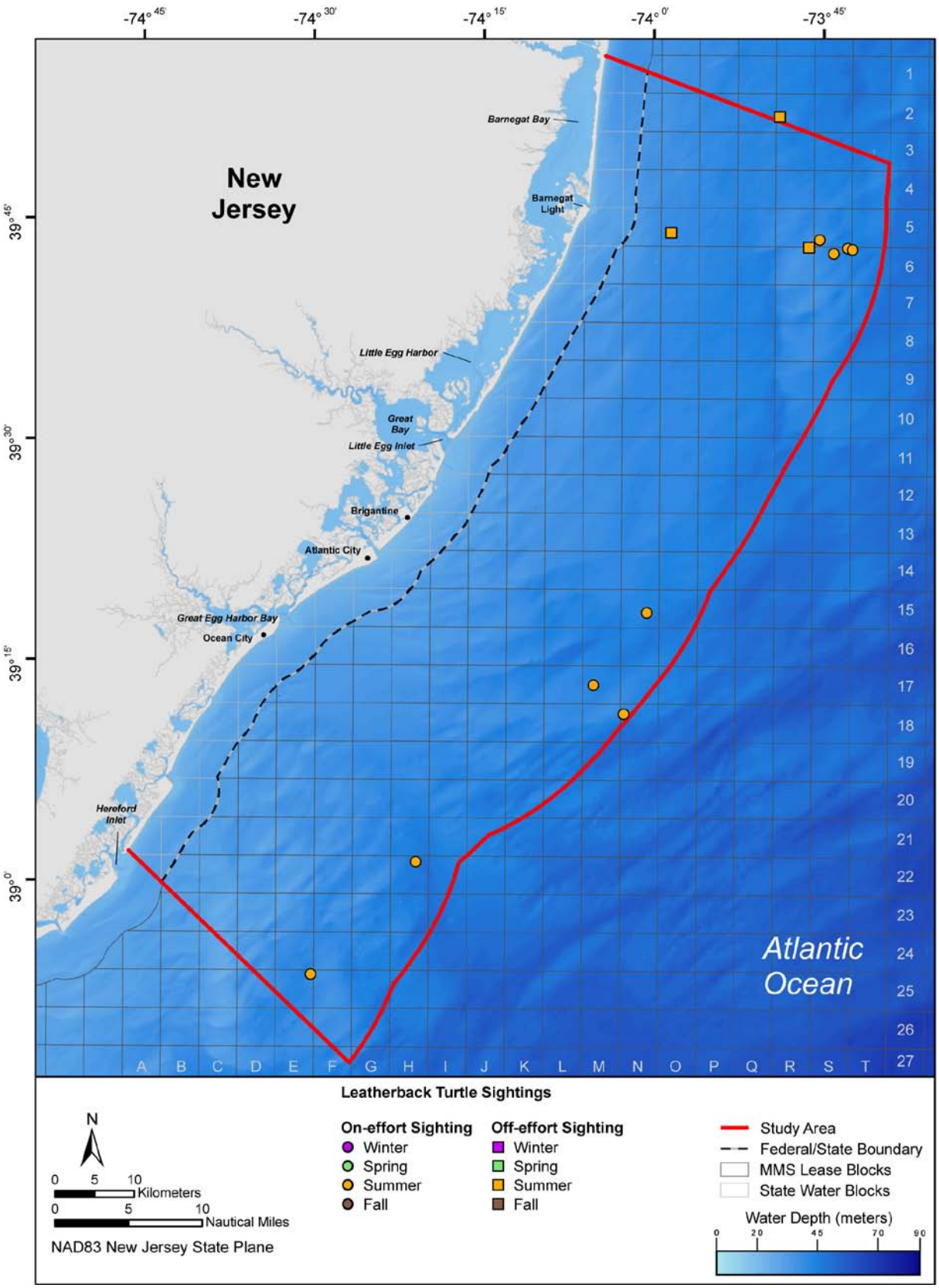

Figure 5-12. On-effort and off-effort sightings of the leatherback turtle in the Study Area and vicinity from the shipboard and aerial surveys.

Stranding and sightings data indicate that not all loggerheads leave mid-Atlantic and New England waters during the winter; individuals present during this time period may reach the lower level of their thermal limit (Burke et al. 1991).

Feeding/Fisheries—Loggerhead turtles are broadly omnivorous, feeding on vegetation, zooplankton, "jellyfish", crustaceans (crabs), insects, mollusks, and fish (Carr 1980; Lutcavage and Musick 1985; Dodd 1988; Richardson and McGillivary 1991; Witherington 1994; Seney and Musick 2007). Some of their known prey species that also occur in the Study Area include blue crab (*Callinectes sapidus*), menhaden, and croakers (Sciaenidae).

Many of the species that occur in the Study Area may be prey species for loggerhead turtles. Some of these species are also forage species for several life stages of piscivorous fishes that occur in the Study Area (e.g., black sea bass, monkfish/goosefish, and winter skate).

Prey species of loggerhead turtles are also targeted by commercial fisheries in the Study Area. For example blue crab was the fourth most valuable and squid the sixth most valuable fishery landed in New Jersey between 2003 and 2007. Atlantic menhaden (*Brevoortia tyrannus*) are targeted by purse seine fisheries in the Study Area. Refer to **Volume IV** for more information.

Baseline Study Occurrence—Loggerhead turtles are more common in mid-Atlantic waters during the summer and fall; however, this species may occur in the Study Area year-round. A total of 69 sightings of loggerhead turtles were recorded during the surveys; the vast majority of these (63) were recorded on effort (**Figure 5-13**). The 15 unidentified hardshell turtle sightings recorded during spring and summer may have been loggerhead turtles; however, species identifications could not be confirmed. All loggerhead turtle sightings were of single individuals; four of the total 69 sightings were recorded as juveniles. Loggerhead sightings occurred in water depths ranging from 9 to 34 m (30 to 112 ft) with a mean depth of 23.5 m (77.1 ft). Distance from shore ranged from 1.5 to 38.4 km (0.8 to 20.7 NM; mean=24.6 km/13.3 NM). SSTs associated with these sightings ranged from 11.0 to 20.3°C (51.8 to 68.5°F) with a mean value of 18.5°C (65.3°F). This was the second highest mean SST of all sightings which is consistent with the strong seasonality of loggerhead occurrence in the Study Area. Loggerhead turtles were sighted from late spring through fall. The earliest a loggerhead was sighted was June and the latest was October. Sightings of loggerhead turtles are fairly evenly distributed although over 50% of the sightings were recorded in the eastern half of the Study Area.

During the baseline study period, opportunistic sightings of sea turtles were recorded during monitoring efforts conducted in a potential windfarm site southeast of Atlantic City. Experienced observers recorded two juvenile loggerhead turtles during the geophysical surveys in August 2009 (GMI 2009b).

5.1.4 Density and Abundance

Only on-effort sightings and on-effort portions of the tracklines surveyed in a BSS≤5 were used in the analyses of abundance and density estimates for all species/groups except the harbor porpoise. On-effort harbor porpoise sightings and effort used in the analyses were limited to those recorded in a BSS≤2 due to the difficulty in detecting this species in a higher BSS. Off-effort sightings are discussed in this report but could not be included in the calculation of abundance and density estimates because they did not meet the criteria for analysis. Note that no perpendicular sighting distances could be estimated for the turtle sightings recorded during the aerial surveys. Sea turtle sightings recorded from the shipboard surveys could not be used to generate density/abundance estimates because turtles were only visible when they were very close to the tracklines. Therefore, a detection function could not be fitted to the sea turtle data.

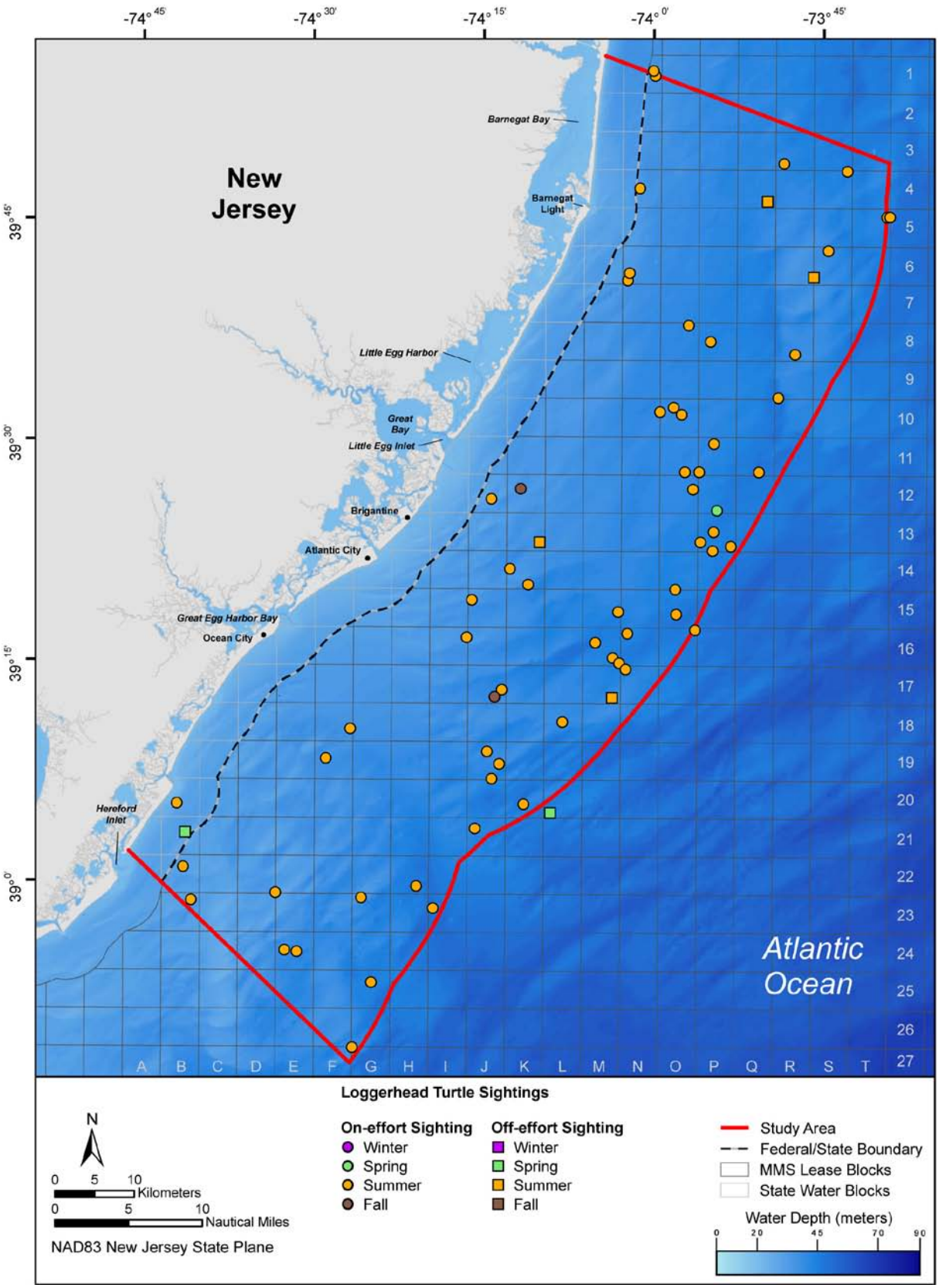

Figure 5-13. On-effort and off-effort sightings of the loggerhead turtle in the Study Area and vicinity from the shipboard and aerial surveys.

As mentioned previously, our analyses were limited to species/groups which had around 20 on-effort sightings with valid perpendicular sighting distances so that we could model the detection functions. The sightings recorded during 2008 and 2009 were combined to maximize the number of sightings for each species/group for analysis. We had a sufficient number of sightings to run separate analyses for three species (fin whale, bottlenose dolphin, and harbor porpoise). To account for other species for which there were an insufficient number of sightings to model species-specific detection functions, species with similar sighting characteristics were pooled into groups, and a pooled detection function was modeled. Then, specific density/abundance estimates could be generated for each species; however, sightings data were too sparse for generating meaningful density/abundance estimates for some species, such as the North Atlantic right whale for which only two on-effort sightings were recorded.

For some species and groups, sufficient sightings data were recorded such that density/abundance estimates could be generated for different seasons. Year-round analyses were limited to those species and groups for which sightings were recorded throughout the year, but not enough sightings were recorded for any particular season. Note that no aerial surveys were conducted in the fall, and the small number of sightings from the shipboard fall surveys prevented the fit of any detection functions for this season.

The CDS analyses generated abundance/density estimates for the entire Study Area. These estimates are based on the study design and, thus, are robust. As noted previously, the density and abundance estimates calculated for this report should be considered underestimated due to both perception and availability bias. The DSM approach also generates abundance estimates for the Study Area; however, the approach is based on model selection and model fitting which are not as straightforward. If a poor model is selected, there may be a substantial bias in abundance estimation. Therefore, the CDS approach is generally the preferred method for simply estimating overall abundance/density (Hedley and Buckland 2004). Therefore, we recommend the use of the CDS estimates of overall abundance/density for each species or group in the Study Area. The DSM predicted abundance estimates are included in the results below for comparison with the CDS estimates; however, the most important DSM results are the predicted density surfaces which provide a visual depiction of how the density of each species or group varies throughout the Study Area.

5.1.4.1 Conventional Distance Sampling Results

Abundance/density estimates were generated for the following species/groups:

Shipboard Data Analyses

1) Endangered marine mammals—year-round
   - North Atlantic right whale
   - Fin whale
   - Humpback whale
2) Fin whale—year-round
3) Delphinids (from the family Delphinidae--dolphins)—winter
   - Short-beaked common dolphin
   - Unidentified small delphinid
   - Unidentified dolphin
4) Bottlenose dolphin—spring
5) Bottlenose dolphin—summer
6) Harbor porpoise—winter

Aerial Data Analyses

7) Bottlenose dolphin—summer

Results of the CDS analyses for all of the seven species/groups, including density/abundance estimates with corresponding 95% CIs and CVs, are summarized in **Tables 5-4** and **5-5**. Detection functions were

also plotted versus perpendicular sighting distance in the form of histograms of the collected data overlaid by a curve describing the fit of the optimal model to the sightings data. These plots are shown in **Figures 5-19** through **5-25**. The modeled detection function (red curve) is plotted assuming *g*(0)=1 (i.e., 100% detection probability for species located at zero perpendicular distance from the trackline) and shows a general monotonic decrease in detection probability with increasing perpendicular sighting distance. The histograms were generated by grouping the sightings versus distance data into distance bins of a given (user-specified) width and plotting the average detection probabilities for each distance bin (rather than for each individual distance). Binning the distances and using relatively wide bins reduces the noise associated with the small-scale variations in detectability with distance (i.e., smoothes out the plot); however, in some cases, the first several bins were sub-divided into smaller bins to make the pattern of detections close to the trackline more evident. Note that several of the histograms show >100% detection probability at the shortest distance from the trackline. This phenomenon is due to the spikes in detections resulting from attractive animal movements toward the survey platform prior to detection so that not only are near-100% of animals actually within the range of short distances covered by the left-most distance bin being detected, but also some animals not originally within this distance range (but actually at farther distances associated with adjacent distance bins) are being detected and (erroneously) included in the left-most distance bin. In these cases, the detection functions were not fitted to the spikes to avoid generating inflated abundance/density estimates.

Endangered Marine Mammals (Shipboard Survey Data)

Marine mammal species that are listed as endangered under the ESA were included in this group. Note that none of the marine mammal species sighted is listed as threatened. The endangered marine mammals group included fin, humpback, and North Atlantic right whales. These species were pooled to fit a detection function since they have similar sighting characteristics due to their large body sizes and distinct blows and because there were not enough sightings recorded for humpback or North Atlantic right whales to fit separate detection functions for these species. Sightings of this group were recorded throughout the year. Due to the overall low number of sightings of this group, abundance/density estimates could only be generated for the entire year and not for any specific seasons. The distance data were truncated at 5,000 m (16,404 ft) which left 32 sightings to be analyzed; only one sighting was removed from the analysis based on the chosen truncation distance (**Table 5-4**). A half-normal key function with no adjustments was chosen as the best model based on the lowest AIC value and the fit of the detection function (**Figure 5-14**). The year-round abundance of endangered marine mammals was estimated at three individuals (95% CI=2-5; %CV=29.91; **Table 5-5**). The data were stratified by species so that an individual year-round abundance estimate could be generated for the humpback whale by using the pooled detection function. The abundance of this species was estimated at one individual (95% CI=0-1; %CV=42.50; **Table 5-5**). Abundance estimates should be considered underestimated due to availability and perception bias which can lead to negative departures of *g*(0) below 1. Availability bias is a particular problem for whales which tend to make long dives and are often not at the surface to be detected. This bias also increases as the group size decreases; the group size of all endangered marine mammal sightings was less than four individuals.

Fin Whale (Shipboard Survey Data)

Due to the small number of sightings of this species, no abundance/density estimates could be generated for specific seasons. A 5,000-m (16,404-ft) truncation was chosen for the year-round analysis which resulted in the removal of only one sighting (**Table 5-4**). The remaining 25 sightings were described well by a half-normal model with no adjustments (**Figure 5-15**). The year-round abundance of this species was estimated at two individuals (95% CI=1-4; %CV=36.75; **Table 5-5**). This estimate is similar to the year-round abundance estimates for endangered marine mammals which is expected since the fin whale was the dominant species included in the endangered marine mammals analysis. No correction for availability or perception bias could be conducted; therefore, the abundance of this species should be considered underestimated.

Table 5-4. Number of sightings meeting the criteria for analysis (before and after truncation), truncation distance, mean group size used in the analysis (expected or observed), fitted detection function model, estimated probability density function evaluated at zero perpendicular sighting distance (f[0]) in km-1 and the corresponding percentage coefficient of variation (CV), effective strip width (ESW), and encounter rate of each species or group in km-1 analyzed using the CDS method. All analyses, except those designated as "Aerial", were conducted with the ship survey data. All analyses were fitted to the half-normal key function with no adjustments.

Common Name or Group	Sightings n_{Before}	Sightings n_{After}	Truncation distance w(m)	Mean Group Size (e=expected; o=observed)	*f*(0)	%CV *f*(0)	ESW (m)	Encounter rate (n/L)
Endangered Marine Mammals								
Year-round	33	32	5,000	1.3181 (e)	0.0003297	13.75	3033.3	0.002651
Humpback Whale*								
Year-round	7	7	5,000	1.143 (o)	0.0003297	13.75	3033.3	0.000580
Fin Whale								
Year-round	25	24	5,000	1.380 (e)	0.000311	15.48	3220.6	0.001988
Delphinids								
Winter	21	18	2,500	9.000 (o)	0.0007970	16.37	1254.7	0.005260
Short-beaked Common Dolphin*								
Winter	14	12	2,500	12.33 (o)	0.0007970	16.37	1254.7	0.003507
Bottlenose Dolphin								
Spring	67	66	3,500	19.833 (o)	0.0005671	9.86	1763.5	0.026677
Summer	94	93	3,500	9.573 (e)	0.0004955	8.83	2018.4	0.025627
Summer (Aerial)	71	39	10**	18.436 (o)	0.0014557	12.61	687.0	0.020238
Harbor Porpoise								
Winter	30	27	2,200	1.889 (o)	0.0008475	16.11	1,179.9	0.025568

* Species were pooled with others to model detection functions due to the limited number of sightings of the individual species.
**Left truncation was chosen within 10 m of the trackline due to the limited visibility of the trackline from the survey plane.

Table 5-5. Estimates of abundance and density (individuals/km^2) and the corresponding 95% confidence intervals (CI) and percentage coefficient of variation (CV) for each species or group analyzed using the CDS method. All estimates, except those designated as "Aerial", were generated from the ship survey data.

Common Name or Group	Abundance (N)	95% CI(N)	Density (D) per 1 km^2	95% CI(D)	%CV
Endangered Marine Mammals					
Year-round	3	2-5	0.000576	0.000323-0.001027	29.91
Humpback Whale					
Year-round	1	0-1	0.000109	0.000049-0.000245	42.50
Fin Whale					
Year-round	2	1-4	0.000426	0.000211-0.000861	36.75
Delphinids					
Winter	90	38-215	0.018865	0.0079211-0.044929	45.50
Short-beaked Common Dolphin					
Winter	82	32-212	0.017235	0.0067053-0.044298	49.74
Bottlenose Dolphin					
Spring	722	375-1,388	0.15113	0.078604-0.29059	33.09
Summer	289	168-499	0.060604	0.035145-0.10451	27.39
Summer (Aerial)	1,297	777-2,164	0.27156	0.16272-0.45323	26.04
Harbor Porpoise					
Winter	98	47-204	0.020465	0.0098152-0.042672	37.23

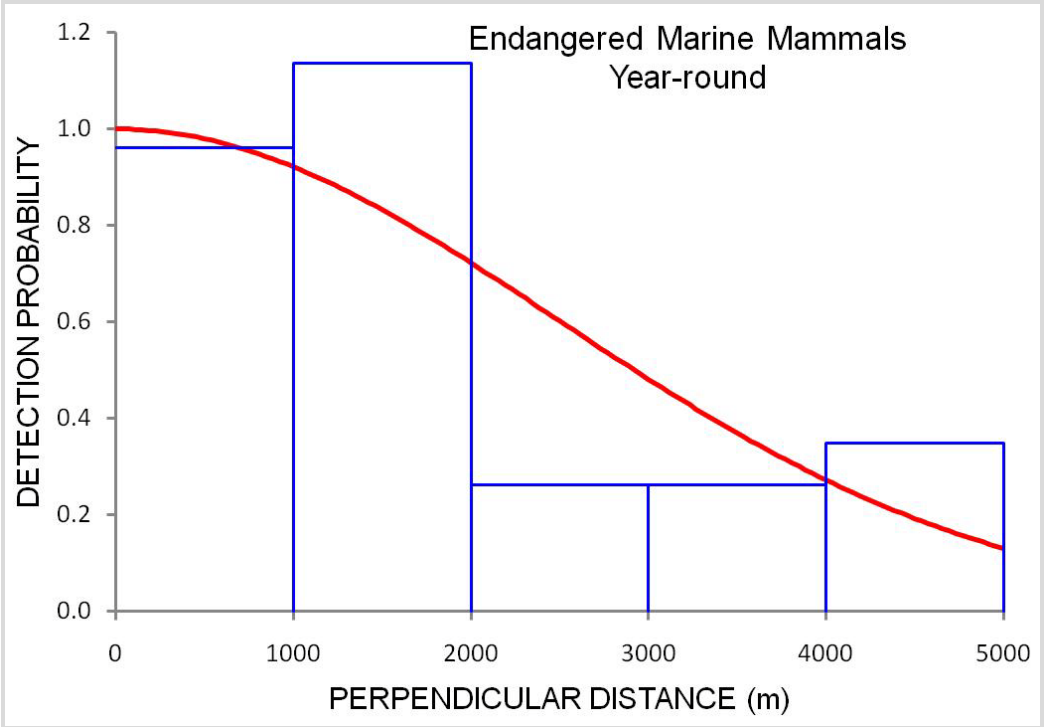

Figure 5-14. Histogram of observed distances truncated at 5,000 m and the fitted detection function for endangered marine mammals year-round based on shipboard survey data (half-normal key function with no adjustments). X^2=4.1591; DF=3; p=0.24479.

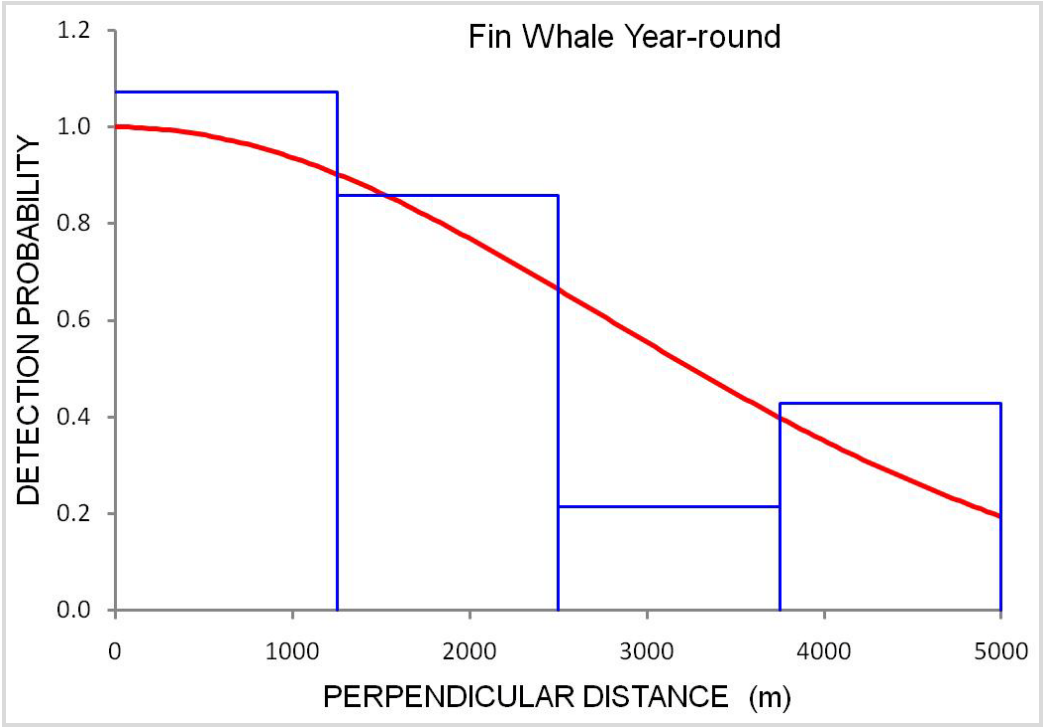

Figure 5-15. Histogram of observed distances truncated at 5,000 m and the fitted detection function for fin whales year-round based on shipboard survey data (half-normal key function with no adjustments). X^2=2.5338; DF=2; p=0.28170.

Delphinids (Shipboard Survey Data)

The short-beaked common dolphin was the dominant delphinid species sighted during the winter surveys. There were not enough sightings of this species to model a detection function; therefore, short-beaked common dolphins were pooled with other delphinid sightings recorded during winter to model a detection function. Fourteen of the sightings included in this delphinids group for winter were of short-beaked common dolphins. The remaining seven sightings were likely of short-beaked common dolphins but were recorded as unidentified dolphins or unidentified small delphinids because species identifications could not be confirmed. A detection function was modeled for the pooled group of short-beaked common dolphins, unidentified dolphins, and unidentified small delphinids for the winter. Detections were truncated at 2,500 m (8,202 ft) which left 18 sightings in the analysis (12 of which were of short-beaked common dolphins) (**Table 5-4**). The large spike of detections during the trackline is likely due to the attraction of this species to the ship; short-beaked common dolphins often approached the ship to bow ride (**Figure 5-16**). The hazard-rate key function had the lowest AIC value but also resulted in very high abundances because this model was fitting the spike of detections near the trackline. The half-normal key function provided a better fit for the data and did not include the entire spike (**Figure 5-17**). The winter abundance estimate for the delphinids group was 90 individuals (95% CI=38-215; %CV=45.50; **Table 5-5**). The data were stratified by species so that a winter abundance estimate could be generated for the short-beaked common dolphin. This abundance estimate was 82 individuals (95% CI=32-212; %CV=49.74; **Table 5-5**). No correction for availability or perception bias could be conducted; therefore, abundance estimates should be considered underestimated. There were not enough ship sightings of this species to generate abundance/density estimates for the other seasons.

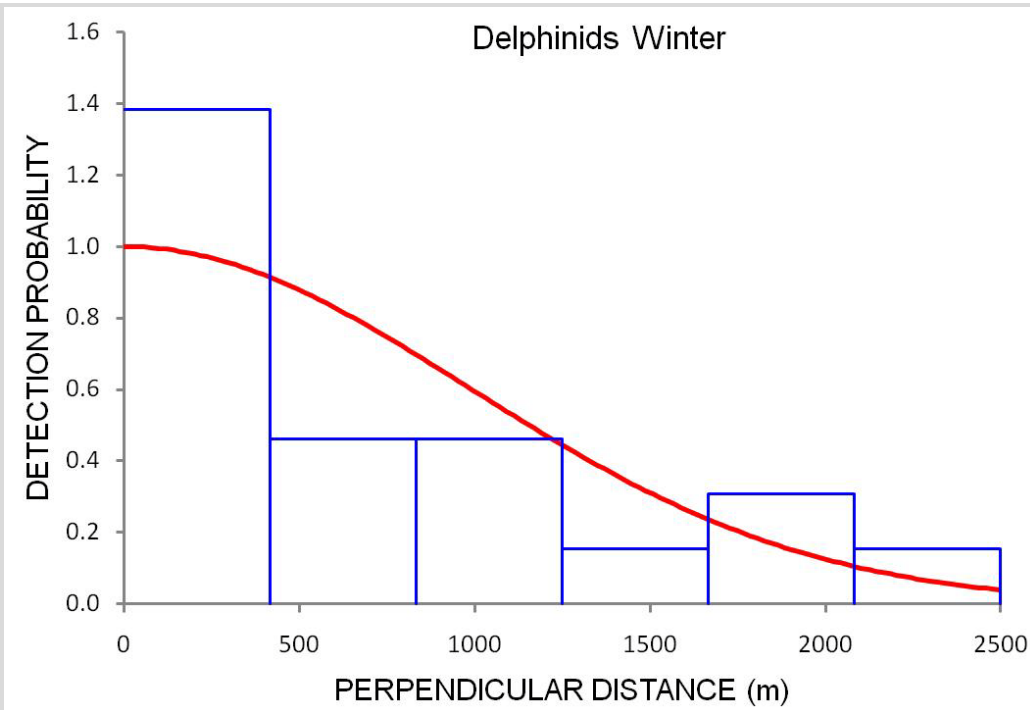

Figure 5-16. Histogram of observed distances truncated at 2,500 m and the fitted detection function for delphinids during winter based on shipboard survey data (half-normal key function with no adjustments). X^2=3.5533; DF=4; p=0.46983.

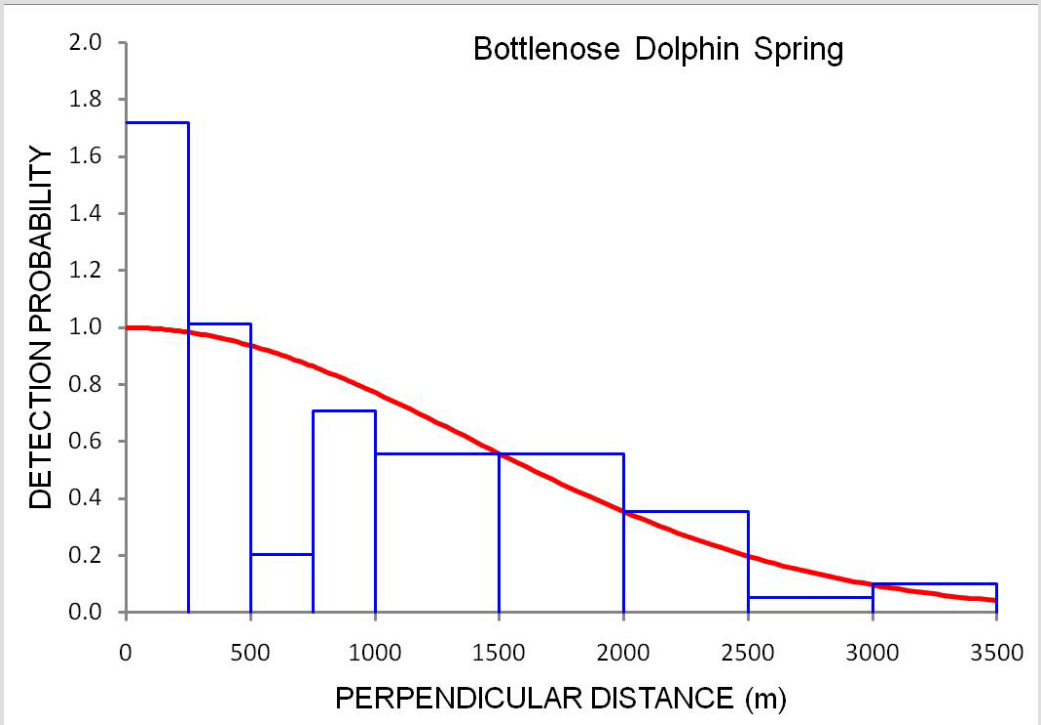

Figure 5-17. Histogram of observed distances truncated at 3,500 m and the fitted detection function for bottlenose dolphins during spring based on shipboard survey data (half-normal key function with no adjustments). X^2=11.3548; DF=7; p=0.12388.

Bottlenose Dolphin (Shipboard and Aerial Survey Data)

There were not enough ship sightings of this species to generate abundance/density estimates for the fall or winter seasons; therefore, only spring and summer analyses could be conducted. The spring analysis using the shipboard survey data included a right truncation at 3,500 m (11,483 ft) which resulted in 66 sightings left for analysis (**Table 5-4**). The half-normal key function was used although the hazard-rate actually resulted in a lower AIC value. A high number of detections of bottlenose dolphins within 250 m (820 ft) of the trackline resulted in a spike near zero (**Figure 5-17**); the hazard-rate key function fitted the detection function to this spike which resulted in a higher estimate of abundance. This spike was likely caused by the attraction of this species to the ship and the failure of observers to detect the animals before any responsive movement occurred. To minimize the influence of this spike, the half-normal key function with no adjustments was used to fit the detection function and resulted in a model with a flatter "shoulder" to the detection function (**Figure 5-17**). The spring abundance of bottlenose dolphins using the half-normal model was estimated at 722 individuals (95% CI=375-1,388; %CV=33.09; **Table 5-5**).

The CDS analysis of bottlenose dolphin sightings recorded from the shipboard surveys during the summer was based on a right truncation at 3,500 m (11,483 ft) which resulted in 93 sightings left for analysis and provided a reasonable fit to the data using a half-normal key function with no adjustments (**Table 5-4**; **Figure 5-18**). Note that the spike in detections near the trackline likely results from the responsive movement of the species as during the spring season (**Figure 5-18**). The half-normal key function with two cosine adjustments actually provided a lower AIC value, but it did not provide a realistic fit to the data and resulted in high %CV values. The summer abundance estimated from the half-normal model without adjustments was 289 individuals (95% CI=168-499; %CV=27.39; **Table 5-5**). As with the spring estimate, the summer estimate of abundance should be considered underestimated due to perception and availability bias.

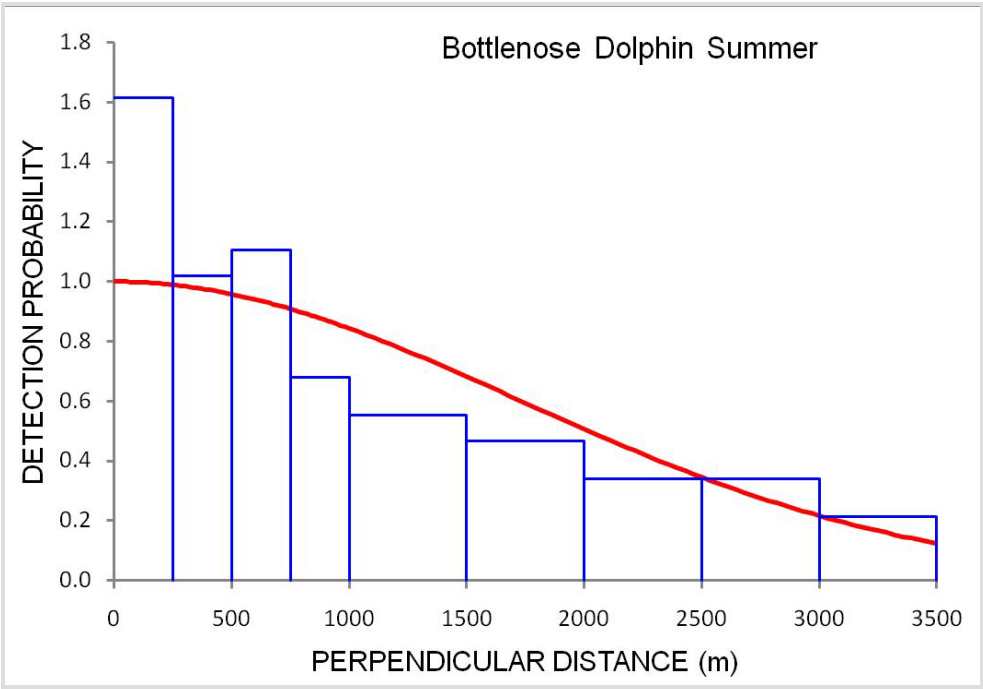

Figure 5-18. Histogram of observed distances truncated at 3,500 m and the fitted detection function for bottlenose dolphins during summer based on shipboard survey data (half-normal key function with no adjustments). X^2=9.0434; DF=7; p=0.24956.

The CDS analysis of bottlenose dolphin sightings recorded from the aerial surveys during the summer was based on a left truncation at 10 m (33 ft; **Table 5-4**). Aerial surveys for the summer were only conducted in 2009. The survey plane used for these surveys did not include bubble or belly windows; therefore, visibility below the aircraft directly on the trackline and within 10 m (33 ft) on either side of the trackline was limited, violating the assumption that all animals on the trackline were detected. Therefore, the left truncation position was chosen to include only the portion of the trackline where detection of animals was certain. Sightings within 10 m (33 ft) of the trackline were recorded when possible; however, exact distances could not be measured, and we could not assume that all animals within 10 m (33 ft) of either side of the trackline were detected. The 32 sightings recorded within 10 m (33 ft) from the trackline provide useful information on the distribution of bottlenose dolphins but could not be included in the abundance/density analyses due to the issues mentioned above. Therefore, 39 sightings were included in the analysis after the left truncation at 10 m (33 ft). The half-normal key function with no adjustments provided the best fit for the data (**Figure 5-19**). The summer abundance estimated from these aerial survey data was 1,297 individuals (95%CI=777-2,164; %CV=26.04; **Table 5-5**). No correction for availability or perception bias could be conducted; therefore, abundance estimates should be considered underestimated.

Harbor Porpoise (Shipboard Survey Data)

There were not enough sightings of this species to conduct a fall, spring, or summer CDS analysis. A right truncation of 2,200 m (7,218 ft) was chosen for the winter analysis to maximize the sample size. This truncation distance only removed three sightings; therefore, 27 sightings remained for the analysis (**Table 5-4**). A very small spike of detections was evident within 250 m (820 ft) from the trackline which might suggest attractive movement; however, no apparent attraction behavior was documented for this species during the survey period, and this species is known to move away from vessels (Barlow 1988; Polacheck and Thorpe 1990; Palka and Hammond 2001). A half-normal key function with no adjustments was chosen at the best model based on the fit and the low AIC value (**Figure 5-20**). The winter abundance of harbor porpoises in the Study Area was estimated at 98 individuals (95% CI=47-204; %CV=37.23; **Table 5-5**). Abundance should be considered underestimated due to perception and availability bias.

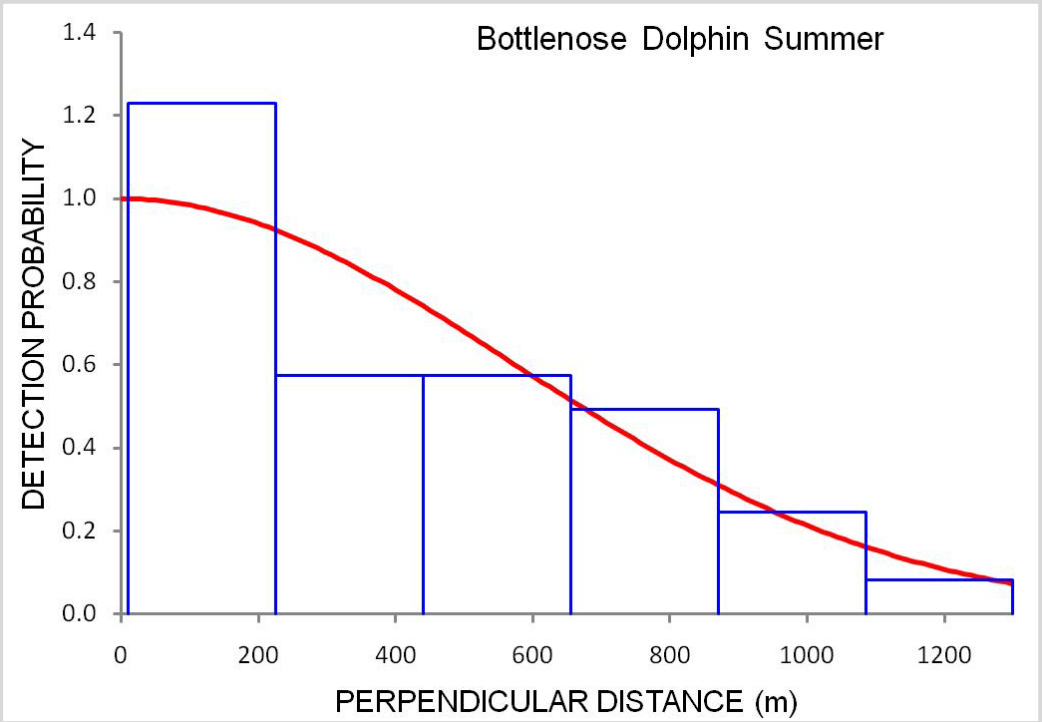

Figure 5-19. Histogram of observed distances truncated from 0 to 10 m and the fitted detection function for bottlenose dolphins during summer based on aerial survey data (half-normal key function with no adjustments). X^2=2.2289; DF=4; p=0.69373.

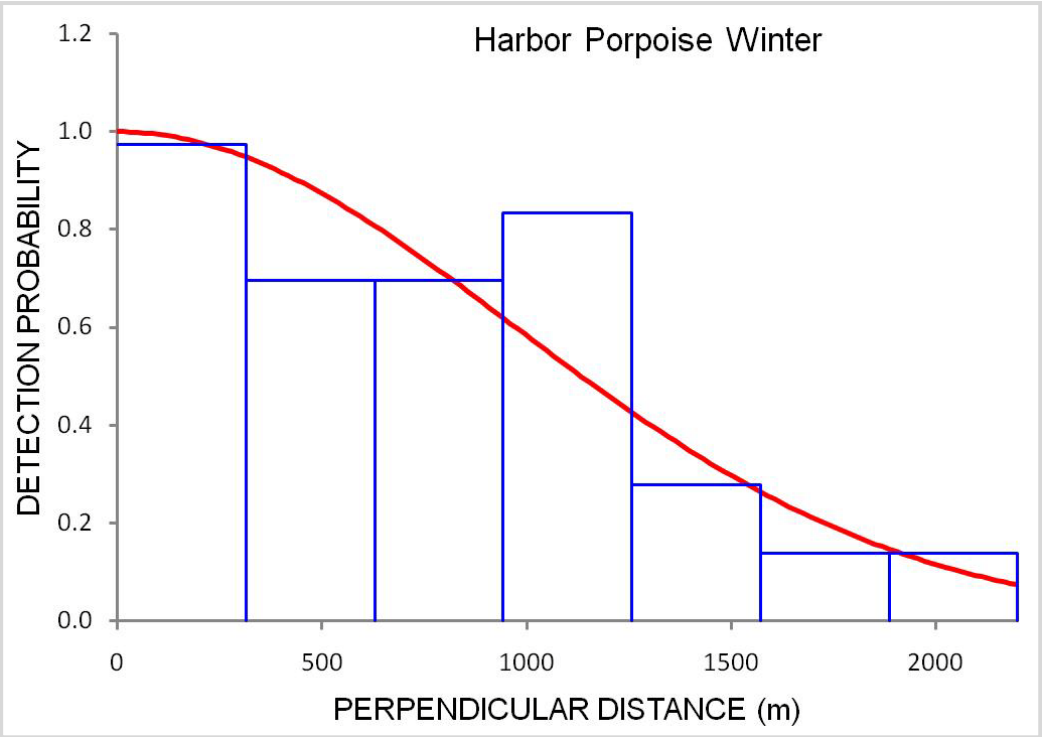

Figure 5-20. Histogram of observed distances truncated at 2,200 m and the fitted detection function for harbor porpoises during winter based on shipboard survey data (half-normal key function with no adjustments). X^2=1.9388; DF=5; p=0.85755.

5.1.4.2 Density Surface Modeling Results

Seasonal analyses were conducted using only covariate data, sightings, and effort from those seasons. Seasonal density surfaces could not be fitted for every species or group due to the limited number of sightings for some seasons. Many of the species occur in the Study Area seasonally; therefore, year-round density surfaces are not realistic for these seasonal species and were not generated. Due to the high variability in SSTs and chl *a* concentration in the Study Area during different seasons, these dynamic covariates were not used to fit the models for the year-round density surfaces. Only the static covariates (depth, offshore distance, and slope) were used for the year-round analyses.

Note that no density surfaces were predicted for all marine mammal species pooled together due to the known variability in habitat associations of the different species of marine mammals sighted in the Study Area. Also, many marine mammal species have different sighting characteristics and cannot be pooled for fitting detection functions. These differences in habitat associations, seasonal distributions, and sighting characteristics make fitting a density surface for all marine mammals difficult and unrealistic. Therefore, the density surfaces were fitted only to individual species or taxonomic groups consisting of species with similar habitat associations and sighting characteristics.

Density surfaces were fitted to the following species/groups:

Shipboard Data Analyses

1) Endangered marine mammals—year-round
2) Fin whale—year-round
3) Delphinids—winter
4) Bottlenose dolphin—spring
5) Bottlenose dolphin—summer
6) Harbor porpoise—winter

Aerial Data Analyses

7) Bottlenose dolphin—summer

Results of the DSM analyses for all of the seven species/groups, including the response surface model (GAM) results and the predicted abundances with corresponding 95% CIs from bootstrapping are summarized in **Table 5-6**. The GAM smooth functions were plotted depicting the interaction of covariates or the individual covariates selected for the species/groups. These plots and the surface maps of smoothed predicted densities of each species/group are displayed below. These maps show the fitted density surfaces for the Study Area. The total number of trackline segments used in each seasonal analysis was as follows: year-round (1,719), winter (166 for the harbor porpoise and 480 for delphinids), spring (381), summer (515), and summer aerial (230).

Endangered Marine Mammals (Shipboard Survey Data)

The following covariates were found to be important in predicting endangered marine mammal density during all seasons: longitude, latitude, depth, distance from shore, and slope (**Figures 5-21** through **5-24**). High densities of endangered marine mammals were predicted throughout the Study Area, particularly in the northern half of the Study Area (**Figure 5-25**). Peak density was predicted just offshore of Little Egg Harbor in waters between 2 and 18 km (1 to 10 NM) from shore and in water depths ranging from 12 to 23 m (39 to 75 ft). Another peak density region was predicted in the southeastern corner of the Study Area in waters around 26 m (85 ft) deep and 31 km (17 NM) from shore. The predicted abundance of approximately three individuals was the same as the abundance estimated from the CDS analysis.

Table 5-6. Response surface model (GAM) results and predicted abundances for each species/group analysis. This table includes the formula of the chosen response surface model, the percent deviance explained by the chosen model, the GCV score of the chosen model, and the predicted abundance and corresponding 95% bootstrap CI.

Species/Group	Formula*	% Deviance Explained	GCV score	Abundance (N)	95% CI(N)
Endangered Marine Mammals					
Year-round	N ~ *s(lon,lat)* + *s(depth)* + *s(distance)* + *s(slope)* + offset(off.set)	16.6	0.345	2.8	2.2-3.7
Fin Whale					
Year-round	N ~ *s(lon,lat)* + *s(depth)* + *s(distance)* + offset(off.set)	20.4	0.26	2.1	1.5-2.8
Delphinids					
Winter	N ~ *s(lon,lat)* + *s(distance)* + offset(off.set)	36.6	4.07	98	67-145
Bottlenose Dolphin					
Spring	N ~ *s(lon,lat)* + *s(depth)* + *s(distance)* + offset(off.set)	46.4	28.61	863	353-2,109
Summer	N ~ *s(lon,lat)* + *s(depth,distance)* + *s(sst,chl)* + offset(off.set)	42.8	18.18	272	228-325
Summer (Aerial)	N ~ *s(lon)* + *s(lat)* + *s(sst)* + offset(off.set)	36.1	28.04	1,655	874-3,133
Harbor Porpoise					
Winter	N ~ *s(lon)* + *s(lat)* + *s(distance)* + offset(off.set)	62.6	1.60	81	45-144

* *s(.)* denotes the inclusion of the covariate as a smooth function in the model: lon=longitude; lat=latitude; distance=distance from shore; sst=sea surface temperature; chl=surface chlorophyll *a* concentration. *s(x,y)* indicates a 2-dimensional smooth function (bivariate) while *s(x)* indicates a 1-dimentional smooth function (univariate).

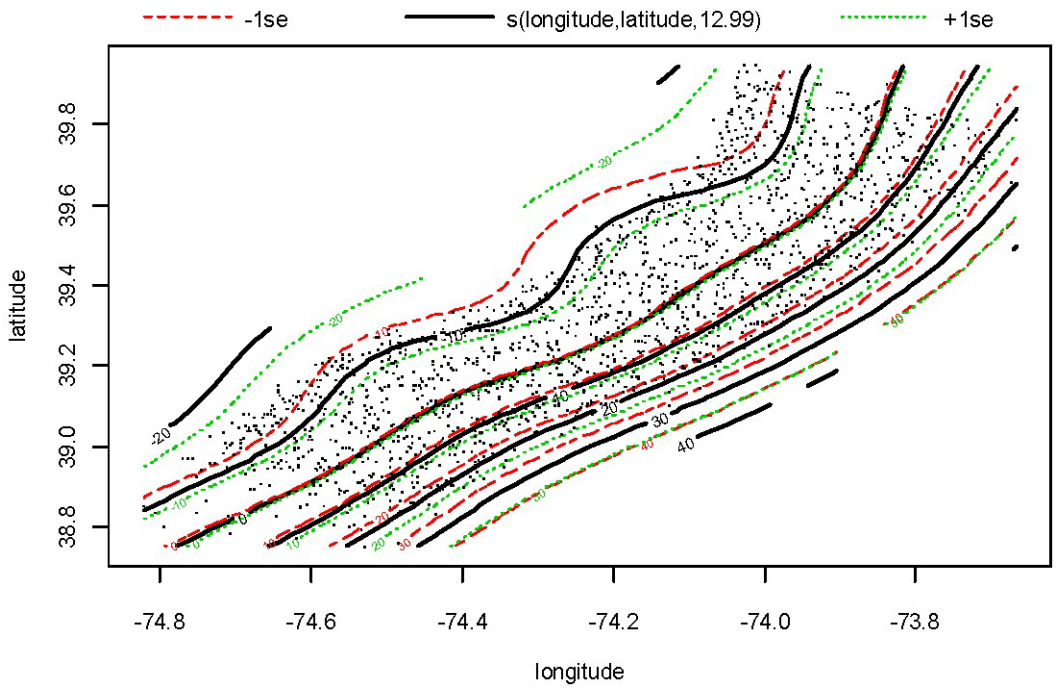

Figure 5-21. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 standard error (SE) confidence limit, and dashed red lines represent the +1 SE confidence limit.

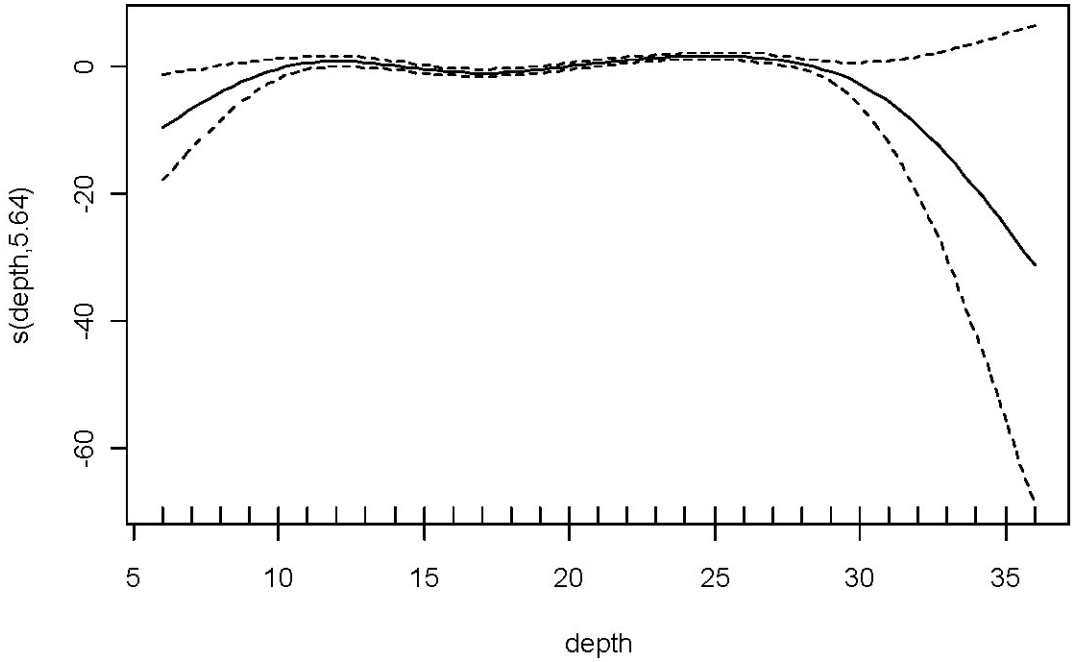

Figure 5-22. Plot of the GAM smooth fit depicting the environmental covariate depth (m) selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

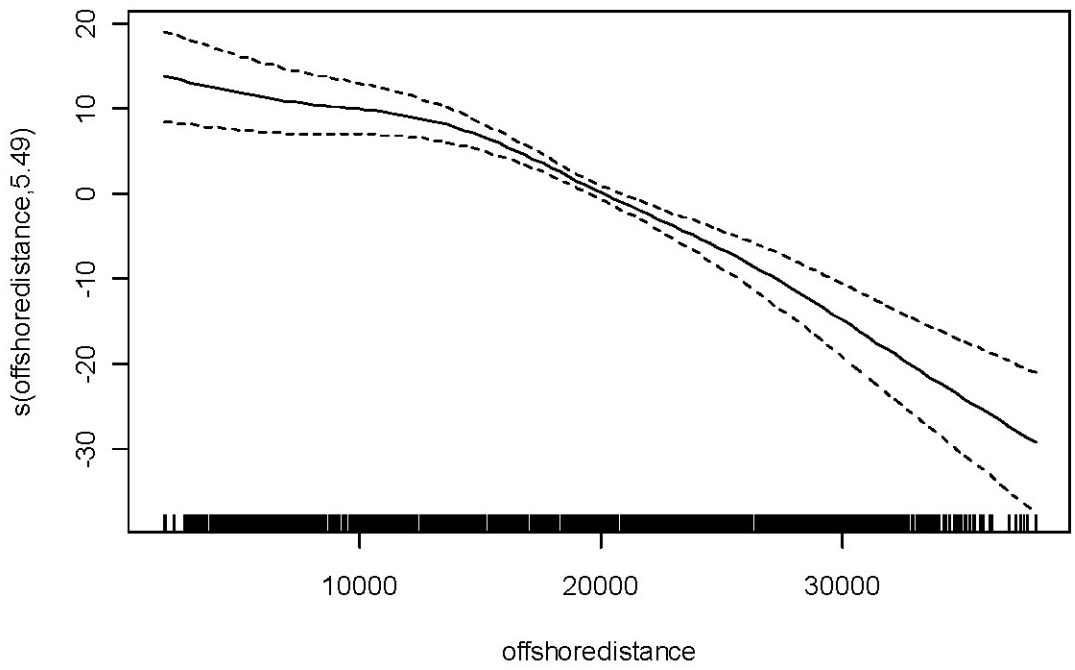

Figure 5-23. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

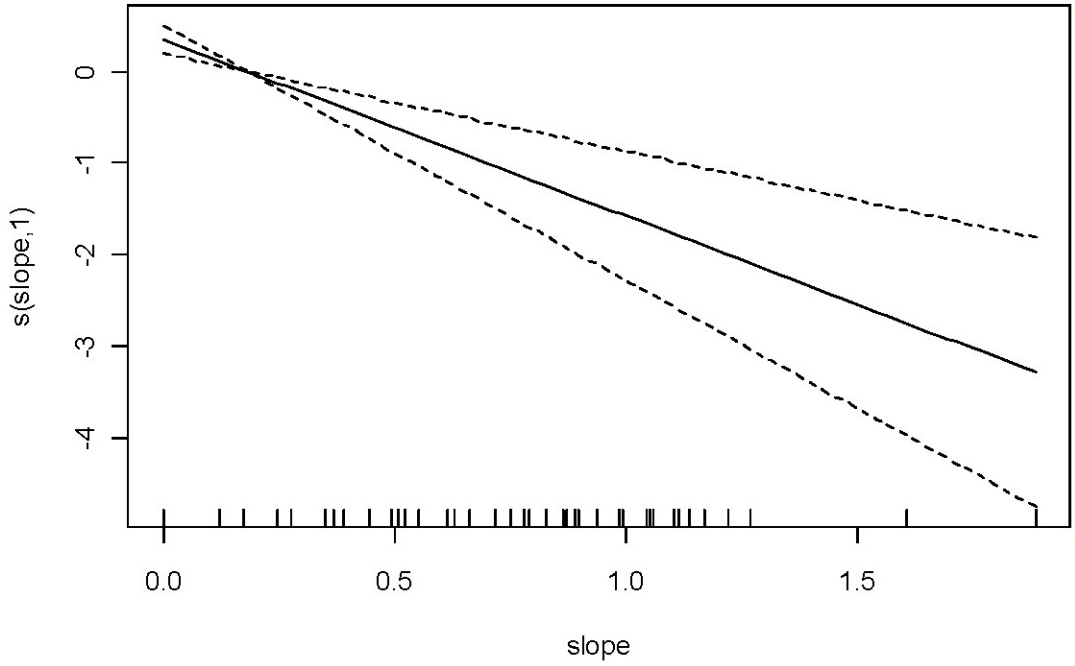

Figure 5-24. Plot of the GAM smooth fit depicting the environmental covariate slope (°) selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

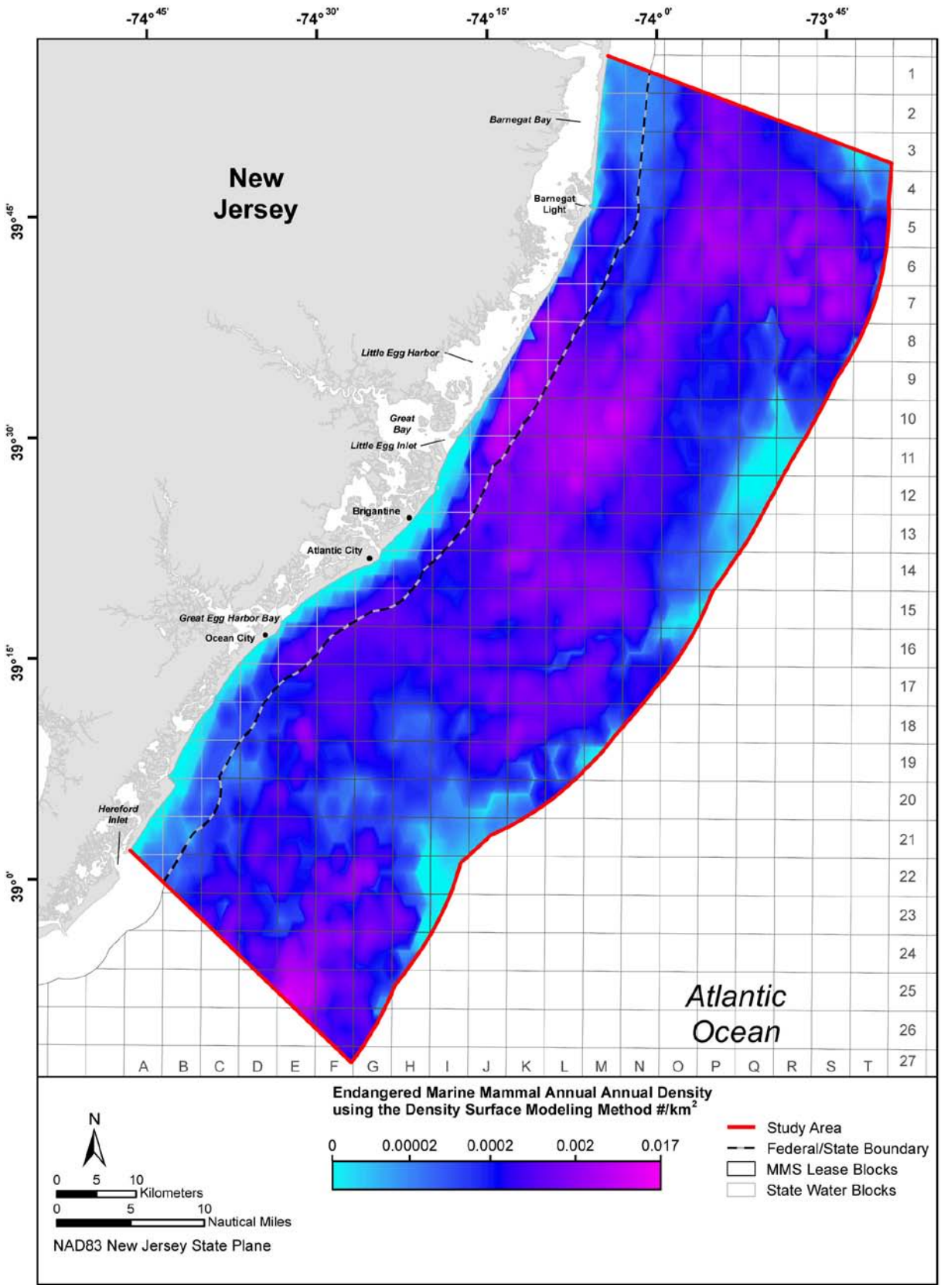

Figure 5-25. Surface map of smoothed predicted density of endangered marine mammals during all seasons in the Study Area based on shipboard survey data.

Fin Whale (Shipboard Survey Data)

The spatial model predicted high densities of fin whales throughout much of the Study Area. Because the fin whale was the dominant species in the endangered marine mammal and all whales groups, the predicted surface density of this species is very similar to the predicted densities of the other two groups. The covariates found to influence the predicted density of the fin whale during all seasons included longitude, latitude, depth, and offshore distance (**Figures 5-26** through **5-28**). Relatively high densities are predicted for this species throughout the Study Area (**Figure 5-29**). The peak density regions are similar to the peak density regions for the endangered marine mammals and all whales groups. The highest densities were predicted offshore of Little Egg Harbor between 2 and 18 km (1 to 10 NM) from shore and in water depths ranging from 12 to 23 m (39 to 75 ft). The predicted abundance of two individuals was the same as the estimated abundance from the CDS analysis.

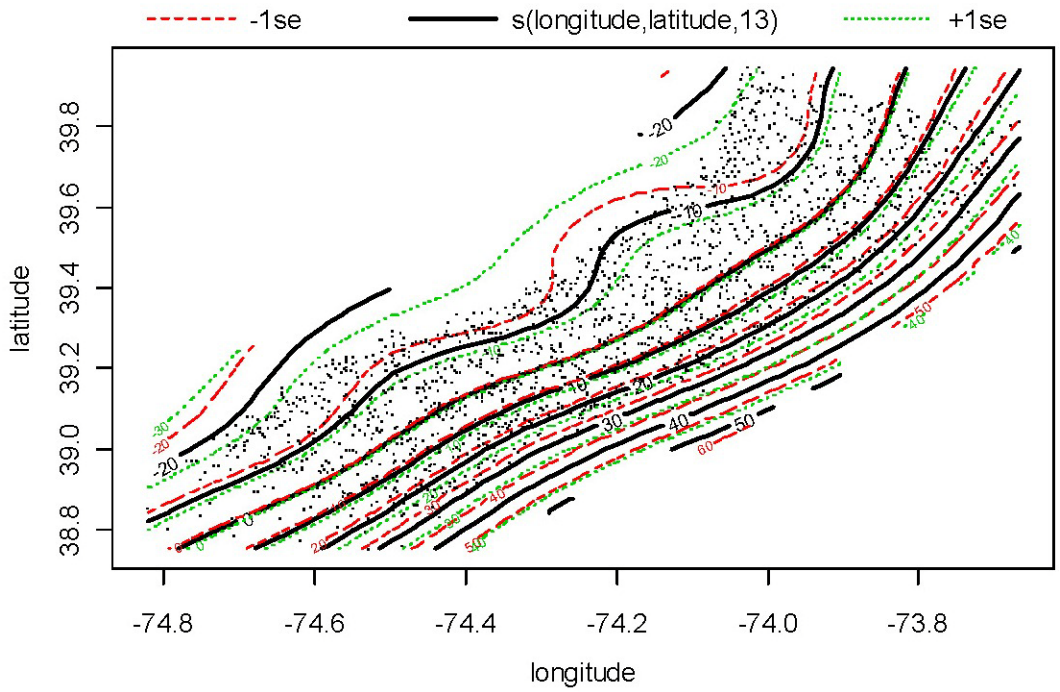

Figure 5-26. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for the fin whale during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

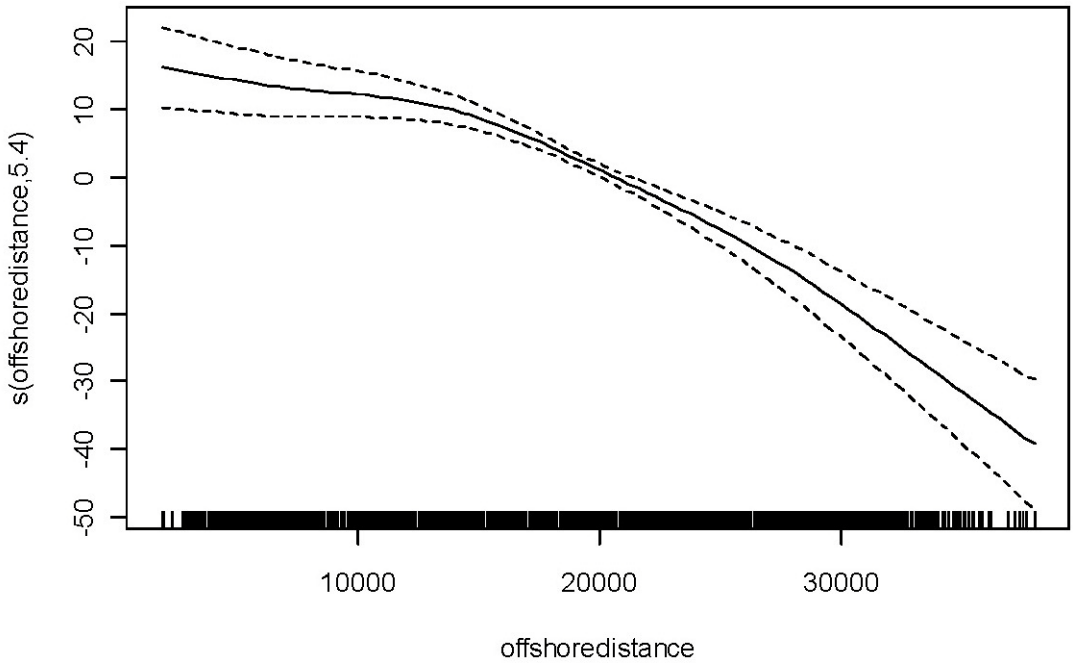

Figure 5-27. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for the fin whale during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

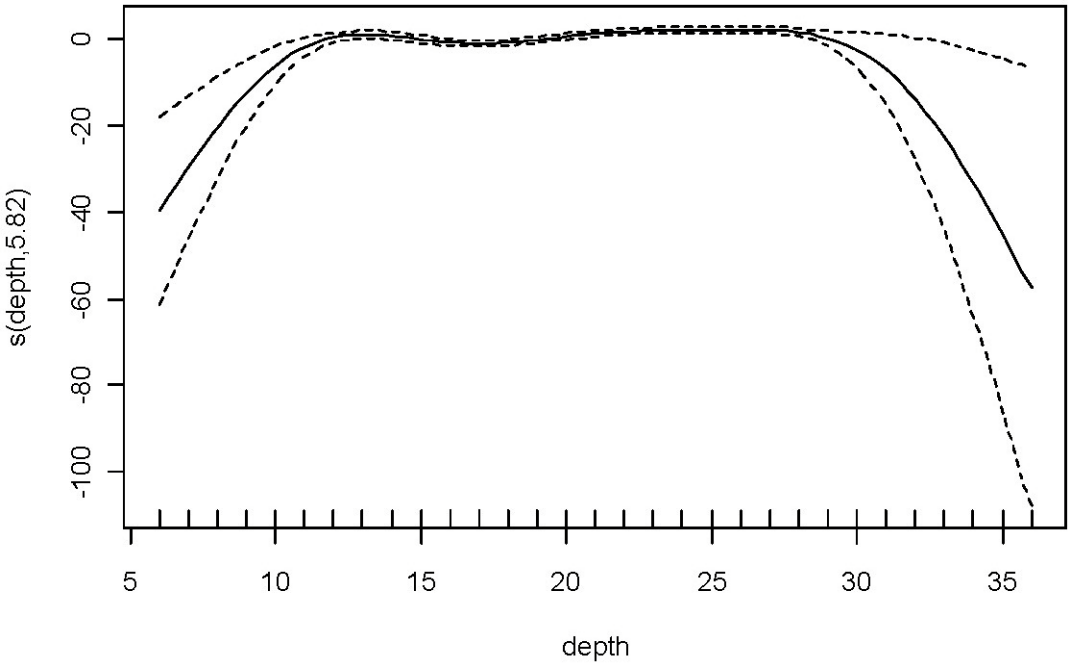

Figure 5-28. Plot of the GAM smooth fit depicting the environmental covariate depth (m) selected for the fin whale during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

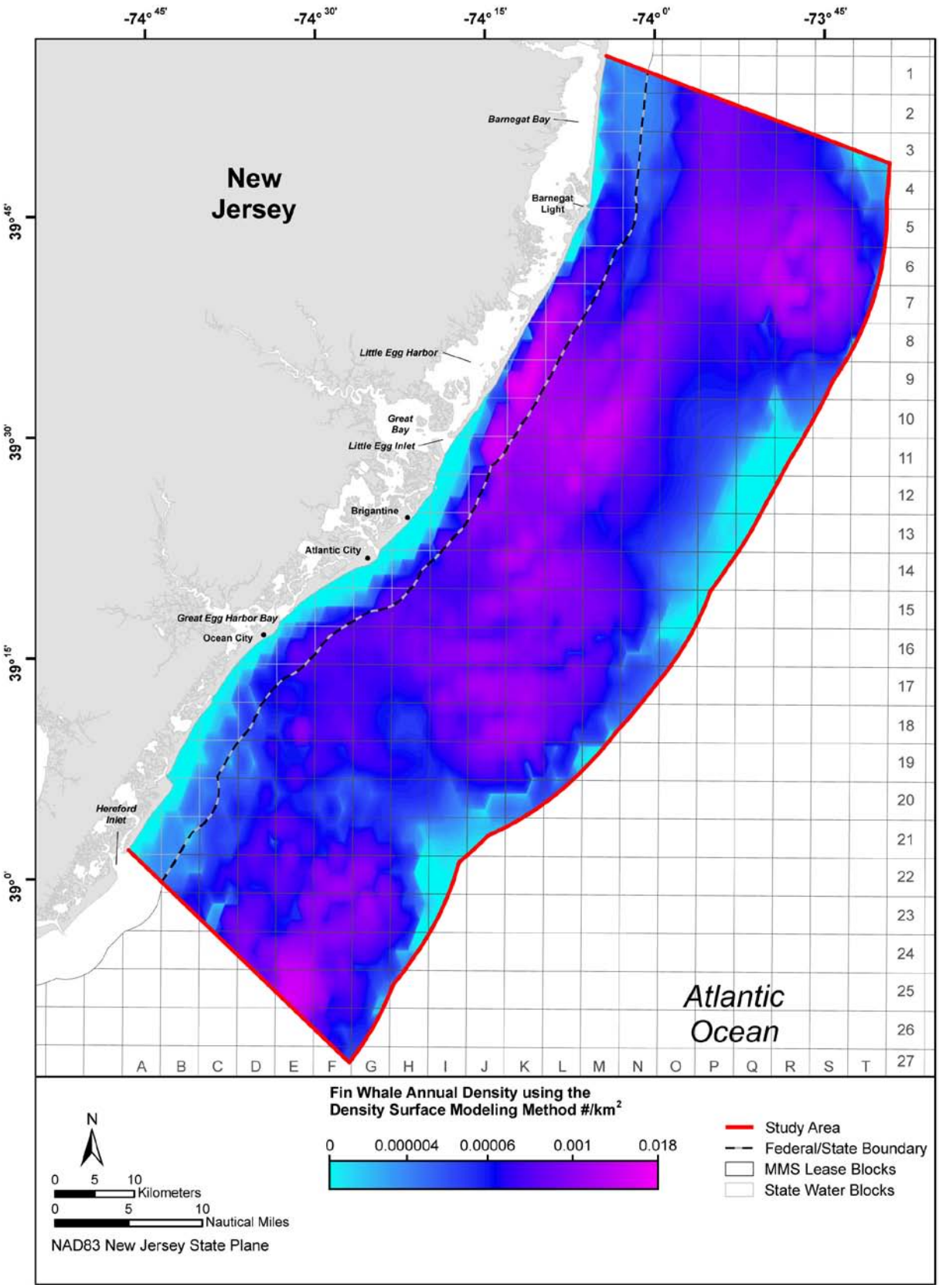

Figure 5-29. Surface map of smoothed predicted density for the fin whale during all seasons in the Study Area based on shipboard survey data.

Delphinids (Shipboard Survey Data)

All of the spring sightings of delphinids were of bottlenose dolphins except for three sightings which were recorded as unidentified dolphins because species identifications could not be confirmed. In addition, all summer sightings of delphinids were of bottlenose dolphins except for one unidentified dolphin. Based on this information, the delphinids as a group was not modeled for spring or summer. The bottlenose dolphin spring and summer models are discussed below. Although there were not enough sightings data to conduct a separate analysis for the short-beaked common dolphin, the majority of delphinid sightings recorded during winter were of short-beaked common dolphins. The rest of the delphinid sightings during this time of year were suspected to be of the same species but could not be confirmed. Longitude, latitude, and offshore distance were the covariates that were chosen as predictors of delphinid density during the winter (**Figures 5-30** and **5-31**). High densities were predicted in the southernmost portion of the Study Area and between 39°06'41"N and 39°43'00"N in the center of the Study Area (**Figure 5-32**). Peak densities were predicted in nearshore waters (0 to 5.5 km [0 to 3 NM] from shore) from Atlantic City to Little Egg Inlet and 30 km offshore of Little Egg Harbor. Peak densities were also predicted between 21 and 32 km (11 to 17 NM) from shore in the southeastern portion of the Study Area. The predicted winter abundance of 98 individuals was similar to the estimated abundance of 90 individuals from the CDS analysis of delphinids during winter.

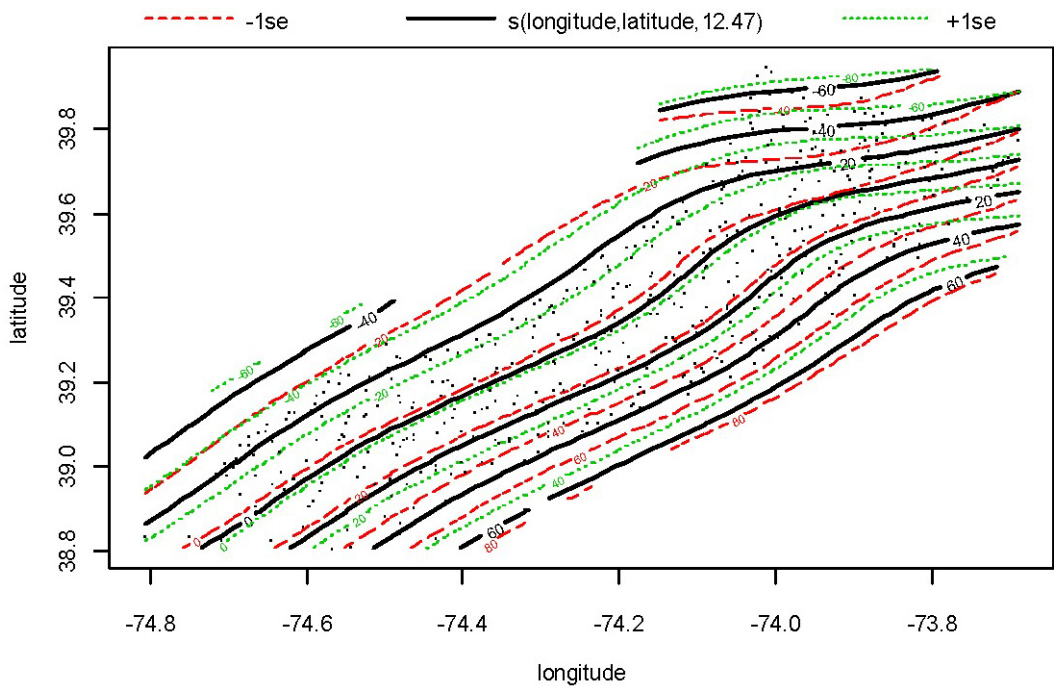

Figure 5-30. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for delphinids during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

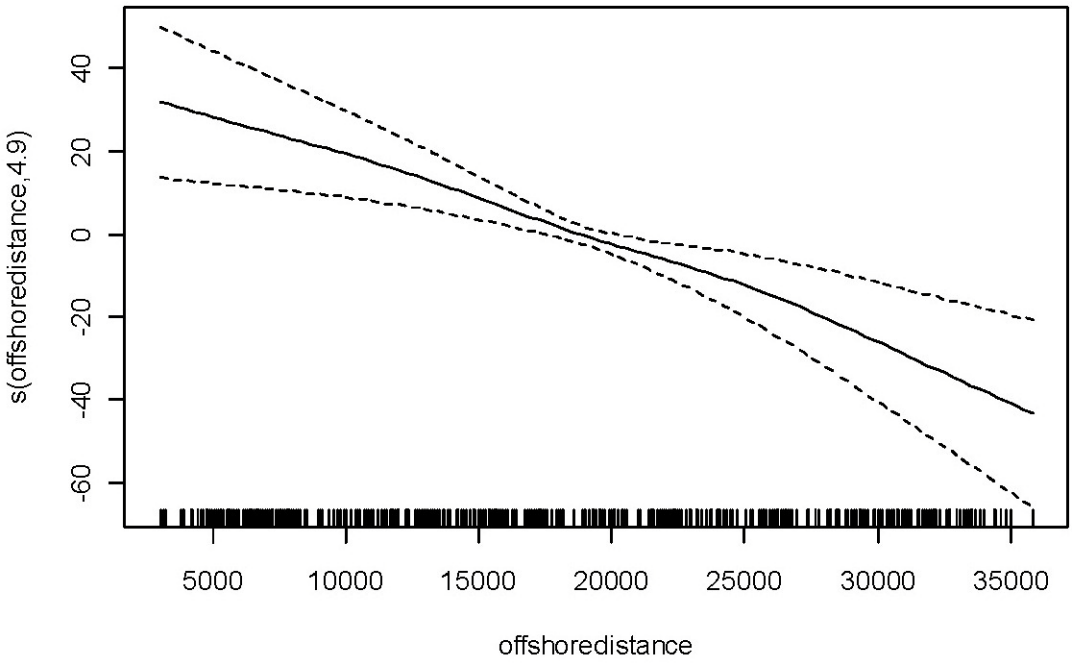

Figure 5-31. Plot of the GAM smooth fit depicting the interaction of the covariate offshore distance (m) selected for delphinids during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

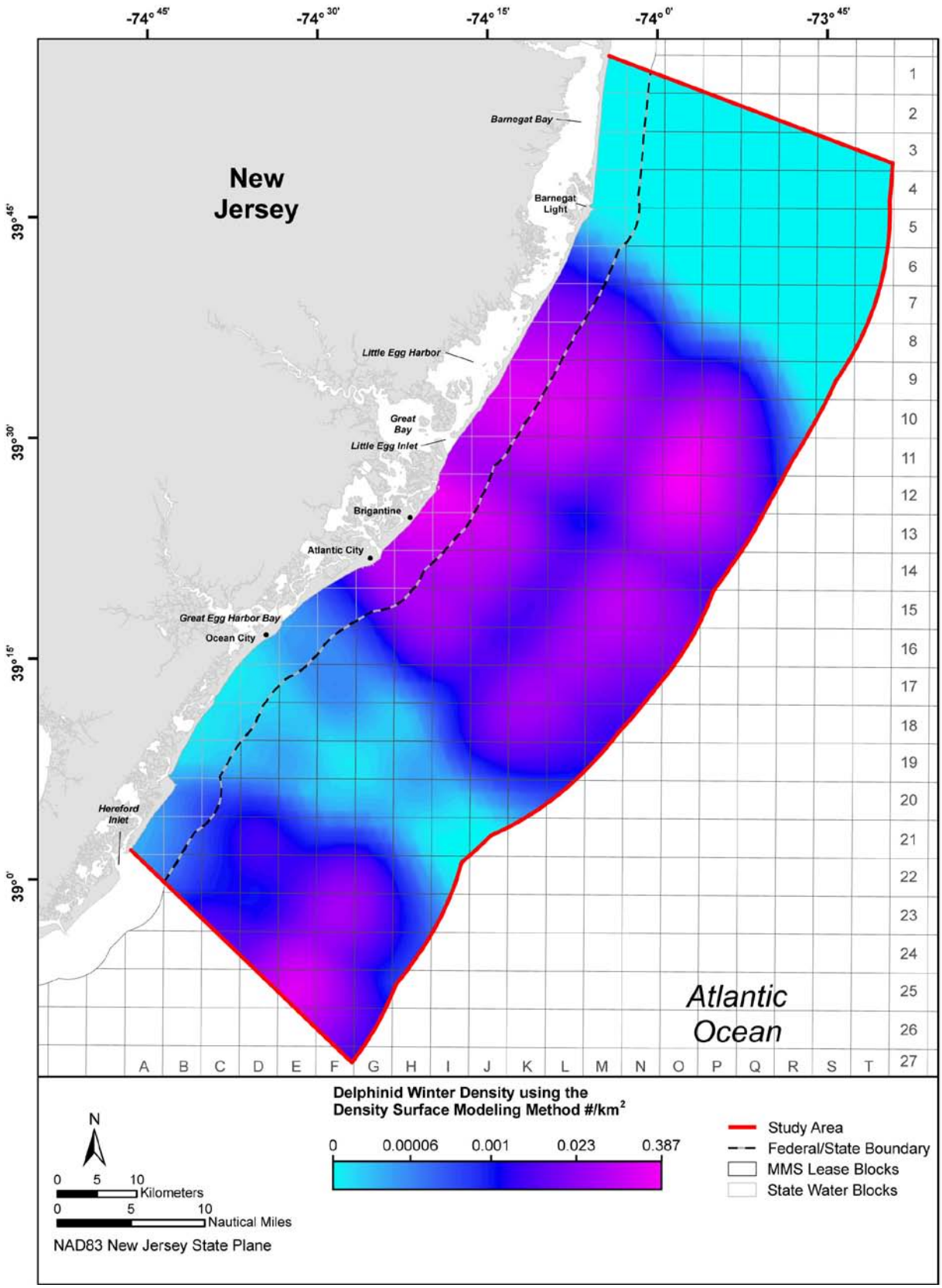

Figure 5-32. Surface map of smoothed predicted density for delphinids during winter in the Study Area based on shipboard survey data.

Bottlenose Dolphin (Shipboard and Aerial Survey Data)

The following covariates were found to be important in predicting the density of bottlenose dolphins during spring using the shipboard survey data: latitude, longitude, depth, and offshore distance (**Figures 5-33** through **5-35**). High densities of this species were predicted south of around 39°37'32"N (south of Barnegat Light) between the shoreline and 28 km (15 NM) from shore in waters ranging from near 0 to 27 m (0 to 89 ft) in depth (**Figure 5-36**). Peak densities were predicted in state waters (0 to 5.5 km [0 to 3 NM] from shore) between Atlantic City and Little Egg Harbor in waters ranging from near 0 to 17 m in depth (0 to 56 ft). The predicted abundance of 863 individuals was higher than the estimate of 722 individuals generated from the CDS analysis.

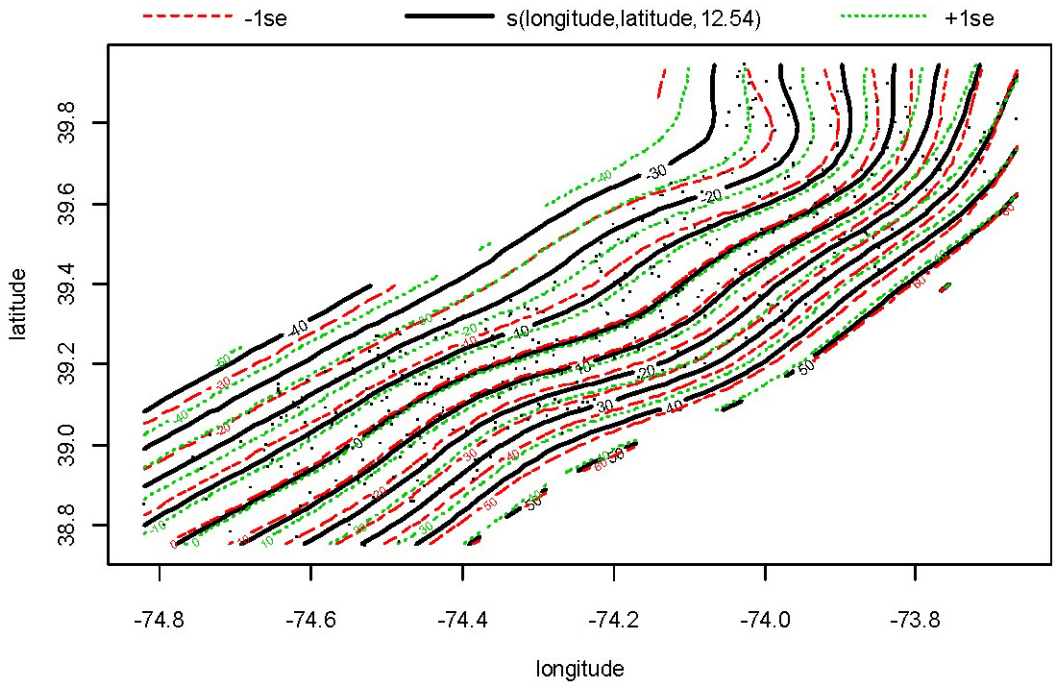

Figure 5-33. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for bottlenose dolphins during spring in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

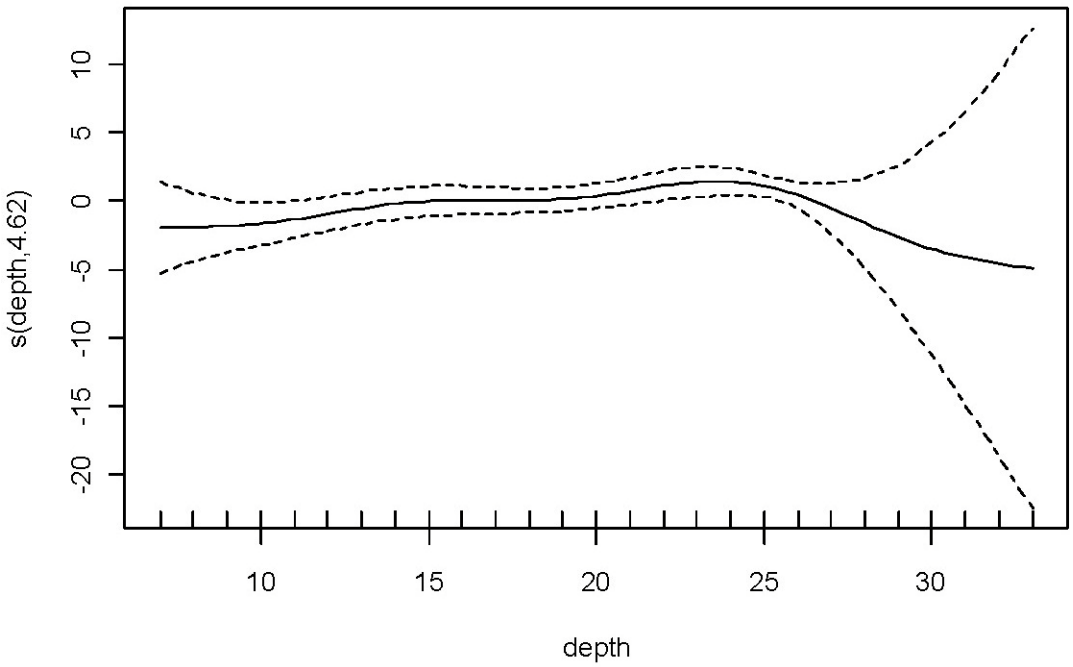

Figure 5-34. Plot of the GAM smooth fit depicting the environmental covariate depth (m) selected for bottlenose dolphins during spring in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

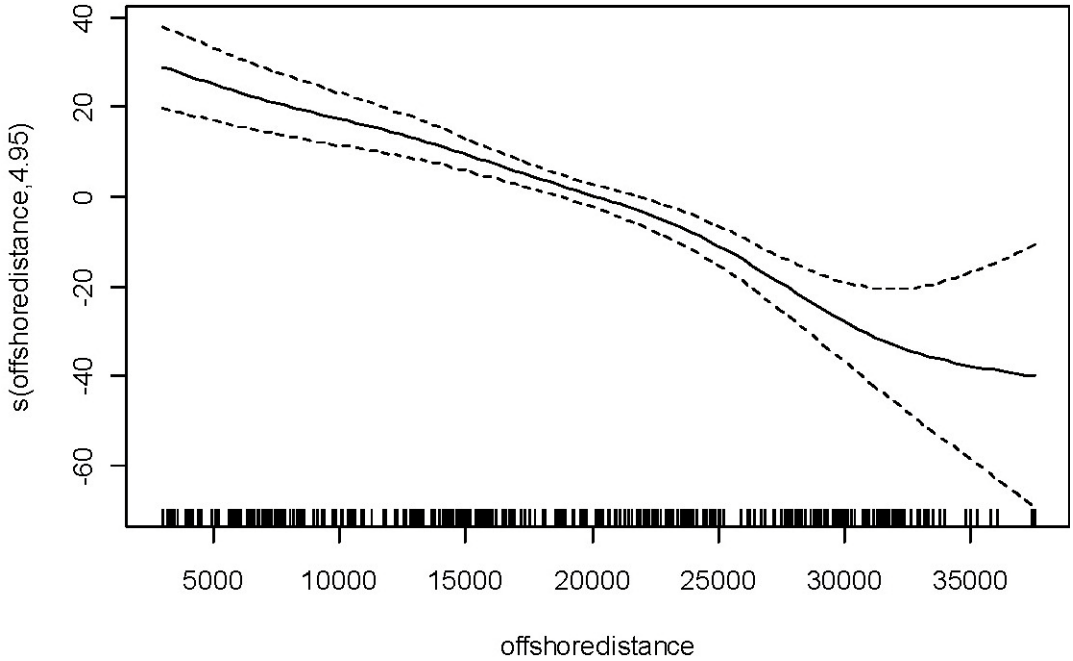

Figure 5-35. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for bottlenose dolphins during spring in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

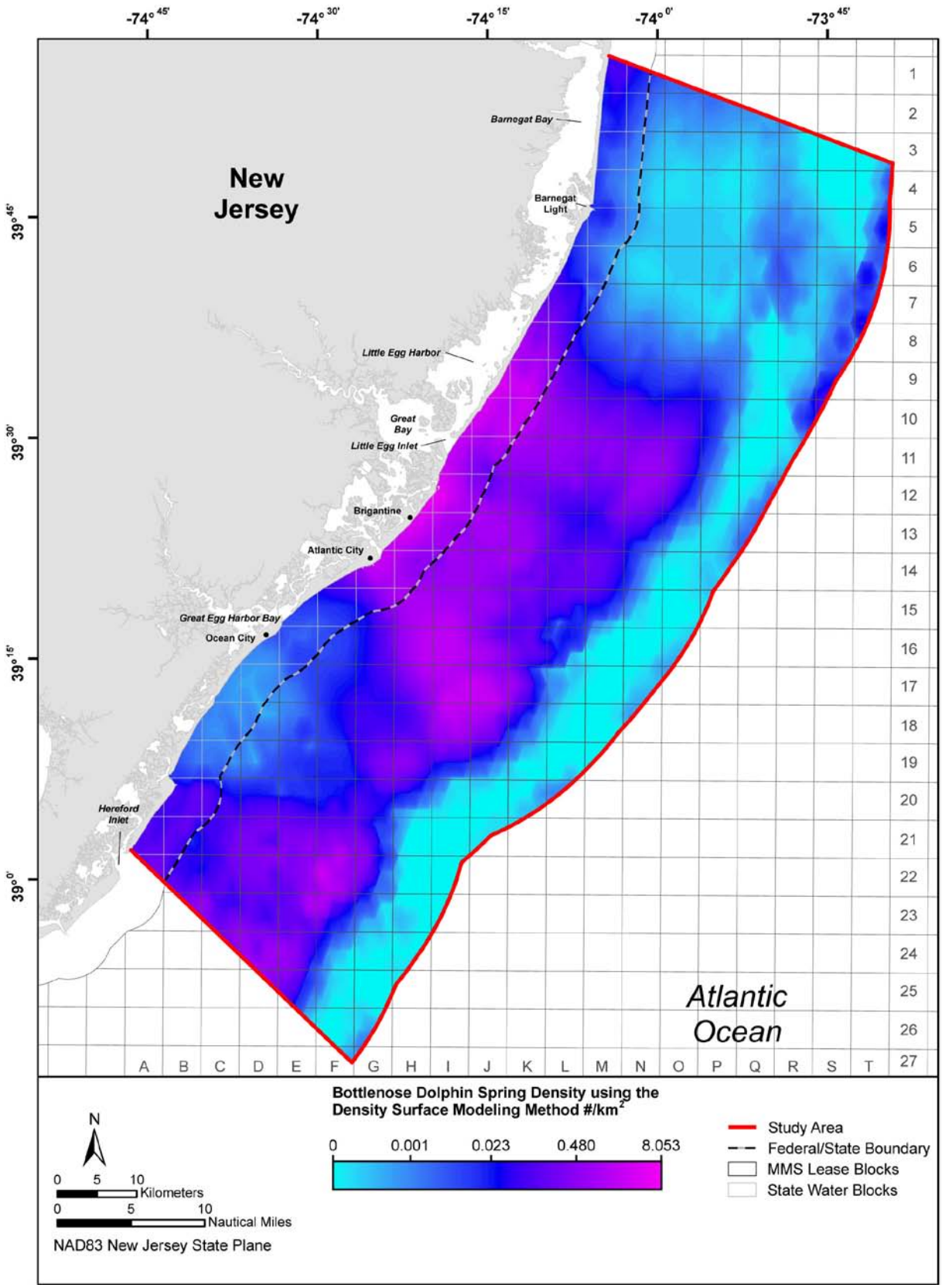

Figure 5-36. Surface map of smoothed predicted density for bottlenose dolphins during spring in the Study Area based on shipboard survey data.

The density of bottlenose dolphins during summer was predicted from both the shipboard and aerial survey data. Based on the shipboard survey data, the predicted density of bottlenose dolphins during summer varied from the spring predictions due to the different covariates chosen from the best-fit model. Latitude, longitude, depth, distance from shore, SST, and chl *a* were the covariates found to be important in predicting the density of bottlenose dolphins during summer (**Figures 5-37** through **5-39**). High densities were predicted in waters around 5.5 to 36 km (3 to 19 NM) from shore and between the 10- and 20-m (33- to 66-ft) isobaths (**Figure 5-40**). Peak densities were predicted 5.5 to 36 km (3 to 19 NM) offshore of Barnegat Light in a region where the chl *a* values were between 2 and 4 mg/m^3 (**Figure 5-40**). Peak densities were also predicted along the federal/state boundary (5.5 km [3 NM] from shore). The predicted abundance of 272 individuals was similar to the 289 individuals estimated from the CDS analysis.

Based on the aerial survey data, the predicted summer density of bottlenose dolphins was influenced by longitude, latitude, and SST (**Figures 5-41** and **5-42**). High densities extended from the southern to northern boundaries of the Study Area and included some offshore waters (**Figure 5-43**). Peak densities were predicted in the northern half of the Study Area, particularly in nearshore waters off Barnegat Light and Barnegat Bay. The predicted abundance of 1,655 individuals was slightly higher than the 1,297 individuals estimated from the CDS analysis.

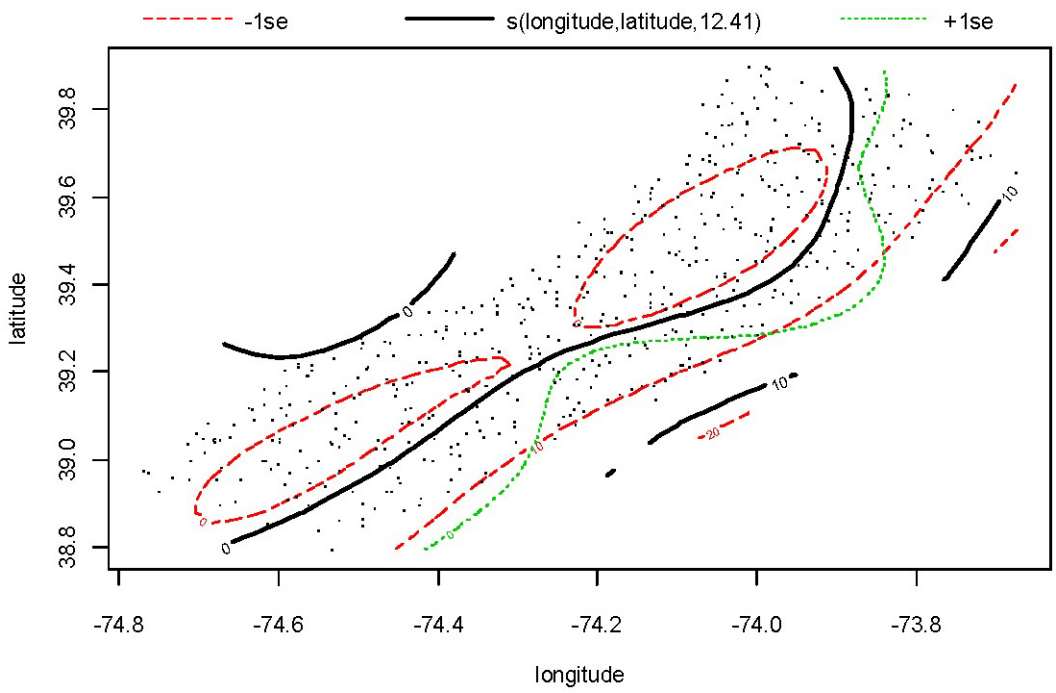

Figure 5-37. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for bottlenose dolphins during summer in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

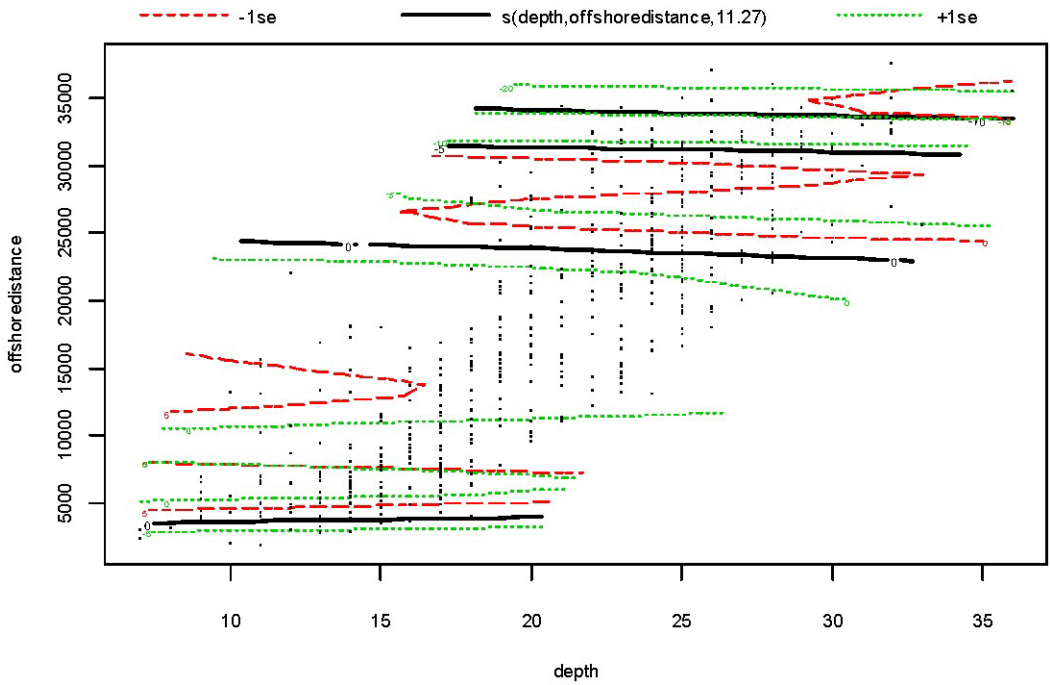

Figure 5-38. Plot of the GAM smooth fit depicting the interaction of the covariates depth (m) and offshore distance (m) selected for bottlenose dolphins during summer in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

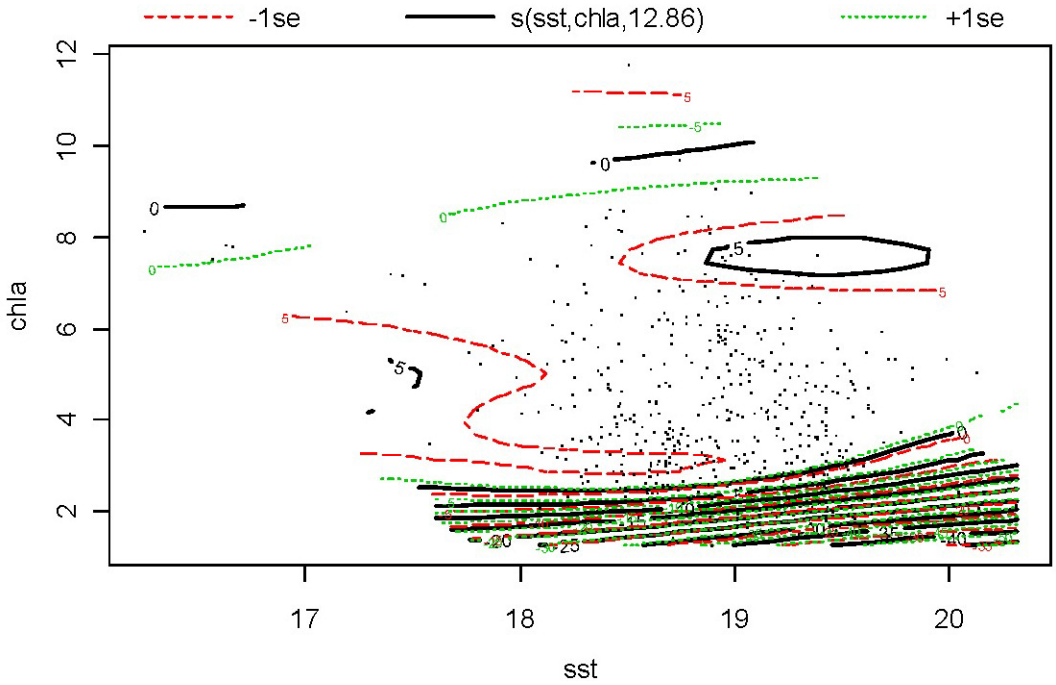

Figure 5-39. Plot of the GAM smooth fit depicting the interaction of the covariates SST (°C) and chl a (mg/m3) selected for bottlenose dolphins during summer in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

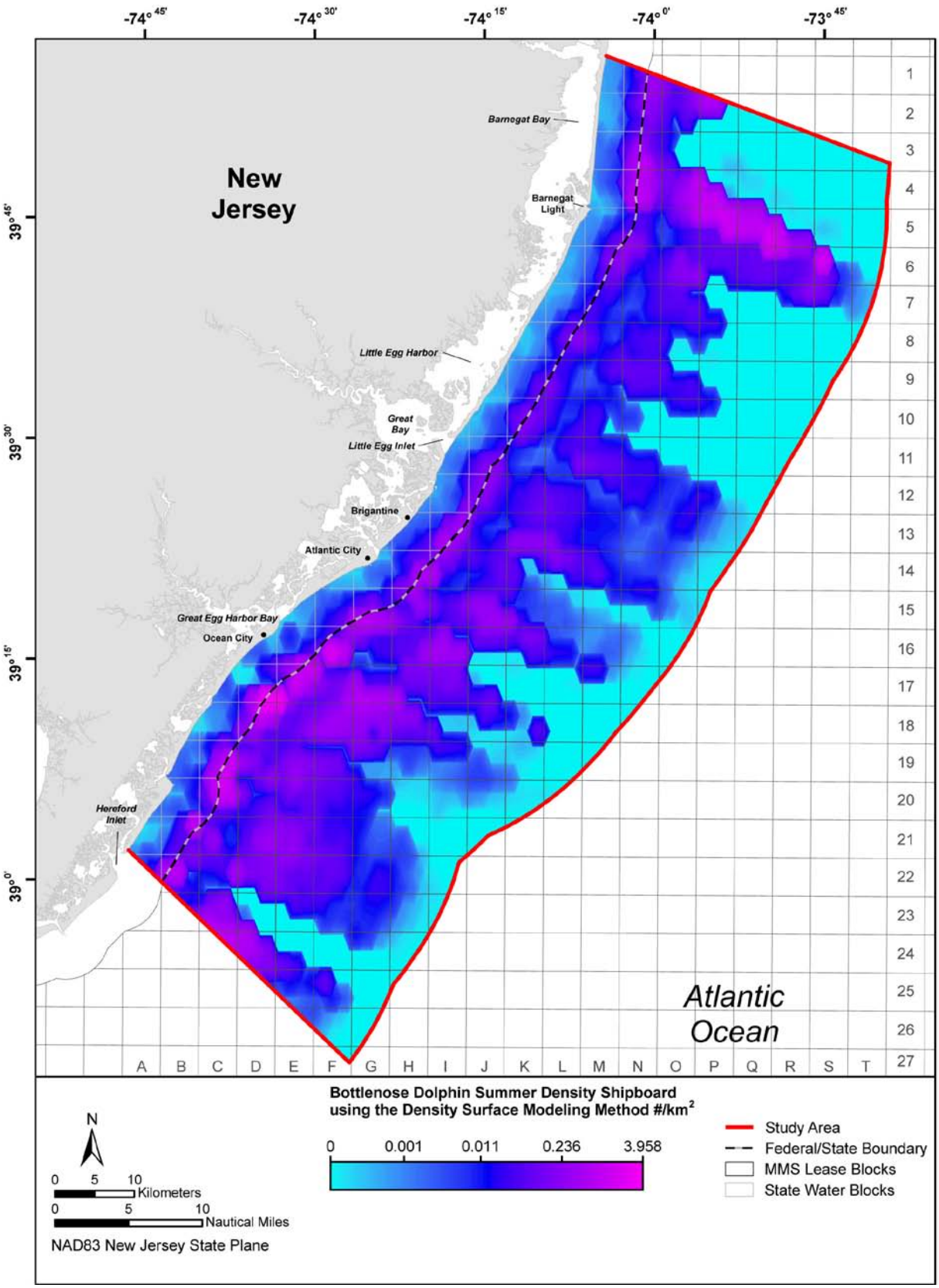

Figure 5-40. Surface map of smoothed predicted density for bottlenose dolphins during summer in the Study Area based on shipboard survey data.

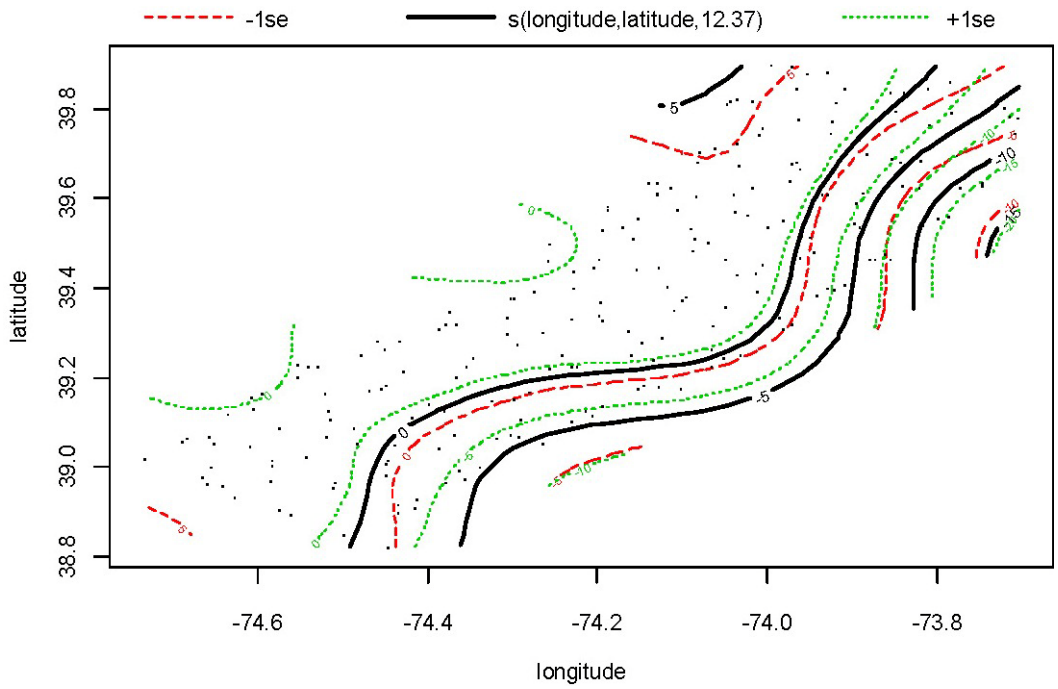

Figure 5-41. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for bottlenose dolphins during summer in the Study Area based on aerial survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

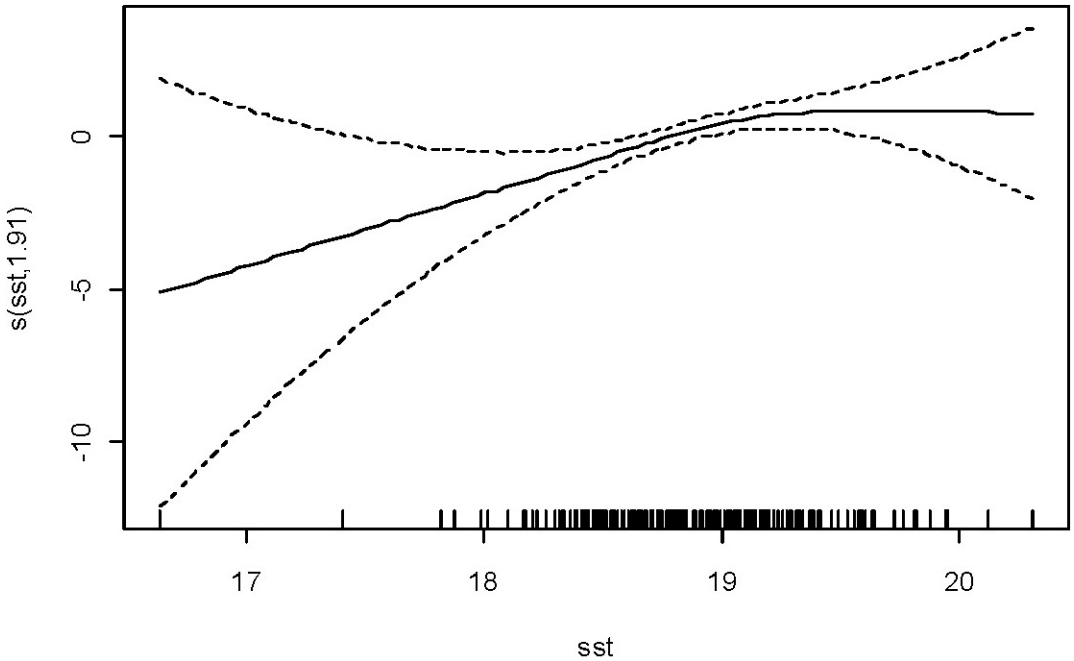

Figure 5-42. Plot of the GAM smooth fit depicting the covariate SST (°C) selected for bottlenose dolphins during summer in the Study Area based on aerial survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

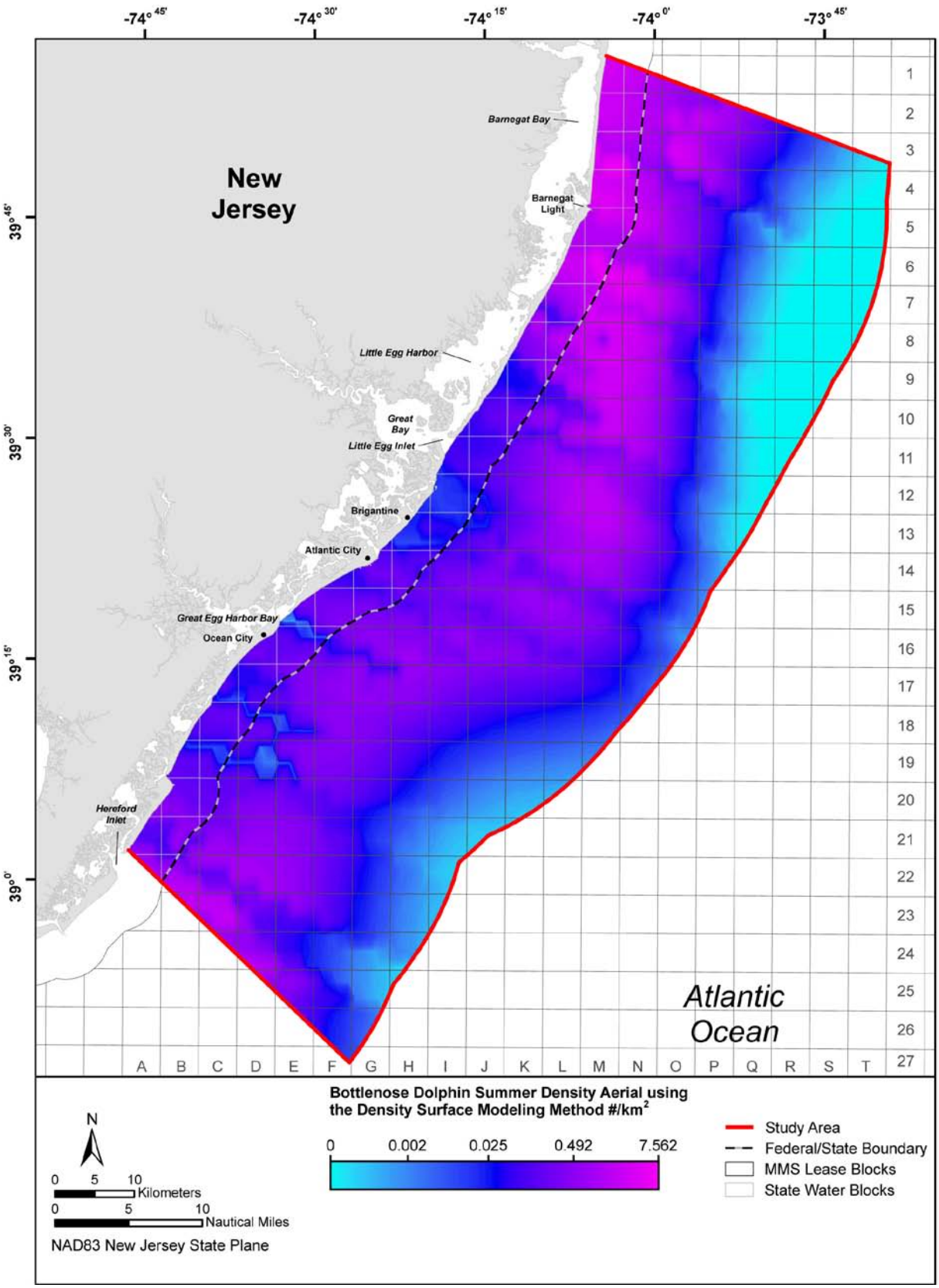

Figure 5-43. Surface map of smoothed predicted density for bottlenose dolphins during summer in the Study Area based on aerial survey data.

Harbor Porpoise (Shipboard Survey Data)

The covariates latitude, longitude, and offshore distance influenced the predicted density of harbor porpoises in the Study Area during winter (**Figures 5-44** through **5-46**). The spatial model predicted high densities of harbor porpoises in the center of the Study Area between 39°04'10"N and 39°45'34"N and between -74°26'41"W and -73°53'36"W (**Figure 5-47**). Peak densities were predicted from the federal/state boundary (5.5 km [3 NM]) to 15 km (8 NM) from shore. Another region of peak density was predicted north of Brigantine in waters 34 km (18 NM) from shore. The predicted abundance was estimated to be 81 individuals which is close to the estimated abundance of 98 individuals from the CDS analysis.

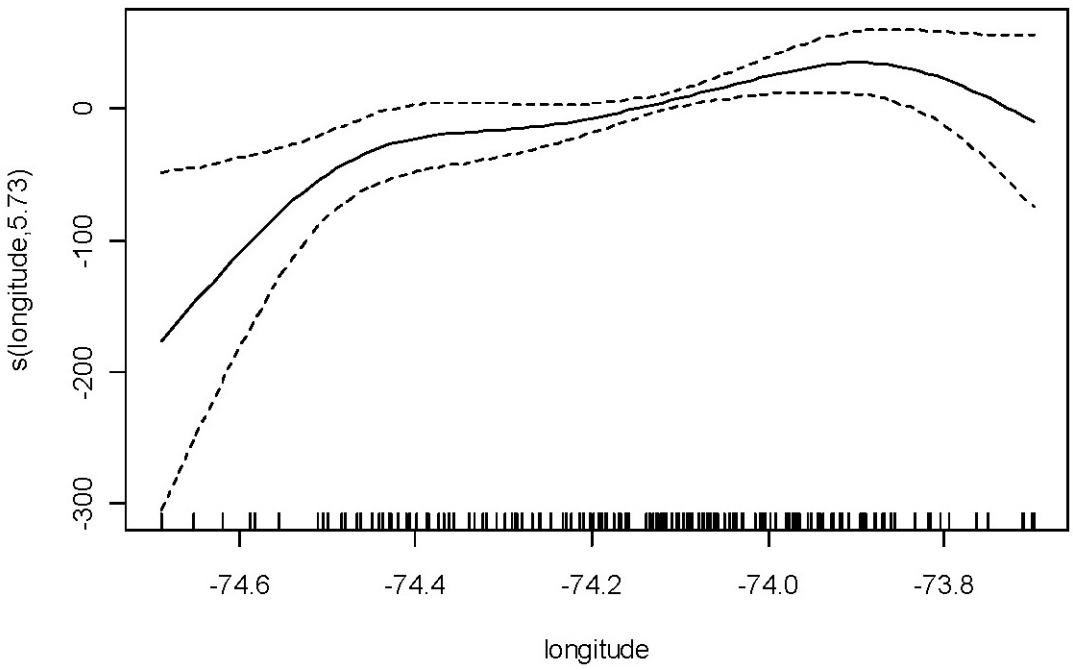

Figure 5-44. Plot of the GAM smooth fit depicting the interaction of the covariate longitude selected for harbor porpoises during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

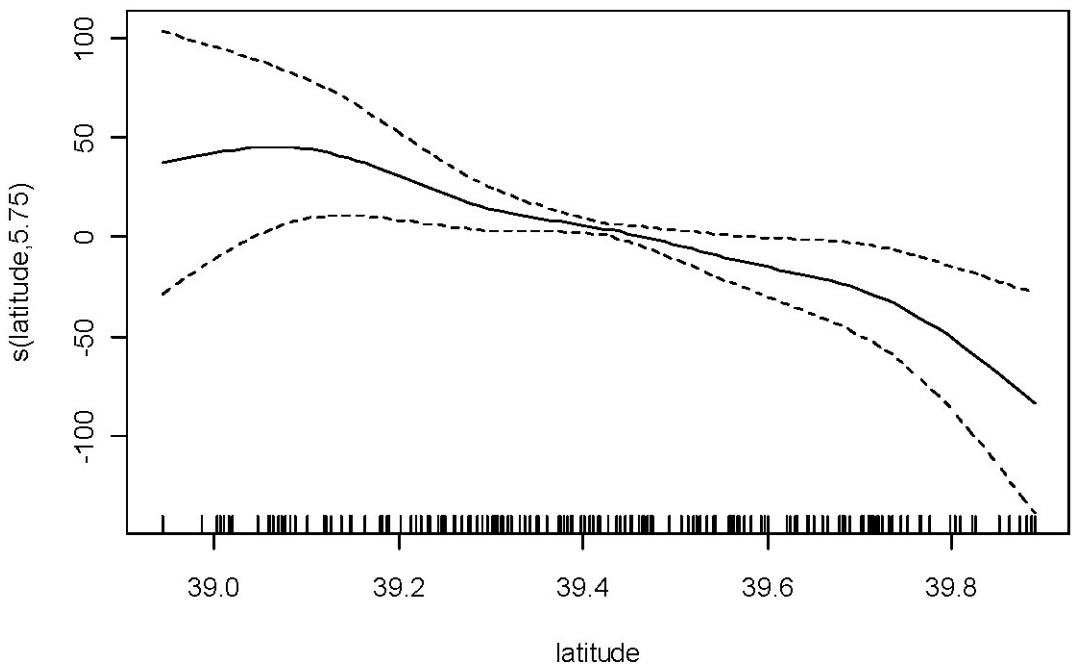

Figure 5-45. Plot of the GAM smooth fit depicting the interaction of the covariate latitude selected for harbor porpoises during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

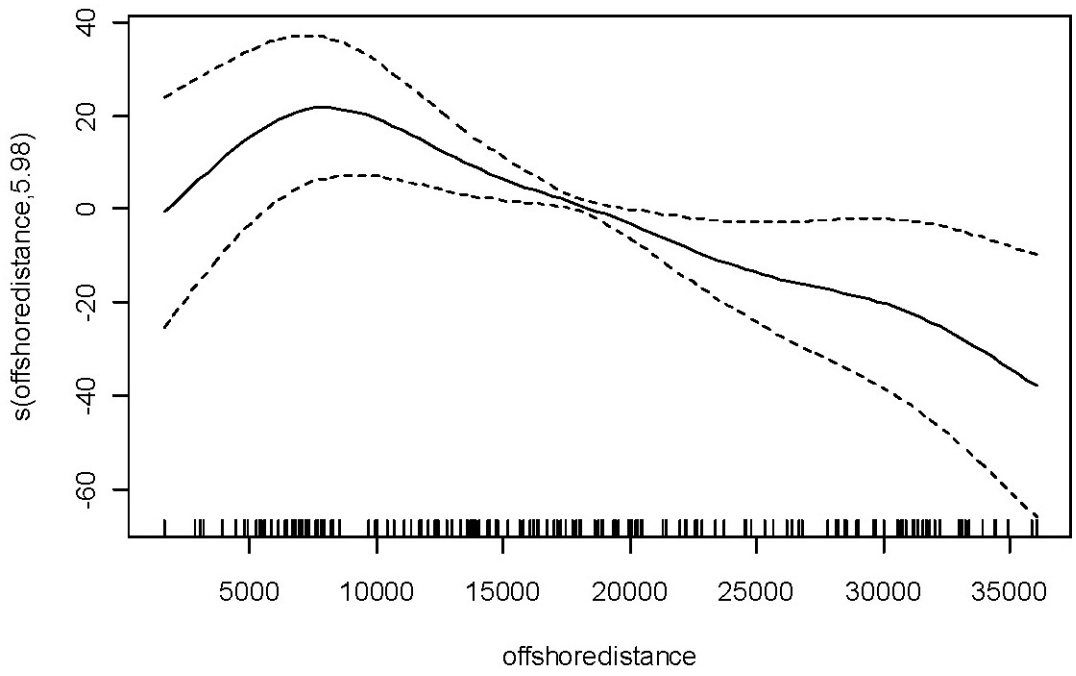

Figure 5-46. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for harbor porpoises during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed data values.

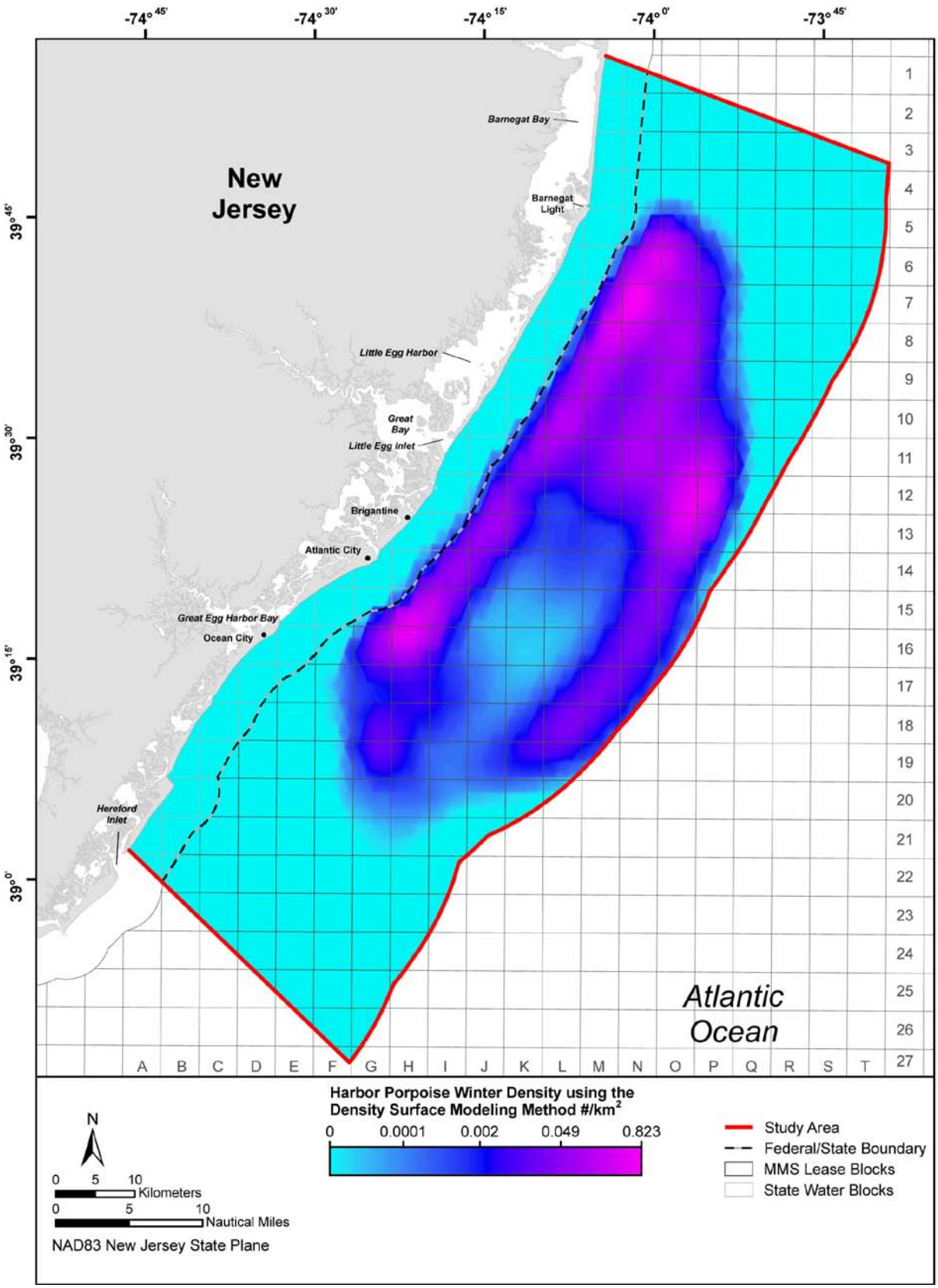

Figure 5-47. Surface map of smoothed predicted density for harbor porpoises during winter in the Study Area based on shipboard survey data.

5.2 ACOUSTIC MONITORING RESULTS

5.2.1 Deployment/Recovery Results

Four pop-ups were recovered from the March 2008 deployment and yielded 8,000 hrs of data. PU039 at S1 was lost and has not been recovered. PU081, PU063, and PU134 (S4, S3, and S5, respectively) each presented data from 26 March 2008 to 17 June 2008 (**Table 4-1** found on **page 4-3**). PU086 (S2) stopped recording 17 days early and presented data from 26 March 2008 to 30 May 2008 (**Table 4-1**). Potential reasons for PU086's cessation in recording have not been determined.

All four pop-ups were recovered from the June 2008 deployment. Two units were fitted with a 2-kHz sample rate (PU063, PU134) while two had a 32-kHz sample rate (PU081, PU086). PU063 and PU081 (S1, S2, respectively) both presented data from 24 June 2008 to 17 September 2008 (**Table 4-1**); PU134 (S5) was deployed for one additional day and thus presented data from 24 June to 18 September 2008 (**Table 4-1**). The burn unit on PU134 did not respond to the acoustic tone and was recovered by a diver. PU086 (S4) stopped recording early with data captured from 24 June to 17 August 2008 (**Table 4-1**). The electronics and hardware for PU086 were returned to BRP for diagnostics and replacement parts were used for the September 2008 deployment.

Three pop-ups (PU086, PU202, and PU203) were recovered from the September 2008 deployment with each unit presenting data for the two-month deployment period. PU063 and PU081 (S1 and S2, respectively) did not respond to acoustic signals and seemed to be missing from the site. Neither of these units has been recovered or found.

No pop-ups were recovered during the initial recovery effort in March 2009 for pop-ups deployed in December 2008. The weather conditions were marginal (1.5- to 2-m [5- to 7-ft] swells, 15 to 25 miles per hour [mph; 24 to 40 kph]) east-northeast winds and surface chop of 1 to 1.5 m [3 to 5 ft]). Recovery of four units (S5, S4, S3, and S2) was attempted during this time. Two units (S4 [PU086] and S5 [PU203]) did not respond to acoustic cues to surface. A cross-search pattern to each of the four geographic coordinates while monitoring a fish finder and the sea surface suggested that the pop-ups were no longer at depth where originally deployed. Two units (S3 [PU202] and S2 [PU134]) responded to audio cues to surface but did not rise to the surface. The weather precluded a return to sea to attempt a recovery of the fifth unit (S1a [PU179]) or to attempt a diver-assisted recovery of PU202 or PU134. On 20 March, a tugboat captain found and recovered PU134 approximately 8 to 11 km (4.3 to 6.1 NM) south of its deployment coordinates. It is estimated that this unit surfaced roughly 2 or 3 hrs after the initial burn unit audio cue was issued. On 26 March, it was confirmed that PU179 (S1a) had also been lost from its deployment mooring. The same search pattern was followed in an attempt to locate this unit, as with the other three pop-ups lost from the December 2008 deployment. Divers were unavailable for recovery assistance because of weather conditions on this day. PU202 (S3) was still present at the drop coordinates but would not surface. This unit was recovered by a citizen near Virginia Beach, Virginia, on 07 June 2009 and shipped to BRP in early July.

Two units (PU002, PU171) from the March 2009 deployment were found on 07 June 2009. PU002 (S1a) was found off Cape May by a sport fisherman, and PU171 (S2) was found a few miles south of Little Egg Inlet by a day fisherman. Each unit was recovered from the fishermen prior to traveling to collect PU182 (S4) on the scheduled recovery date. PU182 responded well to the audio burn cue and surfaced within 7 min of the recall. Both low frequency units recorded during the deployment and yielded the full deployment tenure of data. The high frequency unit (PU171, S2) encountered a preventable gain error (i.e., internal audio gain settings were incorrectly set prior to completion of this unit's preparation for deployment) and did not record data that could be examined for marine mammal calls.

Recovery of pop-ups from the sixth deployment (August 2009) was planned for late October 2009. The units deployed at S4 and S5 (with burn unit engaged and auto burn set for the first week of November) were recovered on 26 October 2009; however, several severe weather fronts caused a delay in the recovery of the other four pop-ups that were shackled to their anchors. Because their burn units were

bypassed, these units would not release automatically at a set date or time. Divers successfully recovered these four units on 07 December 2009.

Data were extracted from all recovered units. All data from the four low-frequency deployed pop-ups were analyzed via auto-detection algorithms for two species of baleen whale; data from the high-frequency pop-ups were examined for delphinid calls.

5.2.2 Species Detections

All low frequency sampled data were processed via application of custom software algorithms (e.g., Israt2, custom fin detectors from BRP) to detect fin whale and North Atlantic right whale calls. All high frequency data were processed manually via application of Raven software (BRP) because toothed whale calls are too variable in structure to allow for consistent computer algorithms to identify standard structural components.

5.2.2.1 Detections per Deployment

Four pop-ups were recovered from the March 2008 deployment. In total from all pop-ups for the March 2008 deployment, fin whales were detected on 54 days, mainly from among the most northern or most eastern locations in the array configuration (**Table 5-7**; **Figure 5-48**). North Atlantic right whales were detected on a total of 78 days from all pop-ups recovered (**Table 5-7**; **Figure 5-49**). This species was detected mostly from the central line of pop-ups off Little Egg Inlet although 14 days of detections were also documented for the northern-most pop-up.

All four pop-ups were recovered from the June 2008 deployment. **Table 5-7** and **Figures 5-50** and **5-51** present details on daily presence for fin and North Atlantic right whales detected at each pop-up station location. Fin whales were recorded almost daily from June to September on S5 and only sporadically on the southern-most pop-up (S1). In total from both low-frequency pop-ups for the June deployment, fin whales were detected on 74 days, and North Atlantic right whales were detected on 12 days. Data from PU081 and PU086 were collected following the high frequency sample rate (32 kHz) to document toothed whale sounds. Delphinid calls are not yet detectable to the species level only from call parameters and are categorized broadly. Delphinid calls (e.g., whistles, clicks) were documented for each day of deployment on PU81 (**Table 5-7**; **Figure 5-52**). On PU086, whistles were detected on 42 days of the deployment; only a handful of days presented no evidence of delphinid vocal activity (**Table 5-7**; **Figure 5-52**).

Three of the five pop-ups were recovered from the September 2008 deployment. Data from two units with a 2-kHz sample rate (PU202 and PU203) and from one unit with a 32-kHz sample rate (PU086) were recovered. These units represent S3, S5, and S4, respectively. Fin whales were detected on 18 days on PU202 and 6 days on PU203 (**Table 5-7**; **Figure 5-53**). North Atlantic right whales were detected on five days on PU202 and on three days on PU203 (**Table 5-7**; **Figure 5-54**). Delphinid calls were detected on PU086 on 16 days of the deployment (**Table 5-7**; **Figure 5-55**).

Two of five deployed pop-ups were recovered from the December 2008 deployment. One (PU202) was set with the low frequency sample rate while the other (PU134) was programmed with the high frequency sample rate. Fin whales were detected on 64 days of the deployment (**Table 5-7**; **Figure 5-56**), and North Atlantic right whales were detected on nine days (mostly in February) of this deployment (**Table 5-7**; **Figure 5-57**). Delphinid calls were detected on about one third (30) of the deployment days (**Table 5-7**; **Figure 5-58**).

Three units were deployed and successfully retrieved from the March 2009 deployment. Fin whales were detected on 24 days (10 of these days on PU002 and 14 days on PU182; **Table 5-7**; **Figure 5-59**). North Atlantic right whales were detected on seven days on PU182 (**Table 5-7**; **Figure 5-60**). North Atlantic right whale calls were not detected on the southern-most pop-up. Data on delphinid call detections are not available because the recording unit settings malfunctioned.

All six pop-ups were recovered from the August 2009 deployment; however, poor weather resulted in delayed recovery of four of these pop-ups. Data from the two units that were recovered in October 2009 (PU162, PU153) and the four low-frequency recorders (PU145, PU160, PU182, PU134) collected in December 2009 were analyzed. Fin whales were detected by the northern-most pop-up (S#5) on 30 days of the deployment, by the central pop-up (PU160, S#3a) on 37 days, on the western-most low-frequency unit (PU182, S#2) on 29 days, and on the southern-most (PU145, S#1b) on 27 days of deployment (**Table 5-7**; **Figure 5-61**). North Atlantic right whales were detected by the northern-most unit, PU162 (S#5), on one day, by the southern-most unit (PU145, S#1b) on six days, by the central recorder (PU160, S#3a) on two days, and by the western low-frequency pop-up (PU182, S#2) on six days (**Table 5-7**; **Figure 5-62**). Delphinid calls were detected on the eastern-most pop-up (PU153) on six days during this deployment and on 38 days on the western unit (P134, S#2) (**Table 5-7**; **Figure 5-63**).

Table 5-7. Summary of deployment dates of pop-ups and species identifications. Data have been examined with data template detectors for North Atlantic right whales (RW) and fin whales (FW). NS indicates not sampled while NA indicates data not available.

Deployment	Station #	Pop-Up ID	Dates Deployed	Baleen Species ID Confirmed (# days detected)	Delphinid Calls Confirmed (# days detected)
March 2008	1	PU039	Lost	NA	NS
	2	PU086	03/26/08 – 05/30/08*	RW(19), FW(16)	NS
	3	PU063	03/26/08 – 06/17/08	RW(21), FW(5)	NS
	4	PU081	03/26/08 – 06/17/08	RW(24), FW(16)	NS
	5	PU134	03/26/08 – 06/17/08	RW(14), FW(17)	NS
June 2008	1	PU063	06/24/08 – 09/16/08	RW(0), FW(18)	NS
	2	PU081	06/24/08 – 09/5/08**	NS	(68)
	4	PU086	06/24/08 – 08/17/08***	NS	(42)
	5	PU134	06/24/08 – 09/18/08±	RW(12), FW(56)	NS
September 2008	1	PU063	Lost	NA	NS
	2	PU081	Lost	NS	NA
	3	PU202	10/01/08 – 12/03/08	RW(5), FW(18)	NS
	4	PU086	10/01/08 – 12/03/08	NS	(16)
	5	PU203	10/01/08 – 12/03/08	RW(3), FW(6)	NS
December 2008	1a	PU179	Lost	NA	NA
	2	PU134	12/14/08 – 03/20/09±	NS	(30)
	3	PU202	12/14/08 – 03/31/09	RW(9), FW(64)	NS
	4	PU086	Lost	NA	NA
	5	PU203	Lost	NA	NA
March 2009	1a	PU002	03/26/09 – 06/07/09†	RW(0), FW(10)	NS
	2	PU171	03/26/09 – 06/07/09†	NS	Malfunctioned
	4	PU182	03/26/09 – 06/07/09	RW(7), FW(14)	NS
August 2009	1b	PU145	08/11/09 – 12/07/09	RW (6), FW (27)	NS
	2	PU134	08/11/09 – 12/07/09	NS	(38)
	2	PU182	08/11/09 – 12/07/09	RW (6), FW (29)	NS
	3a	PU160	08/11/09 – 12/07/09	RW (2), FW (37)	NS
	4	PU153	08/11/09 – 10/26/09	NS	(6)
	5	PU162	08/11/09 – 10/26/09	RW(1), FW(30)	NS

* PU086 stopped recording 17 days early on March 2008 deployment for unknown reasons.

** PU081 was likely snagged by a trawler and came to the surface on 31 August 2008 during the later afternoon. The unit was in air on a boat and then returned to the water on 01 September 2008. It was retrieved by a local fisherman and called in on 05 September 2008. It was recovered by GMI on 15 September 2008.

*** PU086 stopped recording 30 days early on June 2008 deployment for unknown reasons. PU brain (circuit board) was replaced before September 2008 deployment.

± PU134 did not respond to acoustic burn and was recovered two days later by a diver from the June 2008 deployment. PU134 did not respond to acoustic burn on 20 March 2009 but surfaced roughly 2-3 hrs later and was recovered by a tugboat captain.

† PU002 surfaced early and was recovered by a local fisherman and retrieved by GMI on 10 June 2009. PU171 surfaced early and was recovered by a local fisherman and retrieved by GMI on 10 June 2009. Note: a severe storm passed through the area during the first week of June 2009.

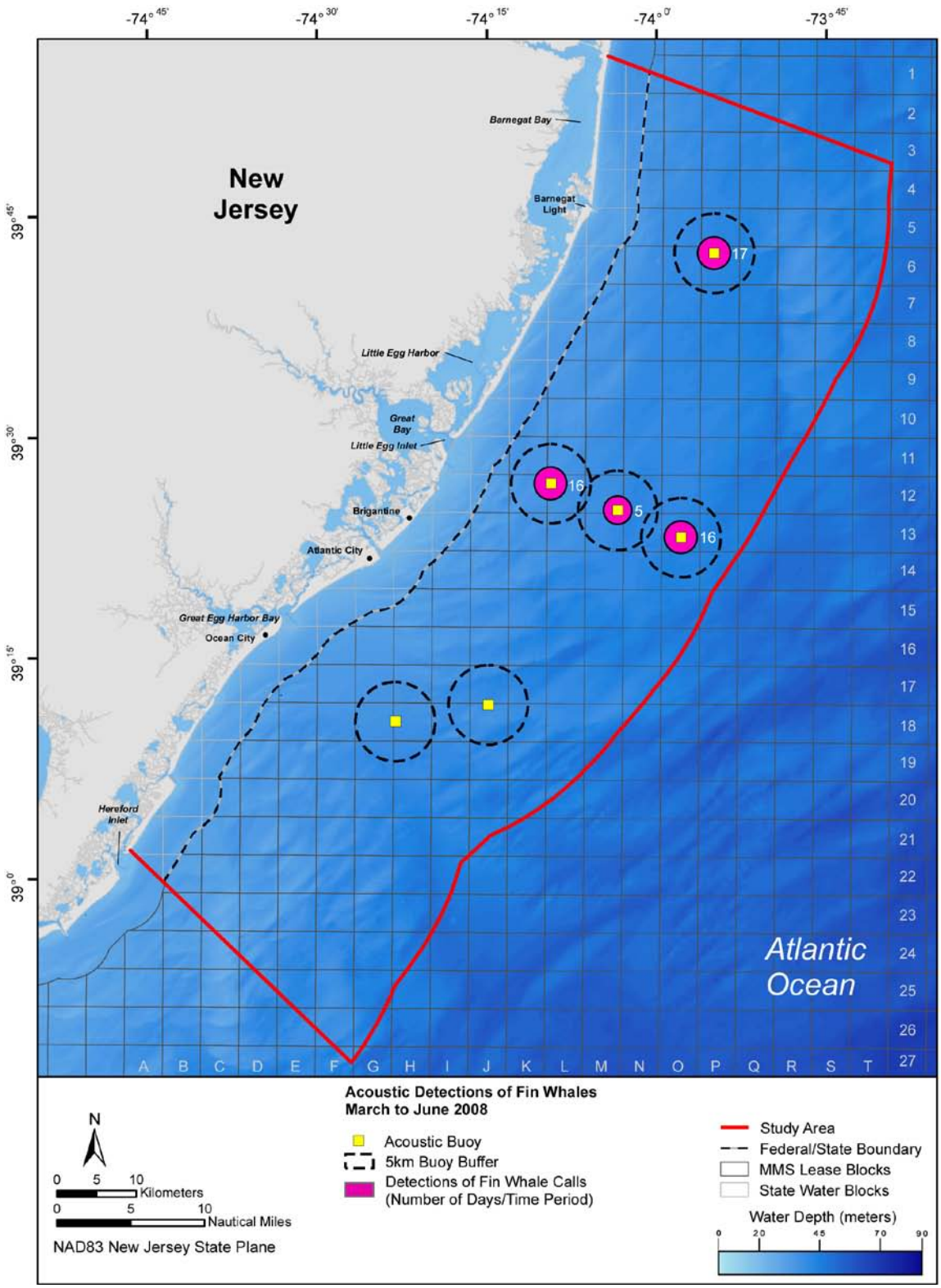

Figure 5-48. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the first deployment from March to June 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected fin whale calls.

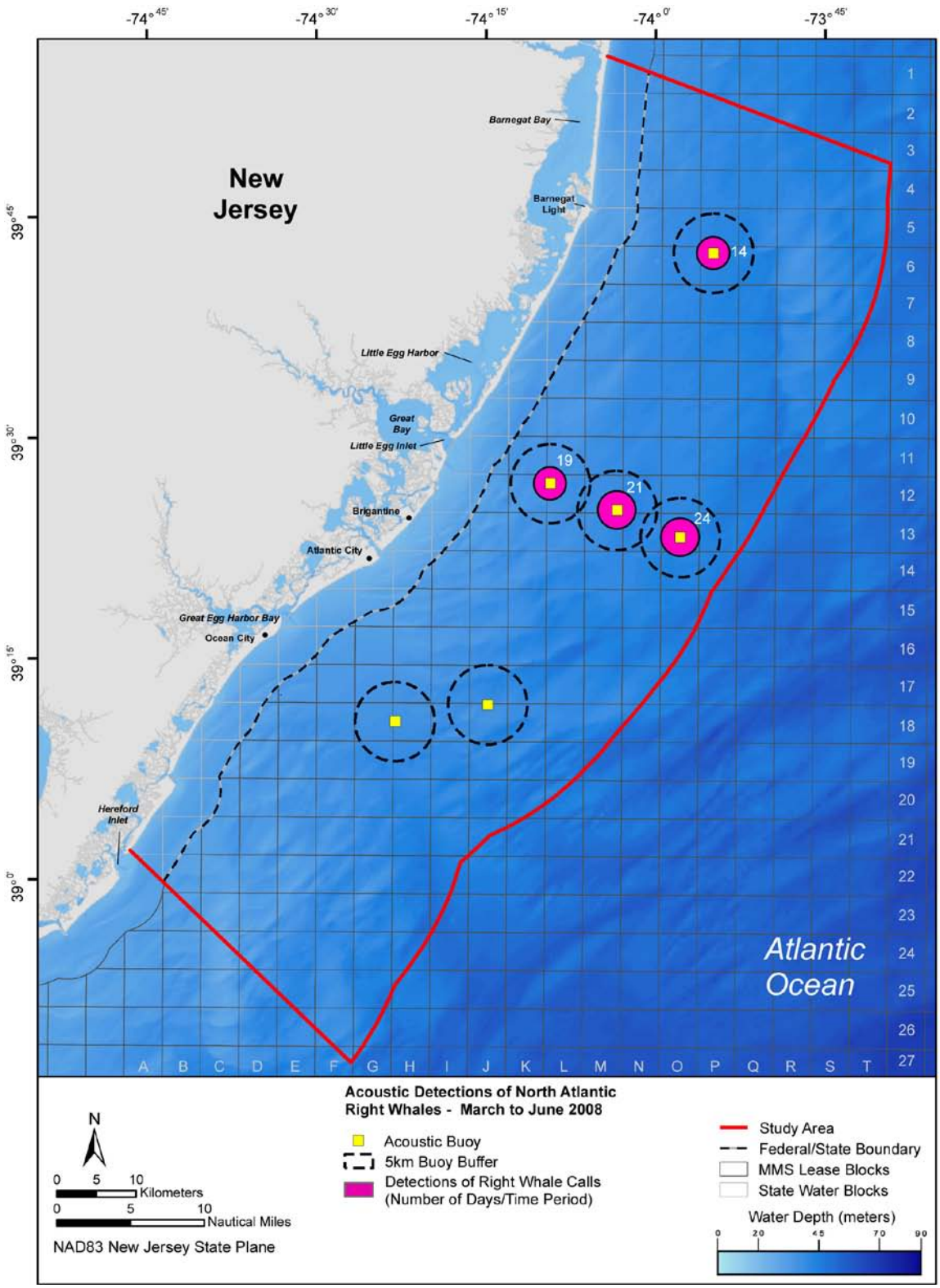

Figure 5-49. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the first deployment from March to June 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected North Atlantic right whale calls.

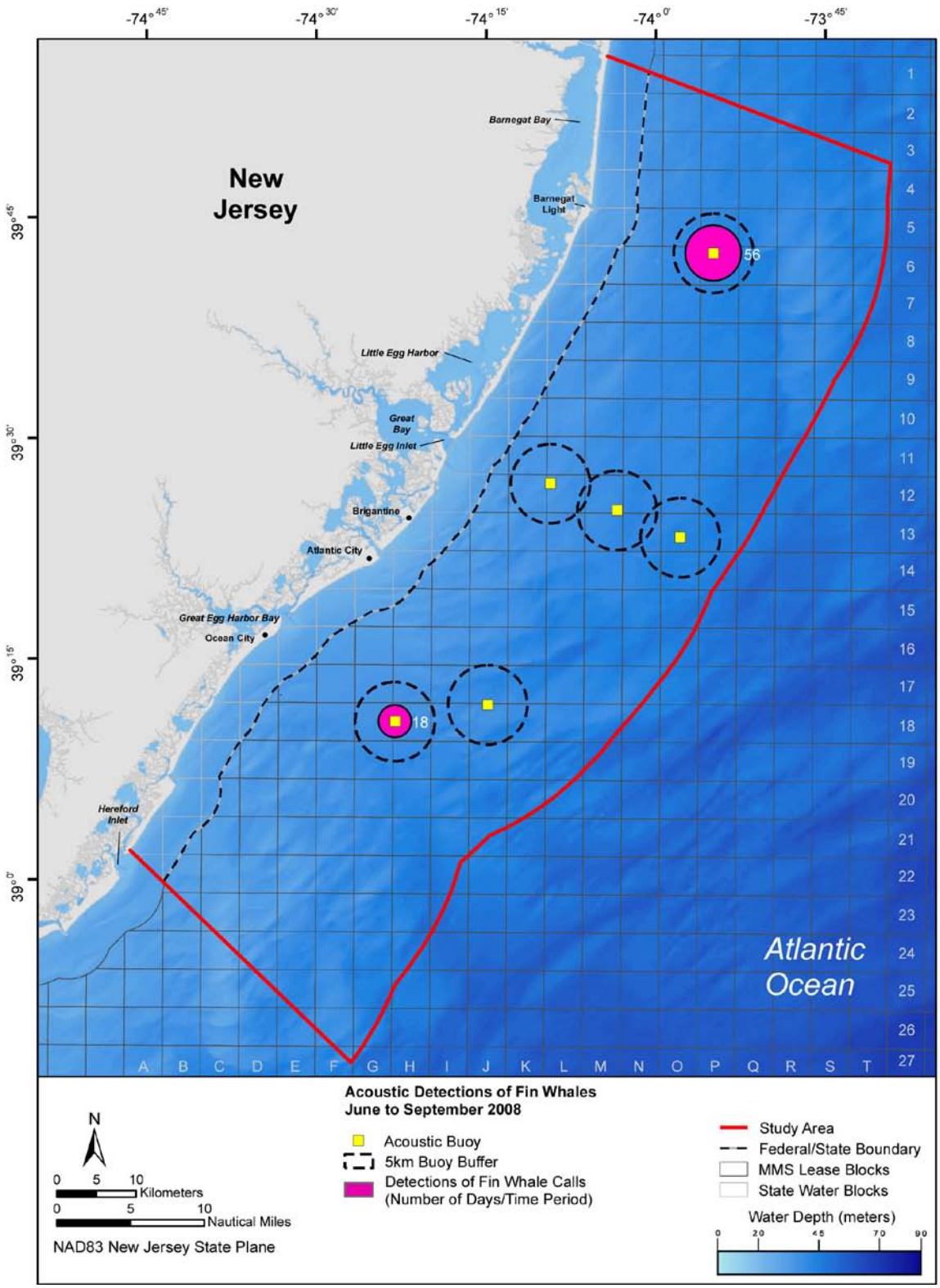

Figure 5-50. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the second deployment from June to September 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected fin whale calls.

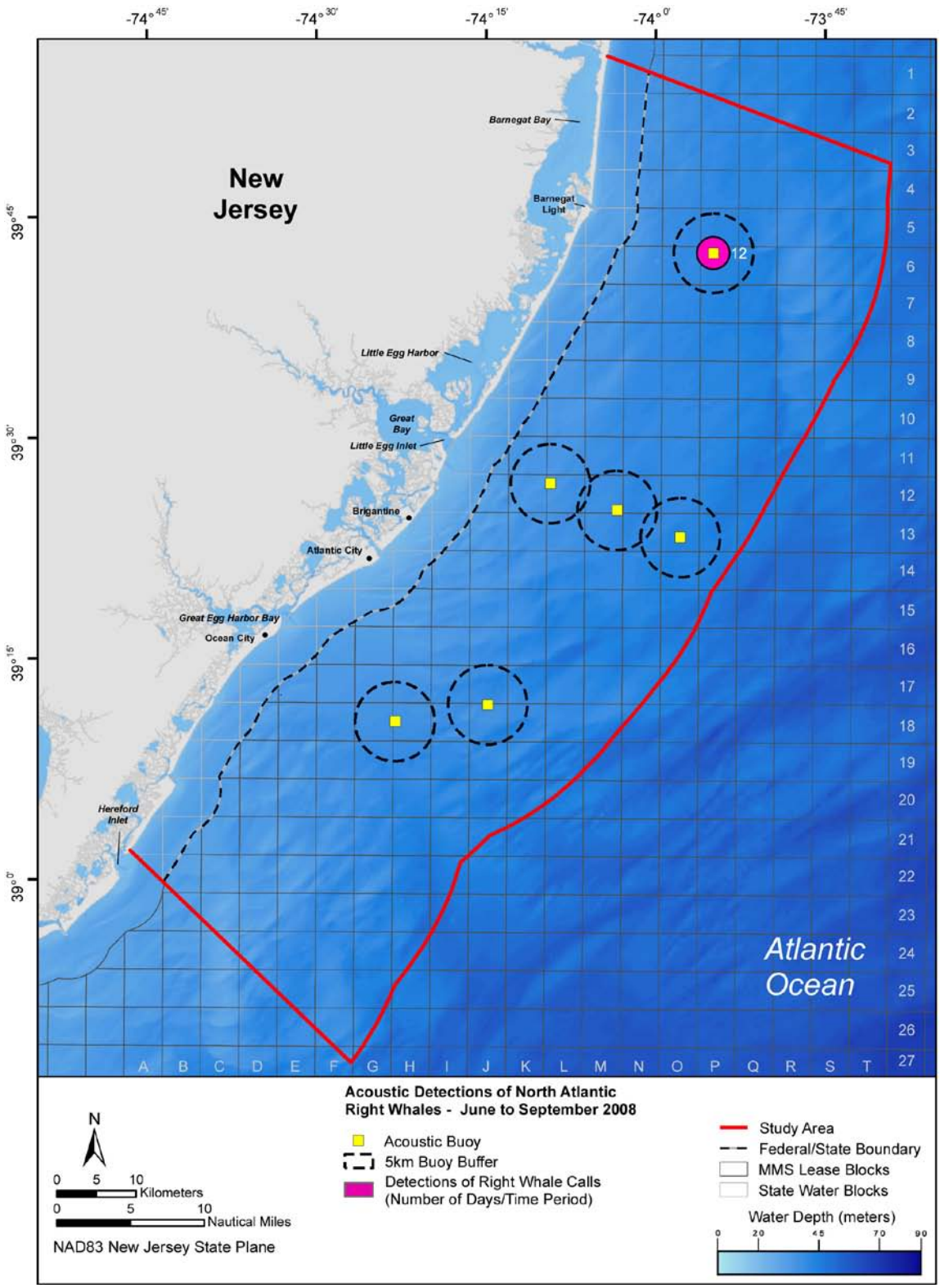

Figure 5-51. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the second deployment from June to September 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected North Atlantic right whale calls.

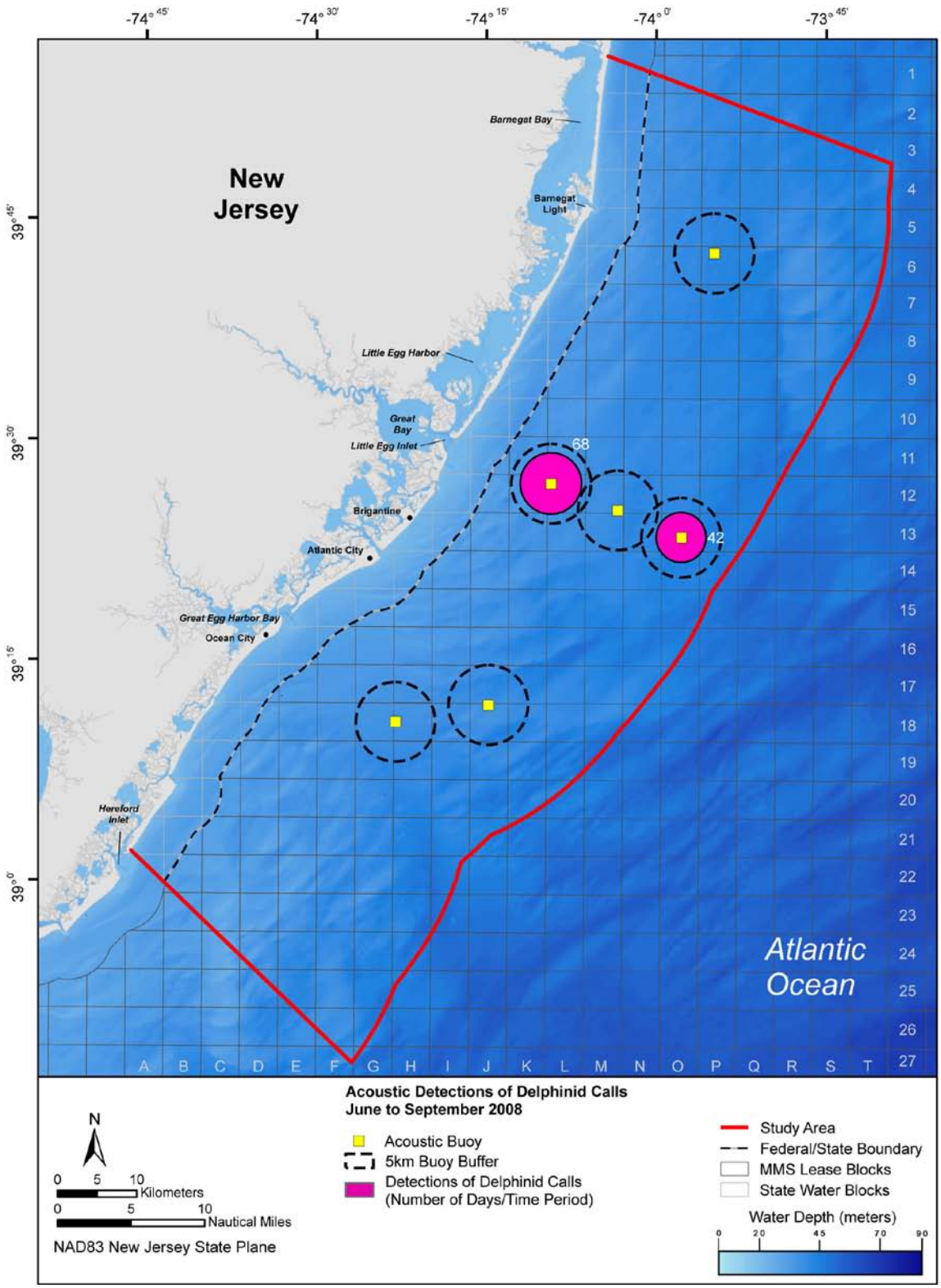

Figure 5-52. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the second deployment from June to September 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected delphinid calls.

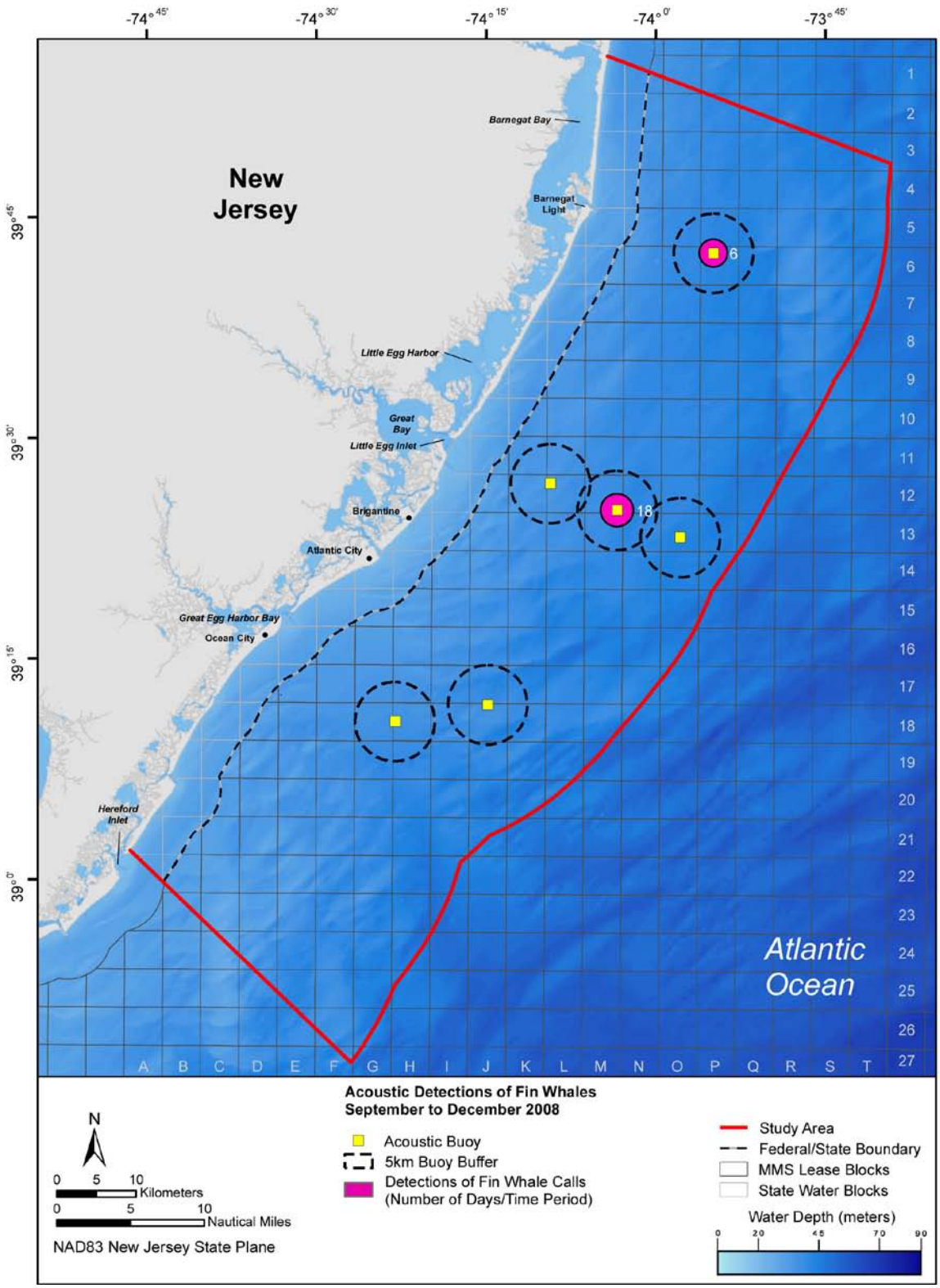

Figure 5-53. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the third deployment from September to December 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected fin whale calls.

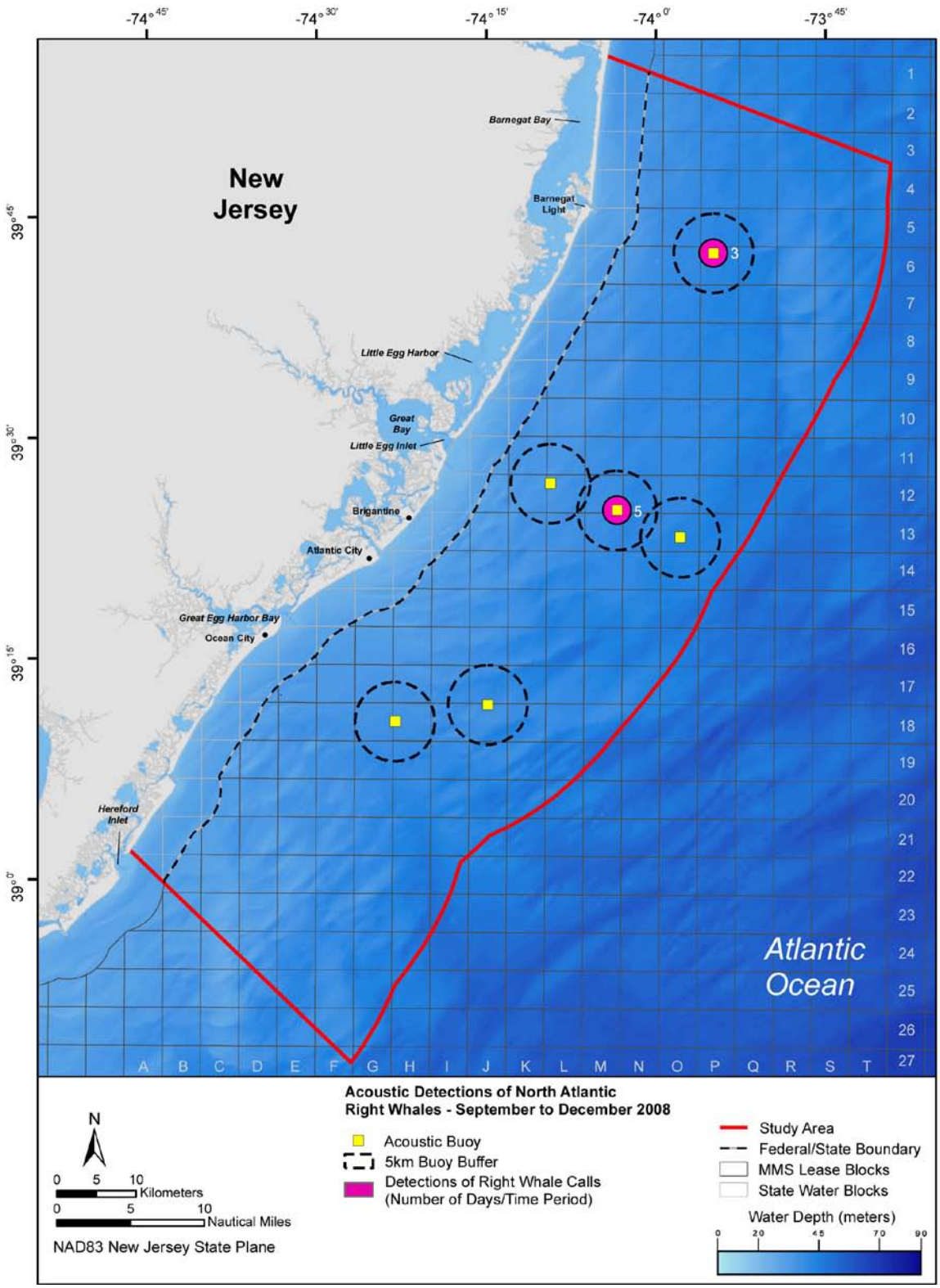

Figure 5-54. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the third deployment from September to December 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected North Atlantic right whale calls.

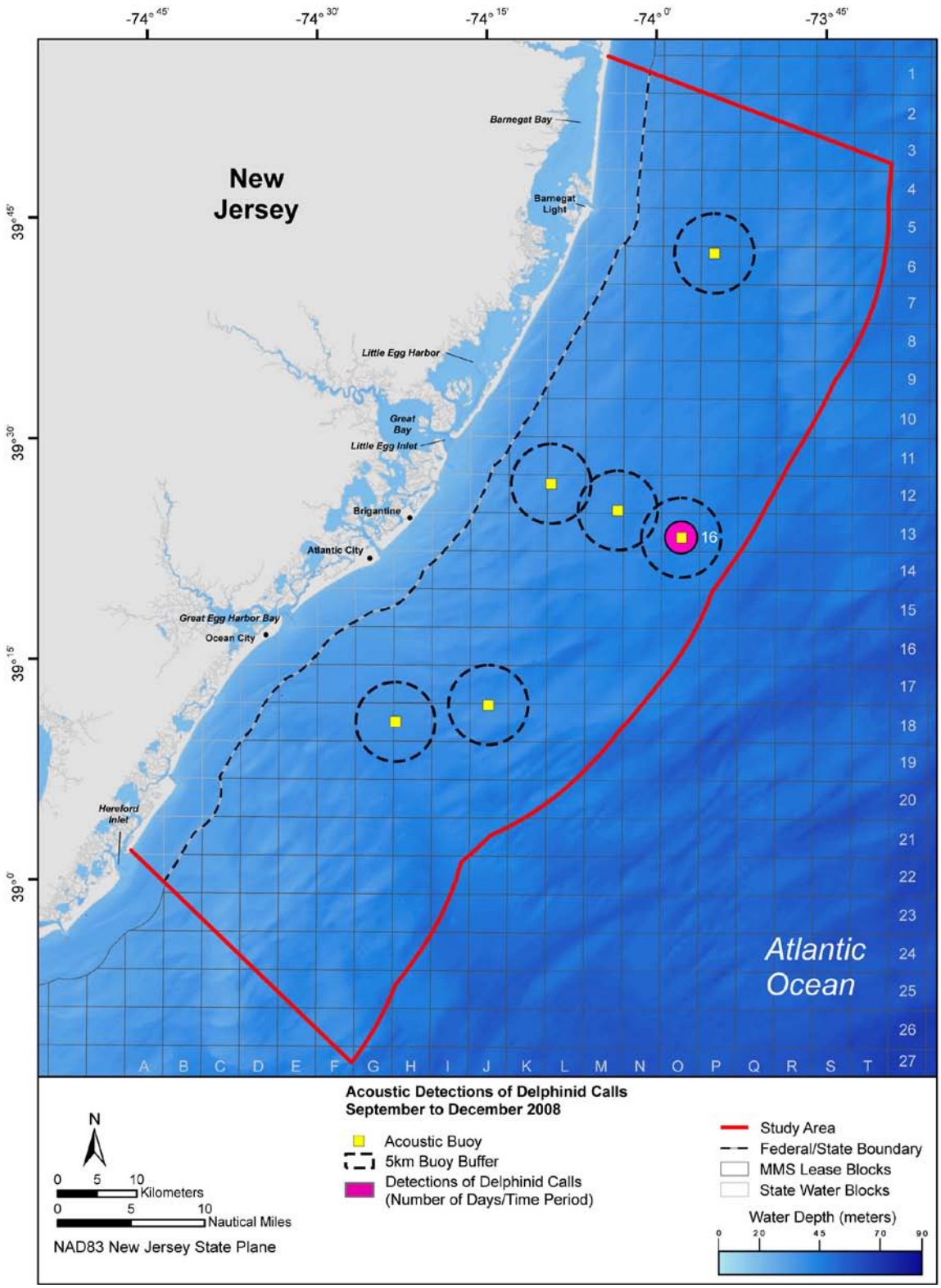

Figure 5-55. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the third deployment from September to December 2008. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected delphinid calls.

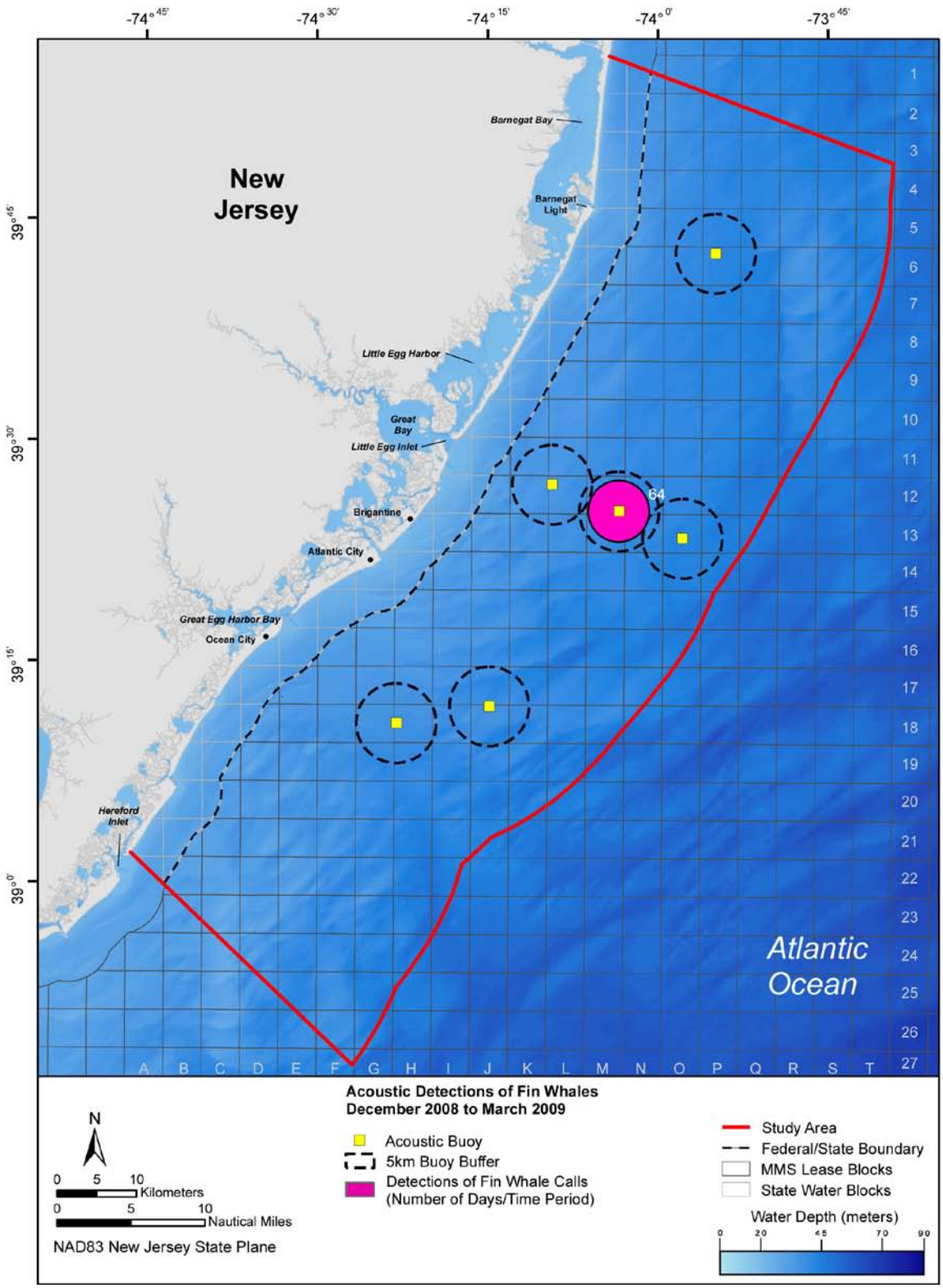

Figure 5-56. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the fourth deployment from December 2008 to March 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected fin whale calls.

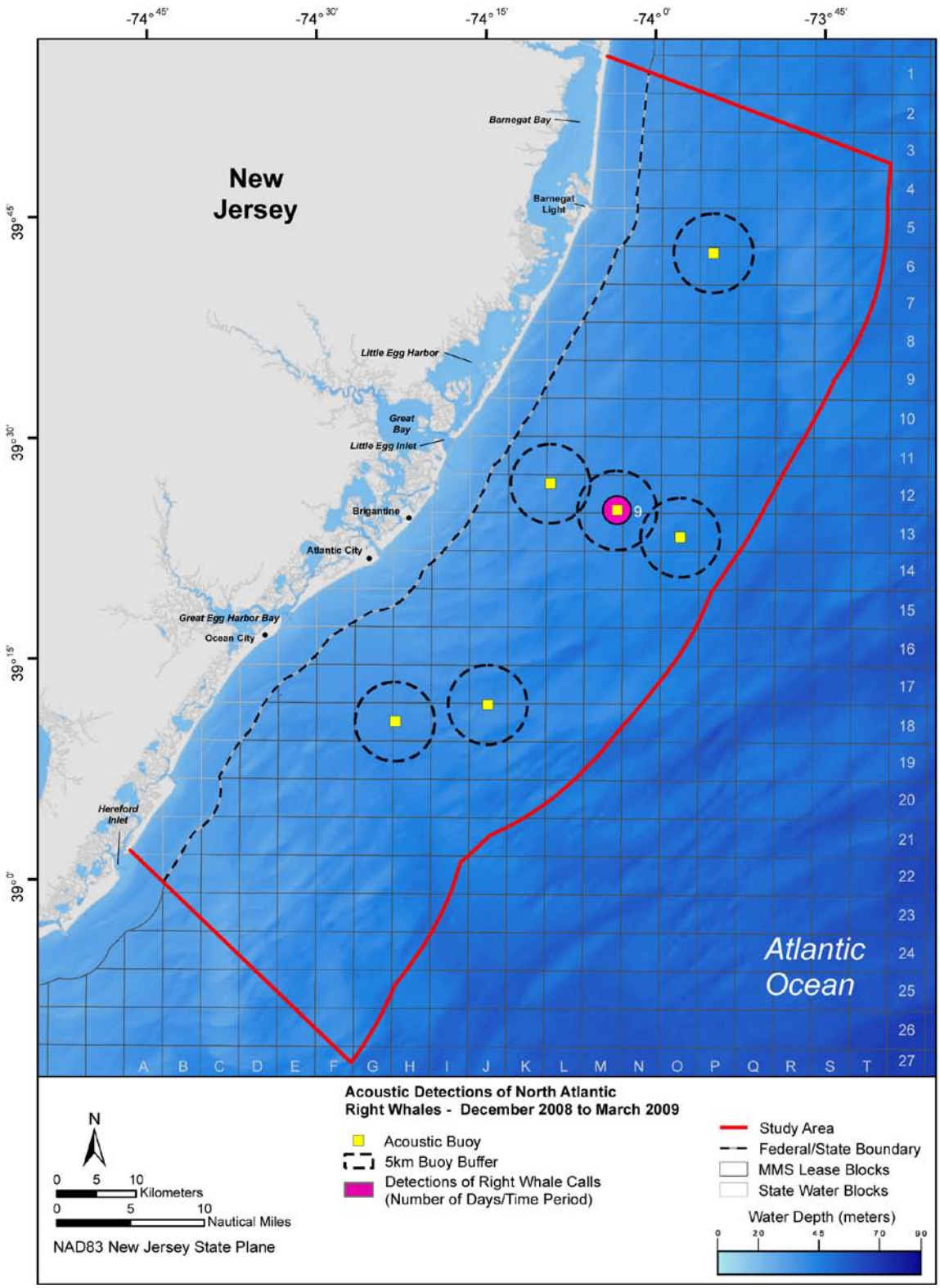

Figure 5-57. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the fourth deployment from December 2008 to March 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected North Atlantic right whale calls.

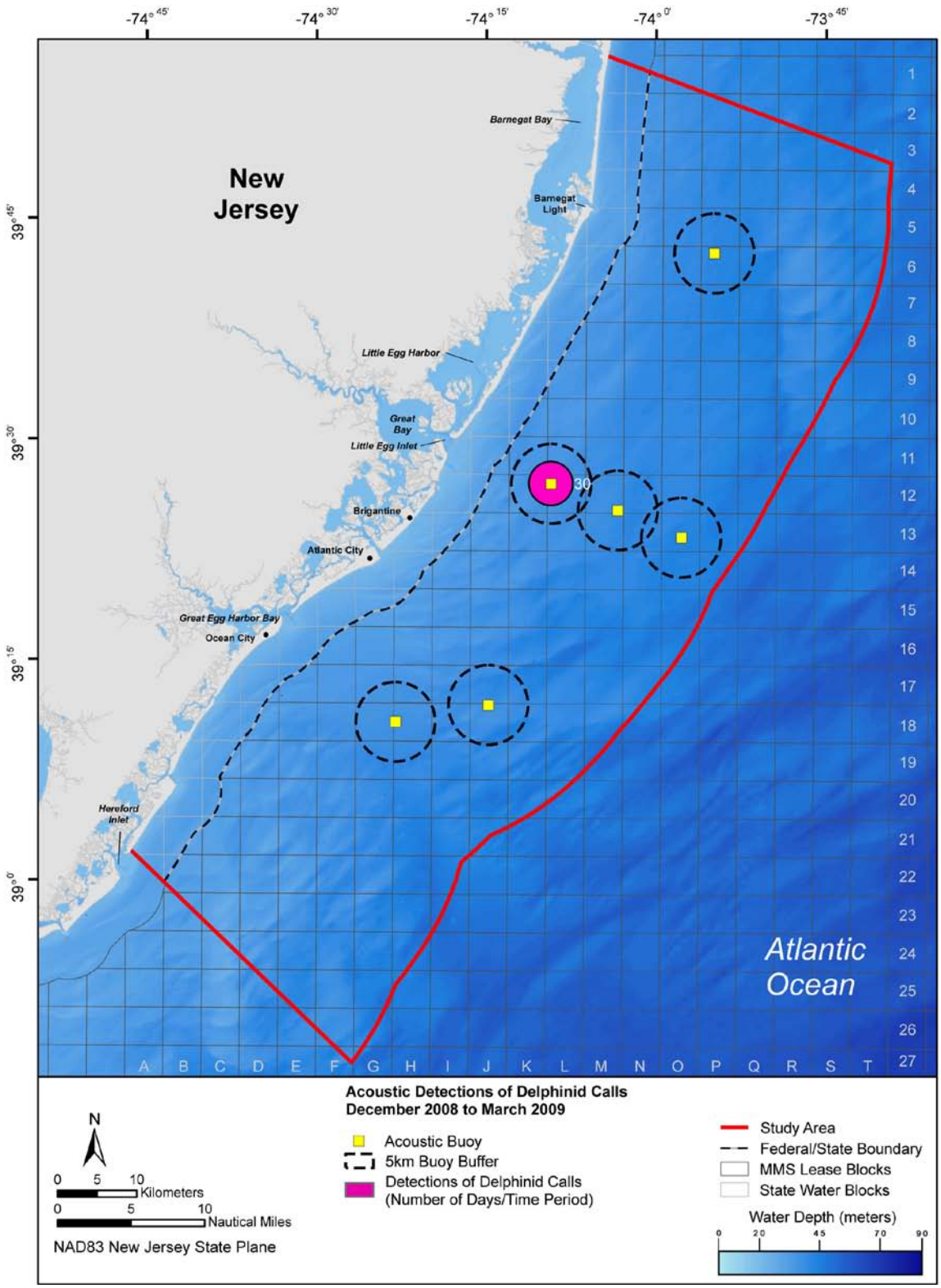

Figure 5-58. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the fourth deployment from December 2008 to March 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected delphinid calls.

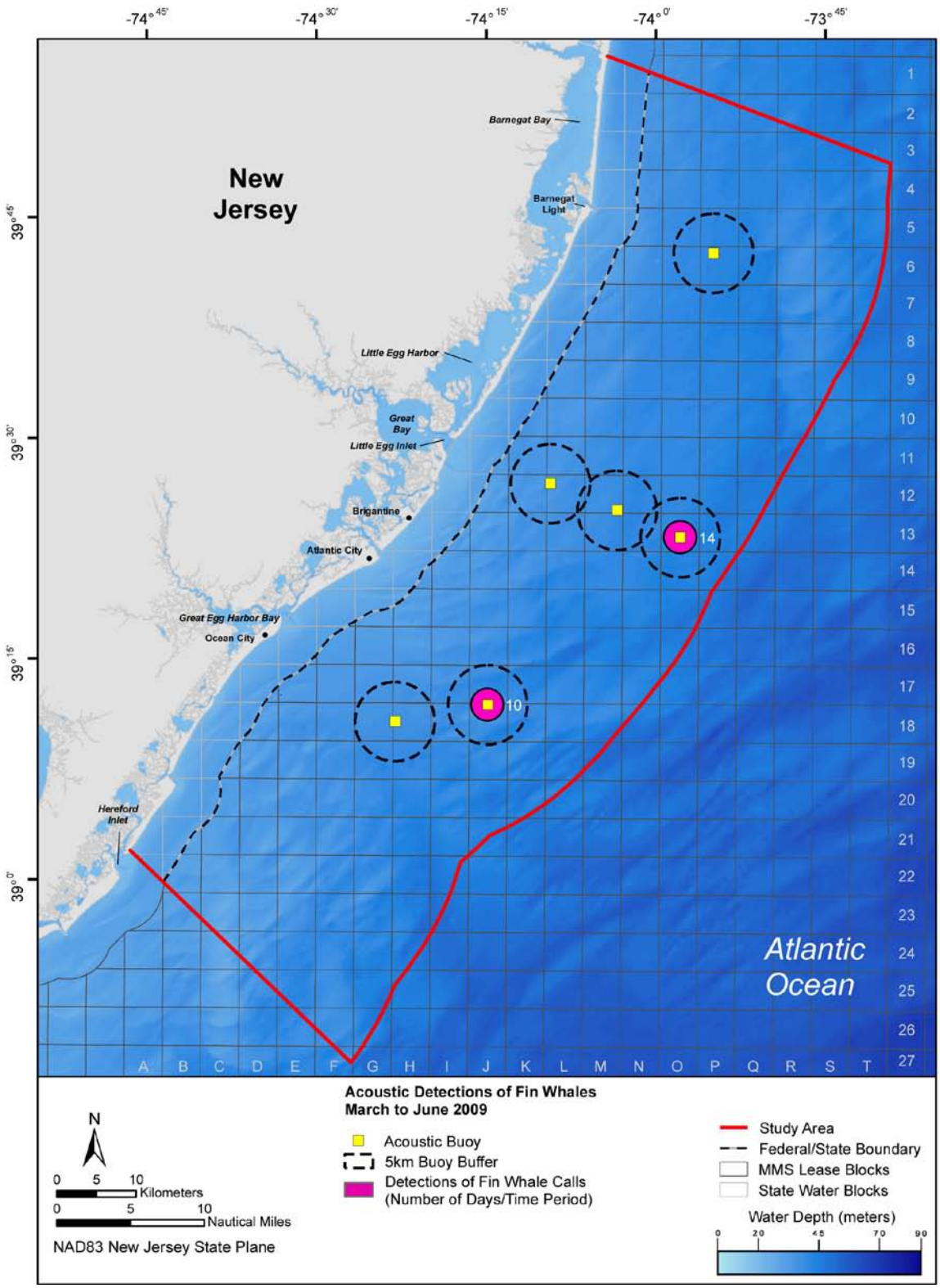

Figure 5-59. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the fifth deployment from March to June 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected fin whale calls.

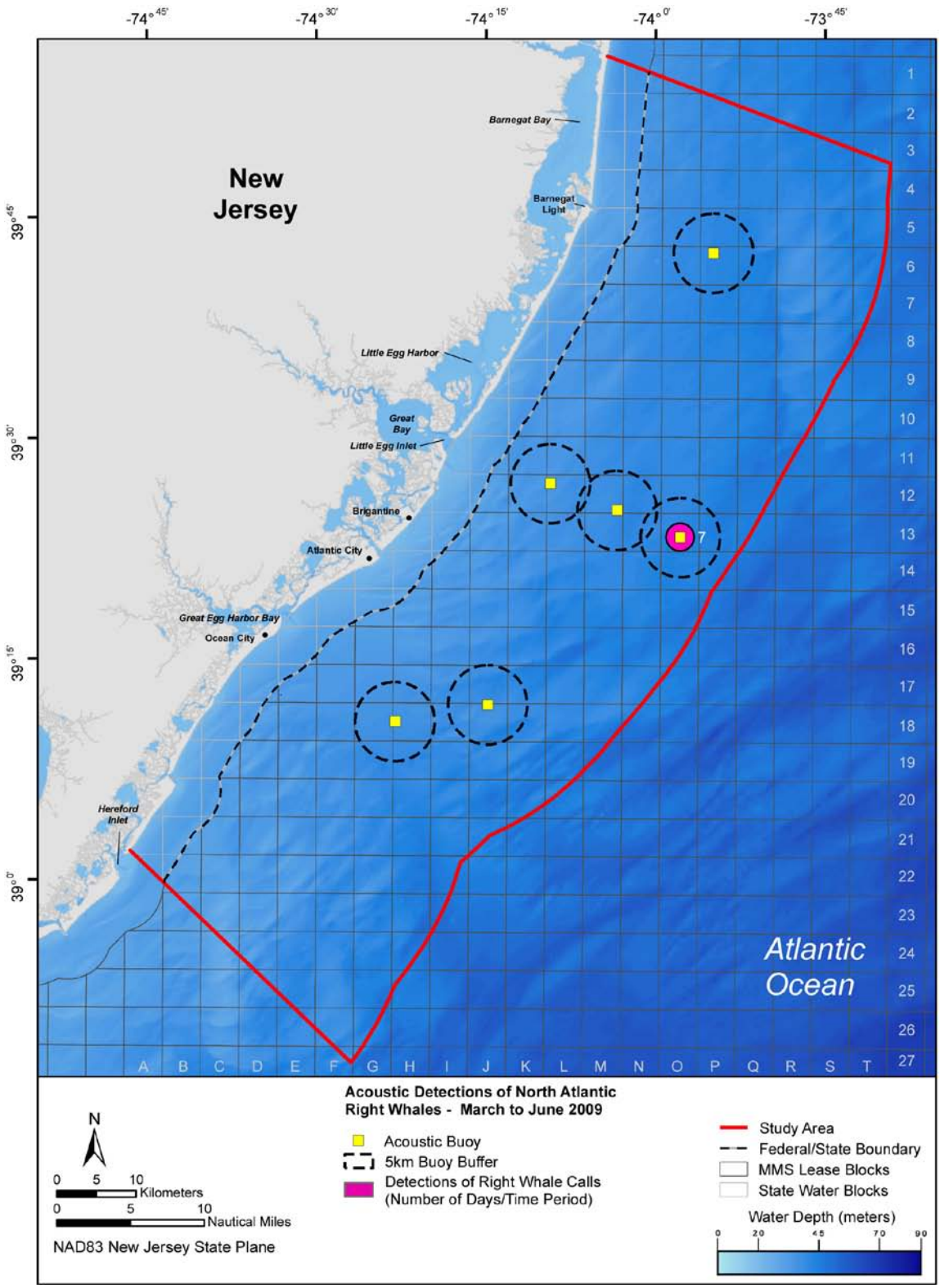

Figure 5-60. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the fifth deployment from March to June 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected North Atlantic right whale calls.

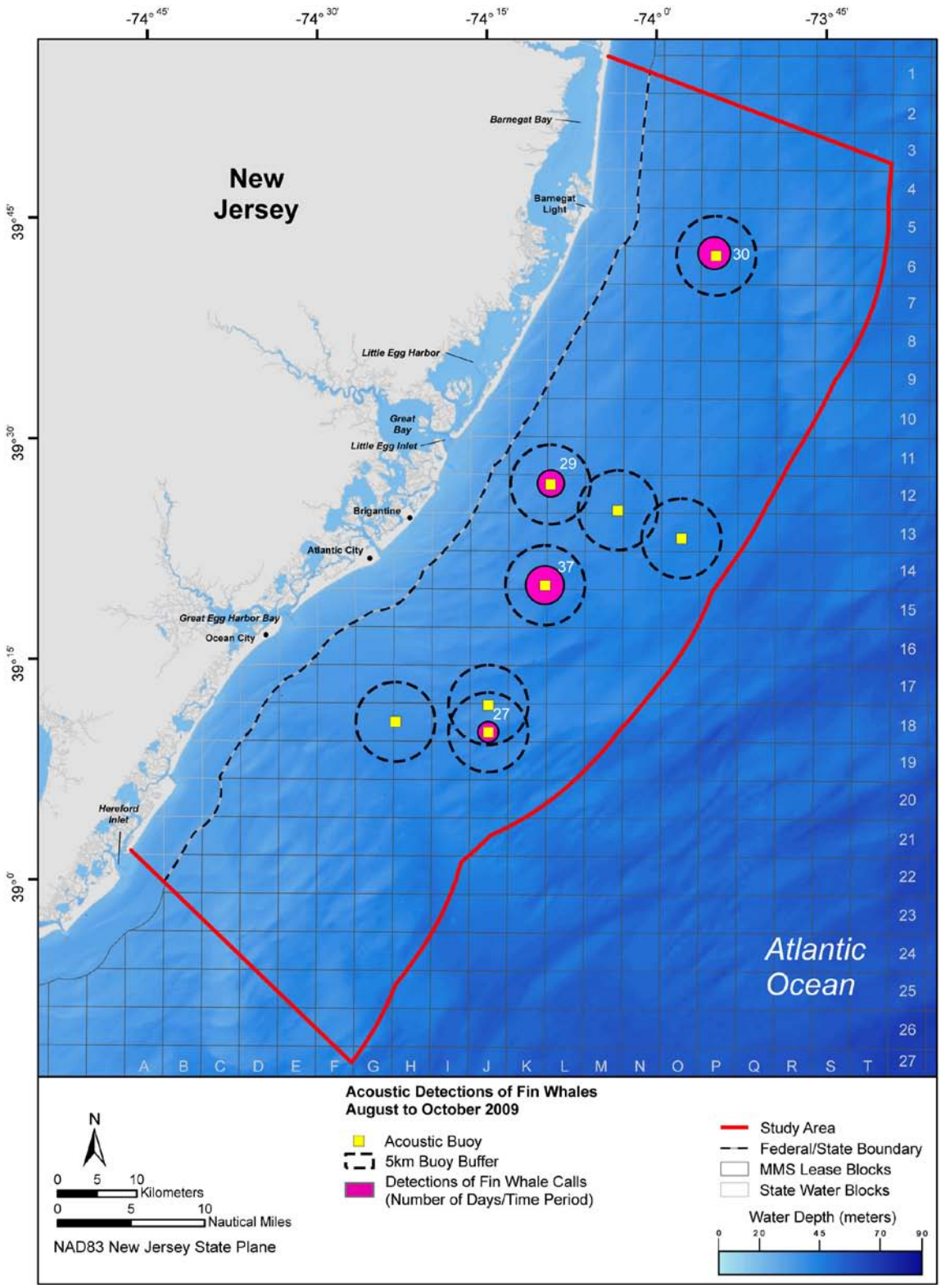

Figure 5-61. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the sixth deployment from August to October 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected fin whale calls.

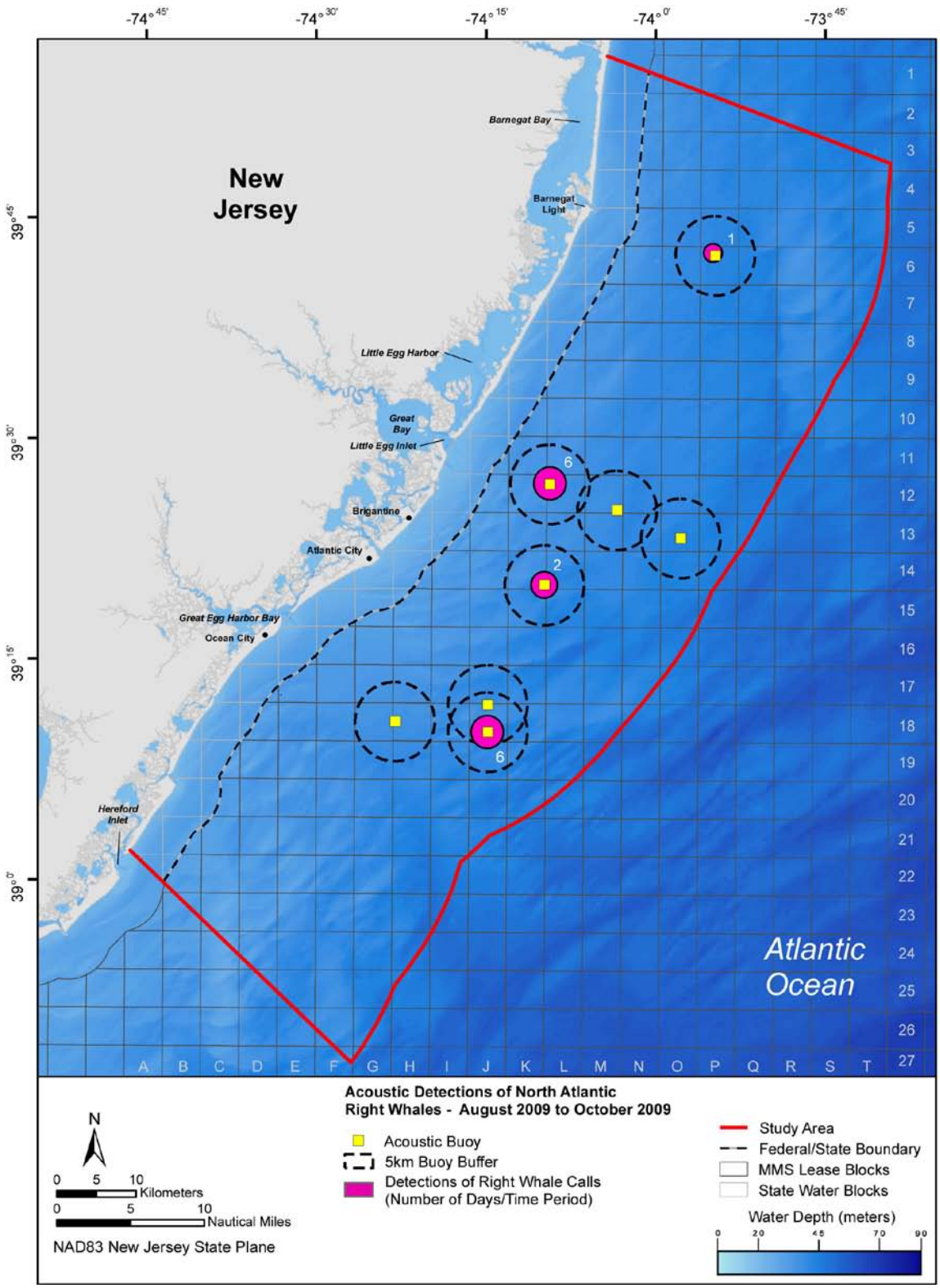

Figure 5-62. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the sixth deployment from August to October 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected North Atlantic right whale calls.

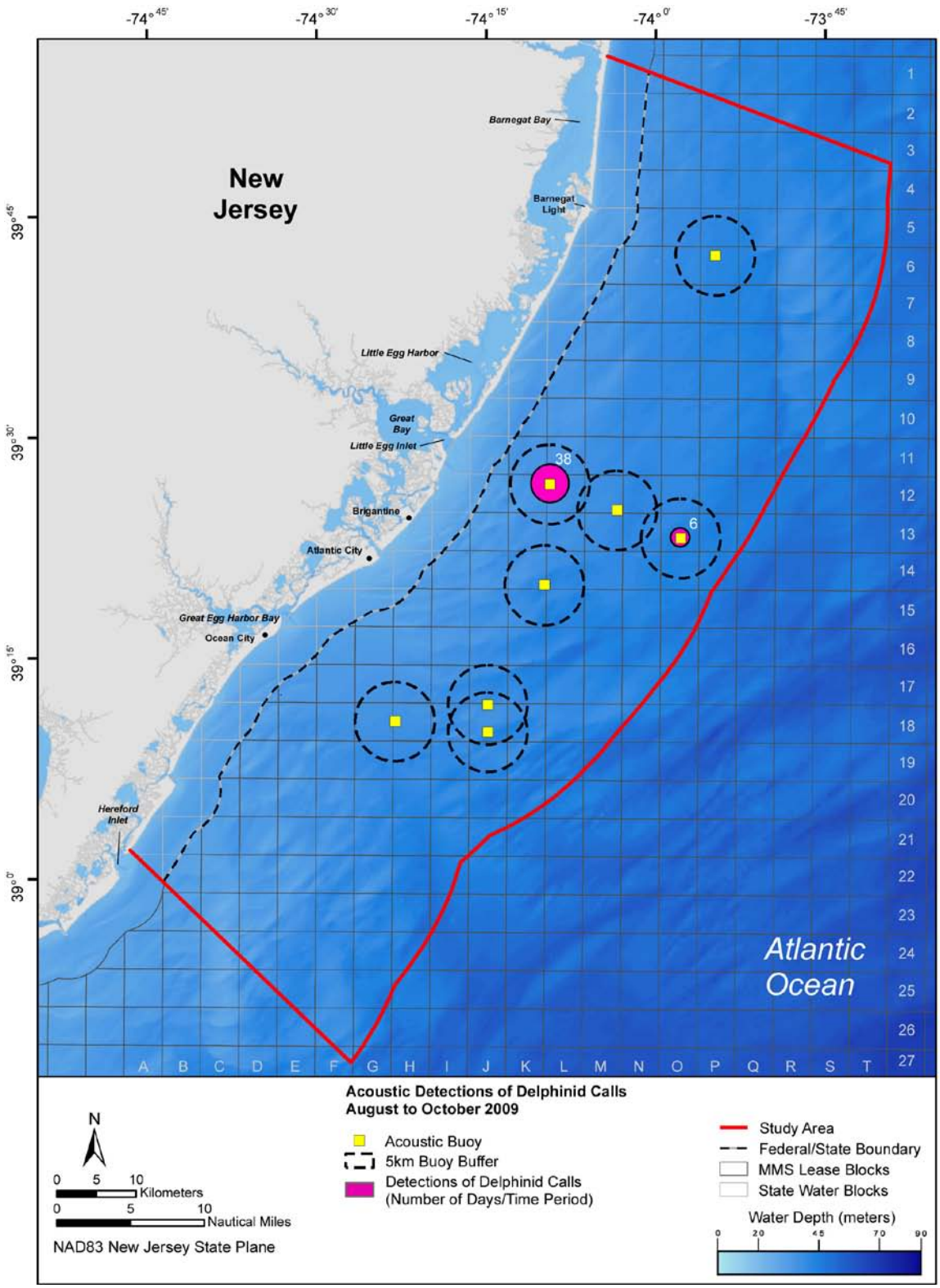

Figure 5-63. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the sixth deployment from August to October 2009. The thickness of the detection ring around the different buoys gives a relative indication of the number of detection dates per pop-up. See Table 5-7 for specific dates for detected delphinid calls.

5.2.2.2 Detections per Species

North Atlantic Right Whale

Analysis of recordings captured in the Study Area during the baseline study period demonstrated North Atlantic right whale occurrence throughout the year, with a peak number of detection days in March through June (46 days in 2008, 10 in 2009 although June was not represented in 2009). North Atlantic right whales were also detected sporadically in the eastern and northern areas of the Study Area during the summer through the fall in 2008 (two days detected during July, five in August, five in September, one in October, six in November, and one in December) and in 2009 (three in August, six in September, four in October, and one in November). Nine days of detection (mid-January to mid-March 2009) resulted from the December 2008 PAM deployment even though only two of the five deployed pop-ups were recovered. During these winter months, the North Atlantic right whale calls were detected on the pop-up located 21.4 km (12 NM) from shore at a depth of 24 m (79 ft). Winter represents the time of year when North Atlantic right whale mothers and calves are found off the southeast U.S. coast (mainly off northern Florida and southern Georgia; Hamilton and Mayo 1990; Hain et al. 1992; Knowlton et al. 1992), but it is unknown where the majority of North Atlantic right whale males and females without calves spend their time during this season. Very little data are represented from the migratory corridor (i.e., the eastern U.S. coast from New Jersey to Virginia) between the southern calving grounds and the northern feeding grounds for comparison (Mead 1986; Knowlton et al. 1992; McLellan et al. 2002); however, these winter detection days are inconsistent with current distribution data.

Fin Whale

The fin whale was the most common marine mammal species detected acoustically during PAM of the Study Area. Fin whale pulses were primarily documented in the northern and eastern range of the Study Area where the shelf waters were deeper (>25 m [82 ft]) and distance from shore was greater than 25 km (13 NM). The consistent presence of fin whale pulses indicates that this species, or at least members of this species, can be regularly found along the New Jersey outer continental shelf. Fin whale pulses and downsweeps were documented in every month of acoustic monitoring. The 20-hertz (Hz) infrasonic pulses have duration of ~1 s (Thomson and Richardson 1995; Charif et al. 2002). Automatic detection software facilitated an examination of all hard drives of data. Fin whales were detected on 47 days from March to May 2008, 62 days from June to September 2008, 31 days from October to December 2008, 57 days from January to March 2009, 16 days in April and May 2009, and 68 days from August to October 2009.

Delphinids

Significant variability has been identified within delphinid whistles, which prevents reliable classification via automatic detection to the species level based on acoustic recordings; however, several delphinid species were documented in the Study Area from the shipboard and aerial surveys that were part of this baseline study. Based on the sightings data collected from these surveys, the most likely species to have been captured on pop-up recordings in the Study Area are bottlenose dolphins and short-beaked common dolphins. Occurrences of other delphinid species are also possible; see **Volume I** for a complete list of species that may occur in the Study Area.

Delphinid whistles were detected during all months of acoustic monitoring; a peak number of detection days occurred from June through September 2008 (total 69 days detected) and from December 2008 through March 2009 (total 33 days detected). Whistles were also detected on five days in October 2008, on eight days in November 2008, and on 41 days from August to October 2009. Whistles were detected on pop-ups placed closer to shore (12.7 km [6.9 NM], S#2) as compared with recorders placed more than 30 km (17 NM; S#4) from the coast. Although New Jersey/New York is the seasonal northern limit of bottlenose dolphins in the Atlantic, members of this delphinid species are known to occur off the coast of New Jersey year-round (CETAP 1982), particularly from May through October in the Study Area (Toth-Brown 2007). During the shipboard and aerial surveys of this baseline study, bottlenose dolphins were recorded from March through October and were the most common delphinid species sighted during the

spring and summer. Therefore, bottlenose dolphins most likely account for the whistle detection days (69) noted from June to September 2008. Short-beaked common dolphins were the most common delphinid species recorded during the shipboard and aerial surveys during the winter. Therefore, this species may account for the whistle detections during the winter months.

Overall, classification of delphinid species based on parameters discerned from frequency-modulated calls (whistles) is not certain at this time; therefore, confirmation of the species that produced the recorded whistles, burst pulses, or click trains during this study is not currently possible.

Other Detections

There are 8,760 hrs in a non-leap year. During the 18 months of acoustic monitoring during which pop-ups were deployed, 38,700 hrs of cumulative audio data were collected from all pop-up devices in-total. Therefore, 4.42 years of continuous acoustic data were collected during the course of this study. That is, between three and six pop-up devices were used per deployment, which yielded between 240 and 2,000 hrs of data each (see **Table 4-1** for details on the number of hours per deployment per pop-up). Because of variability in many species' vocalizations (e.g., dolphin whistles and humpback whale songs) and limitations of current call detection software, only a few species have automated algorithms that are reliable to confirm detection of their calls from within thousands of hours of data. Manual review of 38,700 hrs of data is not an option with current computer capabilities. Therefore, other cetacean species were not examined for acoustic detection from the data set.

During processing of data for North Atlantic right whale calls, several species of fish were acoustically detected. These calls were briefly and opportunistically examined and included drum, scaenids, and other unidentified fish.

Additionally, every day of examined acoustic data per deployed pop-up presented some level of vessel noise. Ship engines ranged from outboard motors of sport fishers to commercial vessels with consistent engine noise for periods of minutes to several hours of detection on pop-up recorders.

5.2.3 Data Analysis QA/QC

QA/QC for high frequency data was confirmed internally by GMI with two acoustic technicians reviewing overlapping samples of data from each high-frequency pop-up. Confirmation of delphinid call data was within 90% for inter-observer reliability for data from each of the high-frequency pop-up data sets. QA/QC for the low frequency data was conducted by acoustic technicians from BRP. The data review summary from BRP was received on 26 January 2010 and is included below.

> "This report accompanies the drive filled with data files pertaining to Geo-Marine, Inc.'s New Jersey DEP project, more specifically the portion of the project that seeks to examine acoustically for the presence of marine mammals in the 20 x 60 NM Study Area along the New Jersey coast. We (BRP acoustic technicians) have reviewed a subset of these data and sample analyses files corresponding to the data subset in response to the "quality control" portion of the agreement between BRP and Geo-Marine (GMI).
>
> Some analysis results from these data were reviewed in conjunction with the specific data files to which they pertain. Results were reviewed related to determination of acoustic presence of North Atlantic right whales and fin whales.
>
> <u>North Atlantic right whales</u>
>
> The procedure used to review these data was to first quickly review ISRAT2.rec files to gain an overview of each day of reviewed data, and then to make XBAT logs from these ISRAT files. These XBAT logs were examined in XBAT.

We have used the results given in the Up calls (Y) column to determine agreement between our assessment and these results. Overall, we agree with the GMI assessments.

Fin whales

The procedure used to review these data was to work with XBAT logs to examine each event to determine true and false detections. Overall, our analysis results regarding both daily presence of fin whales and also true/false classification of individual events agreed with the GMI assessment."