Ocean/Wind Power Ecological Baseline Studies

January 2008 – December 2009

FINAL REPORT

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF SCIENCE

Volume III: Marine Mammal and Sea Turtle Studies

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July 2010

GEO-MARINE GMI
A Subsidiary of Applied Research Associates, Inc.

New Jersey Department of Environmental Protection
Baseline Studies

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LIST OF ACRONYMS AND ABBREVIATIONS

°	Degree(s)
°F	Degree(s) Fahrenheit
°C	Degree(s) Celsius
AIC	Akaike's Information Criterion
BRP	Bioacoustics Research Program, Cornell Laboratory of Ornithology
BSS	Beaufort Sea State
CCL	Curved Carapace Length
CDS	Conventional Distance Sampling
CETAP	Cetacean and Turtle Assessment Program
chl *a*	Chlorophyll *a*
CI	Confidence Interval
cm	Centimeter(s)
CV	Coefficient of Variation
DF	Degrees of Freedom
DSM	Density Surface Modeling
DVD	Digital Video Disc
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
ESW	Effective Strip Half-width
ft	Foot (Feet)
GAM	Generalized Additive Model
GCV	Generalized Cross Validation
GIS	Global Information System
GMI	Geo-Marine, Inc.
GOF	Goodness-of-Fit
GPS	Global Positioning System
hr	Hour
Hz	Hertz
in.	Inch(es)
km	Kilometer
kHz	Kilohertz
kph	Kilometer(s) per Hour
kt	Knot(s)
MATS	Mid-Atlantic *Tursiops* Surveys
m	Meter(s)
mg/m^3	Milligram(s) per Cubic Meter
min	Minute(s)
MMPA	Marine Mammal Protection Act
MODIS	Moderate Resolution Imaging Spectroradiometer
mph	Mile(s) per hour
MRDS	Mark-Recapture Distance Sampling
NARWC	North Atlantic Right Whale Consortium
NASA	National Aeronautics and Space Administration
NJDEP	New Jersey Department of Environmental Protection
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
NMFS-NEFSC	National Marine Fisheries Service-Northeast Fisheries Science Center
NMFS-SEFSC	National Marine Fisheries Service-Southeast Fisheries Science Center
NMFS-SWFSC	National Marine Fisheries Service-Southwest Fisheries Science Center
NOAA	National Oceanographic and Atmospheric Administration
OSA	Ocean Stock Assessment
PAM	Passive Acoustic Monitoring
PU	Pop-up
QA/QC	Quality Assurance/Quality Control

LIST OF ACRONYMS AND ABBREVIATIONS (*continued*)

RU COOL	Rutgers Coastal Ocean Observation Lab
s	Second(s)
S	Station
SAS	Sighting Advisory System
SE	Standard Error
SST	Sea Surface Temperature
U.S.	United States
UBRE	Unbiased Risk Estimator
Var	Variance
VOR	Voice Operated Recording
X^2	Chi-Square

LIST OF METRIC TO U.S. MEASUREMENT CONVERSIONS

To convert from	To	Multiply by
LENGTH		
Kilometer (km)	Mile, statute (mi)	0.6214
	Nautical mile (NM)	0.5400
Nautical Mile (NM)	Mile, statute (mi)	1.151
Meter (m)	Foot (ft)	3.281
	Inch (in.)	39.37
Centimeter (cm)	Inch (in.)	0.3937
Millimeter (mm)	Inch (in.)	0.03937
Micrometer or Micron (µm)	Microinch (µ in.)	39.37
DISTANCE PER UNIT TIME		
Meter per second (m/s)	Mile per second (mi/s)	0.0006214
	Foot per second (ft/s)	3.281
Centimeter per second (cm/s)	Inches per second (in./s)	0.3937
Kilometers per hours (kph)	Mile per hour (mph)	0.6214
	Knot (nautical mile/hour)	0.5400
Knot (nautical mile/hour)	Mile per hour (mph)	1.151
AREA		
Square kilometer (km^2)	Square mile (mi^2)	0.3861
	Square nautical mile (NM^2)	0.2916
Square nautical mile (NM^2)	Square mile (mi^2)	1.324
Square meter (m^2)	Square foot (ft^2)	10.76
VOLUME		
Cubic meter (m^3)	Cubic foot (ft^3)	35.31
	Gallon (gal)	264.2
Liter (L)	Gallon (gal)	0.2642
VOLUME PER UNIT TIME		
Cubic meter per second (m^3/s)	Cubic foot per second (ft^3/s)	35.31
	Gallon per minute (gal/min)	15,850
Sverdrup (Sv) = 10^6 m^3/s	Gallon per second (gal/s)	264.2
WEIGHT		
Metric Ton (MT)	Ton, short (T)	1.102
Kilogram (kg)	Pound (lb)	2.205
DENSITY		
Kilograms per cubic meter (kg/m^3)	Pounds per cubic foot (lb/ft^3)	0.06243
CONCENTRATION		
Microgram per liter (µg/L)	Ounces per gallon (oz/gal)	1.336×10^{-7}
TEMPERATURE		
Degree Celsius (°C)	Degree Fahrenheit (°F)	1.8*(°C + 32)

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1.0 INTRODUCTION

1.1 PREVIOUS STUDIES

Marine mammals and sea turtles are important marine resources found in the New Jersey Department of Environmental Protection (NJDEP) Study Area (hereafter referred to as Study Area); however, the distribution and abundance of these resources in New Jersey's nearshore waters are not well known. The National Marine Fisheries Service (NMFS) and other organizations have been conducting marine mammal and sea turtle surveys along the United States (U.S.) east coast for many years. Although several of these surveys have included waters of the Study Area, none have concentrated efforts specifically in New Jersey's nearshore waters, except a photo-identification survey that was conducted in coastal waters from the shoreline to 6 kilometers (km; 3 nautical miles [NM]) offshore. In addition, no year-round survey efforts have been conducted in this region. The following is a list of the main surveys that were conducted prior to the Ecological Baseline Study and that have effort which overlaps with at least part of the Study Area. Note that most of these surveys were conducted only during the summer months.

<u>Aerial Surveys</u>

- The National Marine Fisheries Service-Southeast Fisheries Science Center (NMFS-SEFSC) conducted the Mid-Atlantic *Tursiops* Surveys (MATS) to determine the distribution and abundance of bottlenose dolphins (*Tursiops truncatus*) in nearshore waters of the U.S. east coast. During the summer of 1994, NMFS-SEFSC conducted a pilot study which consisted of an aerial survey to count the bottlenose dolphins along the shoreline and a line transect aerial survey from Long Island, New York, to Vero Beach, Florida (Blaylock 1995). During the following summer, a line transect aerial survey from Sandy Hook, New Jersey, to Cape Hatteras, North Carolina from the shoreline to the 25-meter (m; 82-foot [ft]) isobath (around 0 to 81 km [0 to 44 NM] from shore; Garrison and Yeung 2001). The MATS surveys flown during the summer (June through July) of 2002 covered coastal waters between Sandy Hook, New Jersey, and Ft. Pierce, Florida (Waring et al. 2009). Additional surveys were flown in the summer of 2004 between Atlantic City, New Jersey, and Fort Myers, Florida (Fertl and Fulling 2007).

- The National Marine Fisheries Service-Northeast Fisheries Science Center (NMFS-NEFSC) conducted aerial (DeHavilland Twin Otter) line transect surveys to estimate cetacean and sea turtle abundance off the mid-Atlantic and northeast coasts. These surveys were flown during the summer in 1995, 1998, and 2004 from the Gulf of St. Lawrence to Virginia (NMFS-NEFSC 1998b; Quintal and Smith 1999; Palka et al. 2001).

- Right Whale Sighting Advisory System (SAS) aerial surveys are currently being flown over a broad region of the western North Atlantic Ocean from just south of Long Island, New York, to the U.S./Canada border and out to the 370 km (200 NM) Exclusive Economic Zone (EEZ).[1] Although the primary focus of these surveys is North Atlantic right whales, other species of marine mammals and also sea turtles are documented. Opportunistic sighting information is also provided to the SAS by other organizations, including state, federal, and non-profit organizations (NMFS-NEFSC 2008).

<u>Shipboard Surveys</u>

- The NMFS-NEFSC conducted a two-week shipboard survey (*Delaware II* 97-05 cruise) in March 1997 to determine the spatial distribution and relative abundance of cetaceans in mid-Atlantic waters between Long Island, New York, and just south of Cape Hatteras, North Carolina (NMFS-NEFSC 1997). Additional surveys (*Delaware II* 98-04 cruise) in this same region were conducted in March 1998 (NMFS-NEFSC 1998a).

- The NMFS-SEFSC conducted a shipboard marine mammal survey (*Oregon II* 99-05 cruise) in August and September 1999 from the 10-m (33-ft) isobath to 185 km (100 NM) offshore from Cape Canaveral, Florida, to just north of Delaware Bay (NMFS-SEFSC 1999).

Small Boat Surveys

- The NMFS-SEFSC and the Rutgers University Marine Field Station funded boat-based photo-identification surveys in southern New Jersey. Surveys were conducted from May through October in 2003, 2004, and 2005 along 70 km (38 NM) of coastline from the northern tip of Long Beach Island to southern Longport, New Jersey. The study area extended from the shoreline to 6 km (3 NM) offshore. The purpose of this study was to determine the occurrence, structure, and characteristics of two bottlenose dolphin population subunits in coastal New Jersey (Toth-Brown 2007).

Aerial/Shipboard Surveys

- The University of Rhode Island conducted systematic seasonal surveys (aerial and shipboard) during the Cetacean and Turtle Assessment Program (CETAP) from October 1978 through January 1982. These surveys covered waters of the U.S. continental shelf (from the coast to 9.26 km [5 NM] seaward of the 2,000-m [6,562-ft] isobath) from Cape Hatteras, North Carolina, to the northern Gulf of Maine (CETAP 1982).

1.2 BASELINE STUDY OBJECTIVES

This Ecological Baseline Study includes the first year-round, systematic survey effort in nearshore waters of New Jersey between Stone Harbor and Seaside Park. The objective of this study was to determine the spatial distribution and to estimate the abundance/density of marine mammals and sea turtles in the Study Area (shoreline to around 37 km [20 NM] offshore). This baseline study was conducted over a 24-month period between January 2008 and December 2009. The three sampling techniques conducted during this study included aerial line transect surveys, shipboard line transect surveys, and passive acoustic monitoring (PAM). Shipboard and aerial line transect surveys are a type of distance sampling method and were used to collect data on marine mammal and sea turtle species found in the Study Area. PAM was conducted to determine the presence of cetaceans in the Study Area.

The survey design, data recording methods, and safety guidelines were prepared in consultation with the NJDEP, NMFS-NEFSC personnel, acousticians from the Bioacoustics Research Program, Cornell Laboratory of Ornithology (BRP), and other experts in distance sampling and acoustic monitoring. The shipboard and aerial surveys were conducted under National Oceanographic and Atmospheric Administration (NOAA) Permit No. 10014.

2.0 AERIAL AND SHIPBOARD SURVEY METHODOLOGY

2.1 AERIAL SURVEY DESIGN

2.1.1 Survey Effort

Aerial surveys were conducted once monthly after the shipboard surveys between February and May 2008 and twice monthly (when possible) between January and June 2009. The surveys were flown in accordance with the Geo-Marine, Inc. (GMI) Aerial Survey Requirements and Provisions (**Appendix A**). The surveys were designed to determine marine mammal and sea turtle distribution and estimate abundance/density using line transect methods (see Buckland 2001). The survey aircraft for the 2008 surveys was a twin-engine, high-winged Cessna Skymaster 337 with bubble windows on each side of the aircraft to allow unobstructed views of the trackline directly beneath the plane. During the 2009 surveys, a Cessna Skymaster without bubble windows was used so visibility below the aircraft was limited. Surveys were flown at ~229 m (750 ft) altitude and a speed of ~220 kilometers per hour (kph; 110 knots [kts]) during daylight hours when there was at least 3.7 km (2 NM) visibility and a Beaufort sea state (BSS) of less than 6.

For the February 2008 survey, pre-determined transect lines (tracklines) were spaced 3.7 km (2 NM) apart and orientated perpendicular to the coastline. The 34 tracklines were divided (even or odd numbered) and flown during separate morning and afternoon sessions (i.e., half were flown in the morning and half in the afternoon). New transect protocol following NOAA survey methodology was initiated for the March 2008 survey and continued for the rest of the aerial surveys. Before each monthly survey, tracklines were randomly generated in a double saw-tooth pattern (see **Figure 2-1** in **Section 2.1** of **Volume II: Avian Studies**) using the program Distance 5.0 (Buckland et al. 2004; Thomas et al. 2010). This design provided comparable spatial and temporal coverage of the entire Study Area and allowed the entire Study Area to be surveyed in one day, thereby minimizing the temporal variation. On each day of the survey, a coin toss determined whether the surveys would start at the north or south end of the Study Area.

Additional strip transects were flown along the coastline (at low tide) when possible to assess the presence/absence of pinnipeds in the Study Area. Pinnipeds at haulout sites were recorded and groups were photographed to assist with species identification and group size estimation. No flights were purposefully flown directly over haulout sites in accordance with NMFS requirements.

Visual observations were recorded by a team of three people during the 2008 surveys. Two experienced observers searched for animals at the surface from directly beneath the aircraft out to a perpendicular distance of ~1,500 m (~4,900 ft). The third person acted as data recorder and was stationed in the co-pilot seat. During the 2009 surveys, flight protocols followed those stated above with some modifications. A co-pilot was added so there was no room in the plane for a dedicated data recorder. Therefore, the two experienced observers were responsible for observations and recording data. This necessitated changes in data recording and sighting protocols in order to maintain observer vigilance. The protocols adopted were those used for two-observer aerial surveys for North Atlantic right whales (*Eubalaena glacialis*) in a Cessna Skymaster off the southeast U.S. (Schulte and Taylor 2009). The two observers sat in the rear seats, one on the right side, and one on the left side. One observer recorded the time and position of each sighting on a laptop while the second observer recorded the sighting information on a digital tape recorder.

2.1.2 Data Logging

The aircraft's position along the trackline (in addition to all other survey information) was collected every 10 seconds (s) on a computer interfaced with the aircraft's global positioning system (GPS) via a custom data acquisition program. Environmental conditions (e.g., BSS, solar glare, water color, and transparency) which may affect the ability to detect animals were recorded prior to the start of each trackline and updated as needed while on effort. All sighting data, including time, position, group size, species, and behavior, were recorded. During the 2008 surveys, the voice-operated recording (VOR) data entry program was used to record all pertinent data. During the 2009 surveys, the data entry program Logger 2000 was used and augmented by voice notes using a hand-held digital recorder.

2.1.3 Recording Sightings

During the 2008 surveys, when an animal was sighted perpendicular to the aircraft along the trackline, the angle to the sighting (≤60 degrees [°]) was determined either using a digital inclinometer or 10° intervals (bins) marked on the aircraft windows for calculation of perpendicular sighting distances. During the 2009 surveys, the perpendicular sighting distances were calculated based on GPS locations. Therefore, when an animal or group was sighted, the GPS point on the trackline was recorded, and a second GPS location was recorded directly over the sightings. The perpendicular sighting distance was calculated from these two GPS locations using a global information system (GIS) distance measurement algorithm. This 2009 survey method differed from that used during the 2008 surveys due to the absence of a dedicated data recorder and the need to incorporate an approach that maximizes observation time from the aircraft. The GPS method has been proven to provide very accurate distance estimates (Marques et al. 2006).

During both the 2008 and 2009 surveys, the observers went into off-effort mode at the time of a sighting to verify species identification and estimate group sizes. The species identification, best estimate of group size, behavior, time, position, and associated animals were also recorded. This information was relayed to the data recorder. A circle-back procedure was used if necessary to verify species identification and estimate group sizes. Attempts were made to photograph all the animals in a sighting to compare with other photo-identification databases.

Sightings of non-target species (species other than marine mammals or sea turtles) were recorded opportunistically throughout the survey period. In addition to records of fish, sharks, and rays, locations of commercial fishing vessels were documented. This information is summarized in **Volume II**.

2.2 SHIPBOARD SURVEY DESIGN

2.2.1 Survey Effort

Shipboard survey effort was conducted monthly between January 2008 and December 2009 on the University of Delaware's R/V *Hugh R. Sharp* (44.5 m [146 ft] in length). The surveys were conducted in accordance with the GMI Shipboard Survey Safety Plan (**Appendix B**). A single platform and standard line transect methods were used (Buckland 2001). The surveys were conducted along predetermined tracklines at 18.5 kph (10 kts) along the designated trackline. Before each monthly survey, tracklines were randomly generated in a double saw-tooth pattern (see **Figure 2-1** in **Section 2.1** of **Volume II: Avian Studies**) using the program Distance 5.0 (Buckland et al. 2004; Thomas et al. 2010) to cross the bathymetry gradient and to maximize uniform coverage of the Study Area. The starting point and time of each cruise was chosen based on the timing of high tide and weather conditions due to the docking criteria of the R/V *Hugh R. Sharp*. Tracklines were altered only if sea state, glare, or weather inhibited the survey effort. In these cases, the vessel diverted off the established trackline up to 30° from the established course. This deviation continued only until the ship was 18.5 km (10 NM) from the original trackline; at this point the ship turned back toward the waypoint of the original trackline.

Visual observations were recorded from the flying bridge (10 m [32.81 ft] above water) during daylight hours (roughly sunrise to sunset) when weather permitted. The marine mammal/sea turtle observer team consisted of six individuals; three observers were actively on duty at any one time. On-duty observers consisted of one observer searching with 25x150 power Fujinon binoculars ("bigeyes") mounted on a pedestal on the port side of the vessel while another observer searched through bigeye binoculars mounted on the starboard side. The third observer served as the data recorder and also searched the water with unaided eyes and 7x hand-held binoculars between the port and starboard bigeye observers. Each observer scanned out to the horizon from abeam (90°) on his/her side of the ship to 10° to the opposite side of the bow (100° in all). The 20° along the ship's trackline thus received overlapping coverage by the two bigeye observers. Observers rotated through these three stations every 40 minutes (min). During each rotation, at least one of the on-duty observers was highly experienced in survey techniques and marine mammal/sea turtle identification.

Survey operations were suspended when wind conditions reached a 6 or higher on the Beaufort scale since visibility was too poor for survey effort to continue. Survey effort was also suspended when rain or fog reduced visibility to 1.9 km (1 NM) or less along the trackline or when greater than 50% of the horizon was obscured.

2.2.2 Data Logging

The data recorder entered a log of weather conditions (BSS, wind speed, swell height and direction, direction of sun, visibility, etc.), visual effort (on or off), sightings, and other survey information into the computer mounted on the flying bridge. All data were recorded using WinCruz, a computer program developed by NMFS-Southwest Fisheries Science Center (SWFSC). The weather conditions were recorded every 40 min (when observers rotated positions) and updated when conditions changed. The GPS position of the vessel, as well as the vessel's course and speed, was automatically recorded every 2 min via an integrated, stand-alone GPS unit on the flying bridge. Detailed paper forms were completed for each marine mammal sighting to supplement and expand upon information recorded in WinCruz. The initial time of the sighting and the angle and reticle of the sighting (recorded from the bigeye binoculars) were listed on each sighting form as a backup to the computer file. Other information on taxonomic identification (including a sketch showing diagnostic features) and the behavior of the animals observed was also documented on the sighting form and used to verify species identification. Each observer maintained a log book which was used primarily to record estimates of the number of individuals (group size) and taxonomic composition (in percentages) for each sighting documented by the observer. Three estimates of group size (best, maximum, and minimum) were recorded for all sightings. Estimates of group size and the percent taxonomic composition were made independently by each observer without discussion among other observers so that the data were not observer-biased. At the end of the day, the chief scientist was responsible for collecting the log books and adding the estimates of group size and composition to the sighting records in the WinCruz dataset.

2.2.3 Recording Sightings

When an individual or group of marine mammals was sighted, the observer team went into off-effort mode so that all observers could stop actively searching and focus on the sighting. Observers measured the angle and distance from the ship to the sighting. The pedestals of the bigeye binoculars were fitted with azimuth rings for measurement of horizontal angles (b) between the trackline and the animals. Vertical angles from the horizon to the animals were measured with reticle scales in the ocular lenses of the binoculars. Reticle values were converted to angular values and to radial distance (R) from the observer based on the average eye height of observers on the flying bridge above the water's surface. The WinCruz program automatically calculated this conversion of reticle value to radial distance. The perpendicular sighting distance (y) between the animals and the trackline was calculated as $y = R*\sin(b)$ where R was the radial distance to the animals and b was the horizontal angle of the animals from the trackline (Lerczak and Hobbs 1998).

The vessel remained in passing mode if species identification and group estimates could be obtained while remaining on the trackline. If necessary, the vessel turned off the trackline to approach the individual or group (closing mode) to obtain this information. The vessel's speed and course were altered as necessary to obtain sighting data. A balance was kept between spending time off effort approaching animals and spending time searching on effort. Attempts were made to photograph all the animals in a sighting to document species identification and to obtain photographs that can be compared to other photo-identification databases for possible matches.

Once all the necessary data were collected for the sighting, the vessel resumed the same course and speed as prior to the sighting. If the vessel had to turn off the trackline for the sighting, then the vessel would resume a course back to the original trackline, and the team would go back on effort as long as the distance from the planned trackline was less than 9 km (5 NM). If the vessel was farther than 9 km (5 NM) from the original trackline, the team would plot a new course to the next waypoint.

Sightings that were made while the survey team was off effort were also recorded. In some cases, another marine mammal or turtle sighting was observed while the vessel was in off-effort mode approaching the original sighting. Also, an occasional sighting was made by off-duty personnel; these sightings were only reported after the animal(s) passed abeam of the ship and were recorded as off-effort sightings. All off-effort sightings are included in this report but could not be used in the generation of abundance and density estimates because they did not meet the criteria for the analyses.

Sightings of non-target species (species other than marine mammals or sea turtles) were recorded opportunistically throughout the survey period. In addition to records of fish, sharks, and rays, locations of commercial fishing vessels were documented. This information is summarized in **Volume II**.

2.3 DATA PROCESSING AND QUALITY ASSURANCE/QUALITY CONTROL

Data collected from the aerial and shipboard line transect surveys were reviewed daily for accuracy. Data Quality Assurance (QA)/Quality Control (QC) procedures included verifying that weather conditions, viewing conditions, observer information, species identification, group size, and location information were all correctly recorded. The sighting sheets were also checked for completeness and readability. The chief scientist compared digital data with data captured through sighting sheets, daily sighting logs, behavior data sheets, and error correction logs. All corrections found either through notes logged on the computer or on the aerial survey error logs were documented and confirmed by the chief scientist. These QA/QC procedures allowed any flaws in the data to be corrected immediately and prevented errors from progressing through data analysis. All data files were backed up on external hard drives, digital video discs (DVDs), and GMI's network.

2.3.1 Seasons

The following periods were used as seasonal designations in the analysis of marine mammal and sea turtle sightings data:

Winter: 18 December – 09 April
Spring: 10 April – 21 June
Summer: 22 June – 27 September
Fall: 28 September – 17 December

These seasons were calculated based on three years (01 January 2007 to 31 December 2009) of SST data derived from the NASA (National Aeronautics and Space Administration), MODIS (Moderate Resolution Imaging Spectroradiometer), Level 3 data collected onboard the Aqua Earth Observing System satellite. These data were post processed by the Rutgers Coastal Ocean Observation Lab (RU COOL) and were originally supplied by the NASA Goddard Earth Sciences Data and Information Services Center. Winter and summer are defined as the time periods when the change in sea surface temperature (SST) is less than the median change, and winter is distinguished from summer by comparing the SST of each sampled day against the mean SST of all sampled days (i.e., the SST of days in winter will be less than the mean SST, and the SST of days in summer will be greater than the mean SST). Spring and fall are defined as the time periods when the change in SST is greater than the median change, and spring is distinguished from fall by comparing the sign of change between each sampled day on the curve (i.e., in spring the SST is increasing and in fall the SST is decreasing, so the sign of a value in spring is positive and the sign of a value in fall is negative). Although some seasons may be shorter or longer than the standard seasonal definitions, the intuitive meaning for each of the seasons still applies. That is, winter and summer are still the times of year with the lowest and highest temperatures, respectively, while spring and fall represent transitional periods between the two temperature extremes.

2.3.2 Calculation of Survey Effort

Shipboard survey data were collected as a series of latitude and longitude points every 2 min while a series of latitude and longitude points were collected every 10 s on the aerial surveys. Daily survey effort was calculated as a summation of the distance between each successive point after the coordinates were converted from degrees to radians. After converting to radians, the coordinates were used to calculate the great circle distance in kilometers between successive latitude and longitude positions. All of the individual distances between points were summed for each day to produce an estimate of daily effort for each survey. All of the daily effort estimates were summed to obtain a total estimate of effort for all days and surveys combined.

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3.0 ABUNDANCE AND DENSITY ANALYSES

3.1 DATA PREPARATION AND ASSUMPTIONS

3.1.1 Sightings Data Criteria

The sightings included in the density/abundance analyses had to meet the following criteria:

1) Sightings were recorded by on-duty observers while the team was searching in on-effort mode. Sightings data recorded from other surveys not associated with this baseline study could not be combined with the sightings data collected during this baseline study to generate abundance/density estimates because we could not assume that the detection function remained constant throughout the different surveys simply due to different weather conditions, observer teams, survey platforms, and protocols. In addition, opportunistic sightings could not be included in the analyses because they were not collected under line transect protocols.

2) Perpendicular sighting distances had to be calculated for each of the on-effort sightings included in the abundance/density analyses.

3) Sightings and effort recorded during a BSS≤5 were included in the density/abundance modeling of all species or groups except the harbor porpoise (*Phocoena phocoena*). The abundance/density analysis for the harbor porpoise was based only on effort conducted in the best survey conditions (BSS≤2). Harbor porpoises are difficult to detect in a higher BSS because their sighting cue (small, dark dorsal fin) is hard to see, particularly as the distance from the vessel increases (Polacheck 1995). In addition, harbor porpoises typically do not spend much time at the surface and often occur singly or in very small groups which adds to the difficulty in detecting this species (Polacheck 1995).

Conservative modeling of data with high precision (low variance) requires an adequate sample size (n). Generally, as sample size increases, variance decreases and precision improves. A sample size of at least 60 sightings is typically recommended for estimating a detection function (Buckland et al. 2001), and 15 sightings may be the absolute minimum number of sightings that can be used to fit a detection function (Barlow et al. 2006). Due to some of the low number of sightings during this baseline study, we specified a minimum sample size of around 20 sightings in order to model a detection function. Species with fewer than 20 sightings were pooled into taxonomic groups with species of similar sighting characteristics when possible, and modeling of a group detection function was then conducted. The data were then stratified by species to estimate abundance/density of individual species using the pooled detection function. In one case, a minimum of 18 sightings was used to fit a detection function.

Aerial and shipboard survey data could not be combined for density/abundance estimation because of the differences in survey techniques and perception bias (animals were at the surface but were not seen). Therefore, separate analyses were conducted for the aerial and shipboard sightings data. The Conventional Distance Sampling (CDS) method was used to generate abundance/density estimates for the overall Study Area, and the Density Surface Modeling (DSM) method was used to generate surface maps of predicted density at a finer spatial resolution using various environmental covariates as predictors of density. All analyses were carried out using Distance 6.0 release 2 (Thomas et al. 2010)[2] and the statistical program R.[3] Note that the PAM results could not be used to generate density/abundance estimates since these results only provided information on the presence of certain species and did not meet the criteria mentioned above.

3.1.2 Modifications to Sightings Data

We estimated detection functions after filtering the data based on the above criteria. During the exploratory data analysis phase, it is important to identify any “spikes” in the data and what the cause may be since different models will give very different abundance/density estimates for spiked data (Thomas et al. 2010). We plotted histograms of the perpendicular distance data, and selected various cutpoints to identify suitable truncation points (for removal of spurious data and outliers) for perpendicular distances in order to conform to the conditions of the “ideal” probability detection function. Buckland et al. (2001) recommend truncation of the most distant 5 to 10% of sightings from the right-hand tail of the detection function to remove outliers and improve the ability to fit the detection function; however, due to our small sample sizes, a 5 to 10% right truncation may remove too many sightings and hinder our ability to fit a detection function. Thus, when considering truncation of some of the data, trade-offs must be weighed between the benefits of removing spurious data (which can reduce variance) and the costs of a reduced sample size (which can increase variance). Instead of truncating 5 to 10% of sightings, right truncations were based on specific distances from the trackline which were determined on a case-by-case basis for the different species/group analyses by assessing the Q-Q plots and histogram plots using various truncation lengths. In some cases, spurious data can cause spikes of detections near the trackline. These spikes often arise when animals (e.g., dolphins) are attracted to the survey vessel and detections were not made before any responsive movement occurred (Thomas et al. 2010). Spikes can also be caused by inaccurate estimation of sighting angles for detections ahead of the vessel (often rounding of perpendicular sighting distances to zero; Thomas et al. 2010). For the shipboard survey analyses, the spiked data were not removed with a left truncation because we did not want to eliminate data with a near-100% detection probability at short distances. A left truncation was used for the aerial survey data collected in 2009 not because of a spike near the trackline but because of the limited visibility of the trackline due to the lack of bubble and belly windows on the survey plane. In this case, a left truncation position was chosen where detection was certain.

Distance data are either recorded as exact measurements or are grouped (“binned”) into distance categories (Buckland et al. 2001). During the shipboard surveys, sighting distances and angles were recorded as exact measurements and were transformed to perpendicular sighting distances for analysis. Therefore, the shipboard sightings data could be analyzed as exact data in Distance; however, the aerial survey data were collected as both exact data and binned data. During the 2008 aerial surveys, the declination angle of each sighting from the plane was recorded either as an exact distance (measured with an inclinometer) or as a bin number which corresponded to a range of declination angles. During the 2009 aerial surveys, the GPS locations of the plane on the trackline and of the sighting were used to calculate the exact perpendicular sighting distance for each sighting. For some analyses it was necessary to combine the aerial survey data from both years to have an acceptable sample size to use for the density/abundance analyses. Therefore, we had to combine the survey data that was collected in bins and the data that was collected as exact distances. To do so, we had to analyze all the data as though it were collected as binned data. When we analyzed data from only the 2009 aerial surveys, we were able to use the exact distance data (unbinned) in our abundance/density analyses.

3.1.3 Assumptions

The key assumptions for line transect surveys are as follows (Buckland et al. 2001):

1) The detection function (see **Section 3.2.1**) was the same for all animals/detections.

2) Animals were detected at their initial location. Marine mammals and sea turtles are highly mobile; therefore, it can be difficult to determine initial locations. For example, some species, such as harbor porpoises, tend to move away from vessels (Barlow 1988; Polacheck and Thorpe 1990; Palka and Hammond 2001) and other species, such as short-beaked common dolphins (*Delphinus delphis*), are attracted to vessels and often approach ships to bow ride (Palka et al. 2005). To minimize the potential bias of responsive behavior of animals to the ship, the observers used high-powered (bigeye) binoculars so that they could see a great distance from the trackline and detect animals before they reacted (positively or negatively) to the presence of the ship.

3) All measurements recorded during the surveys are exact and not subject to rounding (heaping), measurement errors, or recording errors. For grouped or binned data, the measurements are assumed to be assigned to the correct category (or bin). No measurements are likely to be exact on the moving platforms of the plane and ship; however, we attempted to minimize error in our measurements by using the azimuth rings, reticle scales, and inclinometers. Every effort was

made to avoid rounding any measurements. In regards to group size estimates, we were not able to compare our observer estimates with aerial photographs of sightings; however, we did obtain group size estimates from as many of the observers as possible and used the average of the best group size estimates for each sighting.

4) Animals on the trackline (at zero distance) were detected with certainty such that *g*(0)=1. At zero perpendicular distance y=0 (i.e., when the animal is on the trackline), the detection probability should be at or near 100% (i.e., all or nearly all animals on the trackline should be detected). Over a moderate range of short distances, the detection probability should be ideal (100%) or near ideal (i.e., a broad shoulder in the detection function), meaning that all animals that are actually present are detected by the observer for some distance from the trackline. Instruments that aid in detection at short distances (such as high-power binoculars) can increase the distance range of the "broad shoulder". Naturally, as sighting distance increases over longer distances, the number of sightings/detections should begin to decrease, and at a given distance, large animals and animal clusters are more likely to be detected than smaller animals and animal clusters. Assumption of *g*(0)=1 can lead to bias and underestimation of abundance and density (since density is inversely related to *g*[0]). This assumption rarely holds true during marine mammal and sea turtle surveys due to availability bias and perception bias. Perception bias results when an observer fails to detect an animal on the trackline when the animal is actually at the surface on the trackline. Factors that can influence perception bias include viewing conditions (e.g., BSS, glare, swell height), observer condition (e.g., experience, fatigue), and platform characteristics (e.g., pitch, roll, yaw, altitude). Availability bias results when an animal is submerged or otherwise hidden from view while on the trackline and, hence, is unable to be detected. Factors that can affect availability bias include species-specific behavior, group size, blow and dive characteristics, and dive intervals. Availability bias is particularly a problem for long divers, such as sperm whales (*Physeter macrocephalus*) and beaked whales (family Ziphiidae), and is not as much of a problem for species that have shorter dive times, such as common dolphins.

   A discussion of *g*(0), factors affecting animal detectability, and methods of accounting for detection bias are discussed in Thomsen et al. (2005). Estimates of *g*(0) for shipboard and aerial surveys are used to calculate less biased estimates of population size. To estimate *g*(0) for shipboard surveys, there are two methods that can be used. The first uses a two-team approach (double platform) where two independent teams of observers scan the same trackline simultaneously (see Borchers et al. 1998). This approach is very costly in personnel and equipment and requires a ship large enough to accommodate the two platforms of the observer teams. The second method utilizes a survey aircraft to survey the ship's trackline three to four times during a single day. The NMFS has used this method successfully (e.g., Palka 2005). This technique involves simultaneous ship and aerial surveys that cover the same spatial and temporal area. The sightings from the ship and aircraft are then compared to estimate the number sightings missed by the ship but seen from the aircraft. This method is normally used to estimate *g*(0) for aircraft but can be used to approximate this metric in reverse. Although this was the most cost effective method that could be used for our baseline study due to budgetary constraints, this method of conducting ship-plane experiments for every species was not practical for our study due to the relatively low encounter rate recorded from the ship and plane. This method is more conducive to an area with a relatively high density of marine mammals and high encounter rate which would allow for sufficient simultaneous recordings of sightings from the plane and ship. Otherwise, the costs of this method greatly increase due to the amount of simultaneous effort the ship and plane would need to run in order to record enough sightings of each species for calculating *g*(0).

   To estimate *g*(0) for aerial surveys, one of the following three methods is typically used. The Hiby circle-back data collection method uses a double-platform approach in which the aircraft periodically circles back on itself, and thus acts as both platform 1 (on the first pass) and platform 2 (when it circles back; Hiby 1999). Therefore, once a group of animals is sighted, the aircraft will continue to fly the trackline for 30 s, break trackline and fly the reciprocal heading past the sighting for another 30 s, and then rejoin the trackline. This trackline segment is then repeated and the presence/absence of the animals is recorded. The ratio of initial sightings to resighting events provides an estimate of *g*(0). This method is unbiased in low density areas but requires a large sample size; therefore, it is not applicable to most species (Palka et al. 2005). Although this method was originally proposed for the baseline aerial surveys, estimates *g*(0) were not obtained due to several factors. The method was originally designed to be used with at least two observers and a data recorder onboard the aircraft. For safety reasons a co-pilot was added to the crew for the 2009 flights. Because of the seating limitations of a Skymaster aircraft (four seats), the seat for the data recorder was eliminated. During initial attempts to consistently implement the Hiby circle-back method, the additional data recording requirements and the circle-back protocol resulted in unconfirmed or loss of sightings due to the multi-tasking of observers. A second method for estimating *g*(0) for aerial surveys uses two independent observer teams; this method is similar to the double platform approach discussed above for ship surveys; however, this method requires an airplane that can accommodate two teams of observers. Our aircraft did not meet this requirement. The third approach involves the use of the ship as mentioned above. These ship-plane experiments are not conducive to our Study Area due to the relatively low encounter rates.

For the purposes of this report, we assumed a *g*(0) of 1 because we were not able to calculate estimates of *g*(0) due to the limitations discussed above. We chose not to use *g*(0) estimates that have been calculated from other similar surveys since detection probability has been shown to vary substantially among observers, platforms, weather conditions, etc. (Borchers 2005). Therefore, the density and abundance estimates calculated for this report should be considered underestimated due to both perception and availability bias.

3.2 Conventional Distance Sampling

CDS is a design-based approach in which the abundance/density estimates that are generated are based on the survey design which is assumed to provide a representative sample of the entire Study Area. Therefore, we used this method to extrapolate from the sampled strips in our line transect sampling. More information about the CDS approach is discussed below. Additional information can be found in Buckland et al. (2001; 2004) and Thomas et al. (2010).

3.2.1 Detection Function

The CDS engine in Distance uses a flexible semi-parametric detection function modeling framework (Thomas et al. 2010). Sightings data were modeled as a probability detection function g(y), a plot of sightings versus distance between the sighting and the perpendicular distance from the sighting to the trackline on which the ship/plane is traveling. Estimates of density and abundance were based on estimates of encounter rate, detection probability, and mean cluster (group) size.

3.2.1.1 Detection Probability Estimation

An ideal probability detection function has the following characteristics (Buckland et al. 2001):

1) An intercept of *g*(0) = 1.0 (100% probability of detection) at zero perpendicular distance y=0 (where *g*[0] is the probability of detecting an animal on the trackline),
2) A broad shoulder over a range of short distances before beginning to taper off,
3) A monotonically decreasing function *g*(y) with increasing perpendicular distance y, and
4) An upward shift in the detection function *g*(y) as animal/cluster size increases (when animal size or cluster size is included in the modeling).

The decrease in detection probability as a function of increasing perpendicular distance from the transect line was modeled using a half-normal or hazard-rate key function along with cosine series expansion terms as required. This model optimization analysis was conducted for each species/group in which there were around 20 sightings that met the criteria described in **Section 3.1.1**. During the model optimization analysis, the detection functions for each species/group were modeled using different combinations of the half-normal and hazard-rate key functions with the expansion terms. In most cases, the optimal model was chosen as that model which yielded the smallest value of the Akaike's Information Criterion (AIC) index (Buckland et al. 2001, 2004), given by: AIC = -2*ln(L) + 2*q, where ln(L) is the log-likelihood function evaluated at the maximum likelihood estimates of the model parameters and q = number of estimated model parameters. AIC quantifies the bias-variance trade-off. The first term quantifies how well the model fits the data, which can also be quantified via the chi-square (X^2) goodness-of-fit (GOF) test. The second term quantifies the penalty (increased variance) associated with addition of model parameters. Model parameter addition (increase in q) improves model fit and reduces bias at a cost of increasing variance and model complexity. To aid in model selection, the model with the lowest AIC is identified as the optimal model, which has the best combination of a good fit to the data without too many parameters (parsimony principle). In some cases where the behavioral observations indicated a problem with avoidance or attraction to the survey platform, the optimal model was subjectively chosen. For example, when a spike near the trackline was thought to be caused by the attraction of the animals to the platform, the optimal model chosen was the one that did not fit the detection function to the whole spike. Fitting the spike near the trackline results in inflated abundance/density estimates.

3.2.1.2 Mean Group Size Estimation

We are estimating the density/abundance of animals which often occur in groups or clusters. Therefore, the mean group size of the sightings may be subject to size bias. Large groups are often detected at greater distances from the trackline than small groups which can lead to positively-biased estimates of the mean size of detected groups. In general, the arithmetic mean group size may be an overestimate of the true mean group size and could lead to positively-biased density and abundance estimates. To account for group-size bias, the size-bias regression approach was used to estimate an expected mean group size using Distance. In this approach, the expected mean group size of the population is estimated by using a regression method in which the logarithm of cluster size of observation "i", log(si), is regressed against the estimated detection probability, g(yi), where yi = perpendicular distance of object "i" from the trackline: log(si) = a + b*g(yi), where "a" (intercept) and "b" (slope) are regression coefficients. Mean cluster size in the population is estimated from the predicted mean size of detected clusters in the region where the detection probability is at or near 100% (i.e., g[yi=0] = 1.0, at zero perpendicular distance from the trackline). Thus, from the above regression equation, mean cluster size is approximated by s(mean) = a + b, where g(yi) is set equal to 1. This regression method corrects for size-biased detections and for the underestimation of size of detected groups (Buckland et al. 2001). A statistical hypothesis test was applied to the regression of group size on distance, and the expected mean group size was only used in the analysis if it was significantly ($P<0.15$) smaller than the arithmetic mean group size. If it was not significantly smaller, then the observed mean group size was used.

3.2.1.3 Density, Abundance, and Variance Estimation

According to line transect theory (Buckland et al. 2001), density (abundance per unit area) is estimated as a function of:

1) Encounter rate n/L (where n = sample size or number of sightings and L = line transect length or effort),
2) Probability density function at zero perpendicular distance *f*(0),
3) Mean group or cluster size E(s), and
4) Probability detection function at zero perpendicular distance (*g*[0]).

The estimated density (D) is given by the following equation:

$$D = N/A = n*E(s)*f(0)/2L*g(0)$$

where N = abundance, A = Study Area, E(s) = mean group size, and the other parameters are as defined previously. The term *g*(0) (the availability bias) is assumed to be 1.0. Assuming *g*(0) is constant, the sources of variance associated with abundance/density estimation in the CDS method include contributions of encounter rate (n/L), detection probability *f*(0), and mean group size E(s). Encounter rate (n/L) is defined as the ratio of the number of animals observed (n) to the effort L (i.e., transect length) associated with those sightings. Group size (E[s]) is effectively the ratio of the total number of individual animals observed (abundance) to the number of observations (see **Section 3.2.1.2**). Density (i.e., ratio of abundance N to Study Area A) is estimated as the ratio of the number of animals sighted (n) to the survey coverage area (a), where a = 2wL, w = strip half-width (truncation distance), and L = transect length. The effective strip half-width (ESW), μ, is defined as the sighting distance such that the number of animals at distances less than μ that were missed by the observer is equal to the number of animals at distances greater than μ that were detected by the observer. The ESW μ is equal to 1/*f*(0). Using the parameters *f*(0) and μ derived from the optimal detection function and assuming *g*(0)=1, the above density equation can be simplified to the following:

$$D = n^*E(s)/2\mu L$$

The error or uncertainty associated with each estimated parameter (D, n/L, *f*[0], E[s]) can be quantified by the variance (Var), coefficient of variation (CV), and the 95% confidence interval (CI). The CV is the ratio of the square root of variance to the value of the parameter estimate. For example, $CV(x) = Var(x)^{0.5}/x$, where x = D, n/L, *f*(0), or E(s). The CDS engine in Distance uses the delta method to estimate the analytical variance of a density or abundance estimate. According to the delta method, the squared coefficient of variation for density (D) is equal to the sum of the squared CVs for encounter rate (n/L), detection probability *f*(0), and mean group size E(s):

$$CV(D)^2 = CV(n/L)^2 + CV(f[0])^2 + CV(E[s])^2$$

After CV(D) is calculated, then, for the 100*(1 - 2*a) CI, the lower (D_l) and upper (D_u) confidence limits for estimated density D are given by $D_l = D/C$ and $D_u = D^*C$, where $C = \exp(z_a{}^*[\ln\{1 + CV(D)^2\}])$ and where z_a is the critical z value of the Gaussian normal distribution for the “a” confidence level (Buckland et al. 2001, 2004). For example, for the 95% CI, a = 0.025 and $z_a = 1.96$.

In addition to the estimates of density (D) and abundance (N), the model reports the CV, degrees of freedom (DF), and the 95% CI statistics associated with each density and abundance estimate. In addition, the optimal model parameters (of the optimal model used in the density estimates) are reported along with associated variances. Statistics on the components of density (i.e., n/L and *f*[0]) are also reported. In addition, model output includes the percentages of the variance associated with the global density estimate that is attributed to the encounter rate (n/L), density function *f*(0), and mean group size E(s).

3.3 DENSITY SURFACE MODELING

The CDS method provides robust estimates of abundance/density of species or groups but cannot give any information about the potential influences on those estimates. The DSM method provides additional information on distribution and abundance/density of marine species in the Study Area at a finer spatial resolution. DSM is a model-based approach in which animal abundance/density can be modeled as a function of spatially-indexed environmental covariates. This method is also known as spatial modeling or habitat modeling (Thomas et al. 2010). The key step in the first phase of DSM is partitioning the survey effort (tracklines) into segments. The DSM analysis engine in Distance utilizes the “count method” in which segment counts (sightings/detections) are modeled as a function of covariates (Hedley and Buckland 2004). The sightings within each segment are converted into an abundance estimate for each segment. The area of the segment (based on chosen segment length and the truncation distance) serves as an offset (Thomas et al. 2010). Generalized additive models (GAMs; Wood 2006) are used to estimate the spatial distribution of abundance/density or counts (the response variable) as a function of numerous geographical, physical, and environmental covariates (explanatory variables), such as longitude, latitude, water depth, distance from shore, bathymetry, SST, and surface chlorophyll concentration. After fitting GAMs to the survey data, the resulting DSM (the chosen model) is applied to a prediction grid superimposed upon the Study Area so that animal abundance/density can be predicted for any portion of the Study Area and related to specific covariates. The variance of the predicted abundance/density is estimated using the bootstrapping resampling technique (Hedley and Buckland 2004). A brief description of these methods is included below. For more information, please see Hedley and Buckland (2004).

3.3.1 Data Preparation

3.3.1.1 Segmentation Process

The DSM analysis engine in Distance requires all tracklines to be divided into segments (Thomas et al. 2010). There is no objective way to choose the length of segments; however, they should be sufficiently small so that habitat does not vary much within the segments, and expected density is not likely to vary much within the segments (Hedley and Buckland 2004). Due to gaps in search effort along the tracklines (e.g., when the survey team would switch to off-effort mode to approach a sighting to get group size estimates), effort cannot always be split into equal segment lengths. Therefore, the size of each segment may vary.

A variety of segment lengths were assessed for each species/group analysis. We set a goal to have 15% of the segments contain sightings; this goal has been used in other marine mammal DSM analyses (e.g., DoN 2007). The segment length for each analysis was selected to minimize the number of segments with zero sightings and to minimize the variation in habitat within each segment. Due to gaps in search effort along transects, effort could not always be split into segments of the desired length. Therefore, the size of each segment varied, and the model was weighted by segment area. Most segments were around 7 km in length.

For each trackline with and without sightings, effort (transect length L) was calculated as the spatial distance between the starting and ending longitude and latitude coordinates. Efforts were calculated for all tracklines in the survey and summed over the number of tracklines to obtain a total effort (Ltot). Marine mammal sightings were summed to obtain the total number of sightings (Ntot). Total overall encounter rate ER = Ntot/Ltot, and segment length (l) was calculated as:

$$l = 0.15*Etot/Ntot = 0.15/ER$$

where the coefficient "0.15" was chosen so that approximately 15% of the segments would contain a sighting. Each trackline of length L was divided up into equal-sized segments of length "l", where the number of segments in the trackline is Nseg = L/l (i.e., ratio of transect length L to segment length l). The longitude/latitude coordinates of the midpoint of each segment in each trackline were selected based on the length of the segment, and sightings were assigned to the segment whose midpoint was closest to the location of the sightings. The static and dynamic covariates included in the model (see below) were matched to each segment based on the covariate values for the midpoint of each segment.

3.3.1.2 Selection of Covariates (Predictor Variables)

The estimated number of individual animals per segment can be related to environmental covariates by fitting a GAM (**Section 3.3.3**; Wood 2006). A variety of oceanographic and topographic variables can be included in the model as potential predictors of abundance/density; however, the covariate data must be available for the entire Study Area (i.e., not just the segmented tracklines) and the entire study period. Suitable environmental data that meet the criteria can be difficult to obtain. Biological variables, such as the distribution and abundance of prey species, are known factors that influence the distribution of marine mammals but such data are difficult to obtain over a large area (Payne et al. 1986; Kenney et al. 1996). Therefore, remotely sensed data, such as SST and surface chlorophyll *a* (chl *a*) concentrations, and static variables, such as bathymetry and distance from shore, are often the only type of covariates that are available to be included in marine mammal models (e.g., Hamazaki 2002; Cañadas et al. 2005; Ferguson 2005; Redfern et al. 2006; Paxton et al. 2009). Physical oceanographic data are often used as proxies for prey abundance which is thought to directly influence marine mammal distributions (Redfern et al. 2006).

Marine mammal distribution patterns are complex and affected by various demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Forcada 2002). Prey distribution is one of the main influences of marine mammal distribution; marine mammals are usually found in areas with high densities of principal prey species (Payne et al. 1986; Kenney et al. 1996; Forcada 2002). Fine resolution spatial information on the distribution and abundance of prey species is often unavailable over large areas and time periods. Therefore, indirect indicators of prey distribution (SST, topography, chl *a*, etc.) are often used to study potential influences on the distribution and abundance of marine mammal species (Fiedler 2002; Ferguson 2005; Redfern et al. 2006). Important oceanographic variables that influence the distribution of prey and characterize marine mammal habitats include SST and chl *a*. In addition, ocean floor topography and bathymetry are often associated with oceanographic phenomena that influence marine mammal distribution (Forcada 2002). We chose a variety of static and dynamic habitat covariates to include in our abundance/density prediction models. Static covariates included water depth, distance from shore, slope of the seafloor, latitude, and longitude while dynamic covariates included SST and chl *a* (**Table 3-1**).

Static Covariates

Latitude, longitude, distance from shore, depth, and slope of the seafloor are static variables which may influence marine mammal distribution and abundance. There are known variations in geographic distributions based on seasonal migrations and movement patterns. For instance, North Atlantic right whales and humpback whales are known for their well-defined seasonal migratory patterns between feeding grounds off the northeast U.S. and breeding/calving grounds off the southeast U.S. (right whales) and in the Caribbean (humpback whales; Dawbin 1966; Winn et al. 1986; Clapham and Mead 1999; Kenney et al. 2001; Clapham 2009). Smaller-scale migratory movements are also evident in other cetacean species such as the bottlenose dolphin which spends the summer and fall months off New Jersey and higher latitudes and moves southward to Virginia and North Carolina during the winter and spring months (CETAP 1982; Kenney 1990; Garrison et al. 2003; Hohn and Hansen 2009; Waring et al. 2009; Toth et al. in press). Fine-scale movements of this species within the Study Area are also documented based on specific distances from shore (Toth-Brown et al. 2007). Topography (slope and depth) is also a critical factor in marine mammal distribution. Bottom topography can influence the abundance of prey; a change in depth on the shelf is often associated with higher concentrations of zooplankton. Baleen whales are known to be associated with shallow waters with high topographic variation in which prey accumulates at frontal interfaces between mixed and stratified waters (Forcada 2002). Humpback whales, for example, are known to base their foraging strategies on areas with high topographic variation (Payne et al. 1986). The static covariates included in **Table 3-1** were attached to each segment by using the covariate value that is closest to the midpoint of each segment.

Dynamic Covariates

SST and chl *a* are two types of dynamic variables known to influence marine mammal distribution and abundance (Smith et al. 1986; Baumgartner et al. 2001; Kaschner et al. 2006; Redfern et al. 2006). Several marine mammal species have temperature-limited distributions. For instance, harbor porpoises occur in sub-polar to cool-temperate waters and are seldom found in waters warmer than 17ºC (63ºF) (Read 1999). In addition, nearshore bottlenose dolphins shift their distribution in response to changes in water temperatures (Barco et al. 1999). Therefore, SST may help to predict abundance/density of certain species in the Study Area. Chl *a* concentrations may also influence marine mammal abundance/density in the Study Area. High chl *a* values are associated with upwelling centers located offshore of the Hudson-Raritan estuary, Barnegat Inlet, the Mullica River estuary, and Townsend/Hereford Inlet (Glenn et al. 2004). Primary production concentrates within upwelled waters and may attract prey species.

The dynamic covariates SST and chl *a* were evaluated for each segment by first generating 1 km by 1 km (1.9 NM by 1.9 NM) spatial grid maps of seasonal average SST and chl *a* using the same seasons as defined in **Section 2.3.1** and then comparing the longitude and latitude coordinates of each segment's midpoint with the longitude and latitude coordinates of each pixel in the gridmap corresponding to the season associated with the segment. The pixel with valid SST and chl *a* values that is in closest proximity to the segment midpoint was identified, and the seasonal average SST and chl *a* values associated with that pixel were assigned to the given segment. If no data were available for the closest pixel (due to cloud cover, etc.), then the next-closest pixels were assessed until a pixel with valid SST and chl *a* was found.

Table 3-1. Environmental covariates included in the DSM analyses.

Covariate	Description	Source
Depth	Average depth of water in meters	NOAA geophysical data system for gridded bathymetric data, National Geophysical Data Center (NOAA 1999)
Offshore Distance	Distance, in meters, from the shoreline	Calculated with the Point Distance Geoprocessing tool available in ESRI's Arc/Info® Toolbox 9.3 using NOAA bathymetric data
Slope	Slope, in degrees, of the sea floor	Calculated with the Surface Analyst function from ArcGIS® 9.3 Spatial Analyst Extension using NOAA bathymetric data
SST	Seasonal and annual averages of SST (in degrees Celsius [°C]) for the Study Area derived from remotely-sensed data from 01 January 2007 through 31 December 2009	Sensor: Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua. Resolution: 1.0 km. (NASA 2010)
chl *a*	Seasonal and annual averages of surface chl *a* concentrations (in milligrams per cubic meter [mg/m^3]) for the Study Area derived from remotely-sensed data from 01 January 2007 through 31 December 2009	Sensor: Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua. Resolution: 1.0 km. (NASA 2010)
Latitude	Latitude in decimal degrees	
Longitude	Longitude in decimal degrees	

3.3.1.3 Construction of Prediction Grid

After fitting GAMs to the survey data (see **Section 3.3.3**), the resulting DSM was applied to a prediction grid superimposed upon the Study Area. Therefore, animal abundance/density could be predicted for the entire Study Area for each season of interest. To construct the prediction grid, a spatial grid of 1-km by 1-km (1.9-NM by 1.9-NM) cells was created using ArcGIS® and overlaid onto the Study Area. The cells were evenly distributed throughout the Study Area, and a point shapefile of the grid was generated using ArcGIS®. This point file was comprised of 5,000 points which were the centroids of the 1-km by 1-km (1.9-NM by 1.9-NM) grid cells. The centroids of each cell were matched to their corresponding latitude and longitude and their values for the following static covariates: water depth, distance from shore, and the slope of the sea floor (**Table 3-1**).

The dynamic covariates SST and chl *a* were generated for each for the 5,000 centroids in the prediction grid by comparing the longitude and latitude coordinates of the given centroid with the longitude and latitude coordinates of each pixel in the gridmap corresponding to the season associated with the prediction grid. The pixel with valid SST and chl *a* values that is in closest proximity to the centroid was identified, and the seasonal average SST and chl *a* values associated with that pixel were assigned to the given centroid. If no data were available for the closest pixel (due to cloud cover, etc.), then the next closest pixels were assessed until a pixel with valid SST and chl *a* was found.

Separate prediction grids were developed for each seasonal analysis of abundance/density of the species or groups. The values for the static covariates remained the same for each prediction grid. The values for the dynamic covariates (SST and chl *a*) were averaged across each grid cell for the season in question. A total of four prediction grids were developed, one for each of the following seasons: year-round (SST and chl *a* averaged across all seasons), winter (SST and chl *a* averaged across only the winter season), spring (SST and chl *a* averaged across only the spring season), and summer (SST and chl *a* averaged across only the summer season). Note that there were not enough sightings data to model marine mammal abundance/density for the fall season alone.

3.3.2 Fitting a Density Surface

The estimated probabilities of detection were obtained from the fitted models for the detection functions chosen from the CDS analyses (see **Section 3.2**) using the Mark-Recapture Distance Sampling (MRDS) engine in Distance. When using a GAM to model the relationship between the response variable and various covariates, it is ideally desirable to detect all objects (animals) in the segment; however, this is rarely the case, as reflected in monotonically decreasing probability detection functions. Two methods are available to account for objects not detected in a segment: The first method involves estimating the total number (as opposed to the detected number) of objects in the segment, n_i, via the Horvitz-Thompson estimator: n_i = SUM $(1/p_{ij})$, where p_{ij} = probability of detection of object j in segment i, and the summation is conducted from j = 1 to n_i. This method is useful if the detectability is different for objects within the same segment. The second method involves decreasing the segment area (a_i) to reflect the effective area surveyed rather than the covered area (count), using the effective strip half-width μ (or ESW = 1/f[0]): $a_i = 2\ \mu_i\ l_i$, where l_i = length of segment i. The μ value is defined as the sighting distance such that the number of undetected animals at distances less than μ is equal to the number of detected animals at distances greater than μ. After using these two methods to account for undetected objects in a segment in the n_i and a_i terms, density in segment i is then calculated as $D_i = n_i/a_i$.

In the CDS/MRDS methods, the statistical criterion for model selection (i.e., probability detection function) is AIC minimization. In the subsequent DSM analysis, the criteria for selection of the optimal GAM model is (among other criteria) GCV/UBRE minimization (GCV = generalized cross-validation; UBRE = unbiased risk estimator). To fit a GAM to the observed data, we specified the following information: 1) the explanatory variables (covariates) to include in the model (see **Section 3.3.1.2**); 2) the dimension of the smooth functions (univariate which includes one covariate versus bivariate which includes two covariates); 3) the degree of smoothness of the functions (controlled by the number of knots (k): DF = # knots-1; 4) error distribution (quasipoisson); and 5) the logarithmic link function. A small number of knots increases smoothness while suppressing the expression of small-scale variability; this is desired if the function exhibits sharp gradients (i.e., high sensitivity of the response variable to changes in the given covariate) over small scales. Conversely, a large number of knots decreases smoothness while enhancing small-scale variability; this is desired if the functional dependence of the response variable on the given covariate exhibits very low sensitivity. We chose to limit the number of knots used in the analyses to k=7 for univariate smooth functions and k=14 for bivariate smooth functions in order to allow moderate flexibility while reducing the likelihood of fitting unnecessarily complicated functions.

Identification of the “optimal” GAM was aided with the following information and model output: 1) minimization of the GCV/UBRE score; 2) maximization of the % of deviance explained by the model; 3) inspection of the diagnostic plots of the residuals (e.g., normal Q-Q plot, residuals versus linear predictor, frequency histogram of residuals, response versus the fitted values); 4) inspection of the plots of smooth functions (increase or decrease the maximum number of knots, include as a linear term, etc.); 5) assessment of the response surface summary (sensitivity of the density surface/abundance to different models); and 6) assessment of the significance of the covariates in the GAM.

Different GAMs that incorporate various combinations of smooth functions of covariates were tested and compared to each other using the above criteria for ideal model selection. The total number of different combinations of covariates is quite large. In addition to univariate (1-dimensional) functions of the individual covariates, bivariate (2-dimensional) functions were applied to various pairwise combinations of covariates (e.g., longitude and latitude, depth and offshore distance, SST and chl *a*). Generally, for N covariates there are N(N-1)/2 pairwise combinations (i.e., 21 pairs for the total seven covariates). It was not necessary to test every possible combination of smooth functions of covariates. As GAMs were formulated on a trial-and-error basis, we were able to discern which covariates were more significant than others. The decision to include a given covariate in the model was made based on a tradeoff between model fit (using the above statistical criteria characterizing an "optimal" model) and model complexity. A given covariate was excluded from the GAM if: 1) the estimated DF for the covariate were close to 1; 2) the plotted confidence band for the covariate included zero everywhere; and 3) the GCV/UBRE score decreased when the covariate was omitted from the GAM. After the excluded covariates were identified, a (significantly smaller) list of potential GAMs that include combinations of the remaining covariates were developed, while the combinations involving the excluded covariate(s) were eliminated from further consideration. From this restricted list of potential GAMs, optimal model selection was based on the above statistical criteria (e.g., GCV/UBRE minimization, maximization of % deviance explained, etc.).

3.3.3 Predictions of Density and Abundance

In the DSM analysis, GAM models were developed and an optimal model was chosen based on numerous selection criteria. This optimal GAM was chosen as the best fit to the observations of the response variable (density, abundance) as a function of smooth functions of the various covariates at the available sampled sites, and was used to generate predictions of density and abundance at unsampled sites (i.e., sites where estimates of the covariates are available but where the response variable has not been observed or measured) on a prediction grid that encompasses the entire Study Area.

Caution should be exercised when extrapolating model predictions from regions with observational data to regions far removed from observational data, particularly in situations where sharp spatial gradients in density/abundance and covariates occur. It is probable that the GAM will be applied to regions within the Study Area that are not sufficiently surveyed (i.e., areas with little or no survey effort). In this case, it is imperative that covariate data be collected at these unsampled sites (rather than interpolated from sampled sites) if possible, so that the GAM can be adequately applied to obtain predictions (estimates) of density and abundance. For example, the GIS database stores an abundance of data on static covariates (depth, offshore distance, bathymetric slope) at every conceivable offshore longitude and latitude location. Given the availability and time-invariance of these covariate data, it is more accurate to obtain values of these covariates at the exact locations of the unsampled sites (rather than interpolating from values at sampled sites) and using these exact values in the GAM to generate estimates of abundance and density at these unsampled sites. Using this procedure of covariate data collection at unsampled sites (i.e., every grid cell in the prediction grid), the GAM is applied to estimate density and abundance and extrapolate these predictions to each grid cell, thus generating a density surface (spatial map of density) covering the entire Study Area.

Generally, the accuracy and validity of predictions (of abundance or density) in regions with no observational data (or in regions far removed from observations) depends on model robustness and reliability (model-based analysis) and on the availability of measurements of covariates that are included in the model. At the smallest spatial scale (i.e., within each cell of the prediction grid), the GAM is used to estimate density. Estimated density in each cell is calculated as the ratio of estimated abundance to the cell area. In specified regions of larger spatial scale (i.e., containing several cells of the prediction grid), abundance and density are estimated by density surface integration in which the predicted abundances of all cells in the given region are summed, and density is estimated as the ratio of the summed abundances to the summed areas of all cells in the given region.

3.3.4 Variance Estimation

The variance associated with the prediction grid estimates of density and abundance was estimated using bootstrapping, a technique involving random resampling with replacement (Efron and Tibshirani 1993). Bootstrapping is advantageous in that it is a robust method of variance estimation when variance cannot be calculated analytically. A large number of bootstrap samples are typically generated (to ensure an adequate sample size). The minimum number of resamples should be no less than 200, and 400 to 1,000 resamples are preferred to generate reliable confidence intervals (Buckland et al. 2001). Abundance is estimated from each bootstrap estimate, and these bootstrap abundance estimates are ranked from highest to lowest. The mean of these bootstrap estimates is calculated, and the 95% CI is calculated such that it is bounded by the 2.5% quantile and the 97.5% quantile. Because of this nonparametric measure of uncertainty, the bootstrapping method is not affected by a few extreme outliers.

Different types of bootstrapping methods include nonparametric, parametric, and moving block. The nonparametric method requires no distributional assumptions, whereas the parametric and moving block methods are based on a fitted model (GAM) that incorporates some distributional assumptions and estimated model parameters. The Distance software is currently able to run only the parametric moving block bootstrap in its variance estimation method. The following is a discussion of the advantages and disadvantages of each method, leading to justification of the choice of method used in Distance.

Nonparametric bootstrapping involves random resampling with replacement of some independent sampling unit whose spatial/temporal scale is sufficiently large that autocorrelation between adjacent sampling units is negligible. Sampling units should be numerous, with a sufficiently fine spatial/temporal scale to capture small-scale variability in the data structure; however, adjacent sampling units should also be spatially/temporally independent of each other, and too fine a scale poses the risk of significant autocorrelation between adjacent sampling units since the degree of correlation generally increases with a decrease in spatial/temporal scale (e.g., decrease in separation distance between adjacent units on a spatial scale or decrease in time difference on a temporal scale). Thus, the sampling units should be constructed on a scale sufficiently fine as to be numerous while also sufficiently coarse as to be independent from each other. The transect (which is spatially finer than the Study Area and region levels and coarser than the segment level) is typically chosen as the independent sampling unit since its data structure is both sufficiently fine to be numerous while also sufficient coarse to be independent. The segment data structure is numerous (since transects are divided up into segments) but may not be independent since its relatively smaller spatial scale renders it susceptible to spatial autocorrelation between adjacent segments (e.g., positively correlated objects in adjacent segments). The data structure at the larger levels of Study Area and region are not sufficiently numerous due to their relatively coarser spatial scales. Nonparametric bootstrapping is advantageous in that it preserves spatial correlation, but it does not preserve spatial coverage and can lead to extreme bootstrap abundance estimates.

Parametric bootstrapping uses a model (e.g., a GAM in the DSM analysis) fitted to the observed data to generate new data values which are then used to generate the bootstrap sample. A GAM uses smooth functions (with model parameters) relating the response variable (i.e., abundance or density) to a number of covariates or explanatory variables (e.g., longitude, latitude, depth, offshore distance, bathymetric slope, SST, chl *a*). The residuals (defined as the difference between the observed value and model-estimated value of the response variable) are selected randomly and with replacement in parametric bootstrapping. Whereas nonparametric bootstrapping preserves spatial correlation but not spatial coverage, parametric bootstrapping preserves spatial coverage but not spatial correlation.

In seeking to address the shortcomings of the nonparametric and parametric methods, the moving block method (which is the method of choice in Distance) preserves both spatial correlation and spatial coverage. This method uses a moving block comprised of a number of sampling units (e.g., segments). Block size m (number of segments in a block) should be sufficiently large so that segments more than m units apart (i.e., in different blocks) are independent (i.e., no spatial correlation between blocks), yet also sufficiently small to retain spatial correlation and structure among the segments within a given block (i.e., spatial correlation within blocks). Information on optimal block size can be obtained from a semivariogram of residuals. Semivariance between a pair of points increases (i.e., autocorrelation decreases) asymptotically with increasing separation distance, reflecting decreased similarity until the points become independent (spatially uncorrelated) at a sufficiently large separation distance.

The moving block is selected randomly and with replacement and is then randomly placed back together to generate the bootstrap sample. The original response variable values cannot be moved since they are connected to spatial location and other explanatory variables; however, the residuals can be moved, thus generating bootstrap samples via random resampling with replacement using a moving block as the sampling unit. Then, many bootstrap samples are randomly generated, a mean value of these samples is calculated, and the 95% CI is estimated to obtain the variance estimate associated with the prediction grid estimate of the response variable (abundance).

Due to its inherent advantages and ease of application, the parametric moving block method is currently the method of choice in Distance for variance estimation. Required user-specified parameters include block size m (typically 3), number of bootstraps (10, 99, 199, 499, or 999), confidence interval desired (0.95, 0.90, 0.85, or 0.80) and inter-quartile range for outlier detection (1.5, 2.0, 2.5, or 3.0). Effects of outliers on variance estimation is generally insignificant, especially if a large number of bootstraps are used, since the relatively rare occurrences of anomalously low and high values will be concentrated in the lower and upper tailings, respectively, which are cut off at the 2.5 and 97.5 quantiles in the estimation of the 95% CI. To balance the tradeoff between spatial detail and time constraints, 499 bootstraps is typically optimal. Using a larger number of bootstraps requires more computation time, whereas using fewer bootstraps runs the risk of an inadequate sample size and renders the method increasingly susceptible to outliers. We chose a block size of 2 or 3 and desired confidence interval of 95% and ran 999 bootstraps for each of our DSM analyses.

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4.0 PASSIVE ACOUSTIC MONITORING METHODOLOGY

4.1 ACOUSTICS ARRAY CONFIGURATION

A cross configuration was selected for the placement of five marine autonomous recording units (i.e., "pop-ups") from the BRP with roughly 72 km (39 NM) between the southern and northern stations and about 24 km (13 NM) between the eastern and western deployment coordinates (**Figure 4-1**). The first deployment of these five pop-ups was conducted in March 2008. In June 2008, one pop-up was not recovered from the March deployment; therefore, the four remaining pop-ups were deployed in a diamond pattern (i.e., station [S] 3 was not deployed). The third deployment occurred in September 2008 and consisted of five units deployed in the cross configuration pattern. Four of these units were recovered and refurbished from the previous deployment, and the fifth was a pop-up that was delivered to replace the one lost in March. The recovery of units deployed in September 2008 spanned the first two weeks of December. Weather and equipment issues extended the time frame for recovery, refurbishment, and redeployment. Two pop-ups (PU063 at S1 and PU081 at S2) were not found and did not return to the surface when called. It is likely they were somehow removed from the area. Two replacement units from BRP were provided, and redeployment included five units for the fourth deployment in December 2008. Because of the loss of two pop-ups from S1, new coordinates for this deployment were identified that were slightly to the northwest of the original location (S1a on **Figure 4-1**). The new GPS coordinates placed S1 in an area marked "obstruction" on the chart; the crew and chief scientist agreed that this area would be relatively free from potential trawler activity because trawlers tend to avoid obstructions on the sea floor. The other four pop-ups were deployed in the pre-identified cross-configuration pattern.

The fifth deployment occurred in March 2009. Three pop-ups were deployed at S1a, S2, and S4. In the attempted recovery of one unit from the June 2008 (PU134) and two units from the December 2008 (PU202 and PU134) deployments, the audio burn unit did not work as intended. Unit PU134 from the June 2008 deployment did not respond to the audio burn cue and was thus recovered by a diver. Both PU202 and PU134 responded to audio burn cues but did not rise to the surface for recovery within the allotted time frame. (Typically, one hour maximum is allotted for each PU recovery attempt and usually each recovery requires less than 10 min. from audio signal being sent to the PU arriving at the surface.). Because of the inconsistency with the audio burn units, the pop-ups deployed in March 2009 to the two most-shallow depths (S1a and S2) were shackled directly to their anchor moorings, thus requiring diver-assisted recovery. The burn unit was engaged on the unit deployed to S4. Recovery of the units was scheduled for 11 June 2009. 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 and did not record data that could be examined for marine mammal calls. Thus, BRP offered an additional pop-up for use at no cost during our sixth deployment.

The sixth and final deployment of pop-ups was conducted in August 2009 with six pop-up units deployed. The original cross-configuration array pattern was used with three minor exceptions: 1) S3 was shifted 4.8 to 6.4 km (2.6 to 3.5 NM) to the south-southeast from its original GPS coordinates (S3a); 2) S1b was used for the southern-most drop spot; and 3) two pop-ups were deployed at S2. The units deployed at S4 and S5 were placed in locations consistent with the original plan (**Figure 4-1**). Previously (during the March 2009 recovery), PU134 encountered a burn unit malfunction that could not be diagnosed, nor repeated, in the controlled setting of the engineering lab. That is, the grounding rod of PU134 was coated with a magnesium hydroxide, which is non-conductive to electrical charges. This material prevented the burn unit from functioning properly and, thus, caused the significant delay in recovery of PU134 in March 2009. Therefore, PU134 was re-deployed within 23 m (75 ft) of PU182 in an effort to repeat the error situation while facilitating swift deployment and recovery operations.

Other methodological adjustments were followed in an attempt to facilitate recovery of all units deployed during August 2009. The units deployed to S1b, S2 (both units), and S3a were shackled directly to their mooring anchor. S1b was shifted slightly in an attempt to maximize the possibility of recovery. The burn units were bypassed but included to examine the effect of the sea on these units. Pop-ups deployed at S4 and S5 included a new Argos GPS tracking device so that if the pop-ups released from their burn unit or mooring earlier than planned, the GPS device would send a signal to BRP allowing these units to be tracked.

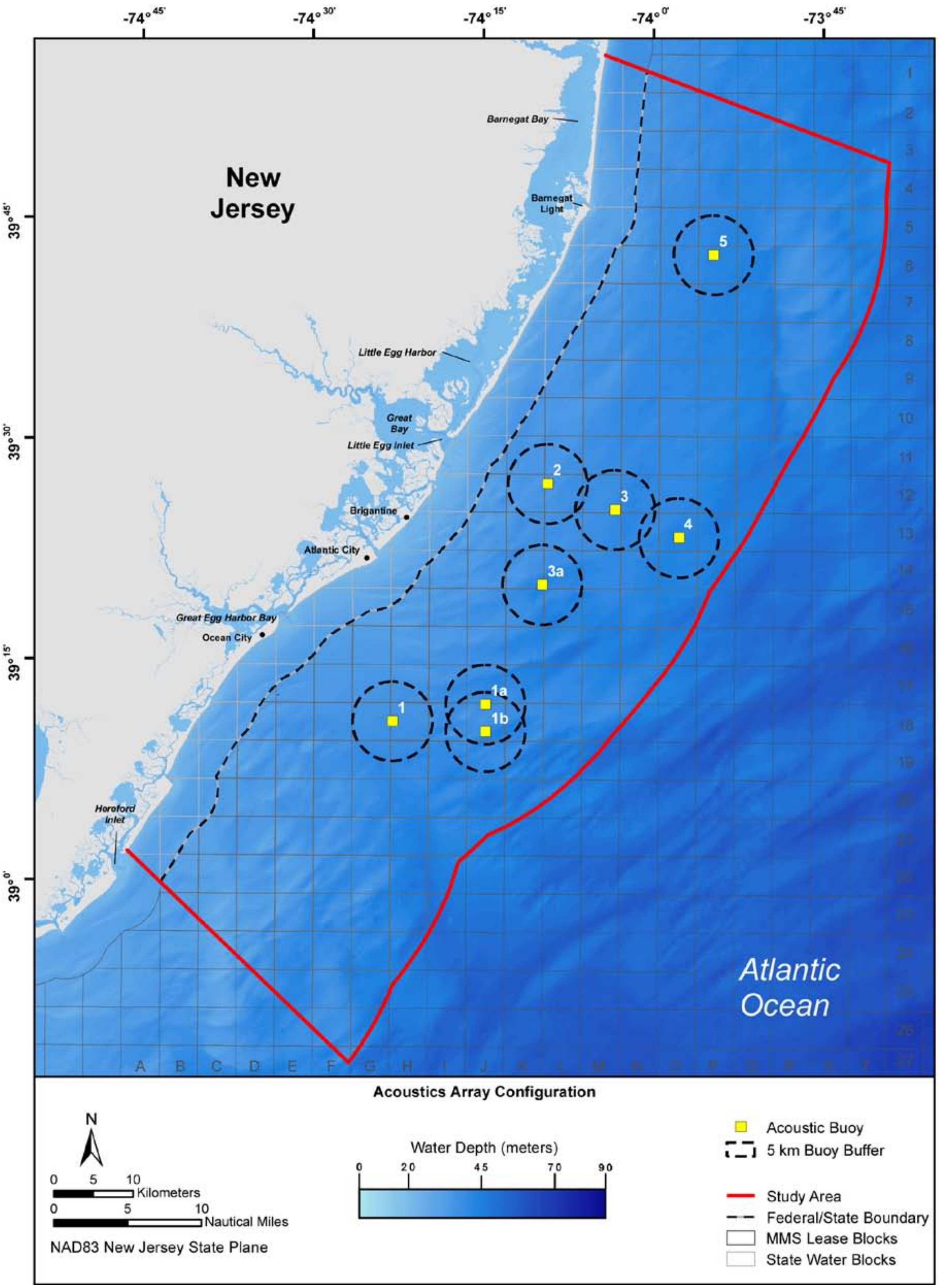

Figure 4-1. Locations of acoustic pop-up buoys in the Study Area from March 2008 to August 2009. The pop-ups were deployed in a cross-configuration in an attempt to record whale and dolphin sounds over as much of the Study Area as possible. Please refer to Table 4-1 for details on sample rate per buoy location per deployment.

Pop-ups were consistently placed within 6 m (20 ft) of the GPS coordinates identified for deployment. Depths for deployed pop-ups ranged from 17.7 to 27.4 m (58 to 90 ft) with the shallowest units at S1 and S2 (new and original coordinates not withstanding).

4.2 ACOUSTIC SAMPLING RATES AND DUTY CYCLES

The March 2008 deployment had five pop-ups each with a 2-kilohertz (kHz) sample rate and continuous duty cycle for recording. This protocol yields roughly 2,000 hours (hrs) of data per pop-up unit recovered; four pop-ups recovered translates to 8,000 hrs of data for processing. A 2-kHz sample rate is biased towards capturing baleen whale calls only. For this reason, two pop-ups were equipped with a modified sample rate and duty cycle for each deployment from June 2008 forward (**Table 4-1**). The pop-ups at S1, S1a, S1b, S3, S3a, and S5 retained the 2 kHz sample rate and continuous duty cycle for deployment. Pop-ups at S2 and S4 were given a 32-kHz sample rate with a 5-min on/25-min off duty cycle. The increased sample rate provided a significantly larger amount of data for each frequency/time period and enabled examination of the data for toothed whale calls (e.g., dolphin whistles). Roughly 240 min (5 min per half hour over 24 hrs) of data were collected per 24-hr period on the units with a high frequency sample rate (the sample rate is twice the frequency of interest).

Table 4-1. Summary of pop-up logistic information per deployment during the study period. Array configuration station, GPS coordinates, pop-up ID number, sample rate, duty cycle and status per deployment for each unit are included. Status relates to whether the unit was recovered, lost, or malfunctioned.

Deployment	Station #	GPS Coordinates	Pop-Up ID	Sample Rate	Target Species Calls	Duty Cycle	Status
March 2008	1	N39° 10.789 W74° 23.298	PU039	2 kHz	Baleen whales	Continuous	Lost
	2	N39° 26.932 W74° 09.511	PU086	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	3	N39° 25.032 W74° 03.651	PU063	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	4	N39° 23.210 W73° 58.264	PU081	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	5	N39° 42.500 W73° 55.022	PU134	2 kHz	Baleen whales	Continuous	Recovered, analyzed
June 2008	1	N39° 10.754 W74° 23.148	PU063	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	2	N39° 26.900 W74° 09.474	PU081	32 kHz	Delphinids	5 min on/25 min off	Recovered, analyzed
	4	N39° 23.159 W73° 58.124	PU086	32 kHz	Delphinids	5 min on/25 min off	Recovered, analyzed
	5	N39° 42.403 W73° 54.991	PU134	2 kHz	Baleen whales	Continuous	Recovered, analyzed
September 2008	1	N39° 10.727 W74° 23.176	PU063	2 kHz	Baleen whales	Continuous	Lost
	2	N39° 26.915 W74° 09.473	PU081	32 kHz	Delphinids	5 min on/25 min off	Lost
	3	N39° 25.067 W74° 03.633	PU202	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	4	N39° 23.188 W73° 58.091	PU086	32 kHz	Delphinids	5 min on/25 min off	Recovered, analyzed
	5	N39° 42.459 W73° 54.942	PU203	2 kHz	Baleen whales	Continuous	Recovered, analyzed

Table 4-1 (*continued*). Summary of pop-up logistic information per deployment during the study period. Array configuration station, GPS coordinates, pop-up ID number, sample rate, duty cycle and status per deployment for each unit are included. Status relates to whether the unit was recovered, lost, or malfunctioned.

Deployment	Station #	GPS Coordinates	Pop-Up ID	Sample Rate	Target Species Calls	Duty Cycle	Status
December 2008	1a	N39° 14.492 W74° 21.553	PU179	2 kHz	Baleen whales	Continuous	Lost
	2	N39° 26.875 W74° 09.483	PU134	32 kHz	Delphinids	5 min on/25 min off	Recovered, analyzed
	3	N39° 25.009 W74° 03.651	PU202	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	4	N39° 23.175 W73° 58.149	PU086	32 kHz	Delphinids	5 min on/25 min off	Lost
	5	N39° 41.330 W73° 55.086	PU203	2 kHz	Baleen whales	Continuous	Lost
March 2009	1a	N39° 11.882 W74° 15.034	PU002	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	2	N39° 26.872 W74° 09.677	PU171	32 kHz	Delphinids	5 min on/25 min off	Malfunctioned
	4	N39° 23.109 W73° 58.204	PU182	2 kHz	Baleen whales	Continuous	Recovered, analyzed
August 2009	1b	N39° 10.011 W74° 14.030	PU145	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	2	N39° 26.866 W74° 09.506	PU134	32 kHz	Delphinids	5 min on/25 min off	Recovered, analyzed
	2	N39° 26.866 W74° 09.506	PU182	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	3a	N39° 20.002 W74° 10.020	PU160	2 kHz	Baleen whales	Continuous	Recovered, analyzed
	4	N39° 23.134 W73° 58.074	PU153	32 kHz	Delphinids	5 min on/25 min off	Recovered, analyzed
	5	N39° 42.333 W73° 54.864	PU162	2 kHz	Baleen whales	Continuous	Recovered, analyzed

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

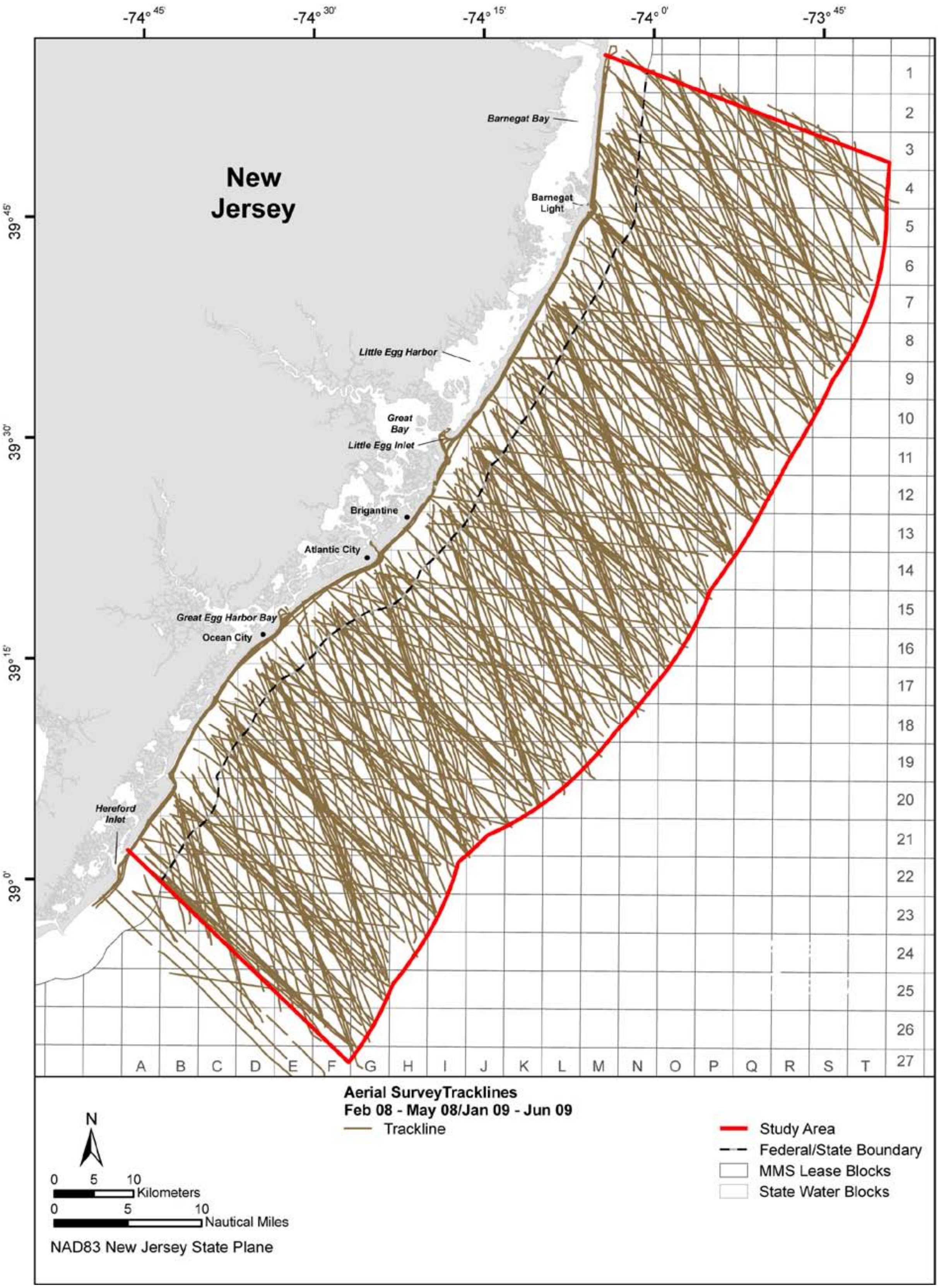

Figure 5-1. Marine mammal and sea turtle aerial survey tracklines in the Study Area for February-April 2008 and January-June 2009.

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**.

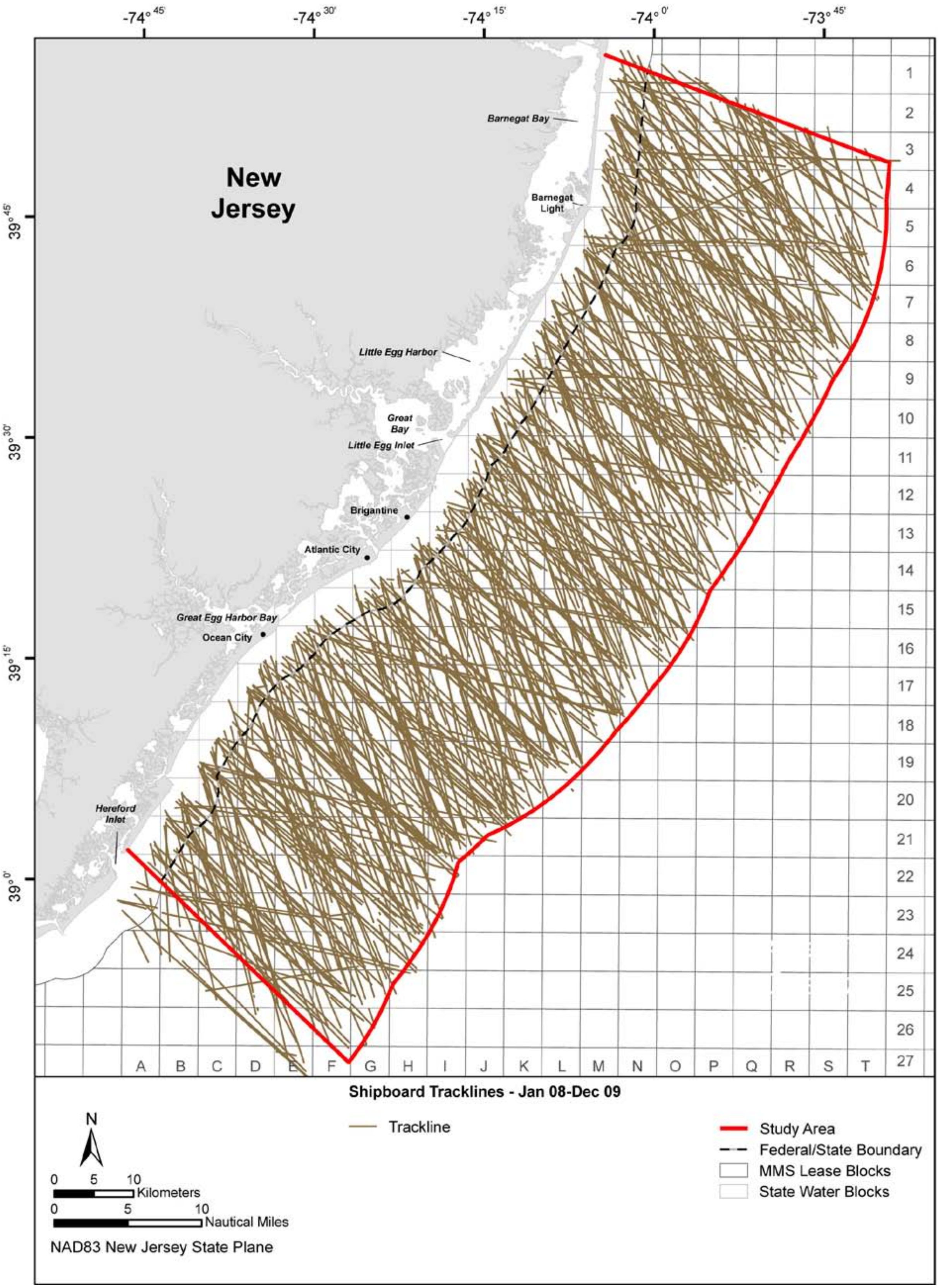

Figure 5-2. Marine mammal and sea turtle shipboard survey tracklines in the Study Area for January 2008-December 2009.

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.

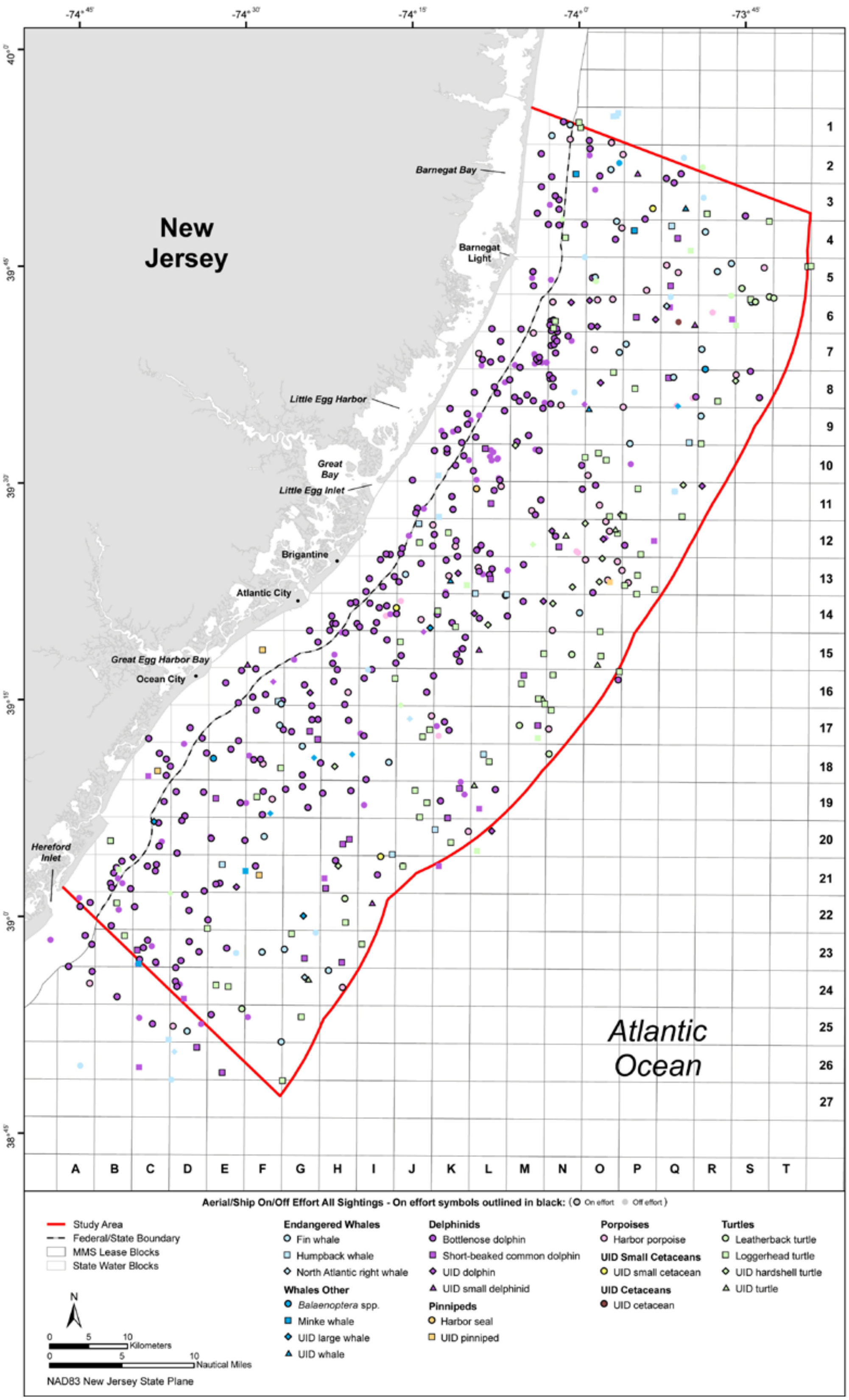

Figure 5-3. Marine mammal and sea turtle sightings (on-effort and off-effort) from shipboard and aerial surveys in the Study Area for January 2008-December 2009.

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).

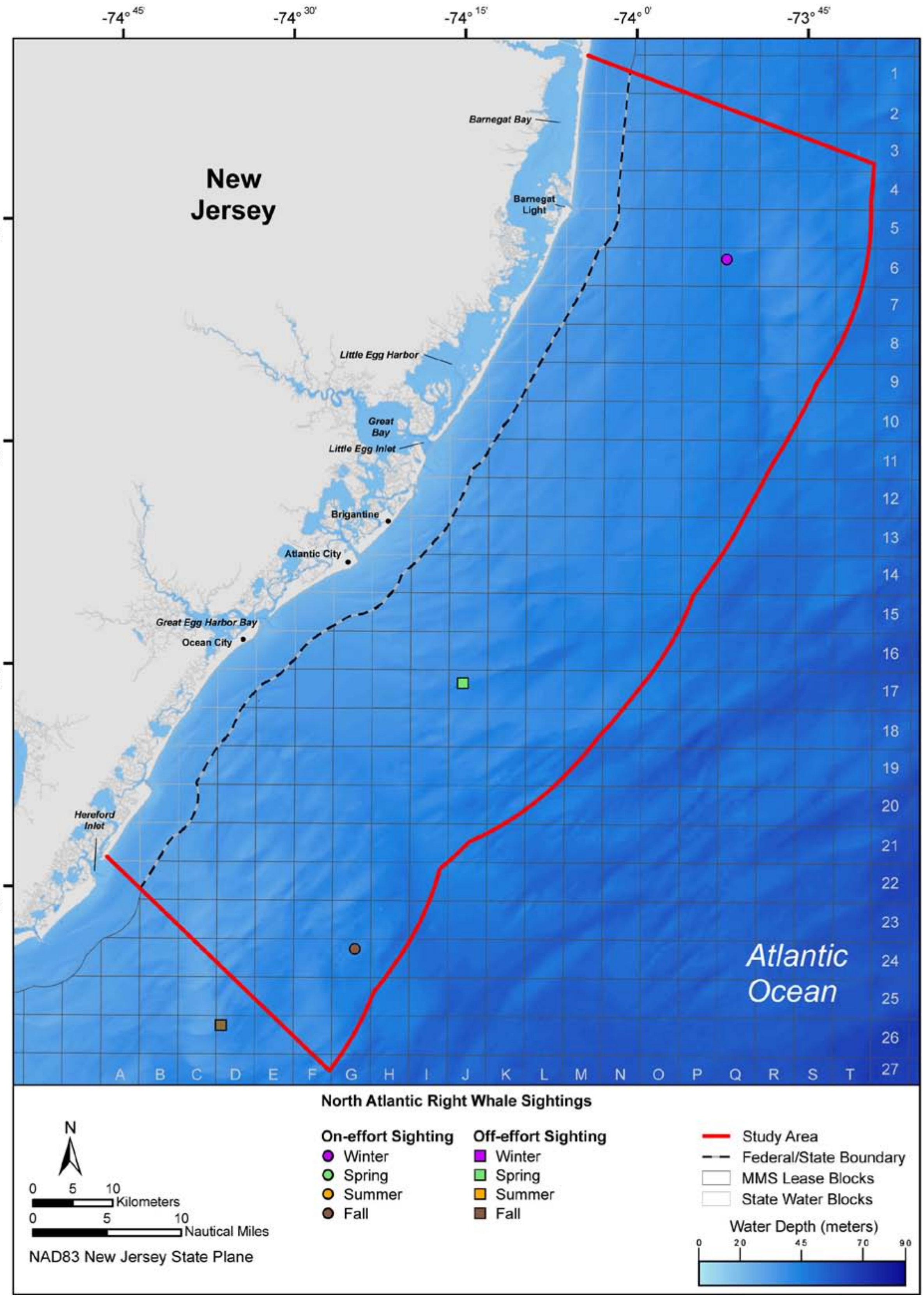

Figure 5-4. On-effort and off-effort sightings of the North Atlantic right whale in the Study Area and vicinity from the shipboard and aerial surveys.

♦ **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

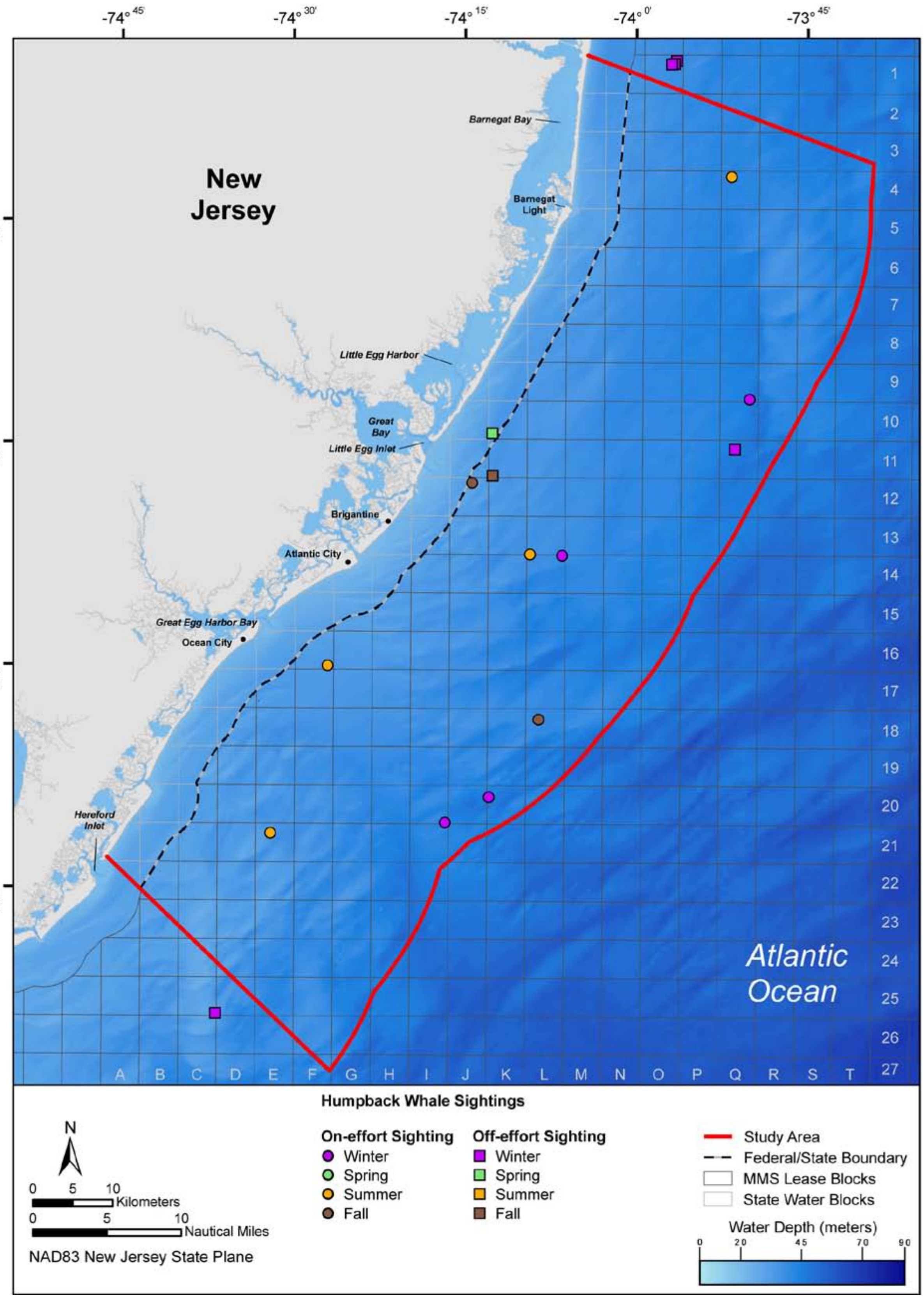

Figure 5-5. On-effort and off-effort sightings of the humpback whale in the Study Area from the shipboard and aerial surveys.

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).

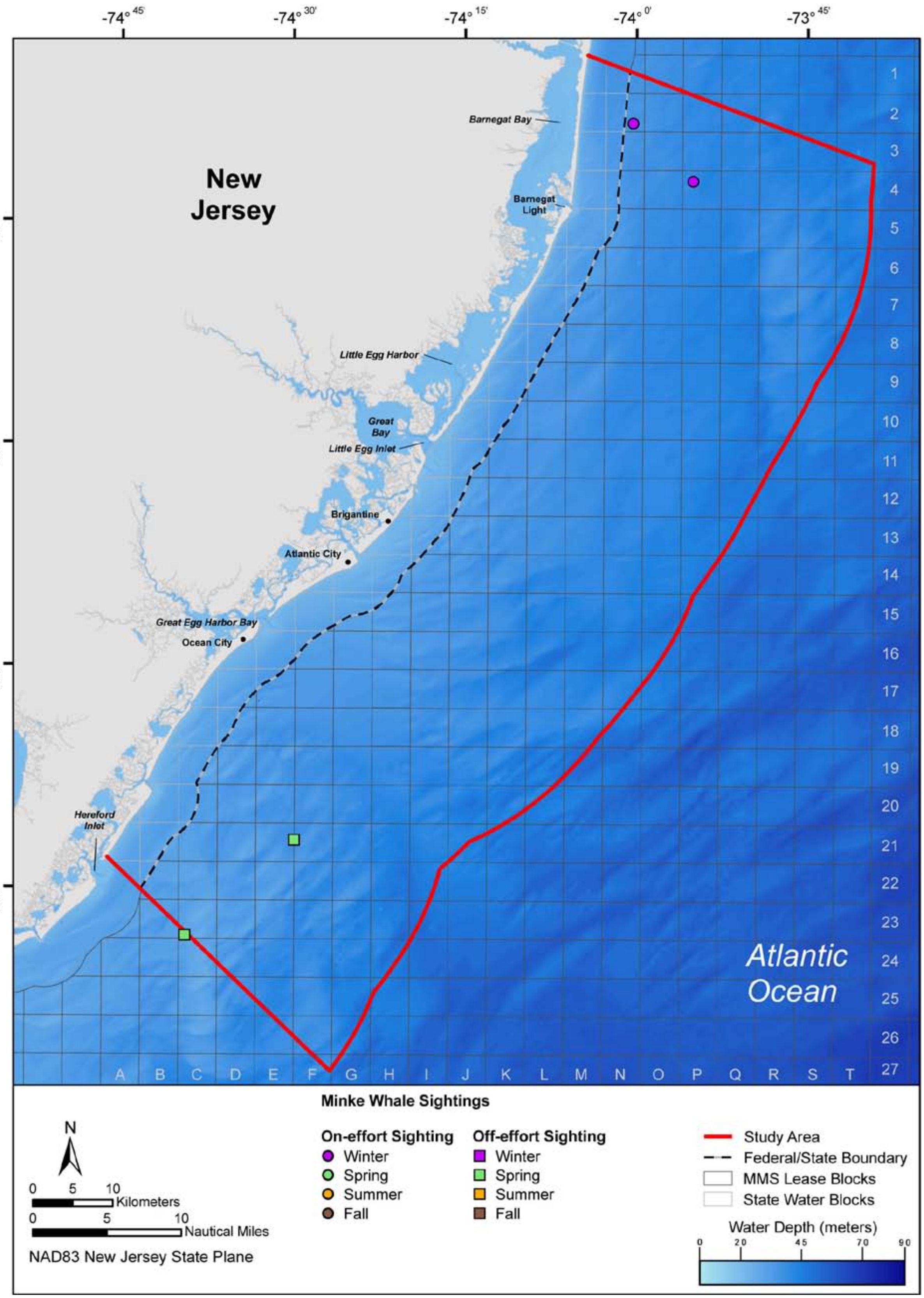

Figure 5-6. On-effort and off-effort sightings of the minke whale in the Study Area from the shipboard and aerial surveys.

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

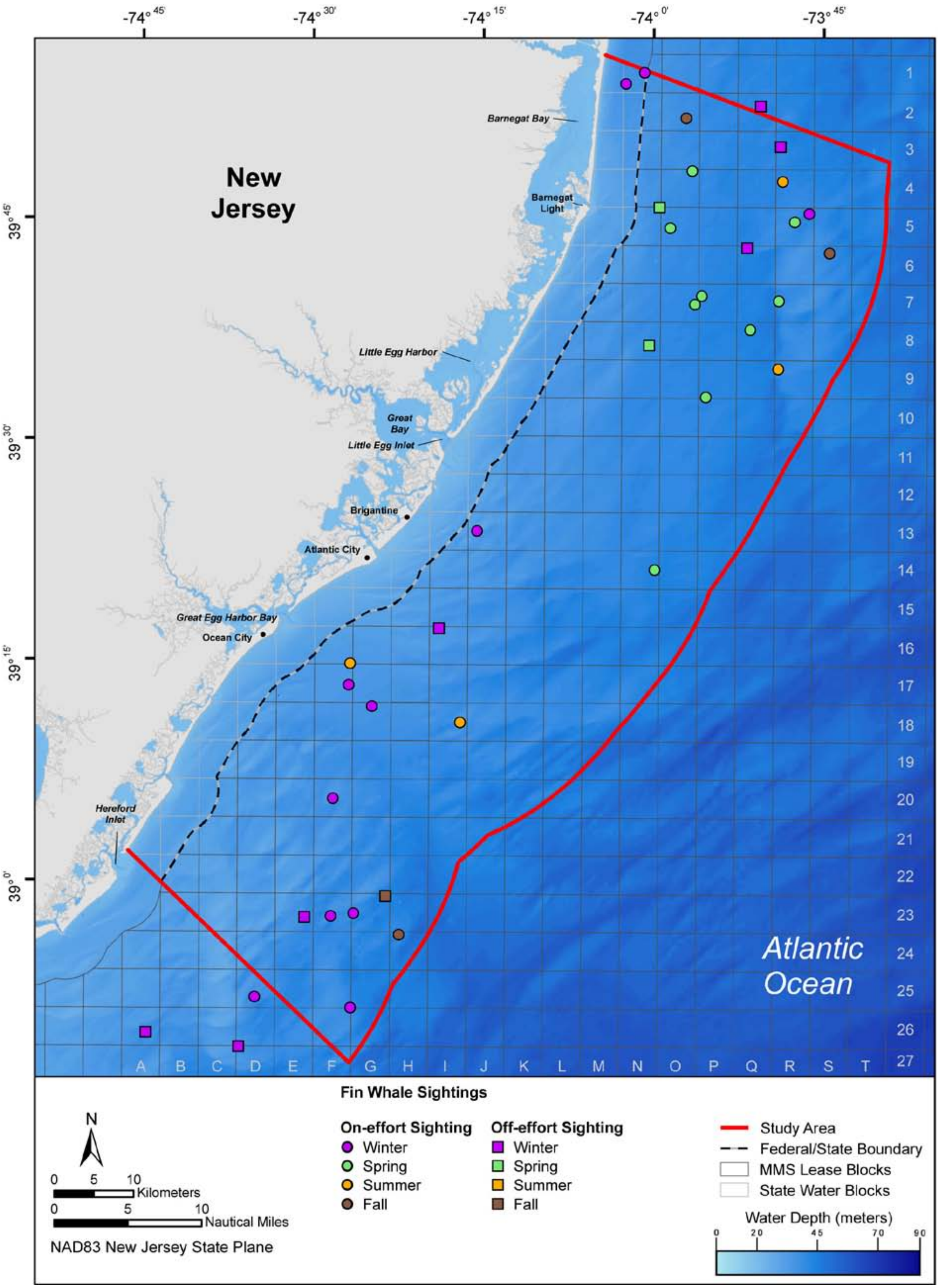

Figure 5-7. On-effort and off-effort sightings of the fin whale in the Study Area and vicinity from the shipboard and aerial surveys.

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.

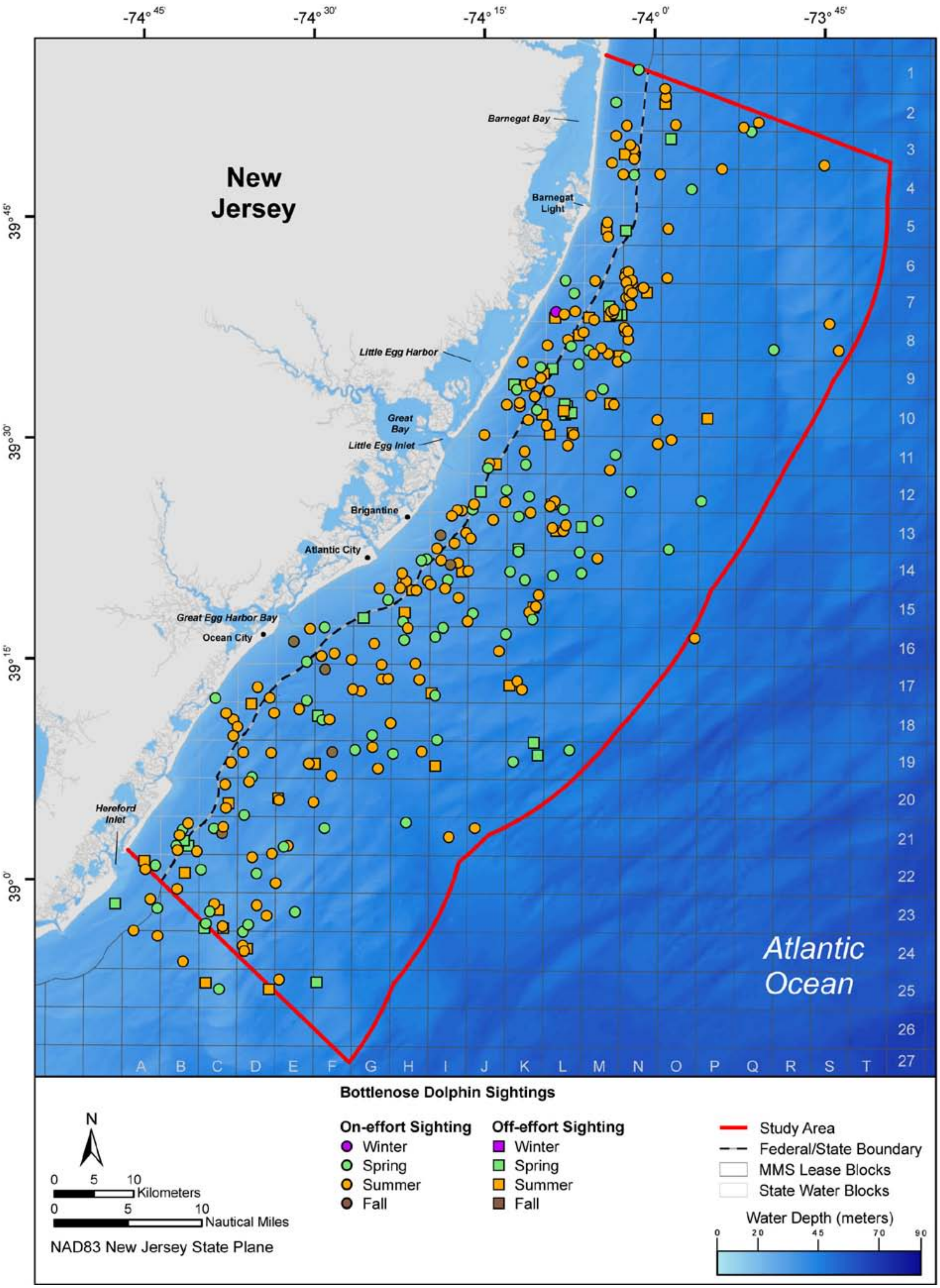

Figure 5-8. On-effort and off-effort sightings of the bottlenose dolphin in the Study Area and vicinity from the shipboard and aerial surveys.

- **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

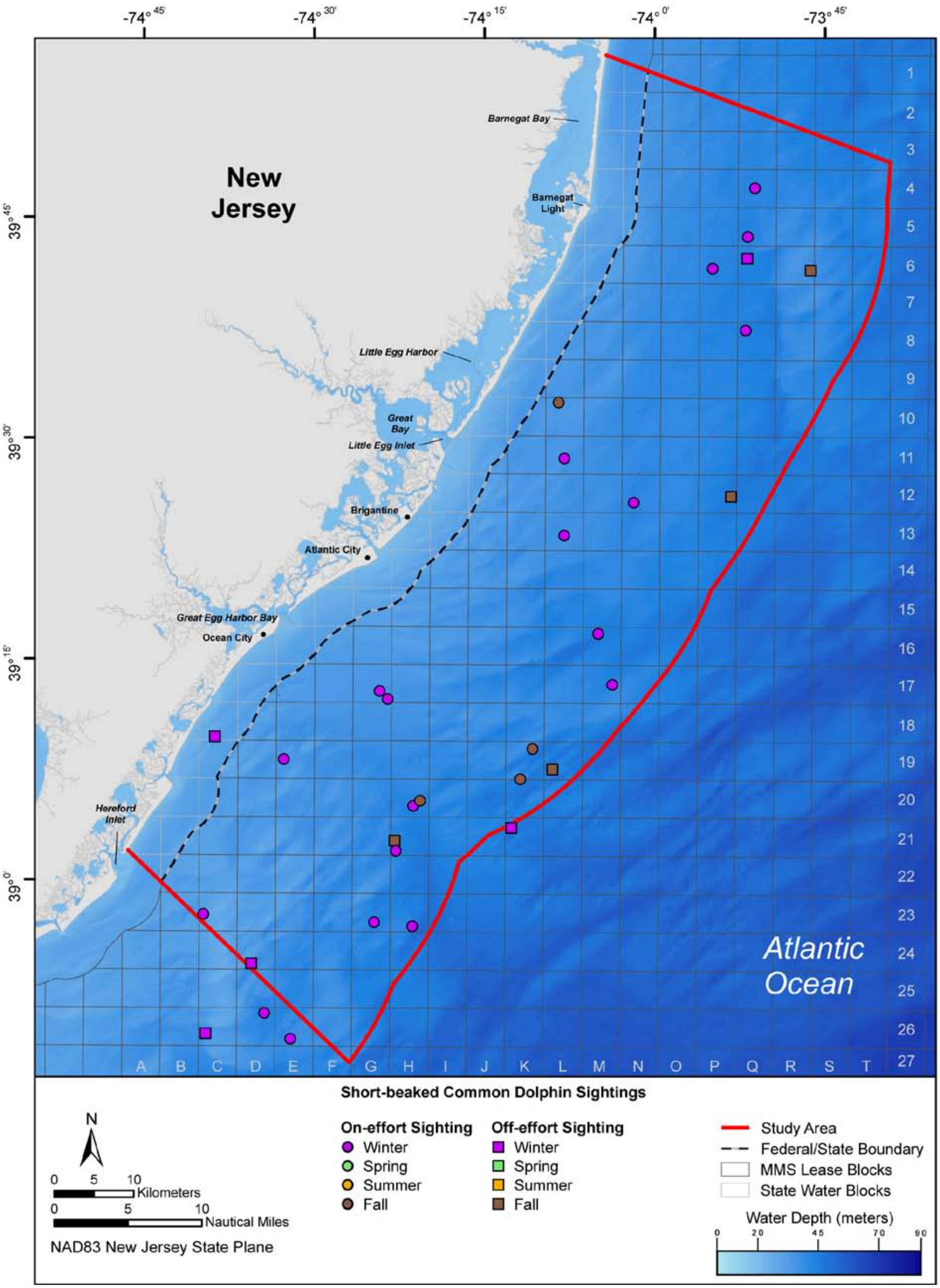

Figure 5-9. On-effort and off-effort sightings of the short-beaked common dolphin in the Study Area and vicinity from the shipboard and aerial surveys.

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).

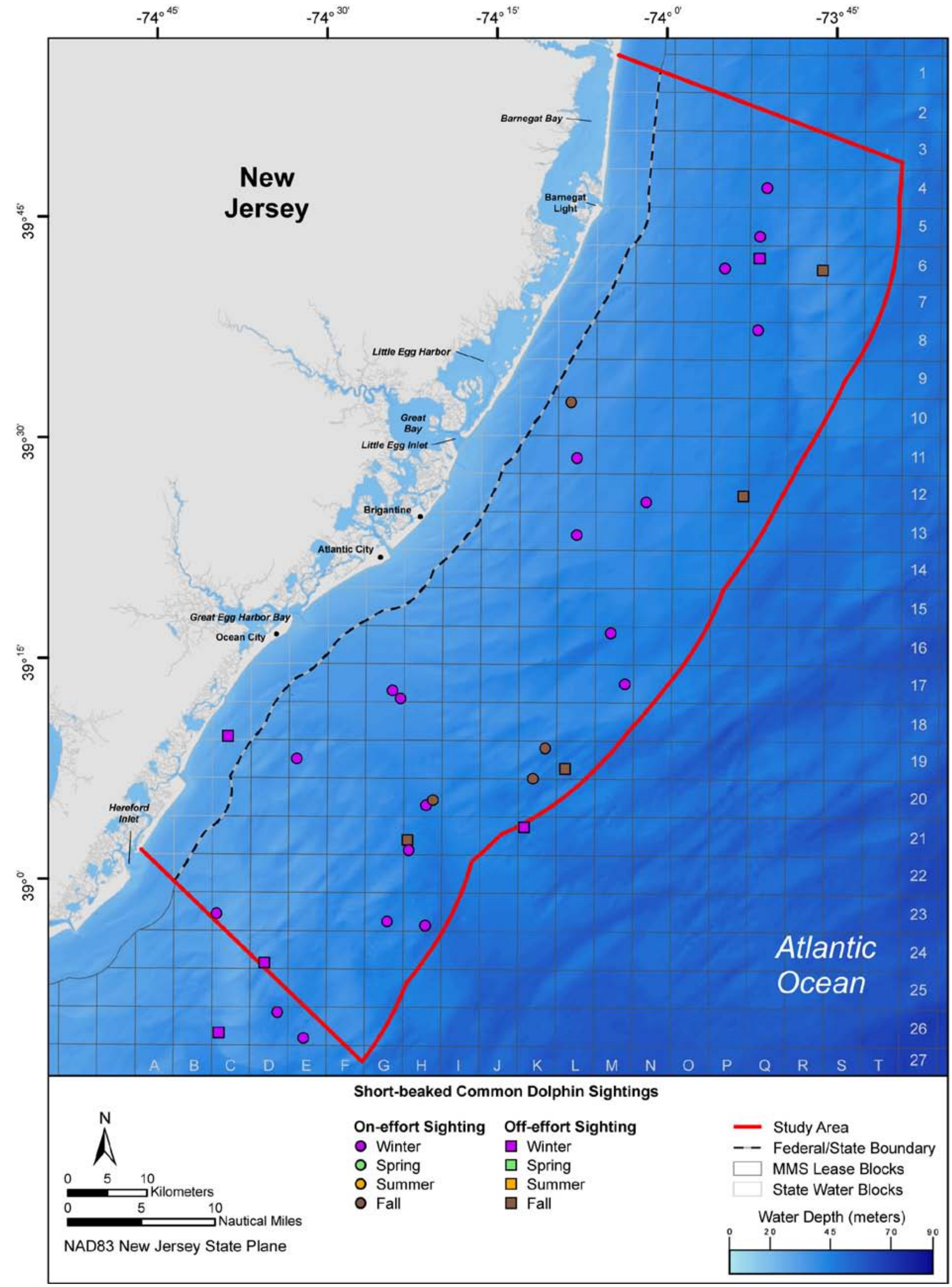

Figure 5-10. On-effort and off-effort sightings of the harbor porpoise in the Study Area and vicinity from the shipboard and aerial surveys.

- **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).

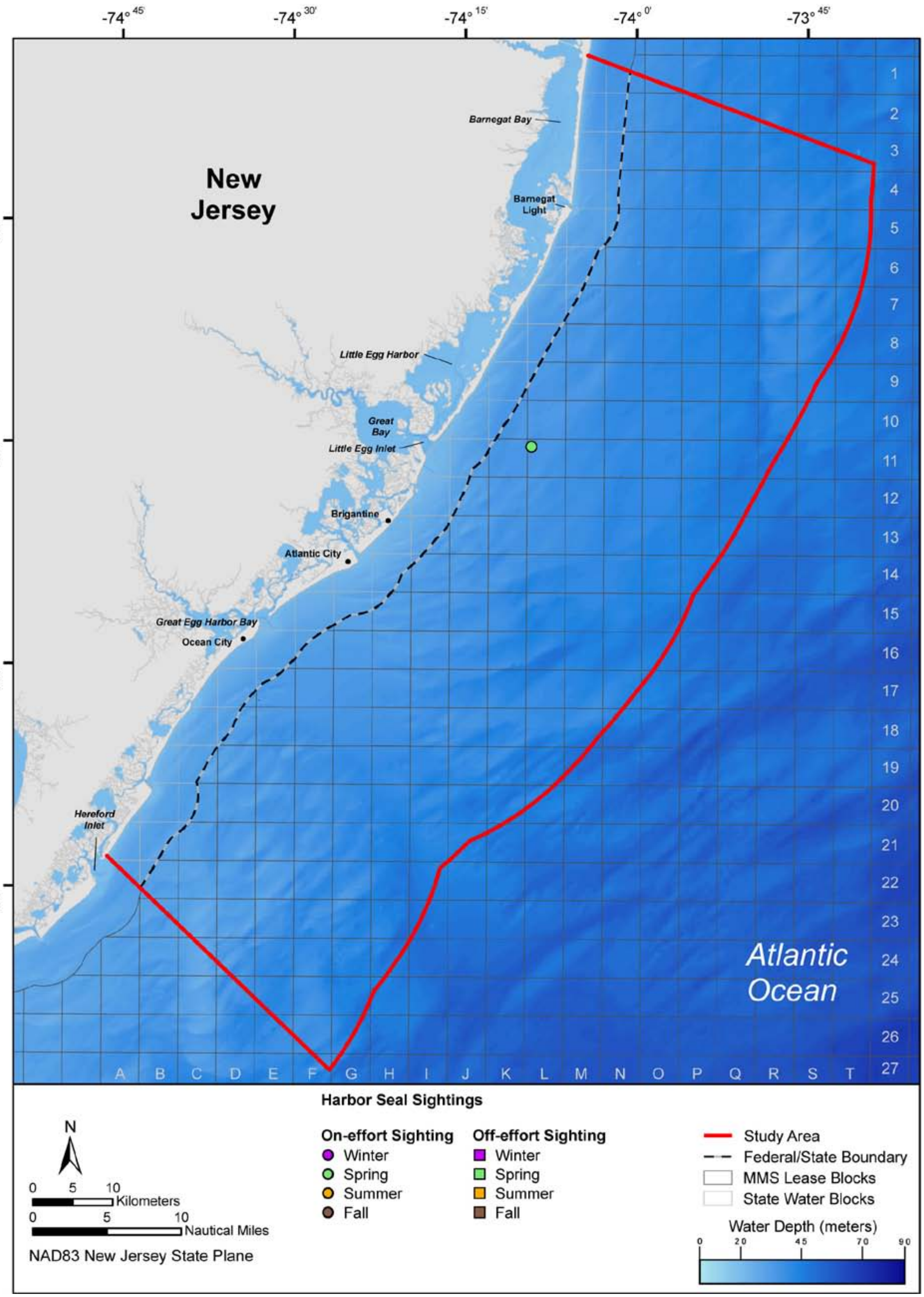

Figure 5-11. On-effort and off-effort sightings of the harbor seal in the Study Area from the shipboard and aerial surveys.

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).

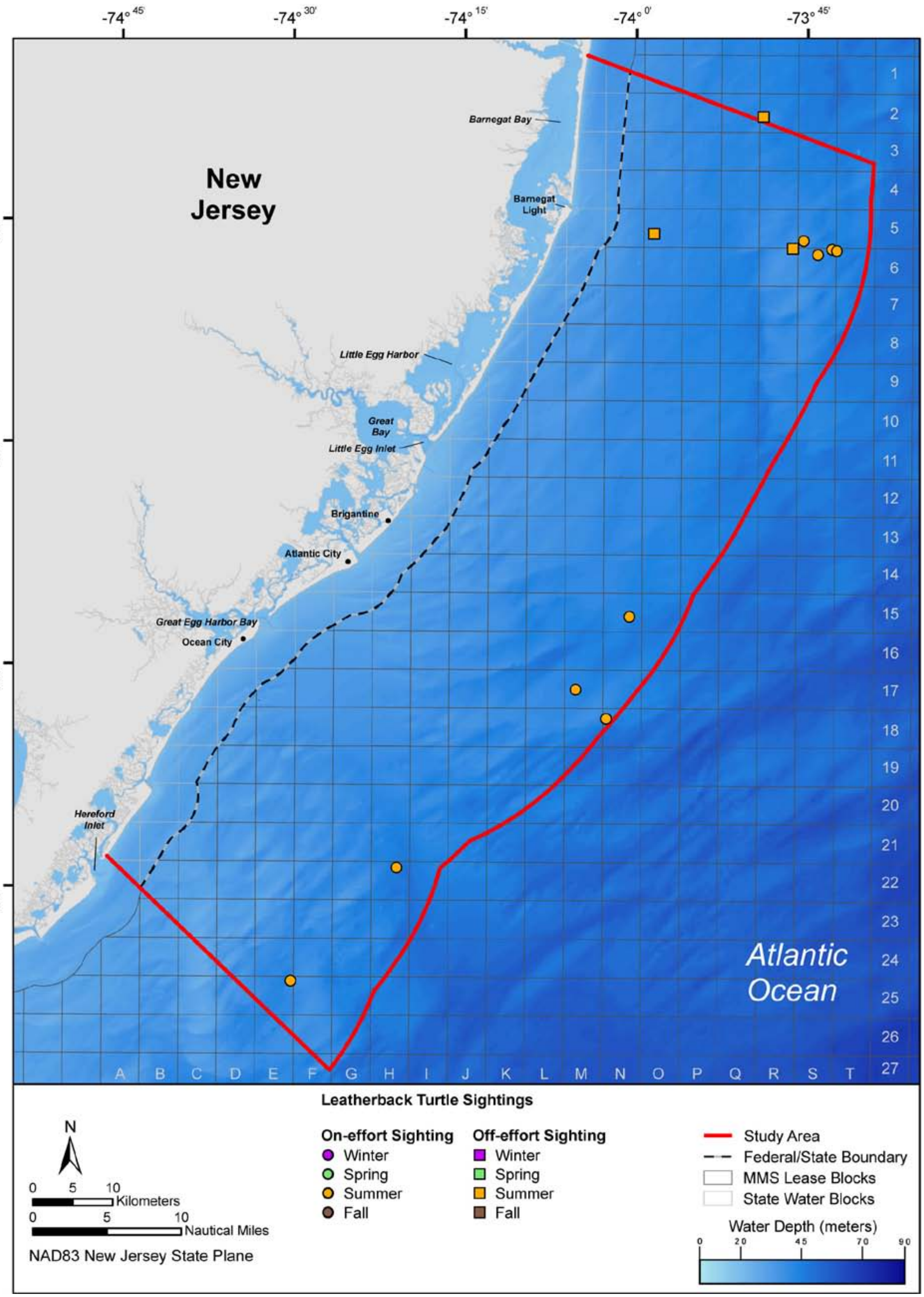

Figure 5-12. On-effort and off-effort sightings of the leatherback turtle in the Study Area and vicinity from the shipboard and aerial surveys.

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.

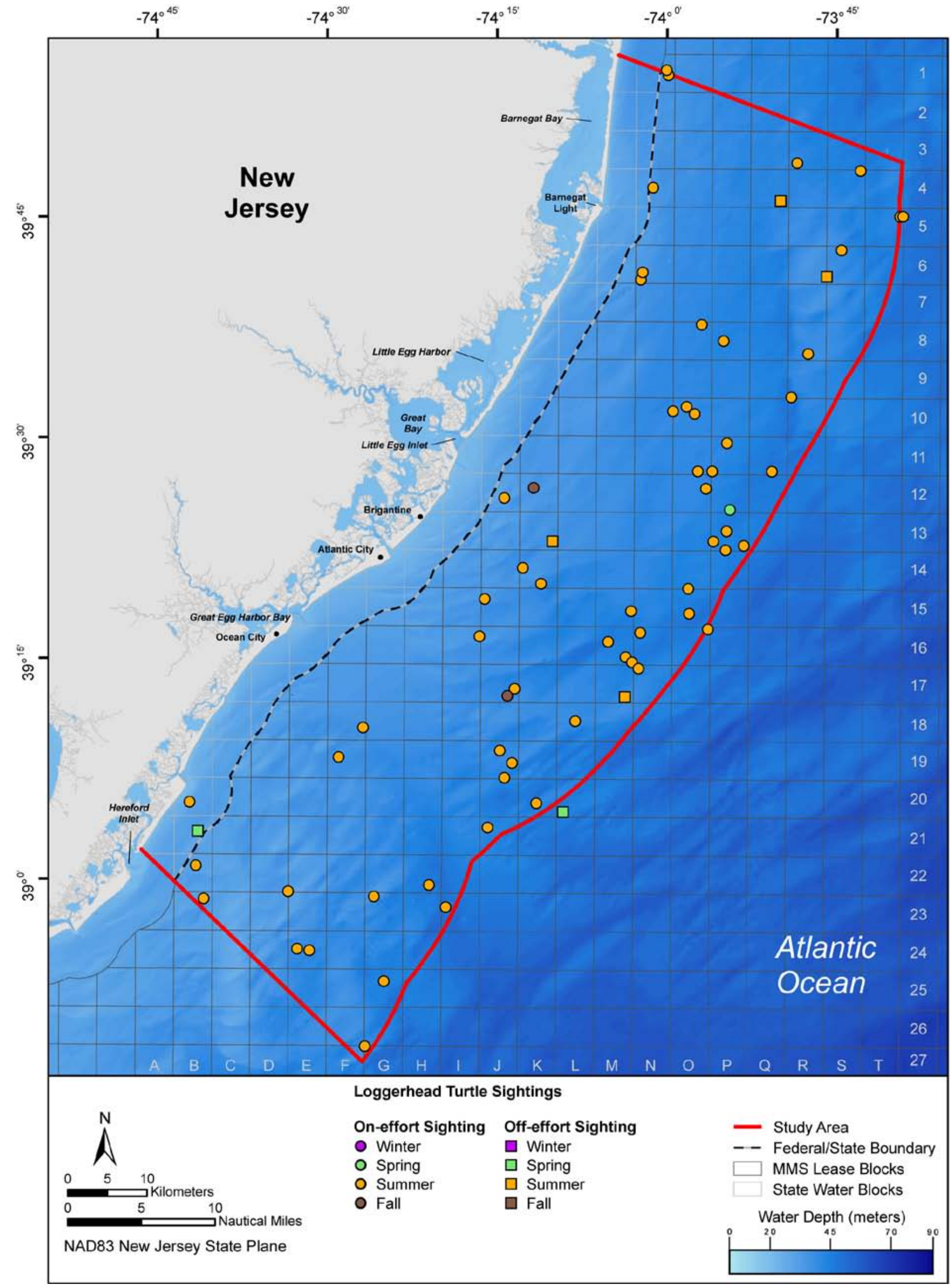

Figure 5-13. On-effort and off-effort sightings of the loggerhead turtle in the Study Area and vicinity from the shipboard and aerial surveys.

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

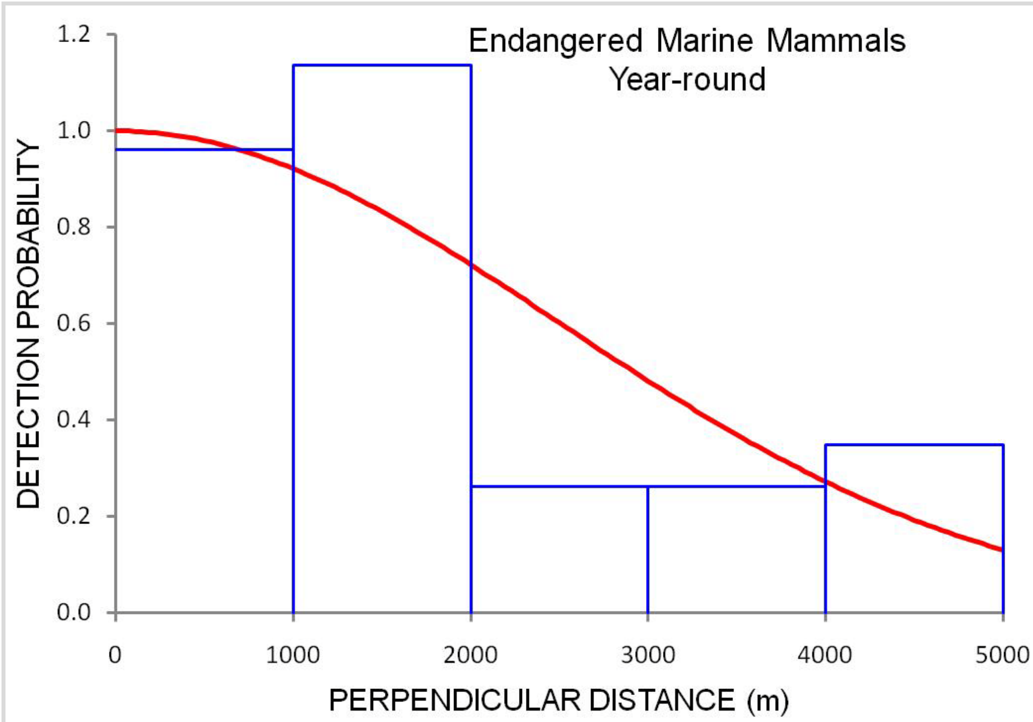

Figure 5-14. Histogram of observed distances truncated at 5,000 m and the fitted detection function for endangered marine mammals year-round based on shipboard survey data (half-normal key function with no adjustments). X^2=4.1591; DF=3; p=0.24479.

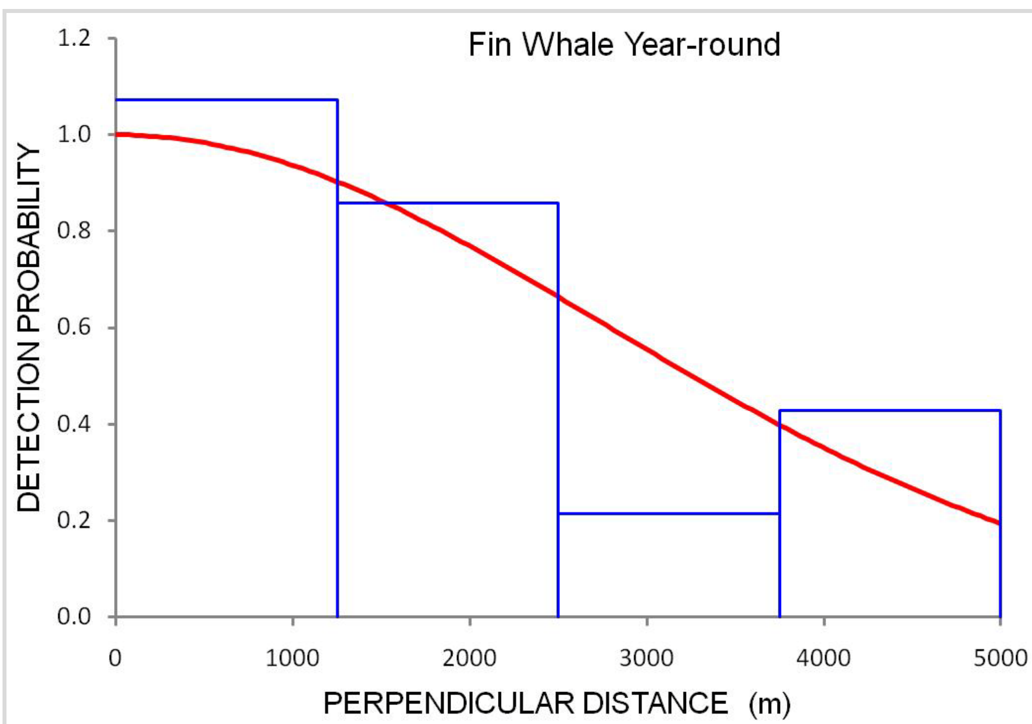

Figure 5-15. Histogram of observed distances truncated at 5,000 m and the fitted detection function for fin whales year-round based on shipboard survey data (half-normal key function with no adjustments). X^2=2.5338; DF=2; p=0.28170.

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.

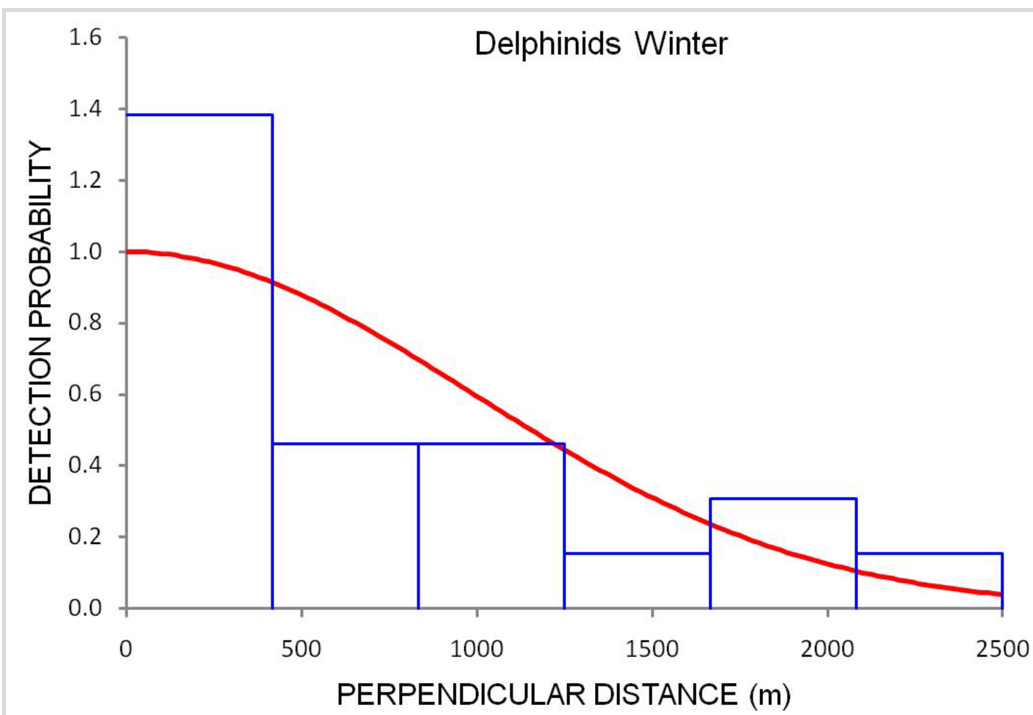

Figure 5-16. Histogram of observed distances truncated at 2,500 m and the fitted detection function for delphinids during winter based on shipboard survey data (half-normal key function with no adjustments). X^2=3.5533; DF=4; p=0.46983.

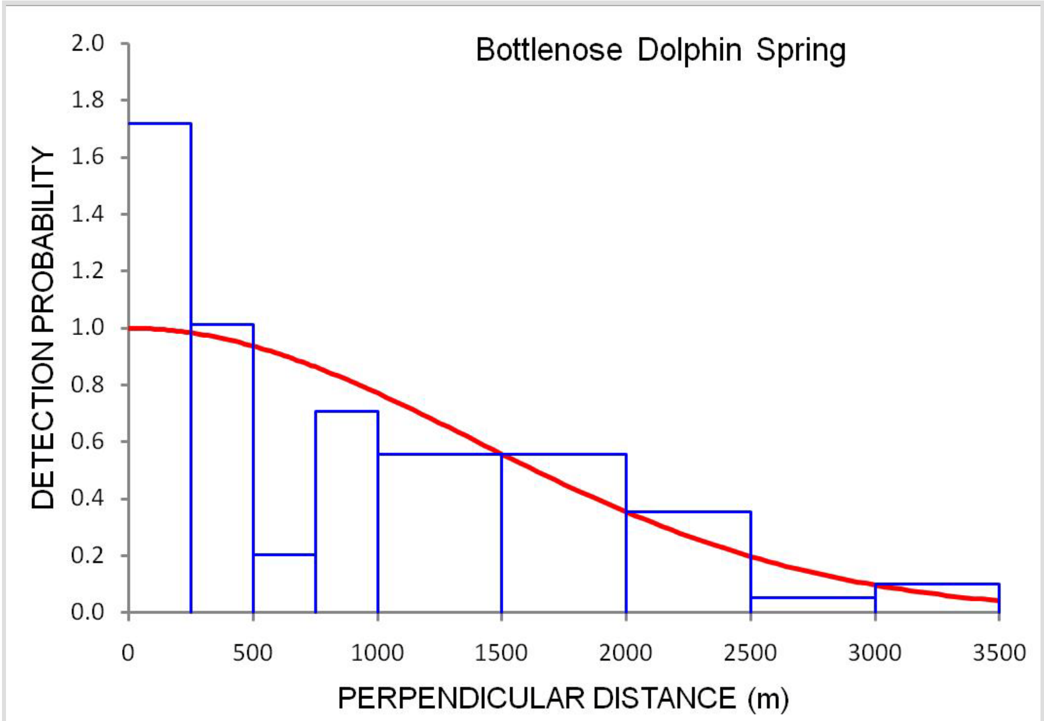

Figure 5-17. Histogram of observed distances truncated at 3,500 m and the fitted detection function for bottlenose dolphins during spring based on shipboard survey data (half-normal key function with no adjustments). X^2=11.3548; DF=7; p=0.12388.

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.

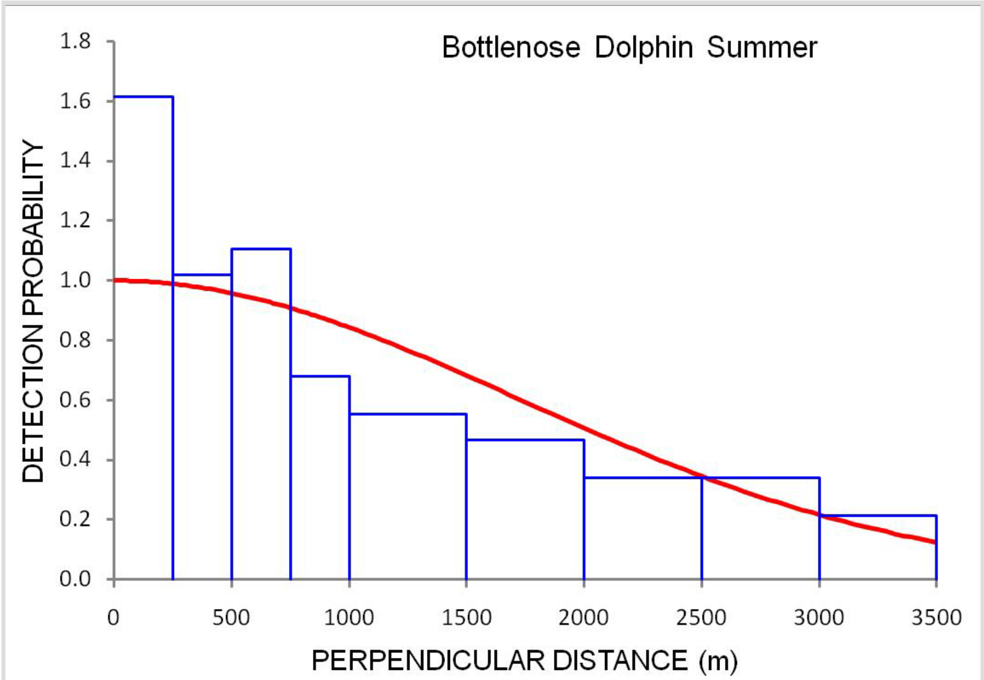

Figure 5-18. Histogram of observed distances truncated at 3,500 m and the fitted detection function for bottlenose dolphins during summer based on shipboard survey data (half-normal key function with no adjustments). X^2=9.0434; DF=7; p=0.24956.

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.

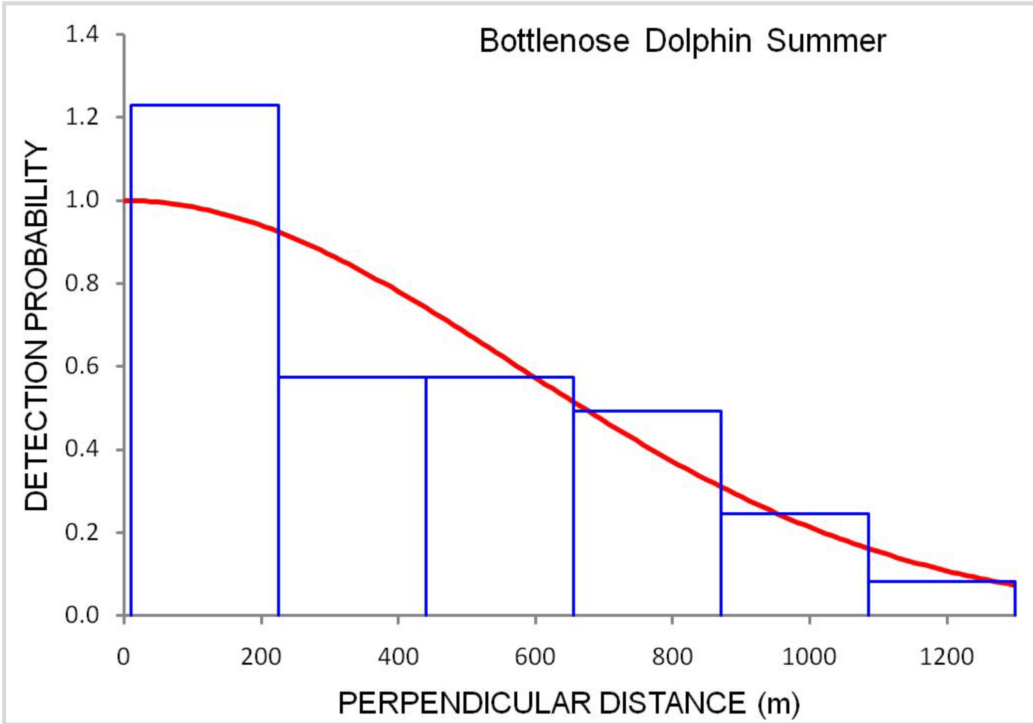

Figure 5-19. Histogram of observed distances truncated from 0 to 10 m and the fitted detection function for bottlenose dolphins during summer based on aerial survey data (half-normal key function with no adjustments). X^2=2.2289; DF=4; p=0.69373.

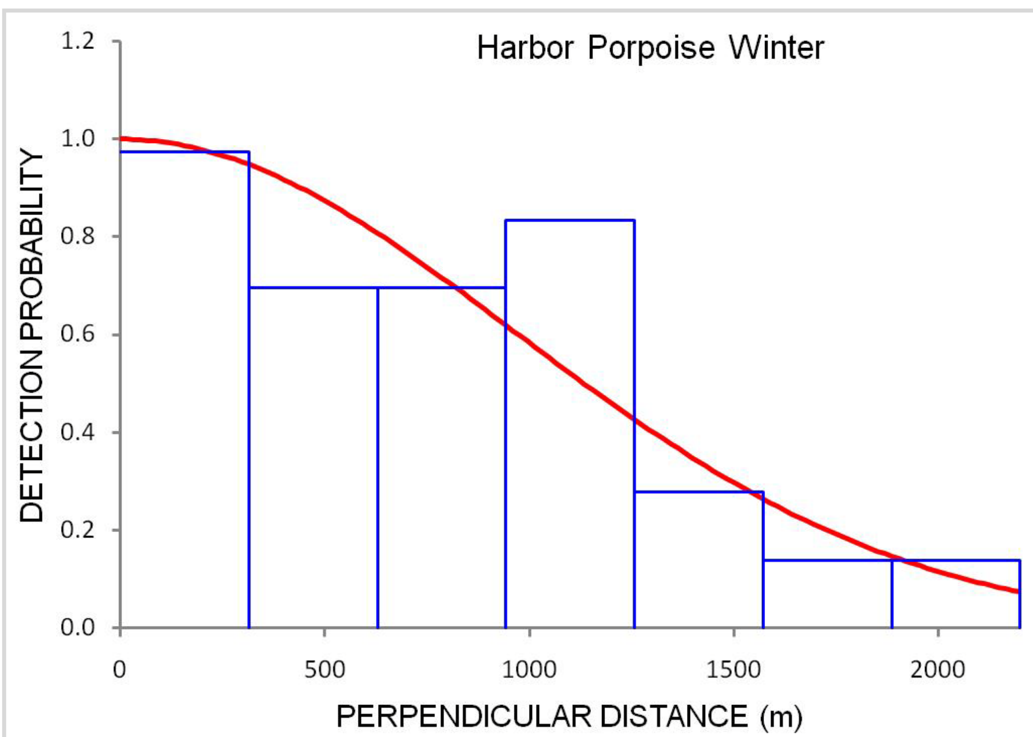

Figure 5-20. Histogram of observed distances truncated at 2,200 m and the fitted detection function for harbor porpoises during winter based on shipboard survey data (half-normal key function with no adjustments). X^2=1.9388; DF=5; p=0.85755.

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).

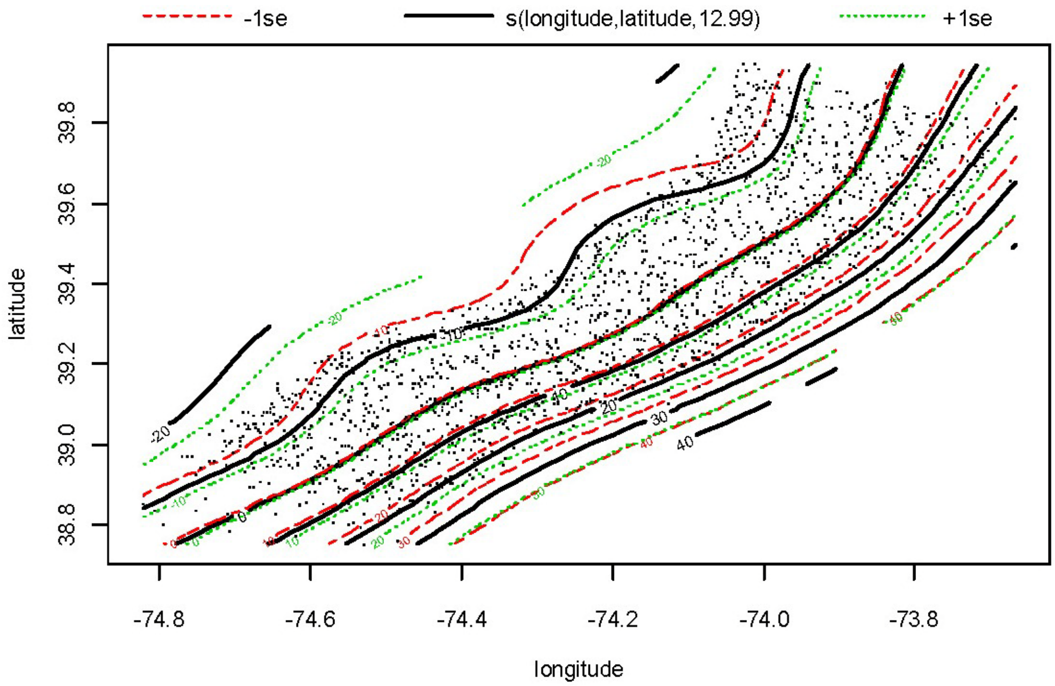

Figure 5-21. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 standard error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

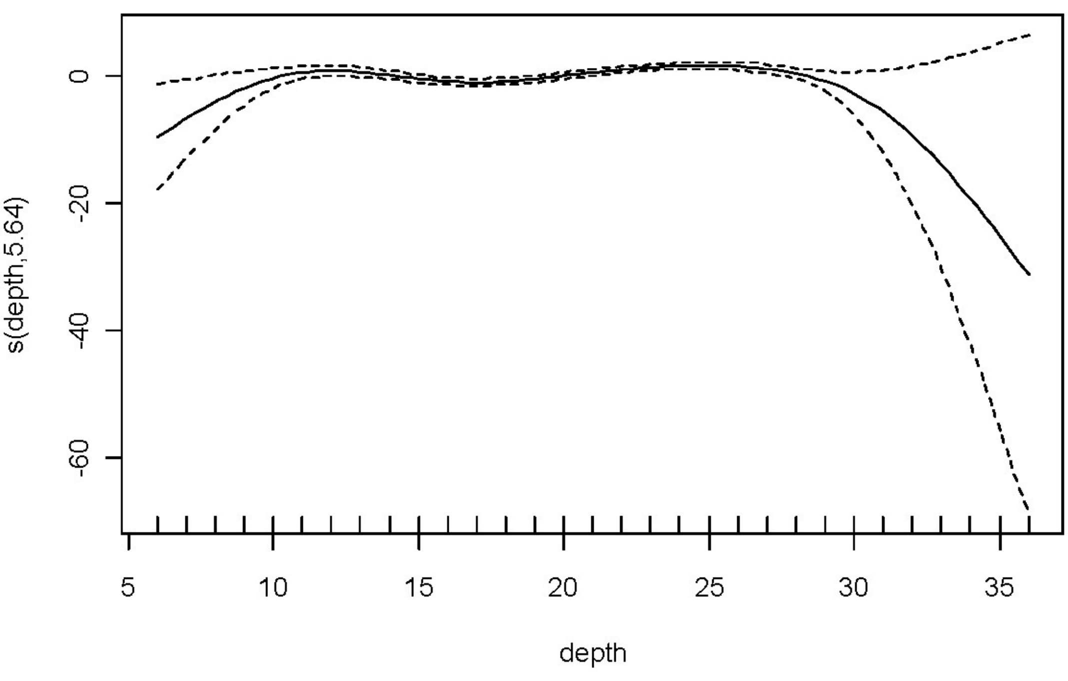

Figure 5-22. Plot of the GAM smooth fit depicting the environmental covariate depth (m) selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines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

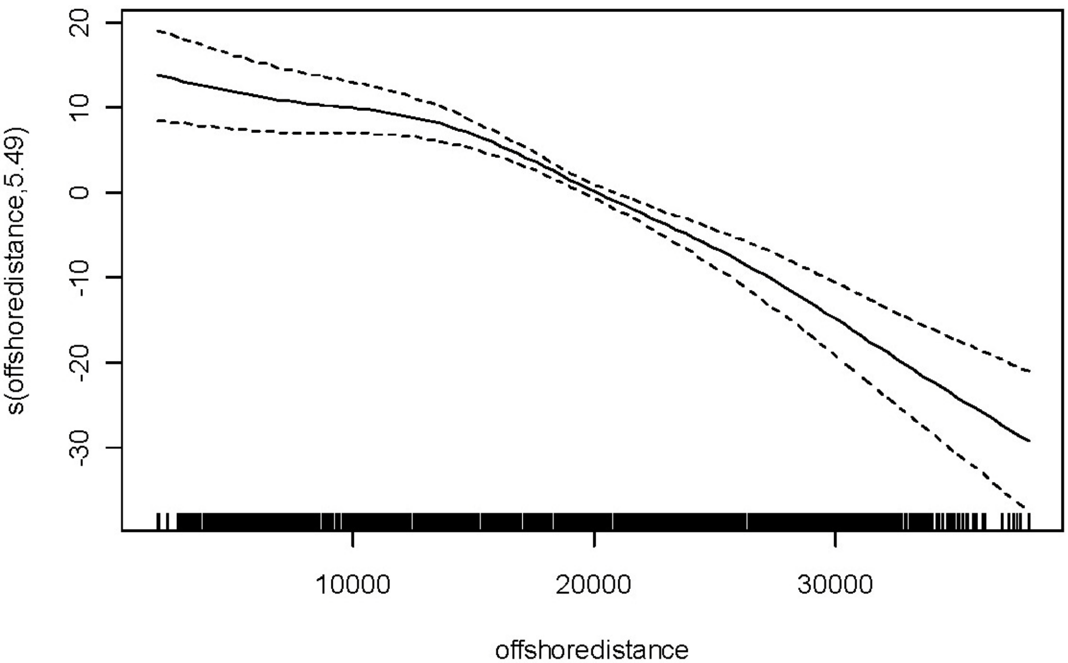

Figure 5-23. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and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

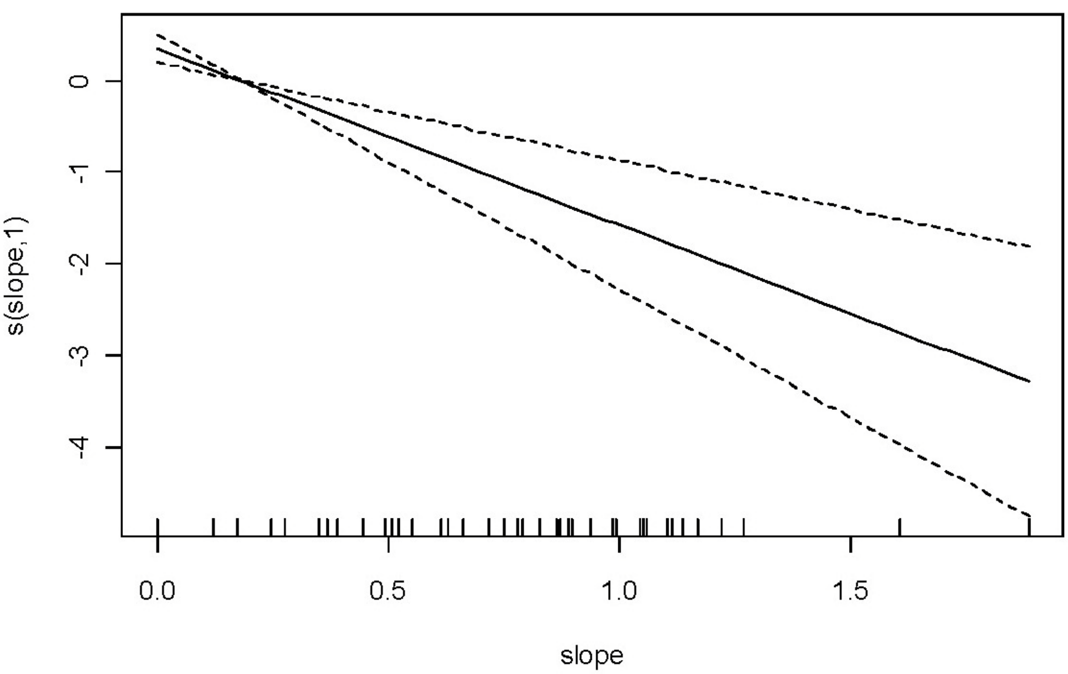

Figure 5-24. Plot of the GAM smooth fit depicting the environmental covariate slope (°) selected for endangered marine mammals during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines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

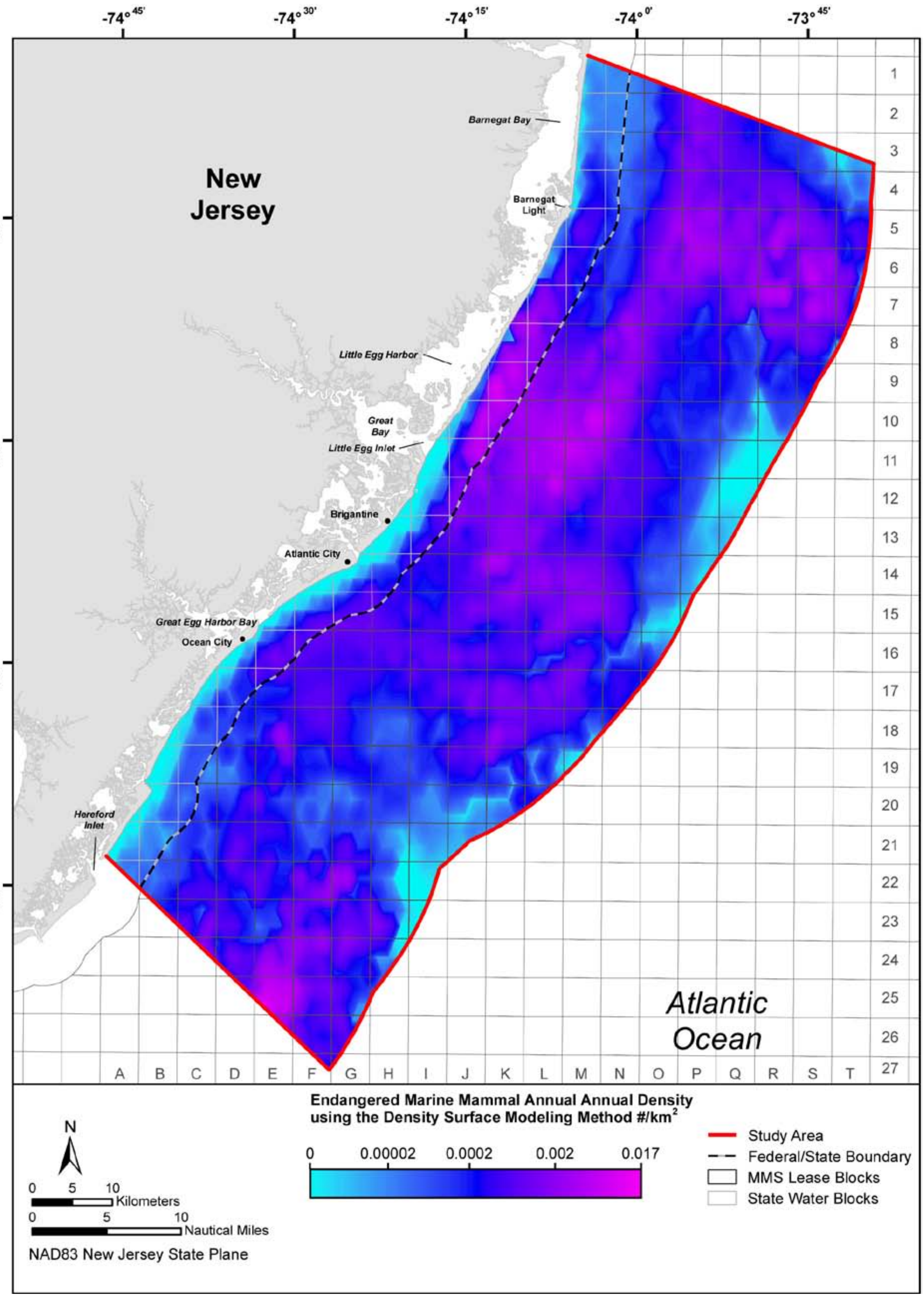

Figure 5-25. Surface map of smoothed predicted density of endangered marine mammals during all seasons in the Study Area based on shipboard survey data.

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.

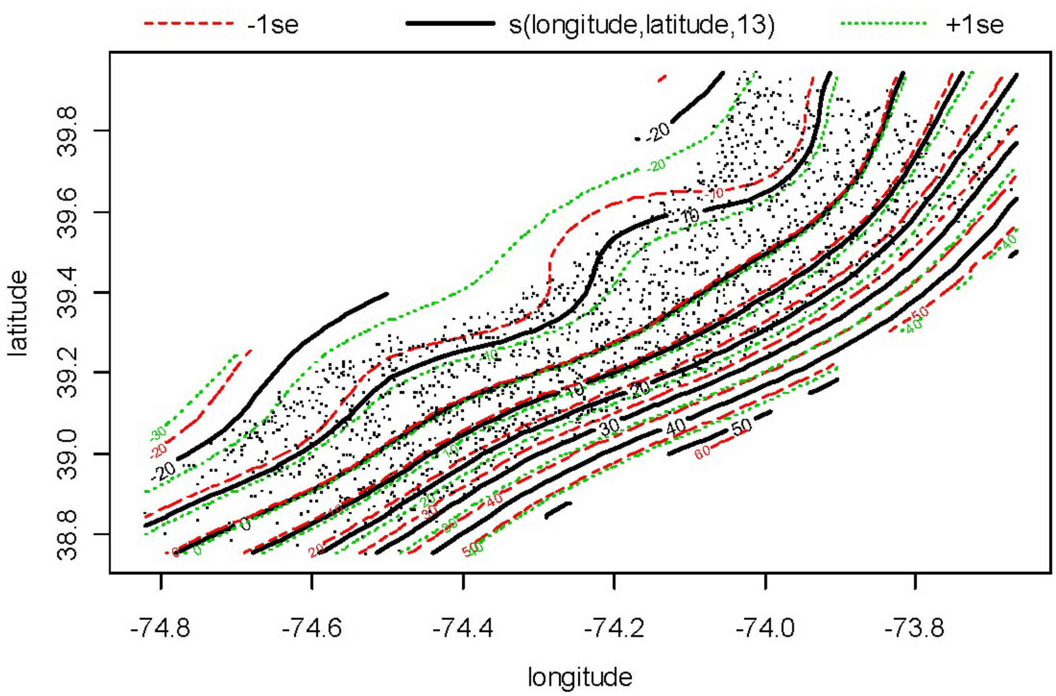

Figure 5-26. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for the fin whale during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed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

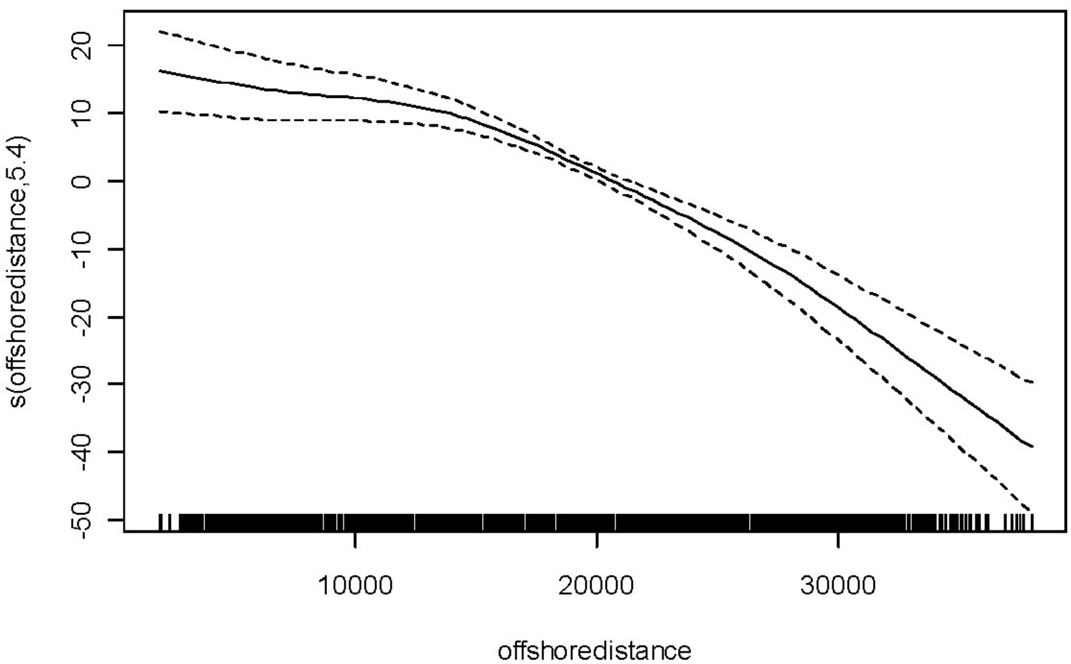

Figure 5-27. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for the fin whale during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines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

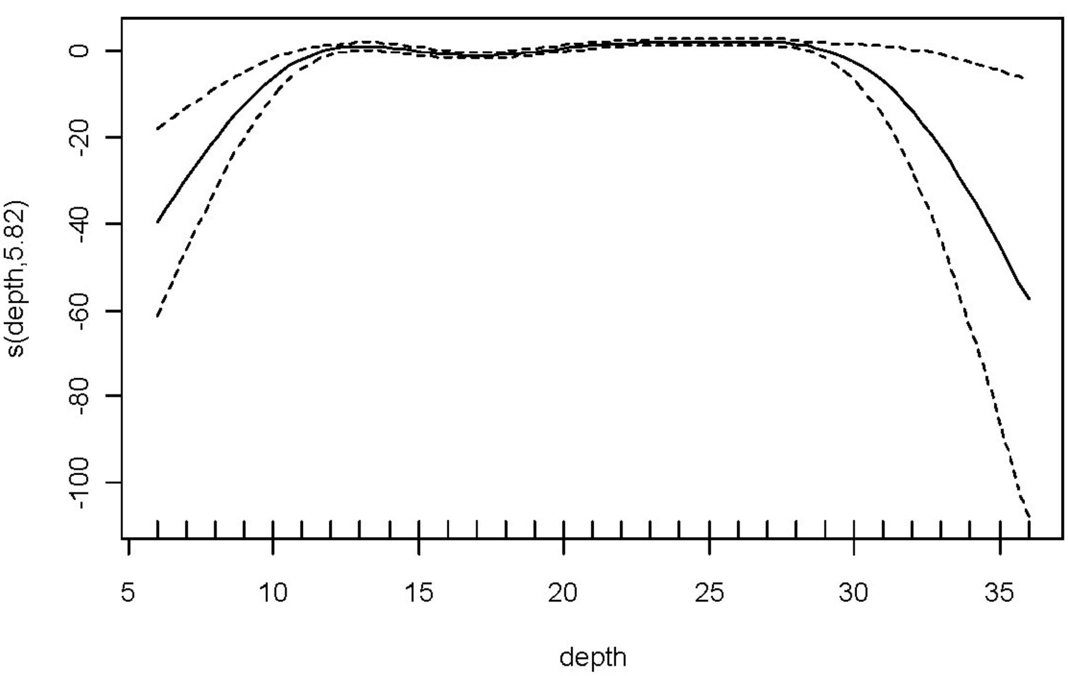

Figure 5-28. Plot of the GAM smooth fit depicting the environmental covariate depth (m) selected for the fin whale during all seasons in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis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

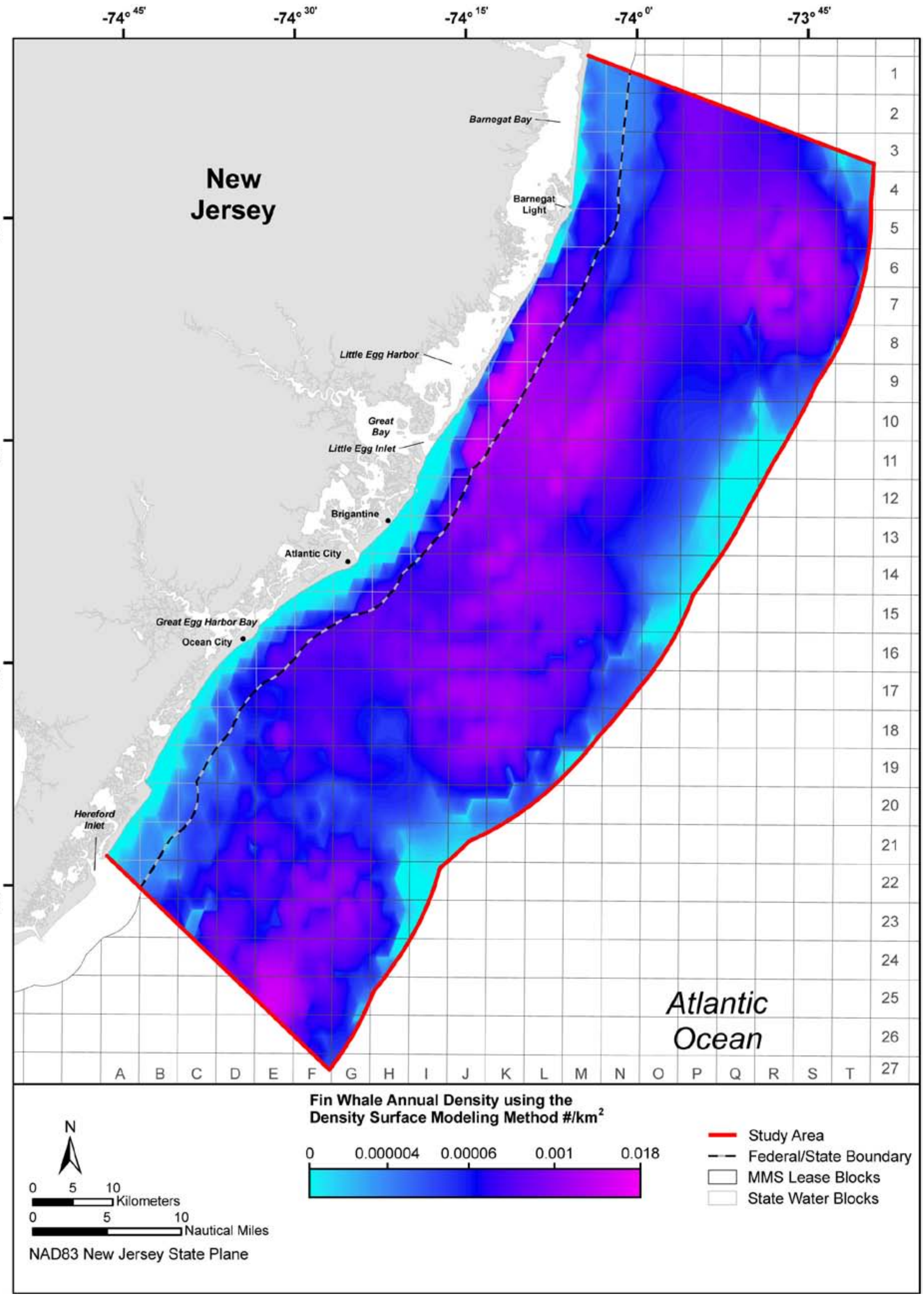

Figure 5-29. Surface map of smoothed predicted density for the fin whale during all seasons in the Study Area based on shipboard survey data.

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.

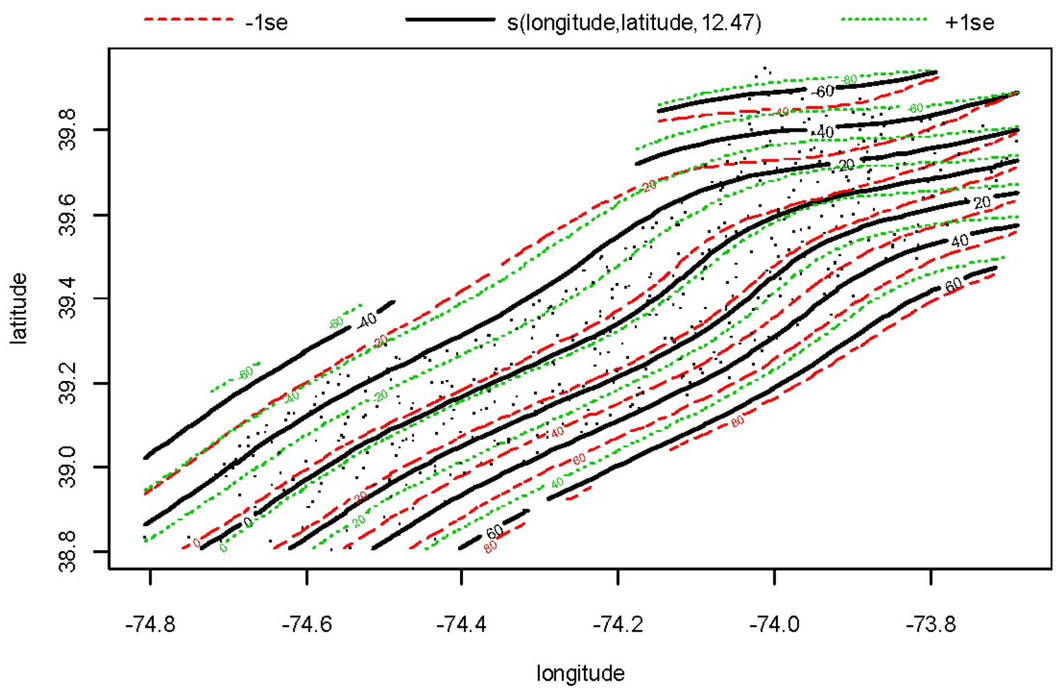

Figure 5-30. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for delphinids during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red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

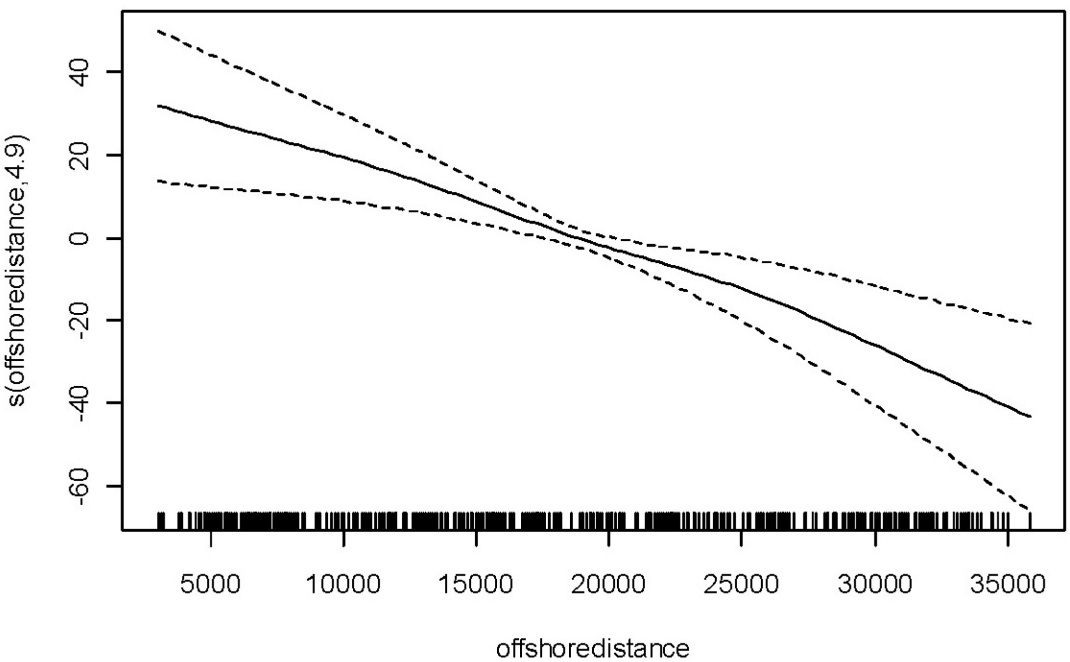

Figure 5-31. Plot of the GAM smooth fit depicting the interaction of the covariate offshore distance (m) selected for delphinids during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines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

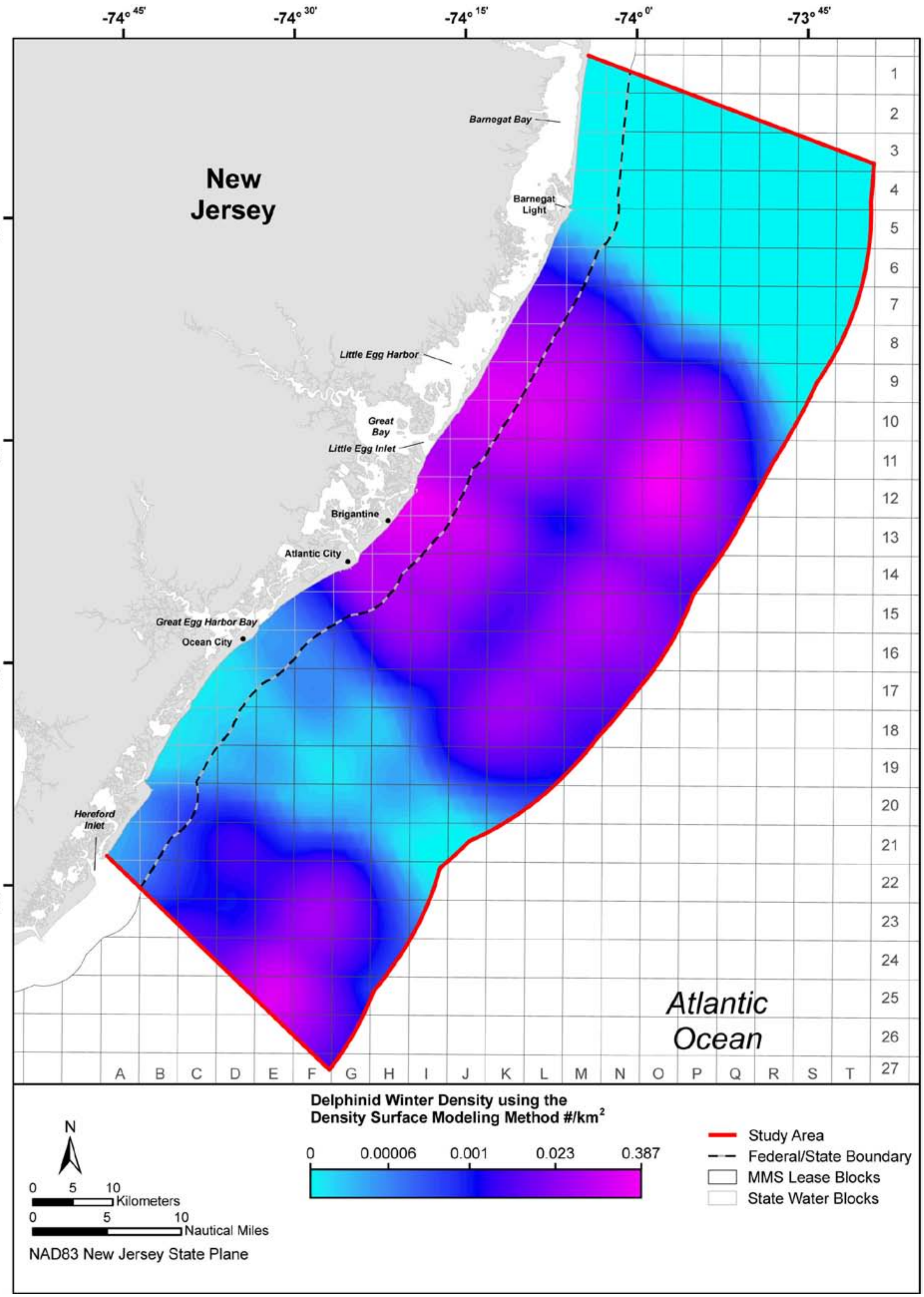

Figure 5-32. Surface map of smoothed predicted density for delphinids during winter in the Study Area based on shipboard survey data.

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.

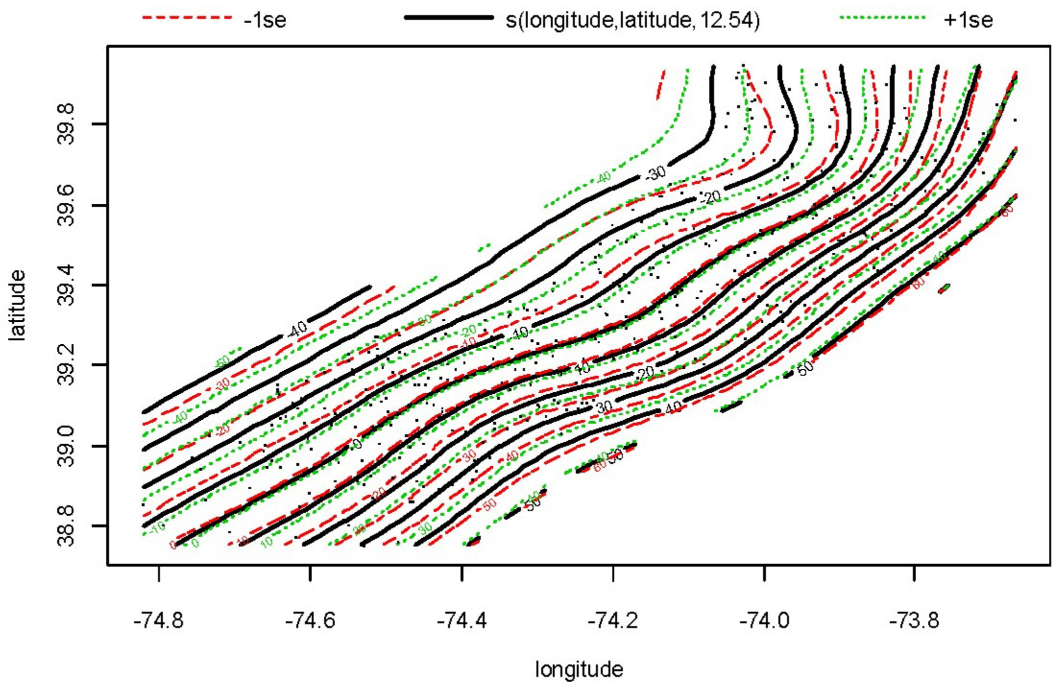

Figure 5-33. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for bottlenose dolphins during spring in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and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

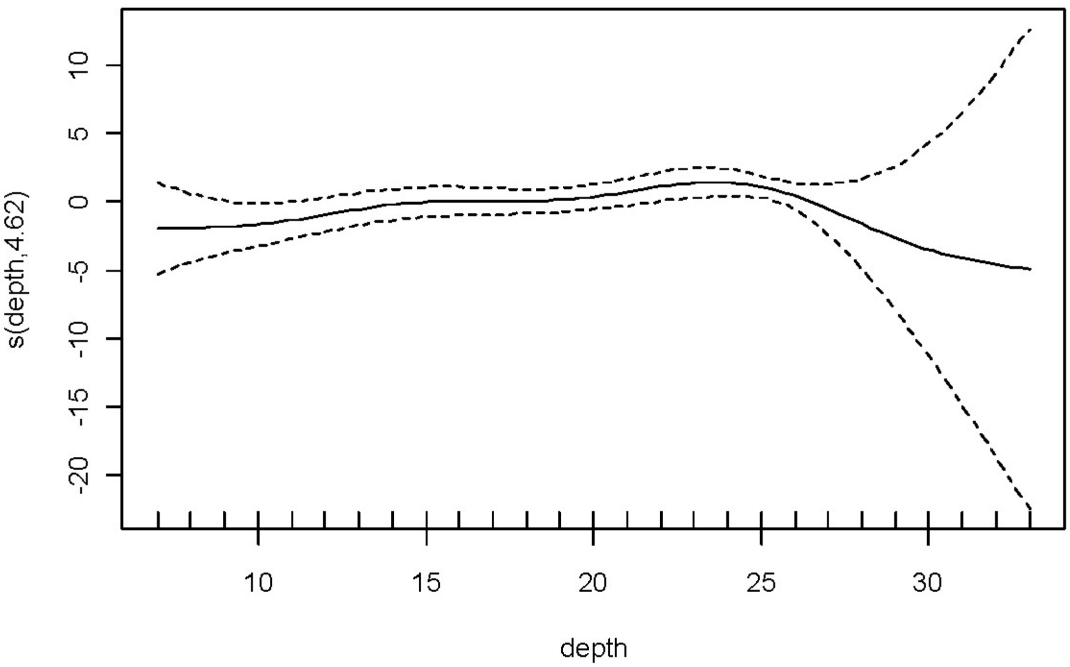

Figure 5-34. Plot of the GAM smooth fit depicting the environmental covariate depth (m) selected for bottlenose dolphins during spring in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis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

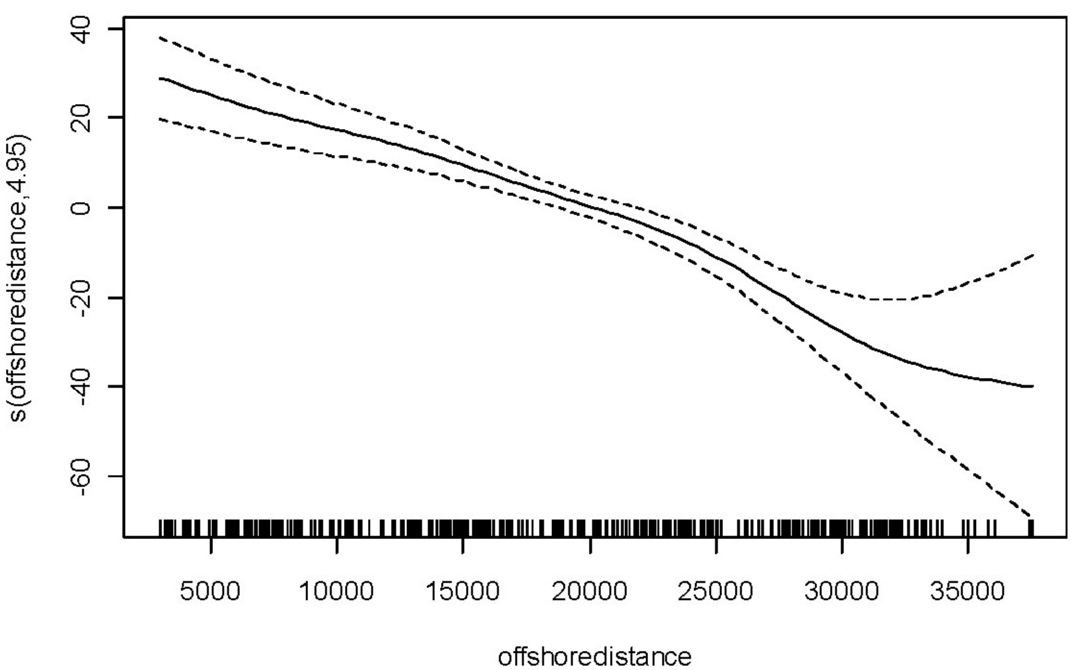

Figure 5-35. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for bottlenose dolphins during spring in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines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

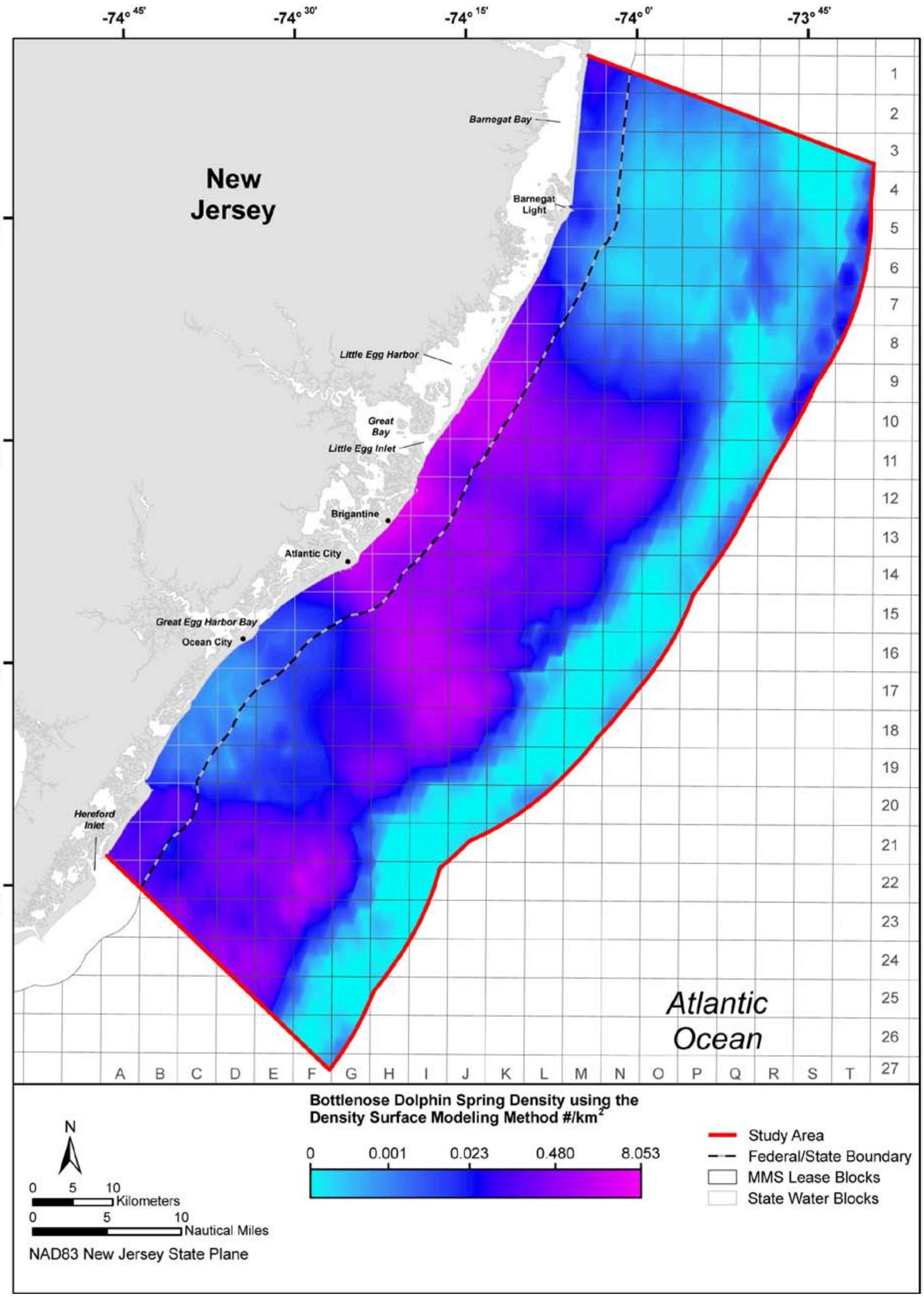

Figure 5-36. Surface map of smoothed predicted density for bottlenose dolphins during spring in the Study Area based on shipboard survey data.

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.

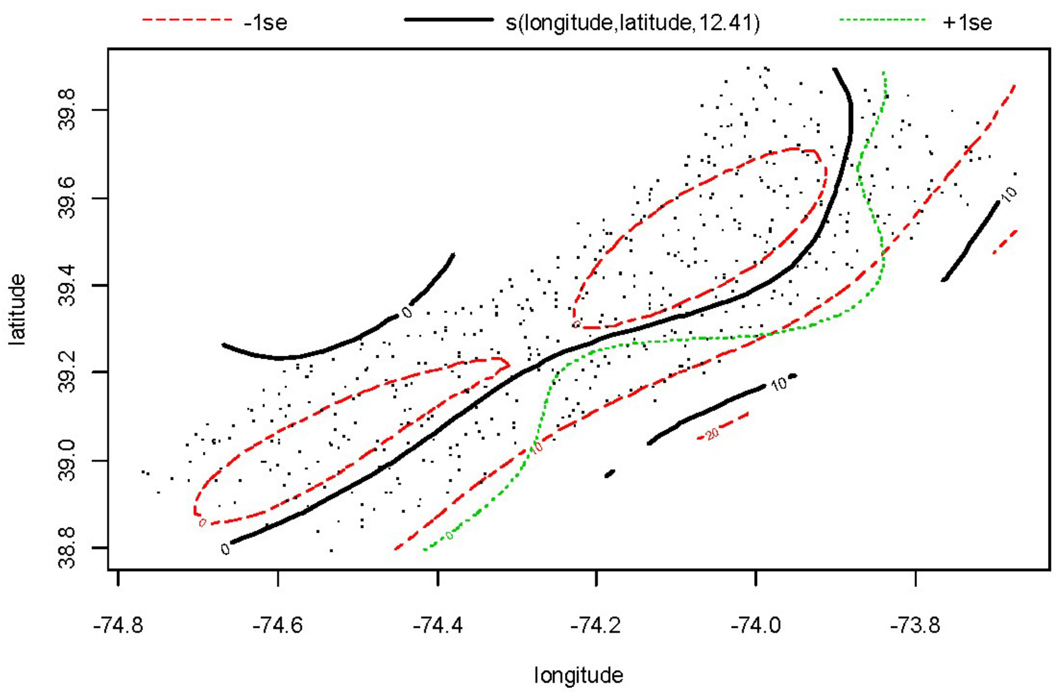

Figure 5-37. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for bottlenose dolphins during summer in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and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

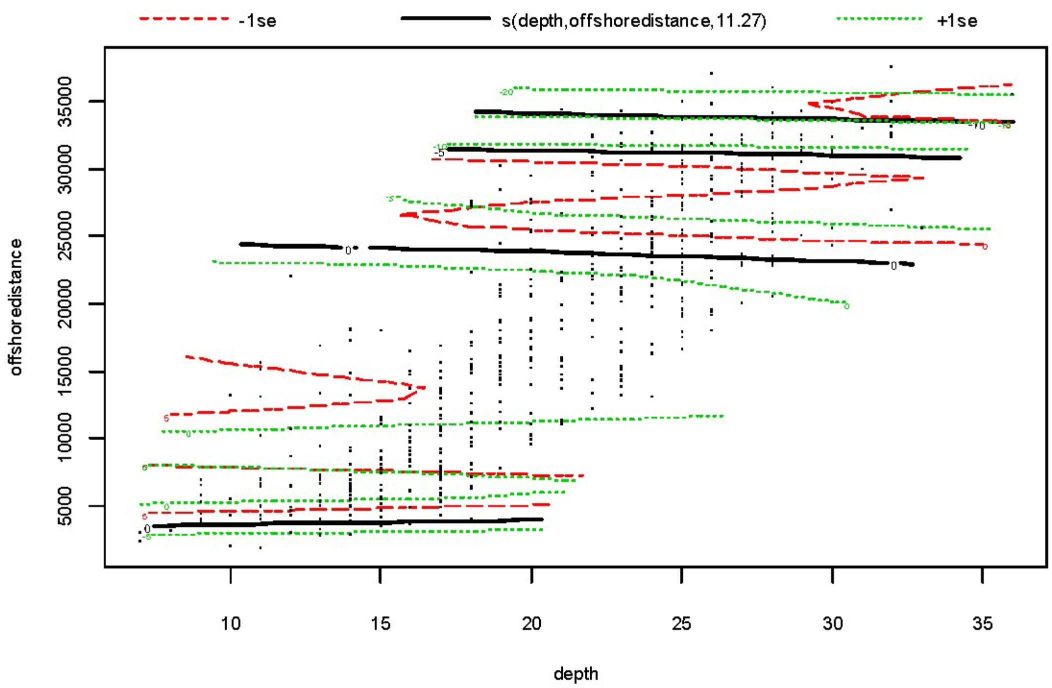

Figure 5-38. Plot of the GAM smooth fit depicting the interaction of the covariates depth (m) and offshore distance (m) selected for bottlenose dolphins during summer in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence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

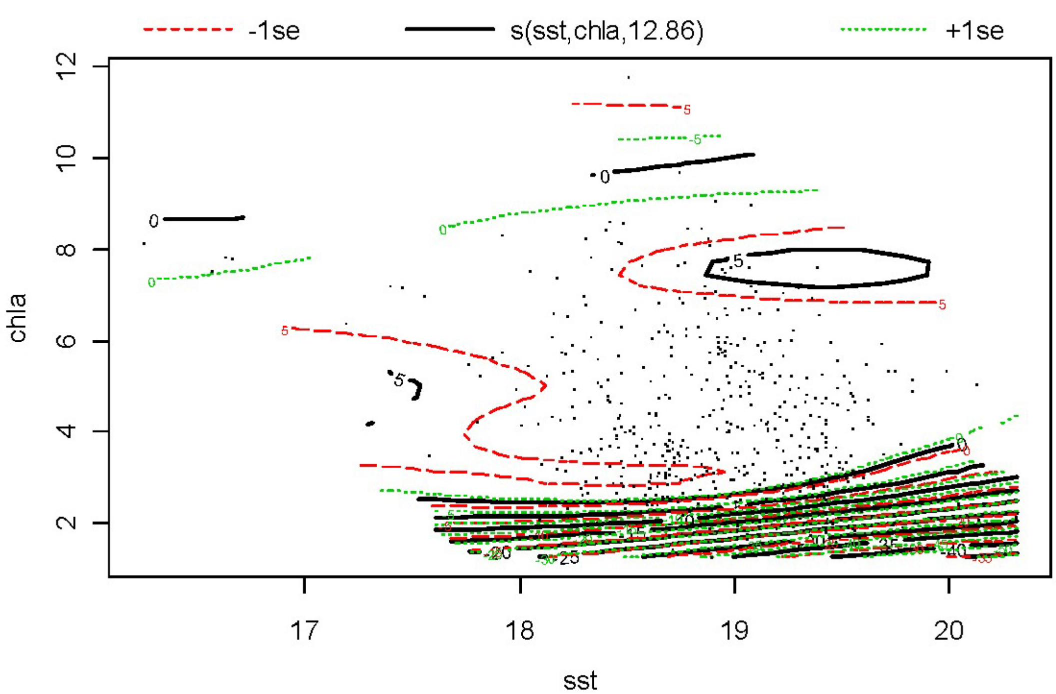

Figure 5-39. Plot of the GAM smooth fit depicting the interaction of the covariates SST (°C) and chl a (mg/m3) selected for bottlenose dolphins during summer in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit,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

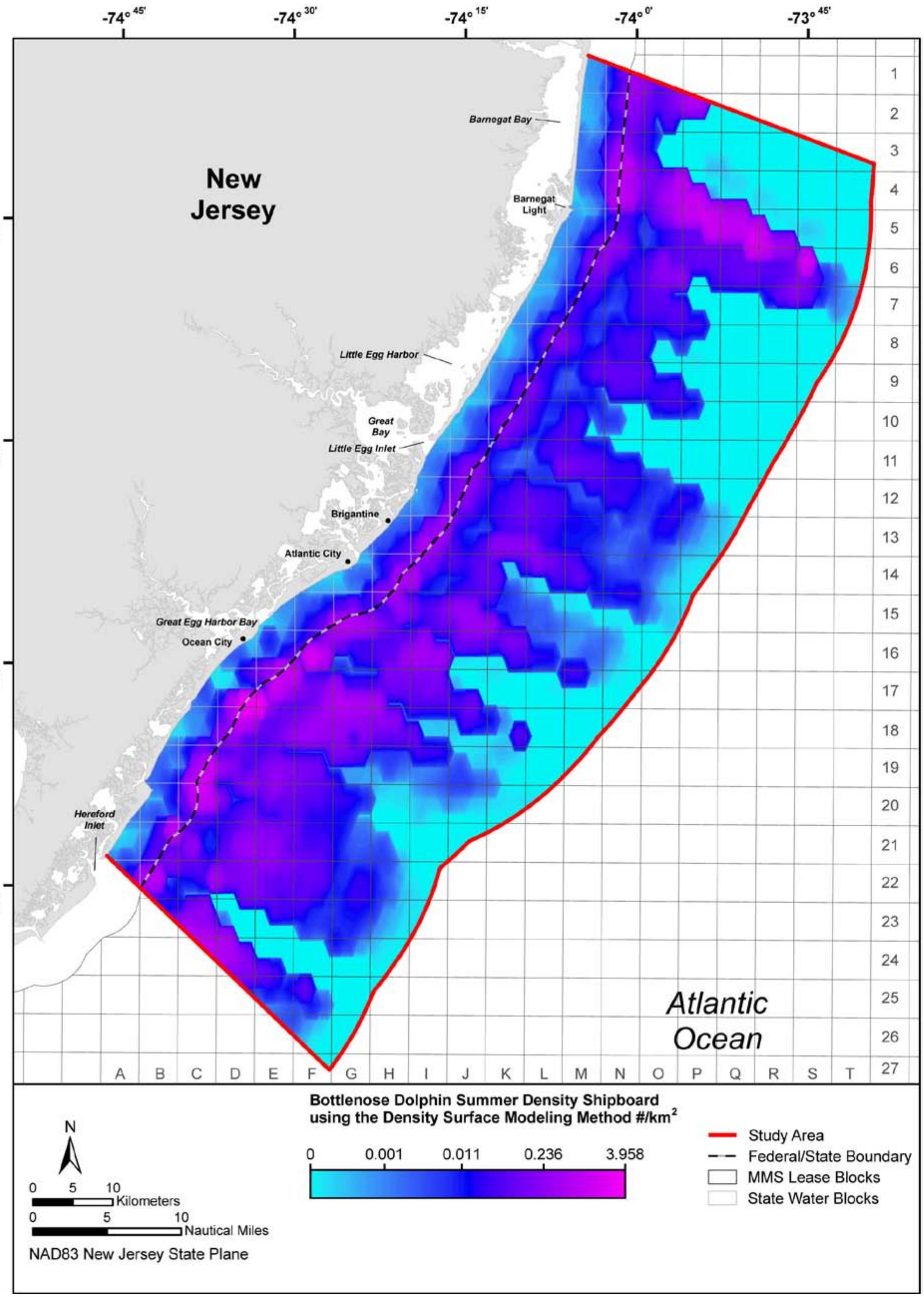

Figure 5-40. Surface map of smoothed predicted density for bottlenose dolphins during summer in the Study Area based on shipboard survey data.

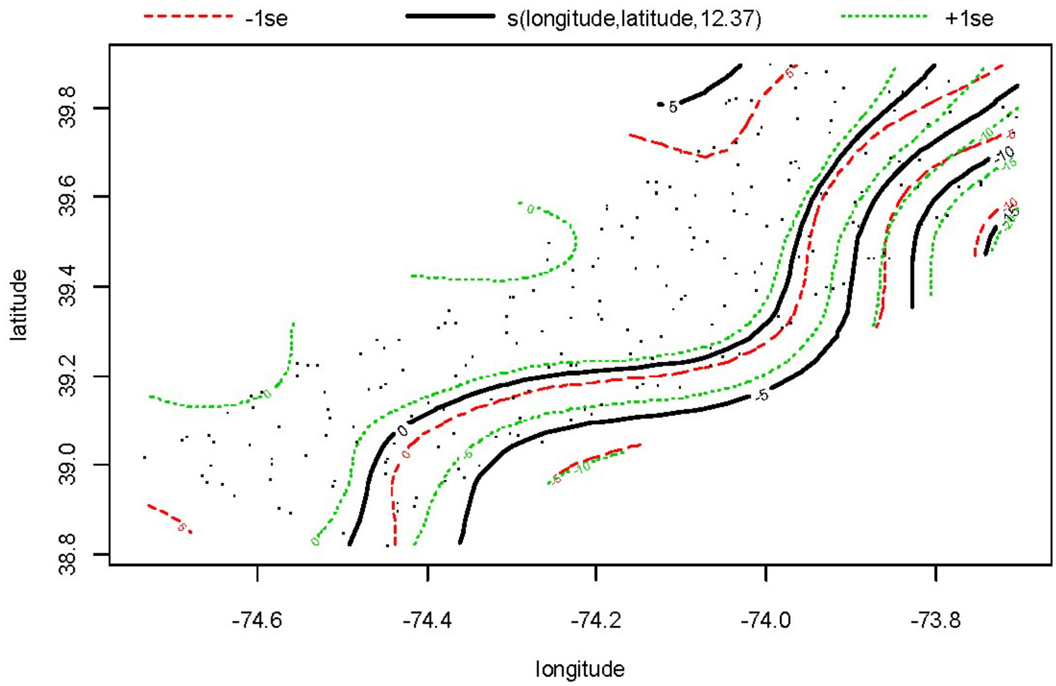

Figure 5-41. Plot of the GAM smooth fit depicting the interaction of the covariates longitude and latitude selected for bottlenose dolphins during summer in the Study Area based on aerial survey data. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed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

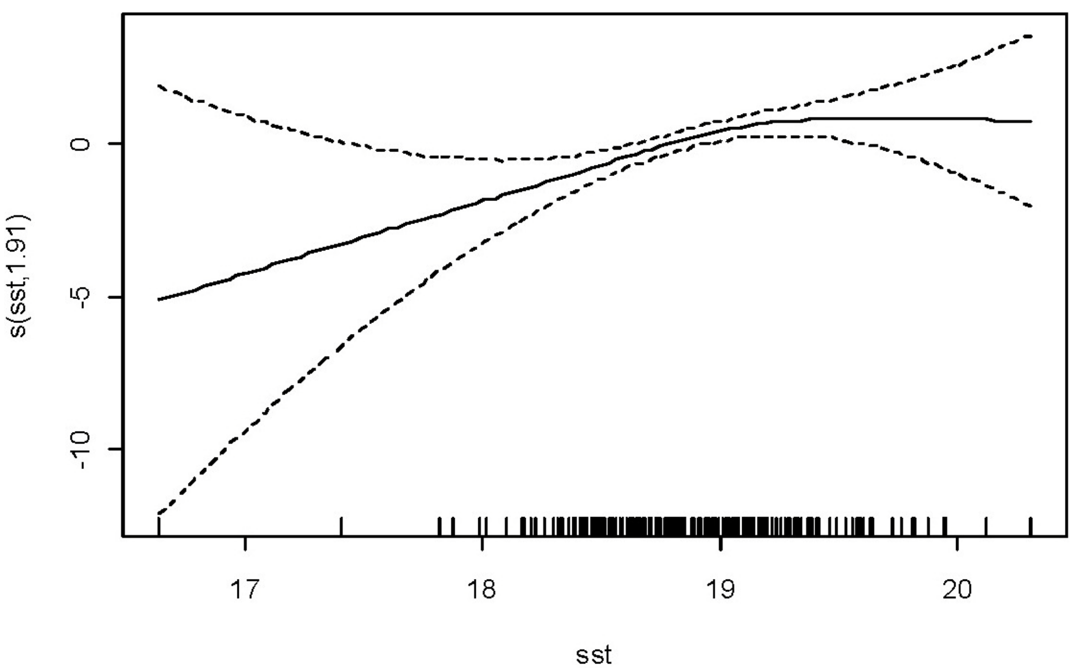

Figure 5-42. Plot of the GAM smooth fit depicting the covariate SST (°C) selected for bottlenose dolphins during summer in the Study Area based on aerial survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the x-axis are the observed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

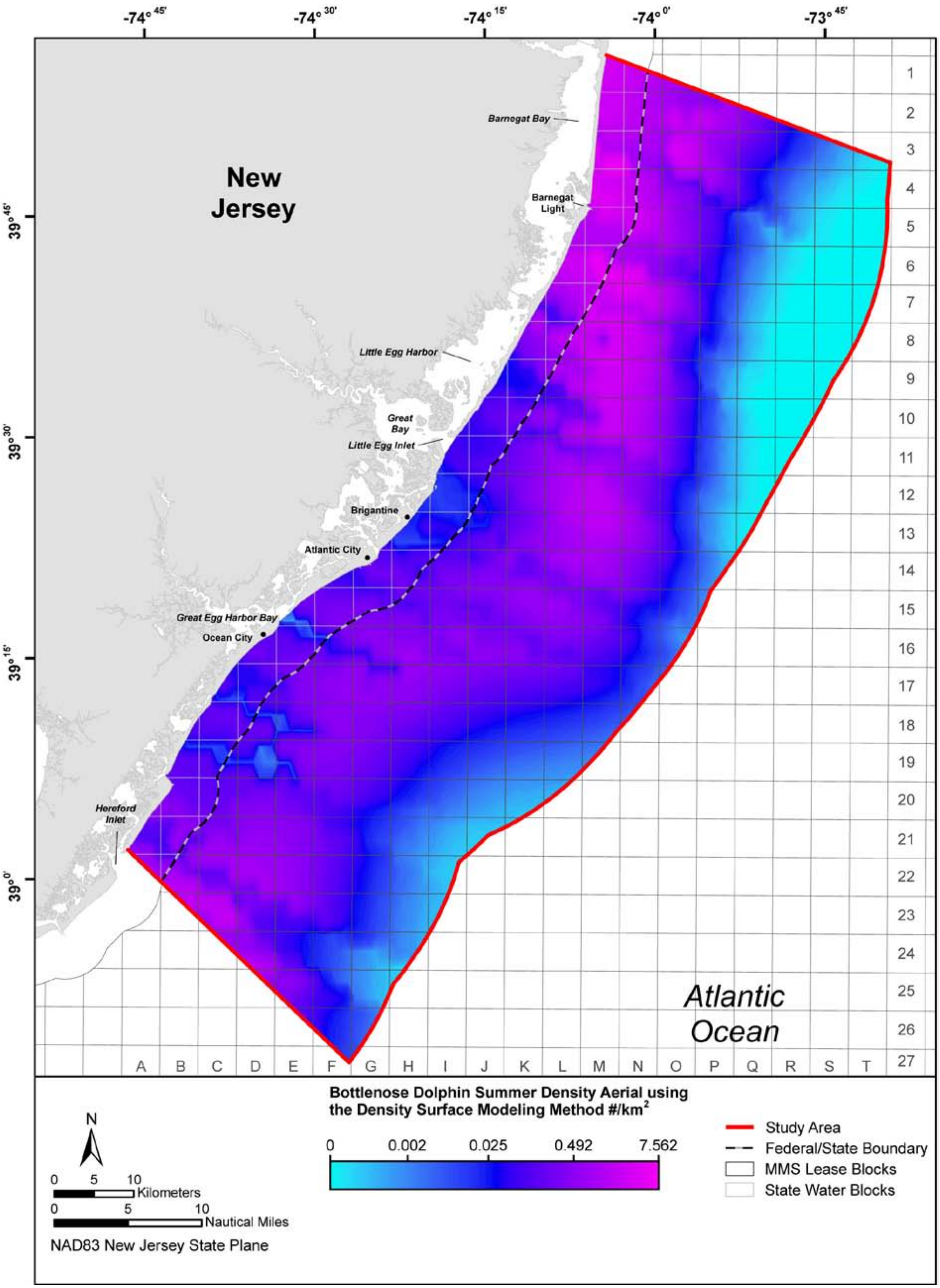

Figure 5-43. Surface map of smoothed predicted density for bottlenose dolphins during summer in the Study Area based on aerial survey data.

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.

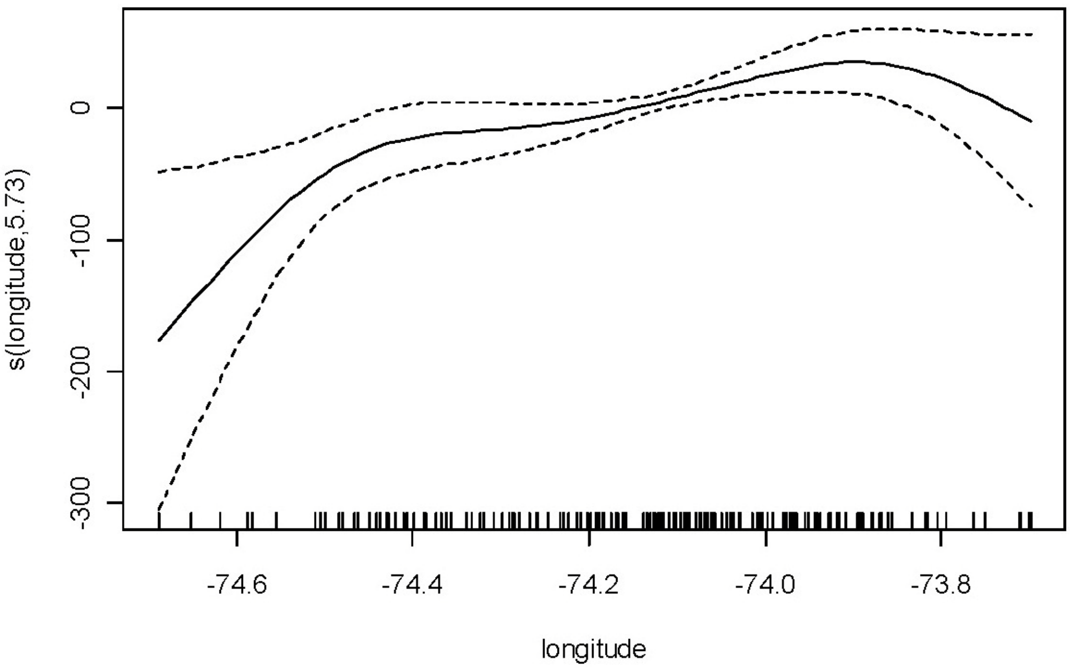

Figure 5-44. Plot of the GAM smooth fit depicting the interaction of the covariate longitude selected for harbor porpoises during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the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

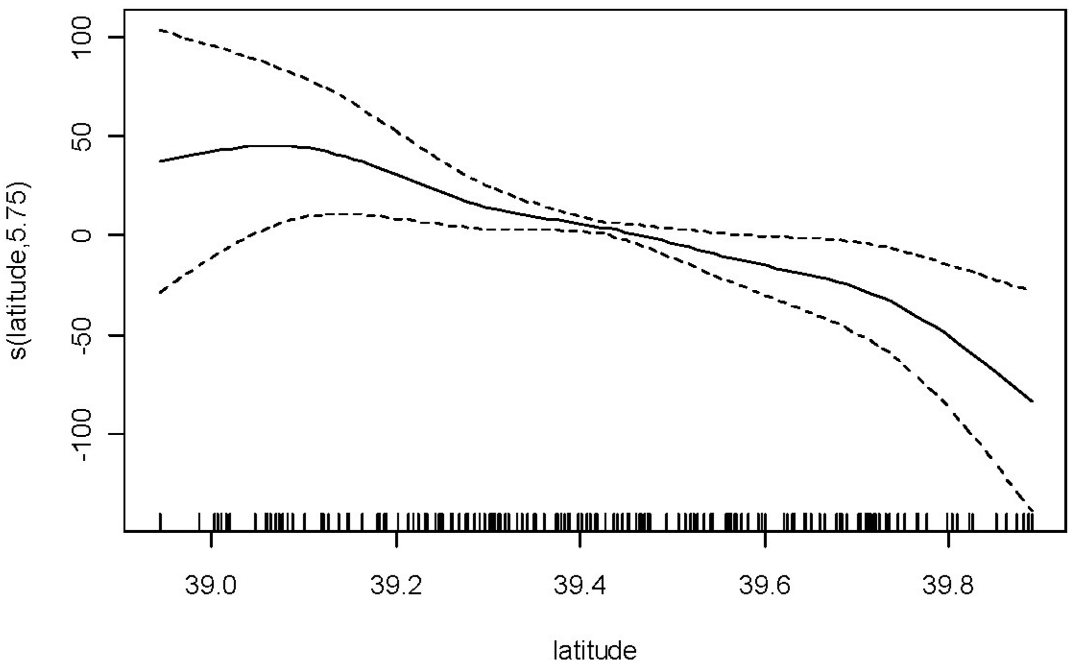

Figure 5-45. Plot of the GAM smooth fit depicting the interaction of the covariate latitude selected for harbor porpoises during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines on the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

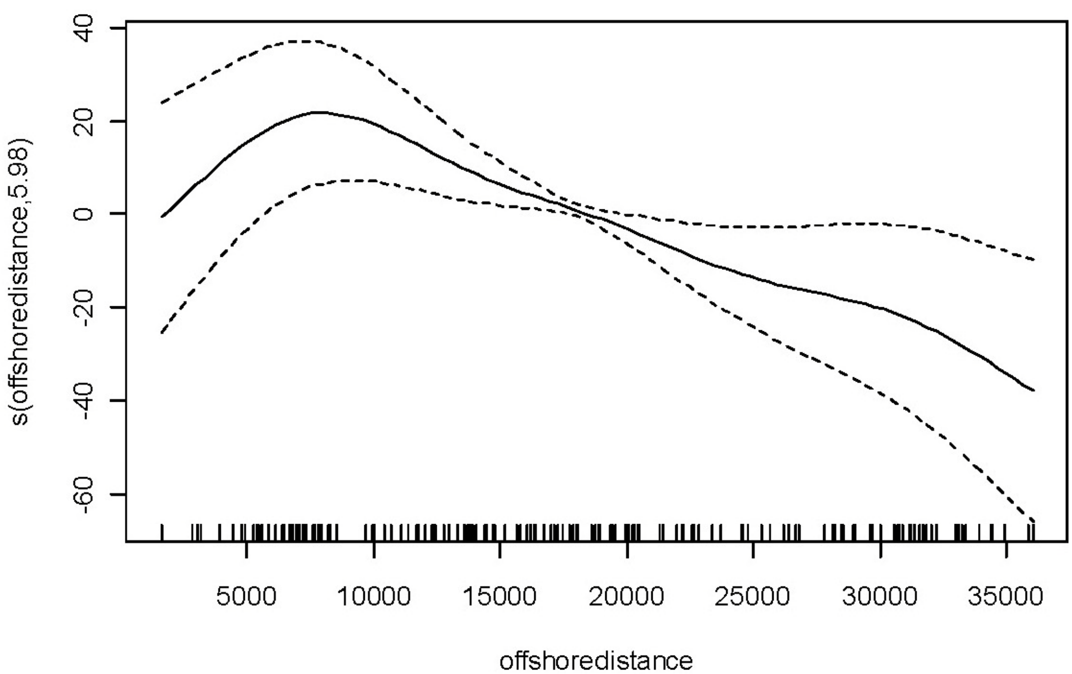

Figure 5-46. Plot of the GAM smooth fit depicting the environmental covariate offshore distance (m) selected for harbor porpoises during winter in the Study Area based on shipboard survey data. Solid lines represent the best fit, dashed lines represent the two SE confidence limits, and vertical lines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

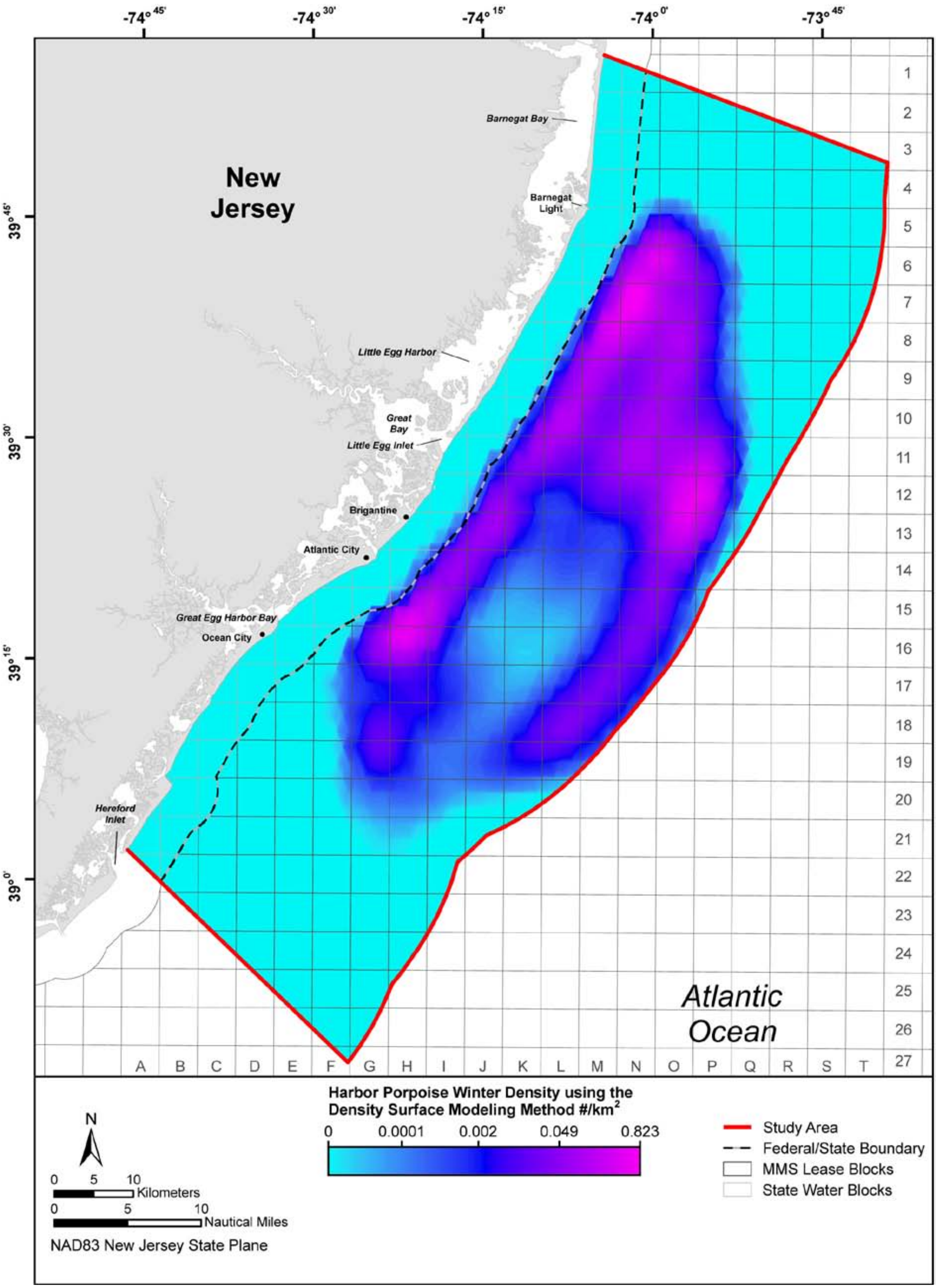

Figure 5-47. Surface map of smoothed predicted density for harbor porpoises during winter in the Study Area based on shipboard survey data.

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.

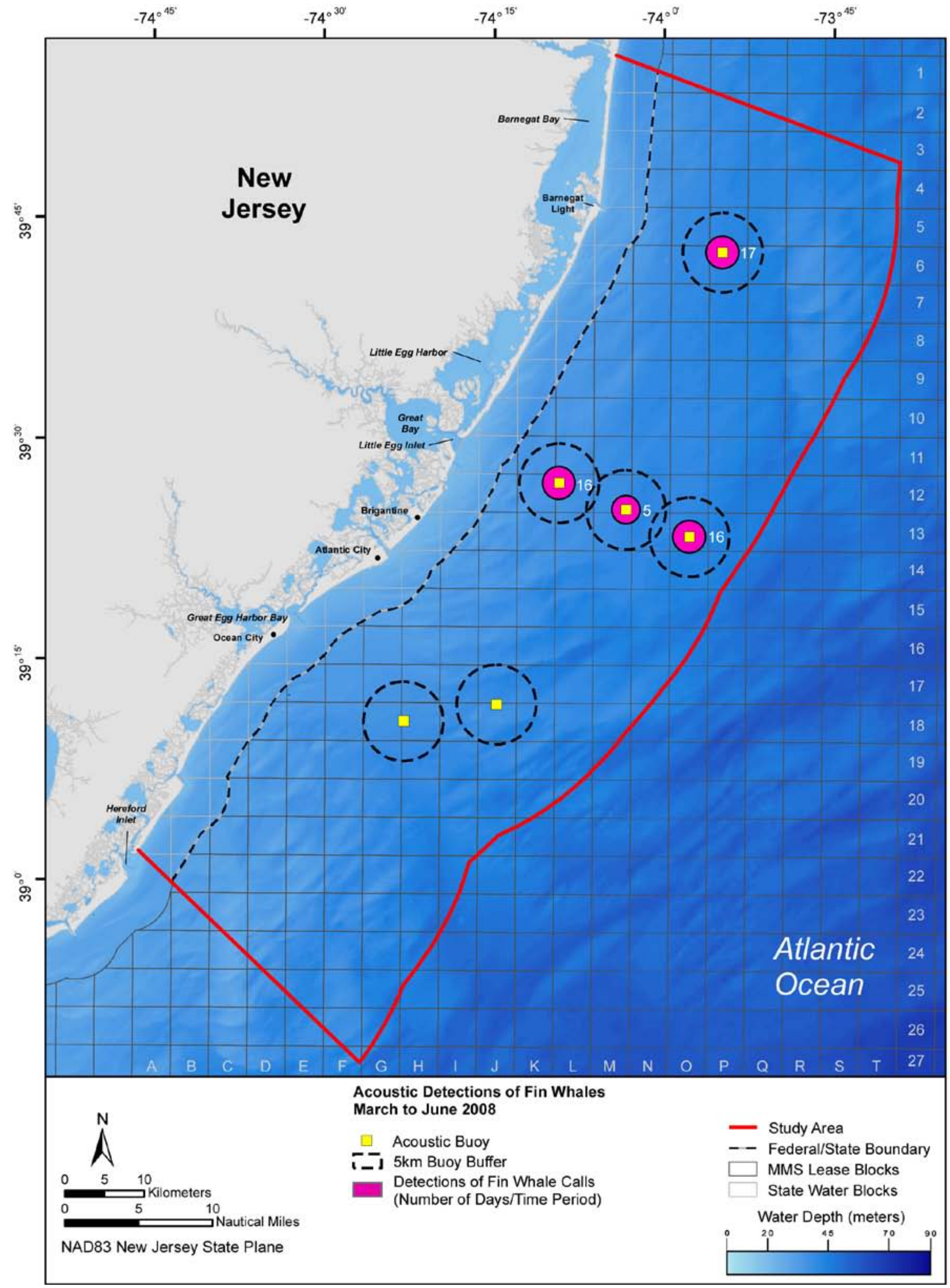

Figure 5-48. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the first deployment from March to June 2008. The thickness of the detection ring around the different buoys gives a relative indication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

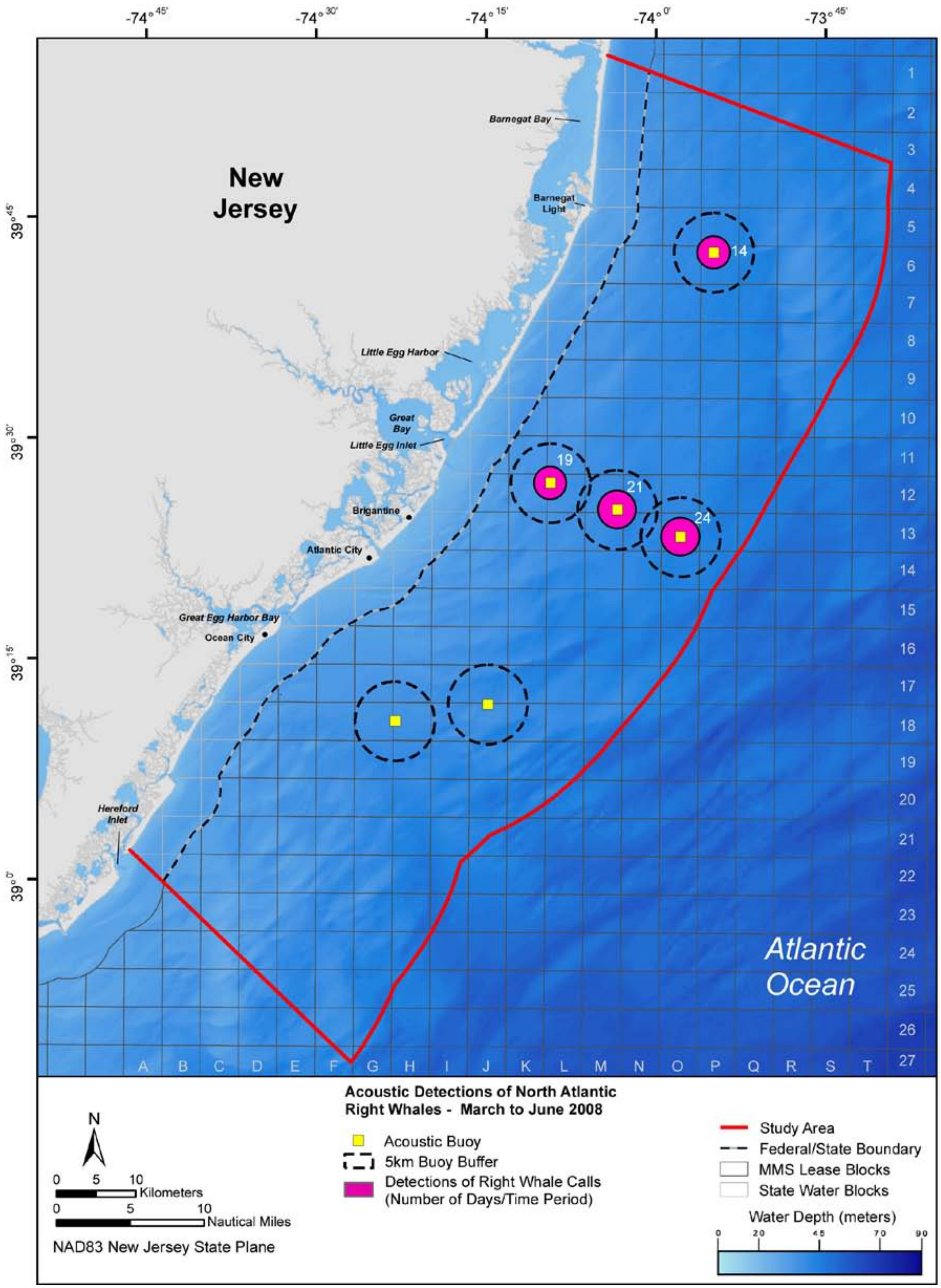

Figure 5-49. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the first deployment from March to June 2008. The thickness of the detection ring around the different 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.

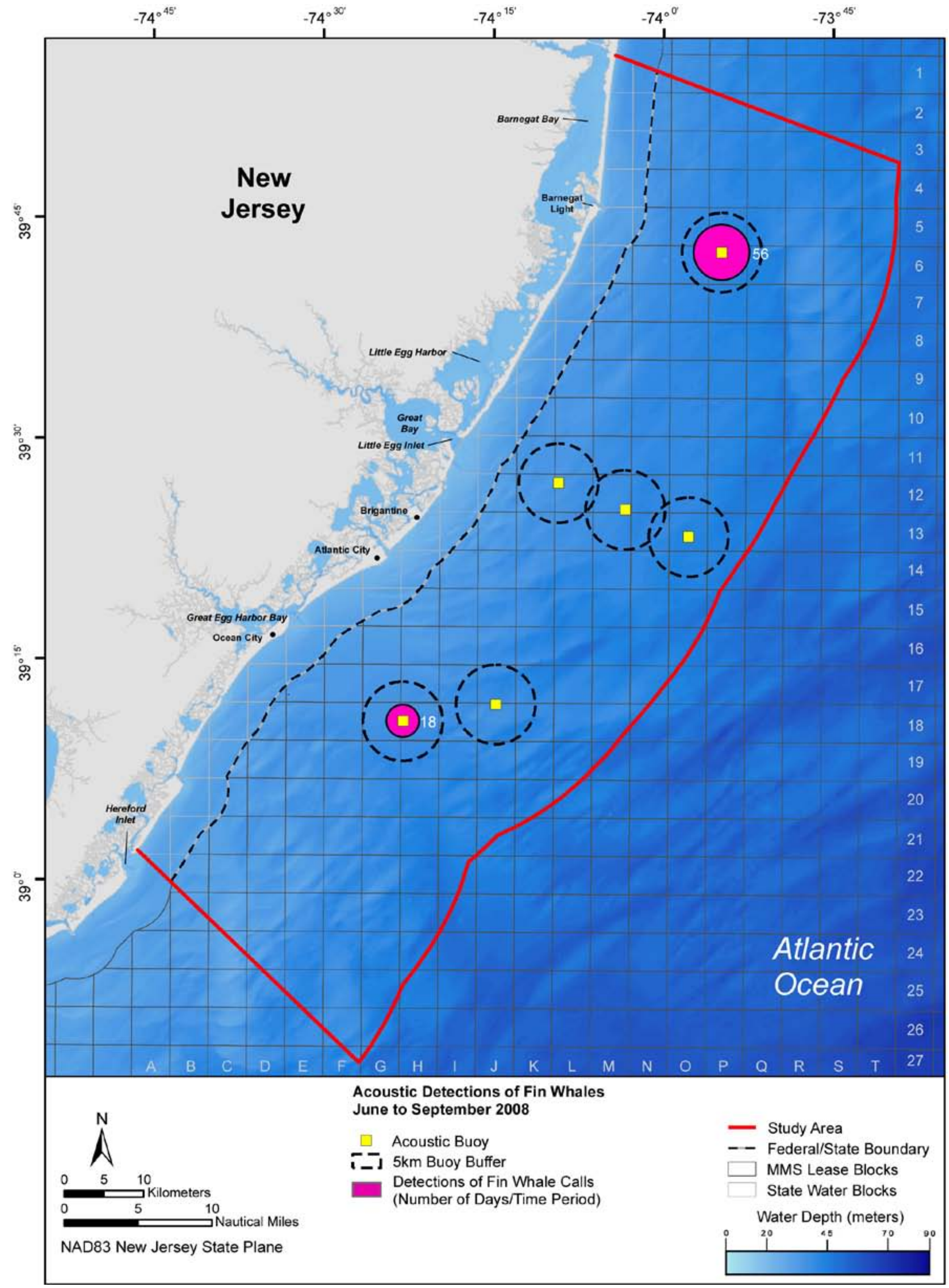

Figure 5-50. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the second deployment from June to September 2008. The thickness of the detection ring around the different buoys gives a relative indication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

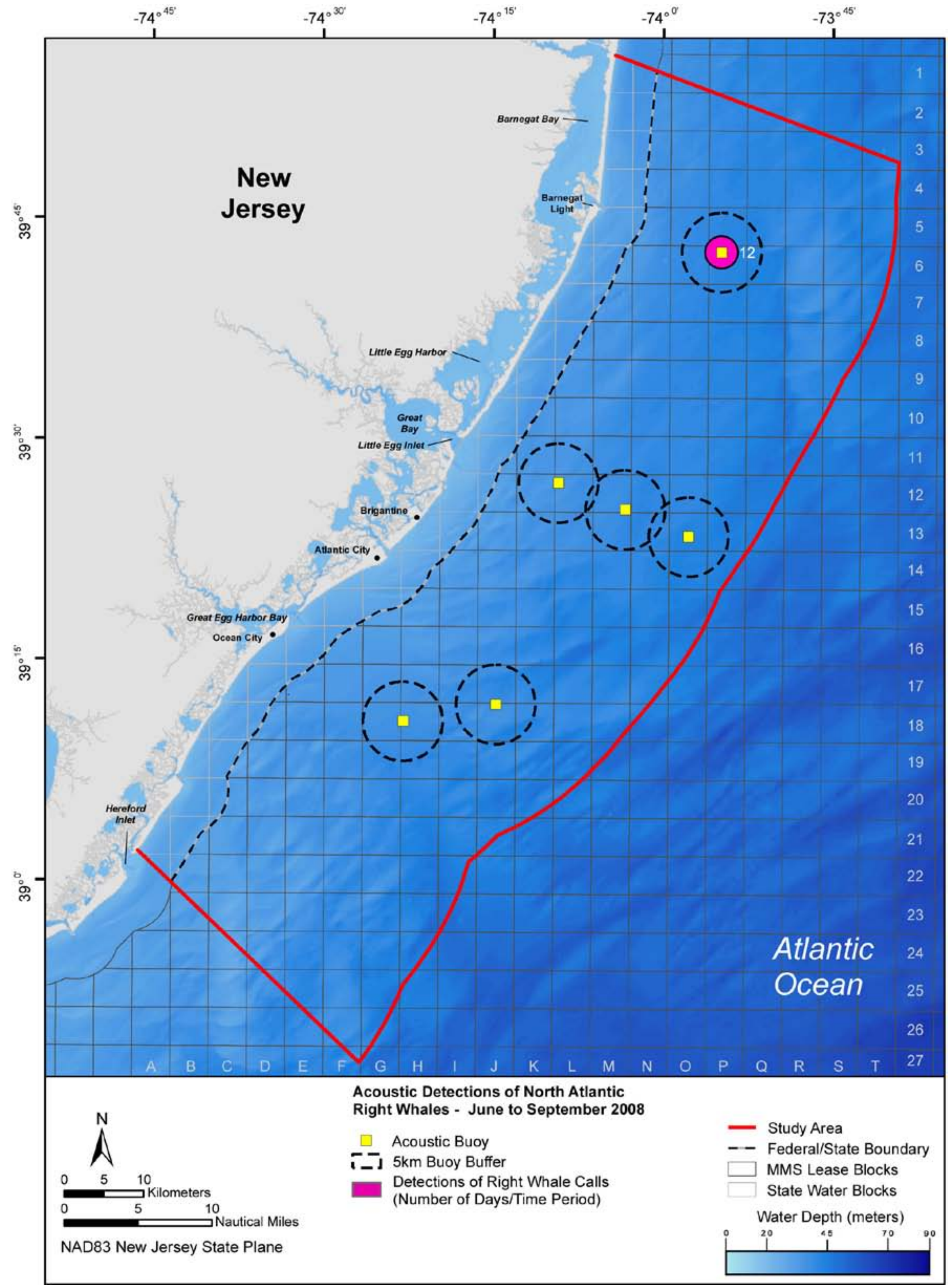

Figure 5-51. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the second deployment from June to September 2008. The thickness of the detection ring around the different 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.

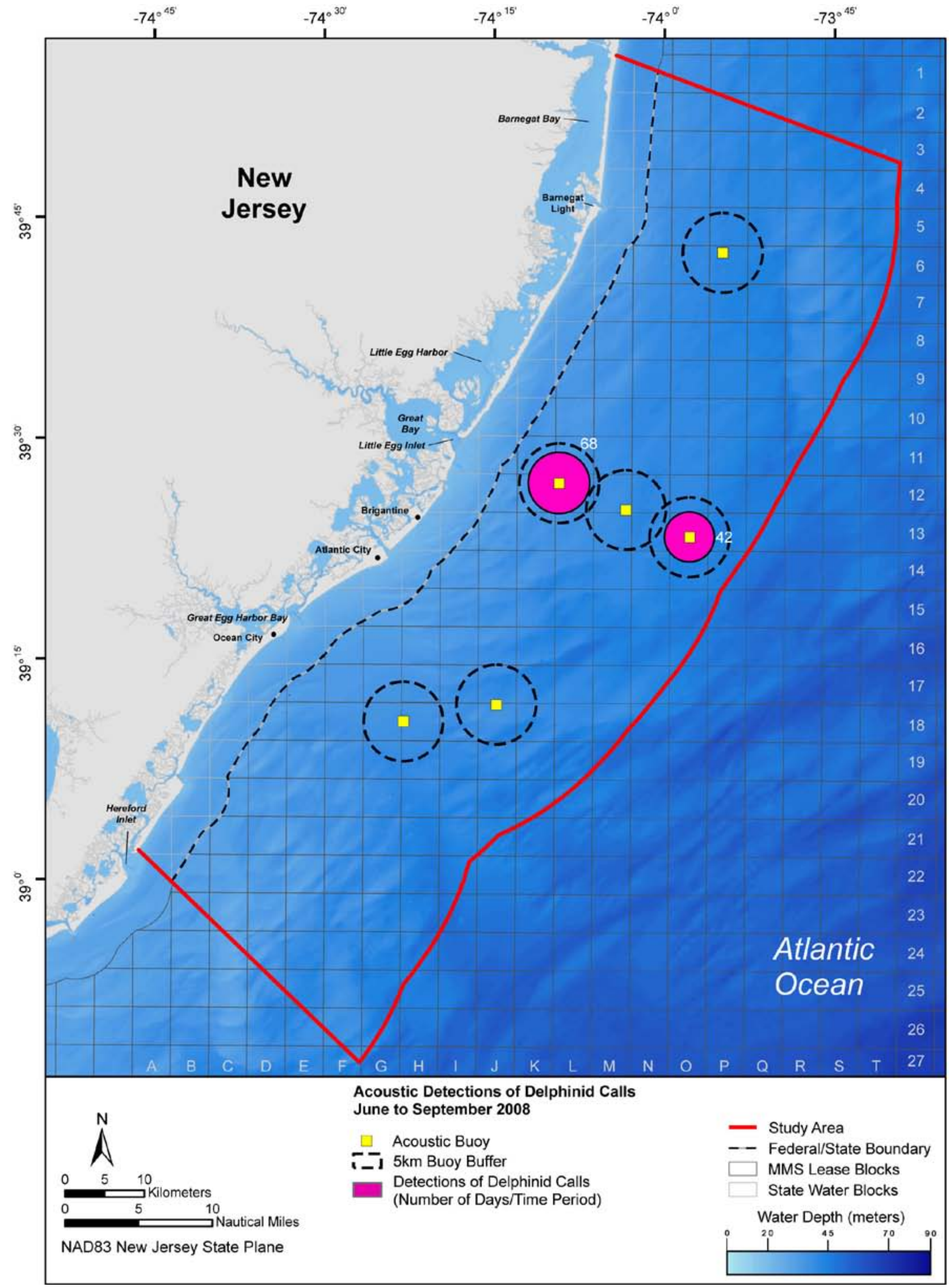

Figure 5-52. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the second deployment from June to September 2008. The thickness of the detection ring around the different buoys gives a relative indication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

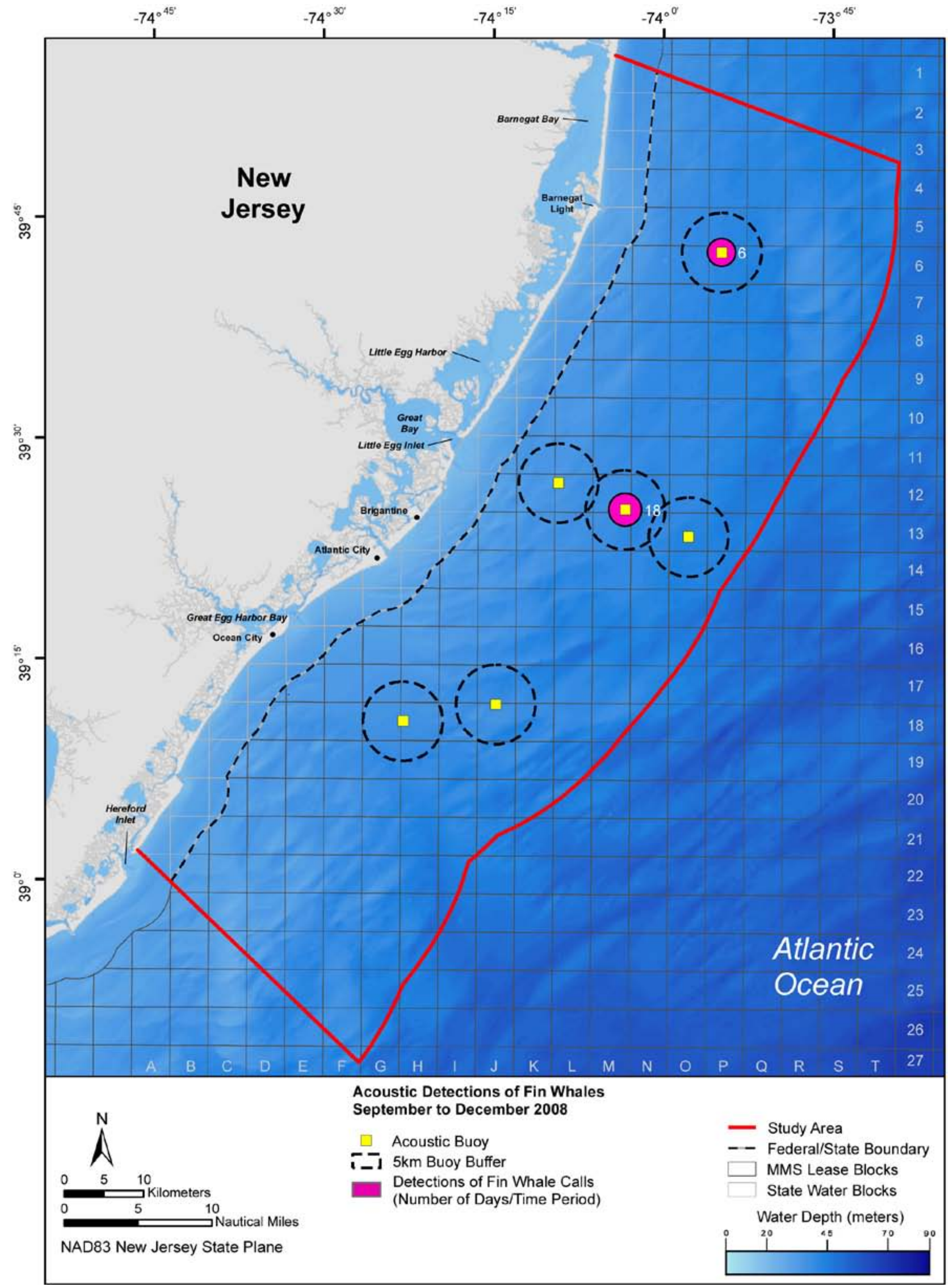

Figure 5-53. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the third deployment from September to December 2008. The thickness of the detection ring around the different buoys gives a relative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

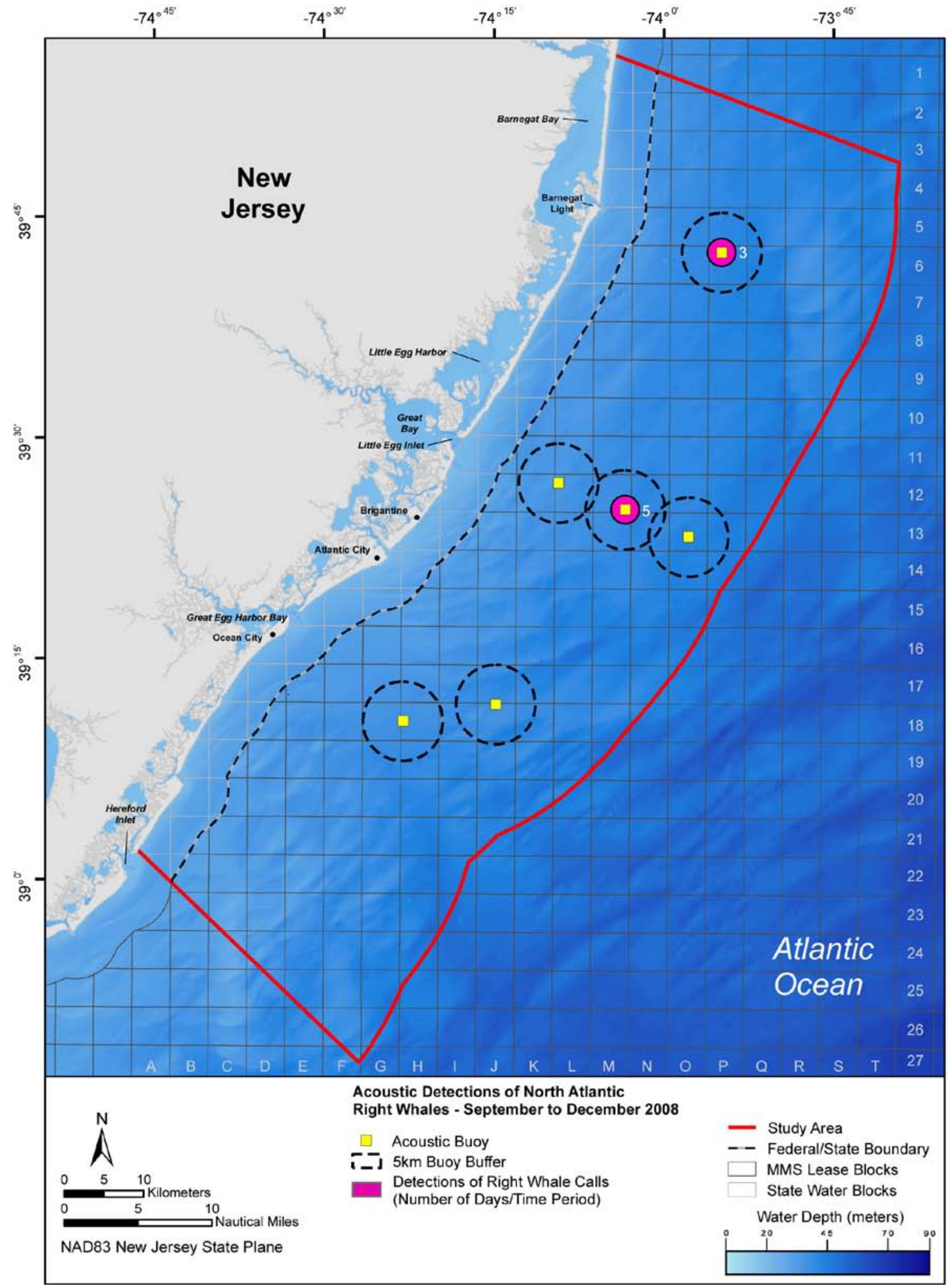

Figure 5-54. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the third deployment from September to December 2008. The thickness of the detection ring around the 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.

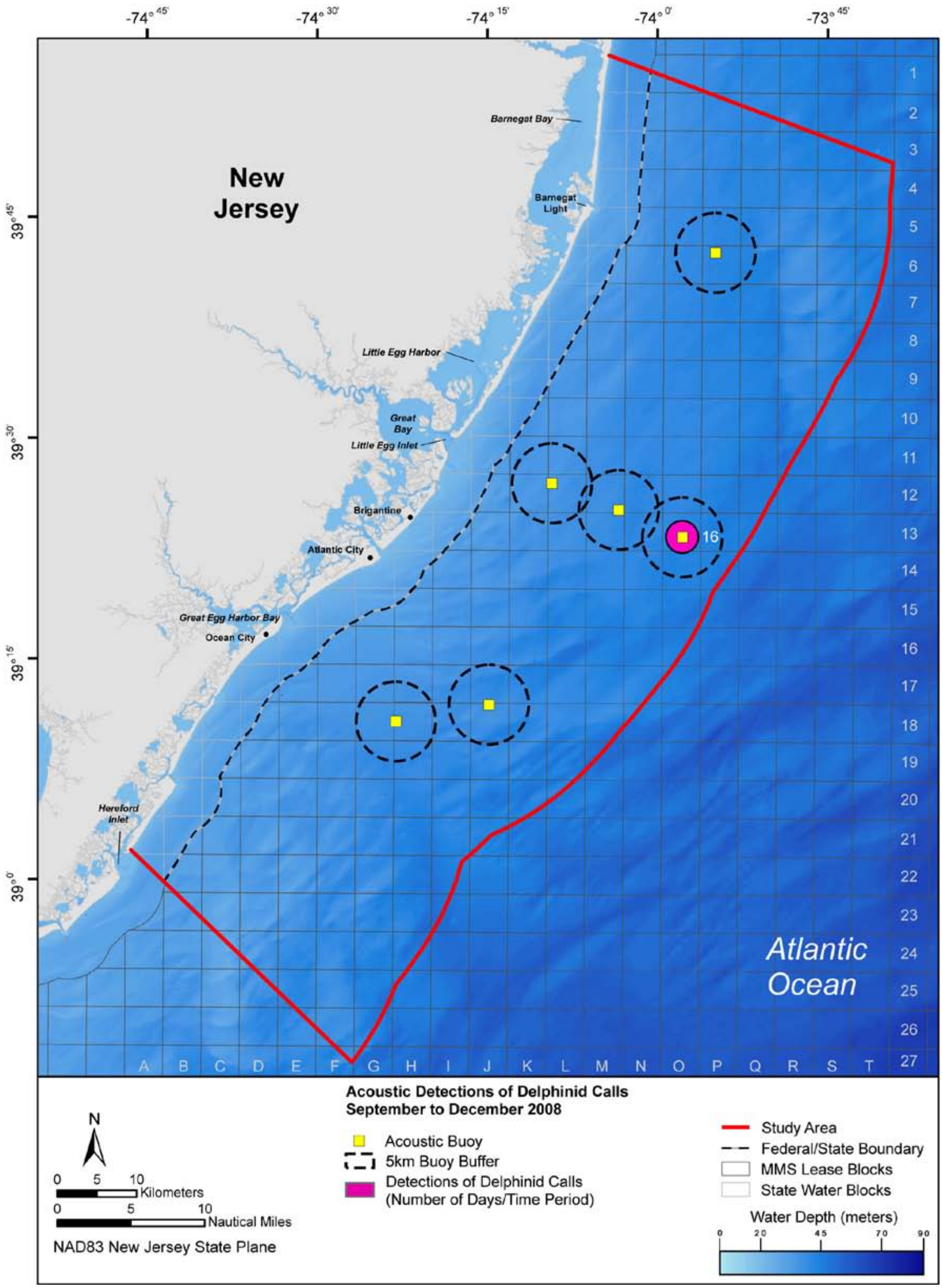

Figure 5-55. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the third deployment from September to December 2008. The thickness of the detection ring around the different buoys gives a relative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

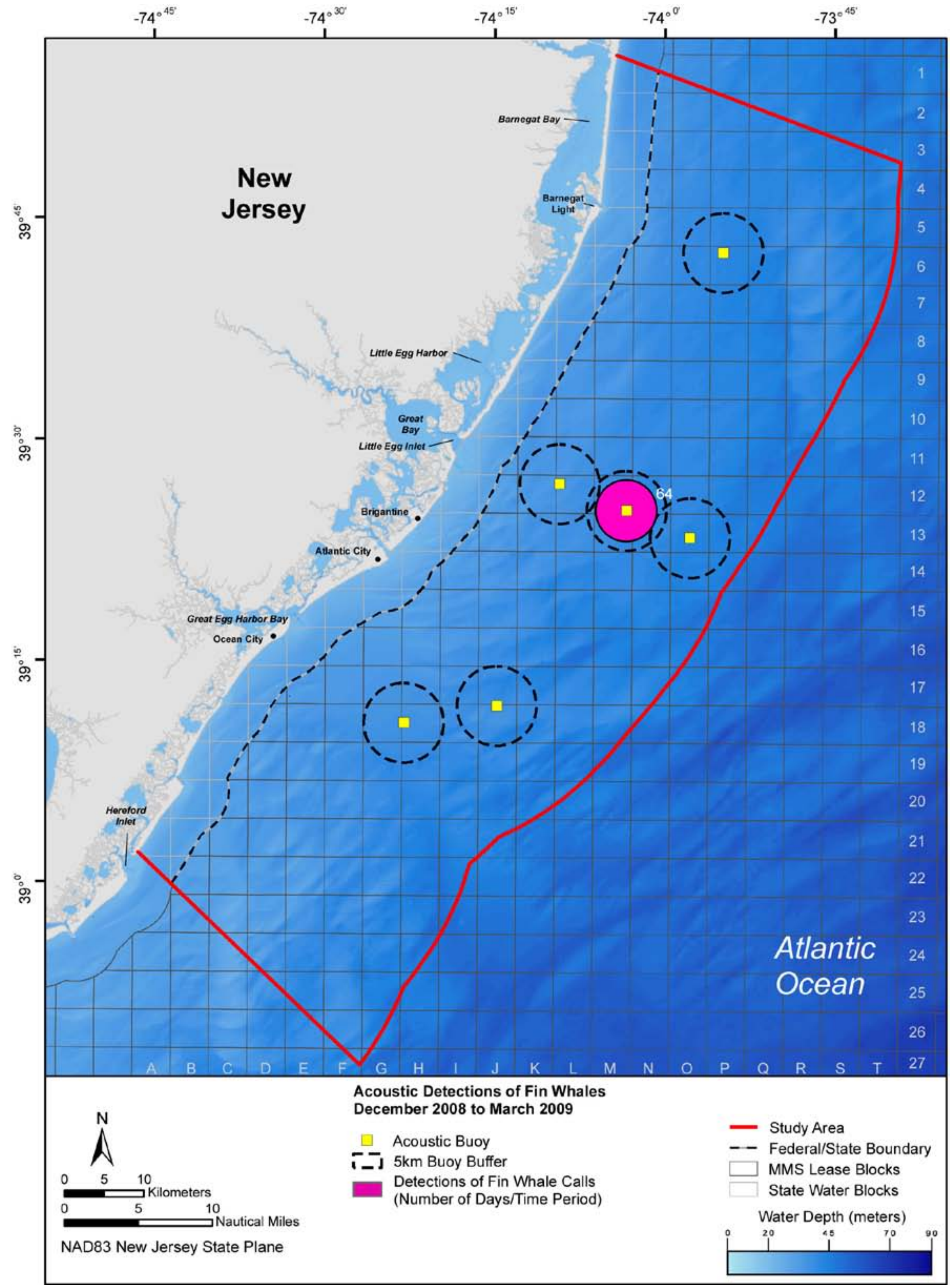

Figure 5-56. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the fourth deployment from December 2008 to March 2009. The thickness of the detection ring around the different buoys gives a relative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

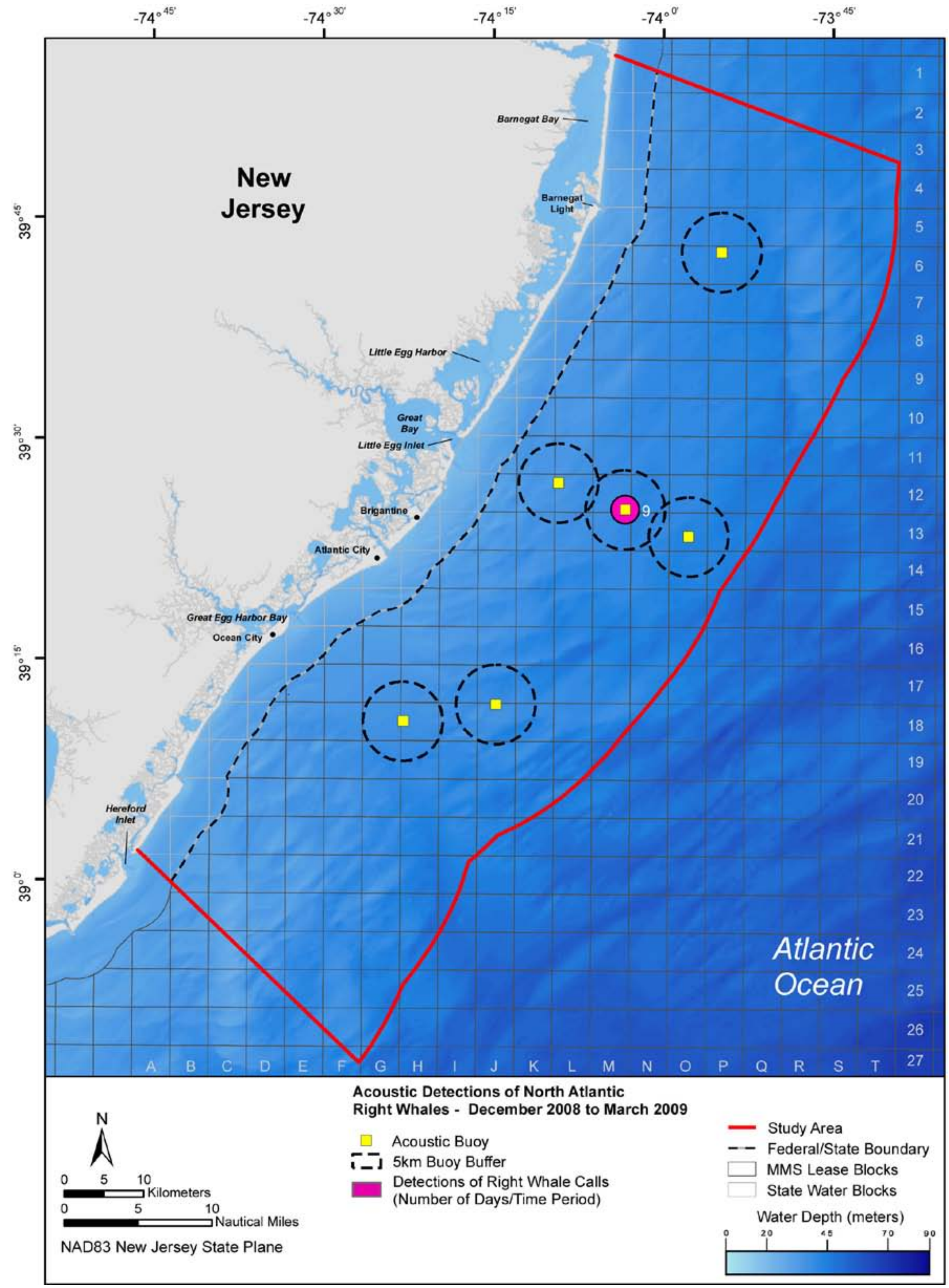

Figure 5-57. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the fourth deployment from December 2008 to March 2009. The thickness of the detection ring around the 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.

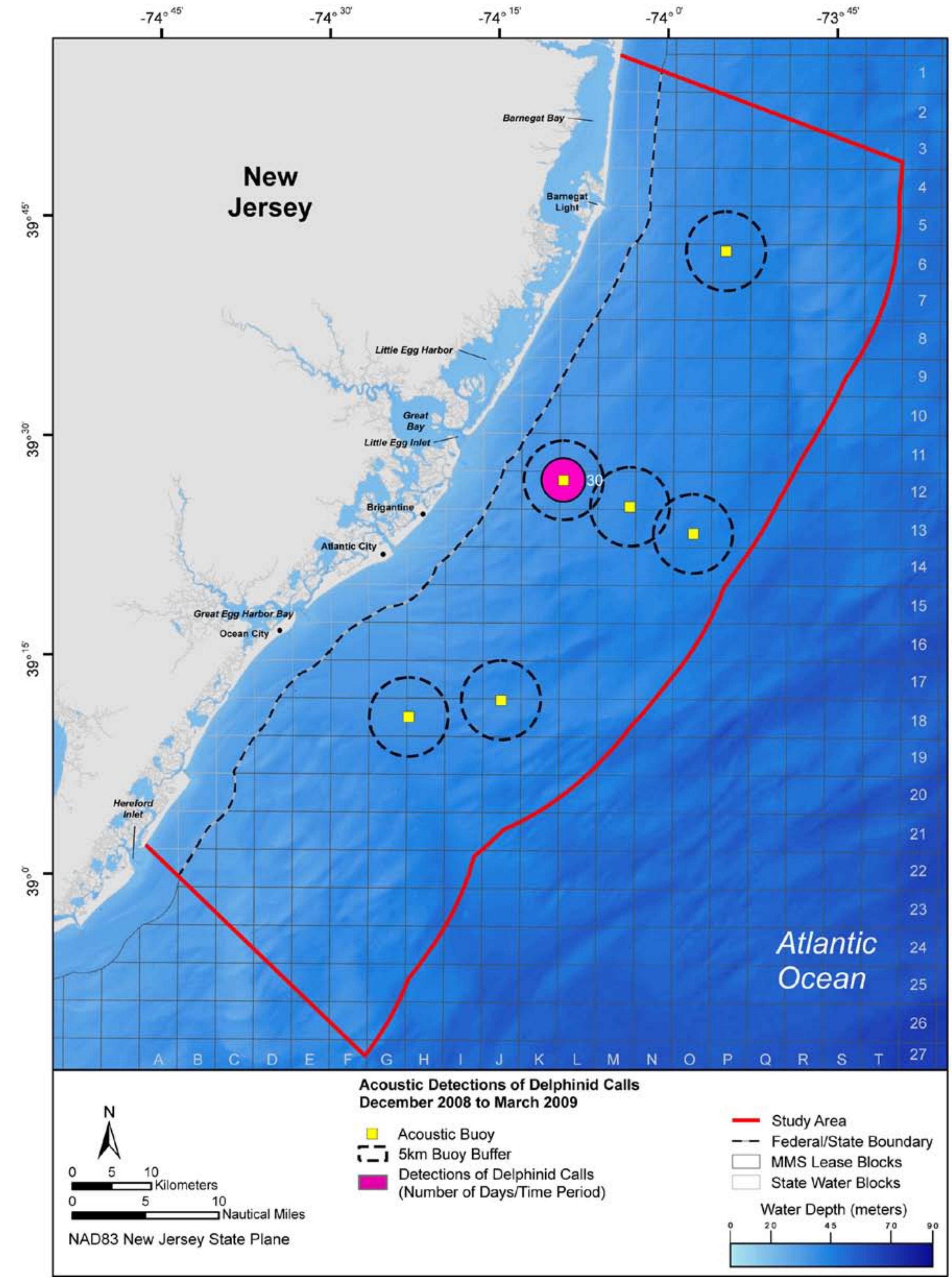

Figure 5-58. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the fourth deployment from December 2008 to March 2009. The thickness of the detection ring around the different buoys gives a relative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

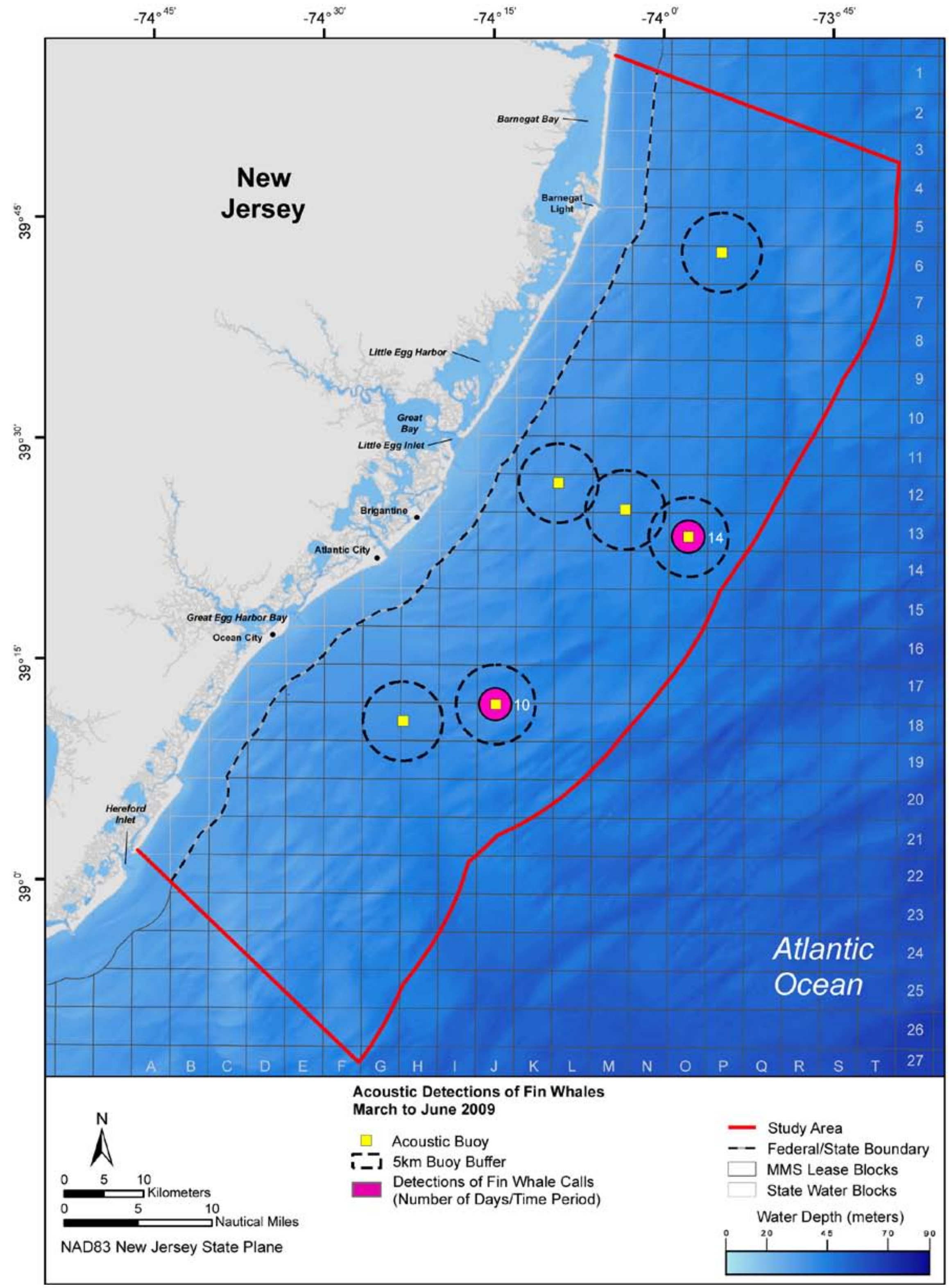

Figure 5-59. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the fifth deployment from March to June 2009. The thickness of the detection ring around the different buoys gives a relative indication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

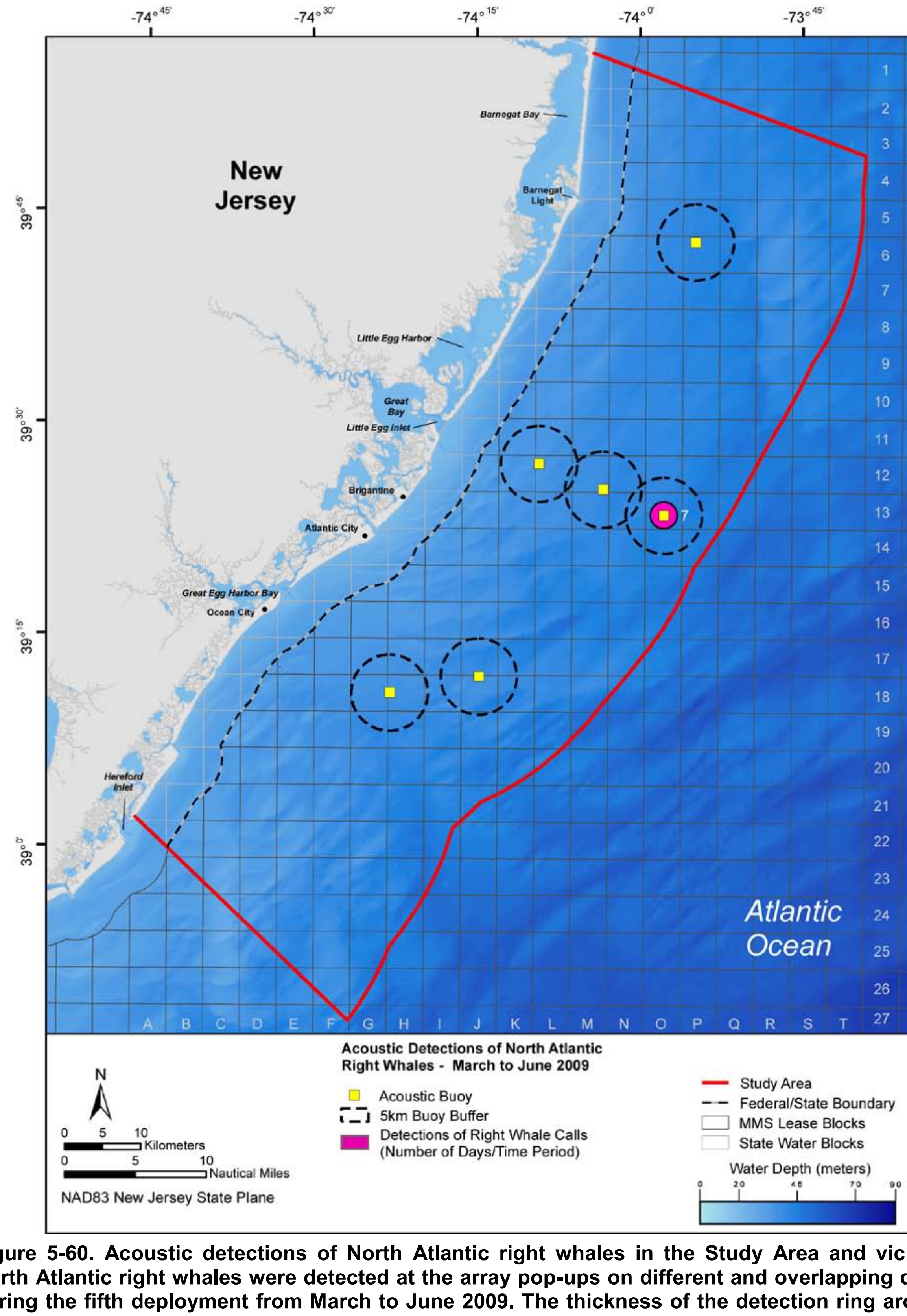

Figure 5-60. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the fifth deployment from March to June 2009. The thickness of the detection ring around the different 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.

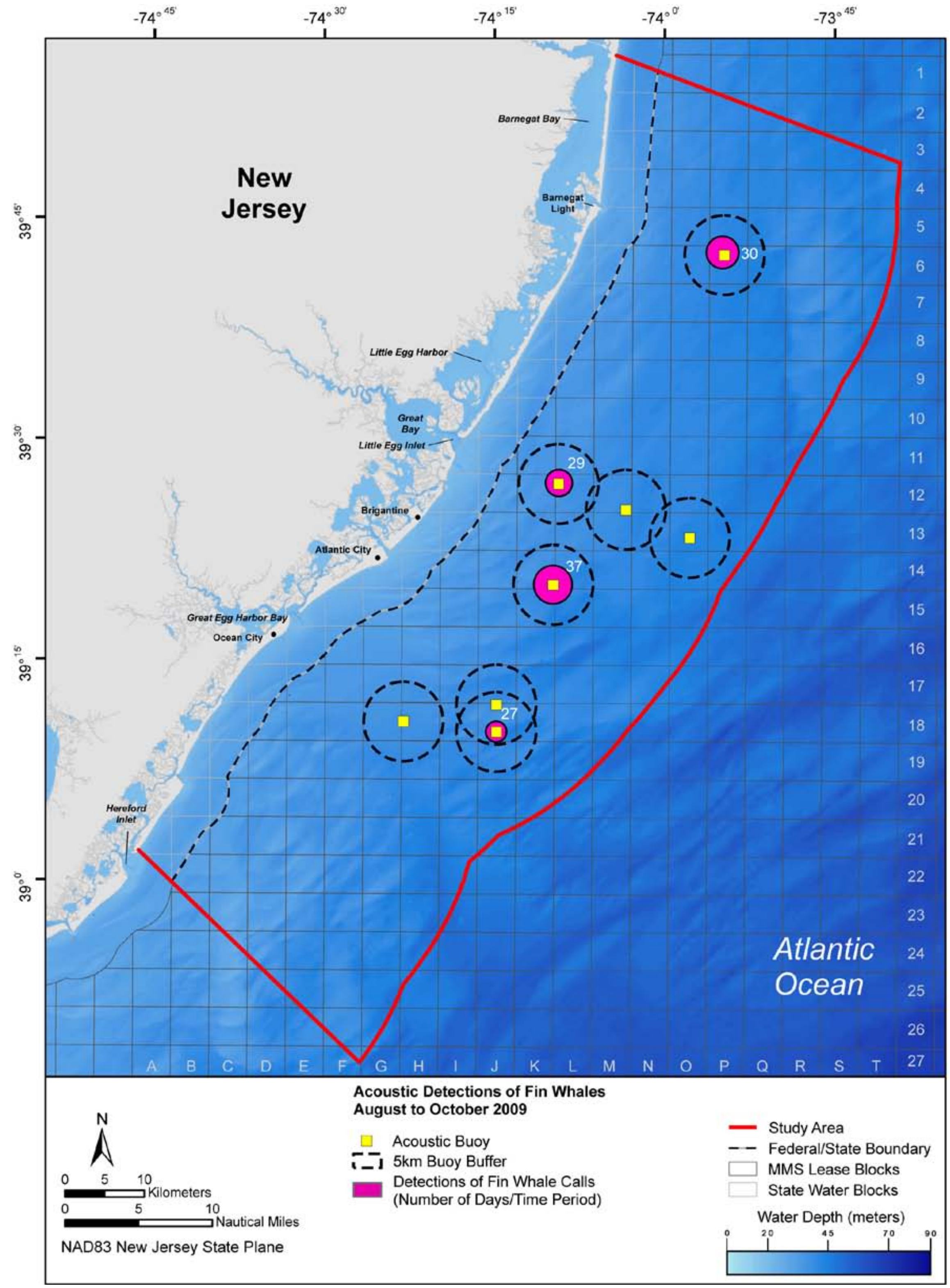

Figure 5-61. Acoustic detections of fin whales in the Study Area and vicinity. Fin whales were detected at the array pop-ups on different and overlapping dates during the sixth deployment from August to October 2009. The thickness of the detection ring around the different buoys gives a relative indication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

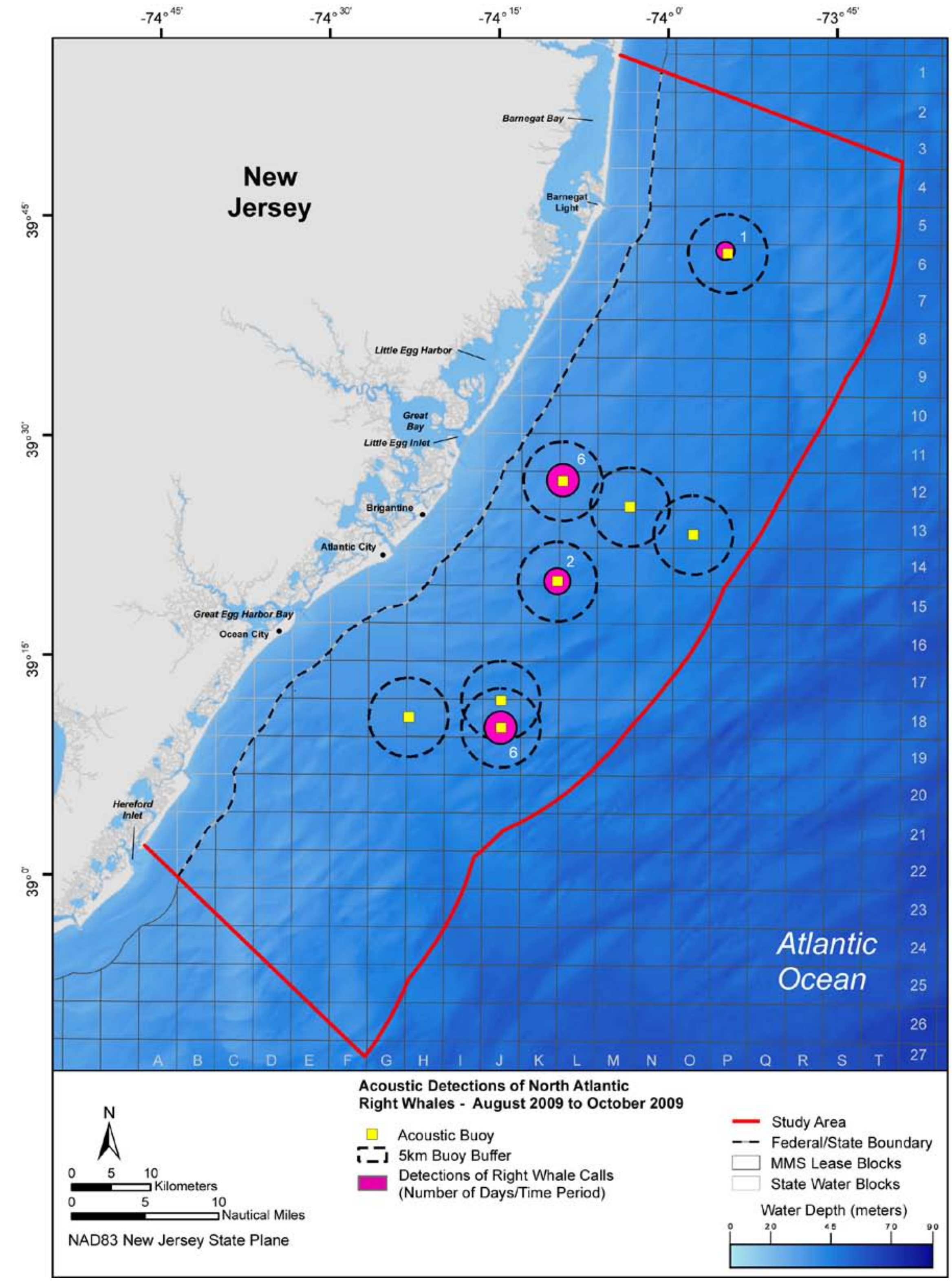

Figure 5-62. Acoustic detections of North Atlantic right whales in the Study Area and vicinity. North Atlantic right whales were detected at the array pop-ups on different and overlapping dates during the sixth deployment from August to October 2009. The thickness of the detection ring around the different 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.

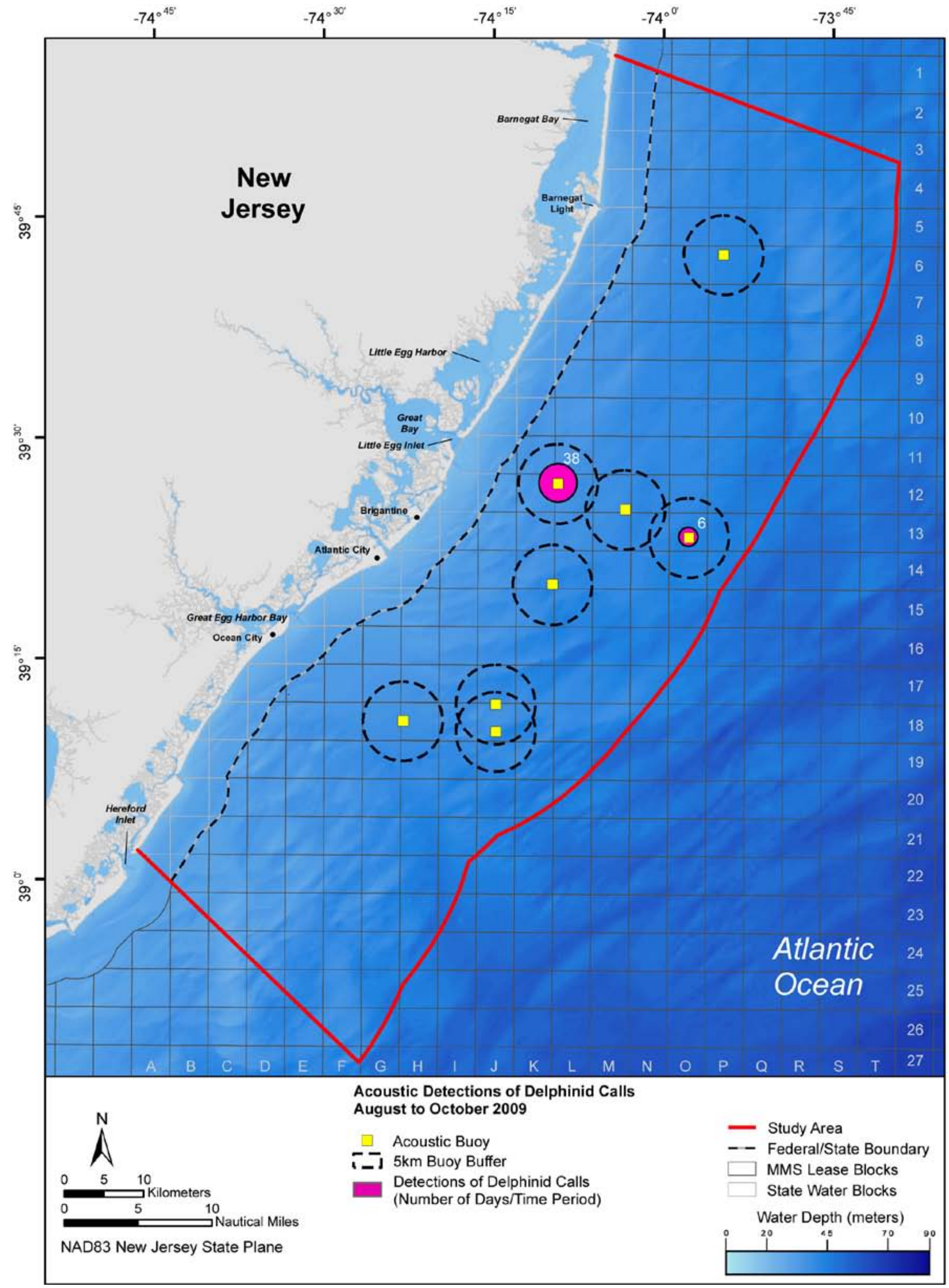

Figure 5-63. Acoustic detections of delphinids in the Study Area and vicinity. Delphinids were detected at the array pop-ups on different and overlapping dates during the sixth deployment from August to October 2009. The thickness of the detection ring around the different buoys gives a relative indication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

6.0 SUMMARY OF RESULTS

Ten of the 47 possible species to occur in the Study Area were detected visually and/or acoustically during the baseline study period. Detected species include the following five federally threatened or endangered species: North Atlantic right whale, fin whale, humpback whale, leatherback turtle, and loggerhead turtle. The minke whale, bottlenose dolphin, short-beaked common dolphin, harbor porpoise, and harbor seal were also detected.

Some clear seasonal patterns in distribution were evident from our study. Although all of the 10 species detected during this study could occur in the Study Area at any time, only the North Atlantic right whale, fin whale, humpback whale, and bottlenose dolphin were detected during all seasons. The occurrence of dolphins and porpoises, as well as turtles, is largely seasonal. Bottlenose dolphins, loggerheads, and leatherbacks mostly occur in the Study Area in the summer, while short-beaked common dolphins and harbor porpoises are common in the Study Area during the winter and spring. The fall season appears to be a transitional period for seasonal cetacean species. Few sightings of bottlenose dolphins and short-beaked common dolphins were recorded during the fall despite the large amount of survey effort. It is likely that most bottlenose dolphins move south of the Study Area, and most short-beaked common dolphins and harbor porpoises are farther north during this time of year.

Of particular ecologic importance are the sightings/acoustic detections of endangered large whale species, the North Atlantic right whale, fin whale, and humpback whale. Each of these species was detected during all seasons, including those seasons during which North Atlantic right and humpback whales are known to occupy feeding grounds north of the Study Area or breeding/calving grounds farther south of the Study Area. Cow-calf pairs of each of these species were also observed in the Study Area. Two North Atlantic right whales exhibited possible feeding behavior, and one humpback whale was observed lunge feeding off the coast of Atlantic City. Based on these occurrences and behavioral observations, the nearshore waters off New Jersey may provide important feeding and nursery habitat for these endangered species. Peak densities were predicted throughout the Study Area for these species and, although the overall abundance estimates of the whale species were relatively low, the Study Area is only a very small portion of the known ranges of these species. These species may use the waters of the Study Area for short periods of time as they migrate or follow prey movements or they may remain in the Study Area for extended periods of time. High concentrations of these species were not documented in the Study Area at any time during the study period; however, the presence of these endangered large whale species in New Jersey waters indicates that these animals are utilizing the area as habitat. The detections of these species in the Study Area, particularly during times of the year when they are thought to be in other areas, demonstrate the potential importance of the Study Area. The occurrence of these endangered species provides critical information on the distribution of the species in this region.

The density and abundance of the dolphin and porpoise species were relatively high for the Study Area. The highest abundances of marine mammals in the Study Area were estimated for the bottlenose dolphin during spring and summer. These bottlenose dolphins are thought to belong to the coastal northern migratory stock which occupies a small range between Long Island, New York and southern North Carolina. The high abundances of bottlenose dolphins in the Study Area coincide with the known movement of this stock into the northern portion of their range. High abundances of short-beaked common dolphins in the Study Area coincided with their known movement patterns south of 40ºN in the winter/spring. High abundances of harbor porpoises also occurred during the winter when the New Jersey waters and the waters of the New York Bight provide an important habitat for this species.

More information on the results of this baseline study is summarized below for each species.

6.1 ENDANGERED MARINE MAMMALS

6.1.1 North Atlantic Right Whale

There is little information on the geographic and temporal extent of the North Atlantic right whale's migratory corridor (Winn et al. 1986); however, our sightings data of females in the Study Area and subsequent confirmations of these same individuals in the breeding/calving grounds a month or less later indicate that the nearshore waters of New Jersey are part of the migratory corridor between feeding grounds in the northeast and breeding/calving grounds in the southeast. The cow-calf pair sighted in the Study Area in May 2008 was previously confirmed in the southeast in January and February and subsequently sighted in the Bay of Fundy in August. Our observations and acoustic detections are consistent with the known migration time periods. Between mid-January and mid-March 2009, North Atlantic right whale calls were detected on the pop-up located 21.4 km (11.6 NM) from shore. All North Atlantic right whale sightings in the Study Area were recorded within 32 km (17 NM) from shore, and high densities of endangered marine mammals were predicted throughout the Study Area between 2 and 37 km (1 and 20 NM) from shore. These distances from shore are consistent with a review of previous sightings data collected in the mid-Atlantic that found that 94% of all sightings of North Atlantic right whales were within 56 km (30 NM) from shore (Knowlton et al. 2002).

The seasonal movement patterns of North Atlantic right whales are well-defined along the U.S. Atlantic coast; however, not all individuals adhere to these patterns and the seasonal distribution of these individuals is unknown. For example, a majority of the population is not accounted for on the breeding/calving grounds during winter, and not all reproductively-active females return to these grounds each year (Kraus et al. 1986). Some individuals, as well as cow-calf pairs, can be seen throughout the fall and winter on the northern feeding grounds with feeding observed (e.g., Sardi et al. 2005), and about half of the population may reside in the Gulf of Maine between November and January based on recent aerial survey data (Cole et al. 2009). Right whale sightings and acoustic detections in the Study Area provide additional evidence of occurrence outside of the typical seasonal migration periods. Although actual feeding could not be confirmed during our study, the January 2009 sighting of two adult males exhibiting skim feeding behavior off Barnegat Light suggests that feeding may occur outside the typical feeding period of spring through early fall and in areas farther south than the main feeding grounds (Winn et al. 1986; Gaskin 1987; Hamilton and Mayo 1990; Gaskin 1991; Kenney et al. 1995). Acoustic detections of North Atlantic right whale calls confirm the occurrence of this species in the Study Area during all seasons with a peak number of detection days in March through June. The documented detections and sightings of North Atlantic right whales in the Study Area suggest that some individuals occur in the nearshore waters off New Jersey either transiently or regularly.

Due to the low number of sightings recorded during the study period, no estimates of abundance could be generated for this species. The pooled year-round abundance of endangered marine mammals, including North Atlantic right whales, in the Study Area was three individuals which should be considered an underestimate due to perception bias and availability bias for large whales which can make long dives. However, based on the migratory nature of this species, a low abundance of this species could be expected for the Study Area, particularly if the North Atlantic right whales mainly use the nearshore waters of New Jersey as a migratory corridor and are not spending a significant amount of time in the region. This estimate is also reasonable due to the low overall abundance (438 individuals) of this stock of North Atlantic right whales (NARWC 2009). Based on the endangered status and low overall abundance of this species, the detection of even one right whale in the Study Area is an important occurrence. We recommend the inclusion of nearshore waters off New Jersey in future North Atlantic right whale studies to better understand the importance of these waters to this species, particularly during the winter months when migrating individuals and possible feeding were documented in the Study Area.

6.1.2 Humpback Whale

Humpback whales were recorded in the Study Area during all seasons. Seven of the 17 sightings were recorded during the winter when many individuals are known to occur on breeding/calving grounds in the West Indies (Whitehead and Moore 1982; Smith et al. 1999; Stevick et al. 2003b). Our winter sightings are consistent with other observations of this species in mid- and high latitudes during this time of year (Clapham et al. 1993; Swingle et al. 1993; Charif et al. 2001). Humpback whales could not be acoustically detected during our study period because of the lack of call detection software for this species which has highly variable vocalizations.

Humpback whale feeding grounds are typically over shallow banks or ledges with high sea-floor relief (Payne et al. 1990; Hamazaki 2002). The main feeding locations off the northeastern U.S. are north of the Study Area in waters off Massachusetts, in the Gulf of Maine, in the Bay of Fundy and surrounding areas (CETAP 1982; Whitehead 1982; Kenney and Winn 1986; Weinrich et al. 1997). There are documented feeding areas for this species south of the Study Area near the mouth of Chesapeake Bay, as well (Clapham et al. 1993; Swingle et al. 1993; Wiley et al. 1995; Laerm et al. 1997; Barco et al. 2002). The lunge feeding behavior observed by one individual humpback whale in September indicates that New Jersey nearshore waters may also be an alternate feeding area for this species. This humpback whale was lunge feeding in the vicinity of an individual fin whale; multi-species feeding aggregations that include humpback whales have also been observed over the shelf break on the southern edge of Georges Bank (CETAP 1982; Kenney and Winn 1987) and in shelf break waters off the U.S. mid-Atlantic coast (Smith et al. 1996).

An abundance estimate for the humpback whale in the Study Area was generated using the pooled detection function for the endangered marine mammals group. The year-round abundance of this species was estimated at one individual; however, this should be considered an underestimate due to perception and availability bias (i.e., diving). The humpback whales occurring in the Study Area are most likely part of the Gulf of Maine stock. In fact, one individual photographed in the Study Area in August 2009 was previously sighted in the Gulf of Maine the year before. Due to the migratory nature of the humpback whale, the relative low estimated abundance in the Study Area is not unexpected.

6.1.3 Fin Whale

The fin whale was the most commonly-detected baleen whale species in the Study Area during the study period. This is the most commonly sighted large whale in shelf waters of the U.S. north of the mid-Atlantic region (CETAP 1982; Hain et al. 1992; Hamazaki 2002). Fin whales were visually detected in the Study Area during all seasons which is consistent with previous sightings of fin whales year-round in the mid-Atlantic region (CETAP 1982; Hain et al. 1992). Fin whale pulses and downsweeps were detected in every month of acoustic monitoring during this baseline study. Fin whales are believed to follow the typical baleen whale migratory pattern consisting of movement between northern summer feeding grounds and southern winter breeding/calving grounds (Clark 1995; Aguilar 2009); however, not all individuals in the western North Atlantic stock undergo this seasonal migration (Aguilar 2009). Our year-round sightings and acoustic detections further support the occurrence of fin whales in this region outside of the typical migratory periods.

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 (Hamazaki 2002). Relatively high densities of fin whales were predicted throughout most of the Study Area including in waters as shallow as 12 m (39 ft) and very close to shore (2 km [1 NM]). The year-round estimated abundance (two individuals) is low for the Study Area; however, abundance should be considered an underestimate due to perception and availability bias in large whales (i.e., whales making long dives are not available for detection at the surface). The occurrence of fin whales in the Study Area is important due to the endangered status of this species. In addition, the occurrence of a fin whale calf with an adult in August 2008 suggests that nearshore waters off New Jersey may provide important habitat for fin whale calves.

6.2 NON-THREATENED OR ENDANGERED MARINE MAMMALS

6.2.1 Minke Whale

Minke whales are most likely to occur in the mid-Atlantic region during winter, but this species is widespread in U.S. waters. Sightings of this species in the Study Area during winter are consistent with the known movement of minke whales southward from New England waters from November through March (Mitchell 1991; Mellinger et al. 2000). Occurrence of minke whales in New England waters increases during the spring and summer and peaks from July through September (Murphy 1995; Risch et al. 2009; Waring et al. 2009). The June sightings recorded during our study period may have been of individuals moving back to New England waters for the summer. Because only four sightings of minke whales were recorded during the study period, no abundance estimates could be generated for this species.

6.2.2 Bottlenose Dolphin

The bottlenose dolphin was the most frequently-sighted species in the Study Area. Although this species was sighted during all seasons, bottlenose dolphin distribution was highly seasonal with most sightings occurring during the spring and summer months, particularly May through August. These sightings data are consistent with the known seasonal distribution patterns of the coastal northern migratory stock of bottlenose dolphins which occur in waters from New York to North Carolina in the summer and are found from southern Virginia to Cape Lookout, North Carolina in the winter (CETAP 1982; Kenney 1990; Garrison et al. 2003; Hohn and Hansen 2009; Waring et al. 2009; Toth et al. in press). Based on our sightings data, bottlenose dolphins move into the Study Area as early as the beginning of March and occur there until at least mid-October. The delphinid whistles detected between March and October are most likely of bottlenose dolphins. The estimated abundances of bottlenose dolphins in the Study Area during the spring (mostly June; 722) and summer (289 ship analysis, 1,297 aerial analysis) are comparable to the estimated abundance of the coastal northern migratory stock (7,789) (Waring et al. 2009). A peak number of days (69) with delphinids whistle detections were also recorded during spring and summer. Only seven sightings were recorded during the fall/winter; therefore, abundance is likely much lower during this time of year when most of the coastal northern migratory stock is farther south off the coasts of Virginia and North Carolina. The seasonal occurrence of bottlenose dolphins off New Jersey is thought to be due to the presence of preferred prey species that also occur seasonally in New Jersey waters (Able and Fahay 1998; Gannon and Waples 2004).

Bottlenose dolphins are known to have a fine-scale distribution within the Study Area based on research by Toth-Brown et al. (2007) who found 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). One group appeared to utilize waters within 2 km (1.1 NM) of the shore while the other group occupied waters outside of 2 km (1.1 NM) of shore. Due to limitations obtaining high quality photo-identification data during the baseline study, this fine-scale distribution pattern was not evident from our results; however, our results emphasize the importance of New Jersey's nearshore waters to bottlenose dolphins. Sightings were recorded close to shore (minimum 0.3 km [0.16 NM]), and peak densities were predicted in state waters (0 to 5.5 km [0 to 3 NM] from shore) off Atlantic City north to Brigantine and Little Egg Inlet during spring and farther north off Barnegat Light and Barnegat Bay during summer. Toth et al. (in press) identified higher levels of use and increased presence of young individuals in the very nearshore waters off Brigantine, just north of Atlantic City.

Several bottlenose dolphin sightings were also recorded in deeper waters (34 m [112] ft) of the Study Area and farther offshore (maximum 38 km [21 NM] from shore), suggesting that their distribution within the Study Area is not limited to a particular depth range or distance from shore. High densities were predicted in some regions of the Study Area up to 28 km (15 NM) from shore in the spring and 36 km (19 NM) from shore in the summer. Predicted densities were more interspersed throughout the northern/ southern range of the Study Area during summer, indicating that higher densities of bottlenose dolphins extend into the northern portion of the Study Area (north of Barnegat Light) during this time of year. Peak densities were predicted from the shoreline to 36 km (19 NM) offshore of Barnegat Light/Barnegat Bay and along the federal/state boundary (5.5 km [3 NM] from shore).

6.2.3 Short-beaked Common Dolphin

The occurrence of this species in the Study Area was strongly seasonal; sightings were only recorded during fall and winter, specifically late November through mid-March. The short-beaked common dolphin was the only delphinid species sighted during the winter, except for one bottlenose dolphin sighting recorded in early March. Therefore, the delphinid whistles recorded from December through at least February were likely of short-beaked common dolphins. This occurrence pattern is consistent with the known seasonal movements of short-beaked common dolphins offshore of the mid-Atlantic in colder months (Payne et al. 1984; Jefferson et al. 2009; Waring et al. 2009).

Although short-beaked common dolphins primarily occur offshore (>37 km [20 NM]) in waters of 200 to 2,000 m in depth (656 to 6,562 ft; Ulmer 1981; CETAP 1982; Canadian Wildlife Service 2006; Jefferson et al. 2009), our sightings data support the occurrence of this species in shallower waters close to shore. Short-beaked common dolphins were sighted throughout the Study Area in waters 3 to 37 km (2 to 20 NM) from shore and 10 to 31 m (33 to 102 ft) in depth. Almost all of the sightings of delphinids recorded during winter were of short-beaked common dolphins. High densities of delphinids were predicted south of Barnegat Light during the winter. Peak densities were predicted in nearshore waters (0 to 5.5 km [0 to 3 NM] from shore) from Brigantine to Little Egg Inlet and 30 km (16 NM) 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.

A winter abundance estimate was generated for this species using the pooled detection function of all delphinids during this season. The abundance was estimated at 82 individuals. This estimate may be high due to the attraction of delphinids to the ship (e.g., bowriding); however, because perception and availability bias were not accounted for, the abundance estimate should be considered underestimated. Only eight short-beaked common dolphin sightings were recorded during the fall. Although abundance estimates could not be generated for this season, the abundance of this species is expected to be lower during this time of year. No sightings of short-beaked common dolphins were recorded during spring or summer. Although this species has been recorded near the Study Area during these seasons (CETAP 1982; Canadian Wildlife Service 2006), abundance in the Study Area is expected to be very low during this time of year.

6.2.4 Harbor Porpoise

Harbor porpoise distribution in the western North Atlantic is seasonal, and New Jersey waters are a known important habitat for harbor porpoises from January through March (Westgate et al. 1998). The sightings of harbor porpoises recorded during the study period support this statement with over 90% of sightings recorded during winter (mainly February and March). Few sightings were also recorded in April, May, and July which indicates that this species could occur in the Study Area during other times of the year. No harbor porpoise sightings were recorded during the fall surveys; however, weather conditions were often above a BSS 2 which makes sighting this species very difficult. The densest concentrations of harbor porpoises are thought to occur from New Jersey to Maine from October through December (NMFS 2001). Therefore, harbor porpoises are likely to occur in the Study Area throughout the fall. Due to the low number of sightings throughout the year, an abundance estimate for the harbor porpoise could only be generated for the winter. The winter abundance of harbor porpoises in the Study Area was estimated at 98 individuals. Abundance is likely underestimated due to this species' known responsive movement away from ships and perception and availability bias (Barlow 1988; Polacheck and Thorpe 1990; Palka and Hammond 2001).

Harbor porpoises are known to occur most frequently over the continental shelf and are most often found in waters cooler than 17°C (Read 1999). Sightings data from the study period provide support for these habitat associations of the harbor porpoise. Sightings of this species were recorded between 1.5 and 37 km (1 and 20 NM) from shore in waters ranging from 12 to 30 m (39 to 98 ft). SSTs for the harbor porpoise ranged from 4.5 to 18.7°C (40.1 to 65.7°F) which is just slightly higher than the typical maximum SST of 17°C (Read 1999). High densities of harbor porpoises were predicted 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. Peak densities were predicted between 5.5 and 15 km (3 and 8 NM) from shore and also 34 km (18 NM) from shore north of Brigantine.

6.2.5 Harbor Seal

Only one harbor seal was recorded in the Study Area during the study period. This seal was sighted in shallow waters east of Little Egg Inlet in June. Other unidentified pinnipeds recorded near Ocean City in

April were likely also harbor seals but could not be confirmed. Harbor seals regularly haul out near Great Bay inshore of the Study Area and along the northern shore of the New York Bight, including Sandy Hook and 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.). The harbor seal observed in June was likely from one of these haulout regions. No haulout sites were detected along the beach adjacent to the Study Area during the shoreline aerial surveys. Although harbor seals could be found in the Study Area during any time of year, they are known to make seasonal movements in New Jersey waters during the winter (Slocum et al. 1999). Although no sightings of harbor seals were confirmed in the Study Area during winter, one probable harbor seal was sighted south of the Study Area near Lewes, Delaware, where the survey vessel was docked in March 2008.

6.3 SEA TURTLES

6.3.1 Leatherback Turtle

Leatherback turtles have a seasonal occurrence in the mid-Atlantic; they are most common off the mid-Atlantic and southern New England coasts in the spring and summer (CETAP 1982; Shoop and Kenney 1992; Thompson et al. 2001; James et al. 2006b). All 12 sightings of this species were recorded in the Study Area during summer. Sightings were recorded in deeper, offshore waters of the Study Area ranging from 10 to 36 km (5 to 19 NM) from shore and water depths of 18 to 30 m (59 to 98 ft). Leatherbacks foraging in the western North Atlantic are known to associate with waters between 16 to 18°C (60 to 64°F) (Thompson et al. 2001; James et al. 2006b), and SSTs between 10 to 12°C (50 to 54°F) may represent the lower thermal limit of this species (Witt et al. 2007). The sightings recorded during the study period had a mean SST of 19.0°C (66°F) which is only slightly higher than the preferred SST for foraging leatherbacks; the lack of sightings during the colder months is consistent with this species preference for warmer SST. Abundance of leatherback turtles in the Study Area is unknown because abundance estimates could not be generated for this species.

6.3.2 Loggerhead Turtle

Loggerhead turtle occurrence along the U.S. Atlantic coast is strongly seasonal. Although sightings are recorded in mid-Atlantic and northeast waters year-round, loggerheads occur mainly north of Cape Hatteras between May and October (CETAP 1982; Lutcavage and Musick 1985; Shoop and Kenney 1992). Loggerheads sighted during the study period were consistent with this seasonal occurrence pattern; sightings were recorded between June and October. The mean SST associated with these sightings was 18.5°C (65.3°F) which is within the preferred SST range for this species (13 to 28ºC [55 to 82°F]; Mrosovsky 1980). Sightings were recorded throughout the Study Area from 1.5 to 38 km (1 to 21 NM) from shore and in water depths ranging from 9 to 34 m (30 to 112 ft). Due to difficulties in measuring the perpendicular distances of the loggerhead sightings from the aerial survey tracklines, abundance estimates could not be generated for the Study Area.

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APPENDICES

MARINE MAMMAL AND SEA TURTLE STUDIES

APPENDIX A

AERIAL SURVEY REQUIREMENTS AND PROVISIONS

Geo-Marine Inc.
Minimum Aircraft and Crew Provisions
for Aerial Surveys

The following applies to aviation services contracted (vendor) by Geo-Marine, Inc (GMI) that includes aircraft and pilot services chartered, contracted or rented. The list includes minimum requirements for all survey flights. Additional requirements may be included that apply to offshore surveys defined as aircraft operations conducted over water and beyond glide distance from shore.

Certification

Preferred certification for planned or routine aerial surveys is as follows:
The vendor shall hold a current Federal Aviation Administration (FAA) Air Carrier or Operating Certificate. Operations Specifications shall authorize operation of the category and class of aircraft and conditions for flights required to complete missions as specified by GMI.

Aircraft and operators must complete a comprehensive safety audit to demonstrate that their operation, aircraft, and pilots meet at least certification requirements under 14 CFR Part 119 and GMI requirements contained in this document. Minimum requirements for offshore flights are listed below:

Offshore Flights

Aircraft and Aircraft Operators must meet any one of the following certification criteria in order of preference:

1. Aircraft will be operated and maintained under provisions of 14 CFR Part 135. Specific aircraft used shall be carried on the list required by 14 CFR 135.63.

or

2. Approval/certification of the vendor/operator by a federal agency, such as NASA, Department of Energy Operations or National Business Center Aviation Management Directorate (NBC-AMD). Aircraft operators which are not part 135 certificate holders but have been approved by a federal agency such as those listed above shall be conducted in accordance with the operation requirements of their approvals and limitations of the aircraft airworthiness certificate.

or

3. The operator can complete a comprehensive safety audit to demonstrate that their operation, aircraft and pilots, meet or exceed Part 135 standards as well as the GMI requirements contained in this document. These audit services are available from private sector aviation consulting firms and the cost of the audit is the burden of the applicant. Operators shall provide a copy of the safety audit to GMI and this audit will be subject to review and approval by GMI.

Flight Plans
Pilots shall file and operate on a FAA flight plan. Vendor flight plans are not acceptable. Flight plans shall be filed prior to takeoff when possible.

Flight Following
One of the flight following methods shall be implemented:

1. Pilots are responsible for flight following with the FAA, USCG, or other responsible governmental entity. Check-in shall not exceed one-hour intervals under normal circumstances.

or

2. The vendor shall provide, install, and maintain an automated flight following (AFF) system per the manufacturer's requirements. The AFF system installed must be one compatible with the Governments AFF network (https://www.aff.gov/). The vendor must procure and maintain a subscription for satellite service that allows interface with the Government's AFF network during any use under this contract. The aircraft vendor must register this installation with AFF. (Registration Information will be provided at award) The standard position-reporting interval shall not exceed two minutes. Aircraft location checks shall not exceed one-hour intervals under normal circumstances. It is incumbent upon the aviation vendor to conduct a thorough evaluation of any potential AFF vendor's services and products to ensure compliance with this requirement.

Manifesting

The pilot-in-command shall ensure that a manifest of all crewmembers and passengers on board has been completed. A copy of this manifest shall remain at the point of initial departure. Manifest changes will be left at subsequent points of departure when practical.

Checklist

Pilot(s) shall utilize a written checklist prior to any departure. Failure to use written checklists required for departures may result in cancellation of any contracts or agreements between the vendor and GMI.

Pilot(s) will make regular use of written checklists for all other necessary flight operations.

The vendor will develop and utilize a secondary written checklist to include applicable requirements of this document.

Passenger Briefing

Before each takeoff, the pilot-in-command shall ensure that all passengers have been briefed in accordance with the briefing items contained in 14 CFR 135 and additionally:

1. Emergency Locator Transmitter (ELT) and Emergency Position Indicating Radio Beacon (EPIRB)
2. First Aid Kit
3. Personal Protective Equipment (if applicable)

Flight Operations

Notwithstanding any status as a Public Aircraft Operation, the vendor shall operate in accordance with his approved FAA Operations Specifications, and all portions of 14 CFR Part 91 and each certification listed above.

1. Flight operations shall not extend beyond 45 minutes reserve fuel at 100 knots at sea level - required
2. High wing loads and excessive banking will not be allowed. A high margin of safety between conditions, loading, airspeed and angle of bank will be maintained.
3. Minimum altitude for the type of flying, requirements of surveys and terrain will be determined before operations and maintained.
4. The pilot in command will ascertain aviation minimums are sufficient for a flight to proceed. GMI survey lead observer will have final authority to determine whether a flight may proceed.

Pilot Authority and Responsibilities

The pilot is responsible for the safety of the aircraft, its occupants, and cargo. The pilot shall comply with the directions of the Government, except, when in the pilot's judGMIent compliance will be a violation of applicable federal or state regulations or agreement provisions. The pilot shall refuse any flight or landing which is considered hazardous or unsafe. The pilot shall not permit any passenger to ride in the aircraft or any cargo be loaded unless authorized by GMI. Pilots are responsible for computing the weight and balance for all flights and for assuring that the gross weight and center of gravity do not exceed the aircraft's limitations. Pilots shall be responsible for the proper loading and securing of all internal or external cargo.

Flight Crew Requirements

Pilots shall have at least a FAA commercial pilot certificate with appropriate category, class, and type rating if required.

Instrument rating for airplanes

Pilots shall hold at least a current second class medical certificate issued under provisions of 14 CFR Part 67.

Pilots shall show evidence of satisfactorily passing all required FAA flight checks in accordance with provisions of 14 CFR Part 135. All pilots shall meet the currency requirements of 14 CFR 61.57.

Pilot flying hours shall be verified from certified pilot records.

Pilot-In-Command shall have recorded minimum flying time as pilot-in-command as follows:

a. 1000 hours total pilot time
b. 100 hours in category within the preceding 12 months
c. 750 hours PIC in airplanes
d. 25 hours make and model
e. 20 hours operating below 1000 feet supporting observational, photogrammetric, or other natural resources surveys (over open ocean preferred)

Pilots shall have completion of a dedicated course on unusual attitude and spin recovery training.

Offshore Flights

Two pilots are required for each offshore flight.

Pilot in command shall have recorded minimum flying time as pilot-in-command as follows:

a. 1500 hours total pilot time
b. 100 hours in category within the preceding 12 months
c. 1200 hours PIC in airplanes
d. 25 hours make and model
e. 200 hours multiengine
f. 100 hours operating below 1000 feet supporting observational, photogrammetric, or other natural resources surveys (over open ocean preferred)

Pilot Second in Command (Copilot)

a. Requirements as specified in 14 CFR Part 135.

Flight crewmembers must demonstrate that they have taken a ditching and water survival training course within the preceding 5 years.

Flight Crewmember's Duty and Flight Limitations

Duty Limitations. Duty includes flight time, ground duty of any kind, and standby or alert status. Local travel up to a maximum of 30 minutes each way between the work site and place of lodging will not be considered duty time. Flight crewmembers will be subject to the following duty hour limitations:

a. A maximum of 14 consecutive duty hours during any assigned duty period
b. Pilots shall be given 1 day of rest within any 7 consecutive calendar days, or two days of rest within any 14 consecutive days.
c. Pilots shall be given a minimum of 10 consecutive hours of rest (off duty), not to include any preflight or post-flight activity, prior to any assigned duty period.

Flight Limitations. All flight time, regardless of how or where performed, except personal pleasure flying, will be reported by each flight crew member and used to administer flight time and duty time limitations. Flight time to and from a duty station as flight crew member (commuting) will be reported and counted toward limitations if it is flown on a duty day. Flight time includes, but is not limited to: military flight time; charter; flight instruction; 14 CFR 61.56 flight review; flight examinations by FAA designees; and flight time for which a flight crew member is compensated; or any other flight time of a commercial nature whether compensated or not. Pilot time computation shall begin at takeoff and end when the aircraft is stopped at the parking spot. Flight crewmembers will be limited to the following flight hour limitations, which shall fall within their duty hour limitations:

a. 10 hours for a flight crew consisting of two pilots during any assigned duty period.
b. A maximum of 50 hours flight time during any consecutive six-day period. When a pilot acquires 50 or more flight hours in a consecutive six-day period, the pilot shall be given the following 24-hour period of rest (off duty) and a new six-day cycle shall begin. The 24-hour period shall be one calendar day off duty.

Pilot Proficiency

Pilots shall display evidence of experience in using all equipment specified (marine and aviation VHF radio, GPS, etc.). Pilots may be required to demonstrate proficiency.
Pilots shall demonstrate their ability to perform the following functions with the required GPS:

1. Determine the geographic coordinates of a destination identified on a sectional aeronautical chart
2. Install destination coordinates
3. Acquire distance/bearing information to a destination
4. Record as a waypoint, coordinates of various locations while enroute to a primary destination
5. Navigate from a present position to a selected recorded waypoint or between two recorded waypoints.

The aircraft vendors shall submit an experience resume for each pilot offered for approval. The resume shall include names and pilot addresses of past employers, substantiation of related type and typical terrain flying and must show any and all accidents involving aircraft.

Pilots shall be knowledgeable of IFR, VFR, low level and slow flight procedures while flying over water. This includes special flight techniques for low level in slow flight configuration. Pilots may be required to demonstrate proficiency during an initial evaluation flight.

Personal Protective Equipment

Personal Flotation Devices (PFD) required by 14 CFR 91 or Life-Preserver(s) (TSO-C13) required by 14 CFR 135 shall be on board all aircraft operated over water and beyond power-off gliding distance to shore.

Anti-exposure suits shall be readily available to occupants of multiengine aircraft when conducting extended over water flight (as defined in 14 CFR 1.1) and when the water temperature is estimated to be 59 degrees Fahrenheit or less.

Aircraft Requirements

These standards are in addition to airworthiness requirements.

Condition of Equipment

Vendor-furnished aircraft and equipment shall be operable, free of damage, and in good repair. All primary and secondary gauges, avionics, and systems shall be operational.

Aircraft systems and components shall be free of leaks except within limitations specified by the manufacturer.

All windows and windshields must be clean and free of scratches, cracks, crazing, distortion, or repairs, which hinder visibility. Repairs such as safety wire lacing and stop drilling of cracks are not acceptable permanent repairs. Prior to acceptance, all temporarily repaired windows and windshields shall have permanent repairs completed or shall be replaced.

The aircraft interior shall be clean and neat. There shall be no un-repaired tears, rips, cracks, or other damage to the interior. The exterior finish, including the paint, shall be clean, neat, and in good condition. Any corrosion shall be within manufacturer or FAA acceptable limits.

Additional Equipment Requirements

Fire extinguisher(s), as required by 14 CFR 135, shall be a hand-held bottle with a minimum 2-B:C rating mounted and accessible to the flight crew.

Shoulder harness and lap belt for front seat occupants and both occupants in tandem seat airplanes are required. The shoulder strap and lap belt will fasten with a metal to metal, single-point, quick-release mechanism.

One automatic-portable/automatic-satellite GPS fixed ELT, utilizing an external antenna and meeting the requirements of 14 CFR 91.207 (excluding section f.), shall be installed per the manufacturer's installation manual, in a conspicuous or marked location.

Minimum Aircraft Specifications

1. At least 830 lb. or 2 passenger capacity –required.
2. High wing-required
3. Safe operation of survey speed of 80kts-100kts.
4. Two positions for biologists with unobscured window views on each side of the aircraft -required.
5. A minimum of 4.5 hours operational flight range –desired
6. Following avionics, at minimum:
    a. GPS navigation aids -required
    b. Radios:
        i. fully operational primary and secondary COMM (VHF radio) units (VHF stand alone linked to the intercom, NAV/COMM, GPS/COMM)
    c. External antenna mount for scientist's GPS -desired.
    d. Intercom (static free, clear communications) with headsets for all occupants of aircraft –required; linkage to marine radio -preferred
7. One opening window accessible to the scientific party for photography and/or a floor camera port -required.
8. AC or DC power for powering lap top computers –required.
9. IFR-certified -required
10. Registered 406 mHz EPIRB capable of being removed from aircraft and operated in a marine environment -required.

<u>Offshore Requirements</u>

1. At least 1200 lb. or 2 passenger capacity –required, 3 passenger capacity -desired
2. High wing-required
3. Multi-engine -required, turbine desired
4. Capable of survey speed of 100 Knots.
5. Two positions for biologists with unobscured window views on each side of the aircraft -required.
6. A minimum of 6 hours operational flight range –desired
7. Flight operations shall not extend beyond 45 minutes reserve fuel at 120 knots at sea level -required
8. Following avionics, at minimum:
    a. GPS navigation aids -required
    b. Radios:

i. fully operational primary and secondary COMM (VHF radio) units (VHF stand alone linked to the intercom, NAV/COMM, GPS/COMM)
ii. aircraft mounted marine radio –desired;

c. External antenna mount for scientist's GPS -desired.
d. Intercom (static free, clear communications) with headsets for all occupants of aircraft – required; linkage to marine radio -preferred

9. One opening window aft of the cockpit and accessible to the scientific party for photography and/or a floor camera port -required.
10. AC or DC power for powering laptop computers -desired
11. IFR-certified -required
12. Extended overwater operations emergency equipment as listed in 14 CFR Part 135 §135.167, including registered 406 mHz EPIRB capable of being removed from aircraft, floating and operated in a marine environment -required.

Maintenance Requirements

Aircraft shall be maintained in accordance with all applicable Mandatory Manufacturer's Bulletins as required by the vendor's operations specifications, and all applicable FAA Airworthiness Directives (AD).

Maintenance Test Flight. A functional maintenance test flight shall be performed, at the vendor's expense, following installation, overhaul, major repair, or replacement of any engine, propeller, or primary flight control. The pilot shall enter the result of this test flight in the aircraft maintenance record.

Fuel and Servicing Requirements

All fuel must be commercial (or military) grade aviation fuel approved for use by the airframe and engine manufacturer.

Passengers shall not be involved with any refueling of aircraft.

Aircraft shall not be refueled while engines are running and propellers are turning.

Aircraft Vendor Insurance

Insurance in amounts equal to or greater than the minimum amounts required by either 14 CFR 205.5, the state in which the vendor is operating, or single liability limit of $100,000 and each occurrence of $1,000,000, whichever is greater.

Observer Crew

Observers shall have successfully completed an aviation safety training as prescribed in the Exhibit to NOAA Administrative Order (NAO) 209-124 (NOAA Aviation Safety Training and ALSE Requirements). For information on training and training requirements see http://www.omao.noaa.gov/aviationsafety/ safety.html.

Observers shall have immediately accessible in the aircraft, applicable Aviation Life Support Equipment (ALSE) prescribed in the Exhibit to NAO 209-124 and the following:

1. Nomex Flight Suit
2. Strobe light
3. Rescue Streamer or Sea Dye Marker
4. Combo-edge Knife

Observers should wear the following personal safety equipment/gear during flight:

1. Leather boot or closed toe shoes

APPENDIX B

SHIPBOARD SURVEY SAFETY PLAN

GMI Shipboard Survey Safety Plan and Procedures
NJDEP Baseline Survey Research Cruise
January 2008 – December 2009

SHIPBOARD FACILITIES AND CONSIDERATIONS

We are fortunate to be aboard the R/V *Hugh R. Sharp*. Please follow link below to familiarize yourself with the vessel.

http://www.ocean.udel.edu/marine/rvhugh/index.shtml

At initial boarding of the research vessel, you will receive a briefing on the specific protocols/procedures of the vessels and there will be a safety overview which will review the protocols for fire and abandon-ship procedures.

The ship will provide all linens, towels, and pillows; depending on the time of year, it may be prudent to bring additional blankets and/or cold weather gear. This survey will be conducted year-round in acceptable sea states.

I. CHAIN OF COMMAND

Members of the scientific party, including Marine Mammal Observers (MMOs), report directly to the Chief Scientist. The Chief Scientist represents the scientific party responsible for communicating with the vessel's staff and has sole authority to act on behalf of the NJDEP and GMI Program Manager. Any and all sensitive or operational communications from the scientific party to the ship's staff needs to pass through the Chief Scientist. The Chief Scientist is responsible for any change in operating procedures or any out of the ordinary matter. If you have a problem, please see the Chief Scientist. Please do not at any time try to resolve the situation yourself by approaching the ship's personnel directly.

II. FOOTWEAR

Closed-toe shoes are mandatory while traveling throughout the ship. Thongs or other open-toe sandals are permitted only while on the flying bridge (wear closed-toe shoes to and from this location) or in the living quarters.

III. DRUGS, ALCOHOL, AND SMOKING

Drugs and Alcohol

There is a zero tolerance policy on the possession of drugs and alcohol on this survey cruise.

Smoking

Smoking is prohibited in all interior spaces on the ship. Smoking is only allowed on the weather decks and only in designated areas.

IV. EMERGENCY CONTACT

In the event of an emergency on land, please provide a family member or friend the following list of contacts.

Hugh R. Sharp - Main Office:
Sharyn Bressler
Staff Assistant
Phone: 302.645.4320
Email: sharyn@udel.edu

Cruise Planning, Scheduling, and Budgets:
Matthew Hawkins
Director of Marine Ops
Office Phone: 302.645.4341
Cell Phone: 410.924.2472
Email: hawkins@udel.edu

Cruise Planning and Logistics:
Captain Bill Byam
Master
Office Phone: 302.645.4343
Cell Phone: 302.381.0346
Email: byam@udel.edu

Cruise Planning and Technical Support:
Timothy Deering
Oceanographic Coordinator
Office Phone: 302.645.4338
Cell Phone: 302.249.6149
Email: deering@udel.edu

V. INTER-PERSONAL RELATIONS

Social Considerations

People working and living together on a ship creates an unusual environment. There is minimal privacy and space for individuals spending an extended amount of time together in an isolated setting. Thus, in this environment, otherwise minor incidents can sometimes escalate unnecessarily. Be aware that your personal feelings may intensify at sea and try to keep things in perspective.

Problems

Sometimes challenging and difficult situations arise while out to sea. If you have difficulty working with someone and/or feel threatened or discriminated against, please alert the Chief Scientist of your situation. Any situation will be kept confidential; your comments will only be used to resolve the issue. Please inform the Chief Scientist as soon as an issue arises so that she can help resolve the issue and prevent an exacerbation of the problem. It is of utmost importance to the Chief Scientist and the Chief Officer (CO) that scientists are comfortable and happy working while living aboard the ship.

Policies on Harassment and Drug and Alcohol Use

The following is the general policy information for all ships leased by GMI.

All persons boarding the vessel give an implied consent to conform to all safety and security policies and regulations which are administered by the CO. All spaces and equipment on the vessel are subject to inspection or search at any time. Additionally, the following is prohibited aboard any U.S. Government vessel: possession and/or use of intoxicating alcoholic beverages, illegal drugs, controlled drugs without a prescription, sexual harassment, or use of shipboard spaces for purpose of sexual liaison. Violators may be removed from the vessel at the earliest opportunity.

<u>Possession or Use of Alcohol or Illegal Drugs</u>

Possession or use of alcohol, illegal drugs, or prescription medications without a prescription on board any GMI vessel by any member of the embarked complement is strictly forbidden and will not be tolerated. When violations of this policy are discovered, the following procedures will be adhered to:

* The alcohol will be confiscated and immediately disposed of in the presence of a witness.
* Drugs will be confiscated and placed in a secured location until the vessel reaches home port or another port of call, at which time the offense will be reported, and the drugs turned over to the appropriate authorities for action.
* Disciplinary or corrective action will be taken in accordance with the applicable Table of Offenses and Penalties.

<u>Sexual Harassment</u>

Sexual harassment will not be tolerated aboard GMI vessels. This applies to all persons, male and female, including members of the operating crew and any embarked scientific personnel or other personnel. Sexual harassment is sex (gender) discrimination that involves unwelcome sexual conduct, which can include both verbal and physical behavior. Some examples of such behavior are as follows: pressure for dates or sex; sexually suggestive looks, comments, or gestures; sexual jokes; displaying material of a sexual nature; and deliberate touching. Conduct is unwelcome if it is unsolicited and an individual finds it undesirable and/or offensive. All instances of sexual harassment should be immediately reported to your CO, the Chief Scientist, and project manager.

<u>Smoking Restrictions</u>

Aboard GMI ships, personnel who smoke may do so only on the weather decks in designated areas. There is no smoking permitted on the interior of any GMI ship. Smokers are expected to observe particular care in disposing of cigarettes or smoking materials. Use ashtrays or butt kits located around the ship for this purpose. Smoking is prohibited:

* on any part of the weather decks when the vessel is fueling or taking on flammable cargo,
* in the vicinity of any gasoline engine undergoing repair,
* in the vicinity of any compressed gas cylinder carrying a flammable gas sticker, which may be stored on deck for the use of the embarked science party, and
* during certain types of scientific missions or in the immediate vicinity of sensitive science mission equipment.

<u>Underway Shipboard Emergencies</u>

Fire

Fire at sea, no matter how small, can become a life-threatening situation. At sea, everyone aboard ship, be they crew, scientist, or passenger, is a member of the fire department. When the General Alarm sounds, everyone has a specific emergency billet assignment and each person is relied upon by all others aboard to carry out that assignment. Be aware of your emergency responsibilities so that carrying them out becomes second nature. Firefighting at sea is a team effort.

Emergency billet assignments are posted on the Watch, Quarter, and Station Bill. These are posted at convenient places throughout the ship. Additionally, each person is provided with a "bunk card" which lists his/her individual emergency billet assignments.

The signal for fire or emergency is a 10 second continuous ringing of the General Alarm bell and a 10 second continuous sounding of the ship's whistle. This alarm will be followed by an appropriate announcement on the general announcing system. When you hear the signal, immediately proceed to your fire and emergency billet station. Firefighting and emergency equipment is distributed throughout the ship. All hands should familiarize themselves with the locations of this equipment, as well as the Damage Control Lockers and their contents.

Abandon Ship

Abandoning ship in the open sea is an action of last resort. All reasonable efforts required of mariners for the saving of their ship must clearly have failed before any decision to abandon the vessel will be taken. Only when there is no reasonable chance of saving the ship will the order ever be given to abandon it. The decision to abandon ship is made only by the CO, or in the CO's incapacity, the senior member of the chain of command.

The signal to abandon ship is seven (7) or more short blasts on the ship's whistle and General Alarm, followed by one (1) long blast.

When the order is given to abandon ship, all hands will proceed to their assigned life raft muster stations. Each shall bring his/her protective survival clothing, survival suit, personal floatation device (life jacket), and other equipment assigned in abandon ship billet. Once the order to abandon ship has been given, the life raft Officers in Charge (OIC) will muster their respective parties and dispatch the assigned crew members to the life raft locations to launch their respective life rafts. Once launched, the remaining personnel will have to act in concert to haul the deployed rafts alongside the main deck embarkation stations. Orderly seamanlike actions at the embarkation stations will assure the rapid and efficient abandoning of the ship.

Man Overboard

Except for uncontrollable fire at sea, there is perhaps no more personally terrifying situation for a member of the ship's complement than being lost overboard. There are two basic man overboard scenarios: witnessed and unwitnessed.

1. Witnessed Man Overboard--Actions of the Witness

Upon observing a person going overboard, the witness shall take the following actions:

1. Call out for assistance and throw a life ring buoy into the water, preferably one equipped with a strobe light. Pass the word to the Bridge by any means possible.

2. Wait about one minute and throw a second life ring buoy (at night –one equipped with a strobe light) into the water. This will create a visual range for the OOD and the lookouts, aiding the search effort.

3. Keep the victim under surveillance if at all possible but do not delay passing the word to the Bridge.

2. Unwitnessed Man Overboard

Underway, until proven otherwise, when a crew member is unaccounted, it will be presumed that the individual has been lost overboard. This situation then becomes a search and rescue problem of a far more complicated nature. The time of the casualty will be unknown, or at best, only grossly estimated. The ship's navigation record, as contained on the Marine Operations Abstract or Dead Reckoning Abstract, will be crucial for search planning, as will the hourly weather observations entered into the Weather Log. Initial actions will be to notify the Marine Operations Center Director of the situation and to notify the nearest Rescue Coordination Center for assistance. Search operations will be conducted with the advice and guidance of SAR professionals.

Drills at Sea

Emergency drills at sea will be held in accordance with the requirements of NC Instruction 5100.1B. Reporting for drills, in accordance with the billets assigned in the Watch, Quarter, and Station Bill, is mandatory for all hands, including the embarked science party, unless the absence is specifically authorized by the CO, XO, or Safety Officer.

For Abandon Ship drills, unless otherwise advised, all hands are required to wear life jackets and carry their survival suits when reporting to their life raft muster stations. All personnel shall be attired in, or bring to the muster, clothing that fully covers legs and arms, a hat, socks, and shoes. Signals to call all hands to emergency stations shall be identical to those that are used for actual emergencies. When a drill is held, the OOD will always state "This is a drill. This is a drill." followed by an appropriate announcement on the general announcing system.

The signals are as follows:

Fire and Emergency	Continuous ringing of the General Alarm bell for 10 seconds and continuous sounding of the ship's whistle for 10 seconds [Image]
Abandon Ship	7 or more short blasts on the ship's whistle and General Alarm bell, followed by one prolonged blast [Image]
Man Overboard	3 prolonged blasts on the ship's whistle and General Alarm bell [Image]
Dismissal from Drill	3 short blasts on the ship's whistle and General Alarm bell [Image]

<u>Working on deck</u>

The following safety regulations will be observed when working on deck:

* Life vests or floats coats will be properly worn when handling equipment over the side, deploying equipment over the side, and on all launches (whether alongside the ship, launching, or recovering).
* Safety belts and lines will be worn by those handling equipment over the side.
* Hardhats will be worn by all those involved in recovery or deployment of equipment and boats.
* Proper footwear should be worn at all times (Open toe shoes are NOT proper work footwear).
* Ship's equipment is to be operated only by qualified members of the ship's complement.

<u>Seasickness</u>

Information on sea sickness and treatments available will be provided by the Medical Officer. Those requiring preventative treatment should see the Medical Officer prior to sailing.

One of the least pleasant aspects of sea duty is the possibility of seasickness. An individual's susceptibility to seasickness is highly variable. If you've experienced motion sickness in cars, planes, or amusement park rides, you may experience seasickness during the cruise. Regardless, most people feel some level of illness or discomfort when they first go to sea. Seasickness is a result of an imbalance in the inner ear (where the human balance mechanism resides) caused by the erratic motion of the ship through the water. Inside the cabin of a rocking boat, for example, the inner ear detects changes in linear and angular acceleration as the body moves with the boat. But since the cabin moves with the passenger, the eyes register a relatively stable scene. Agitated by this perceptual incongruity, the brain responds with a cascade of stress-related hormones that can ultimately lead to nausea and vomiting. Its effect can be magnified by strong smells (like diesel fumes or fish). It usually occurs in the first 12-24 hrs after sailing, and typically dissipates when the body becomes acclimated to the ship's motion (getting one's "sea-legs"). Rarely does anyone stay ill beyond the first couple of days at sea, regardless of sea state, but this can occur. There are several over-the-counter medications available to prevent or minimize motion sickness. These need to be taken about an hour before sailing and as needed at sea; as always, you should follow the instructions for the medication you are taking. All of these medications tend to dehydrate the body, so fluid intake is important. If you should get seasick, take comfort in the fact that recovery is usually only a matter of time, and the survival rate is 100%. Each ship has a trained medical officer who can treat severe cases of sea-sickness. However, all that is usually required for a complete recovery is some sensible eating/drinking and some patience. Here are a few tips and considerations regarding seasickness:

* Vomiting offers relief. Make an effort to continue eating items like crackers, dry toast, dry cereal, etc. (avoid anything greasy, sweet, or hard to digest). Keeping something in your stomach suppresses nausea, or, if vomiting, eliminates painful "dry heaves". Antacid tablets help some people.
* Maintain fluids. Seasickness and related medications cause dehydration and headaches. Try to drink juices low in acidity, clear soups, or water, and stay away from milk or coffee.
* Keep working. Most people find that being busy on deck keeps their minds off their temporary discomfort. Also, the fresh air out on deck is often enough to speed up recovery.
* Carry a plastic bag. This simple trick allows some peace of mind and eliminates some of the panic of getting sick. Do not vomit in sinks or trash cans. If you vomit "over the side", be aware of which way the wind and waves are coming. Going to the "lee" will ensure that an unpleasant experience doesn't become any more unpleasant.

Above all, don't be embarrassed or discouraged! If you get sick, chances are that others are sick too! No one --fishermen, ship's officers, scientists --is immune to seasickness.

Firearms and Other Weapons

Personally owned firearms are not permitted aboard the ship without the advance written approval of the CO. Any firearm permitted aboard the ship must be accompanied by any applicable permits. All firearms and their ammunition will be locked in the ship's weapon's locker until they are removed from the vessel. Firecrackers, fireworks and similar pyrotechnics will not be permitted aboard the ship. Sheath knives are not permitted aboard the ship with the exception of fishing fillet knives which are permitted. Folding knives are permitted to be carried aboard ship and their use is encouraged.

University of Delaware, Marine Operations – Contact Numbers

Revised: 01/15/07

Main Office	302-645-4320
Main Office Fax	302-645-4006

R/V HUGH R. SHARP:

		Comments
Alongside	302-645-4340	
Ship Cellular	302-448-5061	Within 30 nm of shore
INMARSAT Voice	011-874-764-471-442	Dialed as international call.
	Or dial: 1-800-551-7534	at prompt dial 485-837-5907 then 0-764-471-442
INMARSAT Fax	011-874-600-714-099	Used for all Faxes. Dialed as international call.
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APPENDIX C

GLOSSARY TERMS

Abundant—an indication of the plentifulness of a species at a particular place and time; an abundant species is more plentiful than an occasional or rare species

Adult—developmental stage characterized by sexual or physical (full size and strength) maturity

Aggregation—is a group of animals that forms when individuals (usually similar, but can also be dissimilar) are attracted to an environmental resource to which each responds independently; the term does not imply any social organization

Akaike's information criterion—A measure of the goodness of fit of an estimated statistical model

Anthropogenic—descriptive of a phenomenon or condition created, directly or indirectly, as a result of effects, processes, objects, or materials that are derived from human activities

Anticyclonic—descriptive of the clockwise circulation in the Northern Hemisphere and counterclockwise circulation in the Southern Hemisphere; in oceanography, synonymous with warm-core ring

Array—an arrangement of interrelated objects or items of equipment, such as hydrophones, for accomplishing a particular task

Audio burn unit—a device used to release pop-ups from their moorings by projecting a specific sound into the water within range of the pop-up

Audiogram—a hearing sensitivity curve drawn as a function of frequency and sound pressure level; describes the hearing ability of an animal

Baleen whale—any whale of the suborder Mysticeti; characterized by presence of baleen in the upper jaw

Baleen—the interleaved, hard, fibrous plates made of keratin that hang side by side in rows from the roof of the mouth of mysticete whales; baleen takes the place of teeth and serves to filter the whale's food from the water

Barnacles—collectively, various marine crustaceans of the subclass Cirripedia; adult barnacles form a hard outer shell and attach to hard substrates such as rocks and ships, as well as to certain whales

Basking—descriptive of behavior in which an individual (e.g. pinnipeds and sea turtles) exposes itself to the sun, generally for the purpose of increasing its core temperature; may be done at the water's surface or on land

Benthic—in, on, or near the ocean floor; the term is used irrespective of whether the sea is shallow or deep

Bight—an inward bend or bow in the coastline

Biomass—the amount of living matter per unit of water surface or water volume

Blowhole—the nostril(s) on top of the head of a cetacean

Blubber—a specialized layer of fat found between the skin and underlying muscle of many marine mammals; it is used primarily for insulation and energy storage

Boreal—comprising or found throughout far northern regions

Bottlenose dolphin—refers to the former common name for *Tursiops truncatus,* now called the common bottlenose dolphin

Bubble netting—refers to a coordinated feeding technique of humpback whales, in which they use bubbles to corral and trap small fish or invertebrates

Bull—a male seal or whale, especially an adult male

Bycatch—marine species incidentally caught in a fishery targeting another species, but that are not sold and usually not kept for personal use. Bycatch includes economic and regulatory discards; bycatch species can be either alive or dead

Calf—a young animal that is dependent on its mother

Callosity—a patch of thickened, keratinized tissue on the head of a right whale, inhabited by large numbers of whale lice; plural: callosities

Call—refers to a vocal sound of a bird or other animal

Calving—the process of giving birth by cetaceans and sirenians

Calving interval—the period of time from one birth to the next, generally applicable to cetaceans

Carapace—the outer covering on the back of a sea turtle; the carapace is bony in all sea turtle species except the leatherback, which has a leathery covering

Cephalopod—any marine mollusk of the class Cephalopoda, with the mouth and head surrounded by tentacles (squid, octopus, cuttlefish)

Cetacean—an animal of the order Cetacea; these include whales, dolphins, and porpoises

Cheloniidae—family of hard-shelled sea turtles that include the green, hawksbill, Kemp's ridley, olive ridley, and loggerhead turtles

Chevron—a V-shaped stripe; used to describe the diagnostic white pattern on fin whales

Click—a broad-frequency sound used by toothed whales for echolocation and which may serve a communicative function; usually with peak energy between 10 kHz and 200 kHz

Coastal water—water that is along, near, or relating to a coast

Coast—refers to the boundary where land and water meet

Coefficient of variation—coefficient of variation represents the ratio of the standard deviation to the mean; when expressed numerically, the ratio is usually converted to a percentage by multiplying by 100

Cold-stunning—state that sea turtles enter when they are suddenly exposed to very cold water (<10°C); turtles that are cold-stunned become lethargic and begin to float on the surface of the water. In this state, they are more susceptible to predators, accidental boat strikes, and even death if water temperatures continue to drop

Conspecific—a peer, member of the same group, or belonging to the same species

Continental shelf—the province of the continental margin with a gently seaward-sloping seabed (1:1000 gradient change) extending from the low-tide line of the shoreline to 100 to 200 m water depth where there is a rapid gradient change

Continental slope—the province of the continental margin with a relatively steeply sloping seabed (1:6 to 1:40 gradient change) that begins at the continental shelf break (about 100 to 200 m) and extends down to the continental rise; along many coasts of the world, the slope is furrowed by deep submarine canyons

Conventional distance sampling—a design-based approach of distance sampling in which the detection probability [g(0)] is modeled as a function of distance from the transect line and all objects at zero distance are assumed to be detected; abundance/density estimates that are generated through this approached are based on the survey design which is assumed to provide a representative sample of the entire Study Area

Copepod—small planktonic crustacean present in a wide variety of marine habitats and in great abundance, forming an important basis of ecosystems; copepods are a major food of many marine animals and are the main link between phytoplankton and higher trophic levels

Cosmopolitan—widely distributed over the globe

Covered region—the region, with size *a*, searched along the line transect and out to *W* so that *a=2WL*

Critical habitat—U.S. federal designation; refers to the minimum portion of the habitat that is essential for the survival and recovery of protected (threatened and endangered) species, including but not limited to, areas for feeding or reproduction; designated on a case-by-case basis under the provisions of the U.S. Endangered Species Act

Crustacean—any chiefly aquatic arthropod of the class Crustacea, typically having the body covered with a hard shell or crust, including the lobsters, shrimps, crabs, and barnacles

Curved carapace length—a measurement used by sea turtle researchers; CCL is defined as the length of a sea turtle's carapace as measured by a flexible tape measure

Delphinid—a toothed whale belonging to the family delphinidae, commonly known as dolphins

Delphinus—the genus of oceanic dolphins consisting of short-beaked and long-beaked common dolphins, which are similar in appearance

Demography—refers to birth and death rates that determine a population's dynamics; abundance, age, and sex structure of the population and reproductive status and life cycle of individuals

Density surface modeling—a model-based approach in which animal abundance/density can be modeled as a function of spatially-indexed environmental covariates

Density—the physical property measured by mass per unit volume; often used in biology, it is a unit of measurement defined as the number of organisms per unit of distance or volume and may be used as measure of abundance

Developmental habitat—an environment crucial to the growth of late-stage juvenile animals; for some sea turtles, this environment can be a shallow, sheltered habitat where forage items such as seagrasses, sponges, mollusks, and crustaceans are abundant

Deviance explained—the proportion of the null deviance explained by the model

Distance sampling—a widely used technique for estimating the size or density of biological populations

Effective search region—the region searched along the line transect and out to the effective strip half-width, *esw*, so that the effective search region is given by *2eswL*

Effective strip half-width—the half-width of the strip extending either side of a transect centerline such that as many objects are detected outside the strip as remain undetected within it

Endangered Species—legal designation; refers to any animal or plant species in danger of extinction throughout all or a significant portion of its range; the authority to list a species is shared by the USFWS (plants and animals on land) and NMFS (most marine species) under provisions of the ESA

Euphausiid—pelagic, shrimp-like crustacean; krill

f(0)—the value of the probability density function of perpendicular distances, evaluated at zero distance (line transect sampling)

Falcate—sickle-shaped, curved; when used to describe the shape of a dorsal fin, it may be diagnostic for some species of cetaceans

False crawl—an abandoned sea turtle nesting attempt or simply a U-shaped crawl from the ocean up the beach, and then back to the water

Flipper—refers to the flattened forelimb of a marine mammal

Flukes—refers to the horizontally spread tail of a cetacean

Forage—to search for food (prey items) or provisions; can also refer to the act of grazing or consumption

Frequency—cycles per second; the number of cycles completed per unit of time of a wave/oscillation. Sound is measured in cycles per second or frequency, called Hertz

Fusiform—spindle-shaped or torpedo-shaped; tapered at one or both ends

g(0)—the probability that an object that is on a line or point is detected

Gape—used to describe the junction of upper and lower lips on the face of a cetacean

Gastropod—any member of a class of symmetrical, univalve mollusks that has a true head, an unsegmented body, and a broad, flat foot

Genus—penultimate level of taxonomic or scientific classification; plural: genera

Generalized cross validation—a weighted cross-validation technique in which an iteration process leaves out one datum in turn and considers that ability of the models fitted to the remaining data to predict the left out datum

Gregarious—sociable; tending to move in or form a group with others of the same kind

Habitat—the living place of an organism or community of organisms that is characterized by its physical or living properties

Hatchling—a newly hatched bird, amphibian, fish, or reptile; in reference to sea turtles, recently hatched individuals still dependent upon the internalized yolk sac for nutrients

Haul-out site—refers to an area of land adjacent to the water where marine animals, such as pinnipeds, periodically and purposefully come ashore

Haul out—refers to the behavior in which pinnipeds and sea turtles crawl or pull themselves out of the water onto land for the purpose of respite, basking, breeding, nesting and/or molting

Hydrophone—a transducer used for detecting underwater sound pressures; an underwater microphone

Inshore—refers to an area close to the shore or coast

Inter-nesting interval—the amount of time between successive sea turtle nesting events during the nesting season

Irruptive—refers to entering an area where not characteristically recorded

Isobath—refers to the bathymetric contour of equal depth; usually shown as a line linking points of the same depth

Juvenile—an individual animal similar in form to an adult but not yet sexually mature; a smaller replica of the adult

Krill—see euphausiid

Life history—term used to describe collectively the changes through which an organism passes in its development from the primary stage to natural death

Line transect sampling—a method of distance sampling in which the observer travels along a line and records the distance from the line to each object detected

Lost year—the early juvenile stage (first years of life) of most sea turtle species that is spent far offshore; few turtles are observed during this time

Marine—of or pertaining to the sea or ocean

Masking—an acoustic term that pertains to noise that cancels out a sound of interest; e.g., vessel engine noise can mask the calls of some whales because they are produced in the same frequency range

Melon—fatty cushion forming a bulbous “forehead” in toothed whales; may act to focus sound for echolocation

Migrate—to pass periodically and deliberately from one region or climate to another; certain species or individuals of birds, fishes, marine mammals, and other animals are known to migrate

Migration—a periodic movement between one habitat and one or more other habitats involving either the entire or significant component of an animal population; this adaptation allows an animal to monopolize areas where favorable environmental conditions exist for feeding, breeding, and/or other phases of the animals’ life history

Migratory—descriptive of organisms or groups of organisms that undertake a migration as an essential part of their life history

Mollusk—any member of the Phylum Mollusca; a group of marine and terrestrial invertebrates consisting of snails, slugs, squids, octopus, clams, and others

Mooring—the means by which a device, ship, boat, or aircraft is secured in a particular place, fixed firmly

Mysticeti—suborder of Cetacea consisting of the baleen whales

Natal beach—original beach of birth for a sea turtle, to which females may return for nesting

Nearshore—is an indefinite zone that extends seaward from the shoreline; generally refers to waters from the coast to the continental shelf break

Neonate—newly born individual

Neritic zone—the shallow portion of pelagic ocean waters; ocean waters that lie over the continental shelf, usually no deeper than 200 m

Nursery habitat—an environment crucial for the development of early-stage animals; e.g., for some sea turtles, this environment is often an open-ocean area characterized by the presence of *Sargassum* rafts and/or ocean current convergence fronts

Occurrence record—research term; refers to a marine mammal or sea turtle sighting (aerial or shipboard survey), stranding, incidental fisheries bycatch, nesting, or tagging data record for which location information is available. An occurrence record, especially sighting occurrence records, may represent the occurrence of one or multiple animals of a particular species

Oceanic zone—refers to the deepwater portion of pelagic ocean waters; ocean waters beyond the continental shelf or that are deeper than the depth of water overlying the continental shelf break (typically 100 to 200 m deep)

Odontoceti—suborder of Cetacea comprising the toothed whales

Offshore—open ocean waters over the continental slope and beyond that are deeper than 200 m; water seaward of the continental shelf break

Omnivore—an animal that feeds on both plant and animal tissue

Opportunistic—descriptive of organisms that take advantage of all feeding opportunities; having a wide-ranging diet

Overwinter—staying the winter in one area

Passive acoustic monitoring—an acoustic tool where a hydrophone or microphone is used to capture sounds from various sources in a given environment

Pectoral fin—flattened fore-limb of a cetacean supported by bone; flipper

Pelagic—the water or ocean environment, excluding the ocean bottom; the major environmental division or zone in the ocean that includes the entire water column and can be subdivided into the neritic (waters over the continental shelf) and oceanic (deeper waters seaward of the continental shelf) zones

Permanent threshold shift—an increase in the threshold of hearing that results in permanent damage to an individual's hearing capability. This may occur as a result of long-term or extremely loud exposure to noise

Phocid—pinniped belonging to the family Phocidae; true ("earless") seals

Photo-identification—use of photographs to identify animals individually; for example, photos of dorsal fin shape and markings for dolphins and the underside of flukes for humpback whales that identify marks individual to an animal

Pinniped—member of the suborder Pinnipedia; includes seals, sea lions, fur seals, and walruses

Plastron—bony shield composing the ventral side of a turtle's shell

Population—a group of individuals of the same species occupying the same area

Pop-up—jargon for an autonomous underwater acoustic recording device, or hydrophone, designed and engineered by Biological Research Program, Cornell Laboratory of Ornithology

Post-hatchling—sea turtle that is larger and older than those of the hatchling stage, yet not large enough or old enough to be considered a juvenile

Prey—animal hunted or caught by another animal for food

Protected species—a species that is afforded legal protection as a result of being listed, or being considered for listing, under state or federal resource law such as the Endangered Species Act or the Marine Mammal Protection Act; a protected species often has a depleted or imperiled population and is in some form of extinction danger

Pupping—the process of giving birth in some species (e.g. pinnipeds, sharks)

Pup—refers to a young animal in certain species (e.g. pinnipeds, sharks)

Range—refers to the maximum extent of geographic area occupied or used by a species

Rookery—an animal's breeding ground; it is the specific beach on which they nest (turtle or birds) or pup (pinniped)

Rorqual—refers generally to any of six species of baleen whales (the minke, blue, humpback, fin, Bryde's, or sei whale) belonging to the family Balaenopteridae; characterized by a variable number of pleats that run longitudinally from the chin to near the umbilicus; the pleats expand during feeding to increase the capacity of the mouth

Rostrum—refers to the snout or beak of a cetacean; in fish, a forward projection of the snout

Saddle—refers to a light-colored patch behind the dorsal fin of some cetaceans

Sargassum—a genus of brown algae commonly found in temperate and tropical waters both as pelagic and benthic forms

Satellite telemetry—transmission of data over long distance communication links (i.e. satellites) from a transmitter attached to an animal, such as a sea turtle, in order to monitor its movements and/or behavior

Species—a population or series of populations of organisms that can interbreed freely with each other but not with members of other species

Straight carapace length—the body length of sea turtles; it is a straight-line measurement from the rear of the eye socket parallel to the center line of the carapace to the posterior edge of the carapace

Stranding—the act of marine mammals or sea turtles accidentally coming ashore, either alive or dead

Subadult—maturing individuals that are not yet sexually mature

Temperate—the region of the Earth at the mid-latitudes that is characterized by a mild, seasonally changing climate

Temporary threshold shift—an increase in the threshold of hearing that results in temporary damage to an individual's hearing capability. Return to normal hearing ability is attained after a period of time

Thermoregulation—ability to maintain a specific body temperature regardless of the environmental temperature

Threatened species—legal designation; any plant or animal species likely to become endangered within the foreseeable future throughout all or a part of its range; the authority to designate a species as threatened is shared by the USFWS (terrestrial species, sea turtles on land, manatees) and National Marine Fisheries Service (most marine species) under provisions of the ESA

Toothed whale—a whale of the suborder Odontoceti, having teeth in one or both jaws

Trawler—any of various types of vessels used in fishing with a trawl net, a net dragged along the sea bottom

Tursiops—genus of bottlenose dolphins comprised of the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)

Upwelling—refers to the movement of dense, cold, nutrient-rich water up from ocean depths to the surface

Vagrant—refers to a wanderer, in the same sense of an animal moving outside the usual limits of distribution for its species or population

Whale lice—an amphipod crustacean of the family Cyanidae; adapted for living in crevices and other secure places on the skin of cetaceans (for example, right whales), on which whale lice largely feed

Whistle—refers to a narrow band frequency sound produced by some toothed whales and used for communication; whistles typically have energy below 20 kHz

APPENDIX D

SUPPLEMENTAL LITERATURE

Appendix D-1

Marine Mammal Literature

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Appendix D-2

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