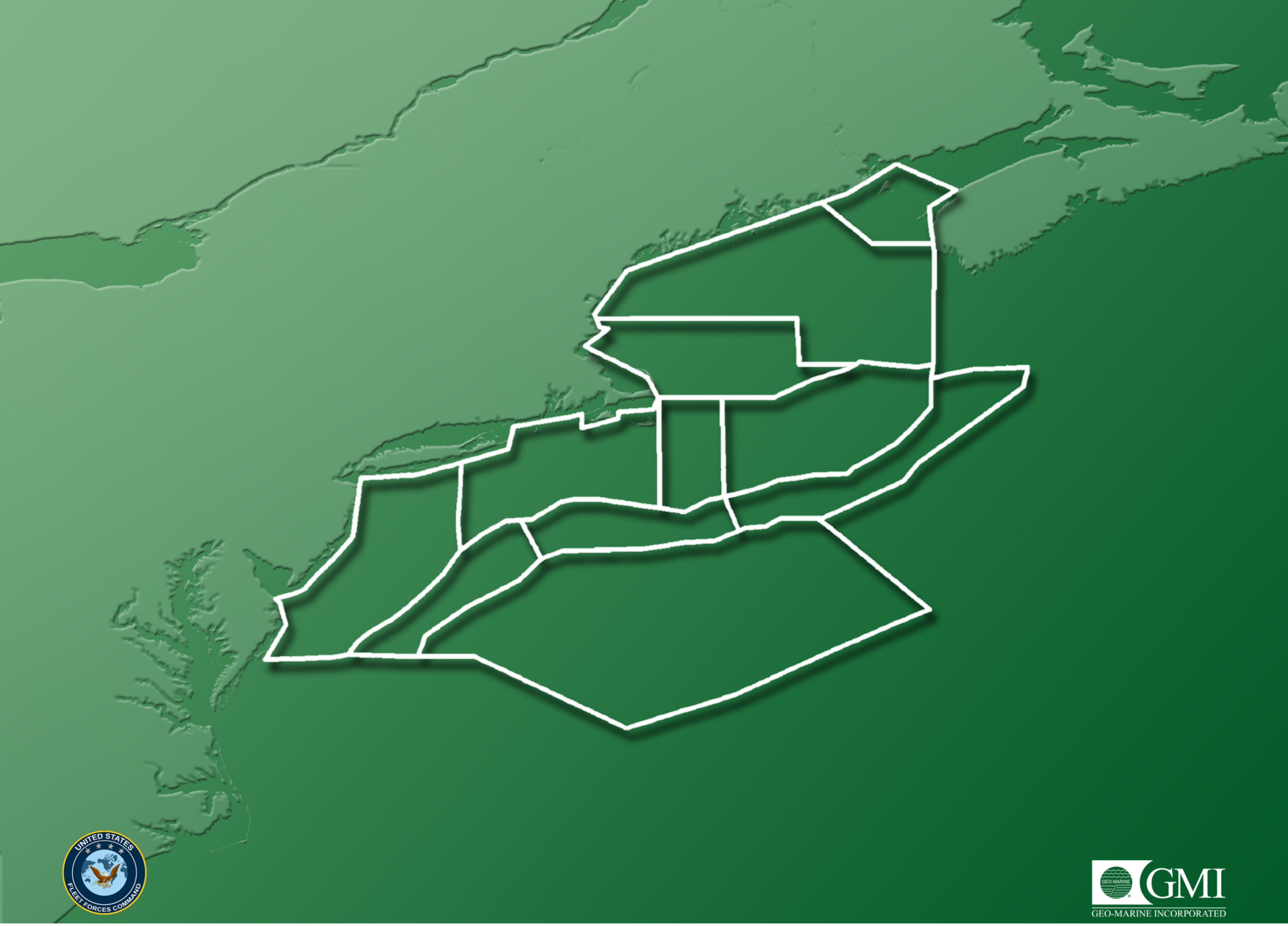
NAVY OPAREA DENSITY ESTIMATES (NODE) FOR THE NORTHEAST OPAREAS: BOSTON, NARRAGANSETT BAY, AND ATLANTIC CITY

FINAL REPORT

AUGUST 2007

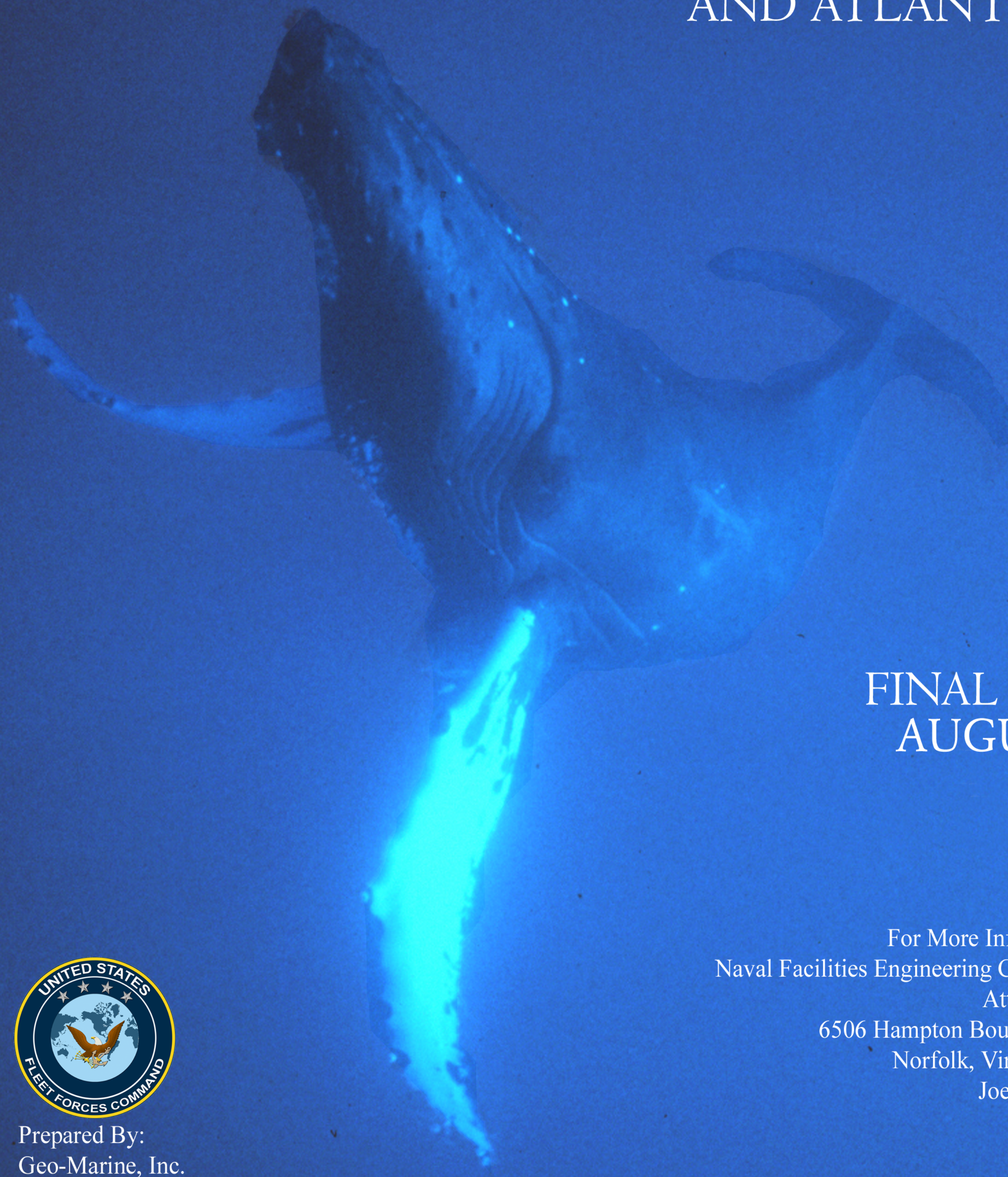


CONTACT:
NAVAL FACILITIES ENGINEERING COMMAND, ATLANTIC
ATTN: MR. JOEL BELL, CODE EV52JB
6506 HAMPTON BOULEVARD, BUILDING A
NORFOLK, VA 23508-1278
JOEL.T.BELL@NAVY.MIL
TELEPHONE: 757.322.4854

PREPARED FOR:
DEPARTMENT OF THE NAVY,
U.S. FLEET FORCES COMMAND

CONTRACT:
N62470-02-D-9997
TASK ORDER: 0045

NAVY OPAREA DENSITY ESTIMATES (NODE) FOR THE NORTHEAST OPAREAS: BOSTON, NARAGANSETT BAY, AND ATLANTIC CITY



FINAL REPORT
AUGUST 2007

For More Information Contact:
Naval Facilities Engineering Command, Atlantic
Attn: Mr. Joel T. Bell
6506 Hampton Boulevard, Building A
Norfolk, Virginia 23508-1278
Joel.T.Bell@navy.mil
757.322.4854

Prepared By:
Geo-Marine, Inc.
2201 Avenue K, Suite A2
Plano, Texas 75074

Prepared For:
Department of the Navy,
U.S. Fleet Forces Command
Contract: N62470-02-D-9997
Task Order: 0045

Suggested Citation: DON (Department of the Navy), 2007. Navy OPAREA Density Estimates (NODE) for the Northeast OPAREAS: Boston, Narragansett Bay, and Atlantic City. Naval Facilities Engineering Command, Atlantic; Norfolk, Virginia. Contract N62470-02-D-9997, Task Order 0045. Prepared by Geo-Marine, Inc., Plano, Texas.

Title Page Photograph: Courtesy of the OAR/National Undersea Research Program (NURP); University of North Carolina at Wilmington. Photographer: R. Wicklund.

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF FIGURES

LIST OF FIGURES
(continued)

LIST OF FIGURES
(continued)

This page intentionally left blank

LIST OF TABLES

This page intentionally left blank

LIST OF ACRONYMS AND ABBREVIATIONS

θ	Angle
°	Degrees
%	Percent
AVHRR	Advanced Very High-Resolution Radiometer
BSS	Beaufort Sea State
C	Celsius
CHPT	Cherry Point
Chl *a*	Chlorophyll *a*
CREEM	Centre for Research into Ecological and Environmental Modeling
CV	Coefficient of Variation
DoN	Department of the Navy
DSM	Density Surface Model
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
EWS	Early Warning System
g (0)	Probability of Detecting an Animal on the Survey Trackline
GAM	Generalized Additive Model
GCV	Generalized Cross Validation
GMI	Geo-Marine, Inc.
GOM	Gulf of Maine
JAX/CHASN	Jacksonville-Charleston
km	Kilometer(s)
km^2	Square Kilometer(s)
m	Meter(s)
mg/m^3	Milligram(s) Per Cubic Meter
MMPA	Marine Mammal Protection Act
MRA	Marine Resources Assessment
N	North
NASA	National Aeronautics and Space Administration
Navy	United States Navy
NE	Northeast
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMFS-NEFSC	National Marine Fisheries Service-Northeast Fisheries Science Center
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy OPAREA Density Estimate
OPAREA	Operating Area
PBR	Potential Biological Removal
PO.DAAC	Physical Oceanography Distributed Active Archive Center
PSD	Perpendicular Sighting Distance
RSM	Response Surface Model
S	South
SAR	Stock Assessment Report
SE	Southeast
SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
spp.	Species
SPUE	Sightings Per Unit Effort
SST	Sea Surface Temperature
U.S.	United States
VACAPES	Virginia Capes
W	West

This page intentionally left blank

ACKNOWLEDGMENTS

We thank Dr. Debi Palka with the National Marine Fisheries Service-Northeast Fisheries Science Center (NMFS-NEFSC) and Drs. Lance Garrison and Keith Mullin (NMFS-SEFSC) for providing recent aerial and shipboard survey data used to estimate marine mammal and sea turtle densities. We also thank Dr. Robert D. Kenney with the University of Rhode Island for his expertise in dealing with North Atlantic right whale density estimation. We appreciate all of the assistance and input from Drs. Eric Rexstad, Louise Burt, Len Thomas, Steve Buckland, and David Borchers with the Centre for Research into Ecological and Environmental Modeling (CREEM).

This page intentionally left blank

1.0 INTRODUCTION

The Department of the Navy (DoN) is committed to demonstrating environmental stewardship while executing its national defense mission. DoN is also responsible for compliance with a suite of federal environmental and natural resources laws and regulations, including the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA), and the Endangered Species Act (ESA). In order to comply with these mandates, up-to-date, area-specific marine mammal and sea turtle density estimates for the Operating Areas (OPAREAs) and adjacent regions were the Navy trains are required.

The United States (U.S.) Navy (Navy) Fleet Forces Command contracted Geo-Marine, Inc. (GMI) to prepare a Navy OPAREA Density Estimate (NODE) report for marine mammals and sea turtles found in the Boston, Narragansett Bay, and Atlantic City OPAREAs, collectively known as the Northeast (NE) OPAREAs (**Figure 1-1**). These OPAREAs are referred to as the "Northeast study area" in this report. The goal of the NODE report was to provide a compilation of the most recent data and information on the occurrence, distribution, and density of marine mammals and sea turtles in this area. The goal of this NODE report is to provide a compilation of the most recent data and information on the occurrence, distribution, and density of marine mammals and sea turtles in this area for the purposes of environmental planning and regulatory compliance documentation.

A Marine Resource Assessment (MRA) for the NE OPAREAs (DoN 2005) serves as the foundation reference document upon which this document is built and should be referenced for additional detail on the biology and ecology of each individual species included in this NODE.

Report Organization

This report consists of six chapters:

- *Chapter 1: Introduction* – provides information on the study area, as well as survey coverage;
- *Chapter 2: Methodology* – describes the methods and analytical mechanisms/decisions involved in deriving the density estimates;
- *Chapter 3: Density Estimates* – lists the species and provides relevant distributional ecology information, discusses caveats to density derivations for each species, and presents the density estimates in tabular form, as well as summary statements;
- *Chapter 4: List of Preparers* – lists all individuals who helped prepare the report;
- *Chapter 5: Literature Cited* – lists the literature cited in this report;
- *Appendix A: Spatial Modeling Output* – provides the output used to determine model fit; and
- *Appendix B: Preliminary Northeast NODE report* – presents partially, the methods and results of the preliminary Northeast study area NODE report (DoN 2006).

1.1 LOCATION OF THE NORTHEAST STUDY AREA

The NE study area is located in the western North Atlantic Ocean off the northeastern coast of the U.S. and the southeastern (SE) coast of Canada (**Figure 1-1**). The NE study area encompasses the shelf waters of the northern part of the Mid-Atlantic Bight, from Delaware Bay to the southwestern flank of Georges Bank, all of New England waters to the Canadian border, as well as Canadian waters off New Brunswick and Nova Scotia. The area extends from the high tide line on the shoreline along Cape Cod and Massachusetts bays out to the shelf break (DoN 2005). The area is bound to the south by the warm water, Gulf Stream Current that warms the waters of the Mid-Atlantic Bight, but has little influence on the temperate waters of New England (DoN 2005). Lying adjacent to the study area are the states of Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine, as well as the Canadian provinces of New Brunswick and Nova Scotia. More details regarding the physical environment of the NE study area are found in DoN (2005).

A portion of this area that has garnered a tremendous amount of attention over the past decade is the federally designated North Atlantic right whale (*Eubalaena glacialis*) critical habitat, which encompasses this highly endangered species' feeding grounds in parts of Cape Cod Bay, Stellwagen Bank, and the Great South Channel. This critical habitat overlaps the Boston OPAREA in several locations.

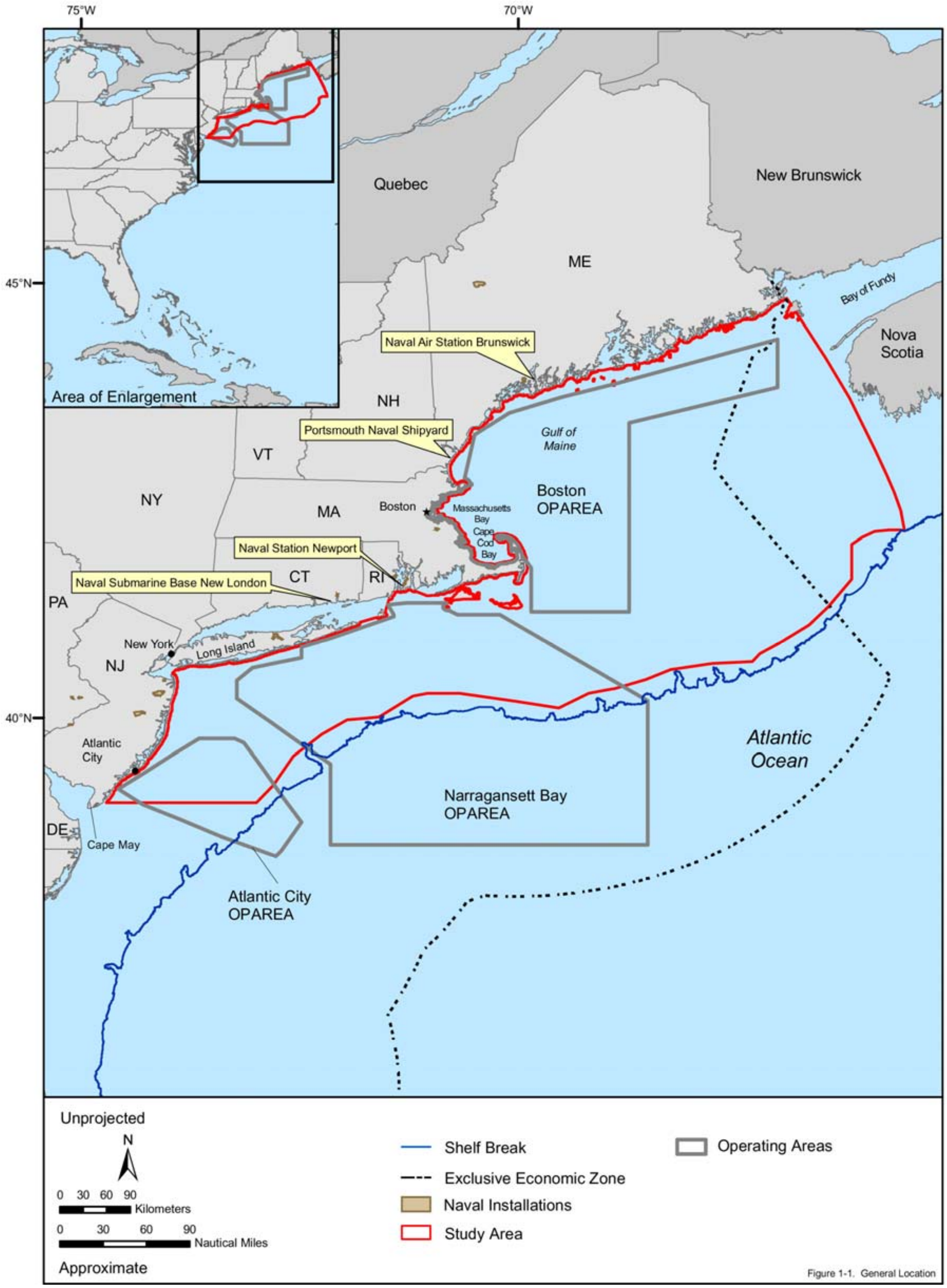


Figure 1-1. The Northeast study area located off the northeastern United States.

2.0 METHODOLOGY

Density estimates for cetaceans were either modeled from data or derived from abundance estimates found in the National Oceanic and Atmospheric Administration (NOAA) stock assessment report (SAR; Waring et al. 2007). **Section 2.2** describes the model-based approach, while **Section 2.6** discusses the process for literature-derived estimates. The approach for density estimation for sea turtles is presented in **Section 2.7.**

2.1 General Introduction

The statistical concept to appreciate in estimating animal abundance or density at small spatial scales is the distinction between model- and design-based approaches. Uncertainty in population assessment can be addressed in either of these two methods. In the design-based approach, predicting the number of animals in areas where surveys (sampling effort) did not occur is taken into account through survey design (e.g., “representative samples”). In a model-based approach, the sampling effort is extrapolated from areas with survey effort to areas of no survey effort using a model.

In this report, we used the model-based approach by constructing a model of animal density and applied that model to regions (and/or seasons) where sampling effort (surveys) did not occur. This approach is not perfect because models are simplifications of the actual biological mechanisms that give rise to animal distribution. However, design-based surveys that apply the usual sampling techniques, such as stratification, cannot provide estimates at the small spatial scales required by the Navy when planning operations.

For the analyses, individual species density estimates were produced for those species with a sufficient number of sightings to create unique detection functions. Individual species density estimates for seasons lacking survey data were “predicted” using the density surface models (DSMs) presented in **Chapter 3**.

<u>Density Estimates</u>

Cetacean abundance in the northeastern U.S. was recently addressed by Palka (2006). Individual species density estimates were produced for those species with a sufficient number of sightings to create unique detection functions. Individual species density estimates for seasons lacking survey data were “predicted” using the density surface models (DSMs) presented in **Chapter 3**. Species with insufficient data were not analyzed using models. These species density estimates were either derived from the SAR and references within that document or other pertinent literature (**Section 2.8**).

2.1.1 Data Used

For this report, all analyses for cetaceans and sea turtles were based on data collected through the National Marine Fisheries Service-Northeast Fisheries Science Center (NMFS-NEFSC) aerial surveys conducted between 1998 and 2005. **Section 2.2** provides details on the surveys.

2.1.1.1 Cetaceans

Only aerial surveys were used to calculate the density estimates for cetaceans in the NE study area. Therefore, all models were based on the regions for which aerial survey data existed. These regions included the continental shelf waters of the NE and portions of the NE OPAREAs.

Only survey data from the NE study area were used to generate the abundance/density estimates (**Section 3.3**). Cetacean density estimates were generated for continental shelf waters only, since only this portion of the study area was covered by the NMFS-NEFSC aerial surveys. Cetacean density estimates for waters past the shelf break are reported in the SE NODE report (DoN 2007b).

2.1.1.2 Pinnipeds

Pinnipeds are rarely sighted during aerial or shipboard line-transect surveys. Abundance/density estimates for pinnipeds are usually based on aerial surveys of coastal haulouts (sites where pinnipeds purposefully come ashore). The density estimates for the two regularly occurring pinniped species in the study area were derived from the most recent Atlantic SAR abundance estimates (Waring et al. 2007) or from scientific literature (Barlas 1999) (**Section 2.8.3**).

2.1.1.3 Sea Turtles

Density estimates for sea turtles were calculated using aerial survey data provided by the NMFS-NEFSC (**Section 2.2**). Estimates were generated for the leatherback turtle, loggerhead turtle, Kemp's ridley turtle, and the group Hardshell Turtles in the same manner as marine mammal species. The species incorporated into the Hardshell Turtles category include green, hawksbill, and unidentified hardshell turtles were pooled together since the numbers of sightings for each species or group were not sufficient to allow spatial modeling. This category did not include leatherback turtles since identification is not difficult. The sea turtle estimates produced are for continental shelf waters only, since only this portion of the study area was covered by aerial surveys.

As with the cetaceans, the turtle estimates produced are for continental shelf waters only, since only this portion of the study area was covered by the aerial surveys. When producing the sea turtle density surface, all aerial survey data from both the NE and SE were used and the surface created extended the entire coastline. However, only data from the NE study area were used to generate the abundance estimates (**Section 3.3**).

2.1.1.4 Age of Data and Annual Variability

All data used for density estimation of cetaceans adhered to the guidelines established by NOAA/NMFS (Wade and Angliss 1997) recommending that no data older than eight years be used to calculate potential biological removal (PBR).

Data used in these analyses were restricted to the seasons/years for which the surveys were conducted. Temporal and spatial variability is to be expected and this is why these data were analyzed using spatial modeling techniques.

2.2 DESCRIPTION OF SURVEY EFFORT IN THE NORTHEAST STUDY AREA

Aerial line-transect surveys conducted by the NMFS-NEFSC in the NE study area provide the on-effort marine mammal and sea turtle sighting data used in this report. For a complete description of the all the surveys, please refer to the source documents listed in **Table 2-1**, brief descriptions of the surveys are found in the MRAs for each of the NE OPAREAs (DoN 2001; 2002a; 2002b; 2007a). Areas of coverage by each survey are depicted in **Figure 2-1.**

2.3 DATA PREPARATION

All datasets received were standardized for uniformity (ensuring variable names and formats matched, etc.) and run through a series of quality assurance steps. Datasets of identical observation platforms (i.e., ship or plane) were combined regardless of year, season, or location for analysis. This was done to provide a more comprehensive view of the overall distribution and relative density of cetaceans and sea turtles throughout the U.S. east coast study areas.

2.3.1 Preparation of the Sighting Data

During the NMFS-NEFSC aerial surveys, up to three separate species were recorded for each sighting event. All sightings were identified to the lowest possible level (species). If identification to species level was not possible, then the observation was not included in the analyses, with the exception of species which fell into the four groups; beaked whales, *Kogia* species (spp.), pilot whales, and Hardshell Turtles.

Table 2-1. List of National Marine Fisheries Service-Northeast Fisheries Science Center (NMFS-NEFSC) aerial survey information used for density estimation for the Northeast study area.

Dates	Source	Platform	Location	Strata covered
1998 18 July and 21 August (**Figure 2-1**)	NMFS-NEFSC (1998)	NOAA Twin Otter Aerial Surveys	Cape Hatteras, NC to Cape Breton Island, Nova Scotia (with additional blocks in La Have/Emerald Basin and Emerald/Western Banks)	Nearshore waters from the coastline to the 73 meter (m) isobath
1999 10 to 29 August (**Figure 2-1**)	NMFS-NEFSC (1999)	NOAA Twin Otter Aerial Surveys	Georges Bank north through the Gulf of Maine (GOM), south to Cape Breton Island, Nova Scotia	GOM, Georges Bank
2002 19 July and 16 August (**Figure 2-1**)	NMFS-NEFSC (2002)	NOAA Twin Otter Aerial Surveys	40 degrees (°) North (N) (just south of Long Island, NY) to the Bay of Fundy (just north of St. John, New Brunswick) and out to 64.5° West (W)	Mid-Atlantic, Georges Bank, GOM, and Scotian Shelf
2004 12 June to 12 July (**Figure 2-1**)	NMFS-NEFSC (2004)	NOAA Twin Otter Aerial Surveys	State border between Virginia and North Carolina (36°N) to the Bay of Fundy (45°N) and from the US Atlantic shoreline to the entrance of the Gulf of St. Lawrence. (58°W)	Mid-Atlantic, Georges Bank, GOM, and Scotian Shelf

2.3.1.1 Seasonal Definitions

Since derived seasonal definitions based on sea surface temperature (SST) can be so disparate between the northern and southern portions of the U.S. Atlantic coastline, the seasons were instead based on three-month periods of time as follows:

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

2.3.1.2 Calculation of Survey Effort

Aerial survey data provided by the NMFS-NEFSC were collected as a series of latitude and longitude points every ten seconds. Survey effort was calculated as the summation of the distance between successive points for each transects line. Each transect line was then used in density calculation of

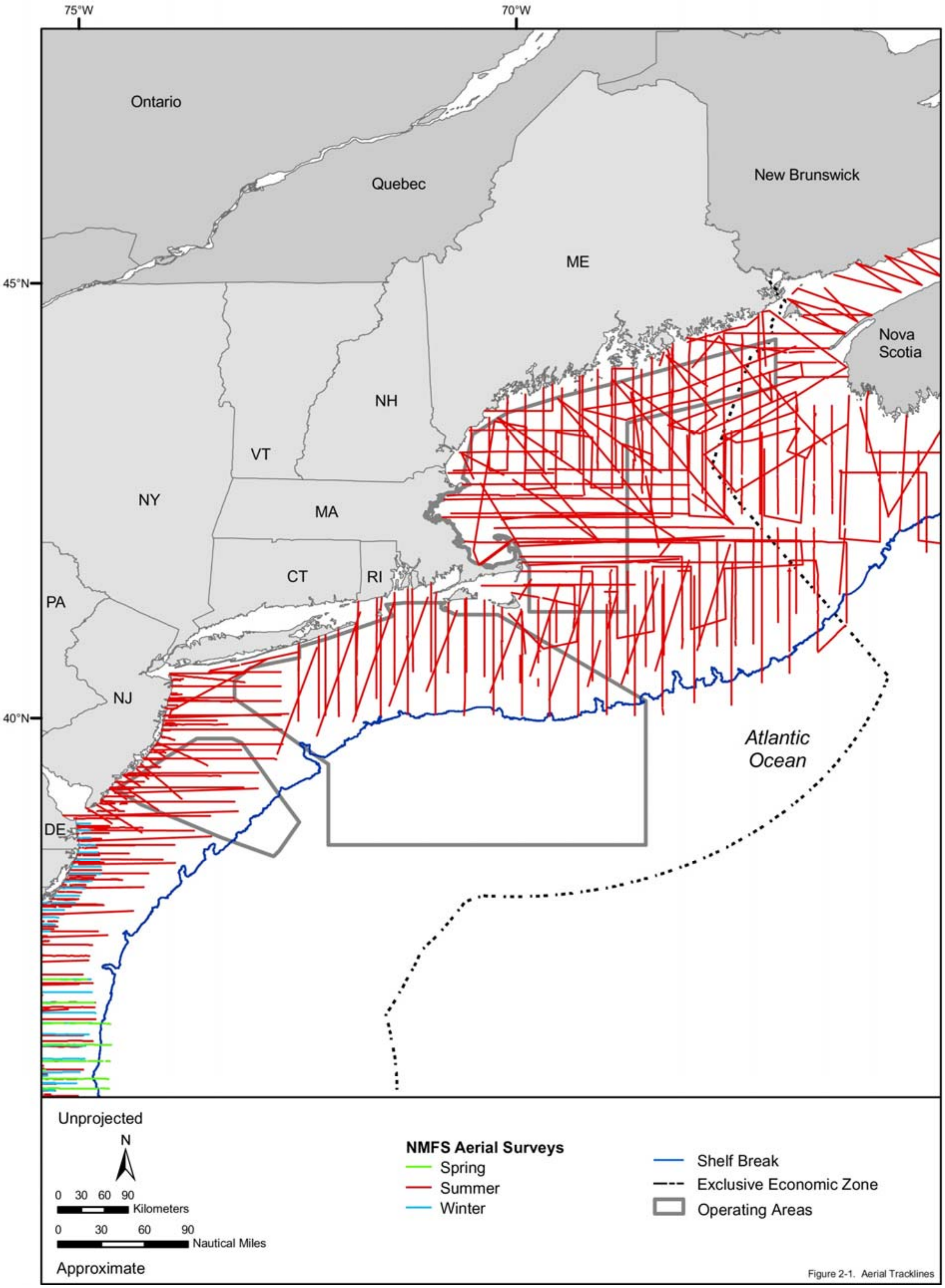


Figure 2-1. Aerial survey effort conducted by the National Marine Fisheries Service (NMFS) in the Northeast study area.

cetaceans in the NE shelf waters or sea turtles along the entire Atlantic coast using the same methods as for shipboard observations.

Only “on-effort” portions of the tracklines conducted in Beaufort sea states (BSSs) ≤4 were used for analyses. “On-effort” means that the observers were in place and actively searching for cetaceans and/or sea turtles and that the observation platform was on its trackline.

2.3.1.3 Calculation of the Perpendicular Sighting Distance

There are two separate methods used for calculating the perpendicular sighting distance (PSD) for sightings: one for ship-based and the other for plane-based (**Figure 2-2**). To calculate the PSD for ship-based sightings, in accordance with Lerczak and Hobbs (1998), the bearing and reticle of the sighting was used in combination with the height of the platform above the water’s surface. A similar, yet simpler method was used for the aerial surveys with angle (θ) or bin (in 10 degree [°] increments) used in combination with the aircraft altitude. For this report, since only aerial survey data were used, the second method was exclusively incorporated for all calculations.

2.4 MODELING FRAMEWORK

The key step in the first phase of modeling line-transect data is partitioning survey effort into segments. Within those segments, estimates of the number of animals within segments are produced that take into account incomplete detectability of animals.

The method of analyzing estimated abundances per segment surveyed was developed by Hedley et al. (1999). Their original application consisted of dividing each transect into small segments, enumerating the area of the segments and the number of animals in each segment. Descriptions of this technique for modeling were expanded upon by Hedley (2000) and Hedley and Buckland (2004). Recent overviews of modeling cetacean detections were published by Ferguson et al. (2006b; 2006a) and Redfern et al. (2006). Briefly, the estimated number of animals per segment was related to the static and dynamic habitat covariates (bottom depth, bottom slope, distance of the sighting from the shelf break, latitude, longitude, SST, and chlorophyll *a* [chl *a*]) by fitting a generalized additive model (GAM; Wood 2006).

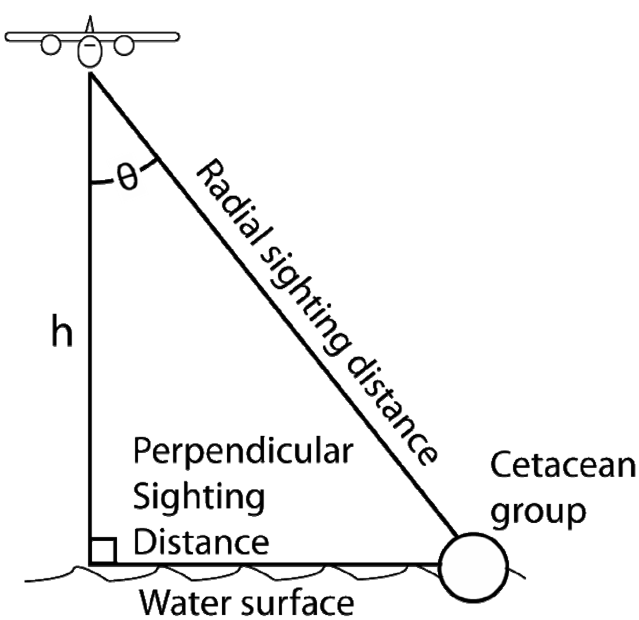


Figure 2-2. Diagram of perpendicular sighting distance (PSD) and other sighting parameters aerial surveys (*θ* = angle between track-line and animal group and h = altitude).

Fitting detection functions to line transect data is thoroughly described by Buckland et al. (2001); this forms the basis of our ability to estimate the probability of detection. We restricted our detection function modeling to the half normal and hazard rate key functions without adjustment terms. We did not explicitly include covariates in the fitting of detection functions; instead we limited our analyses to detections made in BSSs ≤4.

We combined all surveys, regardless of season or location, to provide the greatest possible number of sightings. By combining surveys, we were able to increase the number of sightings for all species. When possible, individual detection functions were estimated for species with 30 or more sightings. In some cases, species with few sightings were pooled into larger groups prior to analysis.

After fitting GAMs to the survey data, the resulting DSM is applied to a prediction grid superimposed upon the U.S. east coast study areas. In this way, animal density can be predicted in regions of the U.S. east coast study areas where little survey effort was conducted. The resulting values are prediction grid cell-specific densities that are depicted in the remainder of this report. Because survey data were largely only available for summer, the species/group density estimates for those seasons were predicted using only the survey data from that particular season. Density estimates for seasons without survey data were generated using all survey data available, regardless of season, and using only the static covariates (bottom depth, bottom slope, distance of the sighting from the shelf break, latitude, and longitude) for the models.

2.5 Steps in Density Surface Modeling (DSM) of Line Transect Data

After all shipboard or aerial survey data were manipulated as described in **Section 2-8**, the following iterative steps were used to estimate the abundance, and subsequent density, of cetaceans and sea turtles in the U.S. east coast study areas:

- I. Survey data segmentation (program SAS®)
- II. Detection function modeling (program DISTANCE)
  - a. Diagnostics and model selection
  - b. Interpretation of program DISTANCE output
- III. Data preparation of covariates for the DSM (program MATLAB®)
  - a. Import of remotely sensed data (dynamic variables; SST and chl *a*)
  - b. Import of static variables (bottom depth, bottom slope, distance from shelf break, latitude, and longitude)
  - c. Define study area boundaries
- IV. DSM modeling (GAM; programs R and MATLAB®)
  - a. Diagnostics and model selection
  - b. Significance of covariates
  - c. Deviance explained
  - d. Generalized Cross Validation (GCV) score
  - e. Density estimate evaluation
- V. DSM prediction (programs DISTANCE and R)
  - a. Density estimation at the study area level
  - b. Extrapolate to areas/seasons where survey data were not collected
- VI. Density estimation at smaller scales
  - a. Seasonal estimates
  - b. Area specific estimates
- VII. Measures of precision
  - a. Variance estimation
  - b. Bootstrap samples

<u>Estimating Bias - *g(0)*</u>

The probability of detecting an object that is on a transect line is very important to generating reliable abundance estimates. A *g(0)* value of 1 indicates that 100 percent (%) of the animals are detected; it is rare that this assumption holds true. Departures of *g(0)* from 1 can be attributed to either a) perception bias (when observers fail to detect an animal on the trackline), or b) availability bias (from animals being submerged while on the trackline and unable to be detected). Various factors are involved in estimating *g(0)*, including: sightability/detectability of the animal (species-specific behavior, school size, blow characteristics, dive characteristics, and dive interval); viewing conditions, (sea state, wind speed, wind direction, sea swell, and glare); observers (experience, fatigue, and concentration), and platform characteristics (pitch, roll, yaw, speed, and height above water). Thomsen et al. (2005) provides a complete and recent discussion of *g(0)*, factors which affect the detectability of the animals, and current thoughts on how to account for detection bias. Failure to address *g(0)* results in abundance and/or density estimates which are biased and underestimated.

For the purpose of this report, we assumed *g(0)* = 1. This is an unrealistic assumption for many of the species addressed in this report, particularly those with long dive times (i.e., beaked whales and the sperm whale) or that are difficult to detect as a result of their size or behavior (i.e., minke whale and harbor porpoise). However, estimates of *g(0)* were not calculated during the surveys which our analyses were based. As stated above, by assuming *g(0)* = 1 for these analyses, the abundance and density estimates for most of the species are underestimated. The magnitude of the bias is species-, area-, and platform-specific. The magnitude of *g(0)* variation is provided in a table of *g(0)* values from various areas, methods of calculations, and platforms for each of the species addressed in this report (**Table 2-2**).

2.6 SPATIAL MODELING DATA MANIPULATION

2.6.1 Segmentation Process

To calculate density estimates using spatial modeling, it was necessary to parse the survey data into segments. When producing the segments, the goal was to have at least 15% of the segments contain one or more sightings. To determine the approximate segment length for each species or species group, the following equation was used:

$$l_S = \frac{E \cdot 0.15}{n_s} \quad \text{(Equation 1)}$$

where E = the total amount of effort in kilometers (km) for all surveys; n_s = the total number of sightings of the species or species group in question; and l_s = the approximate length of each segment. For some of the less- frequently observed species or species groups, this approach resulted in excessive segment lengths. In these cases, the segment length was limited to 60 km. The effort during each day of each survey was then divided into segments based on the calculated segment length. If the remainder of effort left over at the end of the day was less than half the approximate segment length, then it was added to the last segment created. Otherwise, if the leftover effort was greater than the approximate segment length, it became a new segment.

2.6.2 Covariate Data

Incorporating Remotely Sensed Data—Remotely sensed data, including SST and chl *a*, were combined with the survey data based on the appropriate latitude, longitude, and season, to allow for species/group density estimation in each season. For the aerial surveys, bottom depth was also applied in a similar manner, because it was not collected during the actual surveys.

Remotely Sensed Data Sources—Maps of SST were created from data available through the Physical Oceanography Distributed Active Archive Center (PO.DAAC) that is sponsored jointly by the National Aeronautics and Space Administration (NASA) and the NOAA (Goddard DAAC 1986). Sea surface temperature (SST) data were compiled from weekly averaged Advanced Very High-Resolution Radiometer (AVHRR) version 5.0 satellite data, which contain multi-channel SST pixel data (NASA 2000). Seasonal averages of chl *a* concentrations were compiled from monthly averaged Sea-viewing Wide Field-of-view Sensor (SeaWiFS) project data to provide a proxy for primary productivity along the U.S. Atlantic coast (NASA 1998).

SST and Seasonal Delineation—Data from 1998 to 2005 for the U.S. east coast study areas were extracted from the global SST dataset (NASA 2000). The pixel values were converted to SST values using the following function:

$$\text{SST (° Celsius [C])} = (0.075 \cdot \text{DN}) - 3.0 \qquad \text{(Equation 2)}$$

where, DN = pixel value. The analysis was performed using a custom application developed with the MATLAB® software package.

The grid-cell size for the seasonal SST data was four square kilometers (km^2). The range of SST values for the U.S. Atlantic coast study areas were associated with a color spectrum grading from blue to red that represents cooler to warmer SST (°C), respectively.

Chl—Pixel data for the study area and vicinity from 1998 to 2005 were extracted and converted to chl *a* values using MATLAB® and the following function:

$$\text{Chl } a\ (\text{mg/m}^3) = 10^{(\text{DN} \cdot 0.015) - 2.0} \qquad \text{(Equation 3)}$$

where DN is the pixel value.
The chl *a* data were parsed into seasons, and the 9 km^2 grid cell size was interpolated down to 4 km^2, to produce the same grid size as SST. The seasonal range of chl *a* concentrations (in milligrams per cubic meter [mg/m^3]) is visualized in figures as a color spectrum, with chl *a* concentrations increasing from blue to red.

Bathymetry—For each prediction grid cell, bottom depth was queried from NOAA's bathymetry data for the centroid of each grid cell using 30 arc second bathymetry data (Smith and Sandwell 1997; NOAA 1999; 2001). These values, as well as SST, chl *a*, latitude, and longitude were used in the GAM within the program DISTANCE.

Prediction Grid Development—The prediction grid area was defined by the area between a 3 km coastline buffer and the exclusive economic zone (EEZ), extending from the U.S./Canada border to approximately Cape Canaveral, Florida. All survey data used here fell within the defined area. Prediction grids were formatted in a flat file format for import into the program DISTANCE, with each latitude and longitude point having an assigned depth, slope, distance from shelf break, SST, and chl *a* value.

Grid Size Determination— Prediction grids with approximately 10 km^2, 20 km^2, and 40 km^2 grid cell sizes were developed. The optimal grid cells size was determined for each species based on segment length.

DSM Output Review—The DSM estimates of density for each cell in the prediction grid were imported and displayed using custom applications developed with MATLAB. The gridded output was smoothed via linear interpolation and plotted using a color scale to visualize the model results. On effort sightings were overlaid on the density surface for visual reference and comparison. Total density estimates based on the DSM were compared to published density values to ground truth that the model was within reason.

2.7 DENSITY SURFACE MODEL SELECTION

One hundred fifty-nine combinations of the dynamic and static covariates were fitted to segment-specific estimated abundance. From these combinations, the five best models (chosen by the program DISTANCE based on the GCV score) were evaluated for the following criteria: significance of each smooth variable; total deviance explained; GCV score; and density estimate. Lower GCV scores indicate a better fit of the DSM. If a variable in the model was determined to not be significant, the variable was excluded and the model rerun to determine if the resulting GCV score was lowered. If the GCV score decreased, the variable was left out of the DSM. On occasion, the deviance explained was extremely high (>80%), and it was necessary to further evaluate the model based upon the density estimate. In most cases, these high levels of deviance explained resulted in extremely high density estimates (infinity in

Table 2-2. Range of estimates for *g(0)* for each cetacean species found in the Northeast study area that have density estimates provided. These numbers were either determined by the source or applied by the source for abundance/density estimation analyses in the particular geographic location.

g(0)	Location	Platform	Source
Threatened/Endangered Cetacean Species			
Right whale (*Eubalaena* spp.)			
0.29-1.00	U.S. Atlantic Coast	Shipboard	(Palka 2006)
0.19-0.29	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.95	U.S. West Coast	Aerial	(Forney et al. 1995)
Humpback (*Megaptera novaeangliae*)			
0.19-0.21	U.S. Atlantic Coast	Shipboard	(Palka 2005b)
0.90-1.00	U.S. West Coast	Shipboard	(Barlow 1995; Calambokidis and Barlow 2004)
0.95	U.S. West Coast	Aerial	(Forney et al. 1995)
0.26	Hawaii	Aerial	(Mobley et al. 2001)
Fin whale (*Balaenoptera physalus*)			
0.32-0.94	U.S. Atlantic Coast	Shipboard	(Blaylock et al. 1995; Palka 2006)
0.19-0.29	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.90-1.00	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.95-0.98	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
0.90-1.00	Hawaii	Shipboard	(Barlow 2003a)
Sperm whale (*Physeter macrocephalus*)			
0.28-0.57	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.19-0.29	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.53-1.00	U.S. West Coast	Shipboard	(Barlow 1995; Barlow and Gerrodette 1996; Barlow and Sexton 1996; Barlow 2003b; Barlow and Taylor 2005)
0.95-0.98	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
0.87	Hawaii	Shipboard	(Barlow 2003a, 2006)
0.32	Antarctic	Shipboard	(Kasamatsu and Joyce 1995)
Non-Threatened/Non-Endangered Cetacean Species			
Minke whale (*Balaenoptera acutorostrata*)			
0.31-0.70	U.S. Atlantic Coast	Shipboard	(Blaylock et al. 1995; Palka 2006)
0.19-0.29	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.25-0.90	Eastern North Atlantic	Shipboard	(Butterworth and Borchers 1988; Øien 1990; Schweder et al. 1991; Schweder and Høst 1992; Schweder et al. 1992; Schweder et al. 1997; Skaug and Schweder 1999; Skaug et al. 2004)
0.84	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.95-0.98	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
0.63-0.83	Antarctic	Shipboard	(Doi et al. 1982; IWC 1982, 1983)

Table 2-2. Continued.

g(0)	Location	Platform	Source
Non-Threatened/Non-Endangered Cetacean Species (*continued*)			
***Kogia* spp.**			
0.29-0.55	U.S. Atlantic Coast	Shipboard	(Palka 2006)
0.19-0.79	U.S. West Coast	Shipboard	(Barlow 1995; Barlow and Sexton 1996; Barlow 1999, 2003b)
0.35	Hawaii	Shipboard	(Barlow 2003a, 2006)
Ziphiidae (beaked whales)			
0.46-0.51	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.19-0.21	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.13-1.00	U.S. West Coast	Shipboard	(Barlow 1995; Barlow and Sexton 1996; Barlow 1999; Carretta et al. 2001; Barlow 2003b; Barlow et al. 2006)
0.23-0.45	Hawaii	Shipboard	(Barlow 2003a, 2006)*
0.27	Antarctic	Shipboard	(Kasamatsu and Joyce 1995)
0.95-0.98	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
Bottlenose dolphin (*Tursiops truncatus*)			
0.62-0.99	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.58-0.77	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.74-1.00	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.67-0.96	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
0.74-1.00	Hawaii	Shipboard	(Barlow 2003a, 2006)
Spinner dolphin (*Stenella longirostris*)			
0.61-0.76	U.S. Atlantic Coast	Shipboard	(Palka 2006)
0.77-1.0	U.S. West Coast	Shipboard	(Barlow 2003b)
0.77-1.0	Hawaii	Shipboard	(Barlow 2003a, 2006)
Pantropical spotted dolphin (*Stenella attenuata*)			
0.37-0.94	U.S. Atlantic Coast	Shipboard	(Palka 2006)*
0.77-1.00	U.S. West Coast	Shipboard	(Barlow 2003b)
0.76-1.00	Hawaii	Shipboard	(Barlow 2003a, 2006)
Atlantic spotted dolphin (*Stenella frontalis*)			
0.37-0.94	U.S. Atlantic Coast	Shipboard	(Palka 2006)**
Striped dolphin (*Stenella coeruleoalba*)			
0.61-0.77	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.77-1.00	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.76-1.00	Hawaii	Shipboard	(Barlow 2003a, 2006)
Common dolphin (*Delphinus delphis*)			
0.52-0.95	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.58-0.77	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.79-0.81	Eastern North Atlantic	Shipboard	(Cañadas et al. 2004)
0.77-1.0	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.67-0.96	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)

Table 2-2. Continued.

g(0)	Location	Platform	Source
Non-Threatened/Non-Endangered Cetacean Species (*continued*)			
White-sided dolphin (*Lagenorhynchus acutus and L. obliquidens*)			
0.27-0.38	U.S. Atlantic Coast	Shipboard	(Palka 2006)
0.58-0.77	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.77-1.00	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.67-0.96	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
Risso's dolphin (*Grampus griseus*)			
0.51-0.84	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.58-0.77	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.74-1.00	U.S. West Coast	Shipboard	(Barlow 1995, 2003b)
0.67-0.96	U.S. West Coast	Aerial	(Forney and Barlow 1993; Forney et al. 1995)
0.74-1.00	Hawaii	Shipboard	(Barlow 2003a, 2006)
Killer whale (*Orcinus orca*)			
0.90	U.S. West Coast	Shipboard	(Barlow 2003b)
0.95-0.98	U.S. West Coast	Aerial	(Forney et al. 1995)
0.90	Hawaii	Shipboard	(Barlow 2003a, 2006)
0.96	Antarctic	Shipboard	(Kasamatsu and Joyce 1995)
Pilot whale (*Globicephala* spp.)			
0.48-0.67	U.S. Atlantic Coast	Shipboard	(Palka 2005b; Palka 2006)
0.19-0.29	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.74-1.00	U.S. West Coast	Shipboard	(Barlow 2003b)
0.74-1.00	Hawaii	Shipboard	(Barlow 2003a, 2006)
0.93	Antarctic	Shipboard	(Kasamatsu and Joyce 1995)
Harbor porpoise (*Phocoena phocoena*)			
0.35-0.73	U.S. Atlantic Coast	Shipboard	(Palka 1995; Palka 1996; Palka 2006)
0.24-0.49	U.S. Atlantic Coast	Aerial	(Palka 2005a)
0.41-0.71	Eastern North Atlantic	Aerial	(Grünkorn et al. 2005)
0.08-0.85	U.S. West Coast	Aerial	((Barlow et al. 1988; Calambokidis et al. 1993a; Forney et al. 1995; Laake et al. 1997; Carretta et al. 2001; Carretta et al. 2007))
0.54-0.79	U.S. West Coast	Shipboard	(Calambokidis et al. 1993b; Barlow 1995; Carretta et al. 2001)

* per Barlow (2006), Longman's beaked whale (*Indopacetus pacificus*) is not included in Ziphiidae for estimation of g(0) due to its more similar behavior to pilot whales

** g(0) provided for collective grouping of the 2 spotted dolphin species

most cases), likely due to edge effects (an unchecked upward or downward trend in the model that extends beyond the observed data to the edge of the coverage area resulting in artificially high or low estimates of abundance and density). The concept of parsimony (using the fewest predictors to adequately describe the response) was invoked to assist in the model selection. As each variable introduced into the model adds to the uncertainty, models with fewer predictors are preferred. In addition, utilizing too many parameters can result in "connect-the-dots" curve-fitting and little predictive power beyond the observed responses. Therefore, once the models examined had been reduced to a subset in which the scores on all criteria were in agreement, and thereby predicted the best fit, the model with the fewest significant covariates was selected.

Variance Estimation

For design-based estimators of abundance, variance can be calculated analytically. However, using the model-based estimates of abundance with GAM methods, obtaining an analytic expression for variance was impractical. Robust estimates of variance can be obtained by employing appropriate resampling techniques. Parametric bootstrapping was used to estimate the variance in the density estimates obtained in this study. The form of parametric bootstrap was a moving window (Efron and Tibshirani 1993), that shuffled residuals from the fitted density surface model among segments within transects (Burt, M.L., University of St Andrews, pers. comm., August 2006). A sampling unit is defined to be a block of *m* consecutive segments, thus, the first block is defined by the first *m* segments in a transect. The block then moves on one, so that the first segment is dropped and another one added and so on to the end of the series. Blocks of segments are then chosen at random, with replacement from all possible blocks in a transect and pasted back together to create a bootstrap sample. The advantage of this method is that by carefully choosing the block size, observations more than *m* segments apart will be independent, and the correlation present in segments less than *m* units apart will be retained. However, the observations in the marine mammal surveys cannot be moved around at random as in the application to time series because they are associated with explanatory variables. However, residuals, rather than the detections, can be moved around at random. Thus, blocks of residuals were chosen at random and with replacement, and bolted back onto the original data to create the bootstrap sample and thus preserving the spatial coverage of the original surveys.

Given the bootstrap samples, the model selected for the original data is refit to obtain species density estimates from each pseudosample. The sample variances of these estimates provide the bootstrap estimates of the components of variance from the spatial modeling. The component of variance related to detection probability in the count model must then be incorporated to obtain the overall variance estimates of density. The delta method (see Seber 1982) was used to combine both components of variance in the density estimation.

The bootstrapping technique assesses the overall precision of the fitted response surface model (RSM) to any given response variable (e.g., number of animals within a segment), operating as though the number of animals within a given transect segment is known. However, in the case here, the number of animals within a segment is not known, but rather was estimated applying a Horwitz-Thompson-like estimator, using the detection function selected for each species. The second step of the variance calculations takes into account the uncertainty of estimating the number of animals within a segment (attributable to estimation of the parameters of the detection function).

Bootstrapping was repeated 499 times. Bootstrap estimates were then ordered from largest to smallest and the quantiles corresponding to 95% end points of the distribution of bootstrap estimates were reported (Buckland et al. 2001).

Models Were Not All Inclusive

Real-time oceanographic data are preferable for constructing DSM. However, these data were: not available for all cruises; were not available for all cells of the prediction grid (which covers the entire U.S. Atlantic Coast); and would require extensive post-processing time. Instead, our DSMs used some remote sensed data, including SST and chl *a*. Problems can arise with using these types of data, because they are not correlated directly with each individual sighting. The five covariates considered during the modeling process included SST, chl *a*, bottom depth, latitude, and longitude. SST and chl *a* were used as two dynamic covariates in the modeling. The static covariates were bottom depth, latitude, and longitude. SST and chl *a* were generated by averaging each of the values across three months.

Various researchers have worked on habitat modeling and animal distribution in recent years (e.g., Baumgartner 1997; Combs 2005; Ward et al. 2005; Barlow 2006; Ferguson et al. 2006b; Kaschner et al. 2006; Redfern et al. 2006). These studies have used several other covariates including zooplankton biomass, bottom slope, thermocline depth, distance from shore, sea surface height, and prey resources. While these additional variables would certainly improve our density estimates, the purpose of this project was to estimate densities, and not to generate comprehensive habitat models. Due to time constraints, we were unable to fully investigate all potential environmental and biological variables that may influence animal distribution. Our DSMs were limited to data which were readily obtainable and required minimal processing. While this is not optimal, it is practical, and it is the first attempt to model animal densities in the NE study area. It is meant to act as a working tool to assist the Navy in compliance with environmental mandates and will serve as the basis for future modeling work.

2.8 In the Absence of a Spatial Model

For several species, there were not enough sightings to be able to produce a density surface using the program DISTANCE. Three approaches to derive density estimates were adopted during these instances and are described below. We have included the methods and density estimates from the preliminary NE NODE report (DoN 2006) as **Appendix B** for ease of reference within this document.

2.8.1 Northeast Navy Operating Area Density Estimates (NODE) by Strata

When a density surface could not be generated for a given species or species group based on the shipboard and aerial surveys for the waters of the NE study area, density estimates provided by the preliminary NE NODE report (DoN 2006) (**Appendix B**) based on traditional-line transect estimation methods were used. For further explanation of the methods and definitions of the geographic strata used, see **Appendix B**. The species for which density estimates were derived from the previous NE NODE report (DoN 2006) are the sei whale, sperm whale, *Kogia* spp., Beaked Whales, bottlenose dolphin, Spotted Dolphins, striped dolphin, Risso's dolphin, and Pilot Whales.

2.8.2 Exception to the Rule

The North Atlantic right whale was the primary species needing this approach. The approach for handling right whales was to take the abundance estimate of 396 animals (NARWC 2006) and divide that among the four different quartiles from the occurrence polygons found in the NE MRA (DoN 2005). This was under the assumptions that: 1) 75% of the population was found in the NE study area during spring, summer, and fall and that 50% of the population remained there during the winter; and 2) that each quartile represented 25% of the population found in the area at a given time. Therefore, given these assumptions, density estimates were derived for each season by dividing the number of animals assumed to be in each of the quartile regions by the total area (km^2) of that quartile. Regardless of the sizes of the areas for which abundance estimates are provided, the estimate never exceeds 396 animals. The density estimates from Hain and Kenney (2005c; 2005a; 2005b) were used for each of the three SE OPAREAs of Virginia Capes (VACAPES), Cherry Point (CHPT), and Jacksonville-Charleston (JAX/CHASN) (the VACAPES density estimates were extended up to approximately the New York/New Jersey border) and portions of the NE OPAREAs (Boston, Narragansett Bay and Atlantic City).

2.8.3 Density Estimate Calculations for Pinnipeds

Since pinnipeds are rarely sighted during aerial or shipboard line-transect surveys, density estimates for the two pinniped species regularly occurring in the study area, the harbor seal and the gray seal, could not be calculated using survey data from the NMFS-NEFSC. Pinniped abundance estimates are usually based on aerial surveys of coastal haulouts (sites where pinnipeds purposefully come ashore). The density estimates for the two regularly occurring pinniped species in the study area were derived from the most recent Atlantic SAR abundance estimates (Waring et al. 2007) or from the scientific literature (Barlas 1999).

2.8.3.1 Harbor Seal

The SAR provided a land-based abundance estimate of the number of harbor seals along the coast of Maine during the most recent aerial surveys of haulout sites conducted in May and June of 2001 (Waring et al. 2007). The SAR abundance estimate for Maine includes a correction applied to account for the number of seals in the water in addition to those counted on land. Based on the strata used in DoN (2006), the Gulf of Maine (GOM) North and the GOM Central strata together encompass the entire shoreline of Maine. The total combined area of these strata (Palka 2006) (the abundance estimate provided in the SAR was used to calculate the density estimate (Equation 2.1 in **Appendix B**) for the harbor seal in Maine's waters. The resulting density estimate was applied to all seasons for the GOM North and Central strata as harbor seals occur year-round in Maine's coastal waters.

Although harbor seals also occur within the GOM South, Georges West, Georges Central, and Mid-Atlantic spatial strata, this species only occurs seasonally (fall through spring) and in a southward pattern of rapidly declining abundance from the eastern U.S. population center in Maine (Katona et al. 1993). Applying the SAR-derived density estimate to these strata would have overestimated the number of seals occurring in this region both spatially and seasonally. An alternative abundance from Barlas (1999) was used to derive a density estimate for the coastal strata south of GOM Central. All the coastal haulouts from the New Hampshire/Massachusetts region to eastern New York were enumerated by aerial survey during one tidal cycle in winter (9 February) 1999 (Barlas 1999). The resulting relative abundance was used with the combined areas (Palka 2006) of the GOM South, Georges Central, and Georges West strata to derive a density estimate (Equation 2.1 in **Appendix B**). This estimate was applied to fall, winter, and spring. The Barlas-derived density estimate was also applied to the collapsed Mid-Atlantic fall, winter, and spring strata. No density estimates are associated with the summer strata for the Georges West, Georges Central, and Mid-Atlantic strata as harbor seals do not occur in these waters during this season. However, the Barlas-derived density estimate was applied to the GOM South summer stratum to account for the recent reports that late spring to early summer pupping is occurring in Cape Cod Bay (Gilbert et al. 2005).

Although the Barlas-derived estimate is not ideal, as it was based on a relative abundance uncorrected for the number of seals not hauled out (i.e., remaining in the water), the estimate represents the best available and most representative density for the waters of the coastal strata south of Maine.

2.8.3.2 Gray Seal

Land-based abundance estimates for gray seals were presented in the NOAA SAR for two regions within the study area (Waring et al. 2007); estimates of relative abundance provided the number of gray seals hauled out during aerial surveys of the southern Massachusetts haulout sites around Muskeget and Monomoy Islands during March 1999 and of coastal Maine haulouts during May 2001. The gray seal counts used in the NOAA SAR for both regions should be considered minimum or relative abundances since the counts are uncorrected for the number of seals in the water and not ashore.

Although the Georges West stratum encompasses Muskeget and Monomoy Islands, the Monomoy Islands are in such close proximity to the border of the Georges Central stratum that the total areas (Palka 2006) of both strata were combined for use in the density calculation. The combined areas and the Massachusetts SAR abundance were used to calculate the spring density, which was applied to all seasons of both the Georges West and Georges Central strata since gray seals occur year-round in the waters off southern Massachusetts.

The number of gray seals in Maine waters was derived using the total combined areas (Palka 2006) of the GOM North and GOM Central strata as well as the spring 2001 abundance estimate for Maine that was provided in the NOAA SAR. As gray seals are found in the coastal waters of Maine year-round, the derived density estimate for spring was applied to all seasons of GOM North and Central. The same NOAA SAR-derived spring density was also applied to the collapsed seasons of GOM South. Gray seals occur year-round in the coastal waters of eastern Massachusetts, but not in the higher numbers associated with the preferred breeding sites around Muskeget and Monomoy islands off southern Massachusetts (Barlas 1999).

2.8.4 No Estimates Provided

For some species or species groups, there was no density estimate available at all or it was not possible to derive one based on the available abundance estimates.

This page intentionally left blank

3.0 DENSITY ESTIMATES

There are 40 marine mammal species that may occur in the NE study area: 33 cetacean species, 6 pinniped species, and 1 sirenian species (DoN 2005). Due to a lack of sufficient survey data, of the 39 marine mammal species, only 14 species and 4 species groups (*Kogia* spp., Beaked Whales, Spotted Dolphins, Pilot Whales) are covered within this report (**Table 3-1**). This is due 1) to the lack of sufficient observations of the remaining species during the surveys conducted by the NMFS-NEFSC used to develop the density and abundance estimates for this report, and 2) the lack of an abundance estimate from which to derive a density estimate either from the SAR or the literature.

Density estimates for cetaceans were either modeled from data or derived from abundance estimates found in the NOAA SAR (Waring et al. 2007). **Section 2.2** describes the model-based approach, while **Section 2.5** discusses the process for literature-derived estimates. Density/abundance estimates for the North Atlantic right whale were derived in consultation with Dr. Robert Kenney (University of Rhode Island; **Section 2.5**). The density estimates for the two regularly occurring pinniped species in the study area were derived from the most recent abundance estimates in the NOAA SAR (Waring et al. 2007) or from scientific literature (Barlas 1999).

There are seven marine mammal species (five cetacean and two pininped species) with documented or expected occurrence in the NE study area for which abundance/density estimates are not available (See **Table 3.1**)

There are also five sea turtle species with occurrence records within the study area (DoN 2005) and addressed within this report (**Table 3-1**).

Basic habitat preference and distribution information is presented here for each species (or group) to provide relevant information as it relates to density estimation. For a detailed description of the marine mammal species and groups, as well as the sea turtle species presented in this report, their status, habitat preferences, distribution, behavior and life history, and information on acoustics and hearing, please refer to the NE OPAREAs MRA (DoN 2005). In addition to the basic habitat preference and distribution information, the abundance estimates and density surfaces are provided here as well. The results of the models used to generate the abundance estimates and the density surfaces for each species are contained in the **Appendix A**. A summary of the abundance estimates (model-based or literature-derived) for each species considered in this report can be found in **Tables 3.2** and **3.3**.

This section begins with those species with model-based density estimates (**Section 2.4**), followed by those with SAR-derived estimates (**Section 2.8**), ending with those marine mammal species listed in the SAR that could occur in the NE study area and have literature-derived estimates (**Section 2.8**).

Spatial modeling output used to determine model-fit is found in the **Appendix A**. All density estimates (model or SAR-derived) can be found in **Table 3.2**.

Table 3-1. Marine mammal and sea turtle species (or groups) found in the Northeast Study Area for which density estimates are provided. Naming convention matches that used by the National Marine Fisheries Service (NMFS).

<u>Threatened/Endangered Cetacean Species</u>	
North Atlantic right whale[2]	*Eubalaena glacialis*
Humpback whale[1]	*Megaptera novaeangliae*
Sei whale[3]	*Balaenoptera borealis*
Fin whale[1]	*Balaenoptera physalus*
Blue whale[4]	*Balaenoptera musculus*
Sperm whale[3]	*Physeter macrocephalus*
<u>Non-Threatened/Non-Endangered Cetacean Species</u>	
Minke whale[1]	*Balaenoptera acutorostrata*
***Kogia* spp.**[3]	
Pygmy sperm whale	*Kogia breviceps*
Dwarf sperm whale	*Kogia sima*
Beaked Whales[3]	
Cuvier's beaked whale	*Ziphius cavirostris*
True's beaked whale	*Mesoplodon mirus*
Gervais' beaked whale	*Mesoplodon europaeus*
Sowerby's beaked whale	*Mesoplodon bidens*
Blainville's beaked whale	*Mesoplodon densirostris*
Northern bottlenose whale	*Hyperoodon ampullatus*
Bottlenose dolphin[3]	*Tursiops truncatus*
Spotted Dolphins[3]	
Atlantic spotted dolphin	*Stenella frontalis*
Pantropical spotted dolphin	*Stenella attenuata*
Spinner dolphin[4]	*Stenella longirostris*
Striped dolphin[3]	*Stenella coeruleoalba*
Common dolphin[1]	*Delphinus delphis*
Atlantic white-sided dolphin[1]	*Lagenorhynchus acutus*
White-beaked dolphin[4]	*Lagenorhyncus albirostris*
Risso's dolphin[3]	*Grampus griseus*
Pygmy killer whale[4]	*Feresa attenuata*
Killer whale[4]	*Orcinus orca*
Pilot Whales[3]	
Long-finned pilot whale	*Globicephala melas*
Short-finned pilot whale	*Globicephala macrorhynchus*
Harbor porpoise[1]	*Phocoena phocoena*
<u>Pinniped Species</u>	
Gray seal[3]	*Halichoerus grypus*
Harbor seal[3]	*Phoca vitulina*
Harp seal[4]	*Pagophilus groenlandicus*
Hooded seal[4]	*Cystophora cristata*
<u>Sea Turtles</u>	
Kemp's ridley turtle[1]	*Lepidochelys kempii*
Leatherback turtle[1]	*Dermochelys coriacea*
Loggerhead turtle[1]	*Caretta caretta*
Hardshell Turtles[1]	
Green turtle	*Chelonia mydas*
Hawksbill turtle	*Eretmochelys imbricata*
Loggerhead turtle	*Caretta caretta*
Kemp's ridley turtle	*Lepidochelys kempii*
Unidentified hardshell turtle	(does not include Leatherback)

[1] Indicates species for which density estimates were derived through spatial modeling of NMFS-NEFSC survey data
[2] Please refer to **Section 2.8.2** of the Methodology for an explanation on how these estimates were derived
[3] Estimates taken from DoN (2006)
[4] No density estimate was provided

Table 3-2. Seasonal estimates of abundance for marine mammals and sea turtles in the Northeast Study Area. Both model-based estimates and those based on the preliminary Northeast NODE report (DoN 2006) are presented.

Species/Species Group	Spring	Summer	Fall	Winter
Model-Derived Abundance Estimates[1]				
Humpback whale (*Megaptera novaeangliae*)	250	250	250	250
Fin whale (*Balaenoptera physalus*)	346	346	346	346
Minke whale (*Balaenoptera acutorostrata*)	175	175	175	175
Common dolphin (*Delphinus delphis*)	13,061	13,061	13,061	13,061
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	23,489	23,489	23,489	23,489
Harbor porpoise (*Phocoena phocoena*)	11,711	10,208	11,711	11,711
Leatherback turtle (*Dermochelys coriacea*)	242	214	242	242
Kemp's ridley turtle (*Lepidochelys kempii*)	1,134	1,134	1,134	1,134
Loggerhead turtle (*Caretta caretta*)	1,085	1,467	1,085	1,085
Hardshell Turtles	1,227	1,425	1,227	1,227
Design-Based (DoN 2006) Abundance Estimates[2]				
Sei whale (*Balaenoptera borealis*)	1,056	659	209	432
Sperm whale (*Physeter macrocephalus*)	611	1,504	5,579	3,005
Kogia spp.	85	85	85	85
Beaked Whales (Family Ziphiidae)	381	1,339	367	380
Bottlenose dolphin (*Tursiops truncatus*)	3,773	9,960	2,003	1,387
Spotted Dolphins (*Stenella frontalis and S. attenuata*)	8,673	8,673	8,673	8,673
Striped dolphin (*Stenella coeruleoalba*)	507	507	507	507
Risso's dolphin (*Grampus griseus*)	8,710	8,710	8,710	8,710
Pilot Whales (*Globicephala* spp.)	39,114	16,902	15,443	10,259
Harbor seal (*Phoca vitulina*)	101,357	95,121	101,357	101,357
Gray seal (*Halichoerus grypus*)	8,294	8,294	8,294	8,294
Literature-Derived Abundance Estimates[3]				
North Atlantic right whale (*Eubalaena glacialis*)	See **Table 3.3** and **Table 3.19**			
Species for Which Abundance Estimates Do Not Exist				
Blue whale (*Balaenoptera musculus*)	No estimate available			
Spinner dolphin (*Stenella longirostris*)	No estimate available			
White-beaked dolphin (*Lagenorhynchus albirostris*)	No estimate available			
Pygmy killer whale (*Feresa attenuata*)	No estimate available			
Killer whale (*Orcinus orca*)	No estimate available			
Harp seal (*Phoca groenlandicus*)	No estimate available			
Hooded seal (*Cystophora cristata*)	No estimate available			

[1] Please refer to **Section 2.8** of the Methodology for an explanation on how these estimates were derived
[2] Estimates taken from the preliminary NE NODE report (2006)
[3] Please refer to **Section 2.8.2** of the Methodology for an explanation on how these estimates were derived

Table 3-3. Monthly estimates of abundance for the North Atlantic right whale based on the occurrence polygons from the Northeast Operating Area Marine Resources Assessment (DoN 2005) and density estimates for this species produced by Hain and Kenney (2005c; 2005b; 2005a).

North Atlantic right whale (*Eubalaena glacialis*)*

Time Period	Abundance Estimate
January	396
February & March	396
April	230
May & June	229
July - September	67
October & November	67
December	73

* Please refer to **Section 2.8.2** of the Methodology for an explanation on how these estimates were derived

3.1 MARINE MAMMALS

All marine mammal species are afforded protection by the MMPA. Additionally, five of the twenty marine mammal species/species groups considered in this report are listed as endangered under the ESA: North Atlantic right, humpback, fin, sei, and sperm whales. This section of the report addresses each of the cetacean species in the order presented in **Table 3-1**.

3.1.1 Species with Model-Based Density Estimates

➢ Humpback Whale (*Megaptera novaeangliae*)

Distribution and habitat preferences

- The largest numbers of humpbacks occur in the northeast U.S. from mid-April to mid-November on the feeding grounds that are located from south of New England to northern Norway (NMFS 1991). The GOM is one of the principal summer feeding grounds for humpback whales in the North Atlantic.

- Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves (CETAP 1982; Payne et al. 1990a; Payne et al. 1990b; Hamazaki 2002).

- During the winter, most of the North Atlantic population of humpback whales is believed to migrate south to calving grounds in the West Indies region; however, sightings are still made during this time of the year in the northeast U.S. Humpbacks may be found along the continental shelf from southern GOM to Virginia during this time of year (Whitehead and Moore 1982; Stevick et al. 2003).

- Exact migratory routes are not known; however, it is presumed that whales travel more direct routes in deeper, offshore waters since large numbers of humpback whales are not observed close to shore during this time (Smith et al. 1999).

- There has been an increasing occurrence of humpbacks, which appear to be primarily juveniles, during the winter along the U.S. Atlantic coast, from Florida north to Virginia (Clapham et al. 1993; Swingle et al. 1993; Wiley et al. 1995; Laerm et al. 1997). Strandings of humpbacks (mainly juveniles) in this area have also increased in recent years (Wiley et al. 1995). These occurrences are not fully understood. They might be due to shifts in distribution, increases in sighting effort, or habitat that is becoming increasingly important for juveniles. Sighting histories of mature humpback whales suggest that the mid-Atlantic area contains a greater percentage of mature animals than is represented by strandings (Barco et al. 2002). It has recently been proposed that the mid-Atlantic region primarily represents a supplemental winter feeding ground, which is also an area of mixing of humpback whales from different feeding stocks (Barco et al. 2002).

Table 3-4. Density surface model results for the humpback whale by season. These are abundance estimates for the humpback whale in the Northeast study area.

Season	Abundance
Spring	250
Summer	250
Fall	250
Winter	250

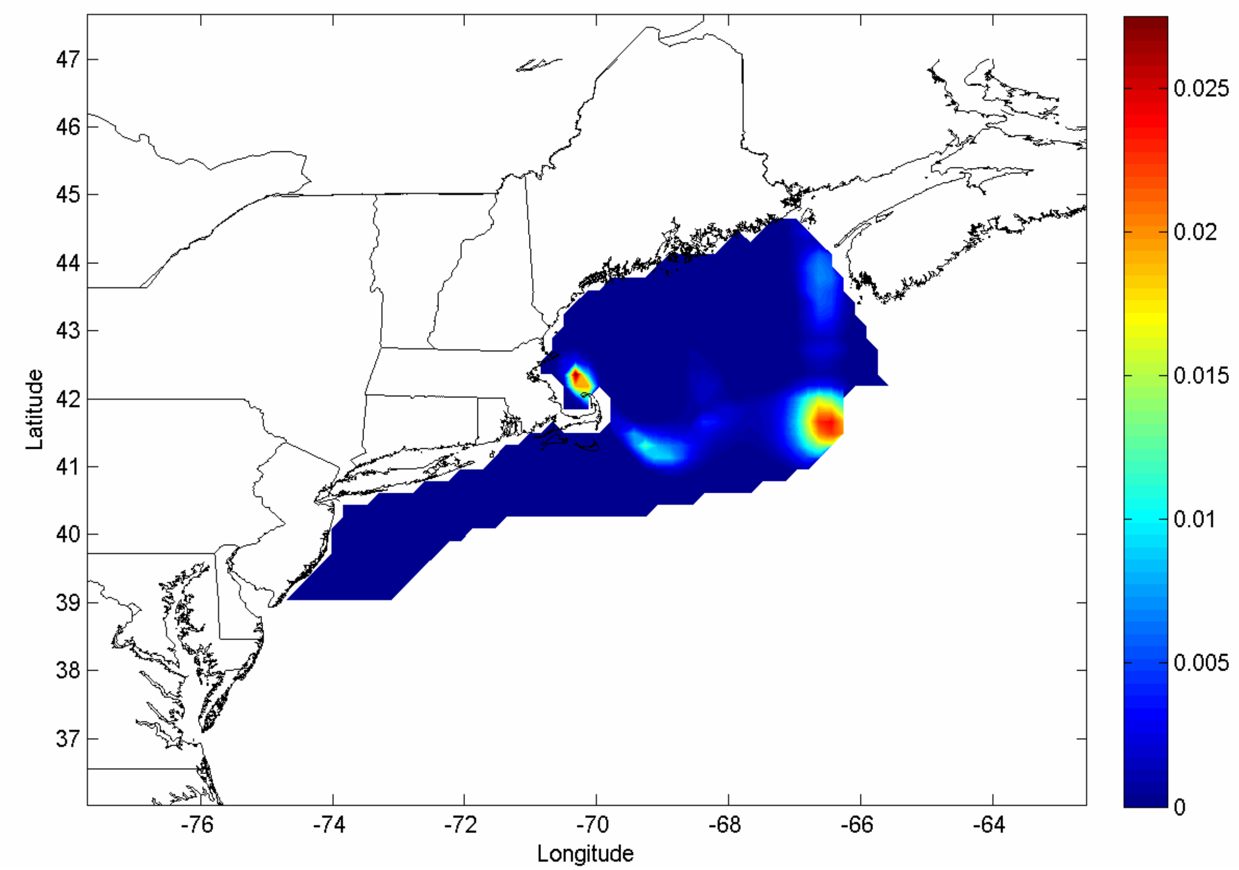


Figure 3-1. Density surface for the humpback whale during all seasons off the United States Atlantic Coast.

➢ Fin Whale (*Balaenoptera physalus*)

Distribution and habitat preferences

- The fin whale is the most common whale species acoustically detected with Navy deepwater hydrophone arrays in the North Atlantic (Clark 1995; Clark and Gagnon 2004). The overall range in the western North Atlantic extends from the Gulf of Mexico (GOMEX)/Caribbean north to Greenland (Gambell 1985; NMFS 2006b). Fin whales are common in waters of the EEZ, principally north of Cape Hatteras (CETAP 1982; Hain et al. 1992; Waring et al. 2007).

- As a species, the fin whale is believed to follow the typical baleen whale migratory pattern, with a population shift north to summer feeding grounds and south to winter breeding grounds; however, the location and extent of the wintering grounds are poorly known (Aguilar 2002). Fin whales have been seen feeding as far south as the coast of Virginia (Hain et al. 1992). Additionally, as noted by Waring et al. (2007), the popular notion that entire fin whale populations make distinct annual migrations like some other mysticetes has questionable support in the data, since in the North Pacific, year-round monitoring of fin whale calls found no evidence for large-scale migratory movements (Watkins et al. 2000).

- Fin whales in the U.S. Atlantic occur in waters over the continental shelf and shelf break (Hain et al. 1992; Waring et al. 2007). There is a strong preference for shelf breaks, seamounts or other areas where food resources are concentrated concentrated (e.g., Kenney and Winn 1987; Hain et al. 1992; Clark and Gagnon 2004).

- Fin whales occur year-round in the NE study area (though with smaller numbers during the winter), particularly in the western GOM, including Jeffreys Ledge and Stellwagen Bank, to the Great South Channel, in waters with a bottom depth of approximately 90 m (Hain et al. 1992; Waring et al. 2007). The shelf break from the northeast peak of Georges Bank to the mid-Atlantic and the mid-shelf from south of New England to the mid-Atlantic Bight are also important habitats. Individuals are scarce in the deeper waters beyond the continental rise (Waring et al. 1992).

Table 3-5. Density surface model results for the fin whale by season. These are abundance estimates for the fin whale in the Northeast study area.

Season	Abundance
Spring	346
Summer	346
Fall	346
Winter	346

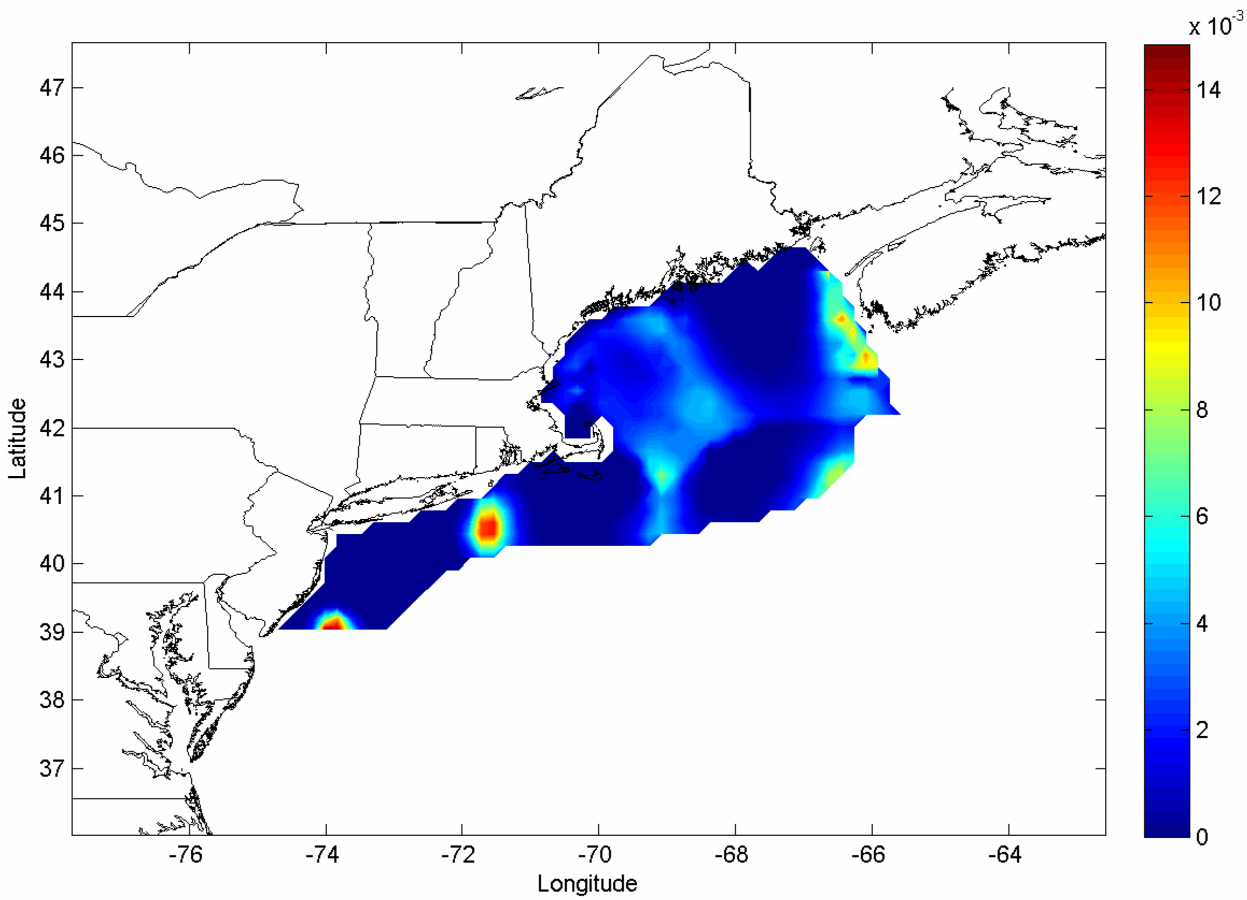


Figure 3-2. Density surface for the fin whale during all seasons off the United States Atlantic Coast.

➢ Minke Whale (*Balaenoptera acutorostrata*)

Distribution and habitat preferences

- Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993); they are less common in the tropics than in cooler waters. This species is most abundant in New England waters rather than the mid-Atlantic U.S. (Hamazaki 2002; Waring et al. 2007).

- Off eastern North America, the minke whale generally prefers waters over the continental shelf, including inshore bays and estuaries, and slope waters (Mitchell and Kozicki 1975; Waring and Palka 2002; Waring et al. 2007). Based on whaling catches and surveys worldwide, there is also a deep-ocean component to the minke whale's distribution (Slijper et al. 1964; CETAP 1982; Horwood 1990; Mitchell 1991; Waring et al. 2007).

- There appears to be a strong seasonal component to minke whale distribution in waters off the northeastern coast of the U.S. Spring and summer are times of relatively widespread and common occurrence; minke whales are most abundant in New England waters during this time of year (Waring et al. 2002). During the winter months (November through March), minke whales are known to occur in the southwestern region of the North Atlantic including the area from Bermuda to the West Indies (Mitchell 1991). The winter distribution in the southern part of the western North Atlantic is supported by acoustics data (Clark 1995; Clark and Gagnon 2004).

Table 3-6. Density surface model results for the minke whale by season. These are abundance estimates for the minke whale in the Northeast study area.

Season	Abundance
Spring	175
Summer	175
Fall	175
Winter	175

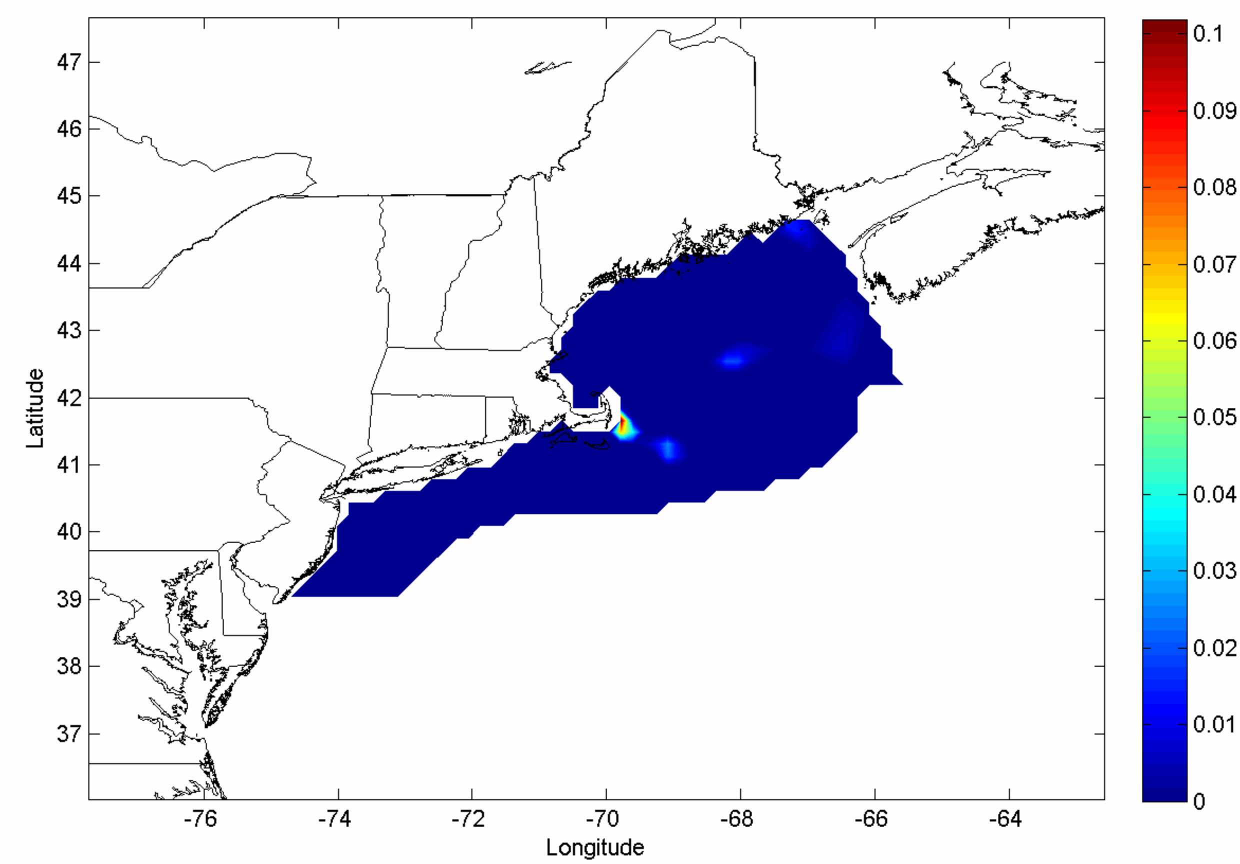


Figure 3-3. Density surface for the minke whale during all seasons off the United States Atlantic Coast.

➢ Common Dolphin (*Delphinus delphis*)

Distribution and habitat preferences

- Common dolphins occur from Newfoundland to Florida in the western Atlantic (Perrin 2002a), although this species more commonly is found in temperate, cooler waters in the western North Atlantic (Waring and Palka 2002). Common dolphins are abundant within a broad band paralleling the continental slope from 35°N to the NE peak of Georges Bank.

- Along the U.S. Atlantic Coast, common dolphins typically occur in temperate waters on the continental shelf between the 100 and 200 m isobaths, but can be found in association with the Gulf Stream (CETAP 1982; Selzer and Payne 1988; Waring and Palka 2002).

- Distribution is primarily along the edge of the continental shelf south of 40°N in spring and north of this latitude in fall (Selzer and Payne 1988). Common dolphins are less common south of Cape Hatteras; however, sightings have not been reported as far south as eastern Florida since the early 1960s (Gaskin 1992).

Table 3-7. Density surface model results for the common dolphin by season. These are abundance estimates for the common dolphin in the Northeast study area.

Season	Abundance
Spring	13,061
Summer	13,061
Fall	13,061
Winter	13,061

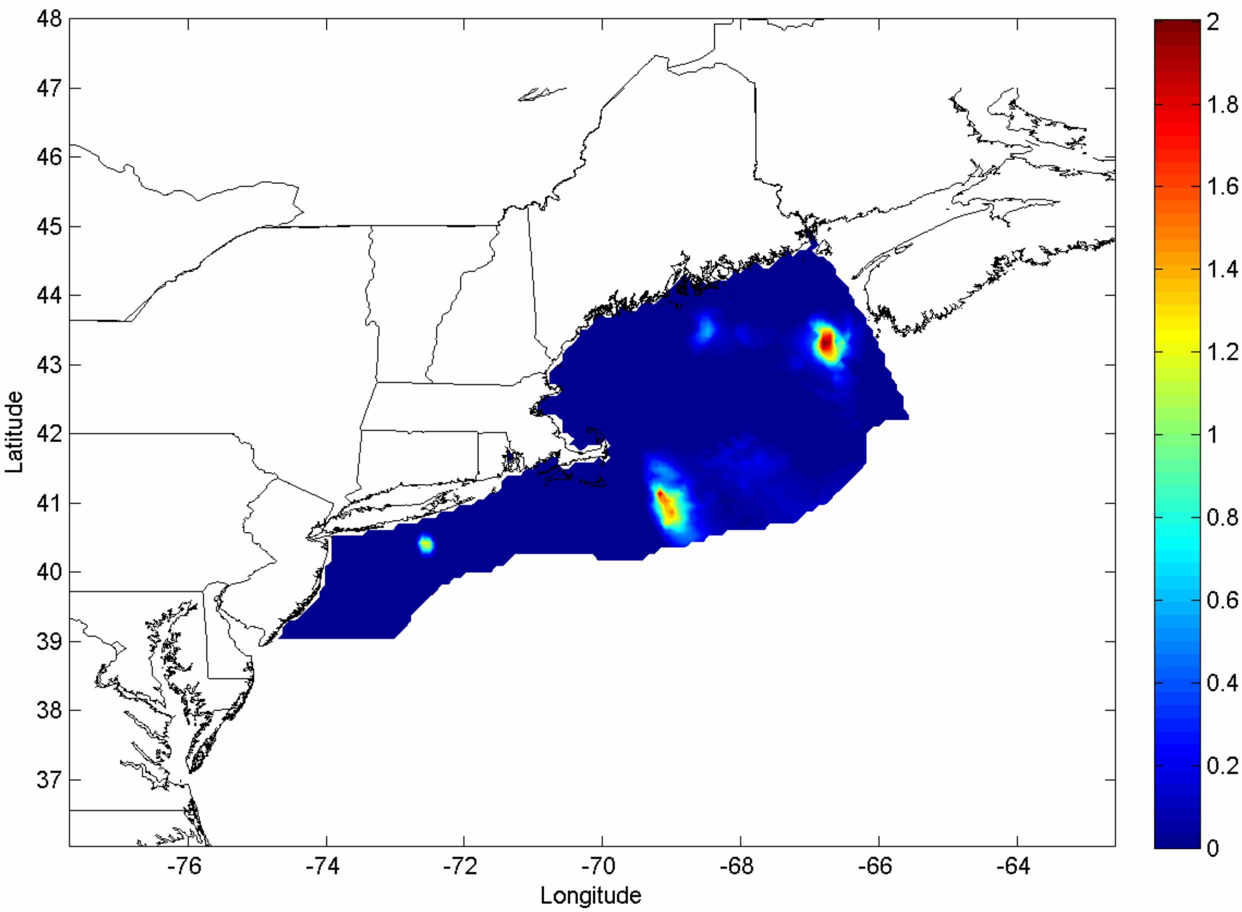


Figure 3-4. Density surface for the common dolphin during all seasons off the United States Atlantic Coast.

➢ Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

Distribution and habitat preferences

- The Atlantic white-sided dolphin inhabits waters from central West Greenland to North Carolina (about 35°N) (Waring et al. 2007). In the western North Atlantic, the Atlantic white-sided is most common over the continental shelf from Hudson Canyon north to the GOM (Palka et al. 1997). Virginia and North Carolina represent the southern edge of the range (Testaverde and Mead 1980). Data indicate seasonal shifts in distribution, perhaps a reflection of an inshore/offshore movement (CETAP 1982; Payne et al. 1990a; Northridge et al. 1997).

- This species is found primarily in continental shelf waters inshore of the 100 m depth contour however, they can also be found in slope waters (CETAP 1982; Selzer and Payne 1988; Mate et al. 1994).

- Primary feeding habitat is around Cape Cod and on the northwest edge of Georges Bank in an area defined as the Great South Channel-Jeffreys Ledge corridor (CETAP 1982).

Table 3-8. Density surface model results for the Atlantic white-sided dolphin by season. These are abundance estimates for the Atlantic white-sided dolphin in the Northeast study area.

Season	Abundance
Spring	23,489
Summer	23,489
Fall	23,489
Winter	23,489

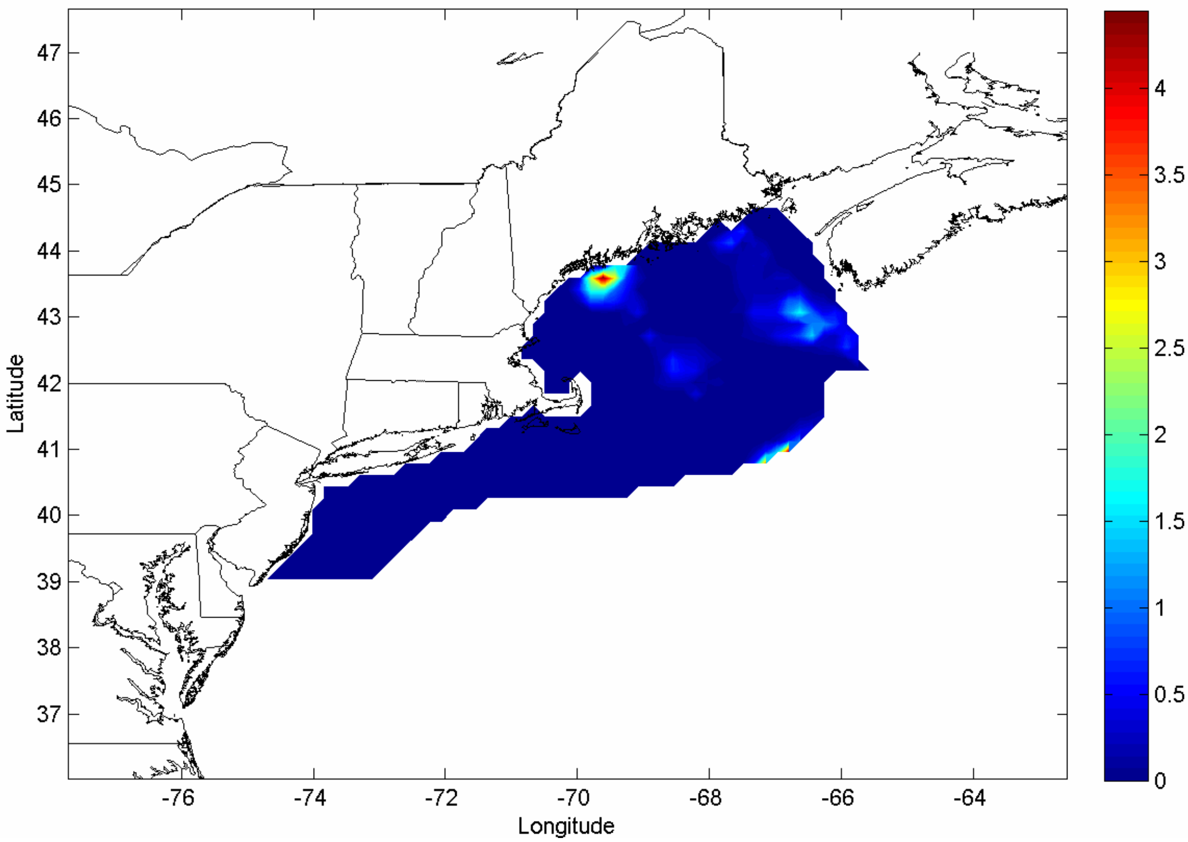


Figure 3-5. Density surface for the Atlantic white-sided dolphin during all seasons off the United States Atlantic Coast.

➢ Harbor Porpoise (*Phocoena phocoena*)

Distribution and habitat preferences

- Harbor porpoises occur in subpolar to cool-temperate waters in the North Atlantic and Pacific (Read 1999). Off the northeastern U.S., harbor porpoise distribution is strongly concentrated in the Gulf of Maine/Georges Bank region, with more scattered occurrences to the mid-Atlantic (CETAP 1982; Northridge 1996). The general distribution shifts further north during July through December.

- 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 further south in the Mid-Atlantic Bight in the fall and winter (Westgate et al. 1998; Waring et al. 2007).

- Harbor porpoises prefer relatively cool waters; they are seldom found in waters warmer than 17°C (Watts and Gaskin 1985; Read 1999).

Table 3-9. Density surface model results for the harbor porpoise by season. These are abundance estimates for the harbor porpoise in the Northeast study area.

Season	Abundance
Spring	11,711
Summer	10,208
Fall	11,711
Winter	11,711

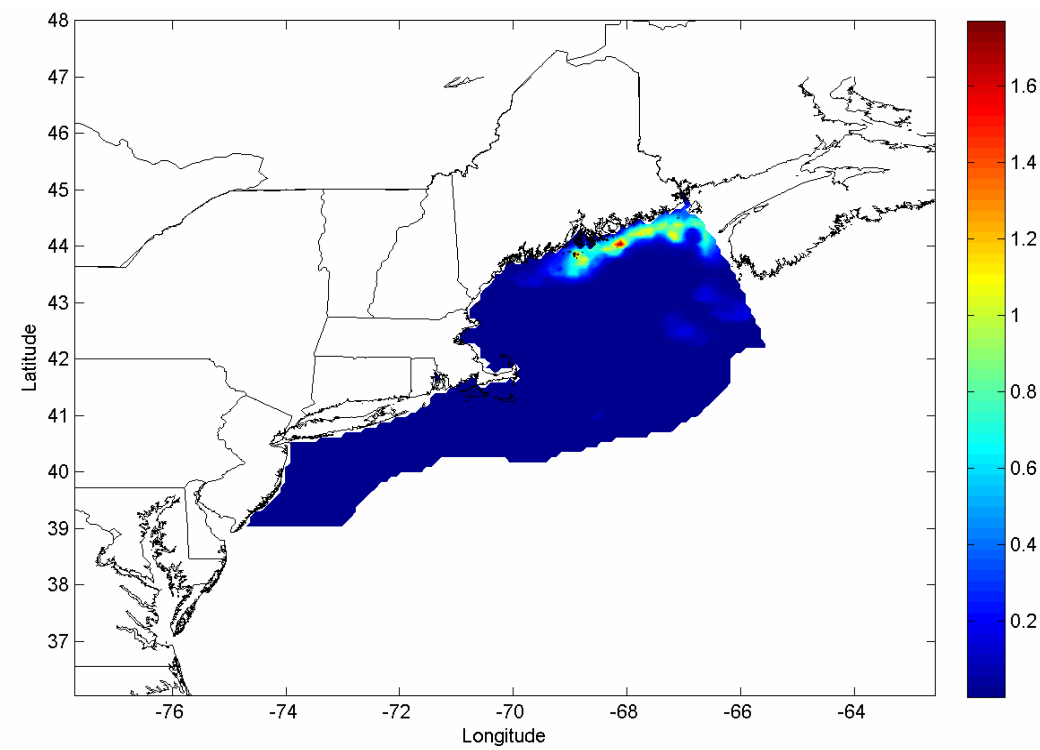


Figure 3-6. Density surface for the harbor porpoise during the summer off the United States Atlantic Coast.

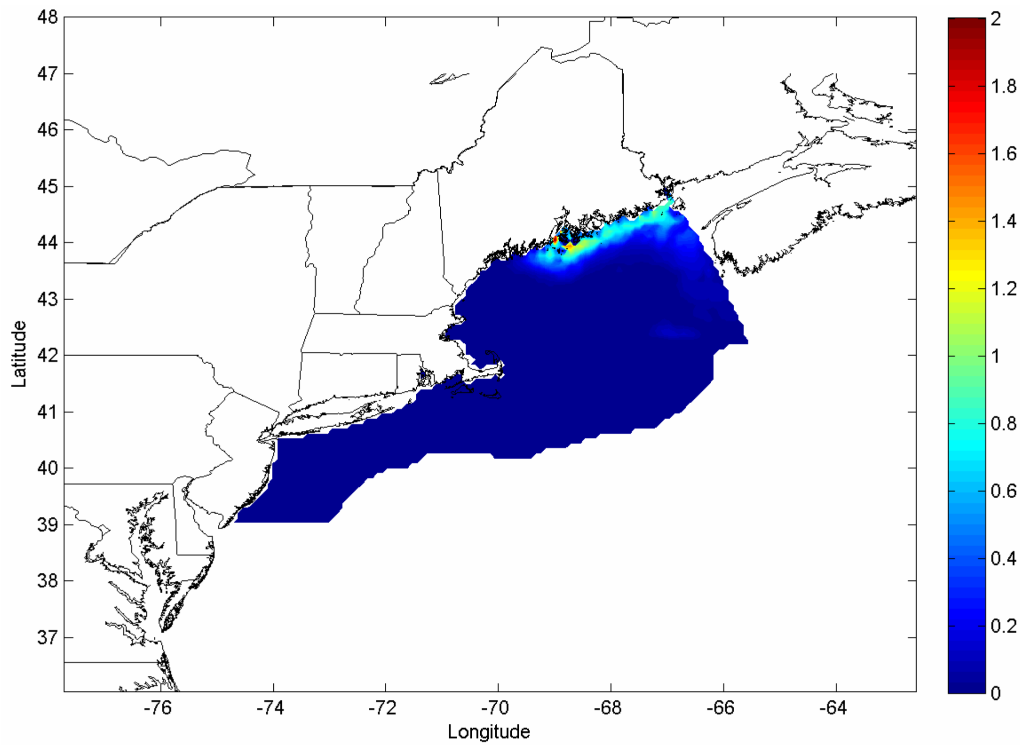


Figure 3-7. Density surface for the harbor porpoise during the fall, winter, and spring off the United States Atlantic Coast.

3.1.2 Species with Design-Based Density Estimates (DoN 2006)

When a density surface could not be generated for a given species or species group based on the shipboard and aerial surveys for the waters of the NE study area, density estimates provided by the previous Northeast NODE report (DoN 2006); **Appendix B**) based on traditional-line transect estimation methods were used. For further explanation of the methods and definitions of the geographic strata used, see **Appendix B**. The species for which density estimates were derived from the previous NE NODE report (DoN 2006) are the sei whale, sperm whale, *Kogia* spp., Beaked Whales, bottlenose dolphin, Spotted Dolphins, striped dolphin, Risso's dolphin, and Pilot Whales.

➢ Sei Whale (*Balaenoptera borealis*)

Distribution and habitat preferences

- Sei whales are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 1987). Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. For the most part, the location of winter breeding areas for the species remains a mystery (Rice 1998; Perry et al. 1999).

- In the western North Atlantic Ocean, the Nova Scotia Stock of the sei whale occurs primarily from Georges Bank north to Davis Strait (northeast Canada, between Greenland and Baffin Island) (northeast Canada, between Greenland and Baffin Island; Perry et al. 1999; Waring et al. 2007) but may be distributed as far south as North Carolina (NMFS 1998).

- The hypothesis is that the Nova Scotia stock moves from spring feeding grounds on or near Georges Bank, to the Scotian Shelf in June and July, eastward to perhaps Newfoundland and the

Grand Banks in late summer, then back to the Scotian Shelf in fall, and offshore and south in winter (Mitchell and Chapman 1977).

- Sei whales are not common in U.S. waters (NMFS 1998); peak abundance here occurs from winter through spring (mid-March through mid-June), primarily around the edges of Georges Bank (CETAP 1982; Stimpert et al. 2003).

- Sei whales are known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades (Horwood 1987; Schilling et al. 1992; Clapham et al. 1997; Gregr et al. 2005).

- The sei whale prefers regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges (Kenney and Winn 1987; Schilling et al. 1992; Gregr and Trites 2001; Best and Lockyer 2002). These areas are often the location of persistent hydrographic features, which may be important factors in concentrating prey, especially copepods.

- On the feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 1987). Characteristics of preferred breeding grounds are unknown. Horwood (1987) noted that sei whales prefer oceanic waters and are rarely found in marginal seas; historical whaling catches were usually from deepwater, and land station catches were usually taken from along or just off the edges of the continental shelf.

Table 3-10. Abundance estimates for the sei whale by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for the sei whale in the Northeast study area.

Season	Abundance
Spring	1,056
Summer	659
Fall	209
Winter	432

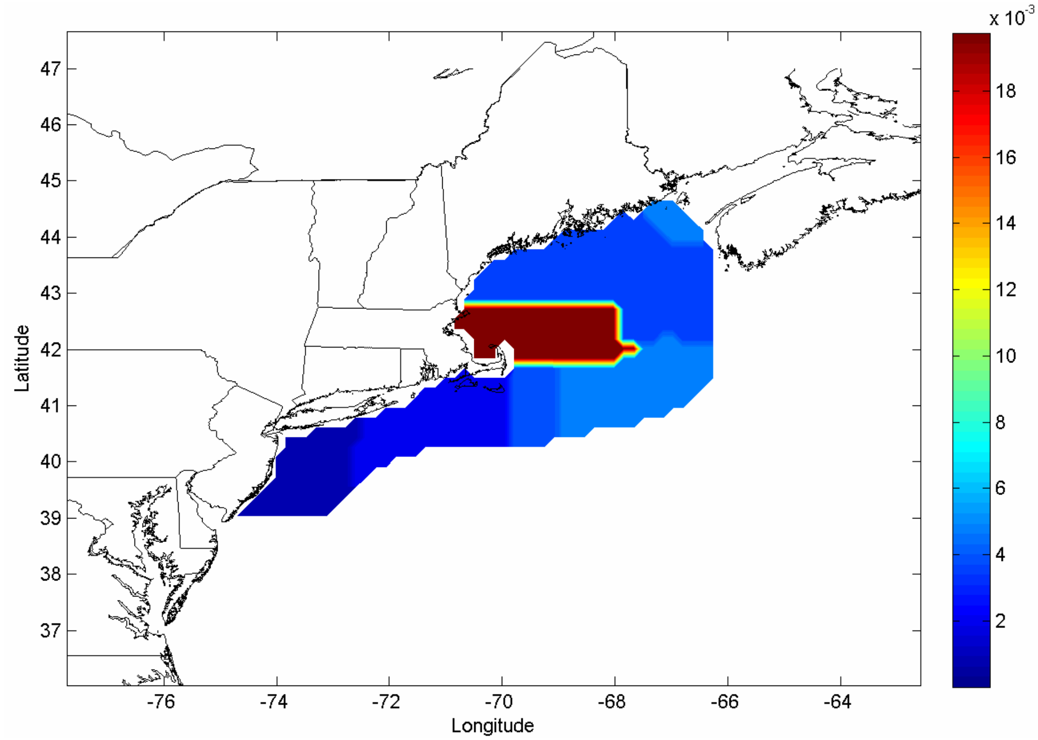


Figure 3-8. Density surface for the sei whale during the spring off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for the sei whale in the Northeast study area.

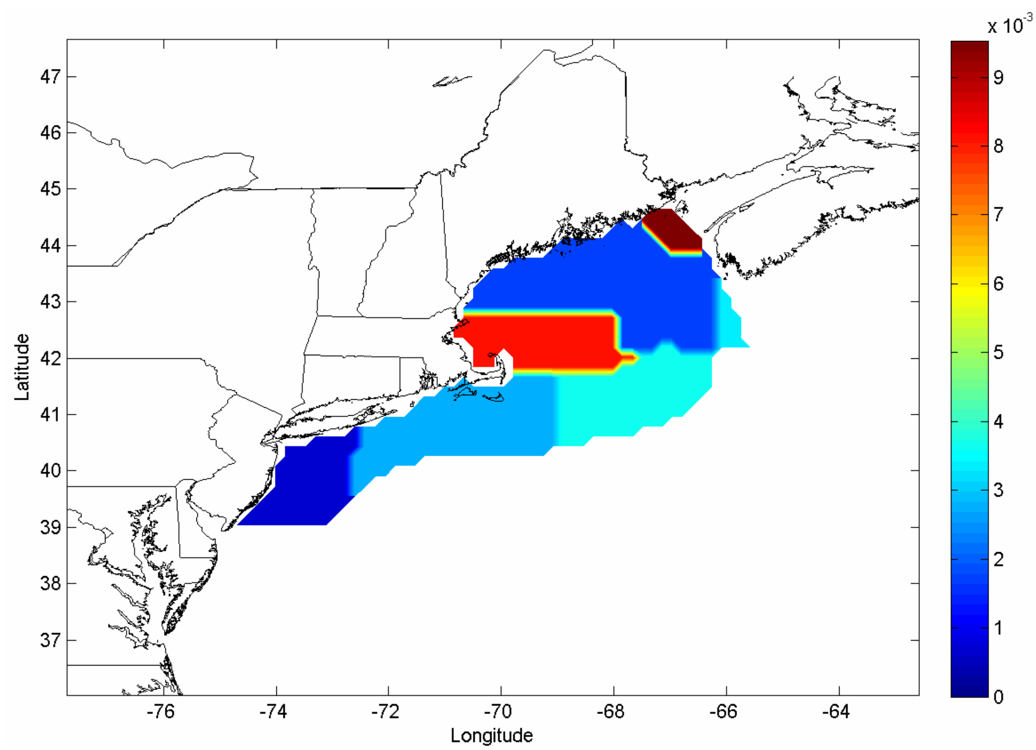


Figure 3-9. Density surface for the sei whale during the summer off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

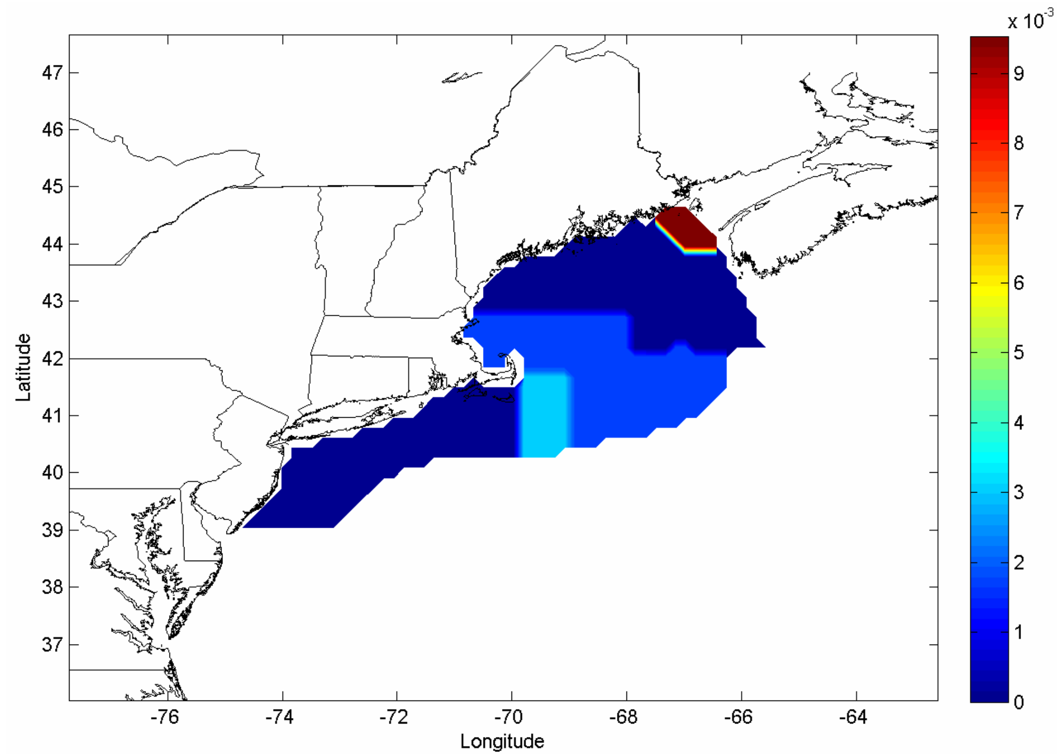


Figure 3-10. Density surface for the sei whale during the fall off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

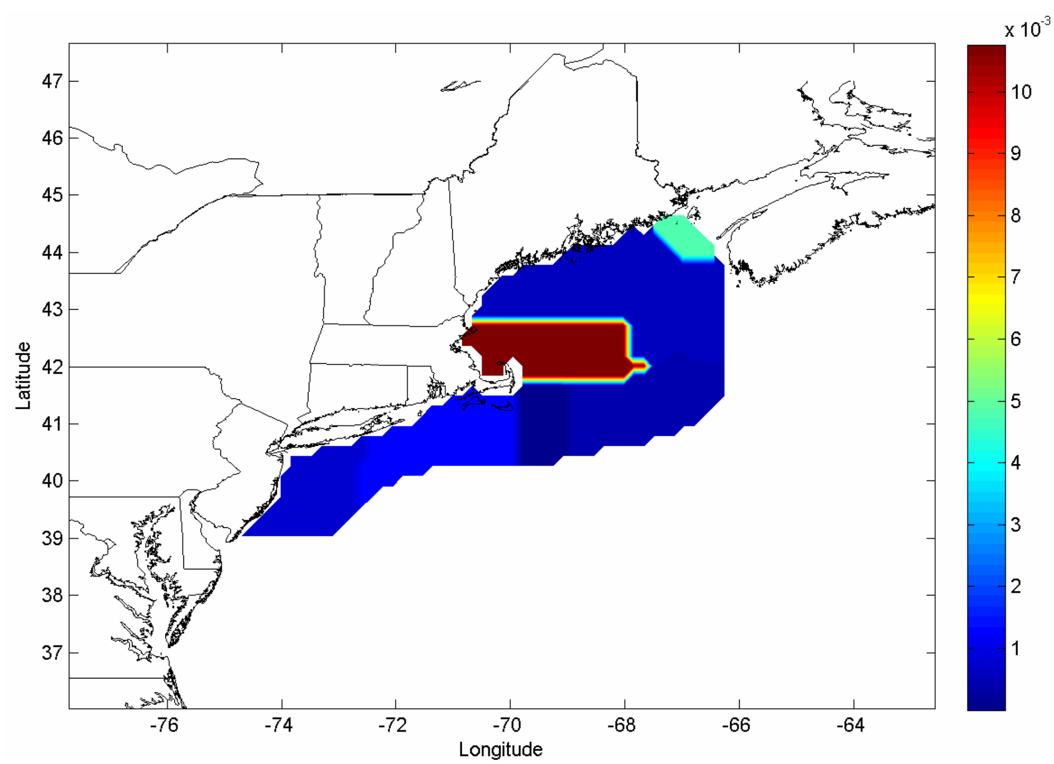


Figure 3-11. Density surface for the sei whale during the winter off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Sperm Whale (*Physeter macrocephalus*)

Distribution and habitat preferences

- Sperm whales off the U.S. Atlantic Coast occur over the shelf break, continental slope, and into deeper waters (CETAP Schmidly 1981; 1982; Kenney and Winn 1987; Waring et al. 1993; Waring et al. 2001; Waring et al. 2007).

- Sperm whales appear to have a distinct seasonal distribution in waters off the U.S. Atlantic Coast (CETAP 1982; Scott and Sadove 1997; Waring et al. 2007). In winter, they are sighted primarily east and northeast of Cape Hatteras. In spring, distribution shifts northward to off Delaware and Virginia and is widespread throughout the central Mid-Atlantic Bight and southern Georges Bank. In summer, the distribution is similar but now also includes the area east and north of Georges Bank and into the Northeast Channel region, as well as the continental shelf (inshore of the 100 m isobath) south of New England. In the fall, sperm whale occurrence south of New England on the continental shelf is at its highest level, and there remains a continental shelf break occurrence in the Mid-Atlantic Bight.

- Sperm whales off the U.S. Atlantic Coast are found in regions of pronounced horizontal temperature gradients, such as along the edges of the Gulf Stream and warm-core rings (Fritts et al. 1983; Waring et al. 1993; Griffin 1999); these are areas of increased productivity. The Gulf Stream is an important influence on sperm whale distribution in the western North Atlantic Ocean (e.g., Townsend 1935; Waring et al. 1993; Griffin 1999; NMFS 2006a).

Table 3-11. Abundance estimates for the sperm whale by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for the sperm whale in the Northeast study area.

Season	Abundance
Spring	611
Summer	1,504
Fall	5,579
Winter	3,005

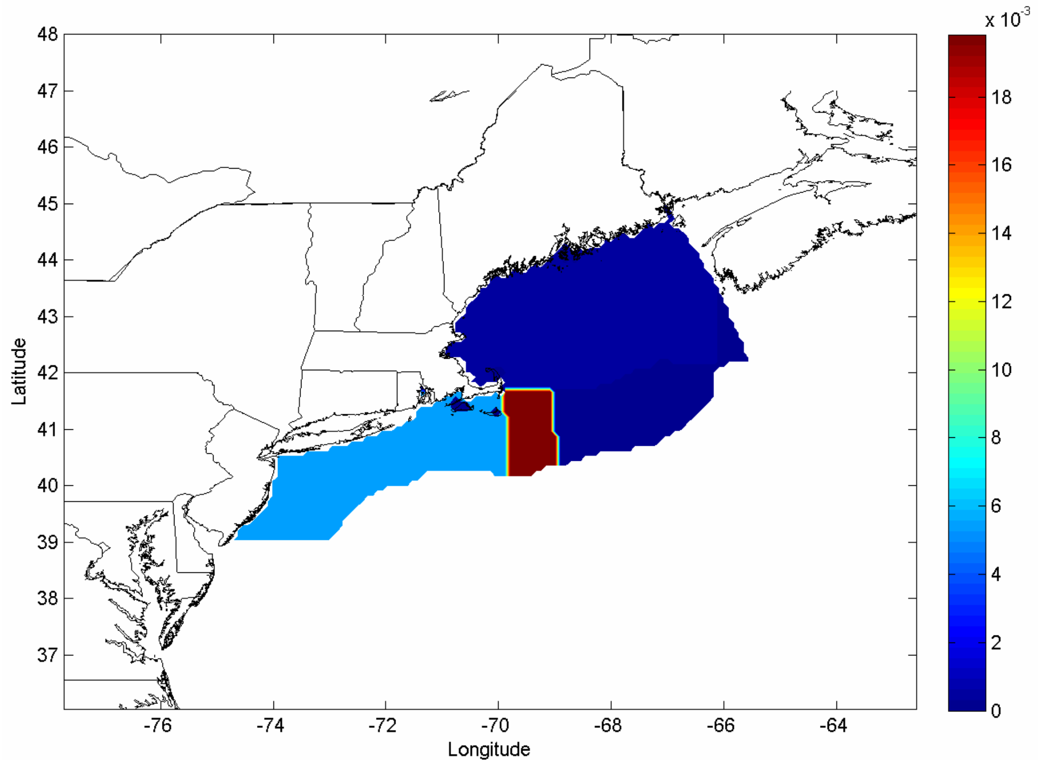


Figure 3-12. Density surface for the sperm whale during the spring off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

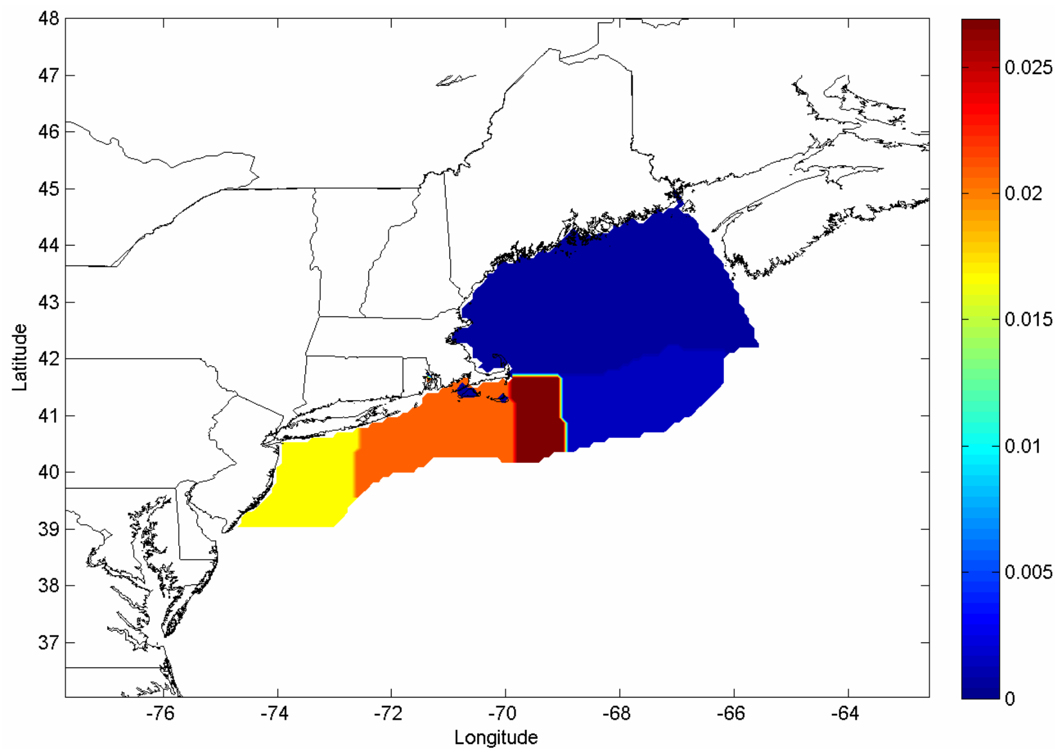


Figure 3-13. Density surface for the sperm whale during the summer off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

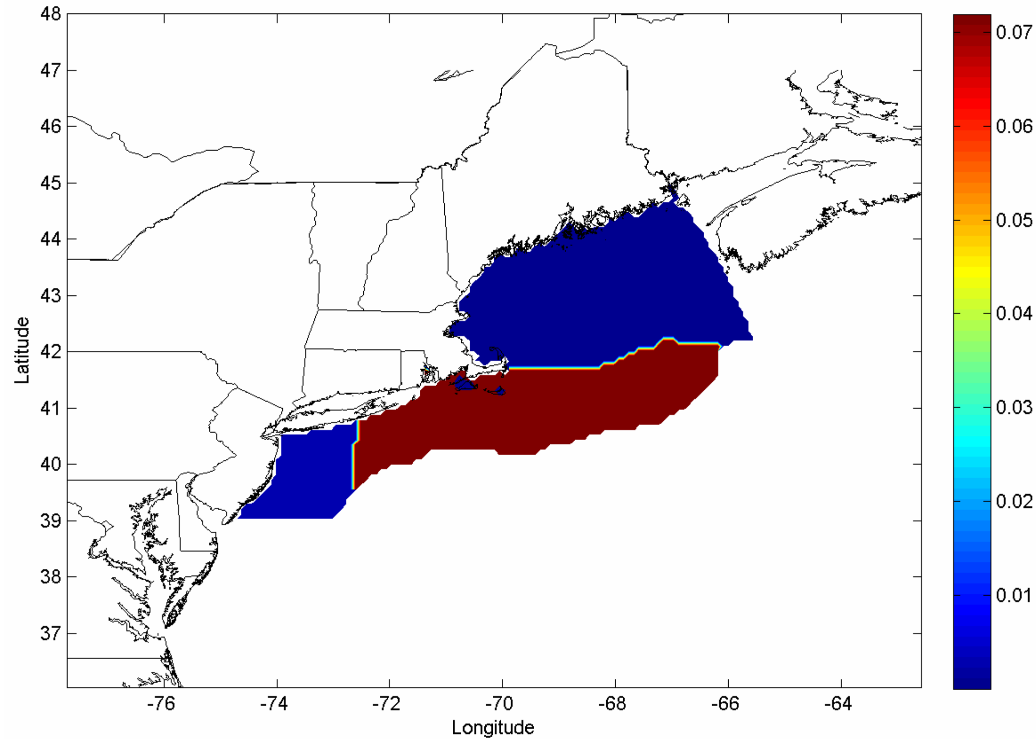


Figure 3-14. Density surface for the sperm whale during the fall off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

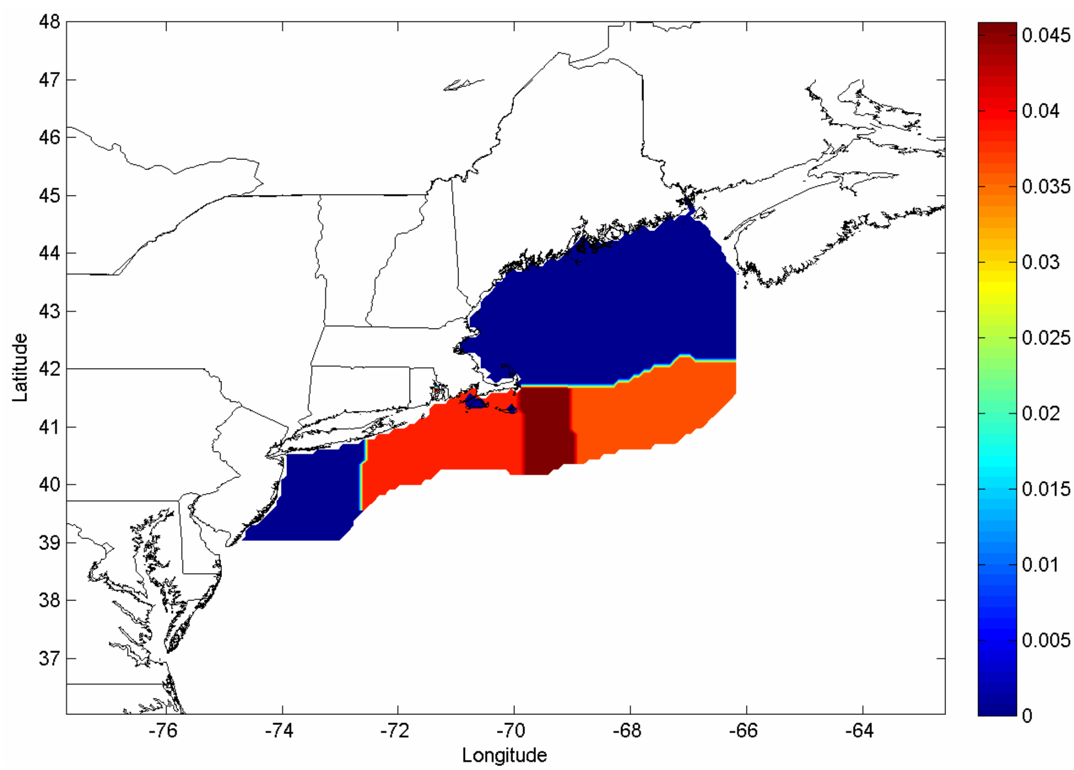


Figure 3-15. Density surface for the sperm whale during the winter off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Kogia *spp.*

There are two species that make up this category: pygmy sperm whale (*Kogia breviceps*) and dwarf sperm whale (*Kogia sima*).

Distribution and habitat preferences

- In the western North Atlantic Ocean, *Kogia* are known to occur as far north as the northern Gulf of St. Lawrence, Quebec, Canada (Measures et al. 2004).

- Globally, both species of *Kogia* generally occur in waters along the continental shelf break and over the continental slope (e.g., Baumgartner et al. 2001; McAlpine 2002; Fulling and Fertl 2003; MacLeod et al. 2004; Baird 2005). Sightings over the continental shelf are known from the GOMEX (Fulling and Fertl 2003). Mullin and Fulling (2003) reported sighting *Kogia* spp. in waters with a bottom depth of 766 to 4,079 m.

Table 3-12. Density surface model results for *Kogia* spp. by season. These are abundance estimates for *Kogia* spp. in the Northeast study area.

Season	Abundance
Spring	85
Summer	85
Fall	85
Winter	85

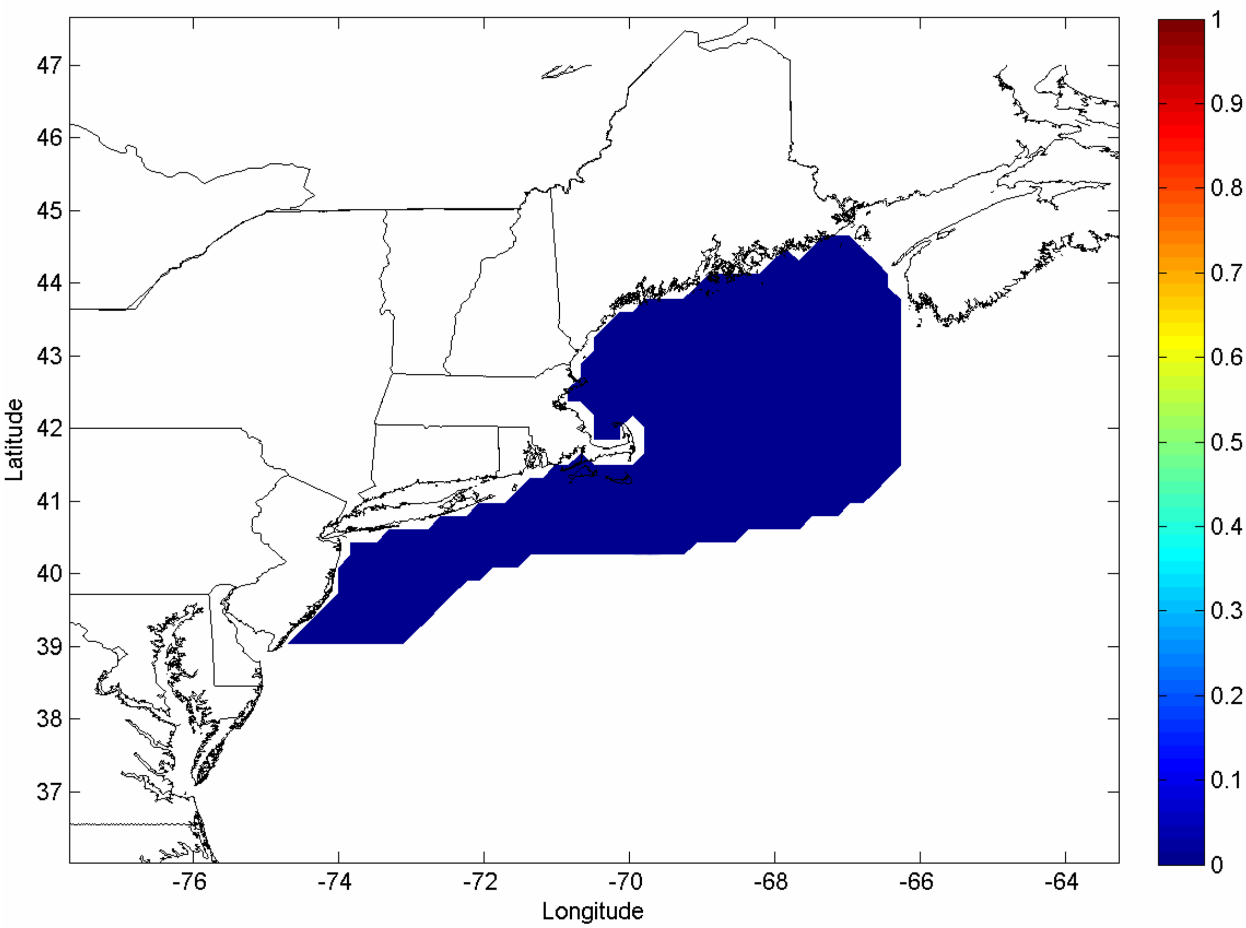


Figure 3-16. Density surface for *Kogia* spp. during all seasons off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Beaked Whales (Family Ziphiidae)

The beaked whales category encompasses species belonging to the Family Ziphiidae occurring in the NE OPAREAs; these are the Cuvier's beaked whale, True's beaked whale, Gervais' beaked whale, Sowerby's beaked whale, Blainville's beaked whale, and northern bottlenose whale.

Distribution and habitat preferences

- The Cuvier's beaked whale is the most widely distributed beaked whale species (MacLeod et al. 2006). It has been reported from Massachusetts and Rhode Island south to the Florida Keys, the West Indies, and the Gulf of Mexico (Würsig et al. 2000). The Blainville's beaked whale is the most widely distributed of the Mesoplodon spp.; it is considered to inhabit all tropical, sub-tropical and warm-temperate waters, with occasional occurrences in cold-temperate areas (MacLeod et al. 2006). The Gervais' beaked whale is endemic to the warm-temperate to tropical Atlantic (MacLeod et al. 2006). Sowerby's and True's beaked whales are the most northerly species (MacLeod 2000). The Sowerby's beaked whale appears to occur primarily between Labrador and New England (MacLeod 2000). The majority of records for True's beaked whale in the North Atlantic are strandings occurring between New Jersey and Maryland (MacLeod 2000). Northern bottlenose whales are restricted to northern latitudes of the North Atlantic, concentrated in cold waters seaward of the continental shelf break (Reeves et al. 1993).

- World-wide, beaked whales normally inhabit continental slope and deep oceanic waters (>200 m) (Waring et al. 2001; Cañadas et al. 2002; Pitman 2002; MacLeod et al. 2004; Ferguson et al. 2006a; MacLeod and Mitchell 2006). Areas of steep bathymetry, such as submarine canyons have also been described as important habitat (e.g., Waring et al. 2001; D'Amico et al. 2003; MacLeod et al. 2004). Beaked whales in the eastern tropical Pacific are found in waters over the continental slope to the abyssal plain, ranging from well-mixed to highly stratified (Ferguson et al. 2006a).

- Beaked whale abundance off the eastern U.S. may be highest in association with the Gulf Stream and the warm-core rings it develops (Waring et al. 1992). In summer, the continental shelf break off the northeastern U.S. is primary habitat (Waring et al. 2001).

Table 3-13. Abundance estimates for Beaked Whales by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for Beaked Whales in the Northeast study area.

Season	Abundance
Spring	381
Summer	1,339
Fall	367
Winter	380

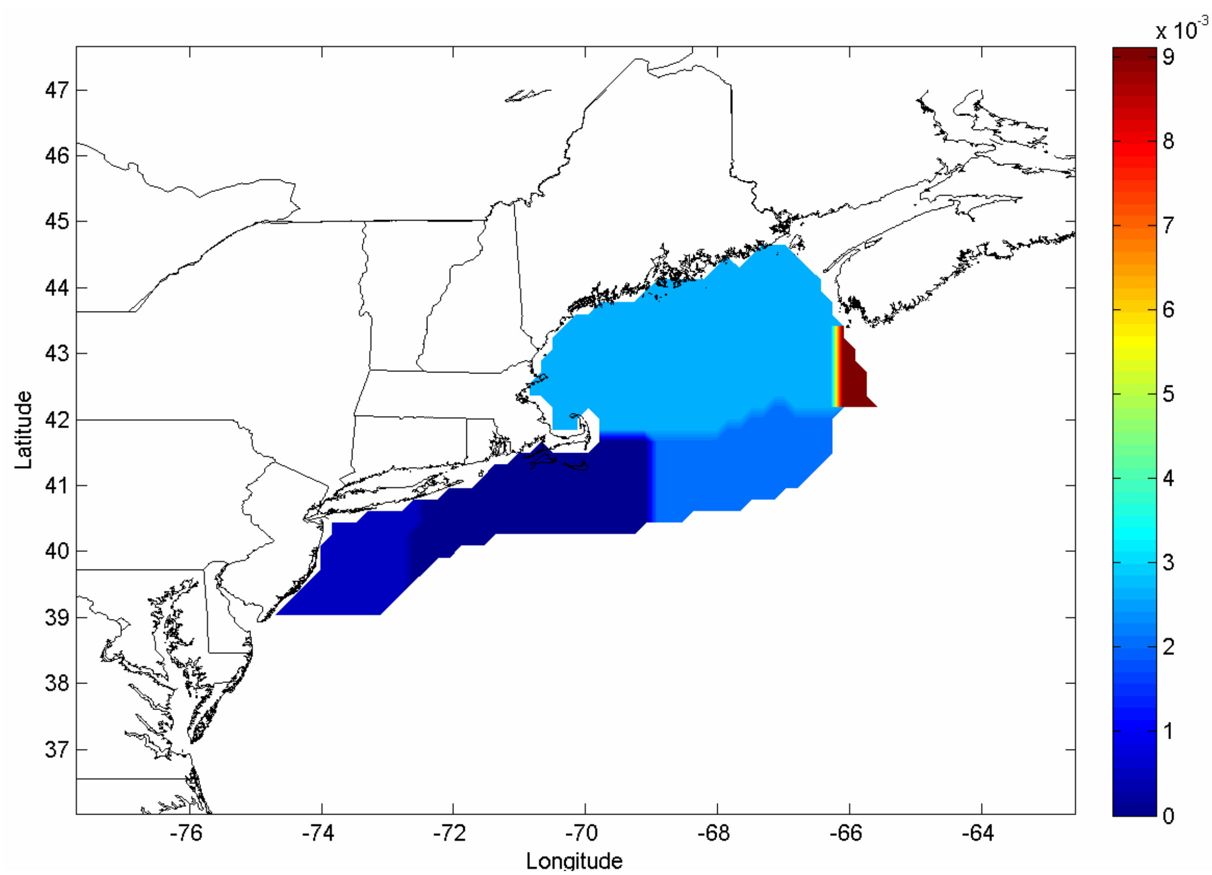


Figure 3-17. Density surface for Beaked Whales during the spring off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

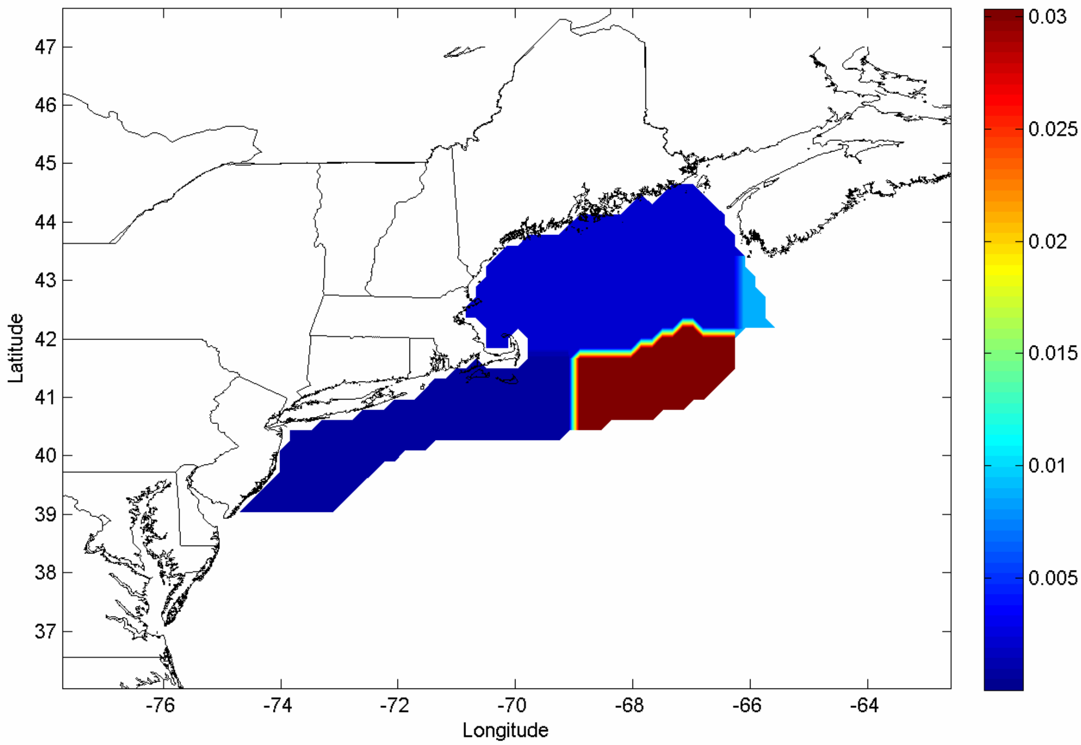


Figure 3-18. Density surface for Beaked Whales during the summer off the Untied States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

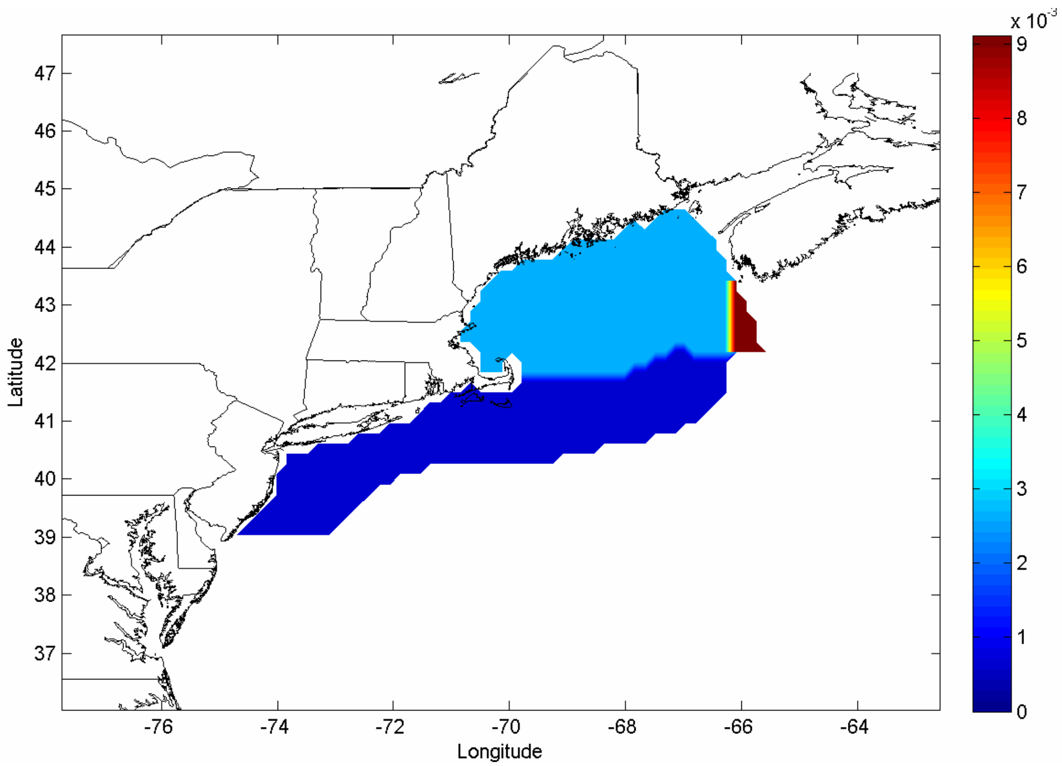


Figure 3-19. Density surface for Beaked Whales during the fall off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

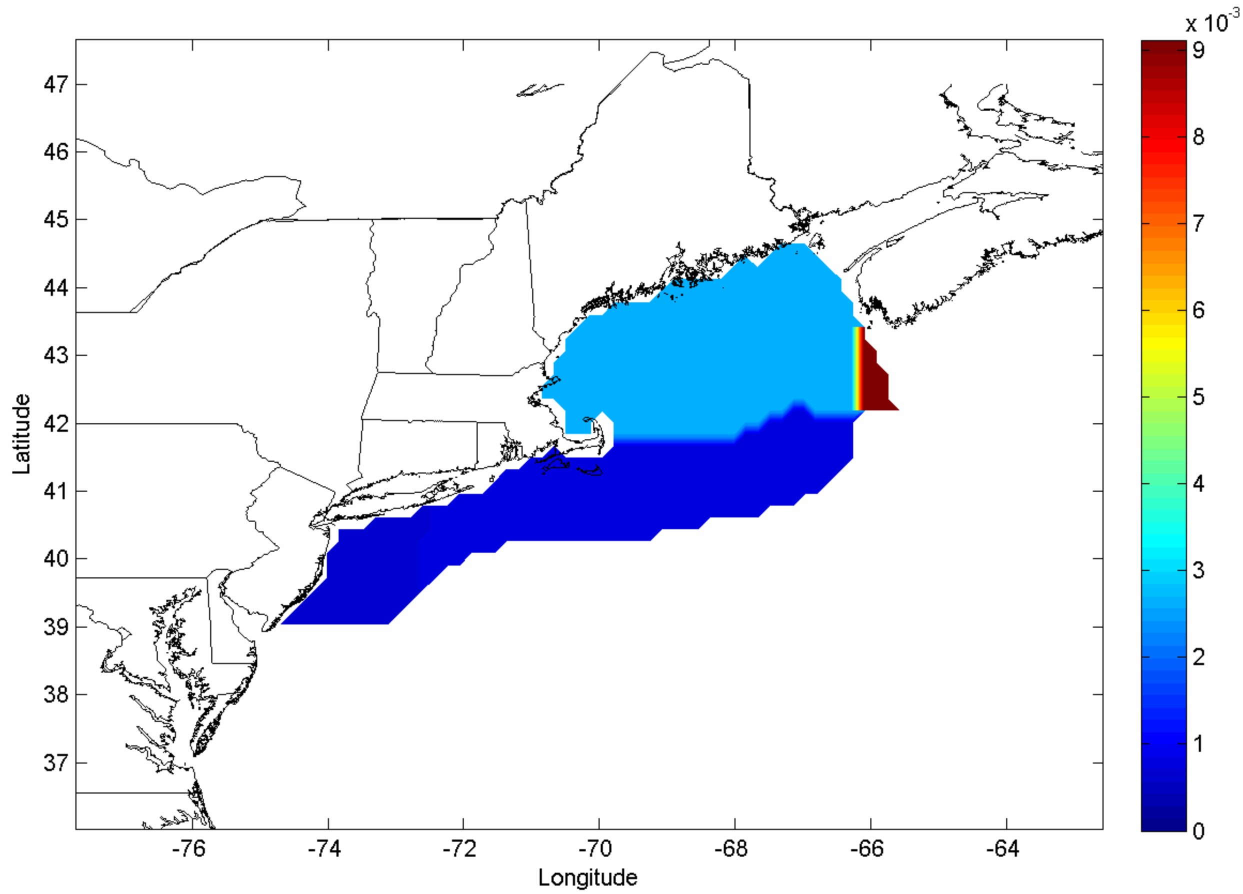


Figure 3-20. Density surface for Beaked Whales during the winter off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Bottlenose Dolphin (*Tursiops truncatus*)

The category for bottlenose dolphins includes both the coastal (nearshore) and the offshore forms that are recognized in the western North Atlantic (Waring et al. 2007).

Distribution and habitat preferences

- Bottlenose dolphins off the U.S. Atlantic Coast are frequently found over the continental shelf and especially along the shelf break (Kenney 1990; Mullin and Fulling 2003). They occasionally move up rivers and may also be found in very deep waters (Caldwell and Caldwell 1972; Kenney 1990; Wells et al. 1999; Gannon 2003).

- Seasonally, bottlenose dolphins occur over the outer continental shelf and inner slope waters as far north as Georges Bank (CETAP 1982; Kenney 1990; Waring et al. 2007).

- The coastal morphotype stock in the western North Atlantic is most often found within 7.5 km of the coast (app. >25 m in bottom depth), although occurrences much further offshore are known (Torres et al. 2003; Waring et al. 2007). The coastal morphotype of bottlenose dolphin (comprised of seven management units) is continuously distributed along the Atlantic coast south of Long Island.

- Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km from the U.S. coastline, in waters with a bottom depth greater than 34 m (Torres et al. 2003; Waring et al. 2007). The coastal ecotype stock shows a temperature-limited distribution, occurs in significantly warmer waters than the offshore stock, and has a distinct northern boundary (Kenney 1990; Waring et al. 2007).

- The coastal morphotype stock shows a temperature-limited distribution, occurs in significantly warmer waters than the offshore stock, and has a distinct northern boundary (Kenney 1990). Although a critical temperature limit for the stock has not been defined, recent winter aerial surveys reported a lack of sightings north of Chesapeake Bay, corresponding to water temperatures less than 9.5°C (Waring et al. 2007). Water temperature may directly affect movements by acting as a thermal barrier to coastal bottlenose dolphin movement (Barco et al. 1999; Torres et al. 2005). Alternatively, water temperature may indirectly affect movements by directly affecting prey movements (Barco et al. 1999; Wells and Scott 1999).

- North of Cape Hatteras, there is clear separation of the two morphotypes relative to bathymetry during the summer. Bottlenose dolphins concentrated close to shore are of the coastal morphotype, while those in waters >40 m in bottom depth are from the offshore morphotype (Garrison et al. 2003).

- During winter months and south of Cape Hatteras, the range of the coastal and offshore morphotypes overlaps to some degree. Over the continental shelf south of Cape Hatteras, the two morphotypes overlap spatially, though the probability of encountering the offshore morphotype increases with increasing depth, though there is significant spatial overlap (Waring et al. 2007). It should be noted that the offshore morphotype has been sampled as close as 7.3 km from shore in waters with a bottom depth of 13 m (Garrison et al. 2003).

Table 3-14. Abundance estimates for the bottlenose dolphin by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for the bottlenose dolphin in the Northeast study area.

Season	Abundance
Spring	3,773
Summer	9,960
Fall	2,003
Winter	1,387

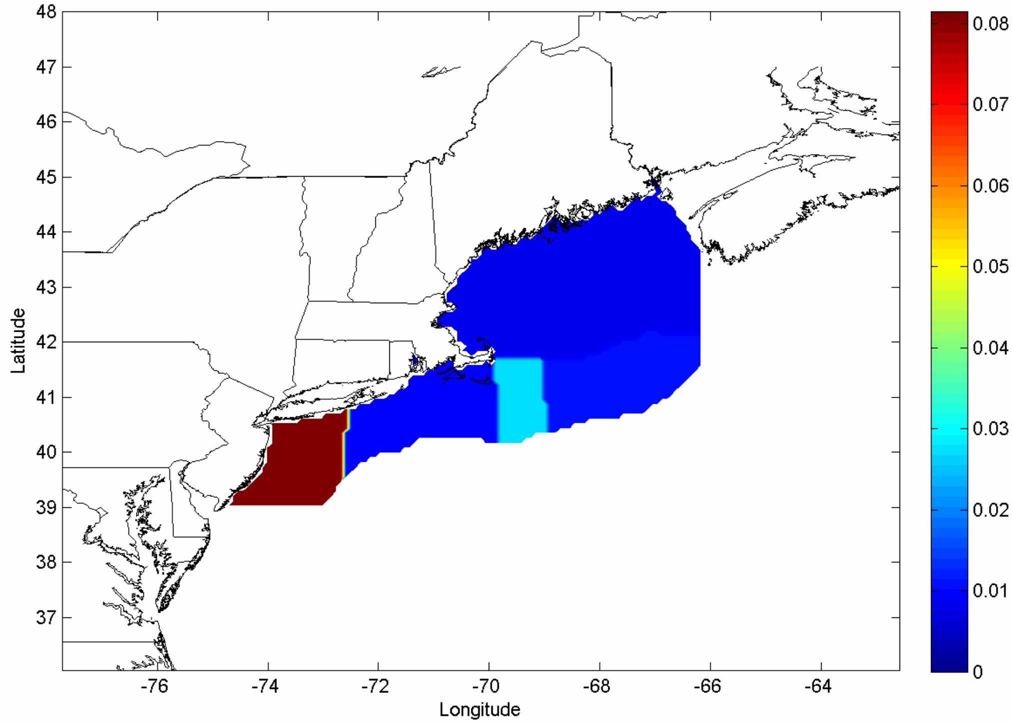


Figure 3-21. Density surface for the bottlenose dolphin during the spring off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

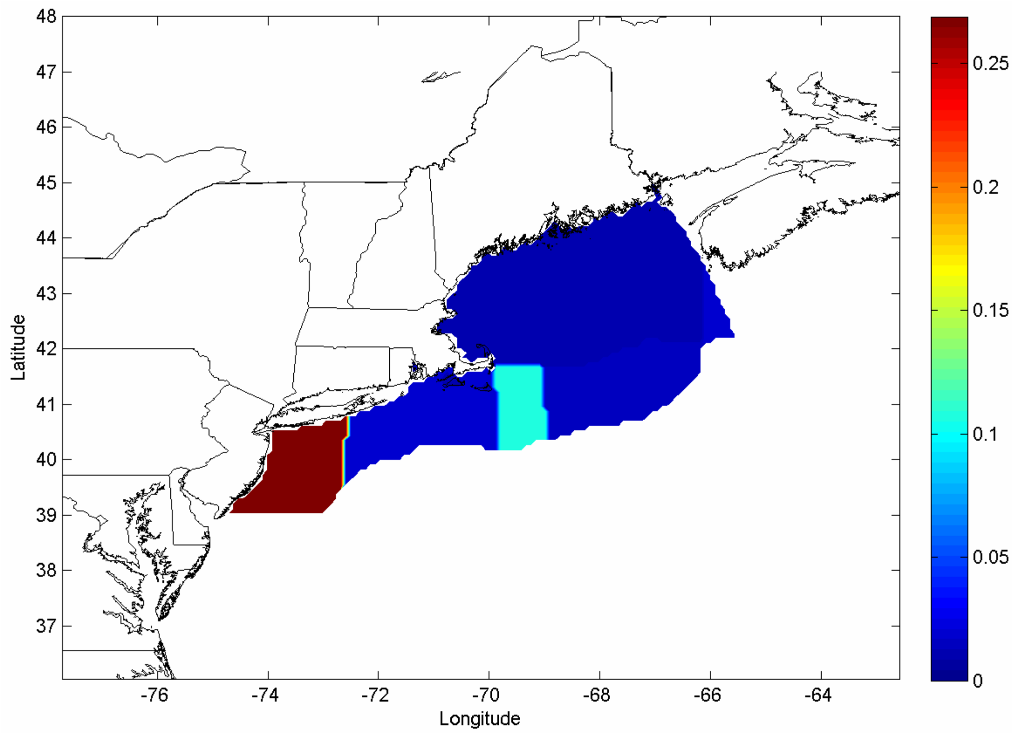


Figure 3-22. Density surface for the bottlenose dolphin during the summer off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

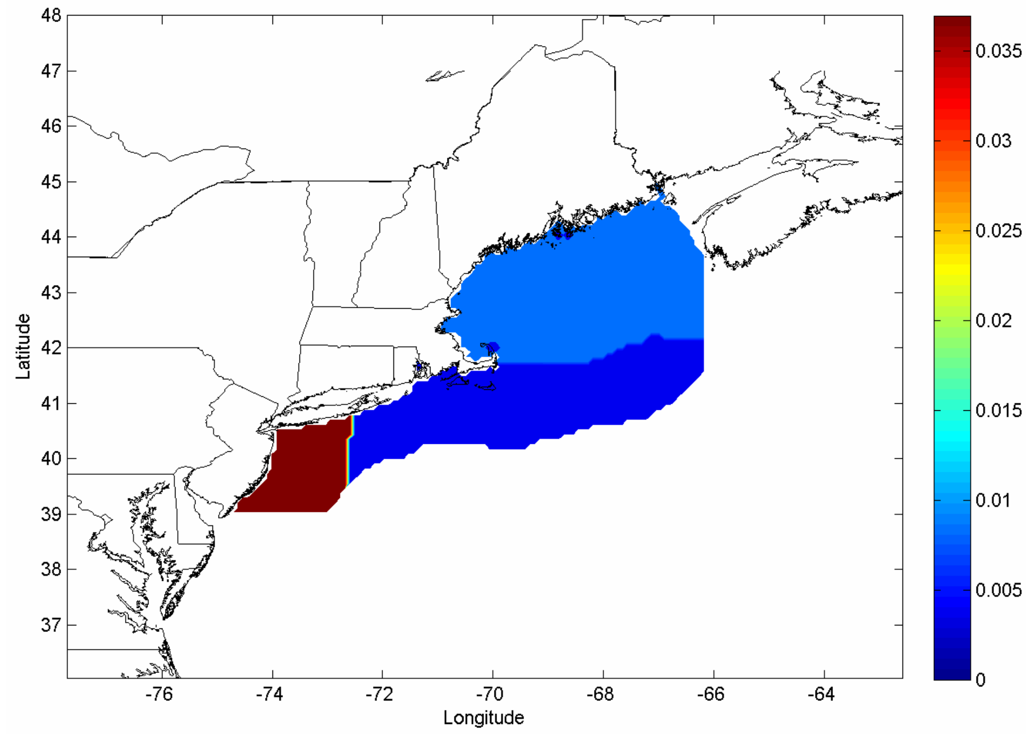


Figure 3-23. Density surface for the bottlenose dolphin during the fall off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

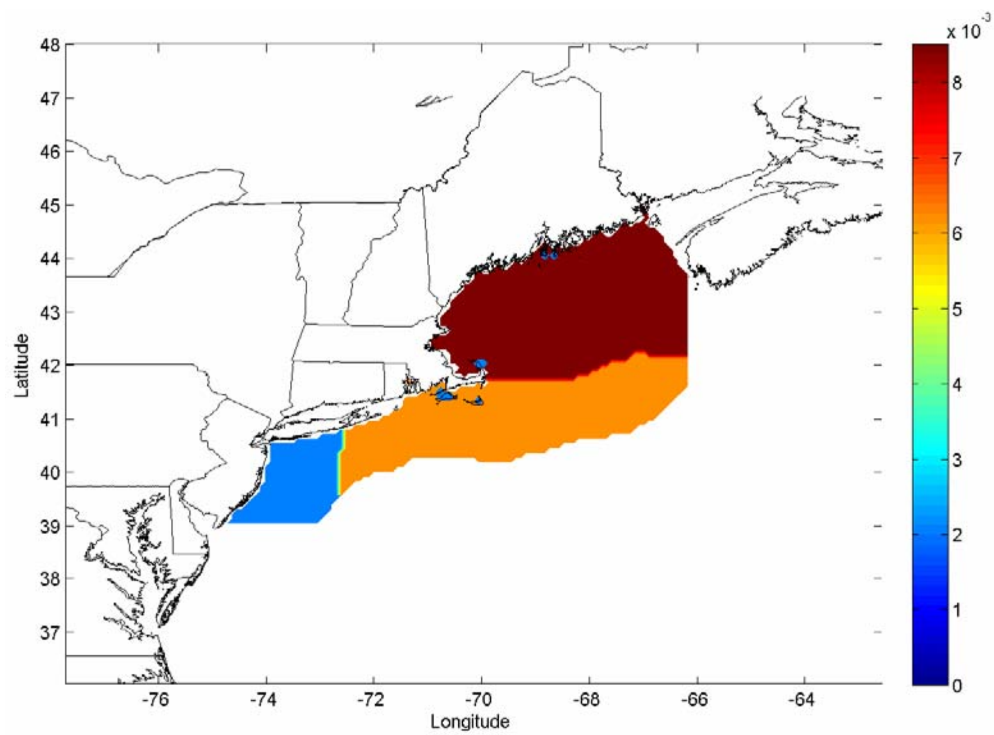


Figure 3-24. Density surface for the bottlenose dolphin during the winter off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Spotted Dolphins (*Stenella frontalis* and *Stenella attenuata*)

There are two species of spotted dolphins in the western North Atlantic: the pantropical spotted dolphin and the Atlantic spotted dolphin. Where the two species co-occur, the the pantropical spotted dolphin and the offshore form of the Atlantic spotted dolphin can be difficult to differentiate at sea (Waring et al. 2007). Prior to 1998, the NMFS-NEFSC did not delineate between the two species of spotted dolphins, and reported abundance for both species of spotted dolphins combined (Waring et al. 2007). Density estimates provided by NMFS-NEFSC for this report were provided for spotted dolphins as a species group (Palka 2006).

Distribution and habitat preferences

- Two distinct morphotypes of the Atlantic spotted dolphin are described for the western North Atlantic: a larger, more heavily spotted form found in waters over the continental shelf, and a smaller, less spotted form found in more pelagic offshore waters (Perrin 2002b; Mullin and Fulling 2003). It is the latter that is the most frequently sighted of the two forms in the NE OPAREAs study area.

- Atlantic spotted dolphins are endemic to warm-temperate and tropical Atlantic waters from approximately 45ºN to 35º South (S); in the western North Atlantic Ocean, this translates to waters from northern New England to Venezuela, including the GOMEX and the Caribbean Sea (Perrin et al. 1987).
- Pantropical spotted dolphins are primarily seen between the 40° latitudes (Perrin 2001), though occurrence records are known as far north as Massachusetts in the western North Atlantic Ocean.

- The Atlantic spotted dolphin typically occurs over the continental shelf inshore of or near the 185 m isobath, usually at least 8 to 20 km offshore (Perrin 2002b). The pantropical spotted dolphin shows a preference for waters beyond the continental shelf break (e.g., Davis et al. 1998; Baumgartner et al. 2001; Moreno et al. 2005). Both species of spotted dolphins occur year-round in the NE study area, typically distributed over the continental shelf break and continental slope (Waring et al. 2007).

- Along the northeastern U.S., Waring et al. (1992) found that stenellids (members of the genus *Stenella*) were distributed along the Gulf Stream's northern wall. *Stenella* sightings also occurred within the Gulf Stream (Waring et al. 1992; Mullin and Fulling 2003), which is consistent with the oceanic distribution of this genus and its preference for warm water.

Table 3-15. Abundance estimates for Spotted Dolphins by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for Spotted Dolphins in the Northeast study area.

Season	Abundance
Spring	8,673
Summer	8,673
Fall	8,673
Winter	8,673

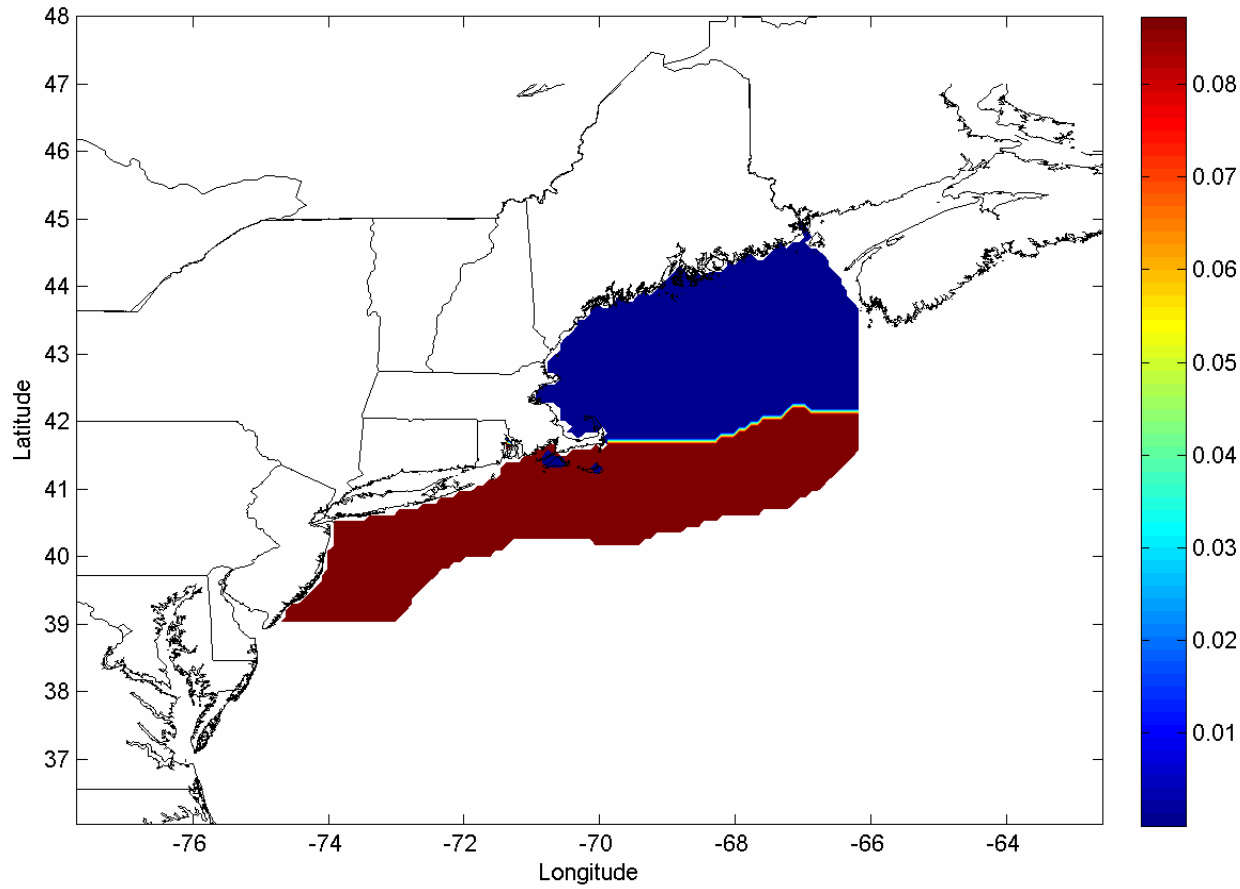


Figure 3-25. Density surface for Spotted Dolphins during all seasons off the United States Atlantic Coast based density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Striped Dolphin (*Stenella coeruleoalba*)

Distribution and habitat preferences

- Striped dolphins have a worldwide distribution in deep and cool temperate to tropical zones.

- In the western North Atlantic, striped dolphins are generally distributed along the continental shelf break from Cape Hatteras to the southern margin of Georges Bank, as well as offshore over the continental slope and continental rise in the mid-Atlantic region (CETAP 1982; Mullin and Fulling 2003). Striped dolphins are known to associate with the Gulf Stream's northern wall and warm-core ring features (Waring et al. 1992).

Table 3-16. Abundance estimates for the striped dolphin by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for the striped dolphin in the Northeast study area.

Season	Abundance
Spring	507
Summer	507
Fall	507
Winter	507

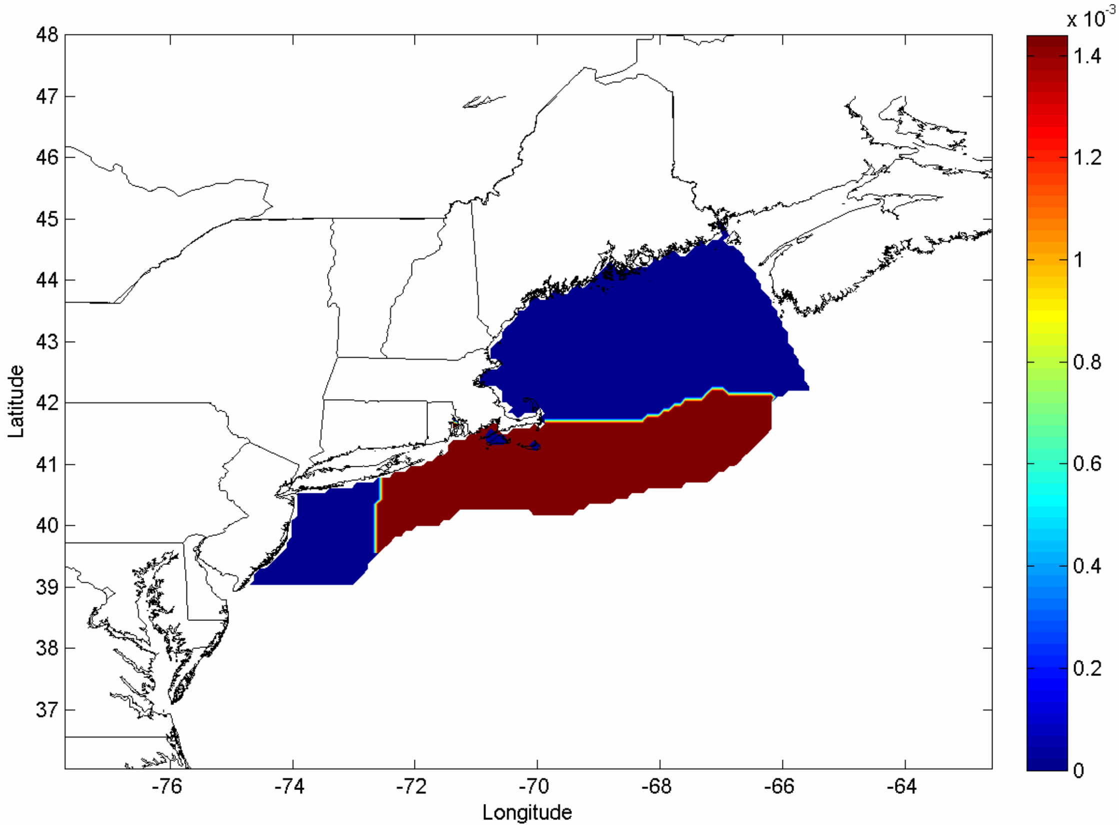


Figure 3-26. Density surface for the striped dolphin during all seasons off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ <u>Risso's Dolphin</u> (*Grampus griseus*)

Distribution and habitat preferences

- In the western North Atlantic, Risso's dolphins are found from Florida to eastern Newfoundland (Leatherwood et al. 1976; Baird and Stacey 1991).

- Several studies have noted that Risso's dolphins are found primarily offshore, along the continental shelf break, and over the slope (CETAP 1982; Green et al. 1992; Baumgartner 1997; Davis et al. 1998; Mignucci-Giannoni 1998; Kruse et al. 1999). Baumgartner (1997) hypothesized that the fidelity of Risso's dolphins on the steeper portions of the upper continental slope in the GOMEX is most likely the result of cephalopod prey distribution in the same area.

- Along the U.S. Atlantic Coast coast between Cape Hatteras and George's Bank, individuals were distributed along the northern wall of the Gulf Stream and associated with warm-core rings (Waring et al. 1992) .

- In general, Risso's dolphins occupy the mid-Atlantic continental shelf year-round (Payne et al. 1984). They are distributed along the continental shelf break from Cape Hatteras north to Georges Bank from March through December (CETAP 1982; Payne et al. 1984). This range extends seaward in the mid-Atlantic Bight from December through February (Payne et al. 1984).

Table 3-17. Abundance estimates for Risso's dolphin by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for the Risso's dolphin in the Northeast study area.

Season	Abundance
Spring	8,710
Summer	8,710
Fall	8,710
Winter	8,710

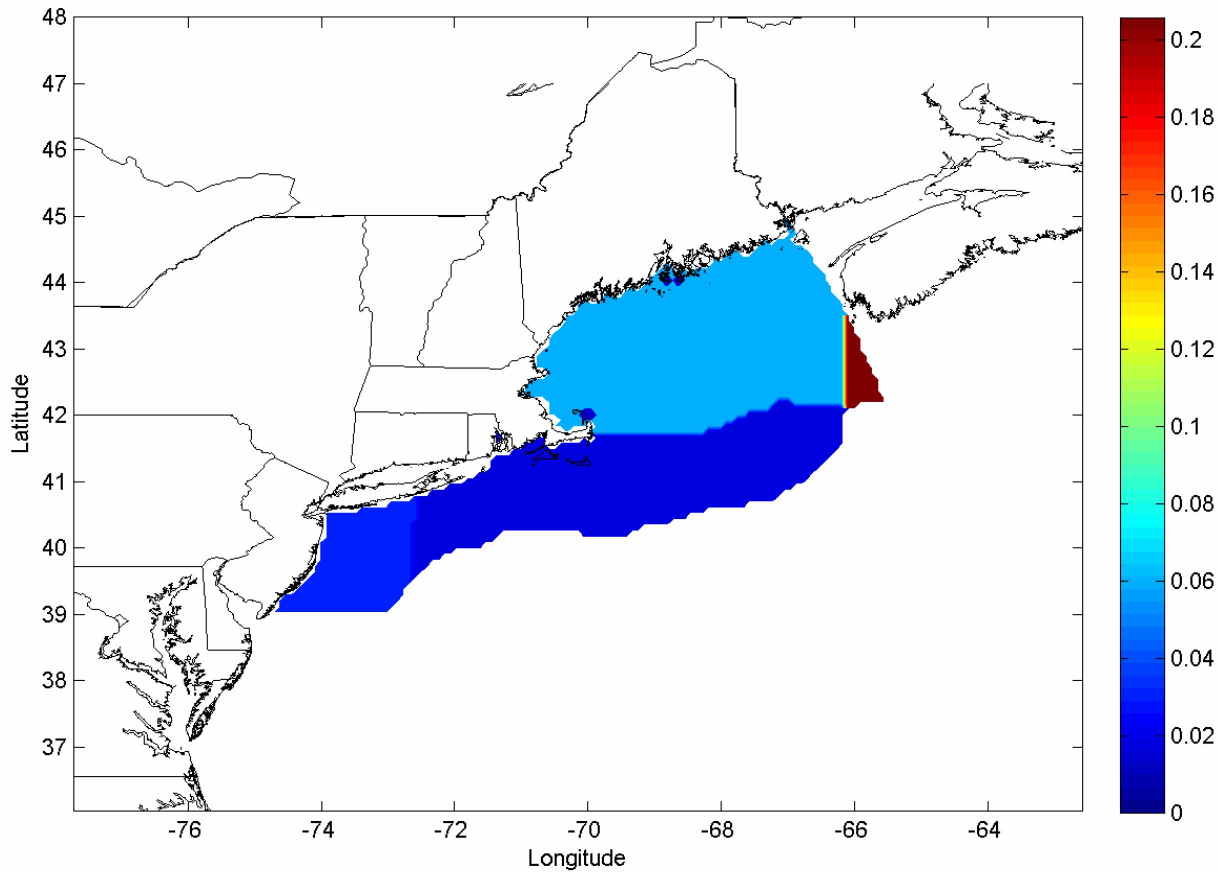


Figure 3-27. Density surface for the Risso's dolphin during all seasons off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

➢ Pilot Whales (*Globicephala* spp.)

The long-finned pilot whale (*Globicephala melas*) and the short-finned pilot whale (*Globicephala macrorhynchus*) comprise this category. These species can be difficult to distinguish from one another in the field.

Distribution and habitat preferences

- Pilot whales are typically found over the continental shelf break, in slope waters, and in areas with steep bottom topography (Olson and Reilly 2002). A number of studies have suggested that the distribution and movements of *Globicephala* spp. coincide closely with the abundance of squid (Hui 1985; Payne and Heinemann 1993; Bernard and Reilly 1999). Pilot whales are also associated with the Gulf Stream north wall and thermal fronts along the continental shelf edge (Waring et al. 1992).

- While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern U.S. (Jefferson and Schiro 1997).

- The apparent ranges of the two pilot whale species overlap in shelf/shelf-edge and slope waters of the northeastern U.S. between 35°N and 38° to 39°N (New Jersey to Cape Hatteras, North Carolina) (Payne and Heinemann 1993). The short-finned pilot whale usually does not range north of 50°N or south of 40° South (S), however, short-finned pilot whales have stranded as far north as Rhode Island. Strandings of long-finned pilot whales have been recorded as far south as South Carolina (Waring et al. 2007). Long-finned pilot whales appear to concentrate during winter along the continental shelf break primarily between Cape Hatteras and Georges Bank (Waring et al. 1990).

Table 3-18. Abundance estimates for Pilot Whales by season based on density estimates from the preliminary Northeast NODE report (DoN 2006). These are abundance estimates for Pilot Whales in the Northeast study area.

Season	Abundance
Spring	39,114
Summer	16,902
Fall	15,433
Winter	10,259

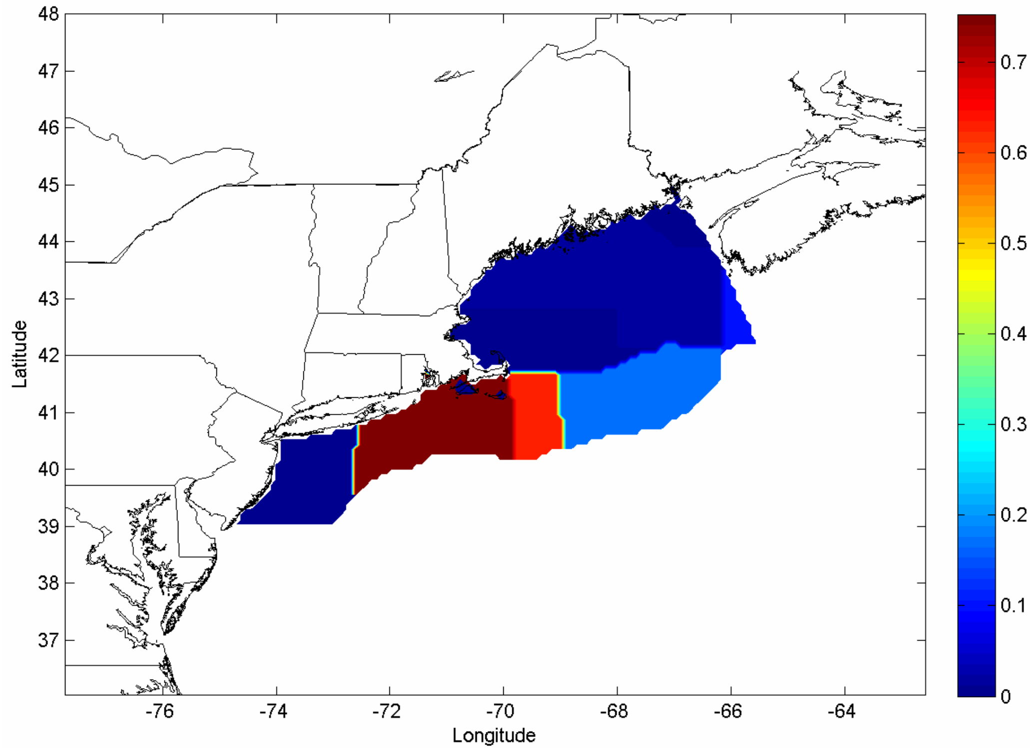


Figure 3-28. Density surface for Pilot Whales during the spring off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

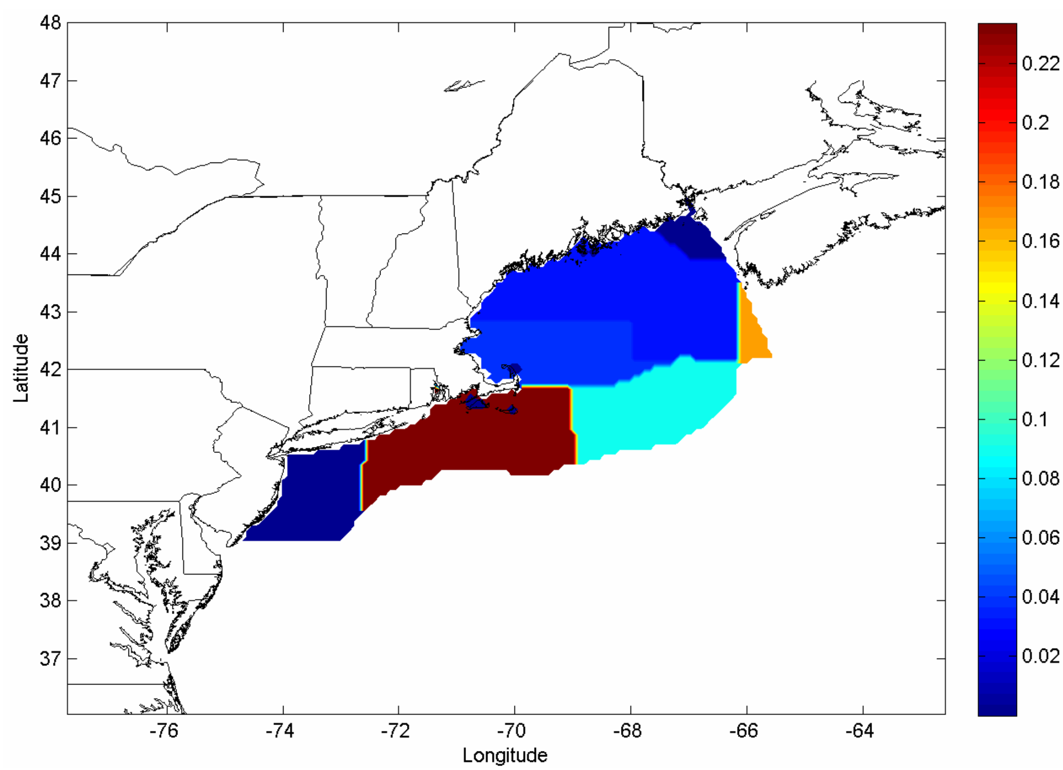


Figure 3-29. Density surface for Pilot Whales during the summer off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

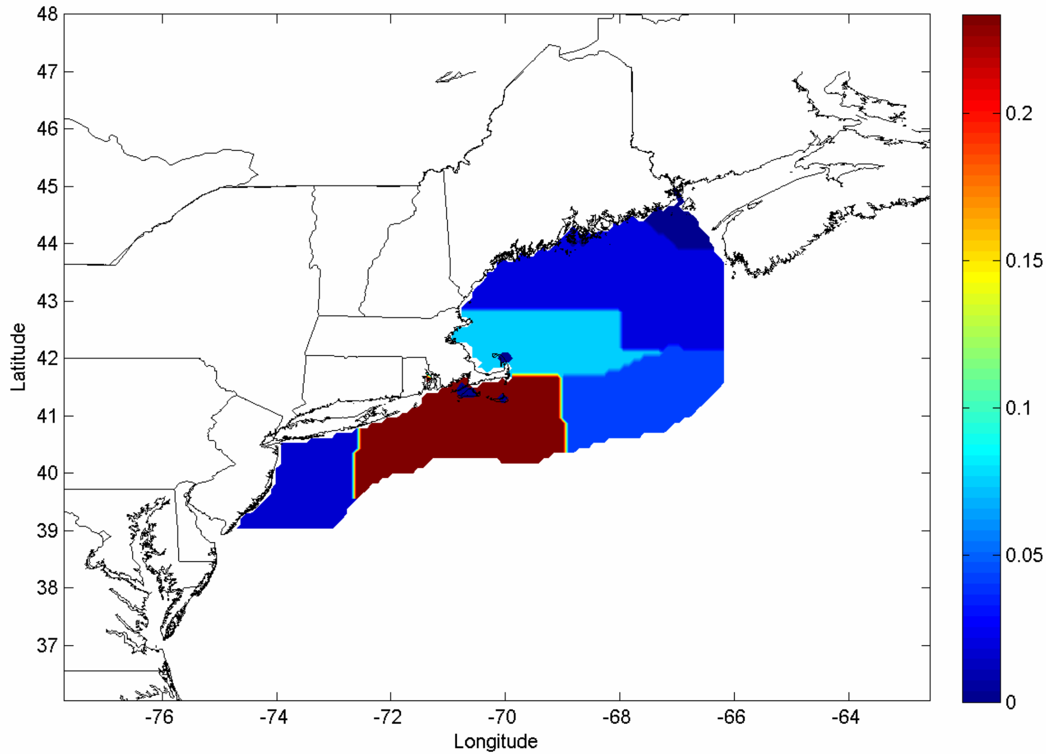


Figure 3-30. Density surface for Pilot Whales during the fall off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

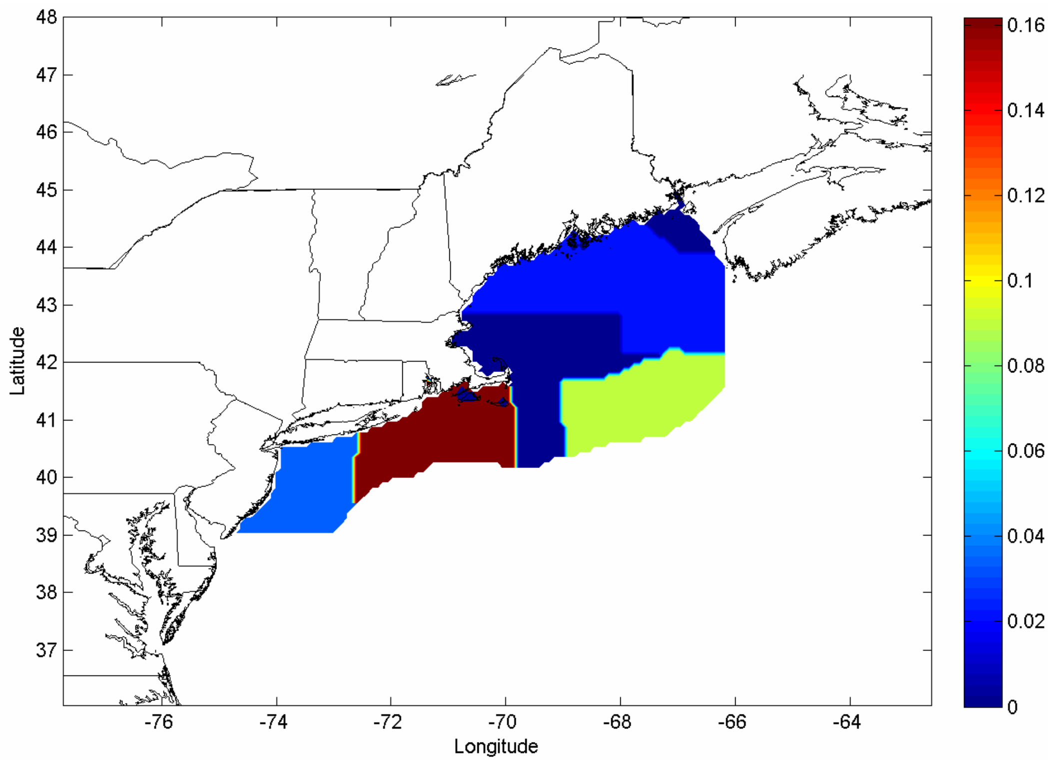


Figure 3-31. Density surface for Pilot Whales during the winter off the United States Atlantic Coast based on density estimates from the preliminary Northeast NODE report (DoN 2006).

3.1.3 Species with Literature-Derived Density Estimates

- North Atlantic Right Whale (*Eubalaena glacialis*)

Density and Abundance Estimate

The North Atlantic right whale was the primary species needing this SAR-derived approach. The approach for handling right whales was to take the abundance estimate of 396 animals (NARWC 2006) and divide that among the four different quartiles from the occurrence polygons found in the NE MRA (DoN 2005). This was under the assumptions that: 1) 75% of the population was found in the NE study area during spring, summer, and fall and that 50% of the population remained there during the winter; and 2) that each quartile represented 25% of the population found in the area at a given time. Therefore, given these assumptions, density estimates were derived for each season by dividing the number of animals assumed to be in each of the quartile regions by the total area (km^2) of that quartile. Regardless of the sizes of the areas for which abundance estimates are provided, the estimate never exceeds 396 animals. The density estimates from Hain and Kenney (2005c; 2005a; 2005b) were used for each of the three SE OPAREAs of VACAPES, CHPT, and JAX/CHASN (the VACAPES density estimates were extended up to approximately the New York/New Jersey border) and portions of the NE OPAREAs (Boston, Narragansett Bay and Atlantic City).

Distribution and habitat preferences

- Right whale distribution extends from the GOM south throughout the southeastern U.S., in continental shelf and slope waters (Winn et al. 1986). Although primarily found in waters over the continental shelf, tagging data indicate that individuals also move into deeper waters (Mate et al. 1997). Knowlton et al. (2002) determined that 94% of all right whale sightings and 80% of tagged animal sightings occurred within 30 nautical miles (NM) (56 km) of land. This corresponds to 80% of all sightings within waters with a bottom depth of 90 ft (27 m), with 71% of all sightings in waters with a bottom depth within 60 ft (18 m) of water (Knowlton et al. 2002).

- Right whales are found on their feeding grounds off the northeastern U.S. during February to November. They also demonstrate habitat usage shifts (using different areas during different months) that are described in detail in Winn et al. (1986) and Kenney et al. (2001).

- The Cape Cod Bay and Great South Channel feeding grounds (which include the Boston OPAREA in locations) are designated as critical habitats under the ESA (NMFS 1994).

- Feeding grounds in the northeastern U.S. are characterized by shallow, shelf waters where bottom topography, water column structure, currents, and tides combine to physically concentrate zooplankton (Wishner et al. 1988; Murison and Gaskin 1989; Baumgartner and Mate 2003).

Table 3-19. Monthly and bi-monthly abundance estimates for the North Atlantic right whale based on Northeast Marie Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007). These are abundance estimates for the North Atlantic right whale in the Northeast study area.

Time Period	Abundance
January	396
February & March	396
April	230
May & June	229
July - September	67
October & November	67
December	73

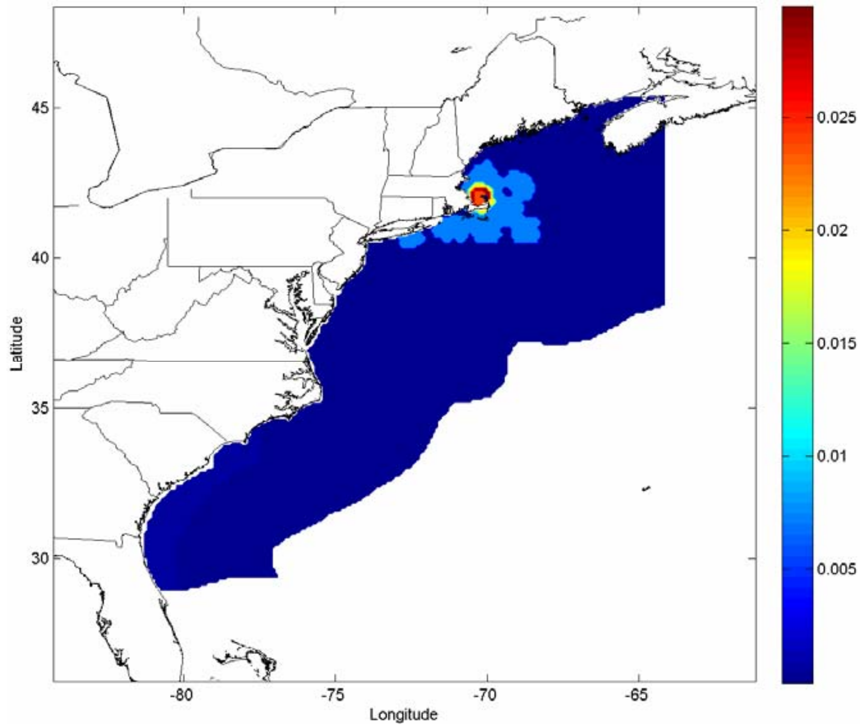


Figure 3-32. Density surface of the North Atlantic right whale for January based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

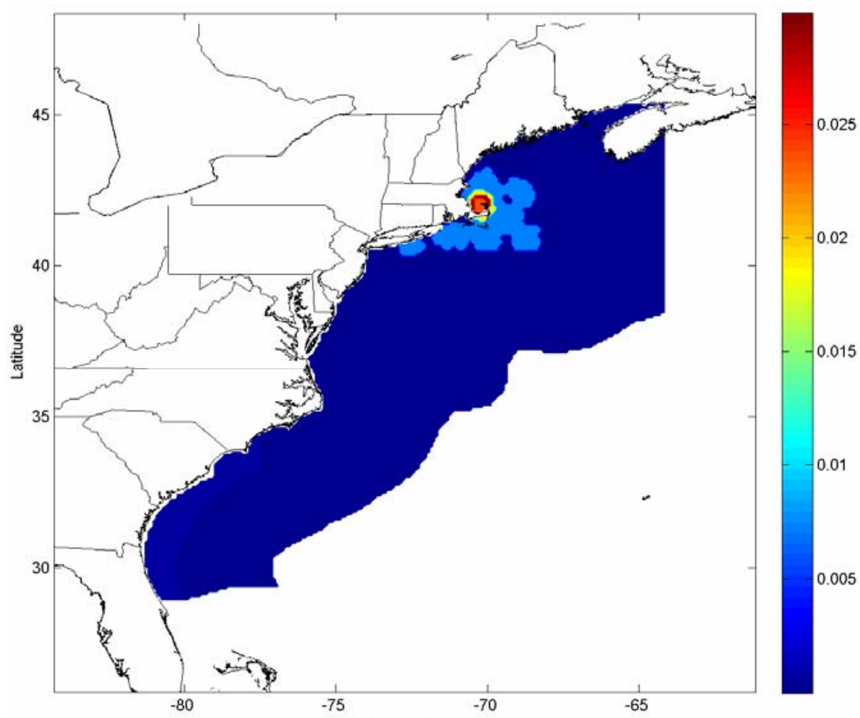


Figure 3-33. Density surface of the North Atlantic right whale for February based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers. comm., April 2007).

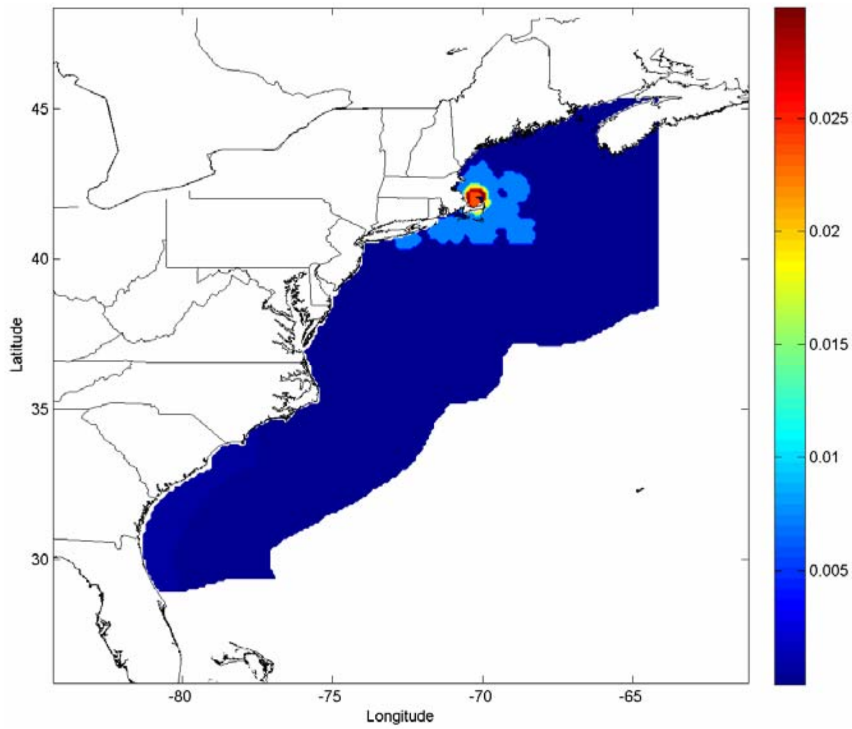


Figure 3-34. Density surface of North Atlantic right whale for March based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers. comm. ,April 2007).

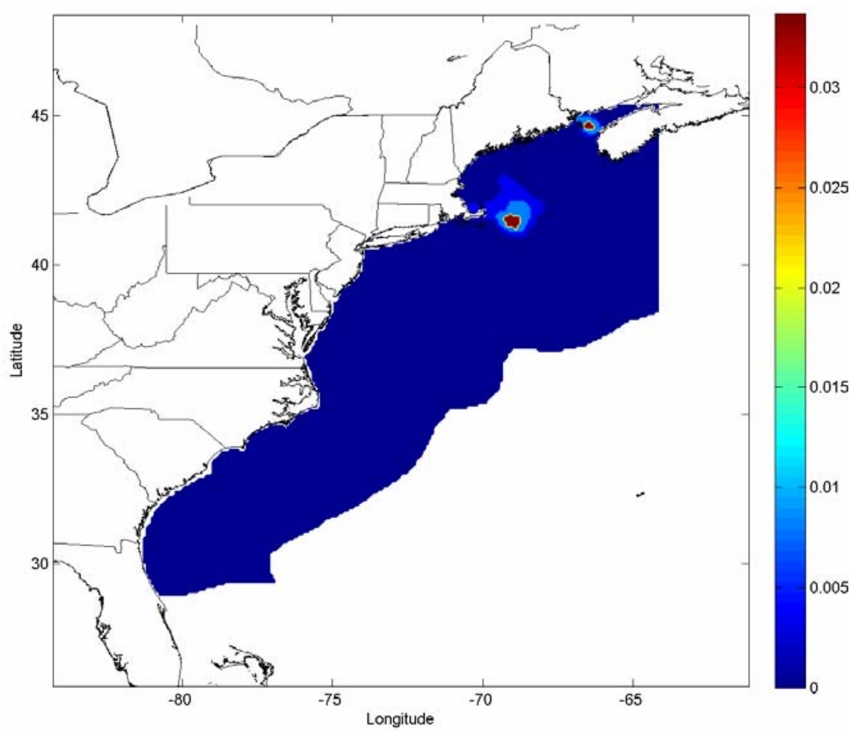


Figure 3-35. Density surface of North Atlantic right whale for April based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

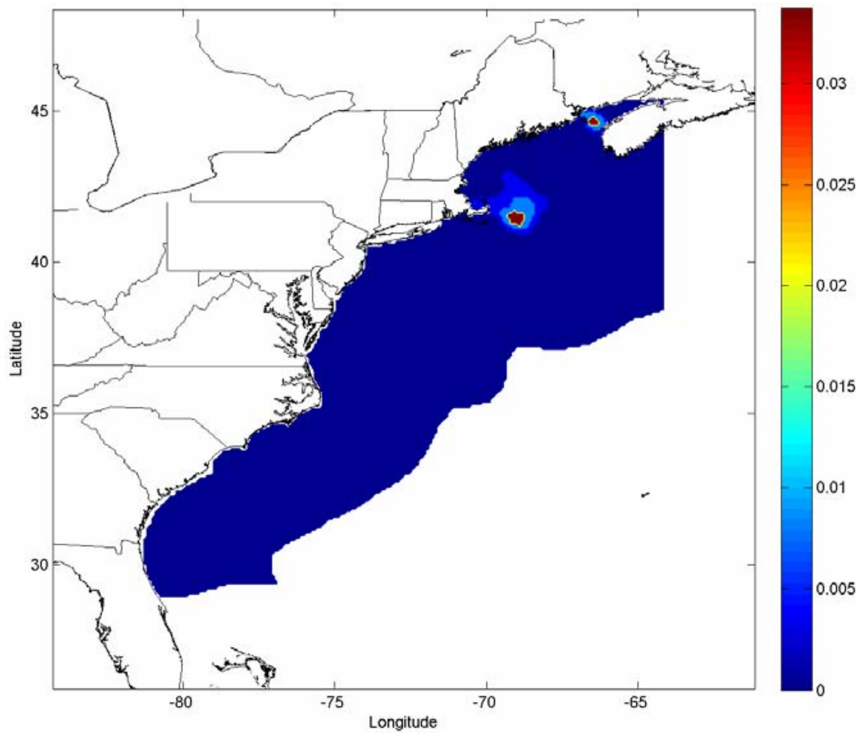


Figure 3-36. Density surface of North Atlantic right whale for May based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

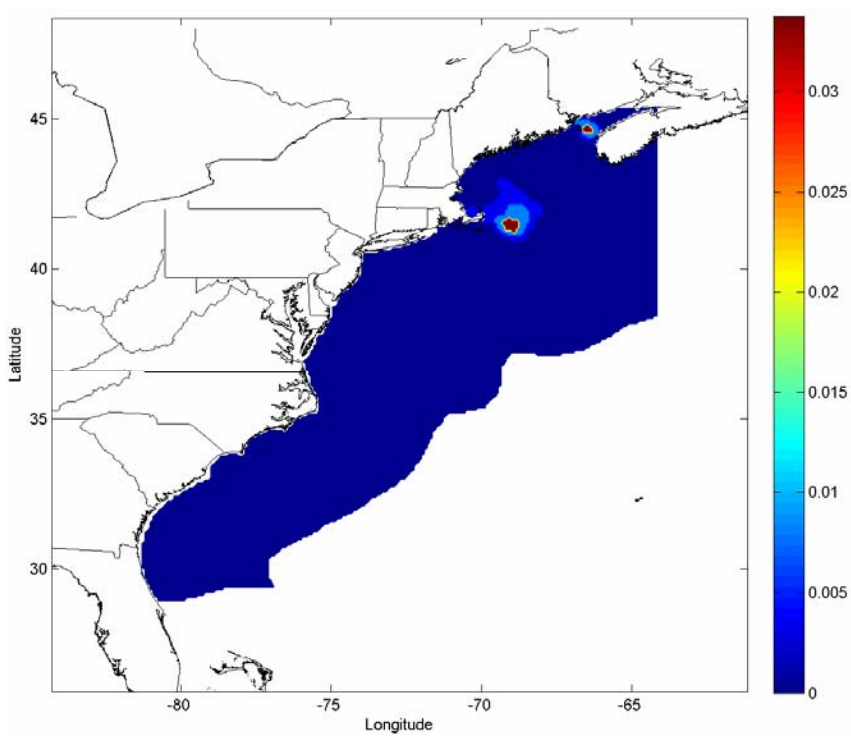


Figure 3-37. Density surface of North Atlantic right whale for June based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

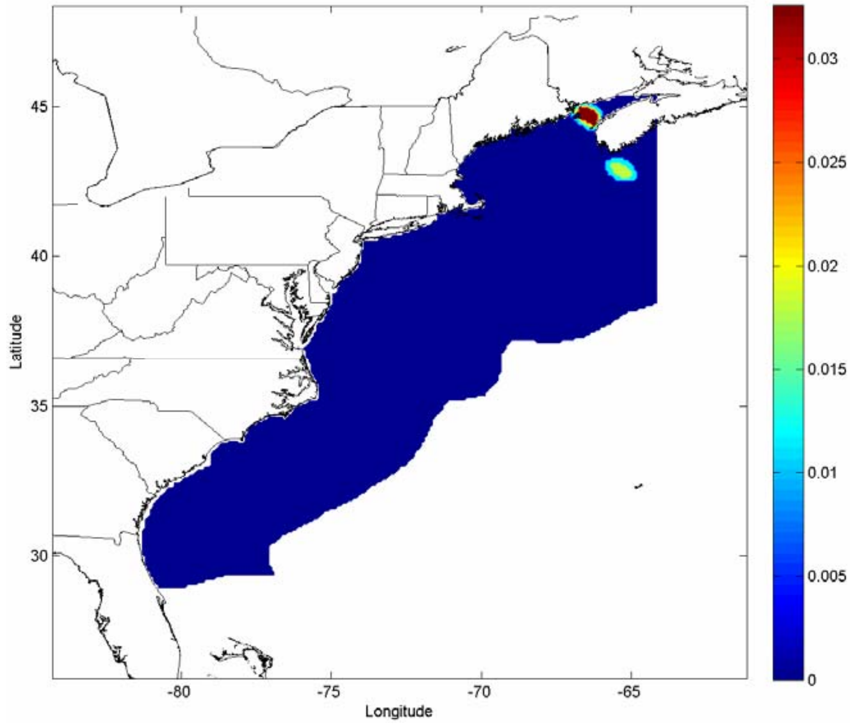


Figure 3-38. Density surface of North Atlantic right whale for July and August based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

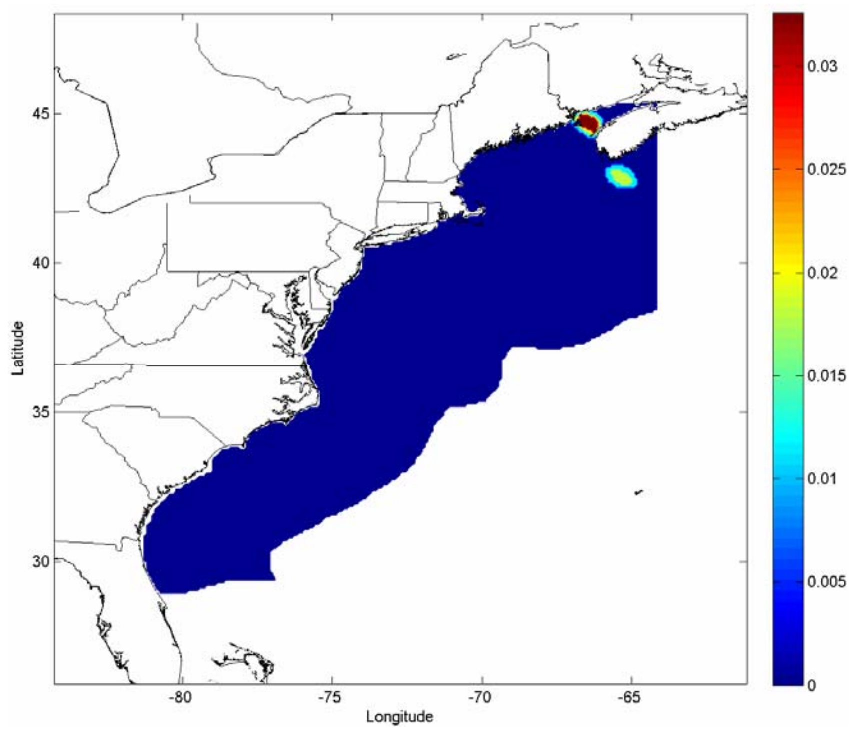


Figure 3-39. Density surface of North Atlantic right whale for September based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

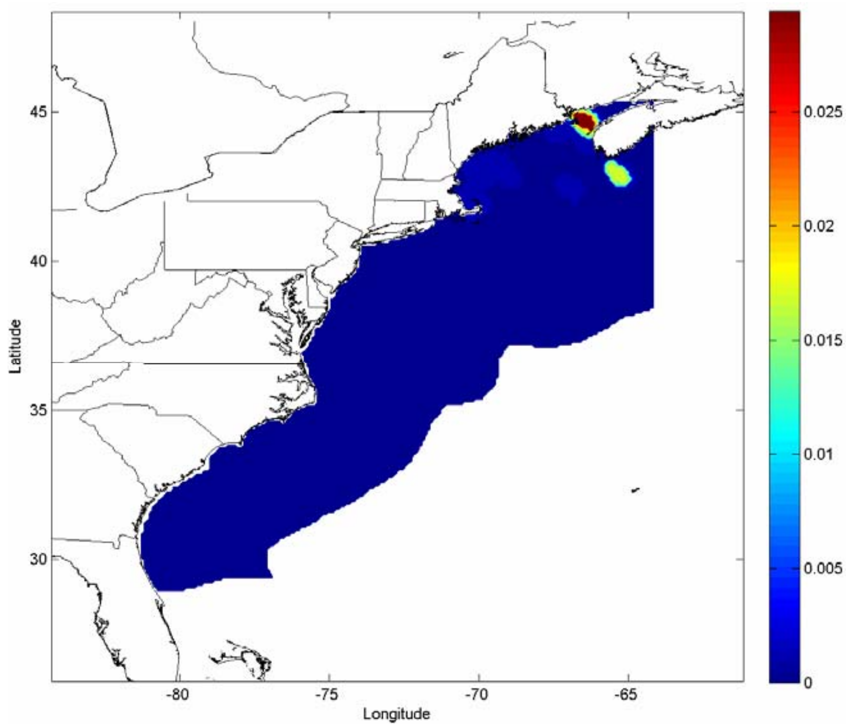


Figure 3-40. Density surface of North Atlantic right whale for October and November based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

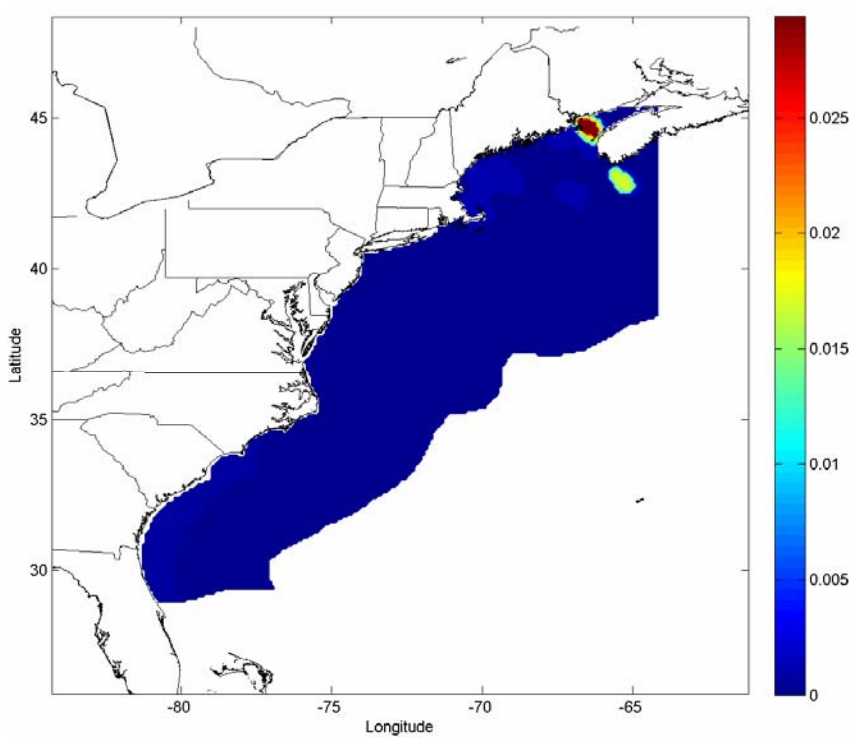


Figure 3-41. Density surface of North Atlantic right whale for December based on Northeast Marine Resource Assessment polygons (DoN 2005) and Dr. Robert Kenney (Kenney, R., University of Rhode Island, pers, comm., April 2007).

3.1.4 Species for Which Density Estimates Are Not Available

For some species or species groups, there was no density estimate available at all or it was not possible to derive one based on the available abundance estimates.

- Blue Whale *(Balaenoptera musculus)*

  Distribution and habitat preferences

  - Stranding and sighting data suggest that the blue whale's original Atlantic range extended south to Florida, the GOMEX, the Cape Verde Islands, and the Caribbean Sea (Yochem and Leatherwood 1985).
  - Blue whales rarely occur in the EEZ and the Gulf of Maine from August to October, which may represent the limits of their feeding range (CETAP 1982; Wenzel et al. 1988). Researchers using Navy-integrated undersea surveillance system (IUSS) resources have more recently been able to detect blue whales throughout the open Atlantic south to at least The Bahamas (Clark 1995; Clark and Gagnon 2004).
  - Blue whales in the Atlantic are primarily found in deeper, offshore waters and are rare in shallower, shelf waters (Wenzel et al. 1988).

  Density and abundance estimates

  - As noted in the NOAA SAR (Waring et al. 2007), there is insufficient data to estimate abundance of the blue whale off the U.S. Atlantic Coast. Therefore, density estimates for this species could not be generated.

- Spinner Dolphin (*Stenella longirostris*)

  Distribution and habitat preferences

  - Spinner dolphin distribution is along most of the U.S. Atlantic Coast, primarily in offshore waters (CETAP 1982; Waring et al. 1992; Waring et al. 2007).
  - Spinner dolphins have been sighted within the Gulf Stream, which is consistent with the oceanic distribution and warm-water preference of this genus (Waring et al. 1992).

  Density and abundance estimates

  - As noted in the NOAA SAR (Waring et al. 2007), there is insufficient data to estimate abundance of the spinner dolphin off the U.S. Atlantic Coast. Therefore, density estimates for this species could not be generated.

- White-Beaked Dolphin *(Lagenorhynchus albirostris)*

  - In the western North Atlantic, white-beaked dolphins occur from eastern Greenland through the Davis Strait and south to Massachusetts (Lien et al. 2001).
  - White-beaked dolphins occupy waters over and beyond the continental shelf (CETAP (Cetacean and Turtle Assessment Program) 1982; Northridge et al. 1997; Lien et al. 2001). During CETAP (1982) surveys, white-beaked dolphins were typically sighted in coastal waters near Cape Cod and along Stellwagen Bank depths between 13 and 748 m. Studies in the eastern North Atlantic suggest that the white-beaked dolphin (which occurs in greater abundance in that part of the

Atlantic) has a more coastal feeding habit in contrast to the Atlantic white-sided dolphin which mainly feeds offshore (Das et al. 2003).

Density and abundance estimates

- As noted in the NOAA SAR (Waring et al. 2007), there is insufficient data to estimate abundance of the blue whale off the U.S. Atlantic Coast. Therefore, density estimates for this species could not be generated.

➢ Pygmy Killer Whale *(Feresa attenuata)*

Distribution and habitat preferences

- Pygmy killer whales have a worldwide distribution in tropical and subtropical waters, generally not ranging north of 40ºN or south of 35ºS (Jefferson et al. 1993). There are few confirmed records of this species in the western North Atlantic (Caldwell and Caldwell 1971; Ross and Leatherwood 1994).

- Pygmy killer whales generally occupy offshore habitats. In the nearby northern GOMEX, this species is found primarily in deeper waters off the continental shelf into waters over the abyssal plain (Davis and Fargion 1996; Davis et al. 2000).

Density and abundance estimates

- As noted in the NOAA SAR (Waring et al. 2007), there is insufficient data to estimate abundance of the pygmy killer whale off the U.S. Atlantic Coast. Therefore, density estimates for this species could not be generated.

➢ Killer Whale *(Orcinus orca)*

Distribution and habitat preferences

- Killer whale occurrence in the western North Atlantic is unpredictable (e.g., Katona et al. 1988; Waring et al. 2007), though (Katona et al. 1988) reported a regular occurrence south of 35ºN (Katona et al. 1988).

- Globally, killer whales can be found in the open sea, as well as in coastal areas (Dahlheim and Heyning 1999). In the western North Atlantic, they are primarily found along the shelf break and farther offshore (Katona et al. 1988; Mitchell and Reeves 1988).

- Killer whales in the western North Atlantic do occur in fishing areas, perhaps coincident with tuna, in warm seasons (e.g., Katona et al. 1988; Waring et al. 2007).

Density and abundance estimates

- As noted in the NOAA SAR (Waring et al. 2007), there is insufficient data to estimate abundance of the blue whale off the U.S. Atlantic Coast. Therefore, density estimates for this species could not be generated.

3.2 PINNIPEDS

The source for the density estimates of the two pinniped species that occur in the study area was the most recent NOAA SAR (Waring et al. 2007). In addition to the limited seasonal occurrence of these species in much of the NE study area, the SAR abundances for the gray and harbor seals are based on coastal haulout counts acquired from a limited geographic area and during a limited time period. As a result, pinniped densities could not be derived for all Navy strata or seasons. To supplement the SAR abundance estimate for the more southerly strata, a different abundance estimate from Barlas (1999) was used to calculate a density for the seasonal distribution of the harbor seal. The following sections provide basic information on the range and habitat preferences of the gray and harbor seals, as well as the estimated densities by Navy strata and season, where applicable.

➢ Gray Seal *(Halichoerus grypus)*

Distribution and habitat preferences

- Gray seals currently range into the northeastern U.S., with strandings as far south as North Carolina (Hammill et al. 1998; Waring et al. 2007).

- Small numbers of gray seals and pupping have been observed on several isolated islands along the central coast of Maine and in Nantucket Sound (the southernmost breeding site is Muskeget Island) (Andrews and Mott 1967; Rough 1995; Waring et al. 2007). Resident colonies and pupping has been observed in Maine since 1994, on a few islands (Seal and Green) in Penobscot Bay (Waring et al. 2007). Spring and summer sightings off Maine are primarily on offshore ledges of the central coast of Maine (Richardson 1976). In the late 1990s, a breeding population of at least 400 animals was documented year-round on outer Cape Cod and Muskeget Island (Barlas 1999; Waring et al. 2004). Hoover et al. (1999) reported sighting as many as 30 adult gray seals at one haulout site in New York. There are also gray seal sightings and strandings on Long Island Sound.

- The gray seal is considered to be a coastal species (Lesage and Hammill 2001). Gray seals may forage far from shore but do not appear to leave the continental shelf regions (Lesage and Hammill 2001).

- Haulout sites are often near rough seas and riptides (Katona et al. 1993). Remote, uninhabited islands tend to have the largest gray seal haulout sites (Reeves et al. 1992).

Density estimates by strata

No density estimates for the gray seal were provided by the NMFS-NEFSC. Density estimates presented here are derived from the SAR abundance estimates (**Table 3-20**) for Spring 1999 (5,611) and Spring 2001 (1,731) for two regions off Massachusetts and the Maine coast, respectively (Waring et al. 2007). The abundance estimate for Maine was used to derive the densities for the GOM North and Central strata, while the densities for the Georges Bank West and Central strata were based on the abundance estimates for Massachusetts.

Gulf of Maine—The gray seal can be found year-round in continental shelf, especially coastal, waters of the GOM, and GOM breeding sites have been identified in the Grand Manan Island group (GOM North) and to a lesser degree in Cape Cod (GOM South). The SAR-derived density of 2.725 gray seals/100 km^2 was computed for the spring of the coast of Maine, which is encompassed by the GOM North and Central strata, based on abundance estimates from aerial surveys of the haulout sites (**Table 3-20**). The SAR-derived spring density was then applied to the remaining seasons for the GOM North and Central strata as well to all seasons of the GOM South stratum.

Mid-Atlantic—Although the gray seal is known to occur in this region from stranding records (DoN 2005), this species occurs so rarely in this region that a density estimate could not be calculated.

<u>Georges Bank</u>

- *Georges Bank West and Central*—The largest number of gray seals likely to occur in the study area may be found year-round in the coastal waters of southern Massachusetts in the vicinity of the breeding sites at Monomoy and Muskeget Islands (Georges West). The SAR-based density estimate of 14.116 gray seals/100 km^2 was computed for the spring of the Georges Bank West and Central strata. The Georges Bank Central stratum was included in the calculation of density since Monomoy Island is in such close proximity to the border of this stratum. The SAR-based spring density estimate was then applied to the remaining seasons (winter, summer, and fall) for Georges West and Central strata (**Table 3-20**).

- *Georges Bank East*—Although encompassing continental shelf waters, Georges Bank East (Georges Bank) is located at such a distance from the nearshore, coastal waters preferred by the gray seal that only the rarest, accidental occurrence is expected in this stratum during any season.

<u>Shelf and Offshore</u>—Prefering the shallower waters found in close proximity to shore, gray seals are unlikely to occur in the deeper waters included in these strata.

Table 3-20. Density estimates for the gray seal by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	2.725	2.725	2.725	2.725
per 100 NM^2	9.348	9.348	9.348	9.348
GOM Central				
per 100 km^2	2.725	2.725	2.725	2.725
per 100 NM^2	9.348	9.348	9.348	9.348
GOM South				
per 100 km^2	2.725	2.725	2.725	2.725
per 100 NM^2	9.348	9.348	9.348	9.348
Mid-Atlantic				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Georges West				
per 100 km^2	14.116	14.116	14.116	14.116
per 100 NM^2	48.419	48.419	48.419	48.419
Georges Central				
per 100 km^2	14.116	14.116	14.116	14.116
per 100 NM^2	48.419	48.419	48.419	48.419
Georges East				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Shelf West				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Shelf Central				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Shelf East				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0

Table 3-20. Continued.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
Offshore				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0

Table 3-21. Abundance estimates for the gray seal by season based on the density estimates presented in Table 3-20. These are abundance estimates for the gray seal in the Northeast study area.

Season	Abundance
Spring	8,294
Summer	8,294
Fall	8,294
Winter	8,294

➢ Harbor Seal (*Phoca vitulina*)

Distribution and habitat preferences

- Harbor seals are year-round residents of eastern Canada (Boulva 1973) and coastal Maine (Katona et al. 1993; Gilbert and Guldager 1998). The greatest concentrations of harbor seals in northeastern U.S. waters are found along the coast of Maine, specifically in Machias and Penobscot bays and off Mt. Desert and Swans Islands (Katona et al. 1993).

- Harbor seals occur south of Maine from late September through late May (Rosenfeld et al. 1988; Whitman and Payne 1990; Barlas 1999; Schroeder 2000). During winter, the population divides and disperses offshore into the Gulf of Maine south into southern New England, and a portion remains in coastal waters of Maine and Canada. Harbor seals have recently been observed over-wintering as far south as New Jersey (Slocum et al. 1999).

- Harbor seals are a coastal species, usually found near shore, and frequently occupying bays, estuaries, and inlets (Baird 2001).

- Ideal harbor seal habitat includes suitable haulout sites, shelter during breeding periods, and sufficient food within close proximity to sustain the population throughout the year (Bjørge 2002). Haulout substrates vary but include intertidal and subtidal rocky outcrops, sandbars, sandy beaches, and even peat banks in salt marshes (Wilson 1978; Schneider and Payne 1983; Gilbert and Guldager 1998). Along the majority of the New England coast, harbor seals haul out on rocky outcroppings and intertidal ledges (Kenney 1994; Gilbert and Guldager 1998; Schroeder 2000).

Density estimates by strata

Density estimates for this species were not provided by the NMFS-NEFSC. The SAR-based density estimate of 156.409 harbor seals/100 km^2 provided in this report is based on the late spring/early summer 2001 counts of 99,340 harbor seals for the coast of Maine (Waring et al. 2007). Since the Maine waters represent the year-round population center for harbor seals in the study area, and this species only occurs seasonally in the remaining coastal waters of the study area (GOM South, Georges Bank Central and West, and Mid-Atlantic strata), application of the SAR-based Maine density estimate to these seasonally occupied areas would result in an overestimation of the number of harbor seals. Thus, an alternative density, derived from the abundance estimate by Barlas (1999), was applied to the coastal strata south of GOM Central. This density estimate of 9.743 harbor seals/100 km^2 is based on the February 9, 1999 aerial surveys and counts of 6,260 harbor seals along the coasts of Massachusetts, Rhode Island, eastern Connecticut, and eastern New York (Barlas 1999).

Gulf of Maine

- *Gulf of Maine (GOM) North and Central*—Harbor seals are year-round residents of Maine coastal waters. The SAR-based density estimate of 156.409 harbor seals/100 km^2 computed for the spring and summer strata of GOM North and Central was also applied to the fall and winter of those same strata (**Table 3-22**). Although the harbor seal is a year-round resident in Maine coastal waters, the number of seals decreases in winter as many seals move into the coastal waters of southern New England and the northern mid-Atlantic (Rosenfeld et al. 1988; Katona et al. 1993). Thus, the winter densities for the GOM North and Central strata, although the best available, may slightly overestimate the number of animals occurring during this season off coastal Maine.

- *Gulf of Maine (GOM) South*—Harbor seals occur seasonally from late fall to late spring in this region, where breeding was thought to have been extirpated from coastal bays since the 1960s (Katona et al. 1993). However, pups have recently been reported from Manomet Island in Cape Cod Bay (Waring et al. 2006). The density estimate of 9.743 harbor seals/100 km^2 derived from the Barlas (1999) abundance estimate for the winter was applied to all seasons of GOM South except summer, when harbor seals are not expected in this region. If pupping is further documented in Cape Cod Bay, the seasonal density estimate may be applied to summer as well.

Mid-Atlantic—Although the center of harbor seal concentration is further north in Maine waters, since the mid-1990s harbor seals have begun occupying a northern New Jersey haulout site from late fall through late spring (Slocum et al. 1999). To account for this apparent range extension or re-occupation of this species historical range, the density estimate of 9.743 harbor seals/100 km^2 derived from Barlas (1999) was applied to the fall, winter, and spring for this stratum. Harbor seals vacate the waters of northern New Jersey before early summer and return to their breeding grounds in Maine and southern Canada.

Georges Bank

- *Georges Bank West and Central*—The harbor seal is a seasonal resident of the coastal waters off southern New England, Connecticut, and New York. The density estimate of 9.743 harbor seals/100 km^2 derived from Barlas (1999) was applied to the fall, winter, and spring when harbor seals are known to occur in the nearshore waters of the Georges West and Central strata (**Table 3-22**). Harbor seals have not been reported from the waters of this region during summer, having moved northward to their breeding haulouts in Maine and southeastern Canada.

- *Georges Bank East*—Although encompassing continental shelf waters, this region overlying Georges Bank is such a great distance from the shore haulouts found in the nearshore, coastal waters of the northeast U.S. that harbor seals are not expected to occur in this stratum and no densities are applied to any seasons of this stratum. The rare occurrence, such as the sighting reported near the eastern section of Georges Bank (DoN 2005), is likely an accidental occurrence.

Shelf and Offshore—No suitable habitat exists in these deepwater regions as the harbor seal prefers shallow, coastal waters close to suitable haulout substrate. Thus, the harbor seal is not expected to occur in the waters of these strata and no densities have been applied.

Table 3-22. Density estimates for the harbor seal by spatial strata and season.

Stratum/Density	Season Winter	Spring	Summer	Fall
GOM North				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.471	536.471	536.471	536.471
GOM Central				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.471	536.471	536.471	536.471
GOM South				
per 100 km^2	9.743	9.743	9.743	9.743
per 100 NM^2	33.418	33.418	33.418	33.418
Mid-Atlantic				
per 100 km^2	9.743	9.743	0	9.743
per 100 NM^2	33.418	33.418	0	33.418
Georges West				
per 100 km^2	9.743	9.743	0	9.743
per 100 NM^2	33.418	33.418	0	33.418
Georges Central				
per 100 km^2	9.743	9.743	0	9.743
per 100 NM^2	33.418	33.418	0	33.418
Georges East				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Shelf West				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Shelf Central				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Shelf East				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0
Offshore				
per 100 km^2	0	0	0	0
per 100 NM^2	0	0	0	0

Table 3-23. Abundance estimates for the harbor seal by season based on the density estimates presented in Table 3-22. These are abundance estimates for the harbor seal in the Northeast study area.

Season	Abundance
Spring	101,357
Summer	95,121
Fall	101,357
Winter	101,357

This page intentionally left blank

3.3 SEA TURTLES

All sea turtle species are listed as threatened or endangered under the ESA. In this section, individual species with density estimates are addressed first and are followed by the species representing the rest of the hard-shelled turtles listed in **Table 3-1**.

When producing the sea turtle density surface, all aerial survey data from both the NE and SE were used and the surface created extended the entire coastline, as depicted in **Figures 3-42** through **3-48**. However, only data from the NE study area were used to generate the abundance estimates contained in **Tables 3-24** through **3-27** (**Section 2.2**).

Density estimates for sea turtles were generated for the leatherback turtle, loggerhead turtle, Kemp's ridley turtle, and the group Hardshell Turtles in the same manner as marine mammal species. The species incorporated into the Hardshell Turtles category included green, hawksbill, and unidentified hard-shelled turtles. These species groups were pooled together since the numbers of sightings for each species or group were not sufficient to allow spatial modeling. This category did not include leatherback turtles since identification of this species is not difficult. The sea turtle estimates produced are for continental shelf waters only, since only this portion of the study area was covered by aerial surveys.

3.3.1 Individual Species

- <u>Leatherback Turtle</u> (*Dermochelys coriacea*)

Distribution and habitat preferences

- Leatherback turtles are the most oceanic and wide-ranging of all sea turtle species. The leatherback turtle is distributed circumglobally in tropical, subtropical, and warm-temperate waters throughout the year and into cooler temperate waters during warmer months (NMFS and USFWS 1992; James et al. 2005). The leatherback often undertakes extensive migrations following depth contours for thousands of kilometers (Morreale et al. 1996; Hughes et al. 1998). Adult leatherback turtles forage in temperate and subpolar regions in all oceans and migrate to tropical nesting beaches between 30°N and 20°S. Female leatherbacks nest from the southeastern United States to southern Brazil in the western Atlantic (The SWOT Team 2007).

- Post-hatchlings and early juveniles are entirely oceanic and restricted to waters warmer than 26°C (NMFS and USFWS 1992; Eckert 2002). Late juveniles and adults range from deep, mid-ocean habitats to the continental shelf and nearshore waters (Schroeder and Thompson 1987; Shoop and Kenney 1992; Grant and Ferrell 1993; Epperly et al. 1995a).

- Tagging studies in the North Atlantic Ocean have indicated many variations in overwintering and onshore-offshore occurrence patterns (Lee and Palmer 1981). The migratory cycles of adult leatherbacks often include movements between temperate and tropical waters.

- Survey data indicate that leatherback migration starts with the northward movement of individuals along the southeast coast of the U.S. in the late winter/early spring. In February and March, most leatherbacks along the U.S. Atlantic Coast are found in the waters off northeast Florida. By April and May leatherbacks begin to occur in large numbers off the coasts of Georgia and the Carolinas (NMFS 1995; NMFS 2000). In late spring/early summer, leatherbacks begin to appear off the mid-Atlantic and New England coasts, while by late summer/early fall, many will have traveled as far north as the waters off eastern Canada (CETAP 1982; Shoop and Kenney 1992; Thompson et al. 2001).

Table 3-24. Density surface model results for the leatherback turtle by season. These are abundance estimates for the leatherback turtle in the Northeast study area.

Density Surface Model (DSM)	Abundance
Spring	2,042
Summer	3,773
Fall	2,042
Winter	2,042

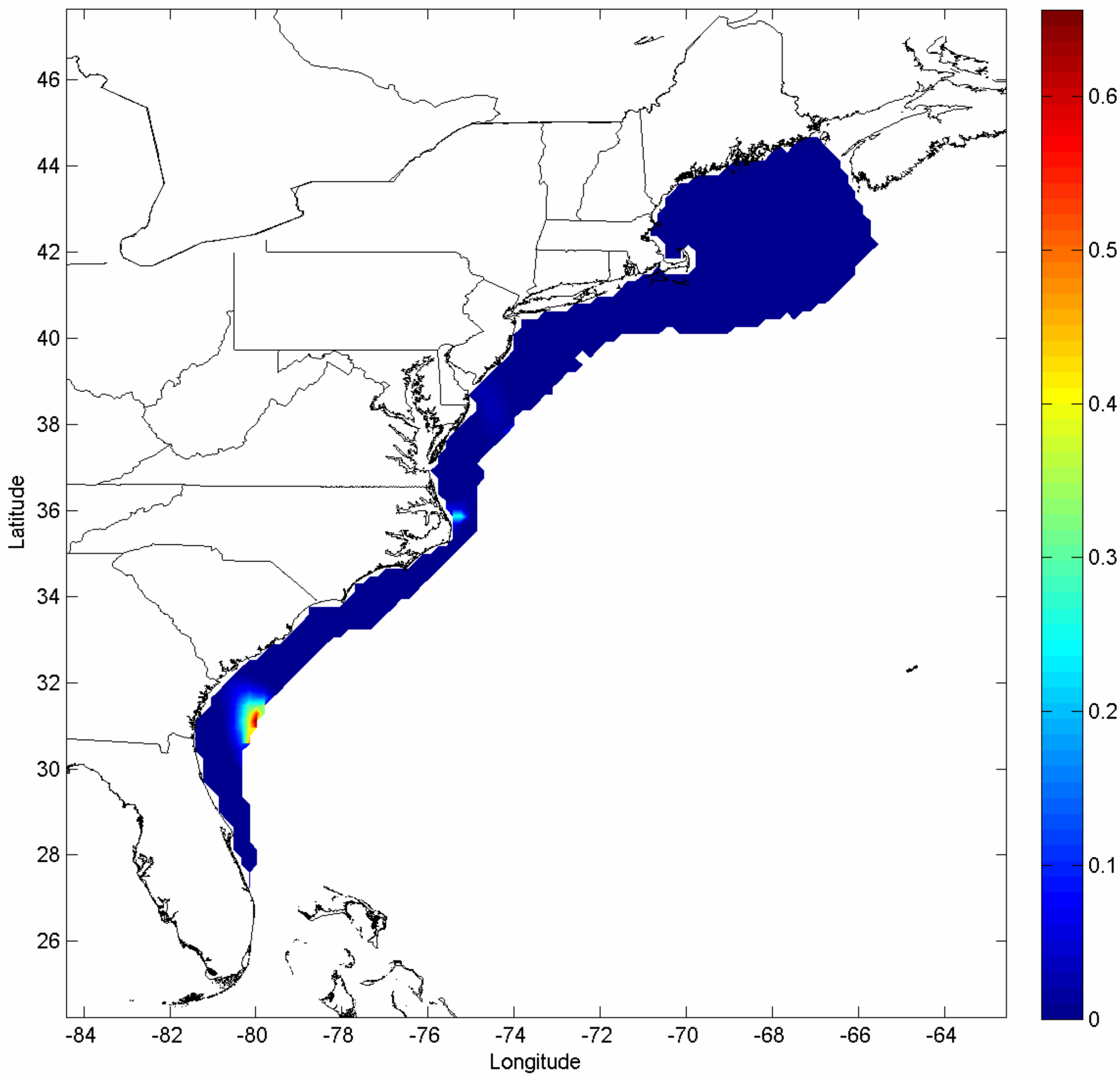


Figure 3-42. Density surface for the leatherback turtle during the summer off the United States Atlantic Coast.

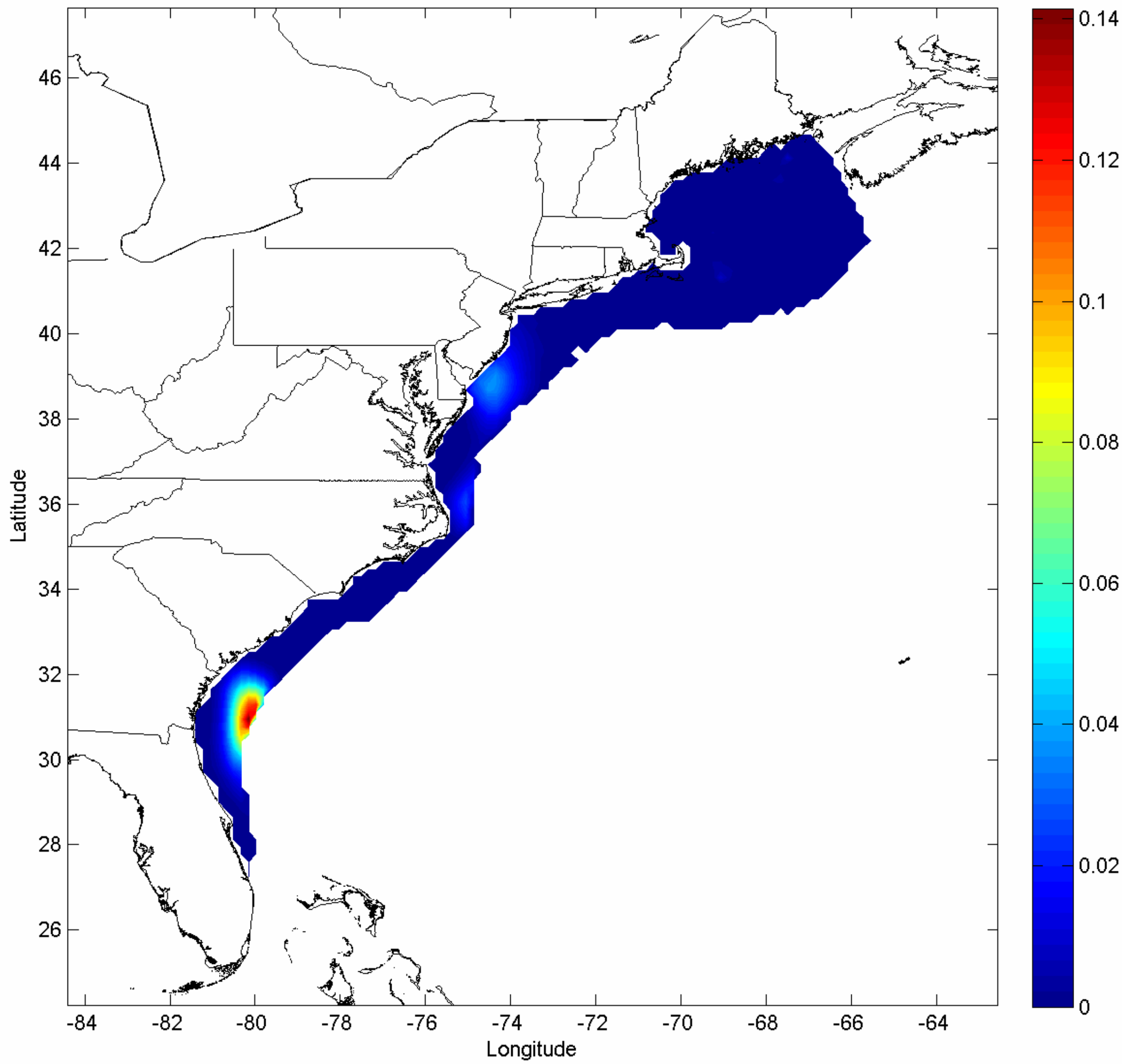


Figure 3-43. Density surface for the leatherback turtle during the fall, winter, and spring off the United States Atlantic Coast.

➢ Kemp's Ridley Turtle (*Lepidochelys kempii*)

Distribution and habitat preferences

- The Kemp's ridley is restricted to the North Atlantic Ocean (Marquez-M. 1994). Individuals occur primarily in the GOMEX and in moderate numbers along the U.S. Atlantic coast as far north as Nova Scotia (Lazell 1980; Morreale et al. 1992).

- Kemp's ridley turtles occur in open-ocean and *Sargassum* habitats as post-hatchlings and early juveniles (e.g., Manzella et al. 1991; Witherington and Hirama 2006). As older individuals, these are coastal migrants that travel along relatively narrow coastal corridors (reviewed by Morreale et al. 2007).

- Habitats frequently utilized include warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where preferred food, including the blue crab (*Callinectes sapidus)*, occurs (Lutcavage and Musick 1985; Landry and Costa 1999; Seney and Musick 2005)

- Along the U.S. Atlantic Coast, known feeding areas include Cape Cod Bay, Long Island Sound, Chesapeake Bay, and bays and sounds from North Carolina south to Florida (Lazell 1980; Lee and Palmer 1981; Lutcavage and Musick 1985; Barnard et al. 1989; Epperly et al. 1995a; Weber 1995). Mature Kemp's ridleys likely forage along the eastern coast of Florida (Henwood and Ogren 1987).

- Offshore water temperatures play a major role in determining the number of Kemp's ridleys present in the North Atlantic Ocean. Kemp's ridleys that forage in nearshore waters of the Mid-Atlantic Bight during warm months often overwinter in waters south of Cape Hatteras (Keinath et al. 1996). Individuals that do not emigrate from these waters become susceptible to hypothermia during late fall and winter. Most Kemp's ridleys overwinter in Florida near Cape Canaveral (Henwood and Ogren 1987).

Table 3-25. Density surface model results for the Kemp's ridley turtle by season. These are abundance estimates for the Kemp's ridley turtle in the Northeast study area.

Season	Abundance
Spring	3,073
Summer	3,073
Fall	3,073
Winter	3,073

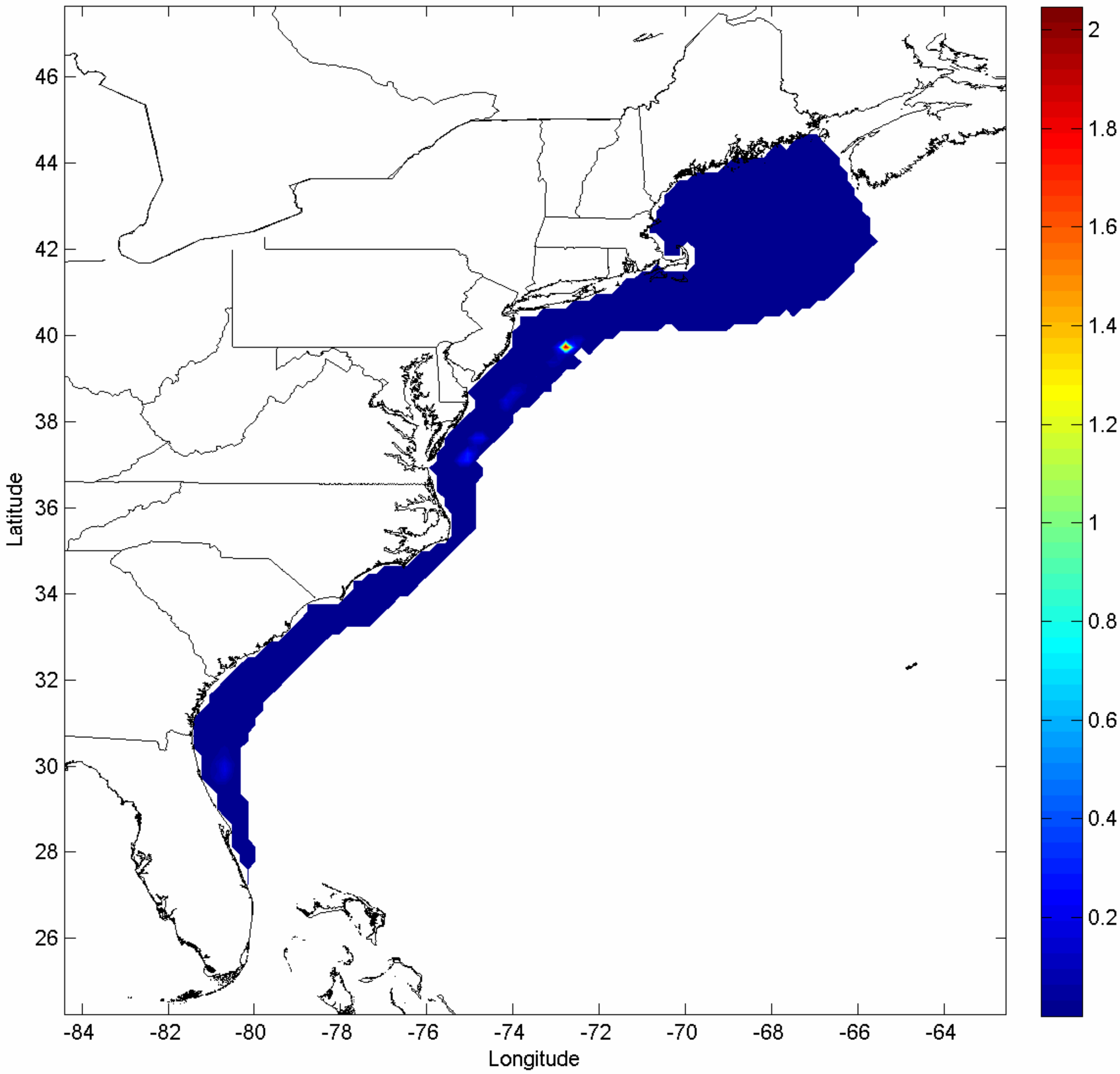


Figure 3-44. Density surface for the Kemp's ridley turtle during all seasons off the United States Atlantic Coast.

➢ <u>Loggerhead Turtle</u> (*Caretta caretta*)

Distribution and habitat preferences

- Loggerhead turtles are widely distributed in subtropical and temperate waters (Dodd 1988). Loggerhead turtles can be found along the U.S. Atlantic coast from Cape Cod to the Florida Keys during any season. Loggerheads seem generally restricted to waters of the North Atlantic Ocean south of 38°N, with mean SSTs around 22.2°C.

- The loggerhead turtle occurs in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd 1988). The species may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers.

- In the Mid-Atlantic Bight, loggerheads concentrate in continental shelf waters but are also commonly sighted in deeper, offshore waters (Shoop and Kenney 1992).

- North of Cape Hatteras, North Carolina, loggerhead occurrence is highly seasonal (CETAP 1982; Lutcavage and Musick 1985; Shoop and Kenney 1992). South of Cape Hatteras, loggerheads are resident year-round. Loggerheads distributions in North Carolina waters vary throughout the year (Epperly et al. 1995a); such variations are based upon seasonal water temperatures that influence migrations. During winter, the species' range is presumed to contract to waters south of where the Gulf Stream Current deflects off Cape Hatteras, so that turtles avoid hypothermia (Shoop and Kenney 1992). In early spring, juvenile loggerheads over-wintering in southeastern U.S. waters begin to migrate north to developmental feeding habitats (Morreale and Standora 2005).

- Loggerheads are primarily oceanic as post-hatchlings and early juveniles, often occurring in *Sargassum* driftlines where they are transported throughout the ocean by dominant currents (Carr 1987; Witherington 1994).

- Results from tagging data of juvenile loggerheads in both the eastern and western North Atlantic suggest that the location of currents and associated frontal eddies is important to the foraging ecology of the pelagic stage of this species (McClellan 2007).

- The neritic juvenile stage and adult foraging stage both occur in the neritic (nearshore) zone. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. The turtles here are active and feed primarily on the bottom (epibenthic/demersal), though prey is also captured throughout the water column (Bjorndal 2003; Bolten 2003). The neritic zone not also provides crucial foraging habitat, but can also provide inter-nesting and overwintering habitat. Tagging data has revealed that migratory routes may be coastal or may involve crossing deep oceanic waters; an oceanic route may be taken even when a coastal route is an option (Schroeder et al. 2003).

Table 3-26. Density surface model results for the loggerhead turtle by season. These are abundance estimates for the loggerhead turtle in the Northeast study area.

Density Surface Model (DSM)	Abundance
Spring	1,355
Summer	14,426
Fall	1,355
Winter	1,355

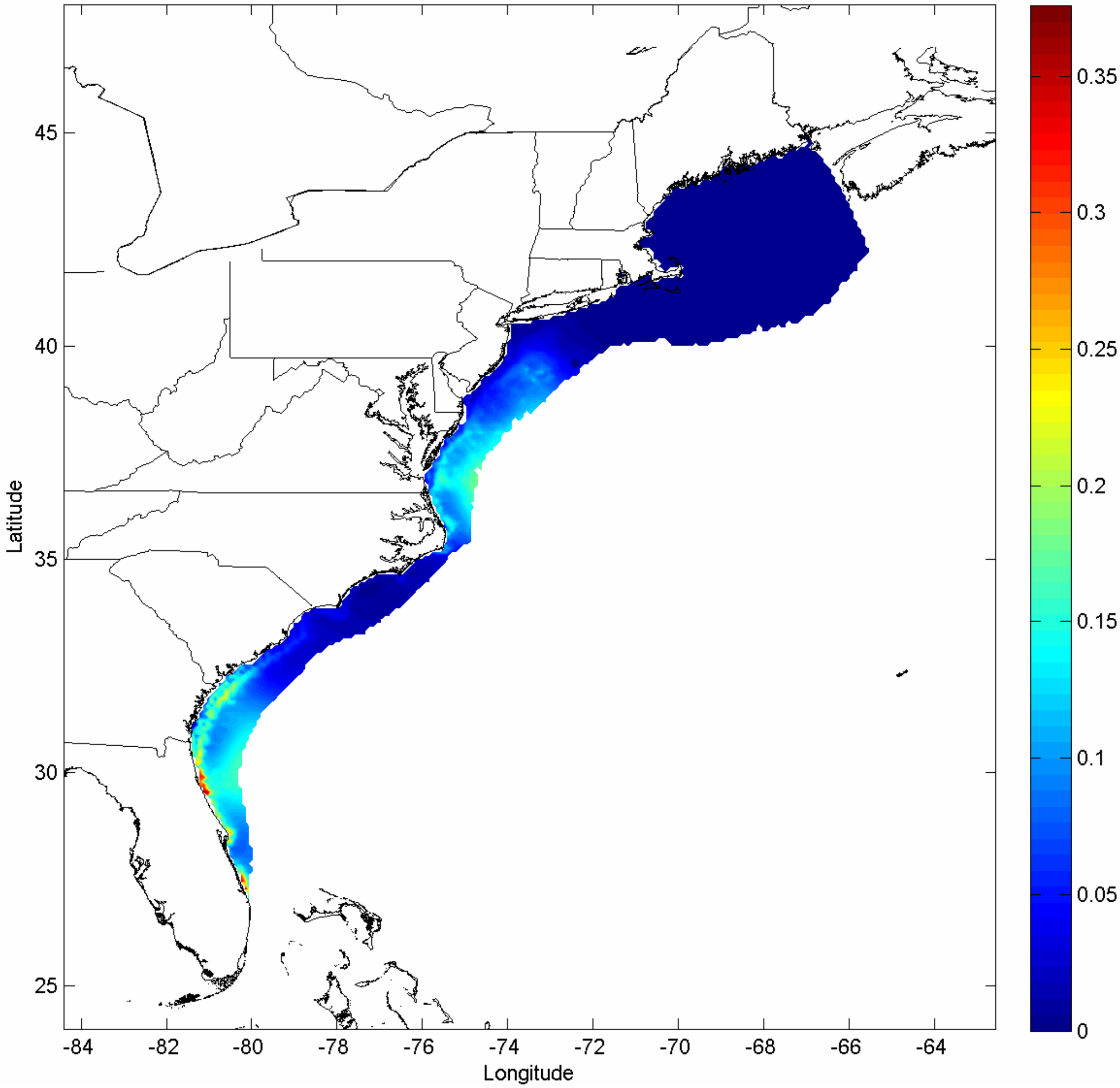


Figure 3-45. Density surface for the loggerhead turtle during the summer off the United States Atlantic Coast.

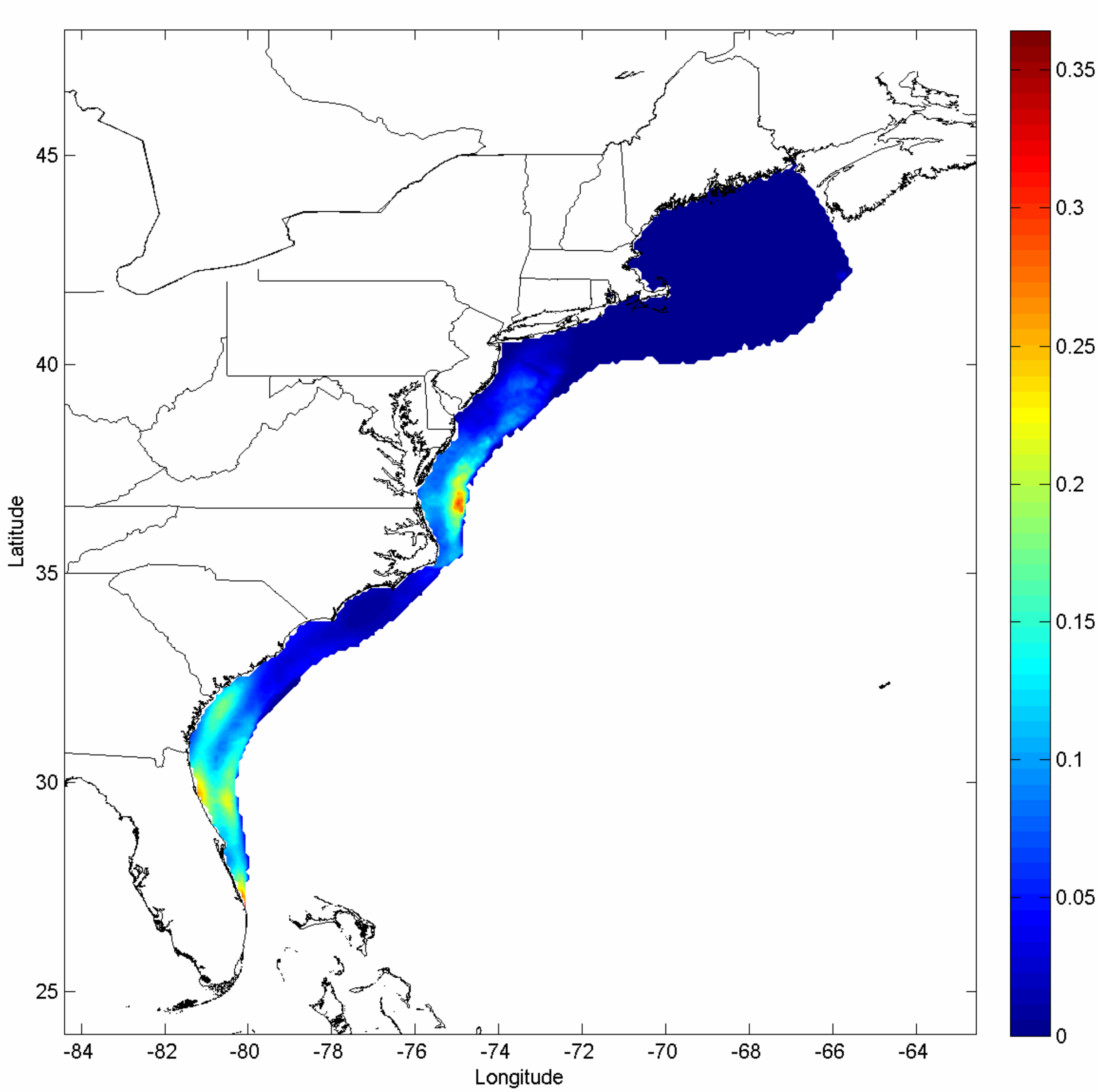


Figure 3-46. Density surface for the loggerhead turtle during the fall, winter, and spring off the United States Atlantic Coast.

3.3.2 Species Groups

Hardshell Turtles

This group includes the green, hawksbill, and unidentified hardshell turtles (which might also include extralimital occurrences of the olive ridley turtle [*Lepidochelys oliveacea*]) (**Table 3-1**). The distribution and habitat preference information for the species in the Hardshell Turtles group is listed below and is followed by the density results for the group.

- Green Turtle (*Chelonia mydas*)

  Distribution and habitat preferences

  - Green turtles are distributed worldwide in tropical and subtropical waters (NMFS and USFWS 1991; Hirth 1997).
  - Nearshore water temperatures play a major role in determining green turtle distribution along the Atlantic and Gulf coasts of the U.S (e.g., Musick and Limpus 1997; Witherington et al. 2006).
  - Juvenile green turtles utilize estuarine waters along the U.S. Atlantic coast as summer developmental habitat, as far north as Long Island Sound, Chesapeake Bay, and North Carolina sounds (Epperly et al. 1995b; Epperly et al. 1995a; Musick and Limpus 1997).
  - The optimal developmental habitats for late juveniles and foraging adults are warm, shallow waters (3 to 5 m in bottom depth), with an abundance of submerged aquatic vegetation, and located in close proximity to nearshore reefs or rocky areas, used by green turtles for resting (e.g., Holloway-Adkins and Provancha 2005; Witherington et al. 2006).
  - Post-hatchling and early-juvenile green turtles reside in convergence zones in the open ocean, where they spend an undetermined amount of time in the pelagic environment (Carr 1987; Witherington and Hirama 2006).

- Hawksbill Turtle (*Eretmochelys imbricata*)

  Distribution and habitat preferences

  - The hawksbill is rare north of Florida (Lee and Palmer 1981; Keinath et al. 1991; Parker 1995; Plotkin 1995; USFWS 2001).
  - Hawksbill turtles inhabit oceanic waters as post-hatchlings and small juveniles, where they are sometimes associated with driftlines and floating patches of *Sargassum* (Parker 1995; Witherington and Hirama 2006).
  - The developmental habitats for juvenile benthic-stage hawksbills are the same as the primary feeding grounds for adults. They include tropical, nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Coral reefs are recognized as optimal hawksbill habitat for juveniles, sub-adults, and adults (NMFS and USFWS 1993; Diez et al. 2003).
  - In neritic habitats, the resting areas for late juveniles and adults are generally located in deeper waters (i.e., on sandy bottoms at the base of a reef flat) than their foraging areas (Houghton et al. 2003).
  - Shallow seagrass beds may also serve as important developmental habitats for late juveniles (Diez et al. 2003).

Table 3-27. Density surface model results for Hardshell Turtles by season. These are abundance estimates for Hardshell Turtles in the Northeast study area.

Density Surface Model (DSM)	Abundance
Spring	10,917
Summer	10,917
Fall	10,917
Winter	10,918

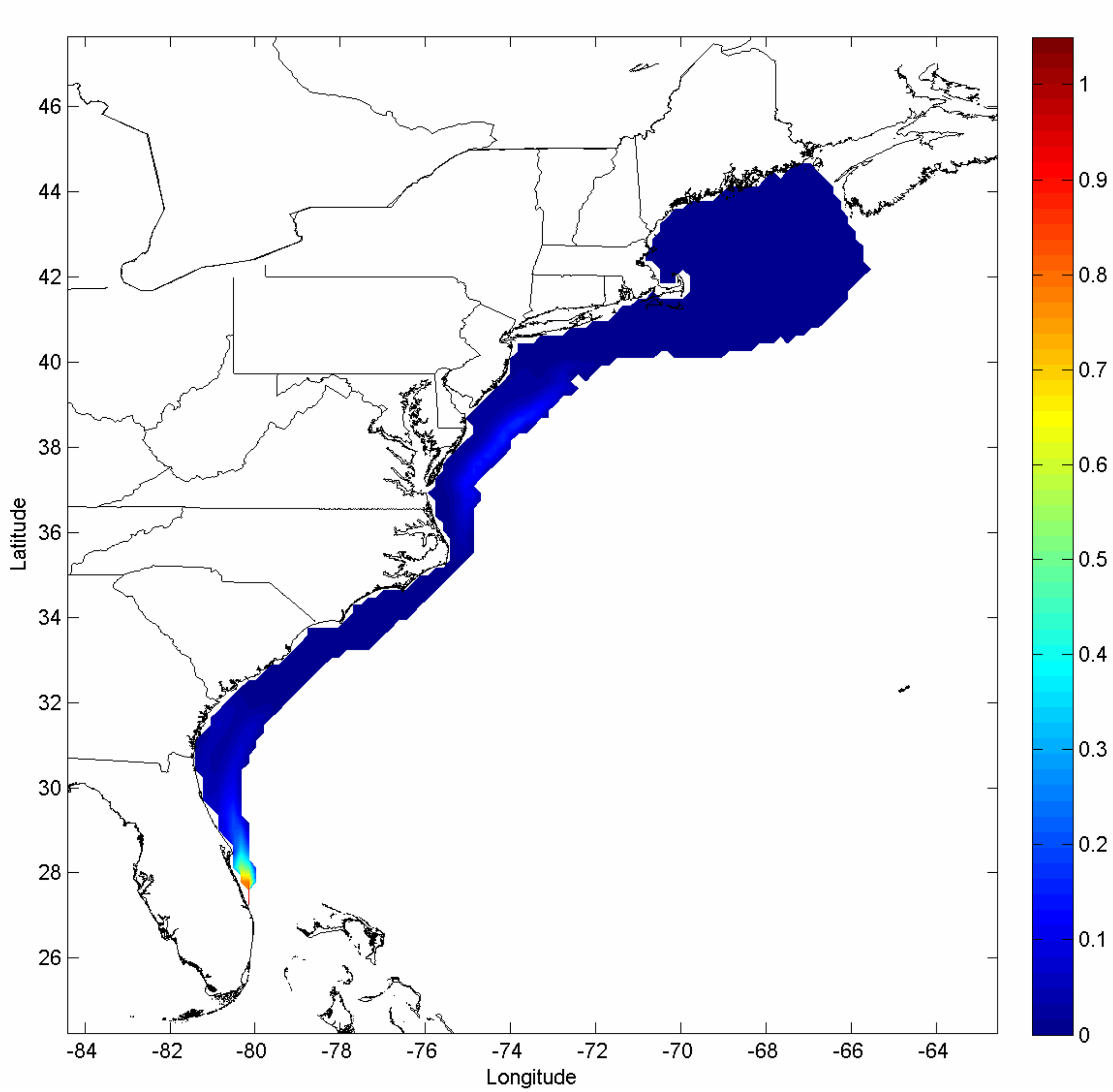


Figure 3-47. Density surface for Hardshell Turtles during the summer off the United States Atlantic Coast.

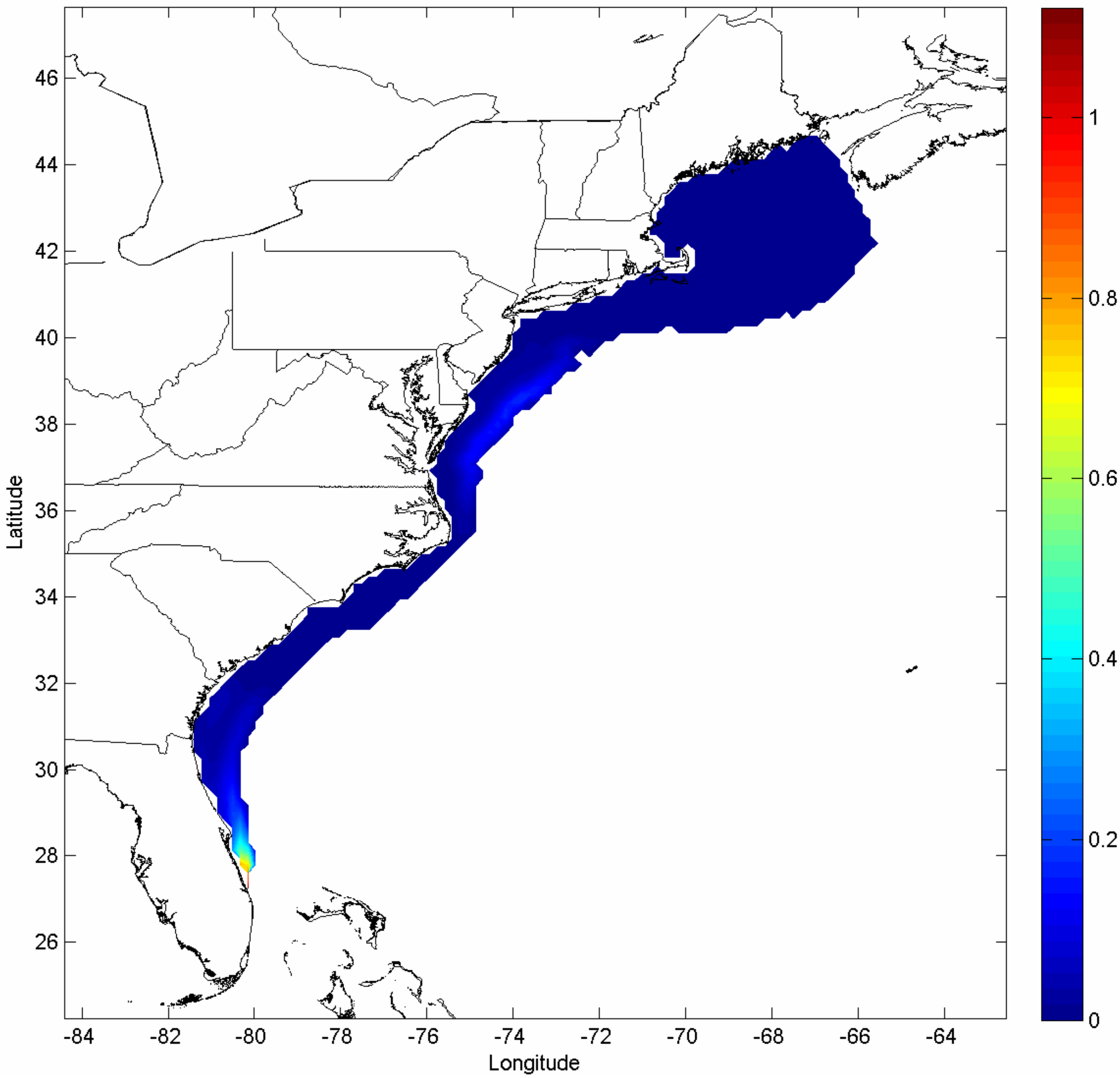


Figure 3-48. Density surface for Hardshell Turtles during the fall, winter, and spring off the United States Atlantic Coast.

This page intentionally left blank

4.0 LIST OF PREPARERS

Name/Title/Affiliation	Education	Project Role
Joel T. Bell Marine Mammal Biologist Naval Facilities Engineering Command, Atlantic Norfolk, Virginia	M.E.M., Coastal Environmental Management Duke University B.S., Marine Science Kutztown University	Navy Technical Representative and Technical Review
Deanna R. Rees Wildlife Biologist Naval Facilities Engineering Command, Atlantic Norfolk, Virginia	B.S., Wildlife Resources University of Idaho	Alternate Navy Technical Representative and Technical Review
Mandy Shoemaker Naval Facilities Engineering Command, Atlantic Norfolk, Virginia	M.E.M., Coastal Environmental Management Duke University B.S., Marine Biology University of California Santa Cruz	Navy Technical Representative
Dan L. Wilkinson, Ph.D. Vice President, Environmental Resources Geo-Marine, Inc. Plano, Texas	Ph.D., Botany Texas A&M University M.S., Zoology Stephen F. Austin State University B.S., Biology Central State University	Program Manager
Gregory L. Fulling, Ph.D. Senior Fisheries Biologist Geo-Marine, Inc. Plano, Texas	Ph.D., Marine Biology The University of Southern Mississippi M.S., Biology Angelo State University B.S., Biology Eastern Washington University	Project Manager, Technical Lead
Eric Rexstad, Ph.D. Centre for Research into Ecological and Environmental Modelling (CREEM) University of St. Andrews St. Andrews, Scotland	Ph.D., Wildlife Biology Colorado State University M.S., Wildlife Ecology Utah State University B.S., Computer Science Luther College	Technical Lead, Technical Review
Dagmar Fertl Senior Marine Mammal Biologist Geo-Marine, Inc. Plano, Texas	M.S., Wildlife and Fisheries Sciences Texas A&M University B.S., Biology Trinity University	Protected Species, Technical Review
Peter Gehring GIS Manager Geo-Marine, Inc. Plano, Texas	M.S., Environmental Science Miami University B.S., Zoology/Biochemistry Miami University	GIS Project Oversight and Graphics
Joseph Kaskey Senior Environmental Scientist Geo-Marine, Inc. Plano, Texas	M.S., Botany Southern Illinois University B.A., Biological Sciences Southern Illinois University	Technical Review

LIST OF PREPARERS
(*continued*)

Name/Title/Affiliation	Education	Project Role
Kevin Knight Senior GIS Analyst Geo-Marine, Inc. Plano, Texas	B.S., Geology University of Texas	GIS Documentation, Data Management, Interactive GIS Tool Development
Anurag Kumar Marine Scientist/ Acoustician Geo-Marine, Inc. Hampton, Virginia	M.S., Marine Science Moss Landing Marine Laboratories, California State University B.S., Biology California State University	Data Analysis
Tamara Lunsman, Ph.D. Marine Scientist Geo-Marine, Inc. Plano, Texas	Ph.D., Marine Science University of California Santa Barbara B.S., Marine Biology Texas A&M University at Galveston	Document Preparation
Matthew Moore GIS Analyst Geo-Marine, Inc. Hampton, Virginia	B.S., Geography Old Dominion University	Graphic Design, GIS Map Production
Anna Perry Report Production Geo-Marine, Inc. Plano, Texas	M.S., Geology Baylor University B.S., Geology Clemson University	Report Production, Acronyms and Abbreviations
Cheryl Schroeder Senior Oceanographer Geo-Marine, Inc. Hampton, Virginia	M.S., Biological Oceanography University of Rhode Island B.S., Marine Biology Texas A&M University	Technical Review
J. Carter Watterson Senior Fisheries Biologist Geo-Marine, Inc. Hampton, VA	M.S., Marine Sciences Dauphin Island Sea Lab, University of South Alabama B.A., Biology University of Richmond	Data Analysis, Technical Review
Amy Whitt Marine Mammal Biologist Geo-Marine, Inc. Plano, Texas	M.E.M., Coastal Environmental Management Duke University B.S., Biology Lyon College	Protected Species
Matthew Wryk GIS Analyst Geo-Marine, Inc. Hampton, Virginia	B.S., Biology Old Dominion University	Map Production, GIS Quality Control

5.0 LITERATURE CITED

Aguilar, A. 2002. Fin whale *Balaenoptera physalus*. Pages 435-438 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Andrews, J.C. and P.R. Mott. 1967. Gray seals at Nantucket, Massachusetts. Journal of Mammalogy 48(4):657-658.

Baird, R.W. 2001. Status of harbour seals, *Phoca vitulina*, in Canada. Canadian Field-Naturalist 115(4):663-675.

Baird, R.W. 2005. Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. Pacific Science 59(3):461-466.

Baird, R.W. and P.J. Stacey. 1991. Status of Risso's dolphin, *Grampus griseus*, in Canada. Canadian Field-Naturalist 105(2):233-242.

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

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

Barlas, M.E. 1999. The distribution and abundance of harbor seals *(Phoca vitulina concolor)* and gray seals *(Halichoerus grypus)* in southern New England, Winter 1998- Summer 1999. Master's thesis, Boston University.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin 93(1):1-14.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209-221 in Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, eds. Marine mammal survey and assessment methods. Rotterdam, Netherlands: A.A. Balkema.

Barlow, J. 2003a. Cetacean abundance in Hawaiian waters during summer/fall of 2002. NMFS-SWFSC Administrative Report LJ-03-13:1-20.

Barlow, J. 2003b. Preliminary estimates of the abundance of cetaceans along the U.S. west coast: 1991-2001. NMFS-SWFSC Administrative Report LJ-03-03:1-31.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464.

Barlow, J. and S. Sexton. 1996. The effect of diving and searching behavior on the probability of detecting track-line groups, g_o, of long-diving whales during line-transect surveys. NMFS-SWFSC Administrative Report LJ-96-14:1-21.

Barlow, J. and T. Gerrodette. 1996. Abundance of cetaceans in California waters based on 1991 and 1993 ship surveys. NOAA Technical Memorandum NMFS-SWFSC-233:1-15.

Barlow, J. and B.L. Taylor. 2005. Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. Marine Mammal Science 21(3):429-445.

Barlow, J., C.W. Oliver, T.D. Jackson, and B.L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon, and Washington: II. Aerial surveys. Fishery Bulletin 86(3):433-444.

Barlow, J., M.C. Ferguson, W.F. Perrin, L. Ballance, T. Gerrodette, G. Joyce, C.D. MacLeod, K. Mullin, D.L. Palka, and G. Waring. 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). Journal of Cetacean Research and Management 7(3):263-270.

Barnard, D.E., J.A. Keinath, and J.A. Musick. 1989. Distribution of ridley, green, and leatherback turtles in Chesapeake Bay and adjacent waters. Pages 201-203 in Eckert, S.A., K.L. Eckert, and T.H. Richardson, eds. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Baumgartner, M.F. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. Marine Mammal Science 13(4):614-638.

Baumgartner, M.F. and B.R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. Marine Ecology Progress Series 264:123-135.

Baumgartner, M.F., K.D. Mullin, L.N. May, and T.D. Leming. 2001. Cetacean habitats in the northern Gulf of Mexico. Fishery Bulletin 99:219-239.

Bernard, H.J. and S.B. Reilly. 1999. Pilot whales *Globicephala* Lesson, 1828. Pages 245-279 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Best, P.B. and C.H. Lockyer. 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. South African Journal of Marine Science 24:111-133.

Bjørge, A. 2002. How persistent are marine mammal habitats in an ocean of variability? Pages 63-91 in Evans, P.G.H. and J.A. Raga, eds. Marine mammals: Biology and conservation. New York, New York: Kluwer Academic/Plenum Publishers.

Bjorndal, K.A. 2003. Roles of loggerhead sea turtles in marine ecosystems. Pages 235-254 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Blaylock, R.A., J.W. Hain, L.J. Hansen, D.L. Palka, and G.T. Waring. 1995. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments. NOAA Technical Memorandum NMFS-SEFSC-363:1-211.

Bolten, A.B. 2003. Variation in sea turtle life history patterns: Neritic vs. oceanic developmental stages. Pages 243-258 in Lutz, P.L., J.A. Musick, and J. Wyneken, eds. The biology of sea turtles, Volume 2. Boca Raton, Florida: CRC Press.

Boulva, J. 1973. The harbour seal, *Phoca vitulina concolor*, in eastern Canada. Ph.D. diss., Dalhousie University.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. New York, New York: Oxford University Press.

Butterworth, D.S. and D.L. Borchers. 1988. Estimates of g(0) for minke schools from the results of the independent observer experiment on the 1985/86 and 1986/87 IWC/IDCR Antarctic assessment cruises. Reports of the International Whaling Commission 38:301-313.

Calambokidis, J. and J. Barlow. 2004. Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. Marine Mammal Science 20(1):63-85.

Calambokidis, J., J.R. Evenson, J. Cubbage, S.D. Osmek, S.D. Rugh, D. Rugh, and J.L. Laake. 1993a. Calibration of sighting rates of harbor porpoise from aerial surveys. Prepared for the National Marine Fisheries Service, Seattle, Washington, by Cascadia Research Collective, Olympia, Washington.

Calambokidis, J., J.C. Cubbage, J.R. Evenson, S.D. Osmek, J.L. Laake, P.J. Gearin, B.J. Turnock, S.J. Jeffries, and R.F. Brown. 1993b. Abundance estimates of harbor porpoise in Washington and Oregon waters. Prepared for the National Marine Fisheries Service, Seattle, Washington, by Cascadia Research Collective, Olympia, Washington.

Caldwell, D.K. and M.C. Caldwell. 1971. The pygmy killer whale, *Feresa attenuata*, in the western Atlantic, with a summary of world records. Journal of Mammalogy 52(1):206-209.

Caldwell, D.K. and M.C. Caldwell. 1972. The world of the bottlenosed dolphin. Philadelphia, Pennsylvania: J.B. Lippincott Company.

Cañadas, A., R. Sagarminaga, and S. García-Tiscar. 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. Deep-Sea Research I 49:2053-2073.

Cañadas, A., G. Desportes, and D. Borchers. 2004. The estimation of the detection function and *g*(0) for short-beaked common dolphins (*Delphinus delphis*), using double-platform data collected during the NASS-95 Faroese survey. Journal of Cetacean Research and Management 6(2):191-198.

Carr, A. 1987. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1(2):103-121.

Carretta, J.V., B.L. Taylor, and S.J. Chivers. 2001. Abundance and depth distribution of harbor porpoise (*Phocoena phocoena*) in northern California determined from a 1995 ship survey. Fishery Bulletin 99:29-39.

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker, B. Hanson, and M.S. Lowry. 2007. U.S. Pacific marine mammal stock assessments: 2006. NOAA Technical Memorandum NMFS-SWFSC-398:1-312.

CETAP (Cetacean and Turtle Assessment Program). 1982. Characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf. Contract AA551-

CT8-48. Prepared for U.S. Bureau of Land Management, Washington, D.C. by Cetacean and Turtle Assessment Program, University of Rhode Island, Graduate School of Oceanography, Kingston, Rhode Island.

Clapham, P., S. Leatherwood, I. Szczepaniak, and R.L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71:440-443.

Clark, C.W. 1995. Annex M. Matters arising out of the discussion of blue whales: Annex M1. Application of US Navy underwater hydrophone arrays for scientific research on whales. Reports of the International Whaling Commission 45:210-212.

Clark, C.W. and G.J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics (US Navy) 52(3).

Combs, R. 2005. Development of mission avoidance zones through habitat suitability modeling in the Eglin Gulf Test and Training Range: Development of a geo-database. Project No. 05-270. Washington, D.C.: Department of Defense Legacy Resource Management Program.

D'Amico, A., A. Bergamasco, P. Zanasca, S. Carniel, E. Nacini, N. Portunato, V. Teloni, C. Mori, and R. Barbanti. 2003. Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. IEEE Journal of Oceanic Engineering 28(1):29-43.

Dahlheim, M.E. and J.E. Heyning. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). Pages 281-322 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Das, K., C. Beans, L. Holsbeek, G. Mauger, S.D. Berrow, E. Rogan, and J.M. Bouquegneau. 2003. Marine mammals from northeast Atlantic: Relationship between their trophic status as determined by $\delta^{13}C$ and $\delta^{15}N$ measurements and their trace metal concentrations. Marine Environmental Research 56:349-365.

Davis, R.W. and G.S. Fargion, eds. 1996. Distribution and abundance of cetaceans in the north-central and western Gulf of Mexico, final report. Volume II: Technical report. OCS Study MMS 96-0027. New Orleans, Louisiana: Minerals Management Service.

Davis, R.W., W.E. Evans, and B. Würsig, eds. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume 2: Technical report. USGS/BRD/CR-1999-0006 and OCS Study MMS 2000-003. New Orleans, Louisiana: Minerals Management Service.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Marine Mammal Science 14(3):490-507.

Diez, C.E., X. Vélez-Zuazo, and R.P. Van Dam. 2003. Hawksbill turtles in seagrass beds. Marine Turtle Newsletter 102:8-10.

Dodd, C.K. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). Biological Report 88(14). Washington, D.C.: U.S. Fish and Wildlife Service.

Doi, T., F. Kasamatsu, and T. Nakano. 1982. A simulation study on sighting survey of minke whales in the Antarctic. Reports of the International Whaling Commission 32:919-928.

Doi, T., F. Kasamatsu, and T. Nakano. 1983. Further simulation studies on sighting by introducing both concentration of sighting effort by angle and aggregations of minke whales in the Antarctic. Reports of the International Whaling Commission 33:403-412.

DoN (Department of the Navy). 2001. Marine resources assessment for the Virginia Capes (VACAPES) operating area. Final report. Contract number N62470-95-D-1160, CTO 0030. Norfolk, Virginia: Atlantic Division, Naval Facilities Engineering Command. Prepared by Geo-Marine, Inc., Plano, Texas.

DoN (Department of the Navy). 2002a. Marine resources assessment for the Cherry Point operating area. Contract number N62470-95-D-1160, Task Order number 0030. Norfolk, Virginia: Atlantic Division, Naval Facilities Engineering Command. Prepared by Geo-Marine, Inc., Plano, Texas.

DoN (Department of the Navy). 2002b. Marine resources assessment for the Charleston/Jacksonville operating area. Final report. Contract number N62470-95-D-1160, CTO 0030. Norfolk, Virginia:

Atlantic Division, Naval Facilities Engineering Command. Prepared by Geo-Marine, Inc., Plano, Texas.

DoN (Department of the Navy). 2005. Marine resources assessment for the Northeast operating areas: Atlantic City, Narragansett Bay, and Boston--Report PDF. Final Report. Contract number N62470-02-D-9997, CTO 0018. Norfolk, Virginia: Department of the Navy, U.S. Fleet Forces Command. Prepared by Geo-Marine, Inc., Newport News, Virginia.

DoN (Department of the Navy). 2006. Navy OPAREA density estimates (NODE) for the Northeast OPAREAS: Boston, Narragansett Bay, and Atlantic City. Contract number N62470-02-D-9997, CTO 0045. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic. Prepared by Geo-Marine, Inc., Hampton, Virginia.

DoN (Department of the Navy). 2007a. Marine resources assessment for the Southeastern Florida and the AUTEC-Andros operating area. Contract number N62470-02-D-9997, CTO 0034. Norfolk, Virginia: Atlantic Division, Naval Facilities Engineering Command. Prepared by Geo-Marine, Inc., Plano, Texas.

DoN (Department of the Navy). 2007b. Navy OPAREA density estimates (NODE) for the Southeast OPAREAs: VACAPES, CHPT, JAX/CHASN, and Southeastern Florida & AUTEC-Andros. Final report. Contract number N62470-02-D-9997, CTO 0045. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic. Prepared by Geo-Marine, Inc., Hampton, Virginia.

Eckert, S.A. 2002. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. Marine Ecology Progress Series 230:289-293.

Efron, B. and R.J. Tibshirani. 1993. An introduction to the bootstrap. London, England: Chapman & Hall/CRC.

Epperly, S.P., J. Braun, and A. Veishlow. 1995a. Sea turtles in North Carolina waters. Conservation Biology 9:384-394.

Epperly, S.P., J. Braun, and A.J. Chester. 1995b. Aerial surveys for sea turtles in North Carolina inshore waters. Fishery Bulletin 93:254-261.

Ferguson, M.C., J. Barlow, S.B. Reilly, and T. Gerrodette. 2006a. Predicting Cuvier's *(Ziphius cavirostris)* and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. Journal of Cetacean Research and Management 7(3):287-299.

Ferguson, M.C., J. Barlow, P. Fiedler, S.B. Reilly, and T. Gerrodette. 2006b. Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. Ecological Modelling 193:645-662.

Forney, K.A. and J. Barlow. 1993. Preliminary winter abundance estimates for cetaceans along the California coast based on a 1991 aerial survey. Reports of the International Whaling Commission 43:407-415.

Forney, K.A., J. Barlow, and J.V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fishery Bulletin 93(1):15-26.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. FWS/OBS-82/65. Washington, D.C.: U.S. Fish and Wildlife Service.

Fulling, G.L. and D. Fertl. 2003. *Kogia* distribution in the northern Gulf of Mexico. Pages 13-16 in Odell, D.K. and N.B. Barros, eds. Abstracts, Workshop on the Biology of Kogia held on 13 December 2003, Greensboro, North Carolina, USA.

Gambell, R. 1985. Fin whale *Balaenoptera physalus (*Linneaus, 1758). Pages 171-192 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Gannon, D. 2003. Behavioral ecology of an acoustically mediated predator-prey system: Bottlenose dolphins and sciaenid fishes. Ph.D. diss., Duke University.

Garrison, L.P., P.E. Rosel, A. Hohn, R. Baird, and W. Hoggard. 2003. Abundance of the coastal morphotype of bottlenose dolphin, *Tursiops truncatus*, in U.S. continental shelf waters between New Jersey and Florida during winter and summer 2002. Unpublished document prepared for the Take Reduction Team on Coastal Bottlenose Dolphins in the Western Atlantic.

Gaskin, D.E. 1992. Status of the common dolphin, *Delphinus delphis*, in Canada. Canadian Field-Naturalist 106(1):55-63.

Gilbert, J.R. and N. Guldager. 1998. Status of harbor and gray seal populations in northern New England. Woods Hole, Massachusetts: National Marine Fisheries Service.

Gilbert, J.R., G.T. Waring, K.M. Wynne, and N. Guldager. 2005. Changes in abundance of harbor seals in Maine, 1981-2001. Marine Mammal Science 21(3):519-535.

Goddard DAAC (Distributed Active Archive Center). 1986. Coastal Zone Color Scanner (CZCS) Level 3 monthly parameter subsets. Greenbelt, Maryland: NASA Goddard DAAC.

Grant, G.S. and D. Ferrell. 1993. Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelidae): Notes on near-shore feeding behavior and association with cobia. Brimleyana 19:77-81.

Green, G.A., J.J. Brueggeman, R.A. Grotefendt, C.E. Bowlby, M.L. Bonnell, and K.C. Balcomb III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pages 1-1 to 1-100 in Brueggeman, J.J., ed. Oregon and Washington marine mammal and seabird surveys. OCS Study MMS 91-0093. Los Angeles, California: Minerals Management Service.

Gregr, E., J. Calambokidis, L. Convey, J. Ford, I. Perry, L. Spaven, and M. Zacharias. 2005. Proposed recovery strategy for blue whales (*Balaenoptera musculus*), fin whales (*B. physalus*) and sei whales (*B. borealis*) in Pacific Canadian waters. Draft. Nanaimo, British Columbia: Fisheries and Oceans Canada.

Gregr, E.J. and A.W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 58:1265-1285.

Griffin, R.B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Marine Mammal Science 15(1):33-51.

Grünkorn, T., A. Diederichs, and G. Nehls. 2005. Aerial surveys in the German Bight — estimating g(0) for harbour porpoises (*Phocoena phocoena*) by employing independent double counts. European Cetacean Society Newsletter 44(Special Issue):25-31.

Hain, J.H.W. and R.D. Kenney. 2005a. A review and update to the technical report of December 2002 for the estimation of marine mammal and sea turtle densities in the VACAPES Operating Area (OPAREA) specific to the distribution and densities of right whales. Prepared for the Department of the Navy.

Hain, J.H.W. and R.D. Kenney. 2005b. A review and update to the technical report of December 2002 for the estimation of marine mammal and sea turtle densities in the JAX/CHASN Operating Area (OPAREA) specific to the distribution and densities of right whales. Prepared for the Department of the Navy.

Hain, J.H.W. and R.D. Kenney. 2005c. A review and update to the technical report of December 2002 for the estimation of marine mammal and sea turtle densities in the Cherry Point Operating Area (OPAREA) specific to the distribution and densities of right whales. Prepared for the Department of the Navy.

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

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, U.S.A. to Nova Scotia, Canada). Marine Mammal Science 18(4):920-937.

Hammill, M.O., G.B. Stenson, R.A. Myers, and W.T. Stobo. 1998. Pup production and population trends of the grey seal (*Halichoerus grypus*) in the Gulf of St. Lawrence. Canadian Journal of Fisheries and Aquatic Sciences 55:423-430.

Hedley, S.L. 2000. Modelling heterogeneity in cetacean surveys. Ph.D. diss., University of St Andrews.

Hedley, S.L. and S.T. Buckland. 2004. Spatial models for line transect sampling. Journal of Agricultural, Biological, and Environmental Statistics 9(2):181-199.

Hedley, S.L., S.T. Buckland, and D.L. Borchers. 1999. Spatial modelling from line transect data. Journal of Cetacean Research and Management 1(3):255-264.

Henwood, T.A. and L.H. Ogren. 1987. Distribution and migrations of immature Kemp's ridley turtles (*Lepidochelys kempi*) and green turtles (*Chelonia mydas*) off Florida, Georgia, and South Carolina. Northeast Gulf Science 9(2):153-159.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). Biological Report 97(1). Washington, D.C.: U.S. Fish and Wildlife Service

Holloway-Adkins, K. and J. Provancha. 2005. Abundance and foraging activity of marine turtles using nearshore rock resources along the mid reach of Brevard County, Florida. Prepared for Olsen Associates, Inc., Jacksonville, Florida by Dynamac Corporation, Cape Canaveral, Florida.

Hoover, K., S.S. Sadove, and P. Forestell. 1999. Trends of harbor seal, *Phoca vitulina*, abundance from aerial surveys in New York waters: 1985-1999. Page 85 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Hawaii.

Horwood, J. 1987. The sei whale: Population biology, ecology, & management. New York, New York: Croom Helm in association with Methuen, Inc.

Horwood, J. 1990. Biology and exploitation of the minke whale. Boca Raton, Florida: CRC Press.

Houghton, J.D.R., M.J. Callow, and G.C. Hays. 2003. Habitat utilization by juvenile hawksbill turtles (*Eretmochelys imbricata*, Linnaeus, 1766) around a shallow water coral reef. Journal of Natural History 37:1269-1280.

Hughes, G.R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. Journal of Experimental Marine Biology and Ecology 229:209-217.

Hui, C.A. 1985. Undersea topography and the comparative distributions of two pelagic cetaceans. Fishery Bulletin 83(3):472-475.

IWC (International Whaling Commission). 1982. Report of the Special Meeting on Southern Hemisphere Minke Whales, Cambridge, 22-26 June 1981. Reports of the International Whaling Commission 32:697-745.

James, M.C., S.A. Eckert, and R.A. Myers. 2005. Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea)*. Marine Biology 147:845-853.

Jefferson, T.A. and A.J. Schiro. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. Mammal Review 27(1):27-50.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine mammals of the world. Rome, Italy: Food and Agriculture Organization of the United Nations.

Kasamatsu, F. and G.G. Joyce. 1995. Current status of Odontocetes in the Antarctic. Antarctic Science 7(4):365-379.

Kaschner, K., R. Watson, A.W. Trites, and D. Pauly. 2006. Mapping world-wide distributions of marine mammal species using a relative environmental suitability (RES) model. Marine Ecology Progress Series 316:285-310.

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

Katona, S.K., J.A. Beard, P.E. Girton, and F. Wenzel. 1988. Killer whales (*Orcinus orca*) from the Bay of Fundy to the Equator, including the Gulf of Mexico. Rit Fiskideildar (Journal of the Marine Research Institute Reykjavik) XI:205-224.

Keinath, J.A., J.A. Musick, and W.M. Swingle. 1991. First verified record of the hawksbill sea turtle (*Eretmochelys imbricata*) in Virginia waters. Catesbeiana 11(2):35-38.

Keinath, J.A., J.A. Musick, and D.E. Barnard. 1996. Abundance and distribution of sea turtles off North Carolina. OCS Study MMS 95-0024. New Orleans, Louisiana: Minerals Management Service.

Kenney, M.K. 1994. Harbor seal population trends and habitat use in Maine. Master's thesis, University of Maine.

Kenney, R.D. 1990. Bottlenose dolphins off the northeastern United States. Pages 369-386 in Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, California: Academic Press.

Kenney, R.D. and H.E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. Continental Shelf Research 7:107-114.

Kenney, R.D., C.A. Mayo, and H.E. Winn. 2001. Migration and foraging strategies at varying spatial scales in western North Atlantic right whales: A review of hypotheses. Journal of Cetacean Research and Management (Special Issue 2):251-260.

Kruse, S., D.K. Caldwell, and M.C. Caldwell. 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). Pages 183-212 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Laake, J.L., J. Calambokidis, S.D. Osmek, and D.J. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: Estimating *g*(0). Journal of Wildlife Management 61(1):63-75.

Laerm, J., F. Wenzel, J.E. Craddock, D. Weinand, J. McGurk, M.J. Harris, G.A. Early, J.G. Mead, C.W. Potter, and N.B. Barros. 1997. New prey species for northwestern Atlantic humpback whales. Marine Mammal Science 13(4):705-711.

Landry, A.M., Jr. and D. Costa. 1999. Status of sea turtle stocks in the Gulf of Mexico with emphasis on the Kemp's ridley. Pages 248-268 in Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of

Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, Massachusetts: Blackwell Science.

Lazell, J.D., Jr. 1980. New England waters: Critical habitat for marine turtles. Copeia 1980(2):290-295.

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: A guide to their identification. NOAA Technical Report NMFS CIRC-396:1-176.

Lee, D.S. and W.M. Palmer. 1981. Records of leatherback turtles, *Dermochelys coriacea* (Linnaeus), and other marine turtles in North Carolina waters. Brimleyana 5:95-106.

Lerczak, J.A. and R.C. Hobbs. 1998. Calculating sighting distances from angular readings during shipboard, aerial, and shore-based marine mammal surveys. Marine Mammal Science 14(3):590-599.

Lesage, V. and M.O. Hammill. 2001. The status of the grey seal, *Halichoerus grypus*, in the Northwest Atlantic. Canadian Field-Naturalist 115(4):653-662.

Lien, J., D. Nelson, and D.J. Hai. 2001. Status of the white-beaked dolphin, *Lagenorhynchus albirostris*, in Canada. Canadian Field-Naturalist 115(1):118-126.

Lutcavage, M. and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985(2):449-456.

MacLeod, C., W.F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). Journal of Cetacean Research and Management 7(3):271-286.

MacLeod, C.D. 2000. Review of the distribution of *Mesoplodon* species (order Cetacea, family Ziphiidae) in the North Atlantic. Mammal Review 30(1):1-8.

MacLeod, C.D. and G. Mitchell. 2006. Key areas for beaked whales worldwide. Journal of Cetacean Research and Management 7(3):309-322.

MacLeod, C.D., N. Hauser, and H. Peckham. 2004. Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. Journal of the Marine Biological Association of the United Kingdom 84:469-474.

Manzella, S., J. Williams, B. Schroeder, and W. Teas. 1991. Juvenile head-started Kemp's ridleys found in floating grass mats. Marine Turtle Newsletter 52:5-6.

Marquez-M., R., compiler. 1994. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempi* (Garman, 1880). NOAA Technical Memorandum NMFS-SEFSC-343:1-91.

Mate, B.R., S.L. Nieukirk, and S.D. Kraus. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61(4):1393-1405.

Mate, B.R., K.M. Stafford, R. Nawojchik, and J.L. Dunn. 1994. Movements and dive behavior of a satellite-monitored Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the Gulf of Maine. Marine Mammal Science 10(1):116-121.

McAlpine, D.F. 2002. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. Pages 1007-1009 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

McClellan, C.M., C.G. Hudson, and A.J. Read. 2007. Use of oceanic habitats by loggerhead sea turtles (*Caretta caretta*). Pages 77-78 in Abstracts, Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. 22-28 February 2007. Myrtle Beach, South Carolina.

Measures, L., B. Roberge, and R. Sears. 2004. Stranding of a Pygmy Sperm Whale, *Kogia breviceps,* in the Northern Gulf of St. Lawrence, Canada. Canadian Field-Naturalist 118(4):495-498.

Mignucci-Giannoni, A.A. 1998. Zoogeography of cetaceans off Puerto Rico and the Virgin Islands. Caribbean Journal of Science 34(3-4):173-190.

Mitchell, E. and V.M. Kozicki. 1975. Supplementary information on minke whale (*Balaenoptera acutorostrata*) from Newfoundland fishery. Journal of the Fisheries Research Board of Canada 32(7):985-994.

Mitchell, E. and D.G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Reports of the International Whaling Commission (Special Issue 1):117-120.

Mitchell, E. and R.R. Reeves. 1988. Records of killer whales in the western North Atlantic, with emphasis on eastern Canadian waters. Rit Fiskideildar (Journal of the Marine Research Institute Reykjavik) 11:161-193.

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

Mobley, J.R., Jr., S.S. Spitz, and R. Grotefendt. 2001. Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. Prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary and the Hawai'i Department of Land and Natural Resources.

Moreno, I.B., A.N. Zerbini, D. Danilewicz, M.C. de Oliveira Santos, P.C. Simões-Lopes, J. Lailson-Brito, Jr., and A.F. Azevedo. 2005. Distribution and habitat characteristics of dolphins of the genus *Stenella* (Cetacea: Delphinidae) in the southwest Atlantic Ocean. Marine Ecology Progress Series 300:229-240.

Morreale, S.J. and E.A. Standora. 2005. Western North Atlantic waters: Crucial developmental habitat for Kemp's ridley and loggerhead sea turtles. Chelonian Conservation and Biology 4(4):872-882.

Morreale, S.J., A.B. Meylan, S.S. Sadove, and E.A. Standora. 1992. Annual occurrence and winter mortality of marine turtles in New York waters. Journal of Herpetology 26:301-308.

Morreale, S.J., E.A. Standora, J.R. Spotila, and F.V. Paladino. 1996. Migration corridor for sea turtles. Nature 384:319-320.

Morreale, S.J., P.T. Plotkin, D.J. Shaver, and H.J. Kalb. 2007. Adult migration and habitat utilization: Ridley turtles in their element. Pages 213-229 in Plotkin, P., ed. Biology and conservation of ridley sea turtles. Baltimore, Maryland: Johns Hopkins University Press.

Mullin, K.D. and G.L. Fulling. 2003. Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin 101:603-613.

Murison, L.D. and D.E. Gaskin. 1989. The distribution of right whales and zooplankton in the Bay of Fundy, Canada. Canadian Journal of Zoology 67:1411-1420.

Musick, J.A. and C.J. Limpus. 1997. Habitat utilization and migration of juvenile sea turtles. Pages 137-163 in Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

NARWC (North Atlantic Right Whale Consortium). 2006. North Atlantic right whale report card. Prepared for the National Marine Fisheries Service.

NASA (National Aeronautics and Space Administration). 1998. Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. Accessed 23 January 2004. ftp://disc1.gsfc.nasa.gov/data/czcs/level_3/monthly_data/subsets/Chlor/.

NASA (National Aeronautics and Space Administration). 2000. AVHRR oceans pathfinder global equalangle best weekly SST averages (NOAA/NASA). Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. Accessed 4 May 2004. ftp://disc1.gsfc.nasa.gov/data/avhrr/tile_8km/.

NMFS-NEFSC (National Marine Fisheries Service-Northeast Fisheries Science Center). 1998. 1998 aerial survey: A component of the NEFSC offshore marine mammal survey. Unpublished survey report. Woods Hole, Massachusetts: National Marine Fisheries Service.

NMFS-NEFSC (National Marine Fisheries Service-Northeast Fisheries Science Center). 1999. 1999 aerial survey: A component of the NEFSC harbor porpoise survey. Woods Hole, Massachusetts: National Marine Fisheries Service.

NMFS-NEFSC (National Marine Fisheries Service-Northeast Fisheries Science Center). 2002. Aerial survey results, NOAA twin otter aircraft, circle-back method experimental abundance survey. Unpublished survey report. Woods Hole, Massachusetts: National Marine Fisheries Service.

NMFS-NEFSC (National Marine Fisheries Service-Northeast Fisheries Science Center). 2004. Aerial survey results, NOAA twin otter aircraft, circle-back abundance survey. Unpublished survey report. Woods Hole, Massachusetts: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1991. Recovery plan for the humpback whale (*Megaptera novaeangliae*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1994. Designated critical habitat; northern right whale. Federal Register 59(106):28793-28808.

NMFS (National Marine Fisheries Service). 1995. Sea turtle conservation; restrictions applicable to shrimp trawl activities; leatherback conservation zone. Federal Register 60(178):47713-47715.

NMFS (National Marine Fisheries Service). 1998. Draft recovery plan for the fin whale *Balaenoptera physalus* and sei whale *Balaenoptera borealis*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2000. Sea turtle conservation; restrictions applicable to shrimp trawl activities; Leatherback Conservation Zone--Temporary rule. Federal Register 65(102):33779-33780.

NMFS (National Marine Fisheries Service). 2006a. Draft recovery plan for the sperm whale (*Physeter macrocephalus)*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2006b. Draft recovery plan for the fin whale (*Balaenoptera physalus)*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1991. Recovery plan for U.S. population of Atlantic green turtle. Washington, D.C.: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. Washington, D.C.: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 1993. Recovery plan for hawksbill turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. St. Petersburg, Florida: National Marine Fisheries Service.

NOAA (National Oceanic and Atmospheric Administration). 1999. NGDC coastal relief model, Volume 02, version 1.0: US South East Atlantic Coast. [CD-ROM]. Boulder, Colorado: National Geophysical Data Center.

NOAA (National Oceanic and Atmospheric Administration). 2001. NGDC coastal relief model, Volume 03, version 4.1: Florida and eastern Gulf of Mexico. [CD-ROM]. Boulder, Colorado: National Geophysical Data Center.

Northridge, S. 1996. Seasonal distribution of harbour porpoises in US Atlantic waters. Reports of the International Whaling Commission 46:613-617.

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

Øien, N. 1990. Estimates of g(0) for minke whales based on an independent observer experiment during the Norwegian sightings surveys in July 1988. Reports of the International Whaling Commission 40:331-335.

Olson, P.A. and S.B. Reilly. 2002. Pilot whales *Globicephala melas* and *G. macrorhynchus*. Pages 898-903 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Palka, D. 1995. Abundance estimate of the Gulf of Maine harbor porpoise. Reports of the International Whaling Commission (Special Issue 16):27-50.

Palka, D. 1996. Update on abundance of Gulf of Maine/Bay of Fundy harbor porpoises. Northeast Fisheries Science Center Reference Document 96-04. Woods Hole, Massachusetts: National Marine Fisheries Service.

Palka, D. 2005a. Aerial surveys in the northwest Atlantic: Estimation of *g(0)*. European Cetacean Society Newsletter 44(Special Issue):12-17.

Palka, D. 2005b. Shipboard surveys in the northwest Atlantic: Estimation of *g(0)*. European Cetacean Society Newsletter 44(Special Issue):32-37.

Palka, D., A. Read, and C. Potter. 1997. Summary of knowledge of white-sided dolphins (*Lagenorhynchus acutus*) from US and Canadian Atlantic waters. Reports of the International Whaling Commission 47:729-734.

Palka, D.L. 2006. Summer abundance estimates of cetaceans in US North Atlantic Navy operating areas. Northeast Fisheries Science Center Reference Document 06-03. Woods Hole, Massachusetts: National Marine Fisheries Service.

Parker, L.G. 1995. Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. Marine Turtle Newsletter 71:19-22.

Payne, P.M. and D.W. Heinemann. 1993. The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf-edge and slope waters of the Northeastern United States, 1978-1988. Reports of the International Whaling Commission (Special Issue 14):51-68.

Payne, P.M., L.A. Selzer, and A.R. Knowlton. 1984. Distribution and density of cetaceans, marine turtles, and seabirds in the shelf waters of the northeastern United States, June 1980 - December 1983, based on shipboard observations. Contract number NA-81-FA-C-00023. Woods Hole, Massachusetts: National Marine Fisheries Service.

Payne, P.M., D.W. Heinemann, and L.A. Selzer. 1990a. A distributional assessment of cetaceans in shelf/shelf-edge and adjacent slope waters of the northeastern United States based on aerial and shipboard surveys, 1978-1988. Woods Hole, Massachusetts: National Marine Fisheries Service, Northeast Fisheries Science Center.

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

Perrin, W.F. 2001. *Stenella attenuata*. Mammalian Species 683:1-8.

Perrin, W.F. 2002a. Common dolphins *Delphinus delphis, D. capensis,* and *D. tropicalis*. Pages 245-248 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Perrin, W.F. 2002b. *Stenella frontalis*. Mammalian Species 702:1-6.

Perrin, W.F., E.D. Mitchell, J.G. Mead, D.K. Caldwell, M.C. Caldwell, P.J.H. van Bree, and W.H. Dawbin. 1987. Revision of the spotted dolphins, *Stenella* spp. Marine Mammal Science 3(2):99-170.

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

Pitman, R.L. 2002. Mesoplodont whales *Mesoplodon* spp. Pages 738-742 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Plotkin, P.T., ed. 1995. National Marine Fisheries Service and U.S. Fish and Wildlife Service status reviews for sea turtles listed under the Endangered Species Act of 1973. Silver Spring, Maryland: National Marine Fisheries Service.

Read, A.J. 1999. Harbour porpoise *Phocoena phocoena* (Linnaeus, 1758). Pages 323-355 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Read, A.J., J.R. Nicolas, and J.E. Craddock. 1996. Winter capture of a harbor porpoise in a pelagic drift net off North Carolina. Fishery Bulletin 94:381-383.

Redfern, J.V., M.C. Ferguson, E.A. Becker, K.D. Hyrenbach, C. Good, J. Barlow, K. Kaschner, M.F. Baumgartner, K.A. Forney, L.T. Ballance, P. Fauchald, P. Halpin, T. Hamazaki, A.J. Pershing, S.S. Qian, A. Read, S.B. Reilly, L. Torres, and F. Werner. 2006. Techniques for cetacean-habitat modeling. Marine Ecology Progress Series 310:271-295.

Reeves, R.R., B.S. Stewart, and S. Leatherwood. 1992. The Sierra Club handbook of seals and sirenians. San Francisco, California: Sierra Club Books.

Reeves, R.R., E. Mitchell, and H. Whitehead. 1993. Status of the northern bottlenose whale, *Hyperoodon ampullatus*. Canadian Field-Naturalist 107(4):490-508.

Rice, D.W. 1998. Marine mammals of the world: Systematics and distribution. Lawrence, Kansas: Society for Marine Mammalogy.

Richardson, D.T. 1976. Feeding habits and population studies of Maine's harbor and gray seals. Final report. Augusta, Maine: Maine Department of Sea and Shore Fisheries.

Rosenfeld, M., M. George, and J.M. Terhune. 1988. Evidence of autumnal harbour seal, *Phoca vitulina*, movement from Canada to the United States. Canadian Field-Naturalist 102(3):527-529.

Ross, G.J.B. and S. Leatherwood. 1994. Pygmy killer whale-*Feresa attenuata* Gray, 1874. Pages 387-404 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Rough, V. 1995. Gray seals in Nantucket Sound, Massachusetts: Winter and spring, 1994. Prepared for the U.S. Marine Mammal Commission, Washington, D.C.

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

Schmidly, D.J. 1981. Marine mammals of the southeastern United States coast and the Gulf of Mexico. FWS/OBS-80/41. Washington, D.C.: U.S. Fish and Wildlife Service.

Schneider, D.C. and P.M. Payne. 1983. Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts. Journal of Mammalogy 64(3):518-520.

Schroeder, B.A. and N.B. Thompson. 1987. Distribution of the loggerhead turtle, *Caretta caretta*, and the leatherback turtle, *Dermochelys coriacea*, in the Cape Canaveral, Florida area: Results of aerial surveys. Pages 45-53 in Witzell, W.N., ed. Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop. NOAA Technical Report NMFS 53.

Schroeder, B.A., A.M. Foley, and D.A. Bagley. 2003. Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. Pages 114-124 in Bolten, A.B. and B.E. Witherington, eds. Loggerhead sea turtles. Washington, D.C.: Smithsonian Institution Press.

Schroeder, C.L. 2000. Population status and distribution of the harbor seal in Rhode Island waters. Master's thesis, University of Rhode Island.

Schweder, T. and G. Høst. 1992. Integrating experimental data and survey data to estimate *g*(0): A first approach. Reports of the International Whaling Commission 42:575-582.

Schweder, T., N. Øien, and G. Høst. 1991. Estimates of the detection probability for shipboard surveys of northeastern Atlantic minke whales, based on a parallel ship experiment. Reports of the International Whaling Commission 41:417-432.

Schweder, T., N. Øien, and G. Høst. 1992. Estimates of *g*(0) for Northeastern Atlantic minke whales based on independent observer experiments in 1989 and 1990, found by the hazard probability method. Reports of the International Whaling Commission 42:399-405.

Schweder, T., H.J. Skaug, X.K. Dimakos, M. Langaas, and N. Øien. 1997. Abundance of northeastern Atlantic minke whales, estimates for 1989 and 1995. Reports of the International Whaling Commission 47:453-483.

Scott, T.M. and S.S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science 13(2):317-321.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters, 2d ed. London, England: Edward Arnald.

Selzer, L.A. and P.M. Payne. 1988. The distribution of white-sided (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. Marine Mammal Science 4(2):141-153.

Seney, E.E. and J.A. Musick. 2005. Diet analysis of Kemp's ridley sea turtles *(Lepidochelys kempii)* in Virginia. Chelonian Conservation and Biology 4(4):864-871.

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

Skaug, H.J. and T. Schweder. 1999. Hazard models for line transect surveys with independent observers. Biometrics 55:29-36.

Skaug, H.J., N. Øien, T. Schweder, and G. Bøthun. 2004. Abundance of minke whales (*Balaenoptera acutorostrata*) in the Northeast Atlantic: Variability in time and space. Canadian Journal of Fisheries and Aquatic Sciences 61:870-886.

Slijper, E.J., W.L. van Utrecht, and C. Naaktgeboren. 1964. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. Bijdragen Tot de Dierkunde 34:3-93.

Slocum, C.J., R. Schoelkopf, S. Tulevech, M. Stevens, S. Evert, and M. Moyer. 1999. Seal populations wintering in New Jersey (USA) have increased in abundance and diversity. Pages 174-175 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Hawaii.

Smith, T.D., J. Allen, P.J. Clapham, P.S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, P.J. Palsbøll, J. Sigurjónsson, P.T. Stevick, and N. Øien. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science 15(1):1-32.

Smith, W.H.F. and D.T. Sandwell. 1997. Global sea floor topography from satellite altimetry and ship depth soundings. Science 277:1956-1961.

Stevick, P.T., J. Allen, M. Bérubé, P.J. Clapham, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Robbins, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology, London 259:231-237.

Stimpert, A.K., T.V.N. Cole, R.M. Pace, III, and P.J. Clapham. 2003. Distributions of four baleen whale species in the northwest Atlantic Ocean based on large-scale aerial survey data. Page 157 in

Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14-19 December 2003. Greensboro, North Carolina.

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

Testaverde, S.A. and J.G. Mead. 1980. Southern distribution of the Atlantic whitesided dolphin, *Lagenorhynchus acutus*, in the western North Atlantic. Fishery Bulletin 78(1):167-169.

The SWOT Team. 2007. Worldwide leatherback nesting sites. SWOT Report-State of the World's Sea Turtles 2:18-19.

Thompson, N.B., J.R. Schmid, S.P. Epperly, M.L. Snover, J. Braun-McNeill, W.N. Witzell, W.G. Teas, L.A. Csuzdi, and R.A. Myers. 2001. Stock assessment of leatherback sea turtles of the western North Atlantic. Pages 67-104 in NMFS-SEFSC (National Marine Fisheries Service-Southeast Fisheries Science Center), ed. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455.

Thomsen, F., F. Ugarte, and P.G.H. Evans, eds. 2005. Proceedings of the workshop on estimation of g(0) in line-transect surveys of cetaceans held at the European Cetacean Society's 18th Annual Conference, Vildmarkshotellet at Kolmården Djur Park, Kolmården, Sweden, 28th March 2004. European Cetacean Society Newsletter 44(Special Issue):1-46.

Torres, L.G., P.E. Rosel, C. D'Agrosa, and A.J. Read. 2003. Improving management of overlapping bottlenose dolphin ecotypes through spatial analysis and genetics. Marine Mammal Science 19(3):502-514.

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

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19(1):3-50.

USFWS (U.S. Fish and Wildlife Service). 2001. Nesting loggerhead sea turtle activity report 2000 and 1980-2000 nesting summary. Prepared for U.S. Army Corps of Engineers, Department of the Army, Norfolk, Virginia by S. Williams and J. Gallegos, Back Bay National Wildlife Refuge.

Wade, P.R. and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks. Report of the GAMMS (Guidelines for Assessing Marine Mammal Stocks) Workshop April 3-5, 1996, Seattle, Washington. NOAA Technical Memorandum NMFS-OPR-12:1-93.

Ward, J.A., G.H. Mitchell, A.M. Farak, and E.P. Keane. 2005. Beaked whale habitat characterization and prediction. NUWC-NPT Technical Report 11,548. Newport, Rhode Island: Naval Undersea Warfare Center Division.

Waring, G.T. and D.L. Palka. 2002. North Atlantic marine mammals. Pages 802-806 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Waring, G.T., J.M. Quintal, and C.P. Fairfield, eds. 2002. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2002. NOAA Technical Memorandum NMFS-NE-169:1-318.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1992. Cetaceans associated with Gulf Stream features off the northeastern USA Shelf. Unpublished meeting document. ICES C.M. 1992/N:12. Copenhagen, Denmark: International Council for the Exploration of the Sea.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. Fisheries Oceanography 2(2):101-105.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley, eds. 2006. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2005. NOAA Technical Memorandum NMFS-NE-194:1-346.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley, eds. 2007. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2006. NOAA Technical Memorandum NMFS-NE-201:1-378.

Waring, G.T., P. Gerrior, P.M. Payne, B.L. Parry, and J.R. Nicolas. 1990. Incidental take of marine mammals in foreign fishery activities off the northeast United States, 1977-88. Fishery Bulletin 88(2):347-360.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker. 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. Marine Mammal Science 17(4):703-717.

Waring, G.T., R.M. Pace, J.M. Quintal, C.P. Fairfield, and K. Maze-Foley, eds. 2004. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2003. NOAA Technical Memorandum NMFS-NE-182:1-287.

Watkins, W.A., M.A. Daher, G.M. Reppucci, J.E. George, D.L. Martin, N.A. DiMarzio, and D.P. Gannon. 2000. Seasonality and distribution of whale calls in the North Pacific. Oceanography 13:62-67.

Watts, P. and D.E. Gaskin. 1985. Habitat index analysis of the harbor porpoise (*Phocoena phocoena*) in the southern coastal Bay of Fundy, Canada. Journal of Mammalogy 66:733-744.

Weber, M. 1995. Kemp's ridley sea turtle, *Lepidochelys kempii*. Pages 109-122 in Plotkin, P.T., ed. Status reviews of sea turtles listed under the Endangered Species Act of 1973. Silver Spring, Maryland: National Marine Fisheries Service.

Wells, R.S. and M.D. Scott. 1999. Bottlenose dolphin--*Tursiops truncatus* (Montagu, 1821). Pages 137-182 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Wells, R.S., H.L. Rhinehart, P. Cunningham, J. Whaley, M. Baran, C. Koberna, and D.P. Costa. 1999. Long distance offshore movements of bottlenose dolphins. Marine Mammal Science 15(4):1098-1114.

Wenzel, F., D.K. Mattila, and P.J. Clapham. 1988. *Balaenoptera musculus* in the Gulf of Maine. Marine Mammal Science 4(2):172-175.

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

Whitehead, H. and M.J. Moore. 1982. Distribution and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60:2203-2211.

Whitman, A.A. and P.M. Payne. 1990. Age of harbour seals, *Phoca vitulina concolor*, wintering in southern New England. Canadian Field-Naturalist 104(4):579-582.

Wiley, D.N., R.A. Asmutis, T.D. Pitchford, and D.P. Gannon. 1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fishery Bulletin 93:196-205.

Wilson, S.C. 1978. Social organization and behavior of harbor seals, *Phoca vitulina concolor*, in Maine. Contract MM6ACO13. Prepared for the U.S. Marine Mammal Commission, Washington, D.C.

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

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

Witherington, B. and S. Hirama. 2006. Sea turtles of the epi-pelagic sargassum drift community. Page 209 in Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. 3-8 April 2006. Island of Crete, Greece.

Witherington, B., M. Bresette, and R. Herren. 2006. *Chelonia mydas* - green turtle. Pages 90-104 in Meylan, P.A., ed. Biology and conservation of Florida turtles. Chelonian Research Monographs No. 3. Lunenburg, Massachusetts: Chelonian Research Foundation.

Witherington, B.E. 1994. Flotsam, jetsam, post-hatchling loggerheads, and the advecting surface smorgasbord. Pages 166-168 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Wood, S.N. 2006. Generalized additive models: An introduction with R. Boca Raton, Florida: Chapman & Hall/CRC.

Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. College Station, Texas: Texas A&M University Press.

Yochem, P.K. and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). Pages 193-240 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

This page intentionally left blank

APPENDIX A: SPATIAL MODELING OUTPUT

TABLE OF CONTENTS

This page intentionally left blank

This appendix contains the spatial modeling output for all species in the NE study area for which density estimates were generated using spatial modeling. These are the data that were used to determine the model fit. Model output results are organized into three distinct sets of results for each species. They are as follows: (1) Detection function (results table and histogram); (2) RSM (GAMs table and two "smooth plots); and (3) variance estimation (results table and histogram). In cases where two separate models were generated (different seasons), there are two separate sets of model output. Sequence of the model output results provided below follow **Table A-1**.

- Humpback Whale (*Megaptera novaeangliae*)

Table A-1. Detection function results for the humpback whale during all seasons in the Northeast study area.

Detection Function		
No. of observations		44
Detection Function Parameters		
Scale Coefficients (Intercept)		
	Estimate	7.3417
	SE	0.1920
Hazard shape parameter (Exponent)		
	Estimate	
	SE	
Average p		
	Estimate	0.6922
	SE	0.0812
	CV (Coefficient of Variation)	0.1173
N in covered region		
	Estimate	63.5574
	SE	9.1593
	CV	0.1441

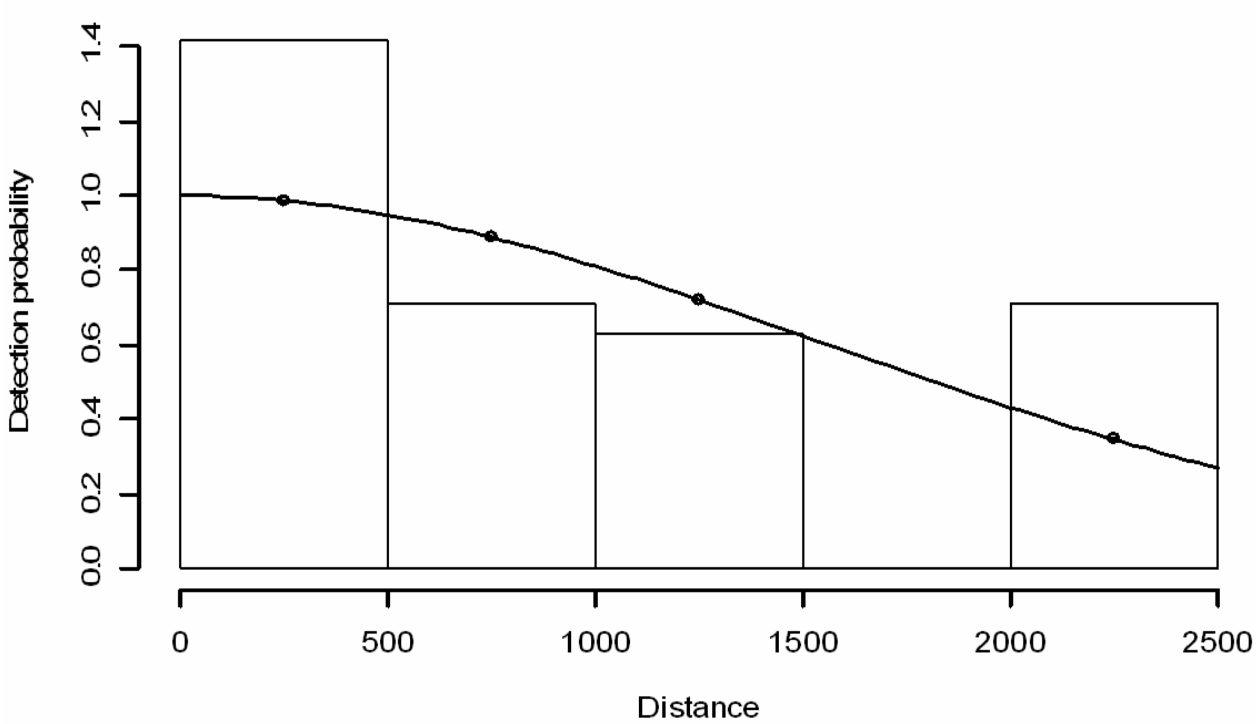


Figure A-1. Plot of the detection function for pooled sightings of the humpback whale during all seasons in the Northeast study area. Distance is measured in meters.

Table A-2. Response surface model (Generalized Additive Model) results for the humpback whale during all seasons in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(depth) + offset(off.set)
Approximate significance of smooth terms		
s(lon,lat)		
	Edf	29.000
	Est. rank	6.000
	F	8.551
	p-value	5.54e-09
s(depth)		
	Edf	1.001
	Est. rank	2.000
	F	11.358
	p-value	1.40e-05
R-sq. (adj)		0.359
n segments		30
Deviance explained		53.1%

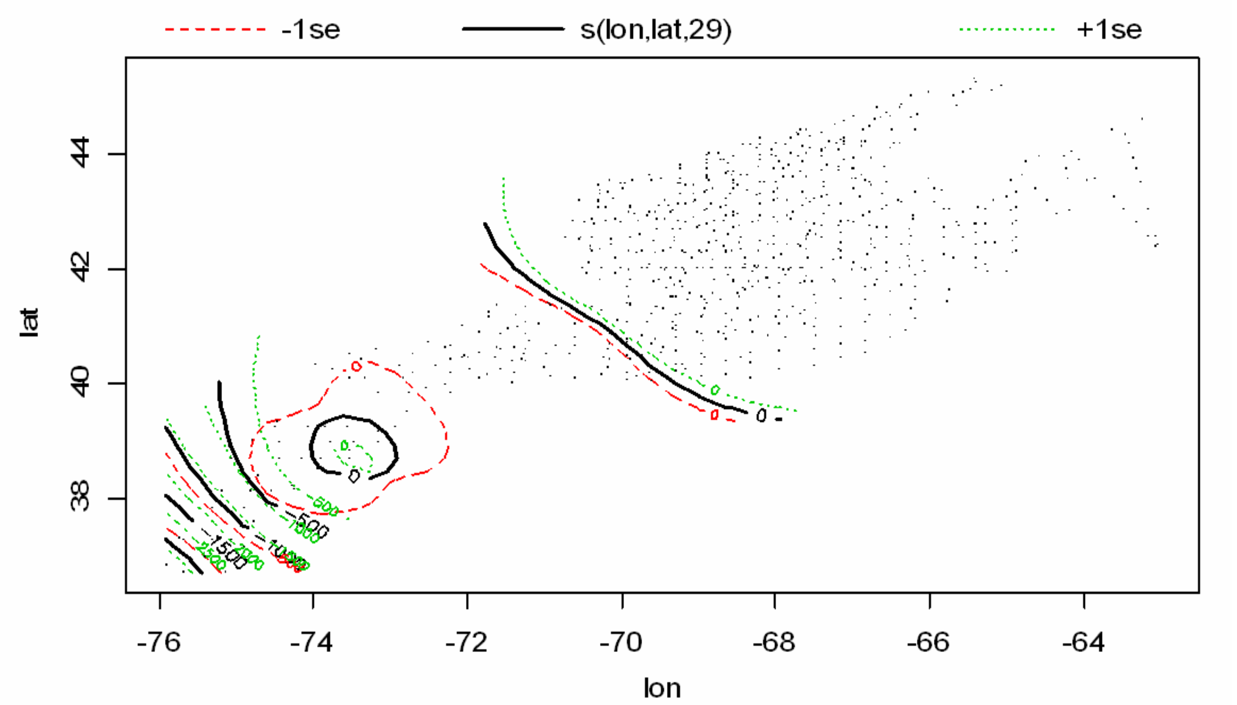


Figure A-2. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the humpback whale during all seasons in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

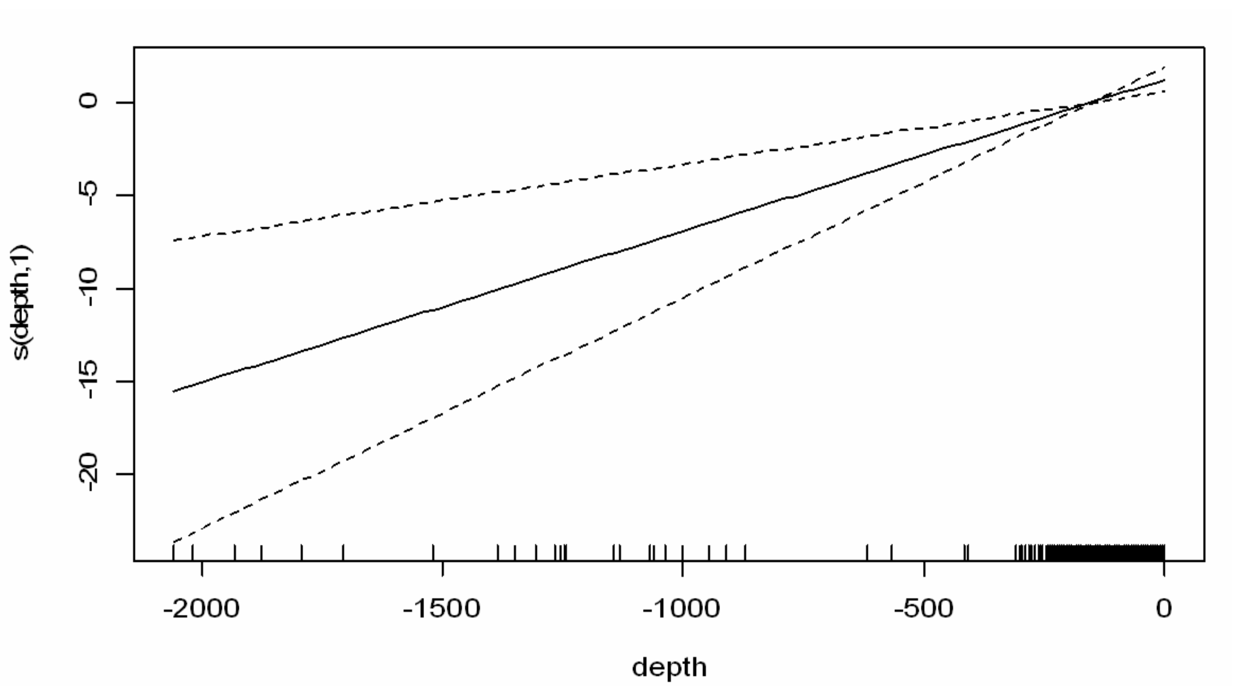


Figure A-3. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the humpback whale during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-3. Variance estimate model results for the humpback whale during all seasons in the Northeast study area.

Variance	
Legitimate values	477
Non-legitimate bootstrap replicates	22
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	227.74 – 270.25
Point estimate	250.178
SE of bootstraps	10.7122
Est. CV for density surface model	0.0428
CV in detection probability	0.5384
CV in overall estimate including density surface model and detection probability	0.5401
Confidence interval incorporating detection function uncertainty	92.804, 574.42

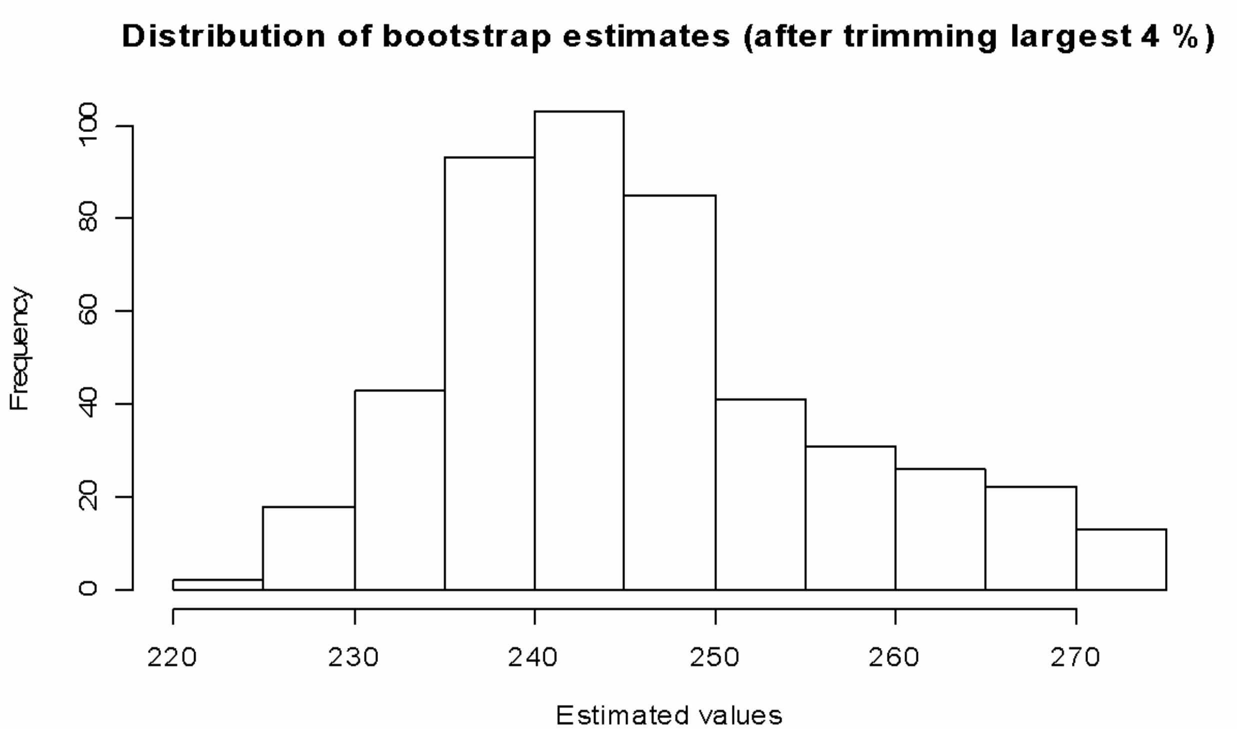


Figure A-4. Distribution of bootstrap estimates (after trimming largest 4%) for pooled sightings of the humpback whale during all seasons in the Northeast study area.

➢ Fin Whale (*Balaenoptera physalus*)

Table A-4. Detection function results for the fin whale during all seasons in the Northeast study area.

Detection Function		
No. of observations		78
Detection Function Parameters		
Scale Coefficients (Intercept)		
	Estimate	6.9261
	SE	0.0858
Average p		
	Estimate	0.4241
	SE	0.0353
	Coefficient of Variation (CV)	0.0831
N in covered region		
	Estimate	183.9049
	SE	21.9880
	CV	0.1196

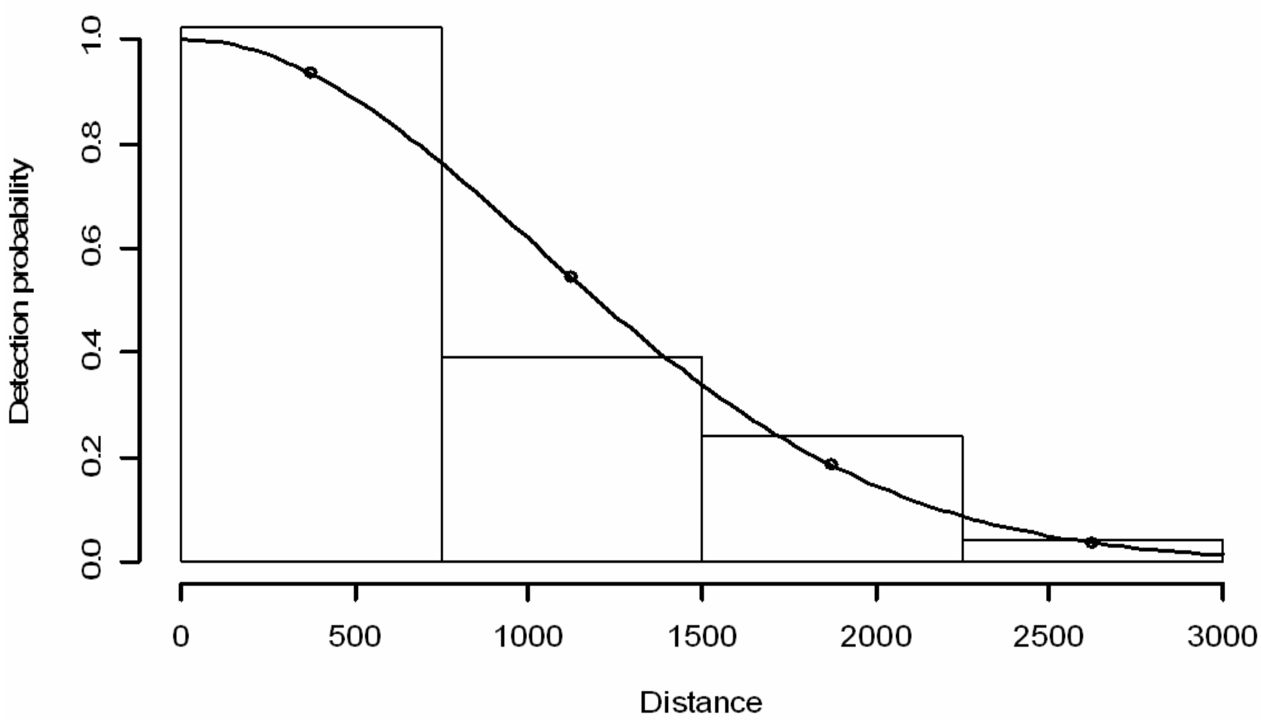


Figure A-5. Plot of the detection function for pooled sightings of the fin whale during all seasons in the Northeast study area. Distance is measured in meters.

Table A-5. Response surface model (Generalized Additive Model) results for the fin whale during all seasons in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(depth) + offset(off.set)
Approximate significance of smooth terms		
s(lon,lat)		
	Edf	29.000
	Est. rank	9.000
	F	3.788
	p-value	1.28e-04
s(depth)		
	Edf	5.489
	Est. rank	9.000
	F	2.490
	p-value	8.77e-03
R-sq. (adj)		0.0322
n segments		55
Deviance explained		25%

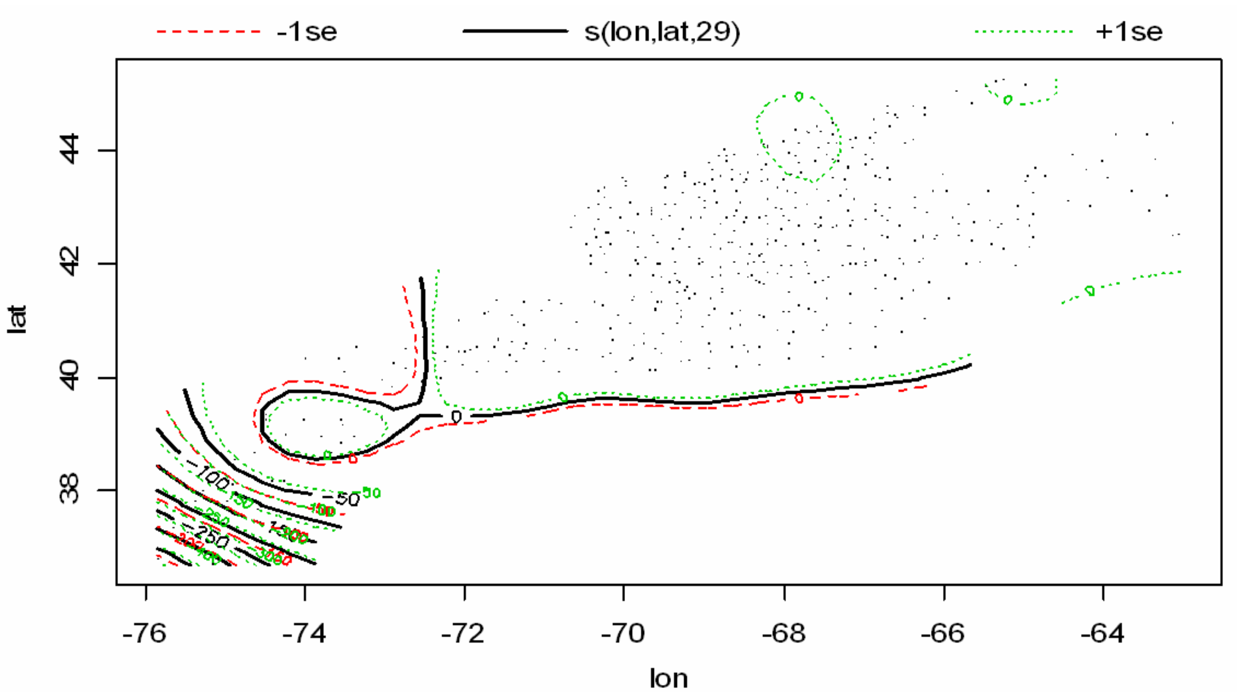


Figure A-6. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the fin whale during all seasons in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

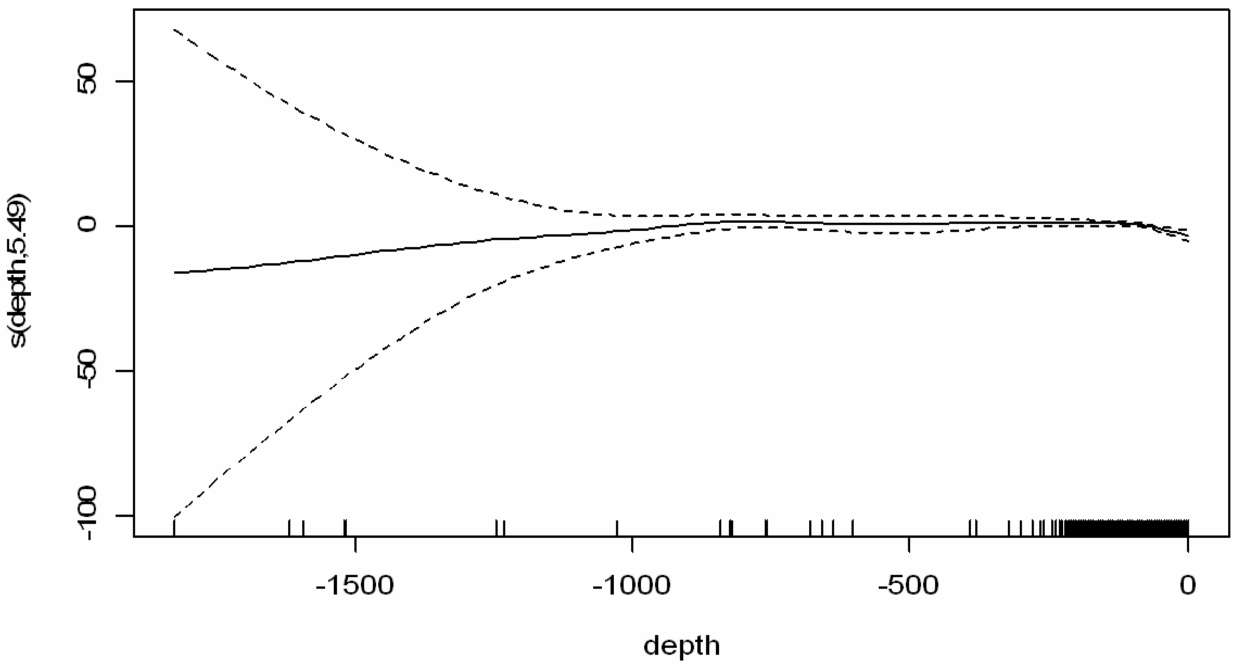


Figure A-7. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the fin whale during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-6. Variance estimate model results for the fin whale during all seasons in the Northeast study area.

Variance	
Legitimate values	489
Non-legitimate bootstrap replicates	10
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	301.9275 – 411.6315
Point estimate	345.6568
SE of bootstraps	27.92837
Est. CV for density surface model	0.0808
CV in detection probability	0.0831
CV in overall estimate including density surface model and detection probability	0.1159
Confidence interval incorporating detection function uncertainty	275.6072 , 433.5107

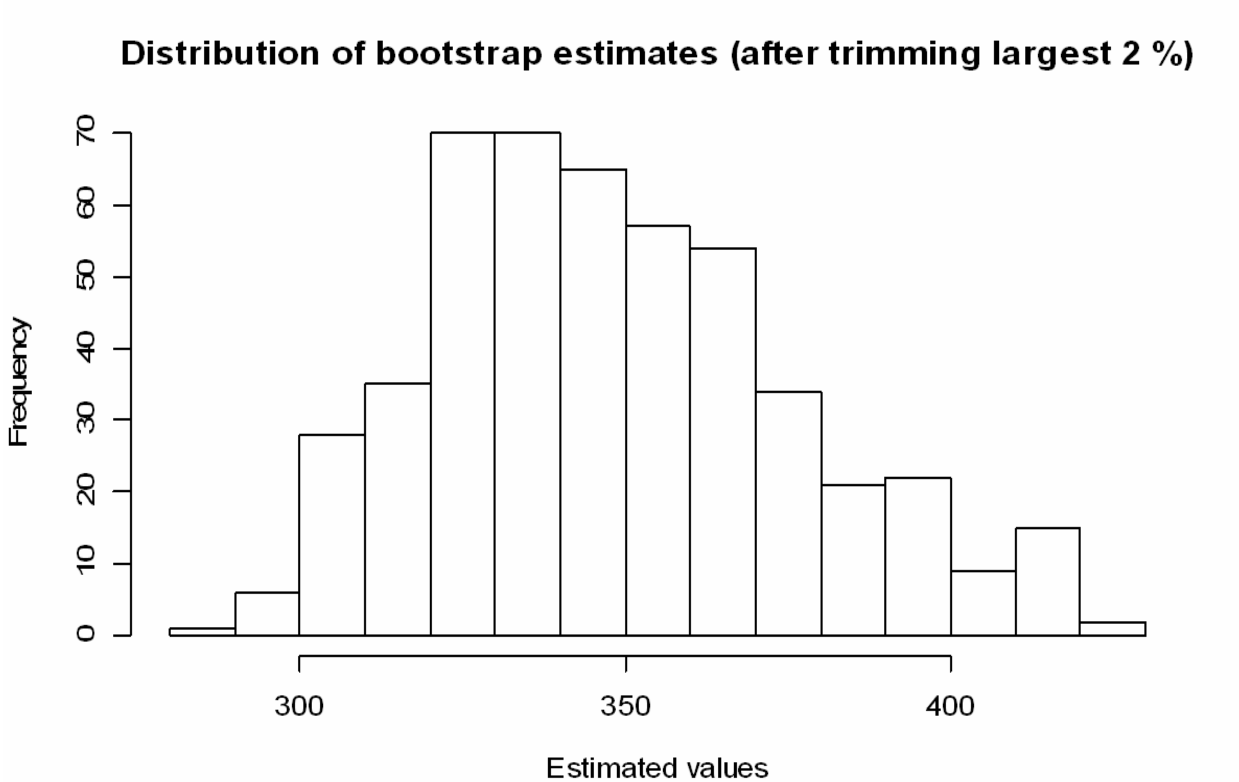


Figure A-8. Distribution of bootstrap estimates (after trimming largest 2%) for pooled sightings of the fin whale during all seasons in the Northeast study area.

➢ Minke Whale (*Balaenoptera acutorostrata*)

Table A-7. Detection function results for the minke whale during all seasons in the Northeast study area.

Detection Function		
No. of observations		21
Detection Function Parameters		
Scale Coefficients (Intercept)		
	Estimate	5.7797
	SE	0.6414
Hazard shape parameter (Exponent)		
	Estimate	1.6149
	SE	0.5006
Average p		
	Estimate	0.2271
	SE	0.0928
	CV	0.4087
N in covered region		
	Estimate	92.4866
	SE	41.7599
	CV	0.4515

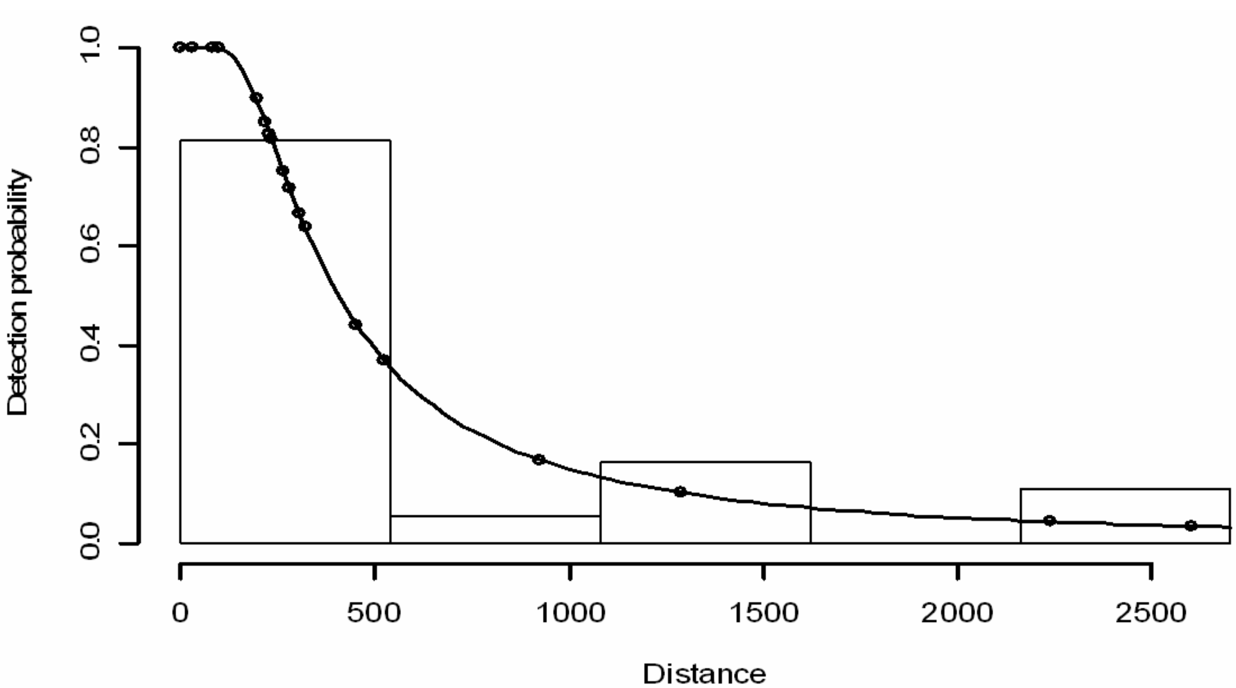


Figure A-9. Plot of the detection function for pooled sightings of the minke whale during all seasons in the Northeast study area. Distance is measured in meters.

Table A-8. Response surface model (Generalized Additive Model) results for the minke whale during all seasons in the Northeast study area.

Response Surface Model (GAM)	
Formula	N ~ s(lon,lat) + s(depth) + offset(off.set)
Approximate significance of smooth terms	
s(lon,lat)	
Edf	28.81
Est. rank	8.00
F	23.477
p-value	<2e-16
s(depth)	
Edf	1.00
Est. rank	1.00
F	0.302
p-value	0.583
R-sq. (adj)	0.621
n segments	16
Deviance explained	66.9%

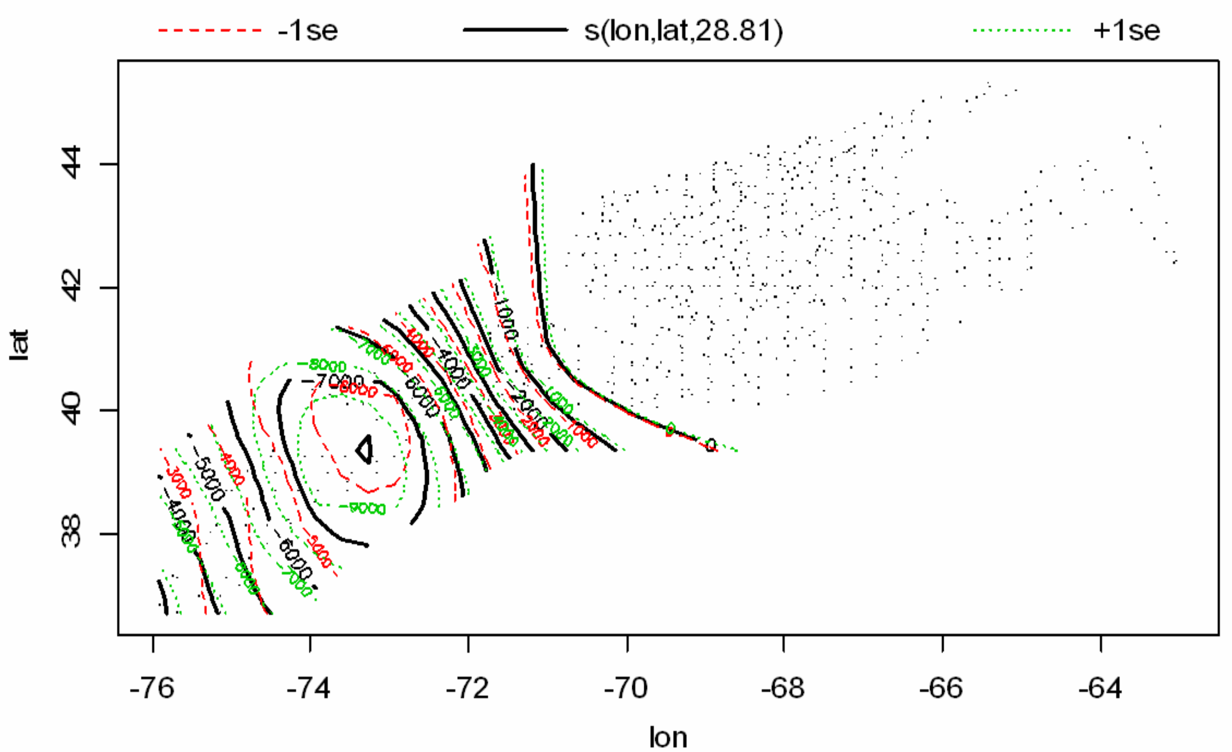


Figure A-10. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the minke whale during all seasons in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

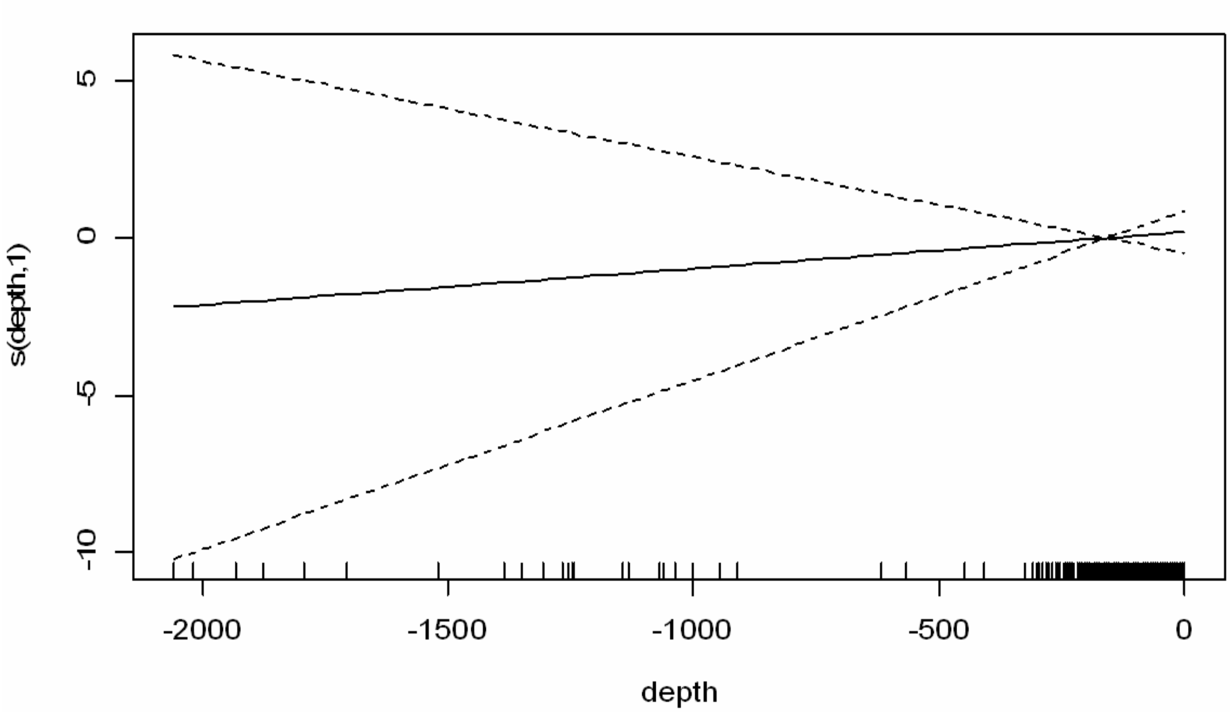


Figure A-11. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the minke whale during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-9. Variance estimate model results for the minke whale during all seasons in the Northeast study area.

Variance	
Legitimate values	446
Non-legitimate bootstrap replicates	53
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	158.9342 - 188.9148
Point estimate	174.8478
SE of bootstraps	7.095214
Est. CV for density surface model	0.0406
CV in detection probability	0.4087
CV in overall estimate including density surface model and detection probability	0.4107
Confidence interval incorporating detection function uncertainty	80.64182, 379.1056

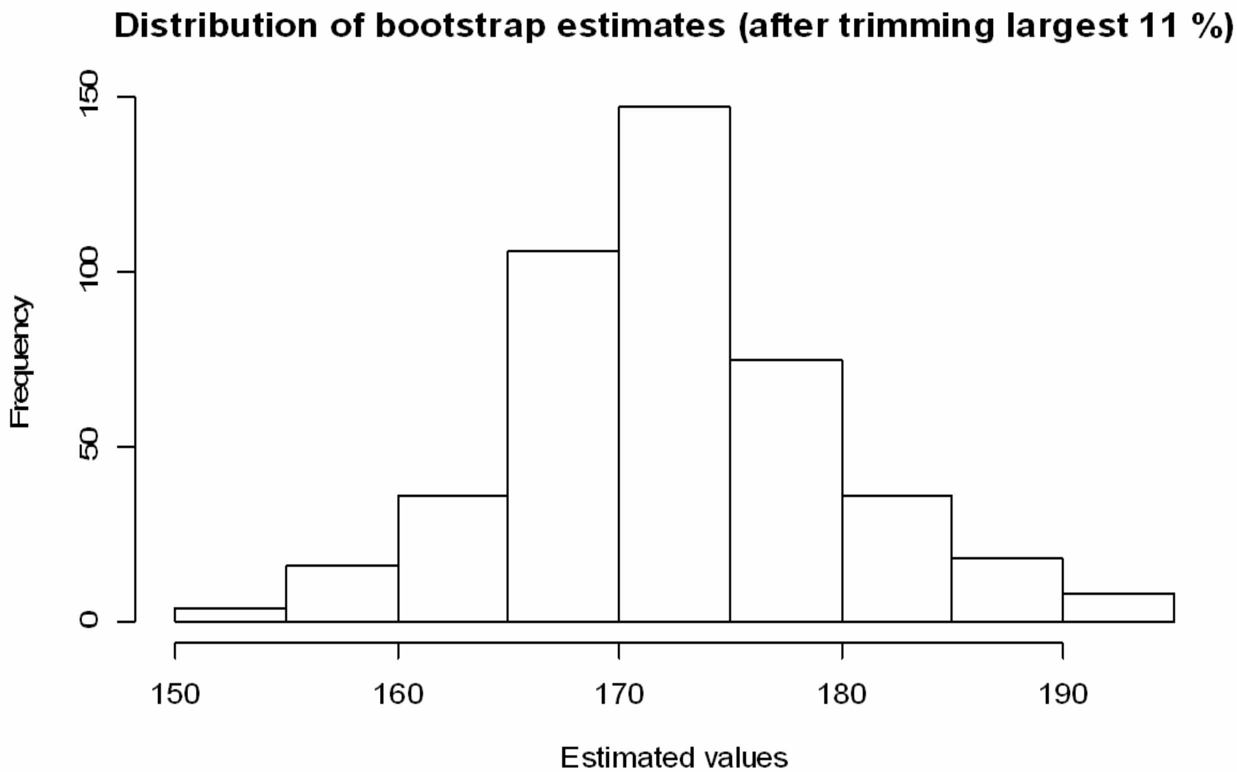


Figure A-12. Distribution of bootstrap estimates (after trimming largest 11%) for pooled sightings of the minke whale during all seasons in the Northeast study area.

➢ Common Dolphin (*Delphinus delphis*)

Table A-10. Detection function results for the common dolphin during all seasons in the Northeast study area.

Detection Function	
No. of observations	55
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.0710
SE	1.8545
Hazard shape parameter (Exponent)	
Estimate	1.1168
SE	0.5229
Average p	
Estimate	0.1839
SE	0.1793
CV	0.9754
N in covered region	
Estimate	299.1209
SE	294.0246
CV	0.9830

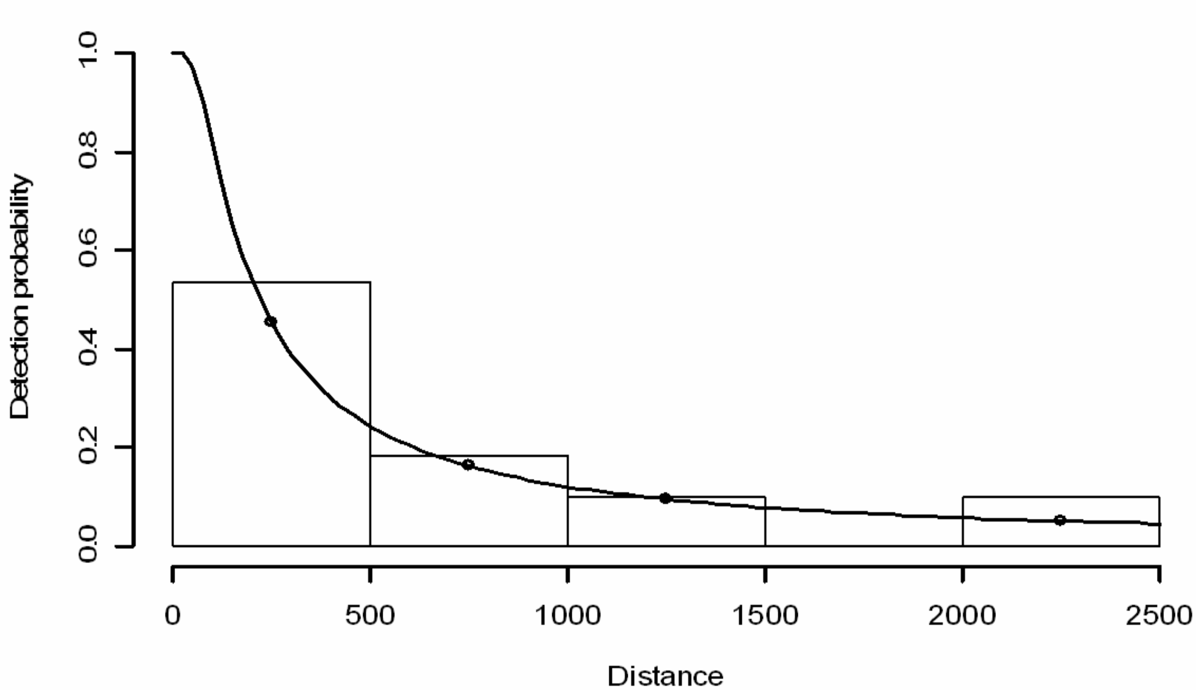


Figure A-13. Plot of the detection function for pooled sightings of the common dolphin during all seasons in the Northeast study area. Distance is measured in meters.

Table A-11. Response surface model (Generalized Additive Model) results for the common dolphin during all seasons in the Northeast study area.

Response Surface Model (GAM)	
Formula	N ~ s(lon,lat) + s(slope) + offset(off.set)
Approximate significance of smooth terms	
s(lon, lat)	
Edf	27.475
Est. rank	11.000
F	5.806
p-value	7e-09
s(slope)	
Edf	4.859
Est. rank	8.000
F	2.123
p-value	0.322
R-sq. (adj)	0.191
n segments	31
Deviance explained	47%

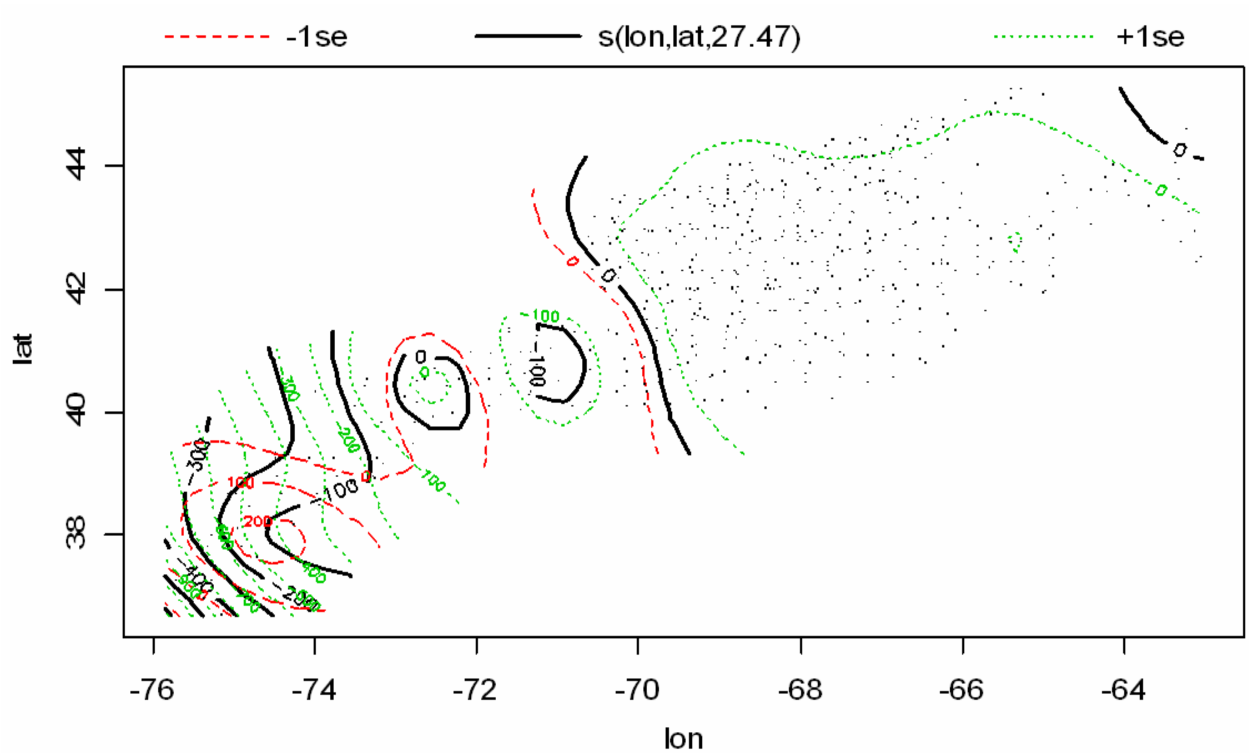


Figure A-14. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the common dolphin during all seasons in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

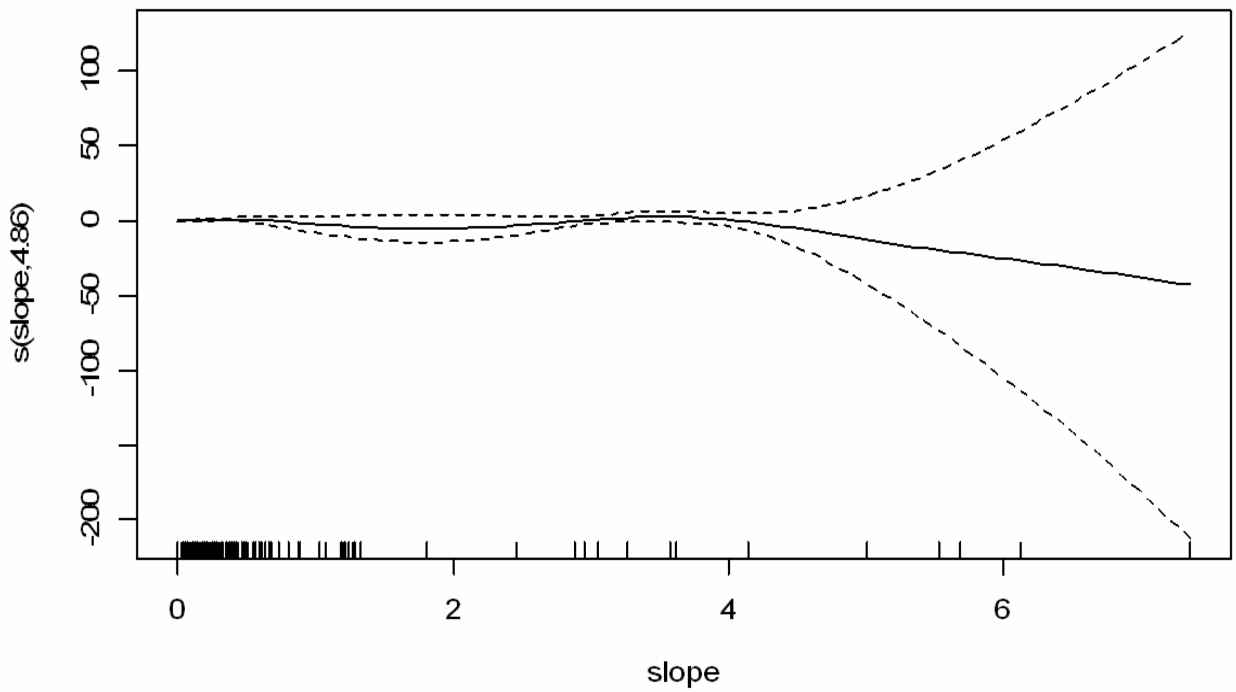


Figure A-15. Plot of the Generalized Additive Model smooth fit of the environmental covariate *slope* selected for the common dolphin during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-12. Variance estimate model results for the common dolphin during all seasons in the Northeast study area.

Variance	
Legitimate values	428
Non-legitimate bootstrap replicates	71
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	6911.205 - 25990.534
Point estimate	13061.37
SE of bootstraps	4904.971
Est. CV for density surface model	0.3755
CV in detection probability	0.9754
CV in overall estimate including density surface model and detection probability	1.0452
Confidence interval incorporating detection function uncertainty	2424.262 , 70371.71

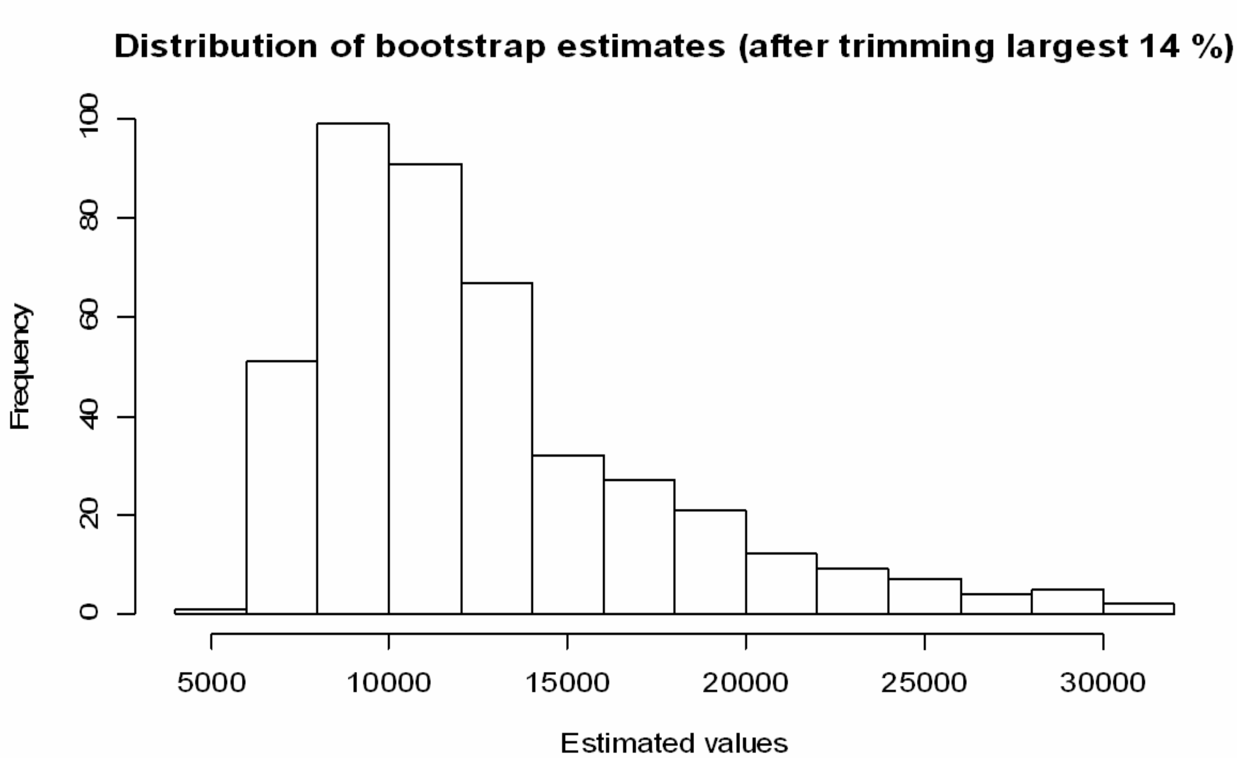


Figure A-16. Distribution of bootstrap estimates (after trimming largest 14%) for pooled sightings of the common dolphin during all seasons in the Northeast study area.

➢ Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*)

Table A-13. Detection function results for the Atlantic white-sided dolphin during all seasons in the Northeast study area.

Detection Function	
No. of observations	73
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.2158
SE	0.1214
Hazard shape parameter (Exponent)	
Estimate	4.0040
SE	0.8228
Average p	
Estimate	0.4451
SE	0.0417
CV	0.0938
N in covered region	
Estimate	163.9808
SE	21.0018
CV	0.1280

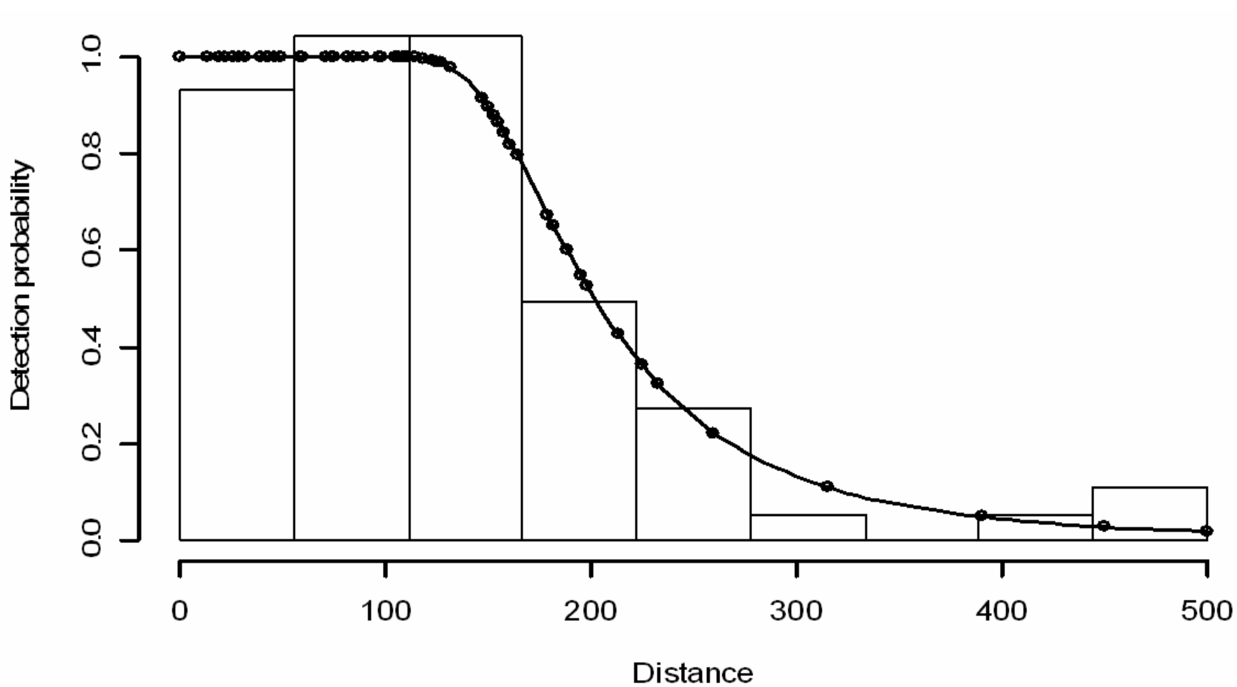


Figure A-17. Plot of the detection function for pooled sightings of the Atlantic white-sided dolphin during all seasons in the Northeast study area. Distance is measured in meters.

Table A-14. Response surface model (Generalized Additive Model) results for the Atlantic white-sided dolphin during all seasons in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~s(lon,lat) + s(depth) + s(slope) + offset(off.set)
Approximate significance of smooth terms		
s(lon,lat)		
	Edf	23.780
	Est. rank	28.00
	F	3.433
	p-value	5.07e-08
s(depth)		
	Edf	7.64
	Est. rank	9.00
	F	6.500
	p-value	1.65e-08
s(slope)		
	Edf	8.862
	Est. rank	9.00
	F	5.378
	p-value	7.26e-07
R-sq. (adj)		0.675
n segments		32
Deviance explained		65.6%

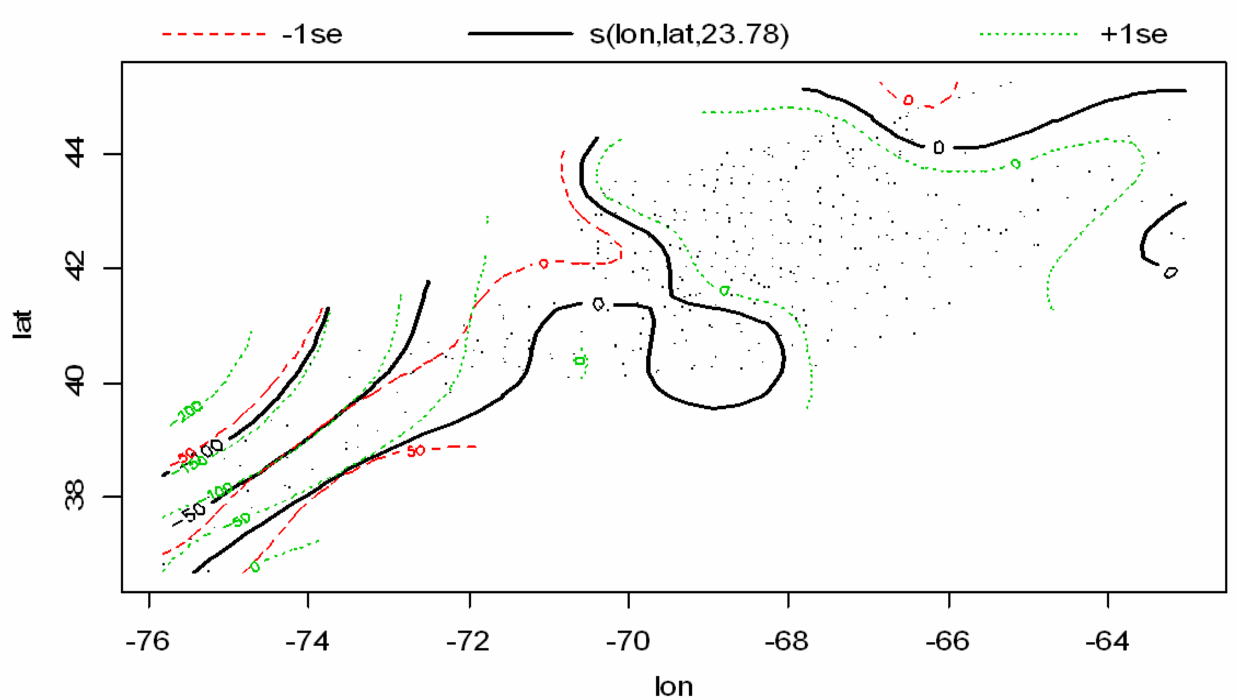


Figure A-18. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the Atlantic white-sided dolphin during all seasons in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

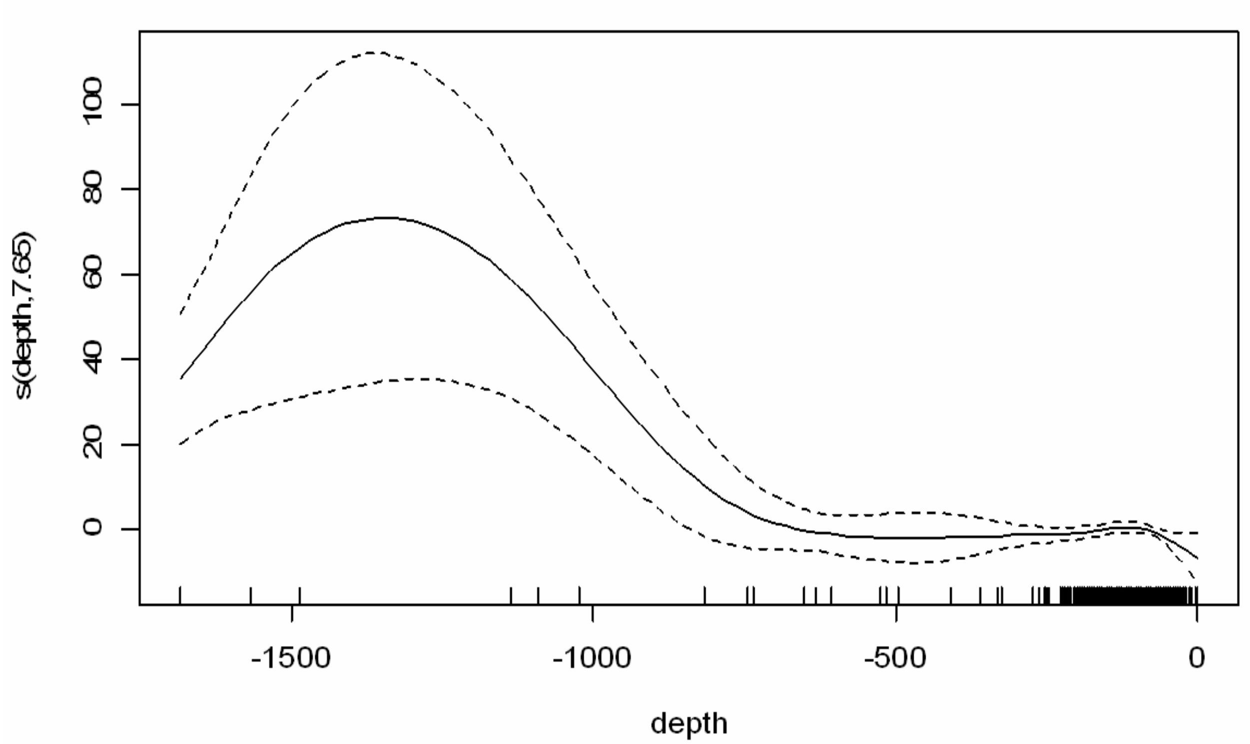


Figure A-19. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the Atlantic white-sided dolphin during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

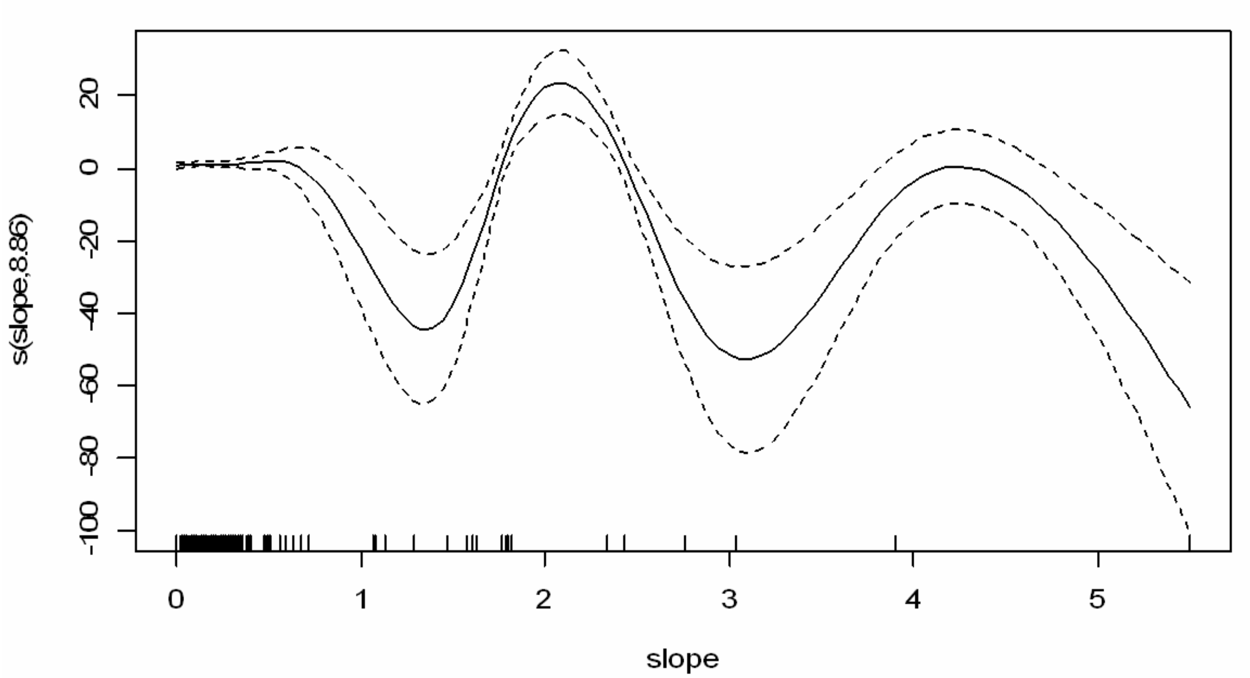


Figure A-20. Plot of the Generalized Additive Model smooth fit of the environmental covariate *slope* selected for the Atlantic white-sided dolphin during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-15. Variance estimate model results for the Atlantic white-sided dolphin during all seasons in the Northeast study area.

Variance	
Legitimate values	440
Non-legitimate bootstrap replicates	59
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	11883.74 - 47057.36
Point estimate	23488.51
SE of bootstraps	8959.535
Est. CV for density surface model	0.3814
CV in detection probability	0.0938
CV in overall estimate including density surface model and detection probability	0.3928
Confidence interval incorporating detection function uncertainty	11179.11 , 49351.86

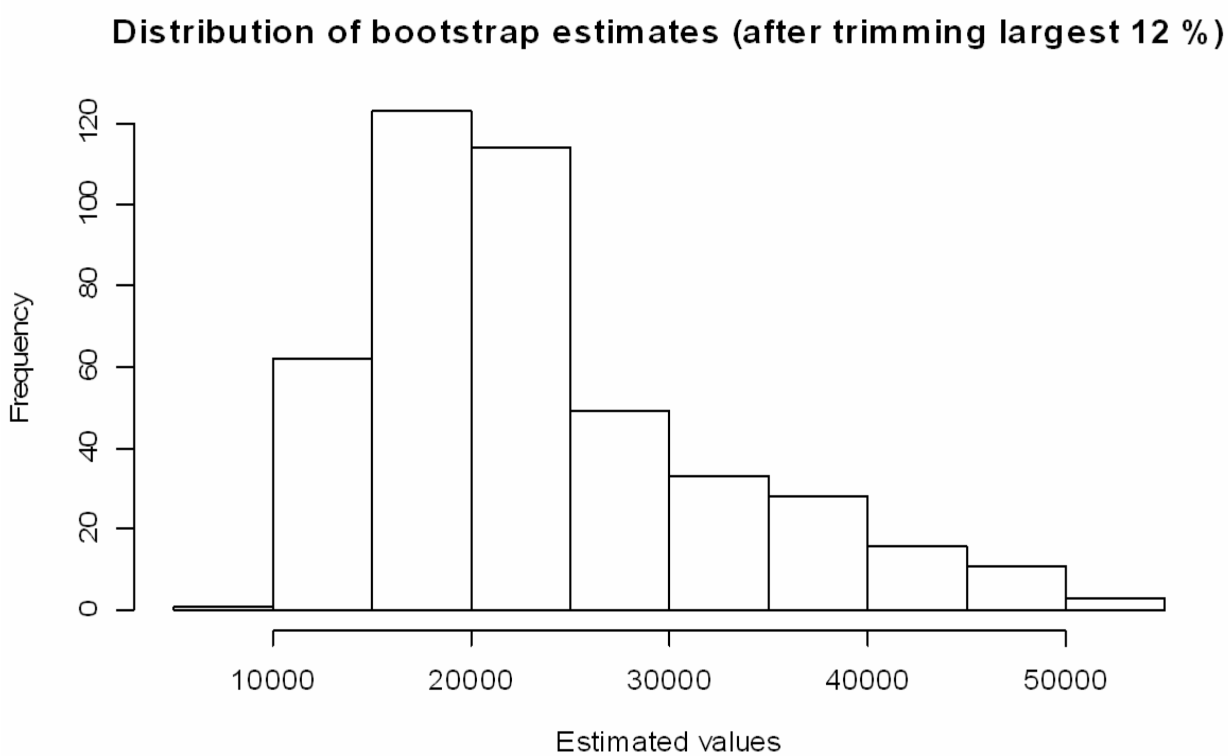


Figure A-21. Distribution of bootstrap estimates (after trimming largest 11%) for pooled sightings of the Atlantic white-sided dolphin during all seasons in the Northeast study area.

➢ Harbor Porpoise (*Phocoena phocoena*)

Table A-16. Detection function results for the harbor porpoise during spring, fall, and winter in the Northeast study area.

Detection Function	
No. of observations	173
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	4.4532
SE	0.2017
Hazard shape parameter (Exponent)	
Estimate	1.5715
SE	0.1680
Average p	
Estimate	0.1733
SE	0.0216
CV	0.1249
N in covered region	
Estimate	998.1050
SE	142.4996
CV	0.1427

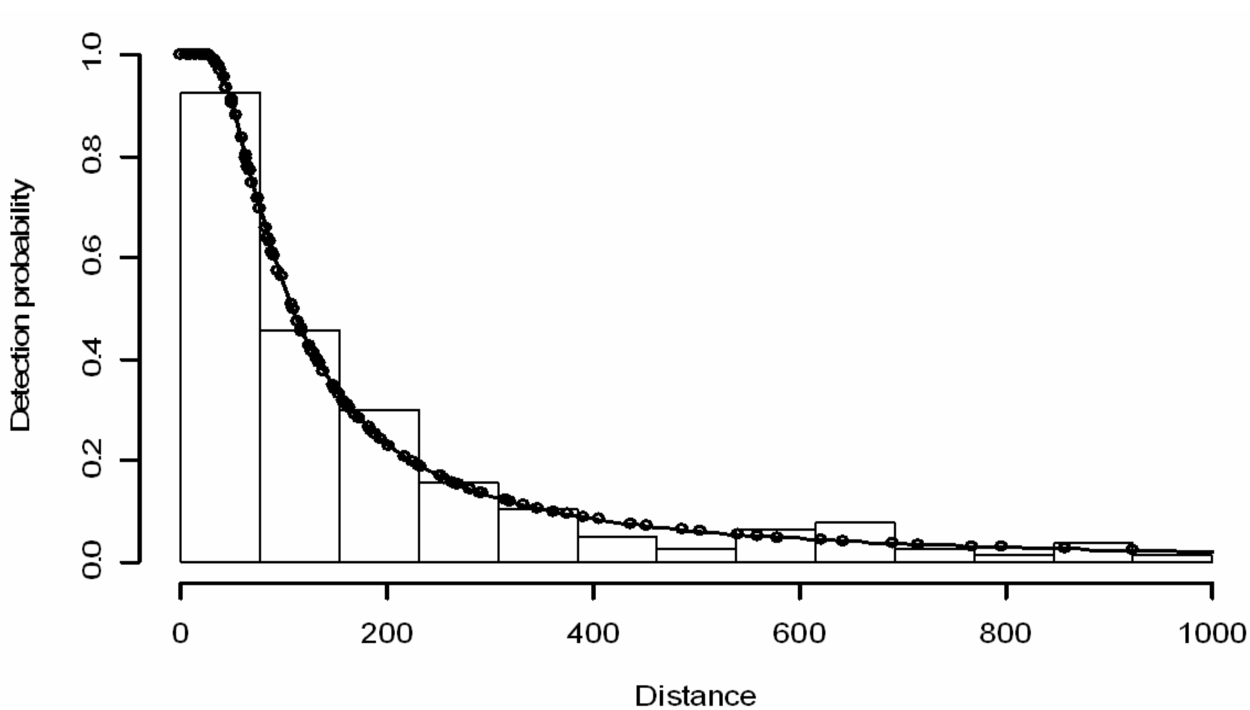


Figure A-22. Plot of the detection function for pooled sightings of the harbor porpoise during spring, fall, and winter in the Northeast study area. Distance is measured in meters.

Table A-17. Response surface model (Generalized Additive Model) results for the harbor porpoise during spring, fall, and winter in the Northeast study area.

Response Surface Model (GAM)	
Formula	N ~ s(lon,lat) + s(depth) + offset(off.set)
Approximate significance of smooth terms	
s(lon,lat)	
Edf	16.889
Est. rank	29.00
F	10.953
p-value	<2e-16
s(depth)	
Edf	5.964
Est. rank	9.00
F	3.874
p-value	8.05e-05
R-sq. (adj)	0.244
n segments	79
Deviance explained	57.5%

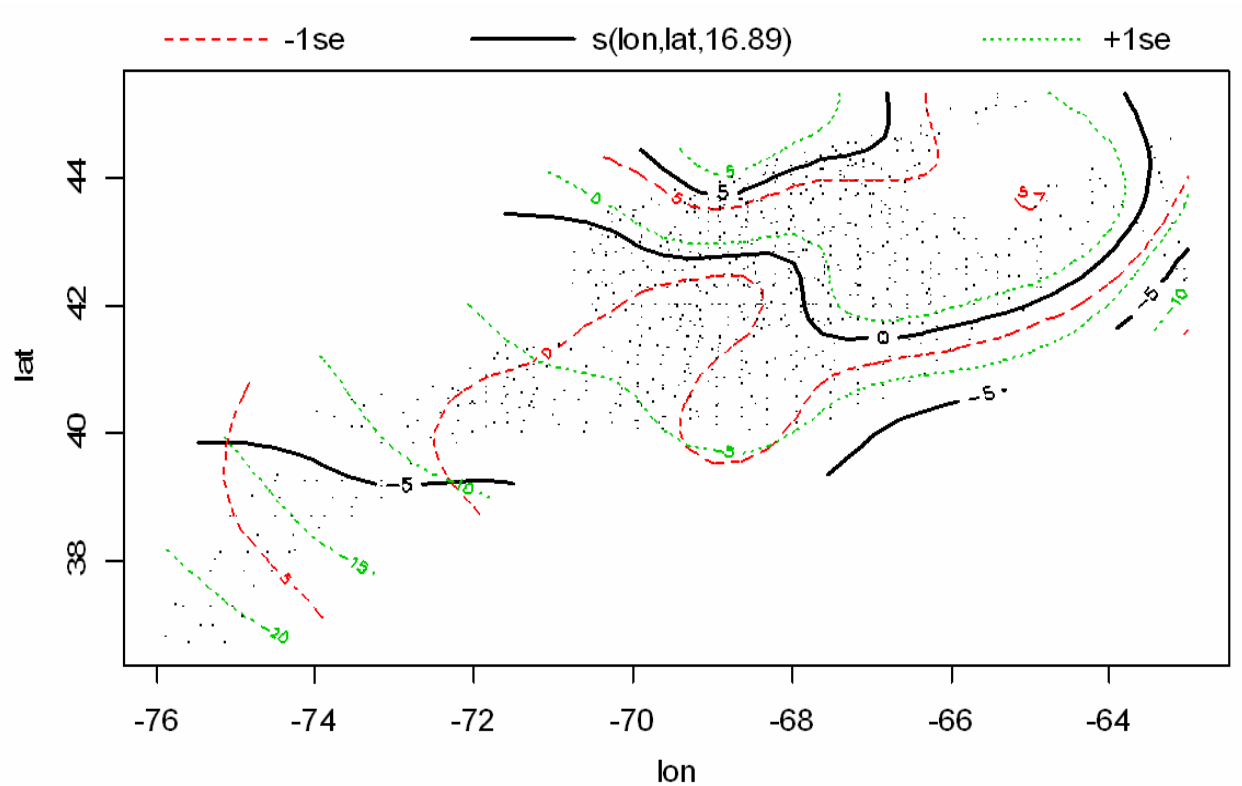


Figure A-23. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the harbor porpoise during spring, fall, and winter in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

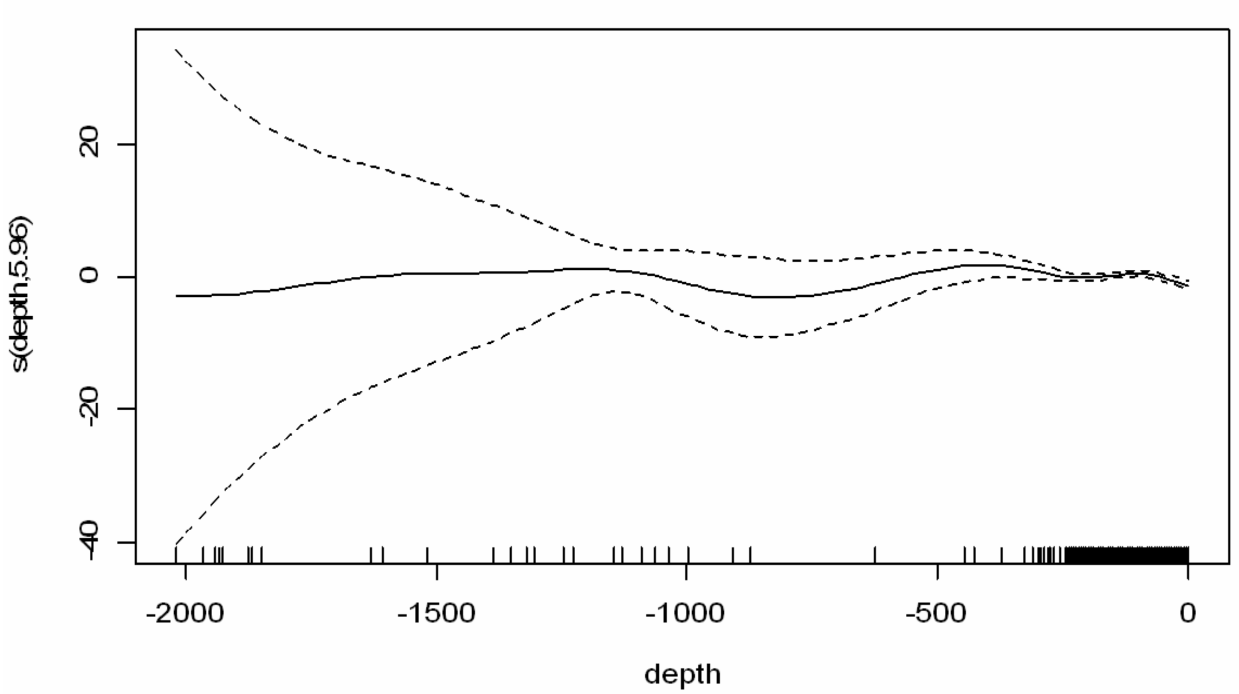


Figure A-24. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the harbor porpoise during spring, fall, and winter in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-18. Variance estimate model results for the harbor porpoise during spring, fall, and winter in the Northeast study area.

Variance	
Legitimate values	478
Non-legitimate bootstrap replicates	21
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	9019.929 - 16953.348
Point estimate	11710.97
SE of bootstraps	2134.654
Est. CV for density surface model	0.1823
CV in detection probability	0.1249
CV in overall estimate including density surface model and detection probability	0.221
Confidence interval incorporating detection function uncertainty	7633.644 , 17966.09

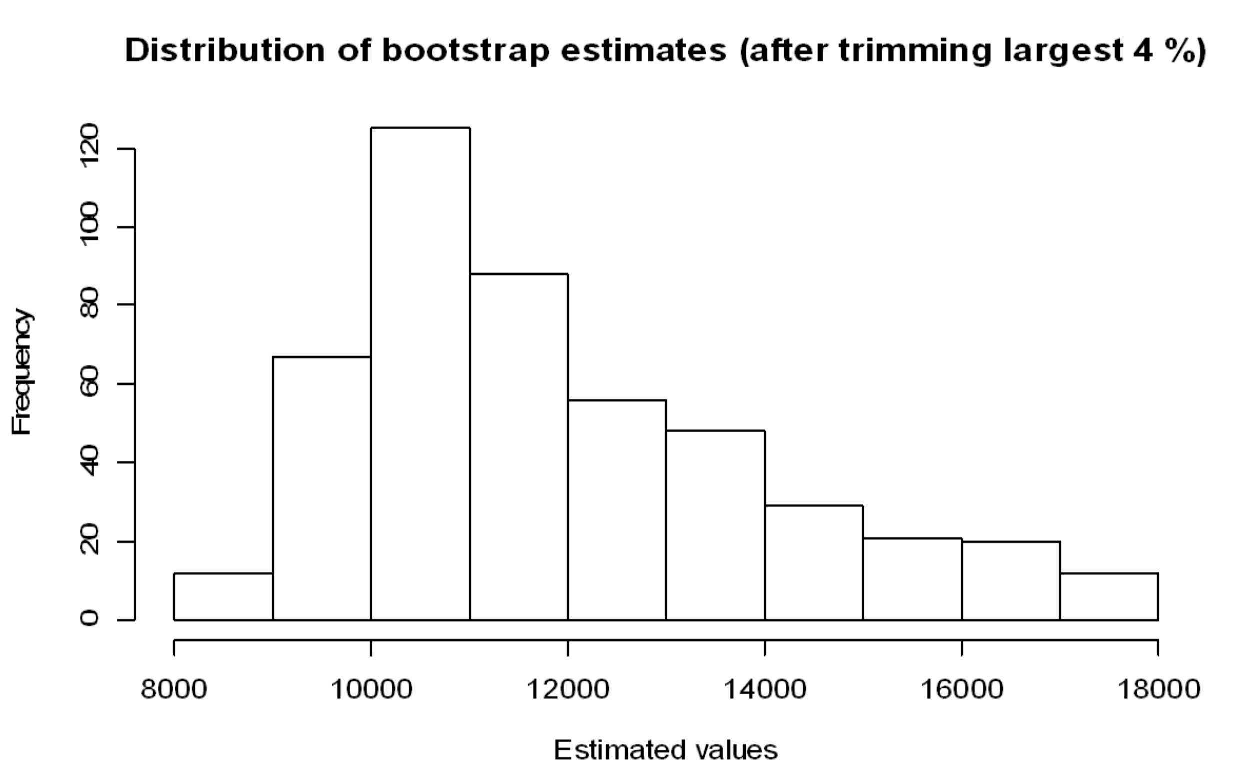


Figure A-25. Distribution of bootstrap estimates (after trimming largest 4%) for pooled sightings of the harbor porpoise during spring, fall, and winter in the Northeast study area.

Table A-19. Detection function results for the harbor porpoise during summer in the Northeast study area.

Detection Function	
No. of observations	173
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	4.4532
SE	0.2017
Hazard shape parameter (Exponent)	
Estimate	1.5715
SE	0.1680
Average p	
Estimate	0.1733
SE	0.0216
CV	0.1249
N in covered region	
Estimate	998.1050
SE	142.4996
CV	0.1427

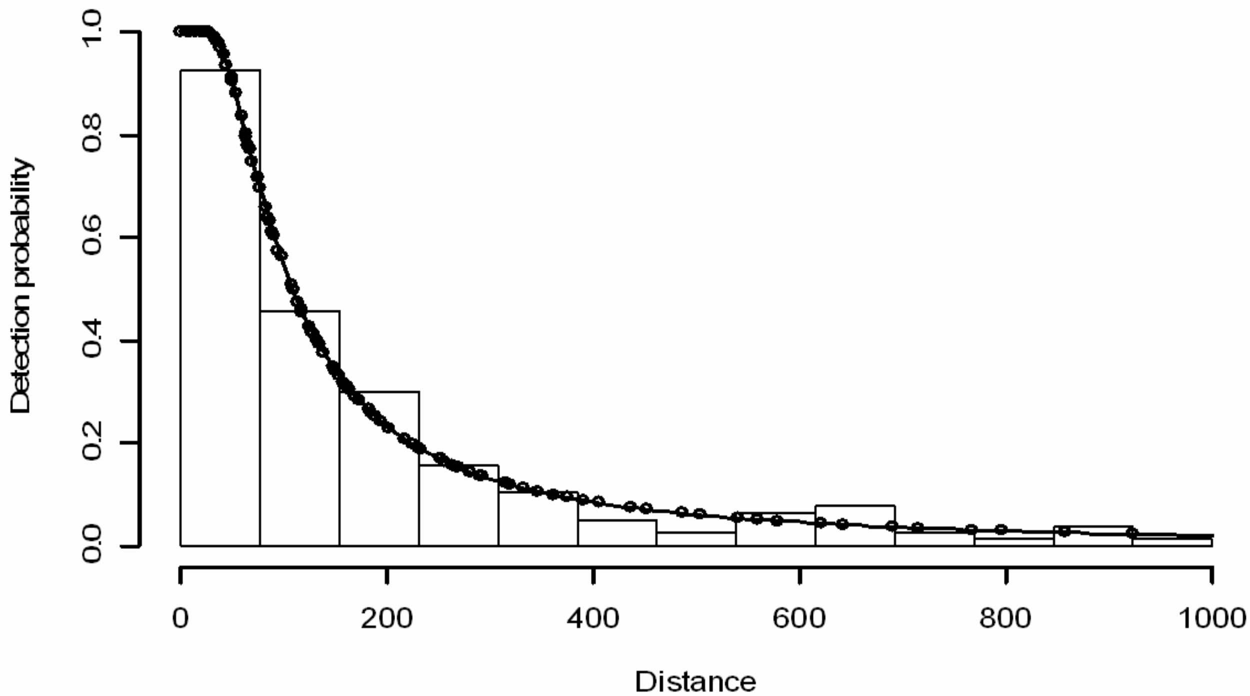


Figure A-26. Plot of the detection function for pooled sightings of the harbor porpoise during summer in the Northeast study area. Distance is measured in meters.

Table A-20. Response surface model (Generalized Additive Model) results for the harbor porpoise during summer in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(SST) + offset(off.set)
Approximate significance of smooth terms		
s(lon,lat)		
	Edf	27.365
	Est. rank	13.00
	F	6.09
	p-value	6.5e-11
s(SST)		
	Edf	3.637
	Est. rank	8.00
	F	12.69
	p-value	8< 2e-16
R-sq. (adj)		0.386
n segments		79
Deviance explained		53.8%

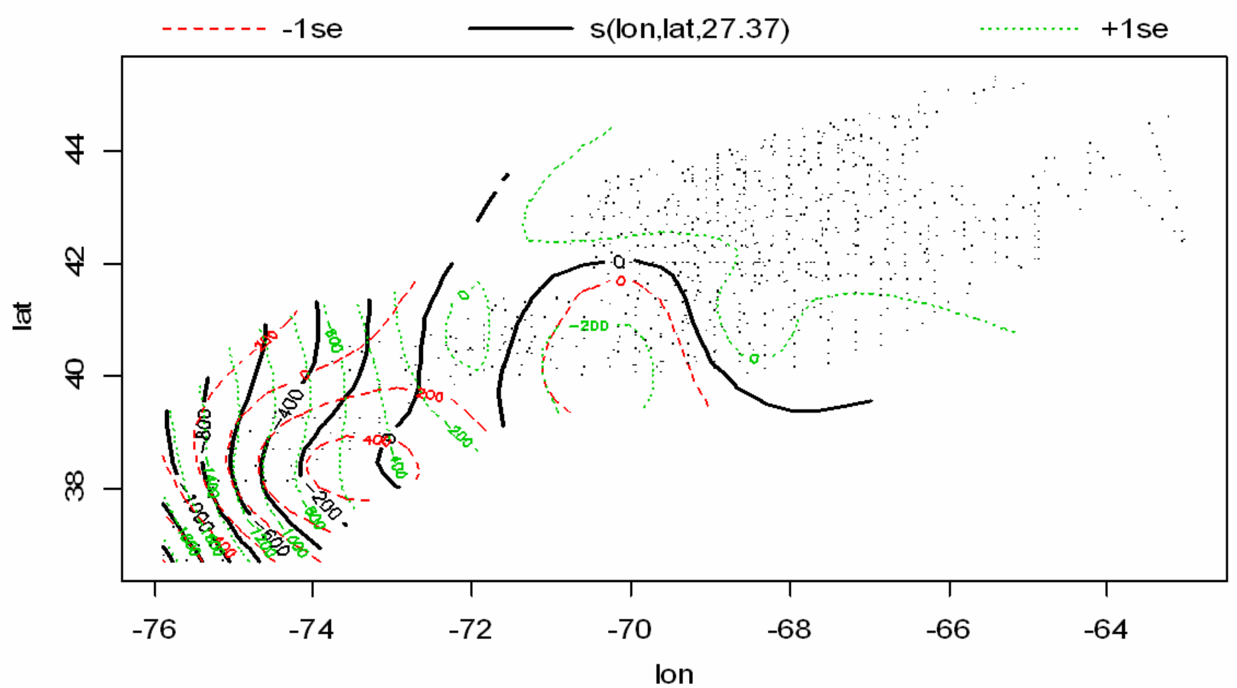


Figure A-27. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the harbor porpoise during summer in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

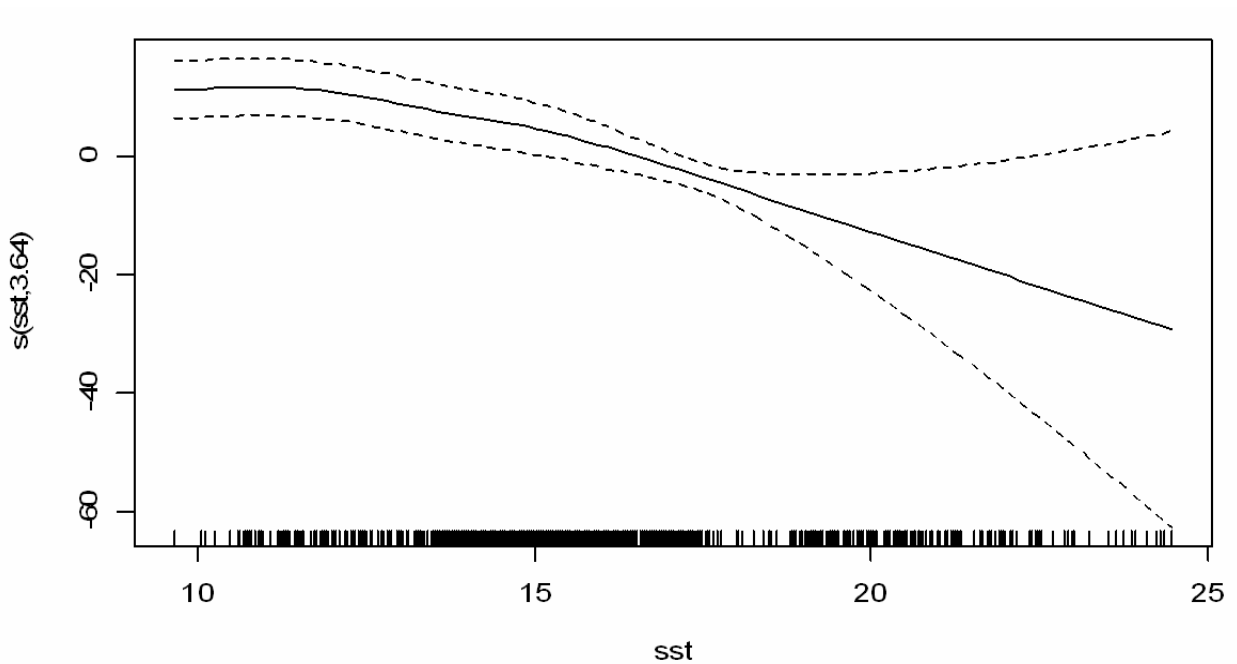


Figure A-28. Plot of the Generalized Additive Model smooth fit of the environmental covariate *SST* selected for the harbor porpoise during summer in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-21. Variance estimate model results for the harbor porpoise during summer in the Northeast study area.

Variance	
Legitimate values	431
Non-legitimate bootstrap replicates	68
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	8383.077 - 17308.332
Point estimate	10207.87
SE of bootstraps	2144.503
Est. CV for density surface model	0.2101
CV in detection probability	0.1249
CV in overall estimate including density surface model and detection probability	0.2444
Confidence interval incorporating detection function uncertainty	6366.39 , 16367.29

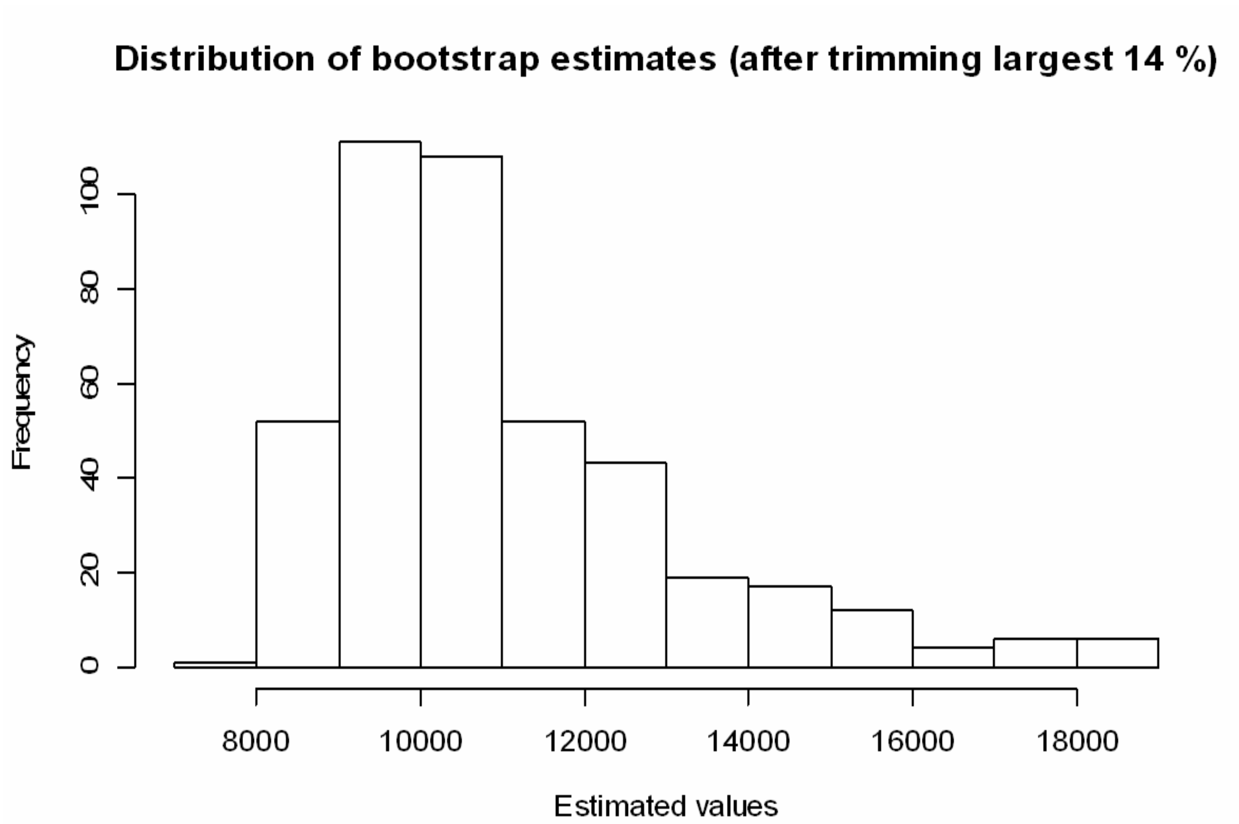


Figure A-29. Distribution of bootstrap estimates (after trimming largest 14%) for pooled sightings of the harbor porpoise during summer in the Northeast study area.

➢ Kemp's Ridley Turtle (*Lepidochelys kempii*)

Table A-22. Detection function results for the Kemp's ridley turtle during all seasons in the Northeast study area.

Detection Function	
No. of observations	104
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	4.8310
SE	0.3720
Hazard shape parameter (Exponent)	
Estimate	1.2717
SE	0.2485
Average p	
Estimate	0.2758
SE	0.0535
CV	0.1941
N in covered region	
Estimate	377.0406
SE	79.6563
CV	0.2113

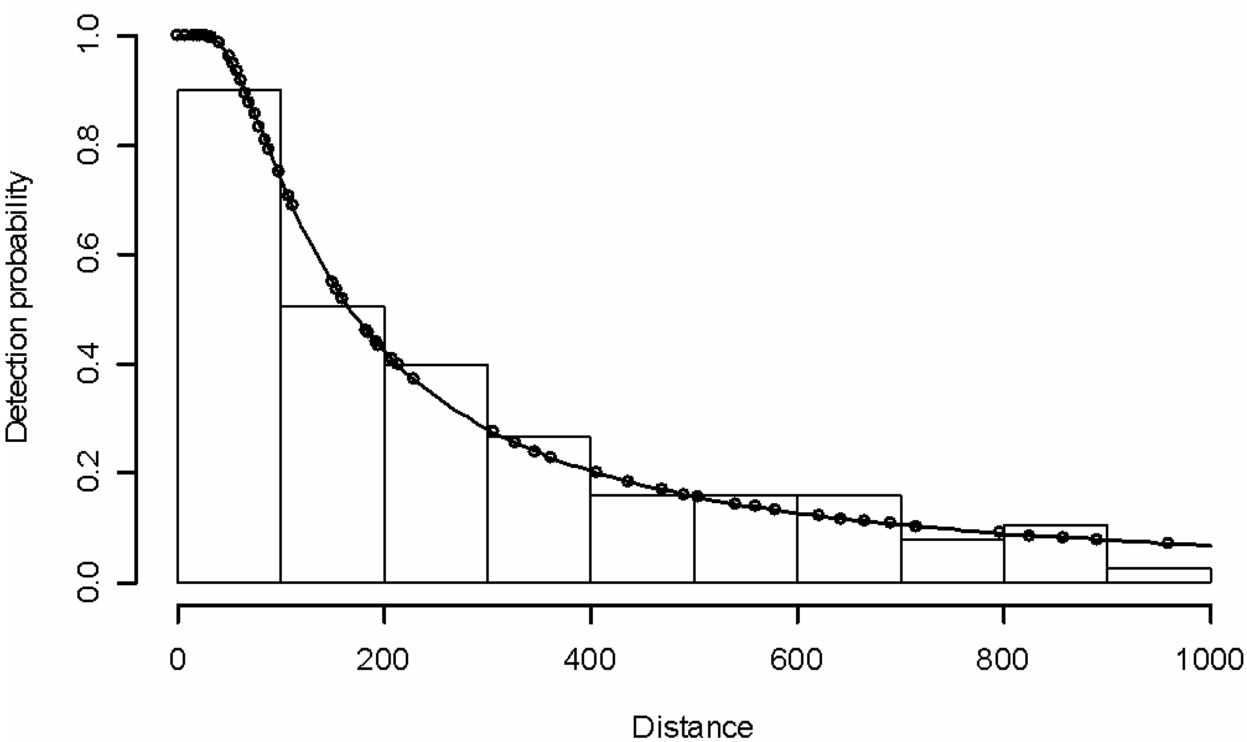


Figure A-30. Plot of the detection function for pooled sightings of the Kemp's ridley turtle during all seasons in the Northeast study area. Distance is measured in meters.

Table A-23. Response surface model (Generalized Additive Model) results for the Kemp's ridley turtle during all seasons in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(depth) + s(shelf) + s(slope) + offset(off.set)
Approximate significance of smooth terms		
s(lon, lat)		
	Edf	27.992
	Est. rank	10.000
	F	19.71
	p-value	<2e-16
s(depth)		
	Edf	1.000
	Est. rank	1.000
	F	48.84
	p-value	3.75e-12
s(shelf)		
	Edf	5.914
	Est. rank	9.000
	F	29.48
	p-value	<2e-16
s(slope)		
	Edf	1.000
	Est. rank	1.000
	F	27.46
	p-value	1.77e-07
R-sq. (adj)		0.589
n segments		49
Deviance explained		60.9%

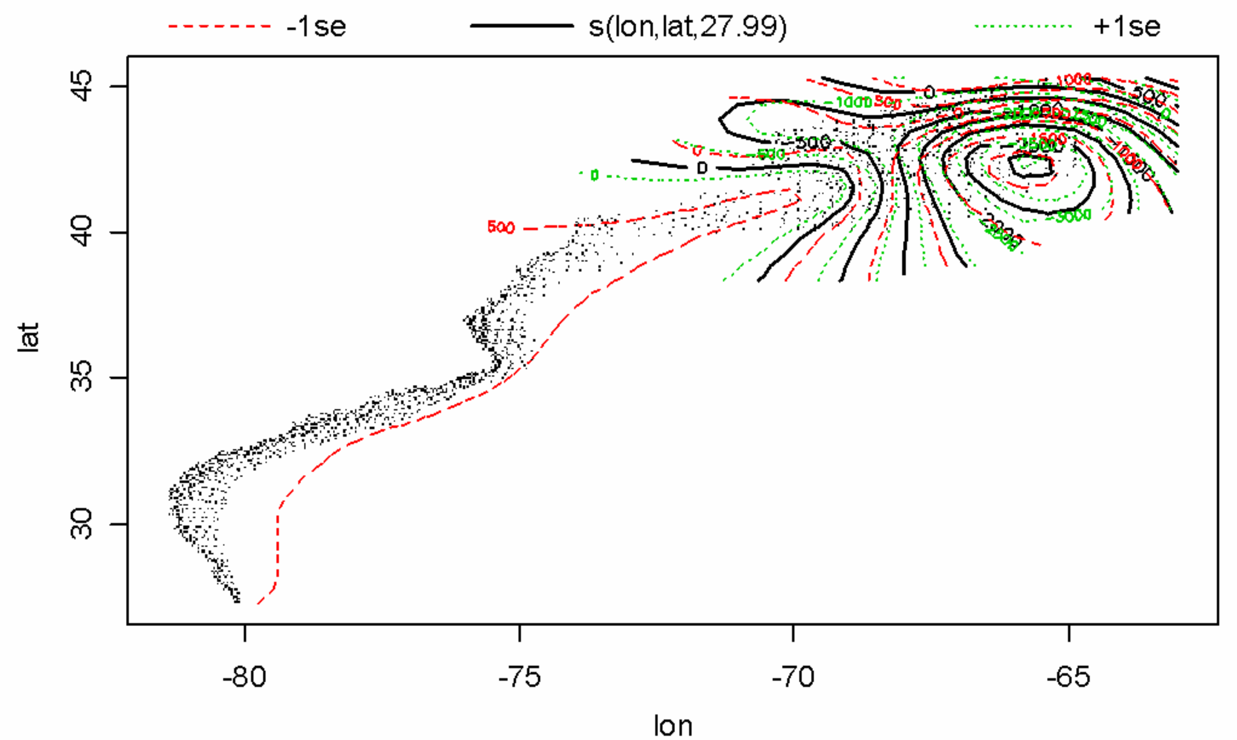


Figure A-31. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the Kemp's ridley turtle during all seasons in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

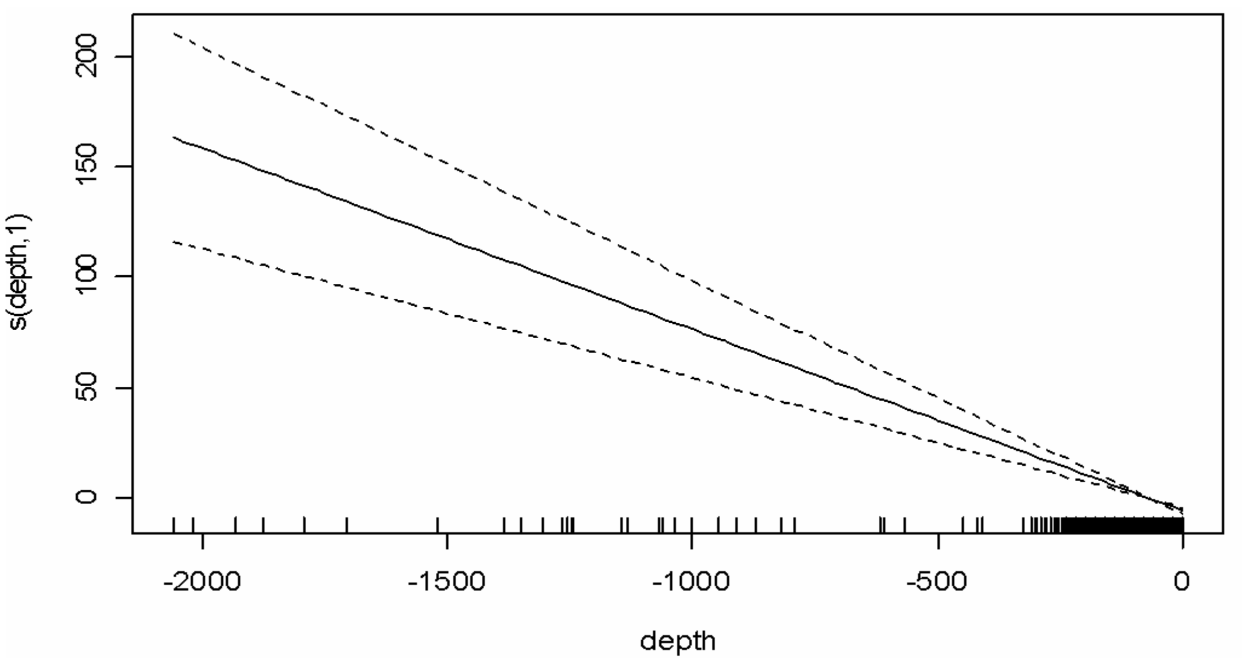


Figure A-32. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the Kemp's ridley turtle during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

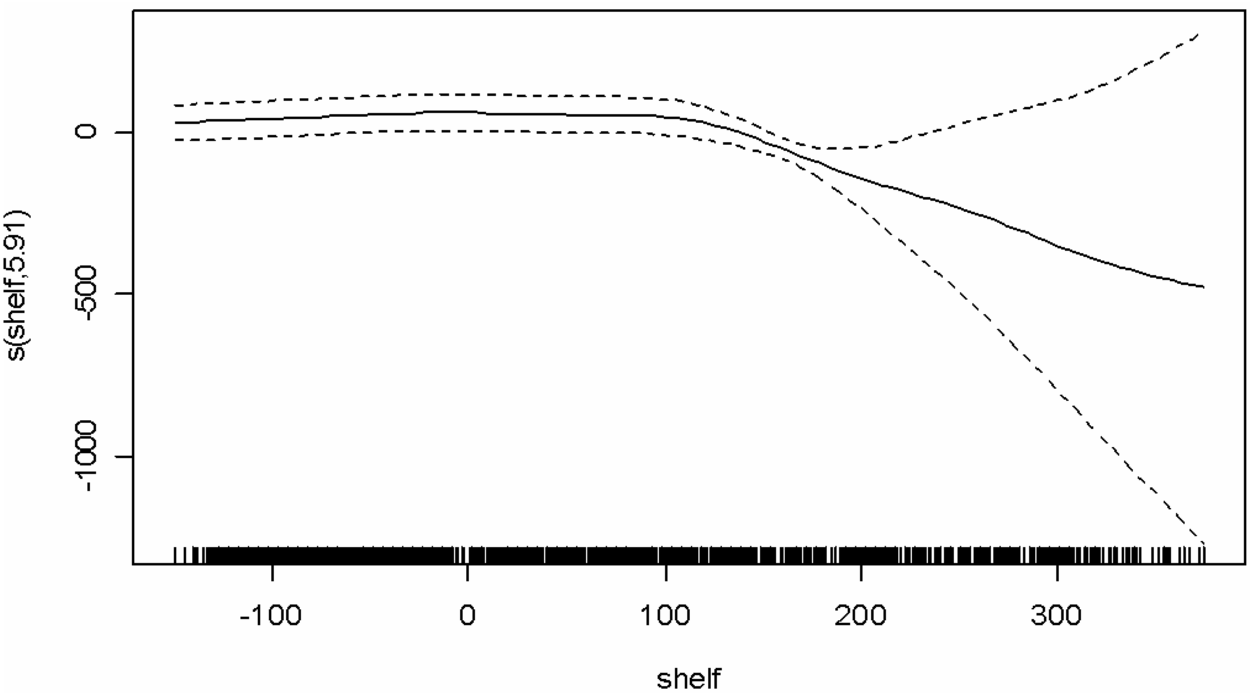


Figure A-33. Plot of the Generalized Additive Model smooth fit of the environmental covariate *shelf* selected for the Kemp's ridley turtle during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

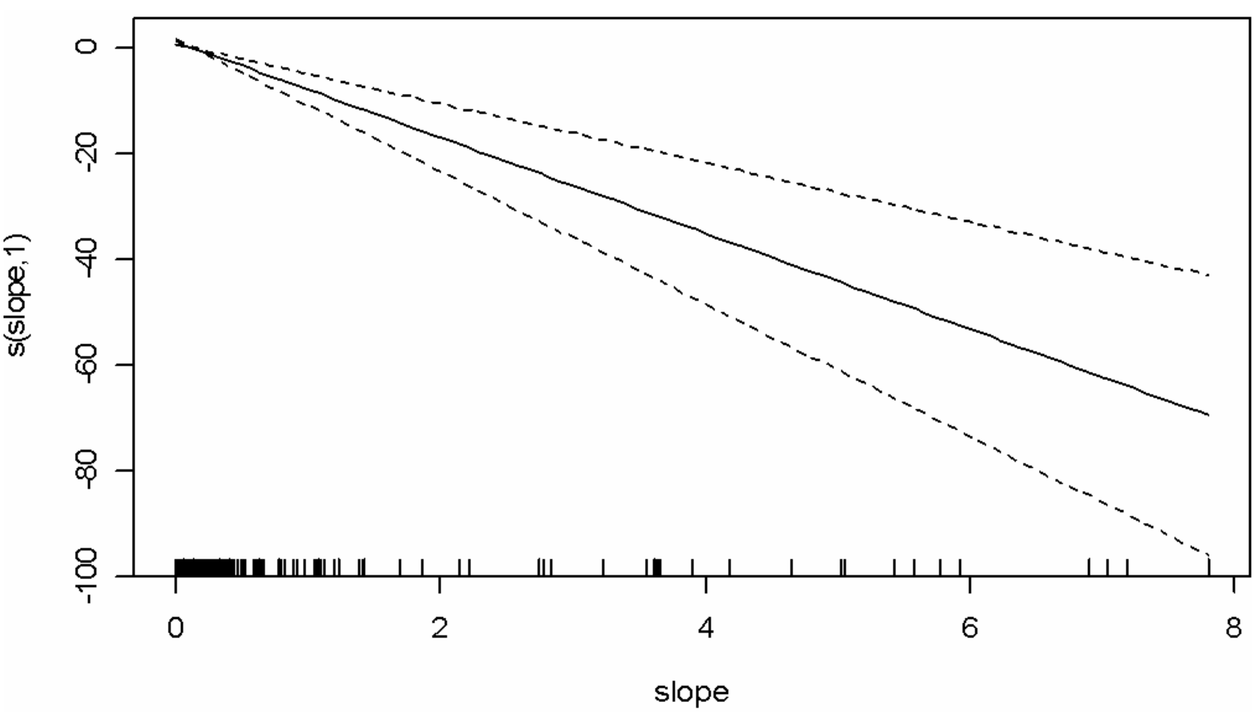


Figure A-34. Plot of the Generalized Additive Model smooth fit of the environmental covariate *slope* selected for the Kemp's ridley turtle during all seasons in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-24. Variance estimate model results for the Kemp's ridley turtle during all seasons in the Northeast study area.

Variance	
Legitimate values	389
Non-legitimate bootstrap replicates	110
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	2229.376 - 5208.289
Point estimate	3073.357
SE of bootstraps	744.9708
Est. CV for density surface model	0.2424
CV in detection probability	0.1941
CV in overall estimate including density surface model and detection probability	0.3105
Confidence interval incorporating detection function uncertainty	1695.692, 5570.308

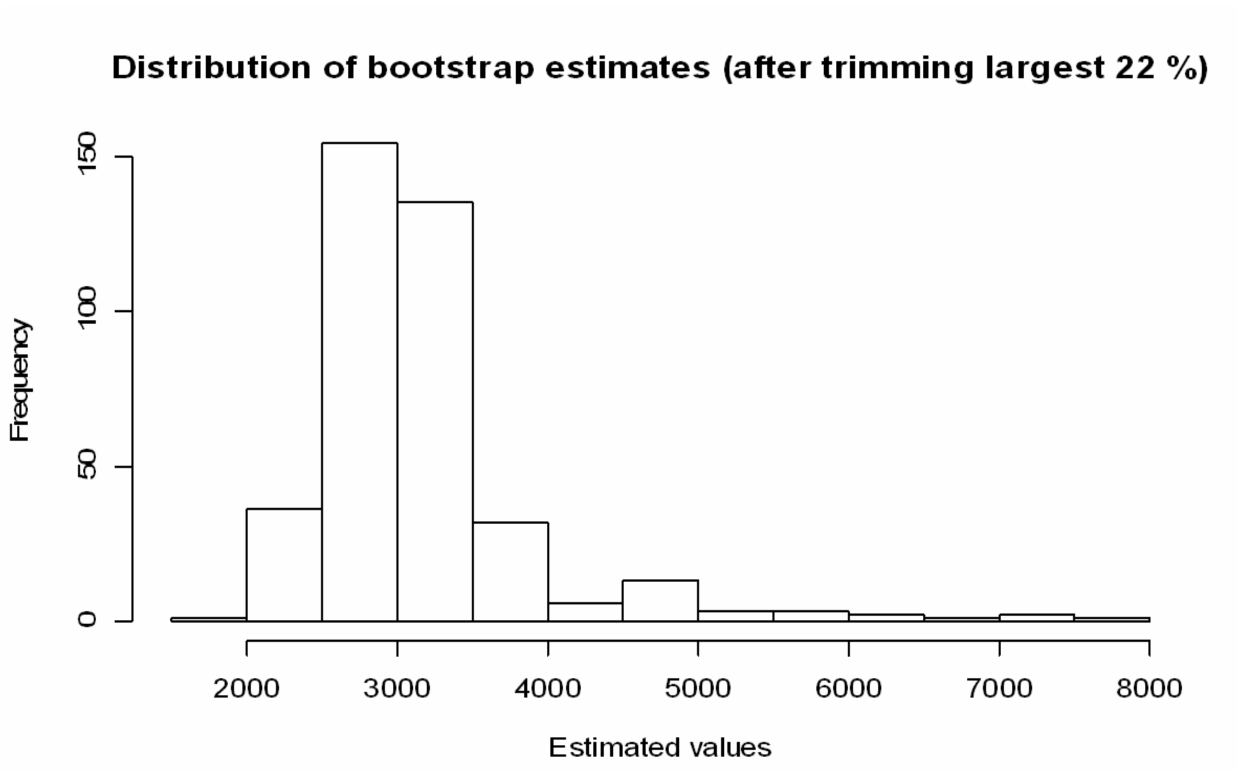


Figure A-35. Distribution of bootstrap estimates (after trimming largest 22%) for pooled sightings of the Kemp's ridley turtle during all seasons in the Northeast study area.

- Leatherback Turtle (*Dermochelys coriacea*)

Table A-25. Detection function results for the leatherback turtle during fall, winter, and spring in the Northeast study area.

Detection Function	
No. of observations	114
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.2089
SE	0.1441
Hazard Shape Parameter (Exponent)	
Estimate	2.5780
SE	0.4275
Average p	
Estimate	0.3002
SE	0.0294
CV	0.0978
N in covered region	
Estimate	379.6949
SE	47.5842
CV	0.1253

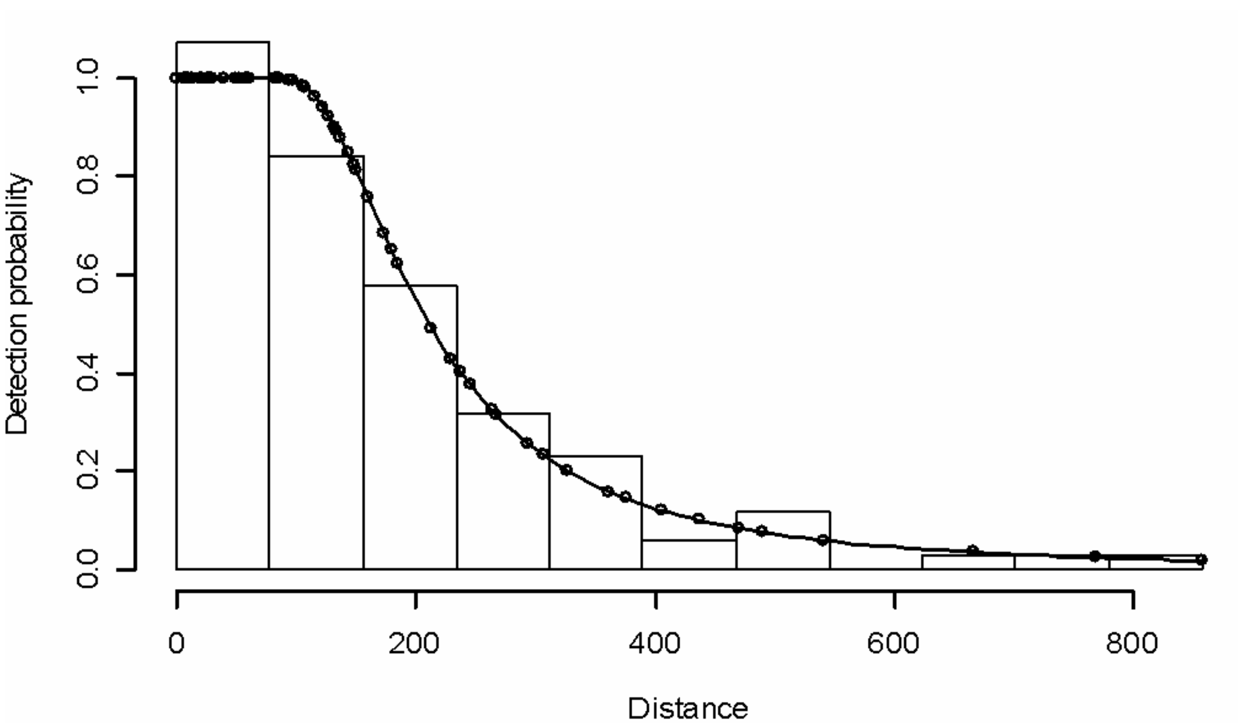


Figure A-36. Plot of the detection function for pooled sightings of the leatherback turtle during fall, winter, and spring in the Northeast study area. Distance is measured in meters.

Table A-26. Response surface model (Generalized Additive Model) results for the leatherback turtle during fall, winter, and spring in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(depth) + s(slope) + offset(off.set)
Approximate significance of smooth terms		
s(lon, lat)		
	Edf	28.352
	Est. rank	29.000
	F	22.272
	p-value	<2e-16
s(depth)		
	Edf	8.936
	Est. rank	3.000
	F	6.707
	p-value	1.68e-04
s(slope)		
	Edf	1.001
	Est. rank	3.000
	F	1.696
	p-value	0.1658
R-sq. (adj)		0.161
n segments		67
Deviance explained		38.7%

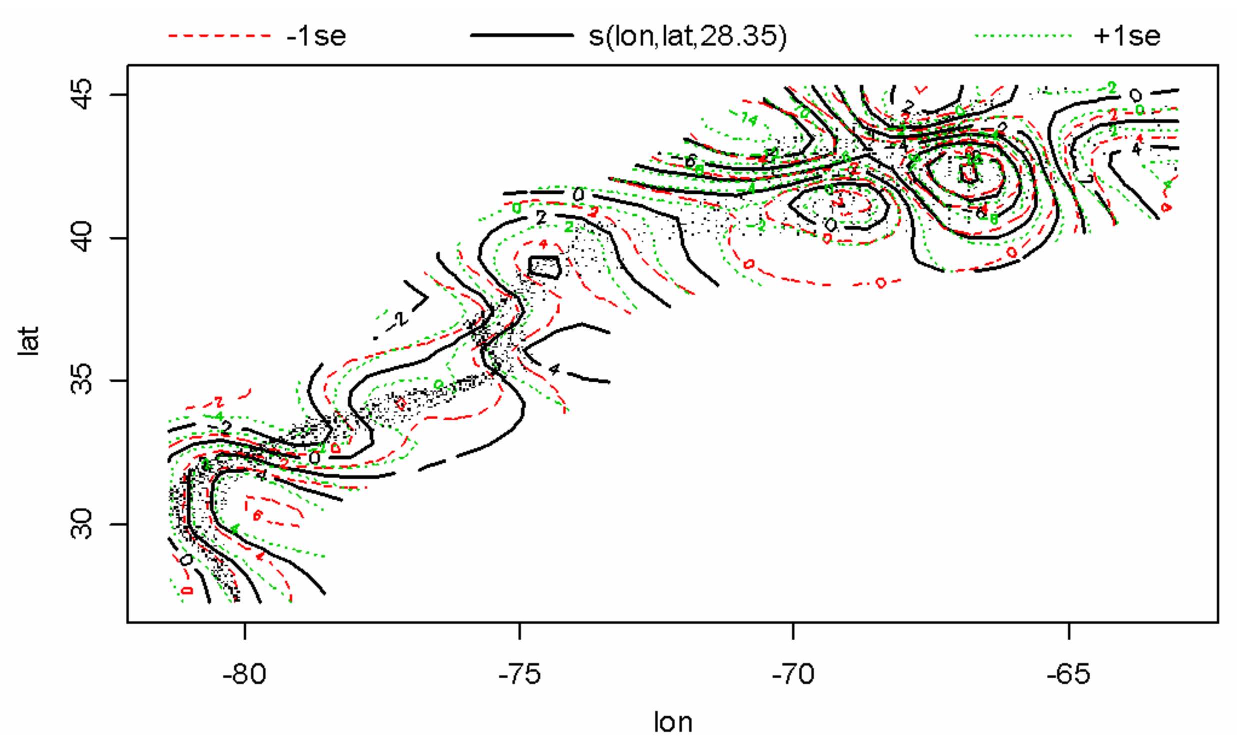


Figure A-37. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the leatherback turtle during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

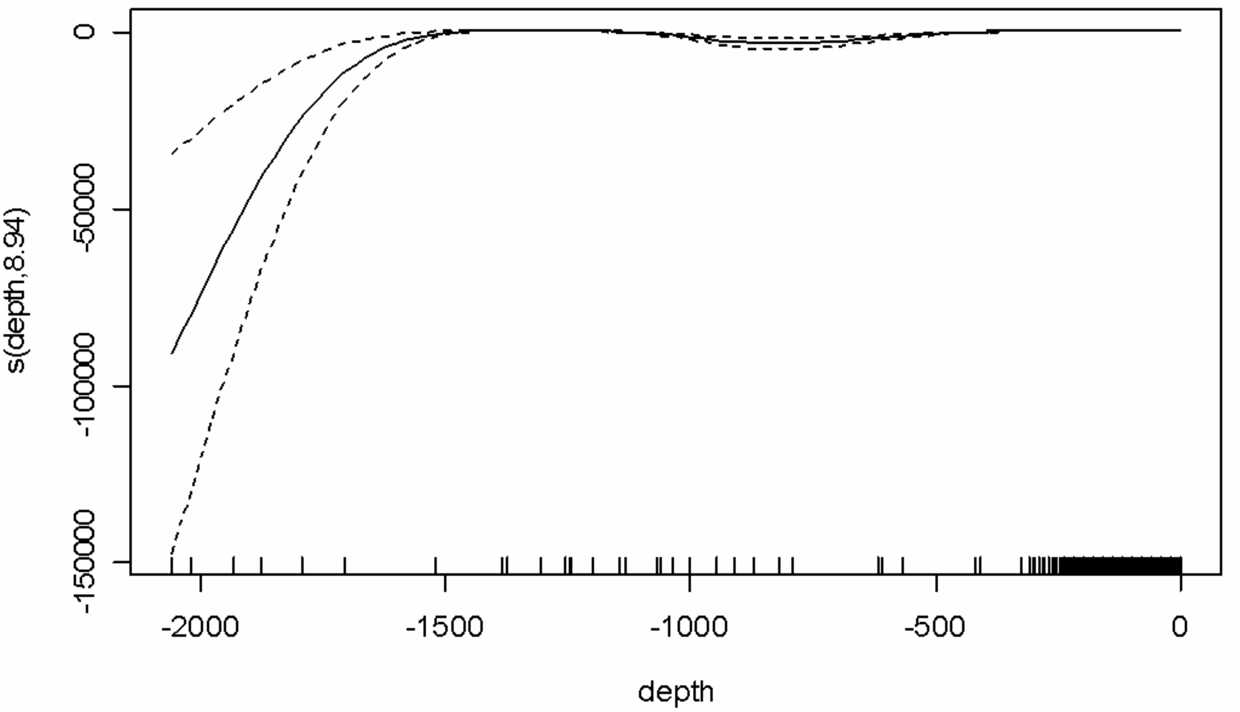


Figure A-38. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the leatherback turtle during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

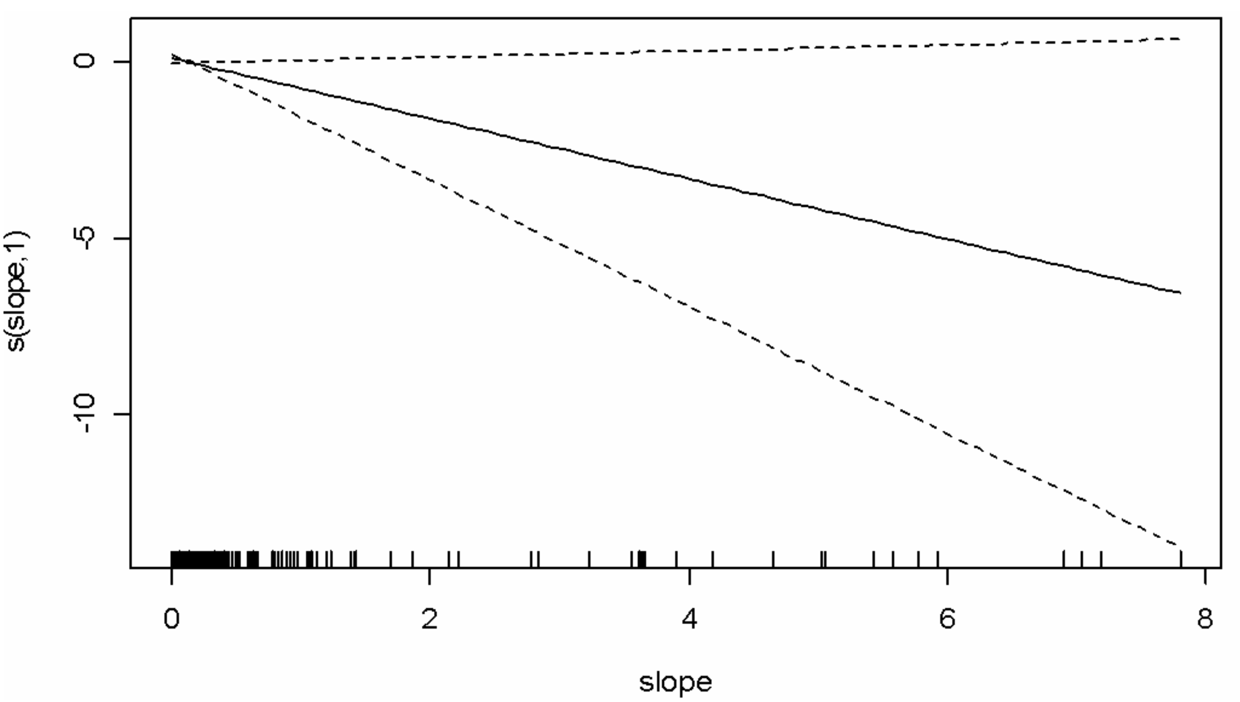


Figure A-39. Plot of the Generalized Additive Model smooth fit of the environmental covariate *slope* selected for the leatherback turtle aerial surveys during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-27. Variance estimate model results for the leatherback turtle during spring, fall, and winter in the Northeast study area.

Variance	
Legitimate values	421
Non-legitimate bootstrap replicates	78
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	1853.876 - 2448.348
Point estimate	2041.509
SE of bootstraps	149.7556
Est. CV for density surface model	0.0734
CV in detection probability	0.0978
CV in overall estimate including density surface model and detection probability	0.1223
Confidence interval incorporating detection function uncertainty	1607.918, 2592.021

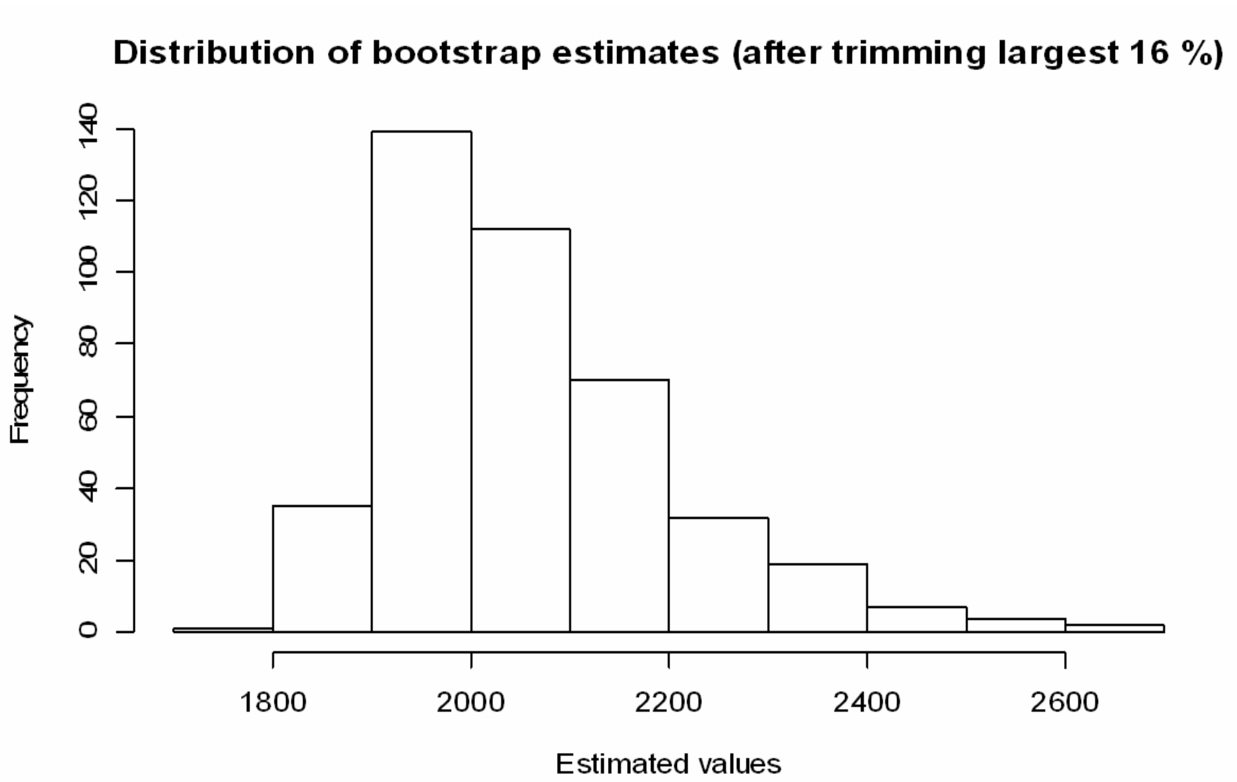


Figure A-40. Distribution of bootstrap estimates (after trimming largest 16%) for pooled sightings of the leatherback turtle during spring, fall, and winter in the Northeast study area.

Table A-28. Detection function results for the leatherback turtle during summer in the Northeast study area.

Detection Function	
No. of observations	102
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.3220
SE	0.0728
Average p	
Estimate	0.4263
SE	0.0300
CV	0.0705
N in covered region	
Estimate	239.2444
SE	24.6174
CV	0.1029

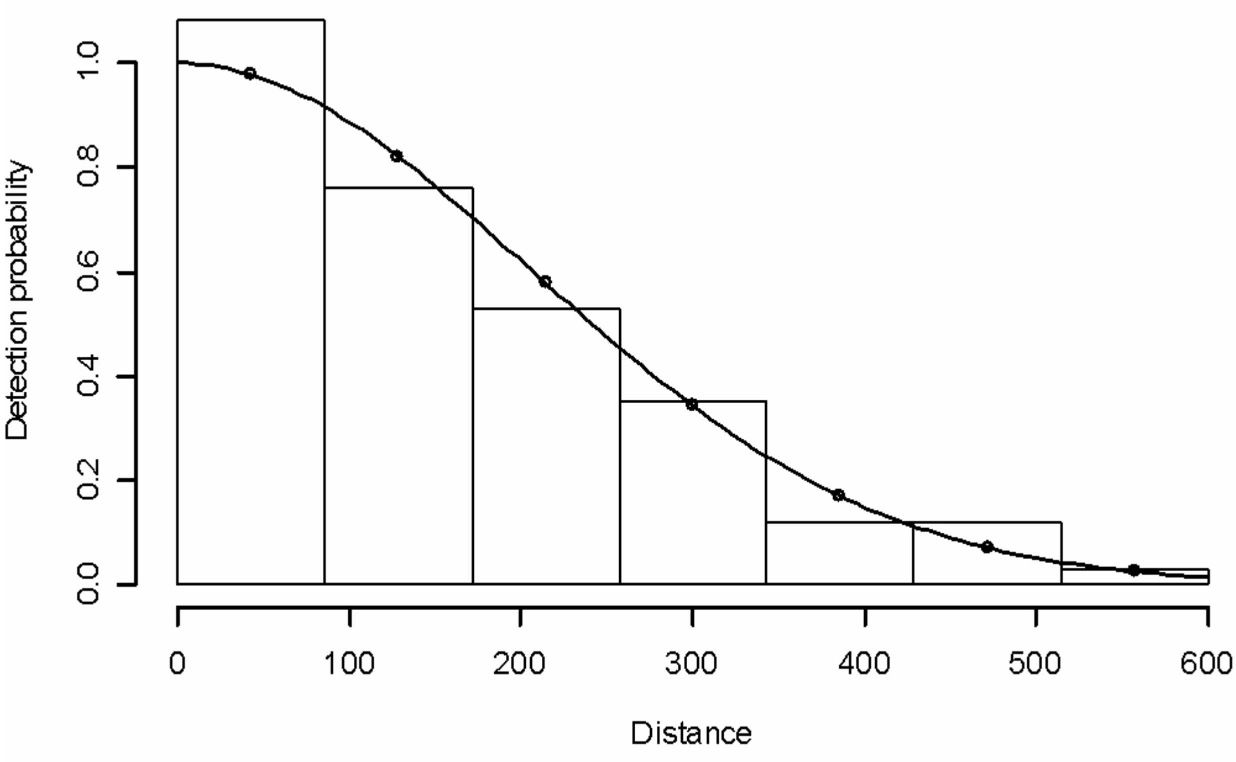


Figure A-41. Plot of the detection function for pooled sightings of the leatherback turtle during summer in the Northeast study area. Distance is measured in meters.

Table A-29. Response surface model (Generalized Additive Model) results for the leatherback turtle during summer in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(depth) + s(SST) + offset(off.set)
Approximate significance of smooth terms		
s(lon, lat)		
	Edf	29.000
	Est. rank	29.000
	F	15.831
	p-value	<2e-16
s(depth)		
	Edf	8.996
	Est. rank	3.000
	F	5.664
	p-value	7.41e-04
s(SST)		
	Edf	9.000
	Est. rank	9.000
	F	10.512
	p-value	6.95e-16
R-sq. (adj)		0.244
n segments		61
Deviance explained		54.4%

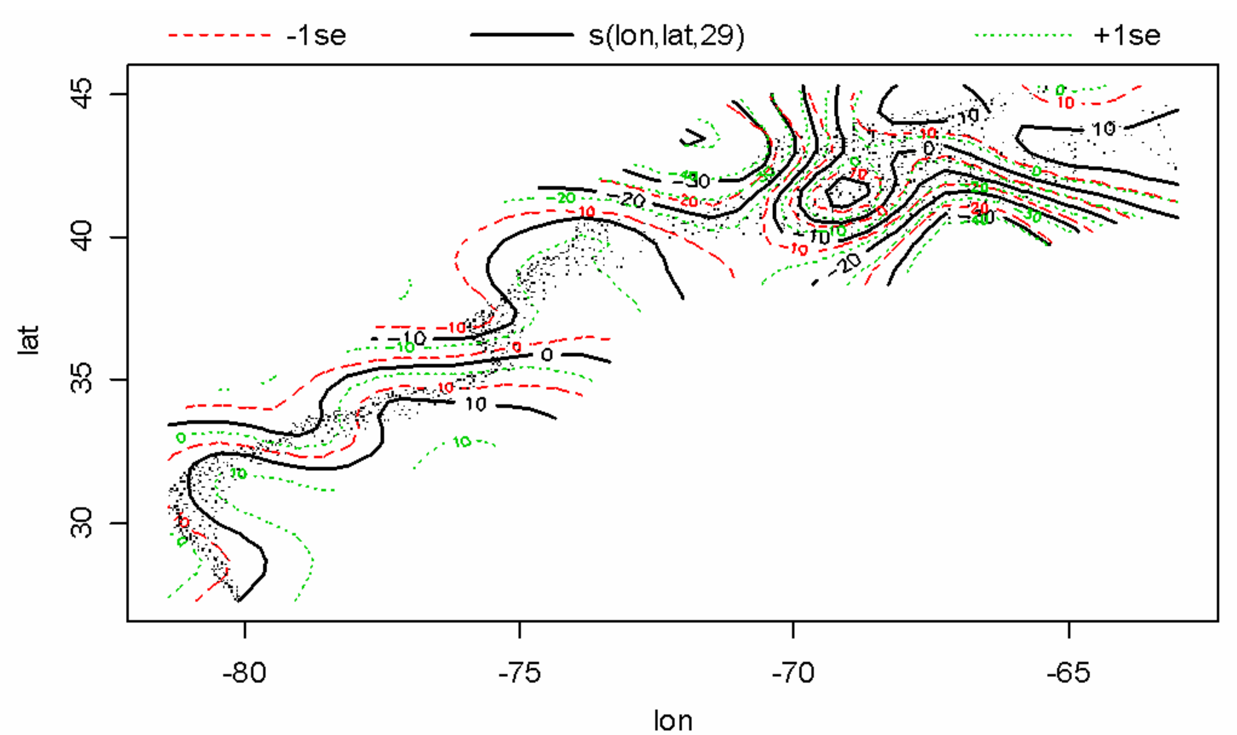


Figure A-42. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the leatherback turtle during summer in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

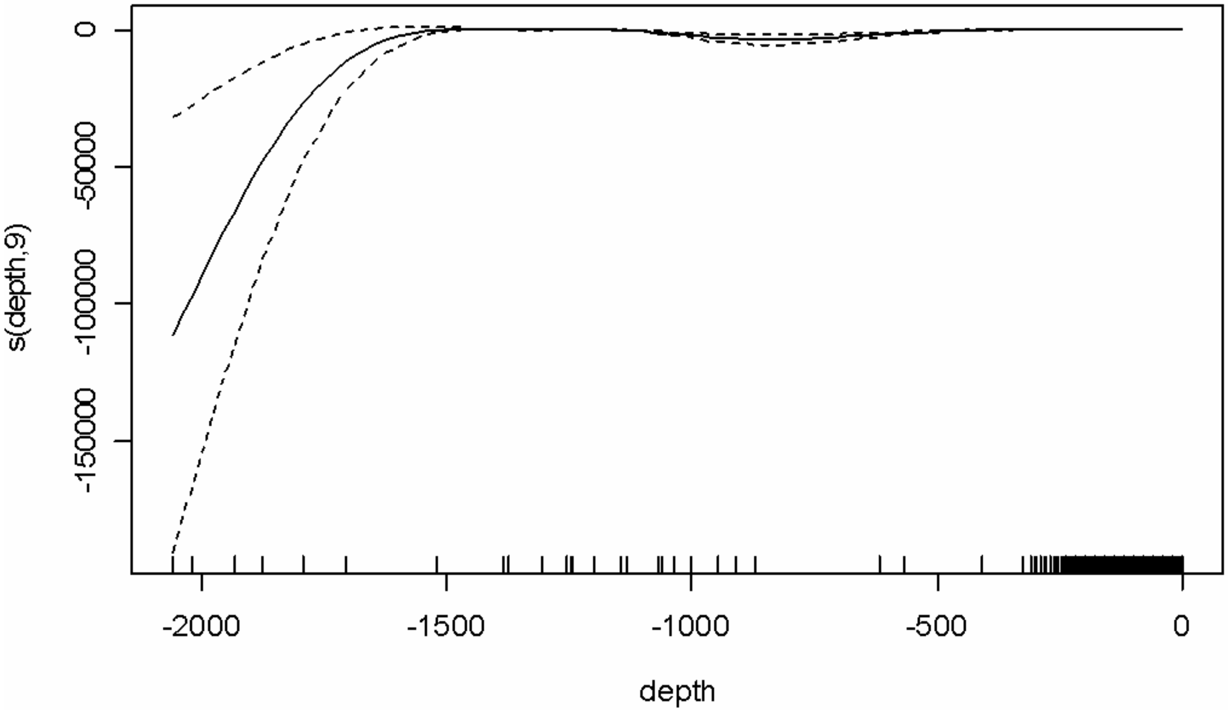


Figure A-43. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for leatherback turtle during summer in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

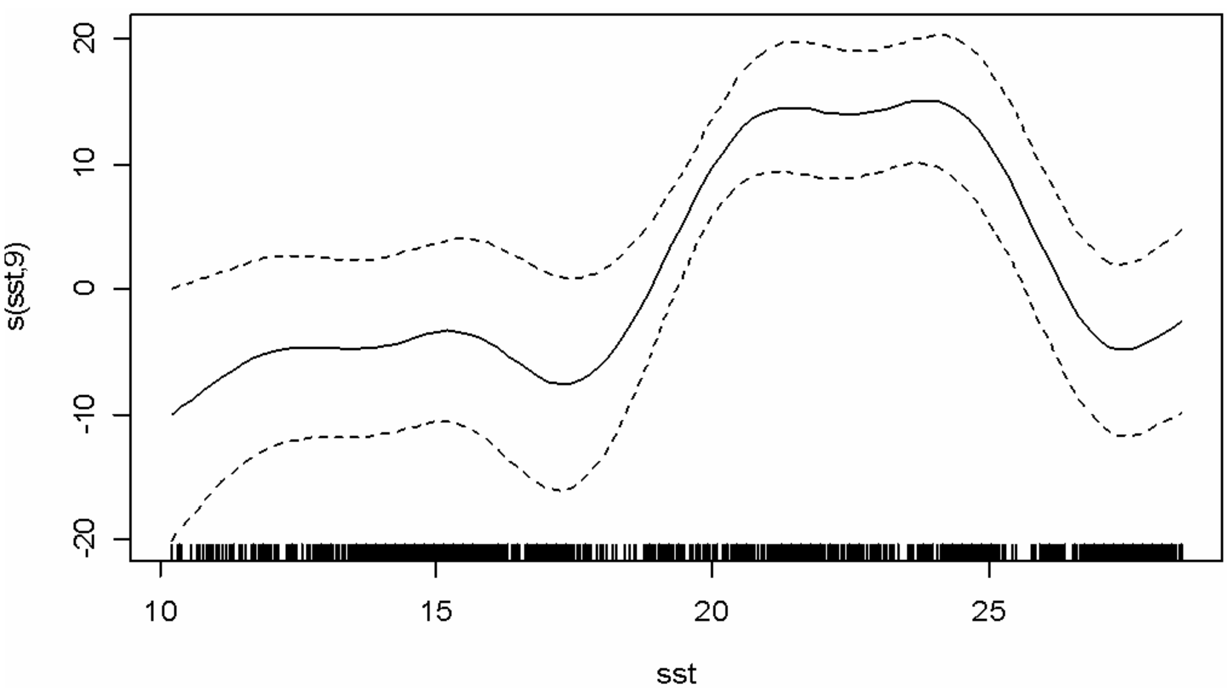


Figure A-44. Plot of the Generalized Additive Model smooth fit of the environmental covariate *SST* selected for the leatherback turtle during summer in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-30. Variance estimate model results for the leatherback turtle during summer in the Northeast study area.

Variance	
Legitimate values	441
Non-legitimate bootstrap replicates	58
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	3259.898 - 4229.054
Point estimate	3773.491
SE of bootstraps	232.4734
Est. CV for density surface model	0.0616
CV in detection probability	0.0705
CV in overall estimate including density surface model and detection probability	0.0936
Confidence interval incorporating detection function uncertainty	3142.331, 4531.423

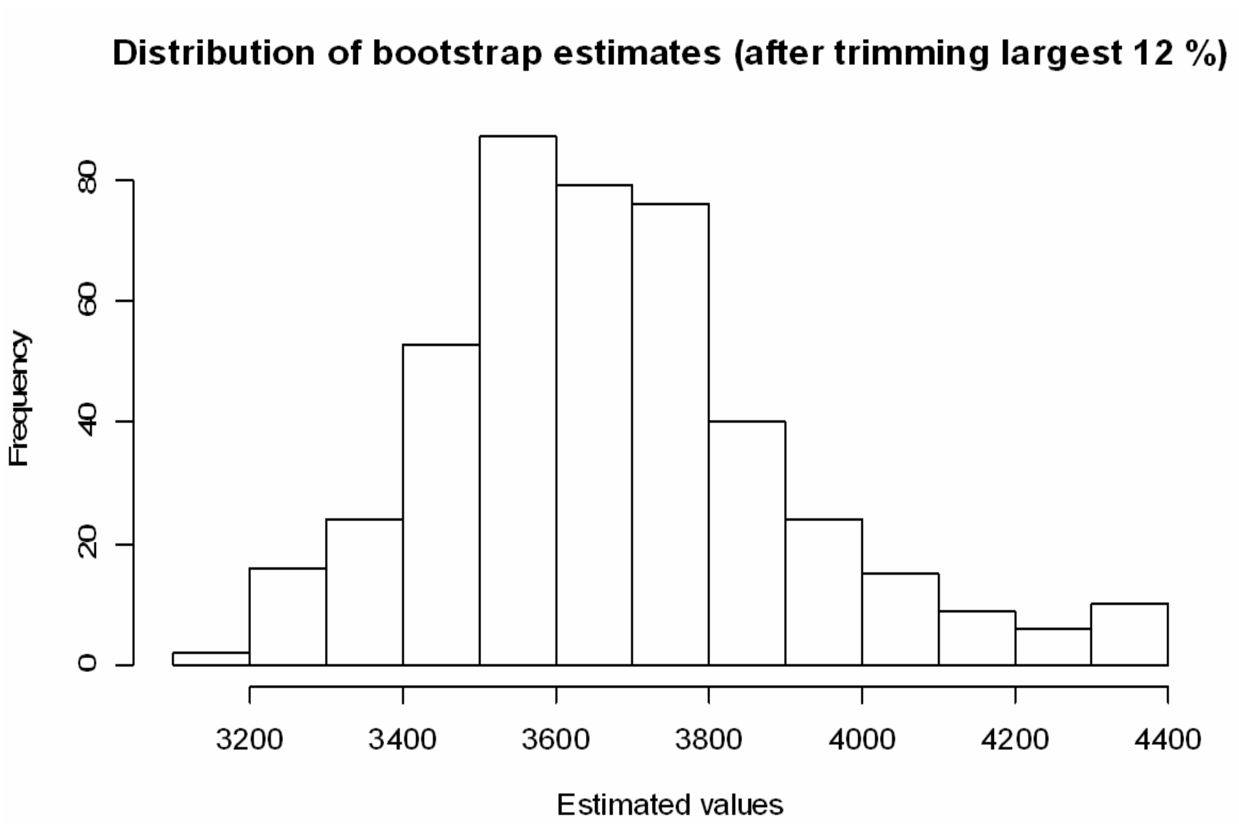


Figure A-45. Distribution of bootstrap estimates (after trimming largest 12%) for pooled sightings of the leatherback turtle during summer in the Northeast study area.

➢ Loggerhead Turtle (*Caretta caretta*)

Table A-31. Detection function results for the loggerhead turtle during fall, winter, and spring in the Northeast study area.

Detection Function	
No. of observations	823
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.5087
SE	0.0507
Hazard Shape Parameter (Exponent)	
Estimate	2.9670
SE	0.1907
Average p	
Estimate	0.3279
SE	0.0117
CV	0.0358
N in covered region	
Estimate	2509.9806
SE	114.9852
CV	0.0458

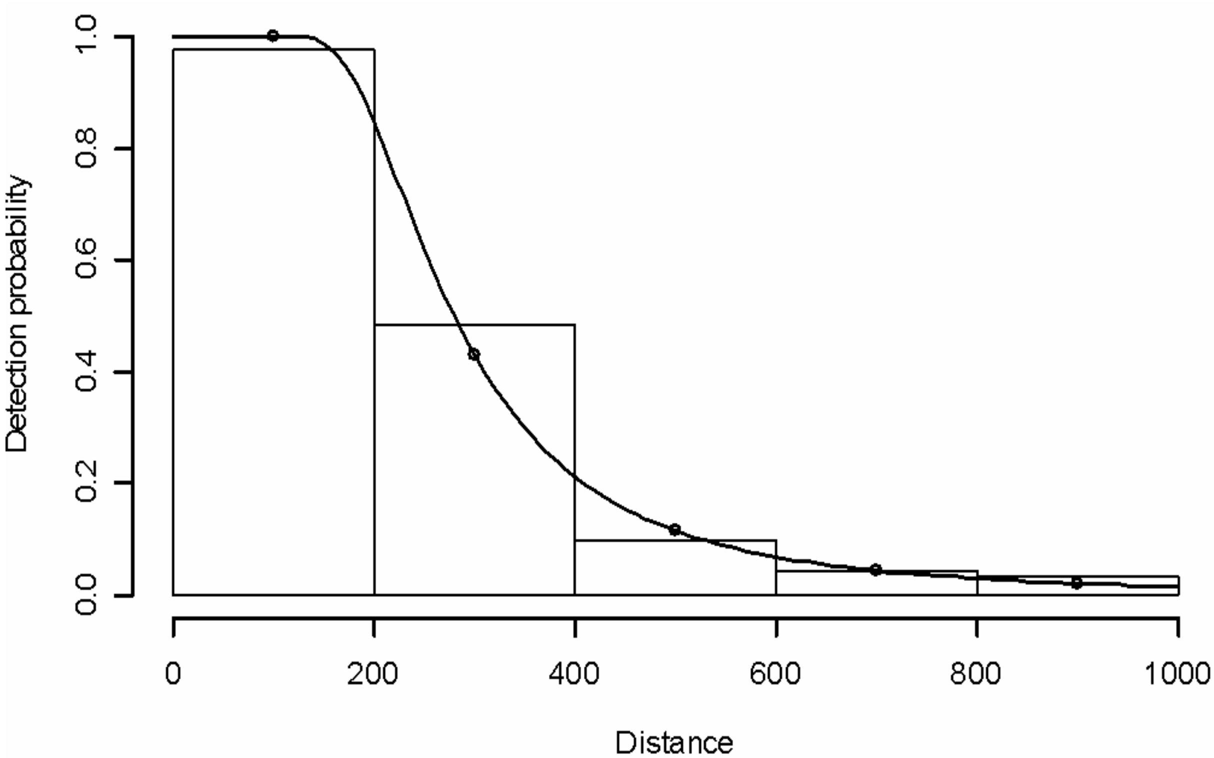


Figure A-46. Plot of the detection function for pooled sightings of the loggerhead turtle during fall, winter, and spring in the Northeast study area. Distance is measured in meters.

Table A-32. Response surface model (Generalized Additive Model) results for the loggerhead turtle during fall, winter, and spring in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(depth) + s(shelf) + offset(off.set)
Approximate significance of smooth terms		
s(lon, lat)		
	Edf	26.859
	Est. rank	28.000
	F	12.825
	p-value	<2e-16
s(depth)		
	Edf	5.733
	Est. rank	7.000
	F	3.610
	p-value	6.99e-04
s(slope)		
	Edf	8.853
	Est. rank	3.000
	F	7.321
	p-value	6.85e-05
R-sq. (adj)		0.376
n segments		575
Deviance explained		41.5%

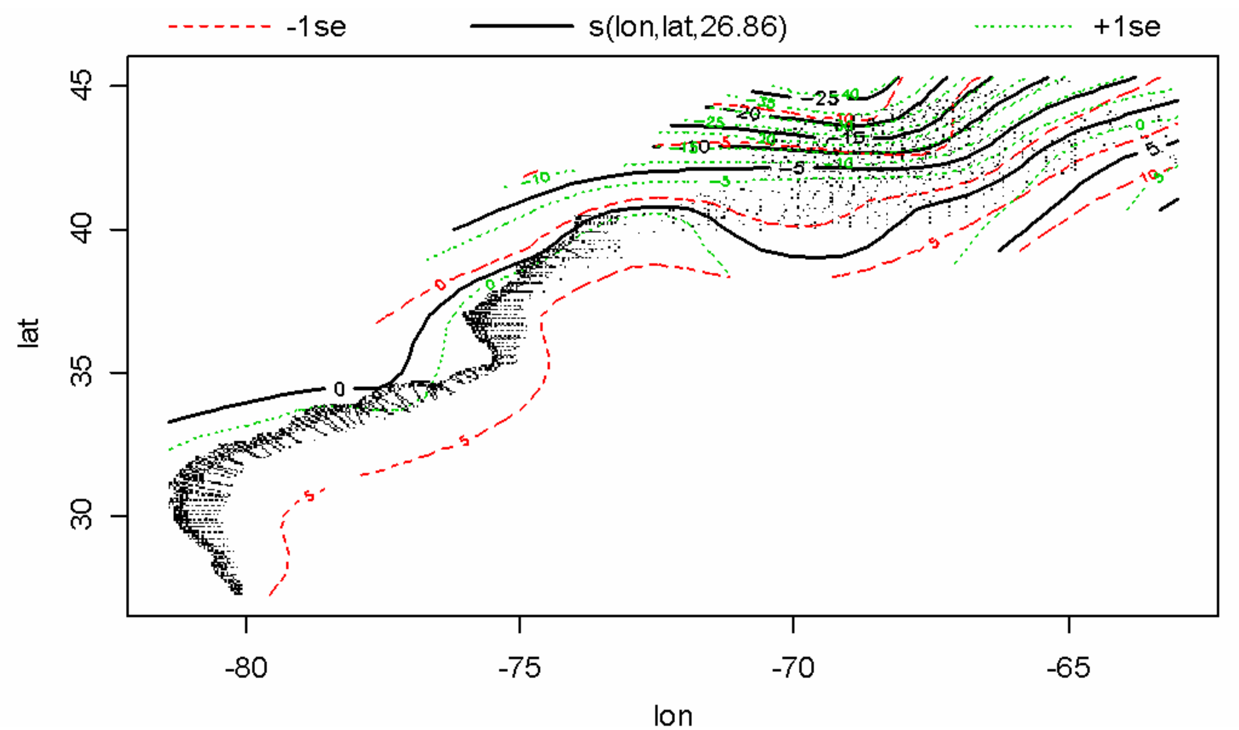


Figure A-47. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the loggerhead turtle during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

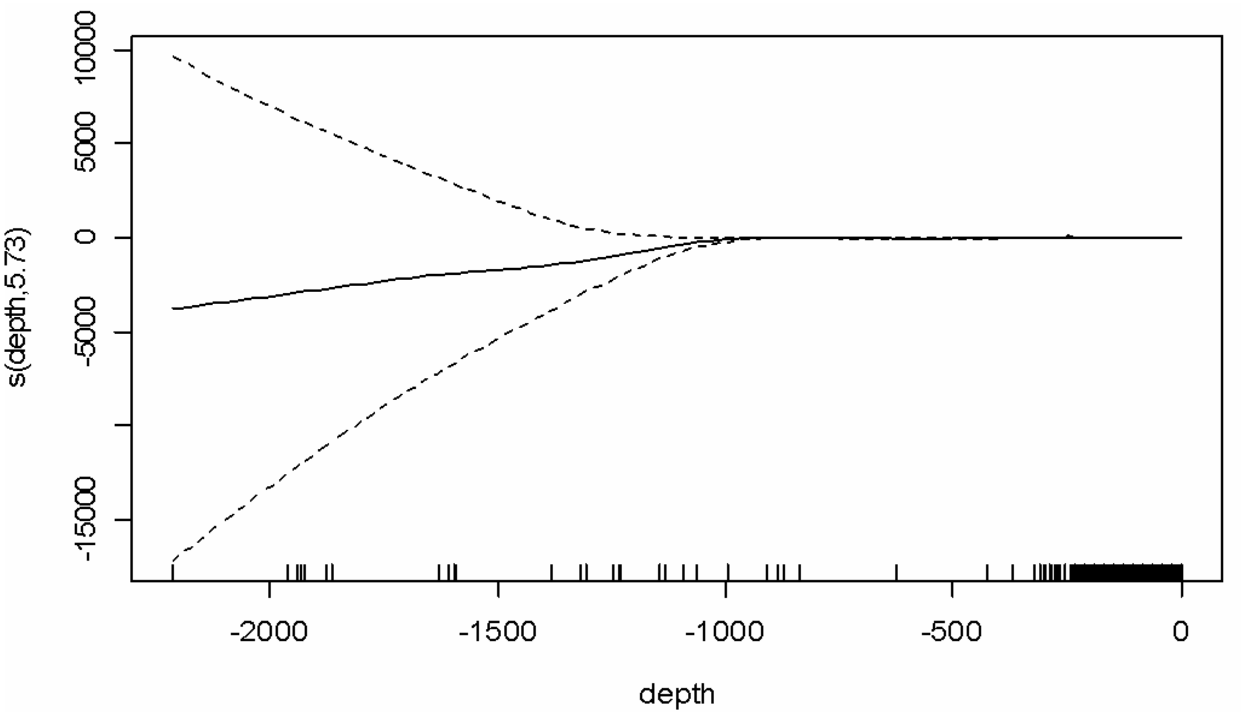


Figure A-48. Plot of the Generalized Additive Model smooth fit of the environmental covariate *depth* selected for the loggerhead turtle during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

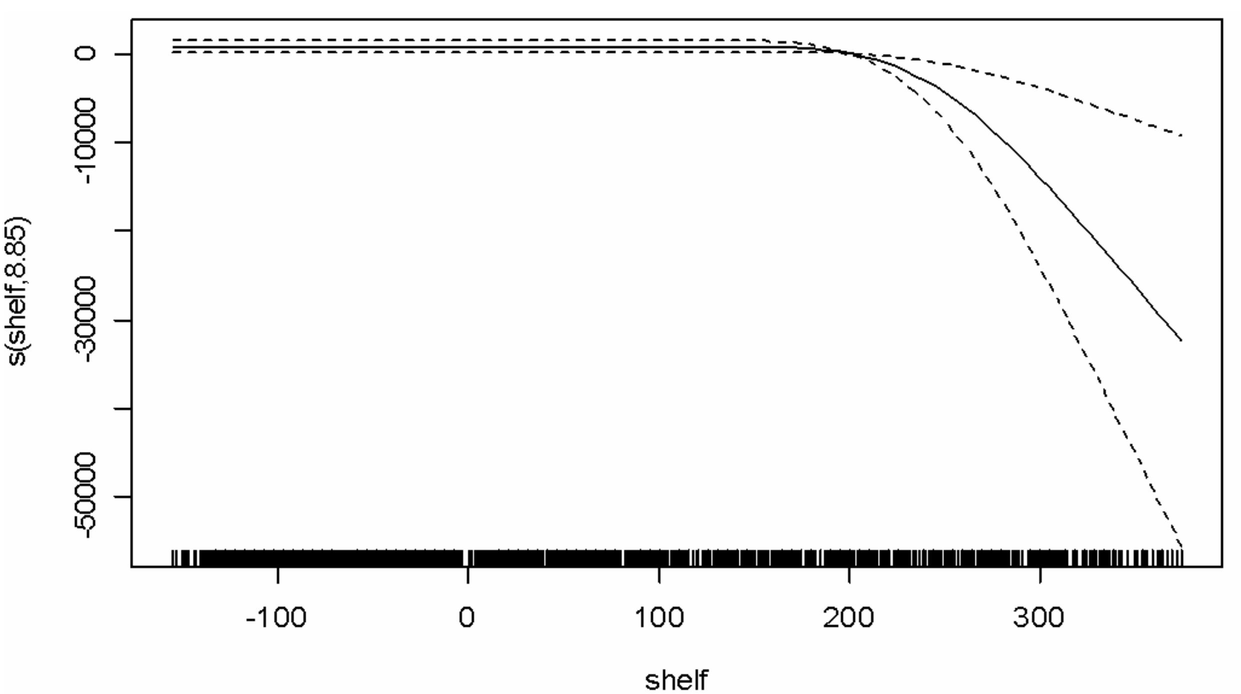


Figure A-49. Plot of the Generalized Additive Model smooth fit of the environmental covariate shelf selected for the loggerhead turtle during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-33. Variance estimate model results for the loggerhead turtle during spring, fall, and winter in the Northeast study area.

Variance	
Legitimate values	446
Non-legitimate bootstrap replicates	53
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	12356.40 - 14921.79
Point estimate	13499.96
SE of bootstraps	636.6307
Est. CV for density surface model	0.0472
CV in detection probability	0.0358
CV in overall estimate including density surface model and detection probability	0.0592
Confidence interval incorporating detection function uncertainty	12021.97, 15159.66

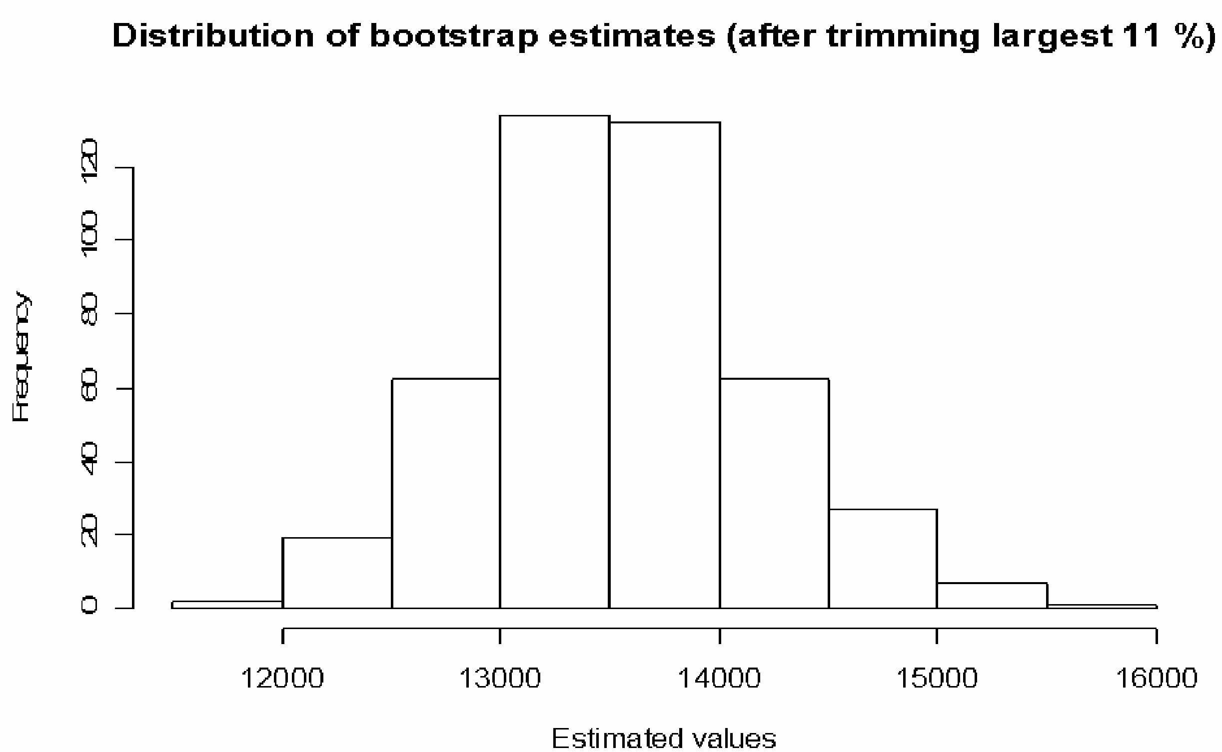


Figure A-50. Distribution of bootstrap estimates (after trimming largest 11%) for pooled sightings of the loggerhead turtle during spring, fall, and winter in the Northeast study area.

Table A-34. Detection function results for the loggerhead turtle during summer in the Northeast study area.

Detection Function	
No. of observations	823
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.5087
SE	0.0507
Hazard Shape Parameter (Exponent)	
Estimate	2.9670
SE	0.1907
Average p	
Estimate	0.3279
SE	0.0117
CV	0.03581
N in covered region	
Estimate	2509.9806
SE	114.9852
CV	0.0458

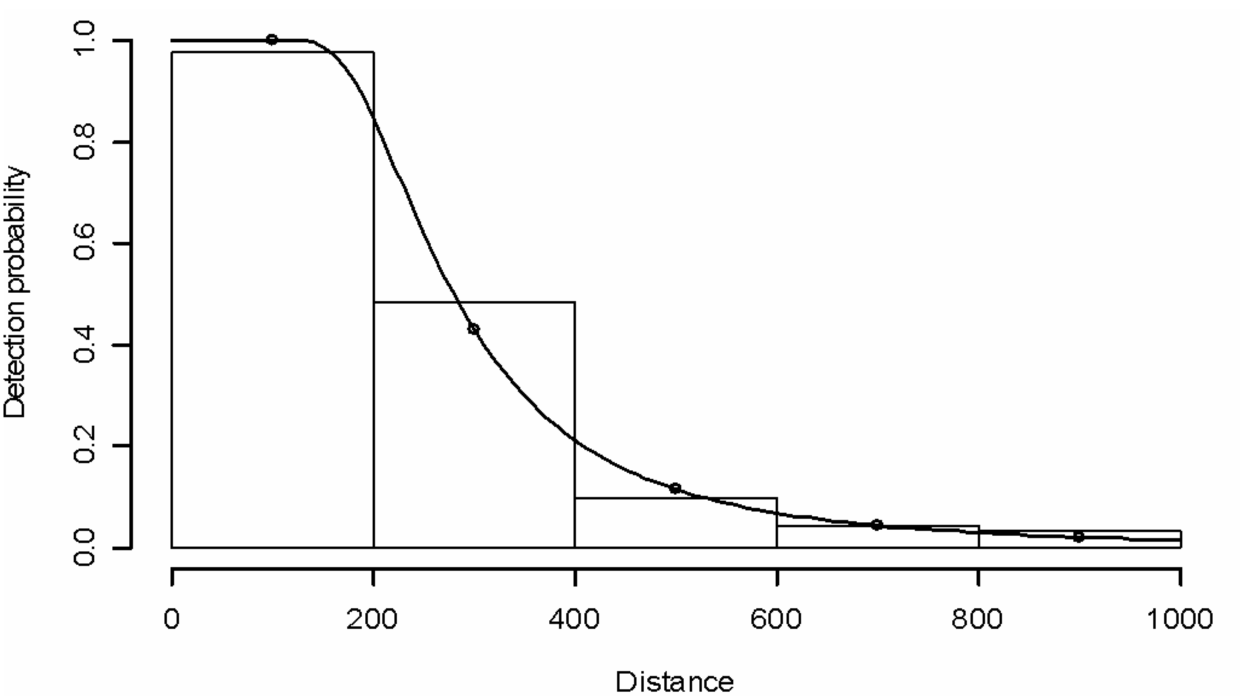


Figure A-51. Plot of the detection function for pooled sightings of the loggerhead turtle during summer in the Northeast study area. Distance is measured in meters.

Table A-35. Response surface model (Generalized Additive Model) results for the loggerhead turtle during summer in the Northeast study area.

Response Surface Model (GAM)	
Formula	N ~ s(lon,lat) + s(chl *a*) + offset(off.set)
Approximate significance of smooth terms	
s(lon, lat)	
Edf	20.304
Est. rank	29.000
F	24.35
p-value	<2e-16
s(chl *a*)	
Edf	8.744
Est. rank	8.000
F	13.45
p-value	<2e-16
R-sq. (adj)	0.302
n segments	575
Deviance explained	41.1%

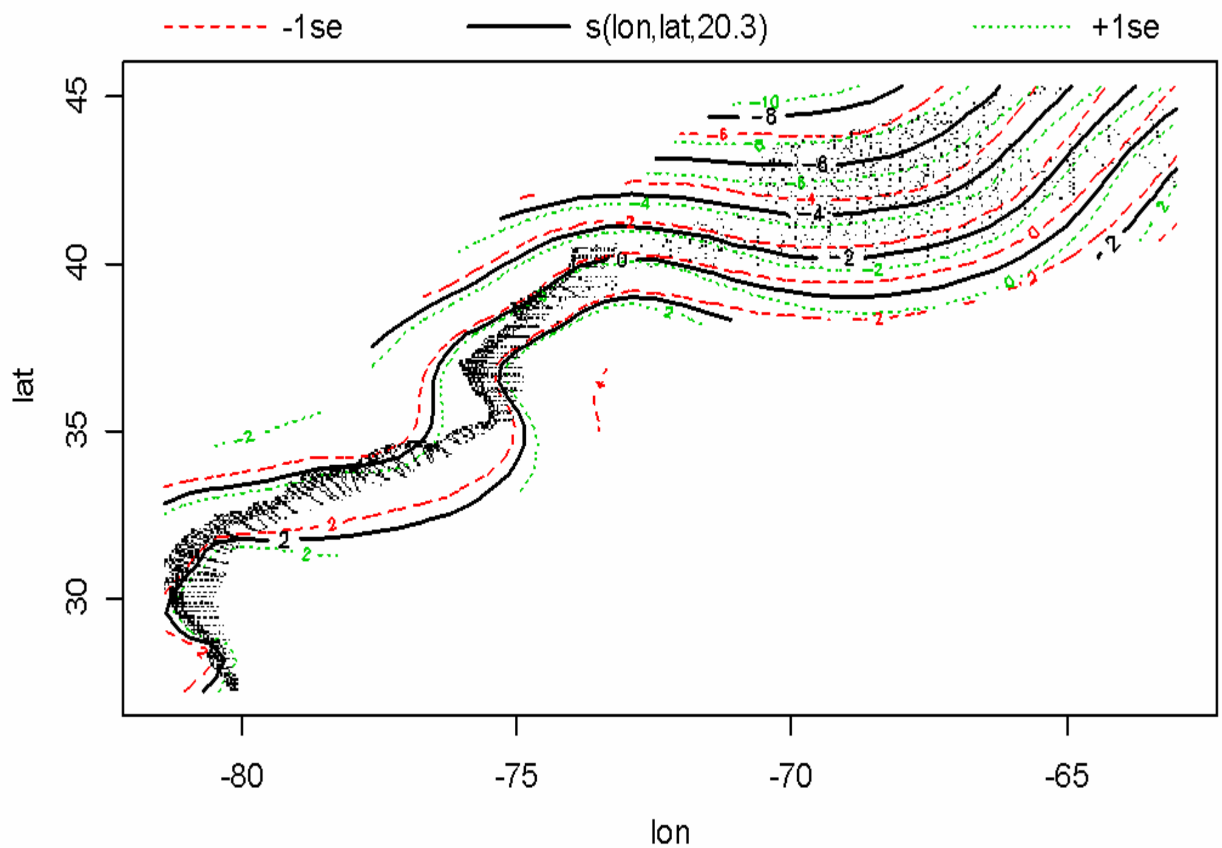


Figure A-52. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for the loggerhead turtle during summer in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

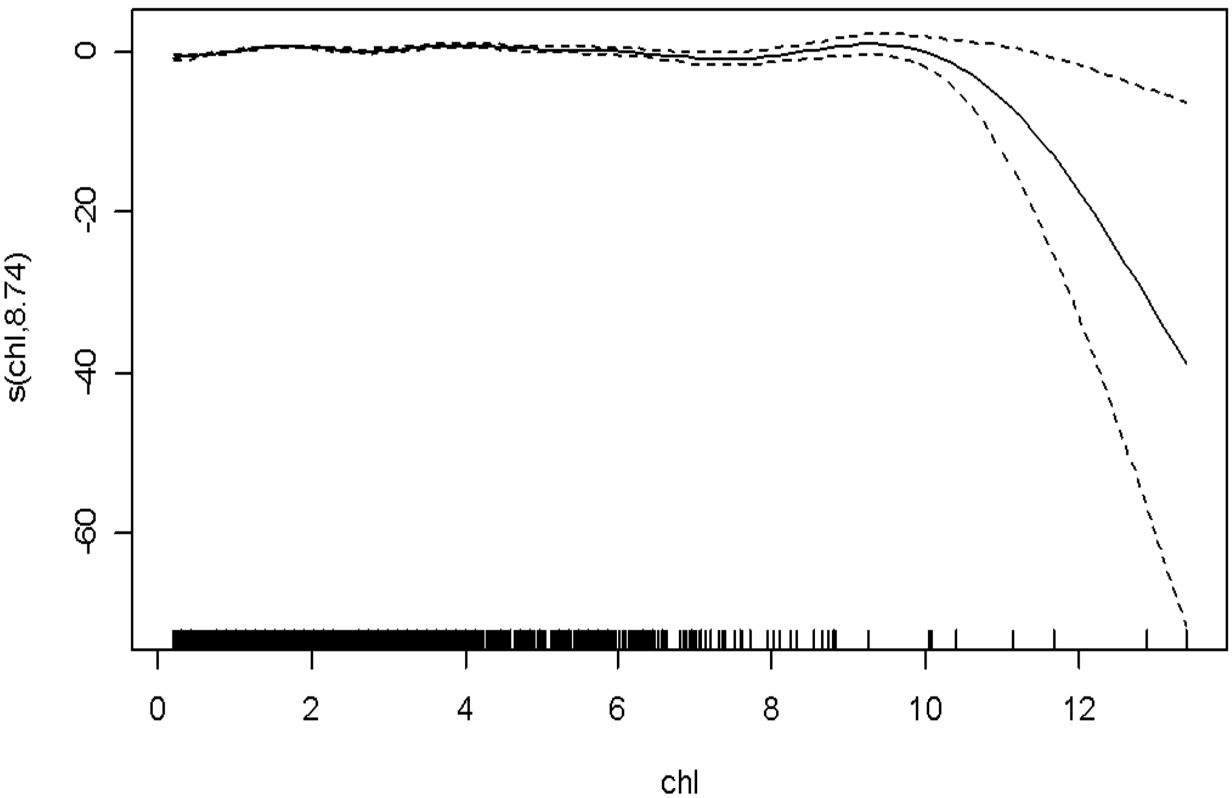


Figure A-53. Plot of the Generalized Additive Model smooth fit of the environmental covariate *chl a* selected for the loggerhead turtle during summer in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-36. Variance estimate model results for the loggerhead turtle during summer in the Northeast study area.

Variance	
Legitimate values	492
Non-legitimate bootstrap replicates	7
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	13107.68 -15679.09
Point estimate	14425.87
SE of bootstraps	659.8748
Est. CV for density surface model	0.0457
CV in detection probability	0.0358
CV in overall estimate including density surface model and detection probability	0.0581
Confidence interval incorporating detection function uncertainty	12874.70, 16163.94

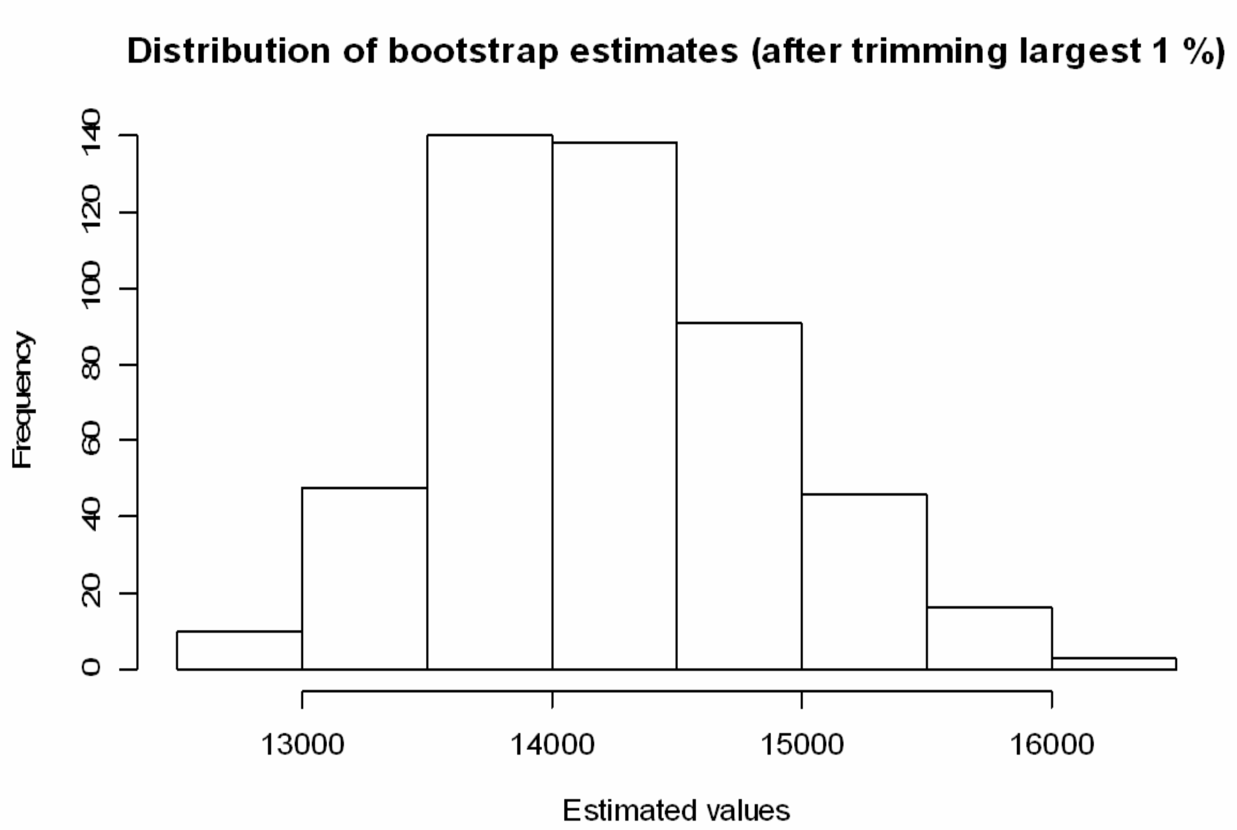


Figure A-54. Distribution of bootstrap estimates (after trimming largest 1%) for pooled sightings of the loggerhead turtle during summer in the Northeast study area.

➢ Hardshell Turtles

Table A-37. Detection function results for Hardshell Turtles during fall, winter, and spring in the Northeast study area.

Detection Function	
No. of observations	823
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.5087
SE	0.0507
Hazard Shape Parameter (Exponent)	
Estimate	2.9670
SE	0.1907
Average p	
Estimate	0.3279
SE	0.0117
CV	0.0358
N in covered region	
Estimate	2509.9806
SE	114.9852
CV	0.0458

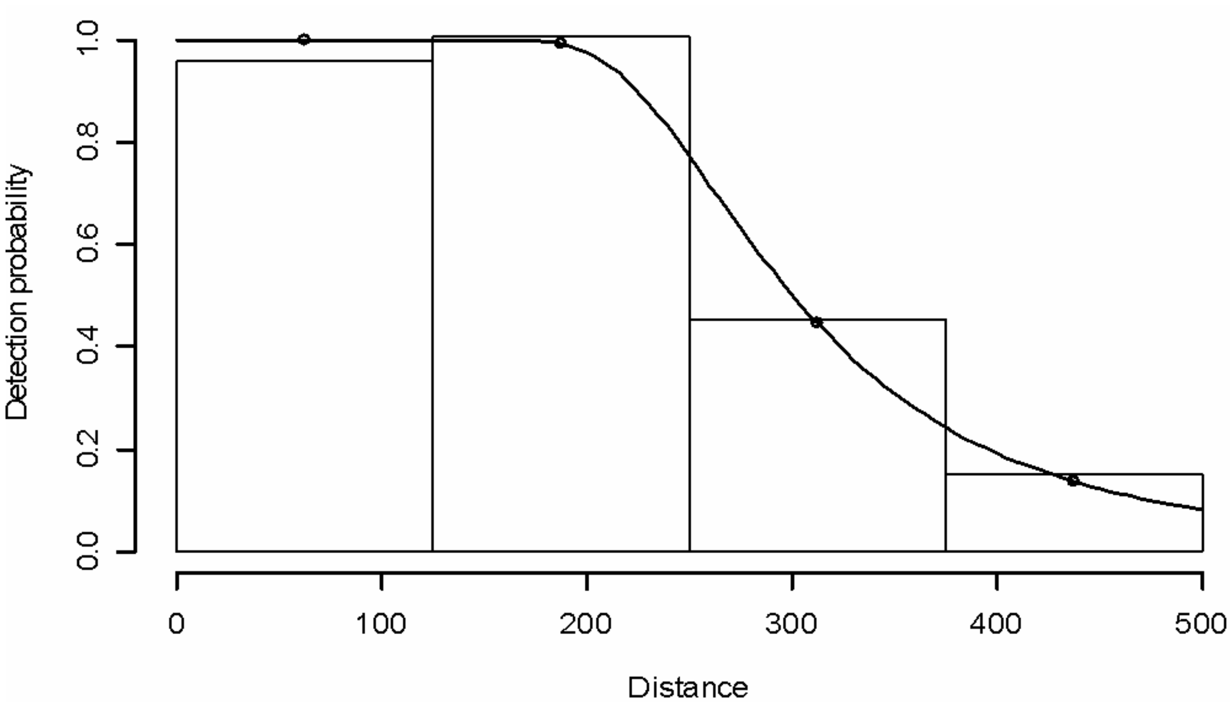


Figure A-55. Plot of the detection function for pooled sightings of Hardshell Turtles during fall, winter, and spring in the Northeast study area. Distance is measured in meters.

Table A-38. Response surface model (Generalized Additive Model) results for Hardshell Turtles during fall, winter, and spring in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(shelf) + offset(off.set)
Approximate significance of smooth terms		
s(lon, lat)		
	Edf	14.738
	Est. rank	29.000
	F	25.254
	p-value	<2e-16
s(shelf)		
	Edf	8.756
	Est. rank	4.000
	F	5.989
	p-value	8.6e-05
R-sq. (adj)		0.291
n segments		244
Deviance explained		61.4%

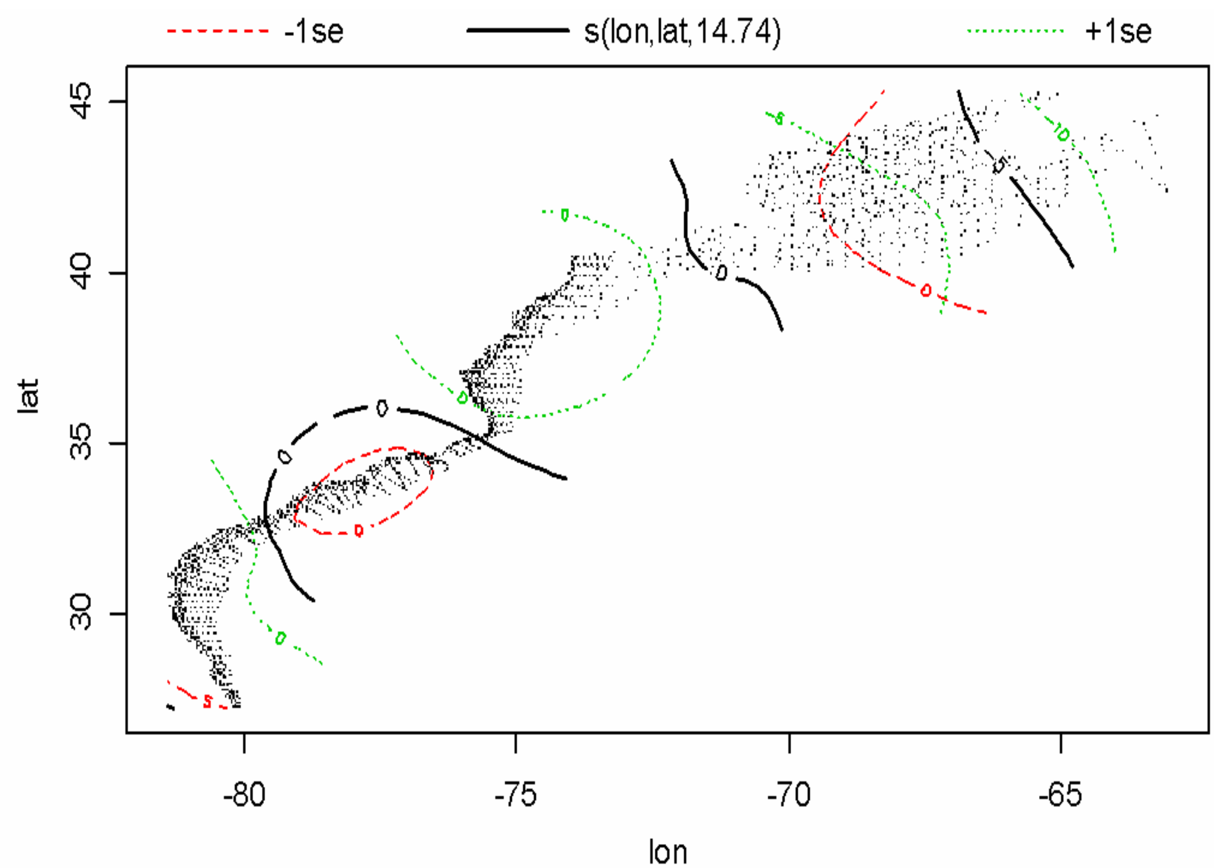


Figure A-56. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for Hardshell Turtles during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

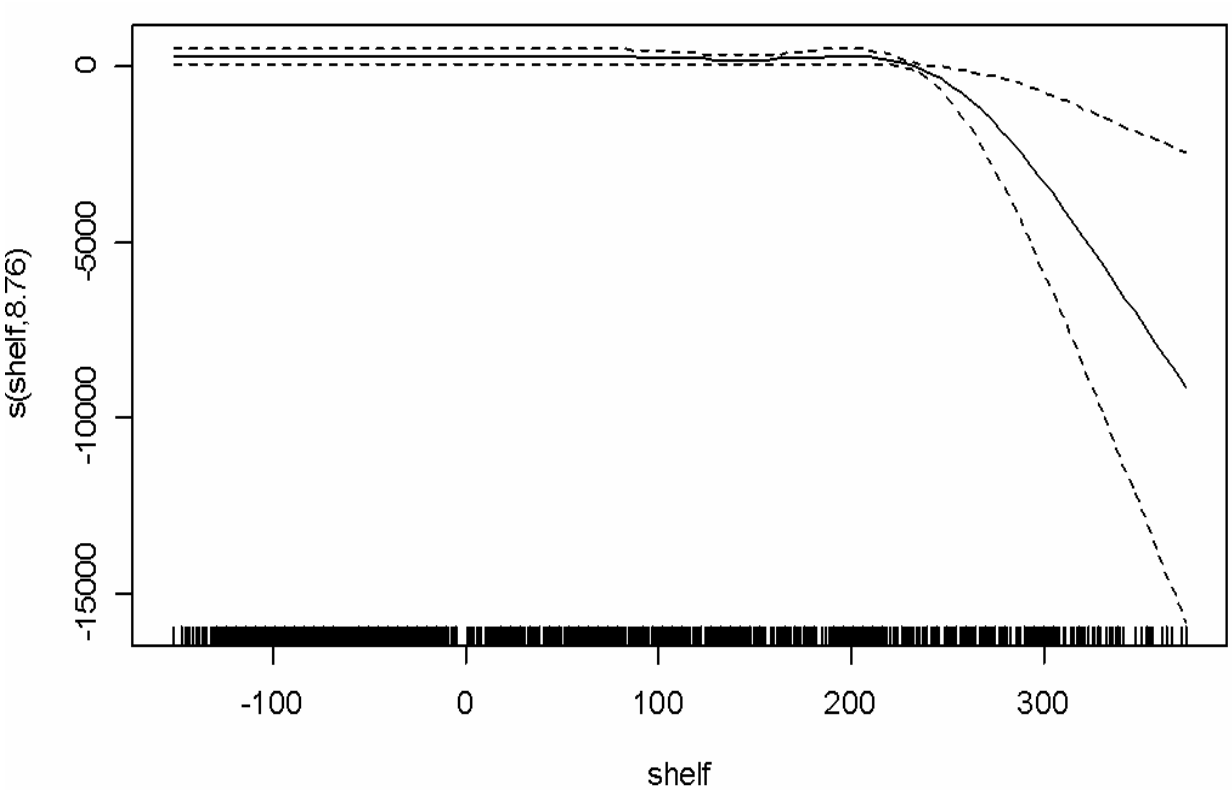


Figure A-57. Plot of the Generalized Additive Model smooth fit of the environmental covariate *shelf* selected for Hardshell Turtles during fall, winter, and spring in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-39. Variance estimate model results for Hardshell Turtles during spring, fall, and winter in the Northeast study area.

Variance	
Legitimate values	486
Non-legitimate bootstrap replicates	13
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	7665.695 - 9661.275
Point estimate	8492.917
SE of bootstraps	525.3194
Est. CV for density surface model	0.0619
CV in detection probability	0.0375
CV in overall estimate including density surface model and detection probability	0.0723
Confidence interval incorporating detection function uncertainty	7371.495, 9784.941

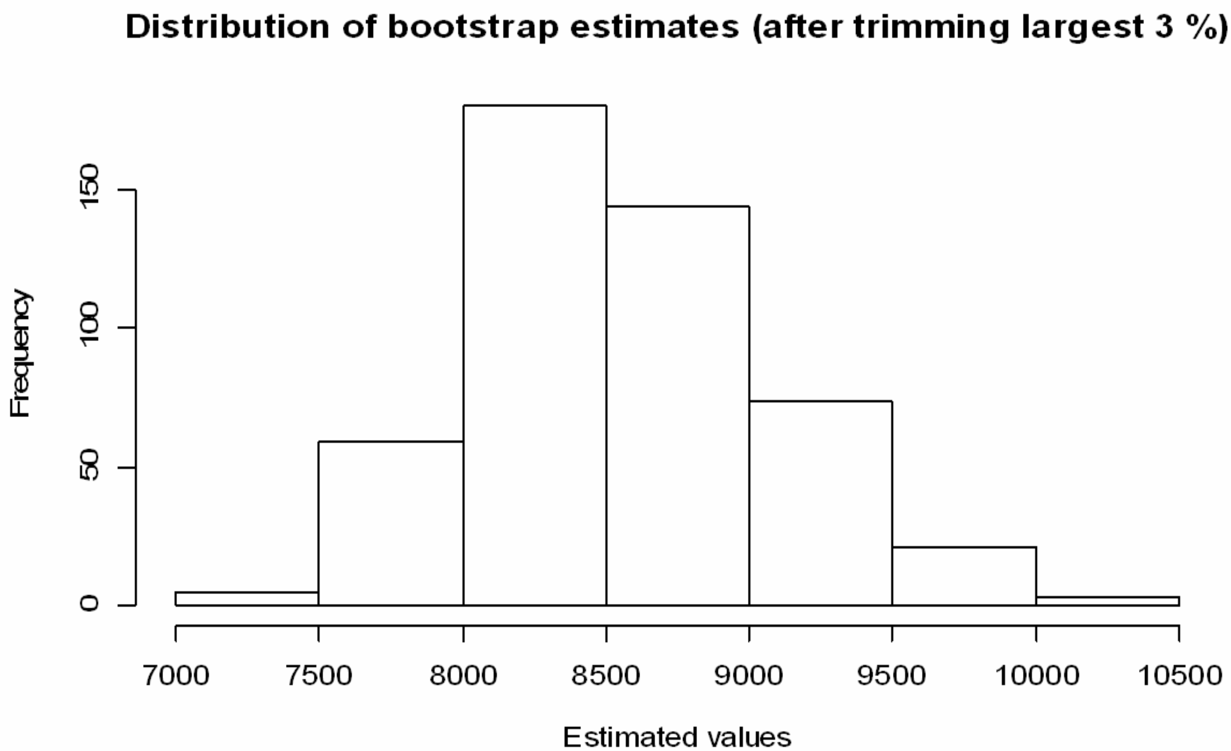


Figure A-58. Distribution of bootstrap estimates (after trimming largest 3%) for pooled sightings of Hardshell Turtles during spring, fall, and winter in the Northeast study area.

Table A-40. Detection function results for Hardshell Turtles during summer in the Northeast study area.

Detection Function	
No. of observations	375
Detection Function Parameters	
Scale Coefficients (Intercept)	
Estimate	5.6161
SE	0.0702
Hazard Shape Parameter (Exponent)	
Estimate	4.1208
SE	0.8655
Average p	
Estimate	0.6415
SE	0.02870
CV	0.0447
N in covered region	
Estimate	584.5676
SE	31.7907
CV	0.0544

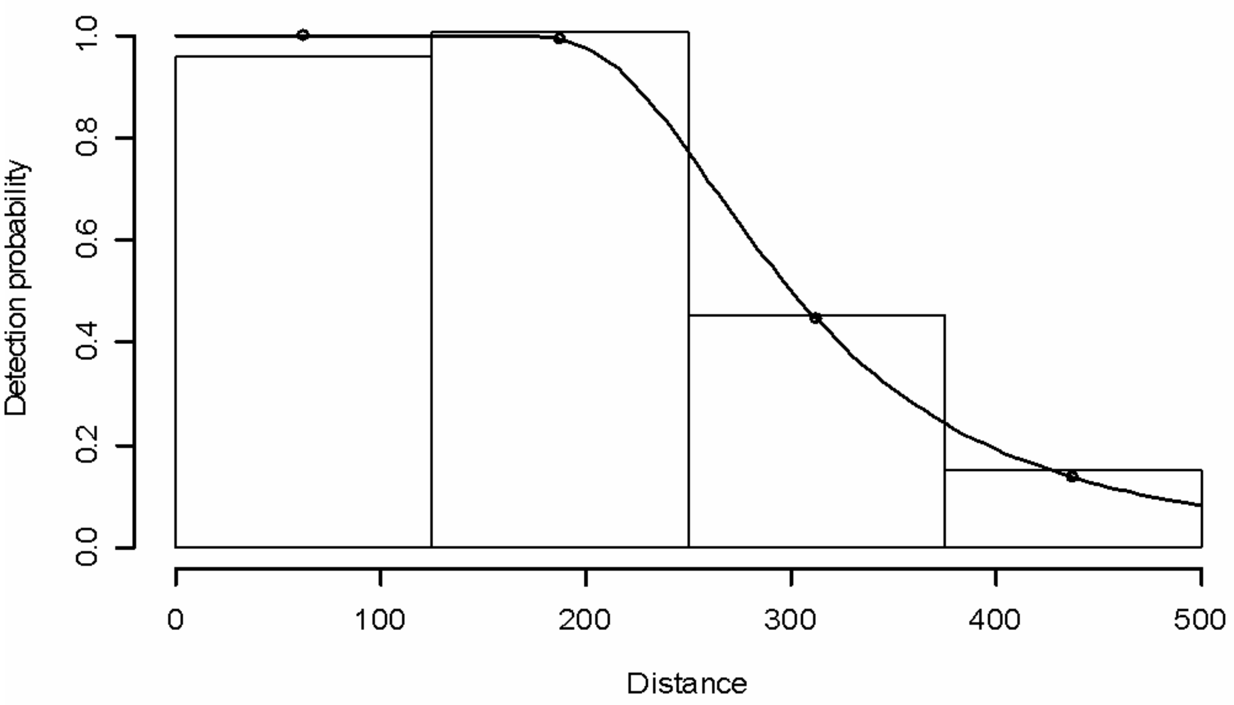


Figure A-59. Plot of the detection function for pooled sightings of Hardshell Turtles during summer in the Northeast study area. Distance is measured in meters.

Table A-41. Response surface model (Generalized Additive Model) results for Hardshell Turtles during summer in the Northeast study area.

Response Surface Model (GAM)		
Formula		N ~ s(lon,lat) + s(shelf) + s(chl *a*) + offset(off.set)
Approximate significance of smooth terms		
s(lon, lat)		
	Edf	14.109
	Est. rank	29.000
	F	25.277
	p-value	<2e-16
s(shelf)		
	Edf	8.709
	Est. rank	4.000
	F	5.049
	p-value	4.74e-04
s(chl *a*)		
	Edf	1.013
	Est. rank	3.000
	F	3.256
	p-value	0.0208
R-sq. (adj)		0.296
n segments		244
Deviance explained		61.5%

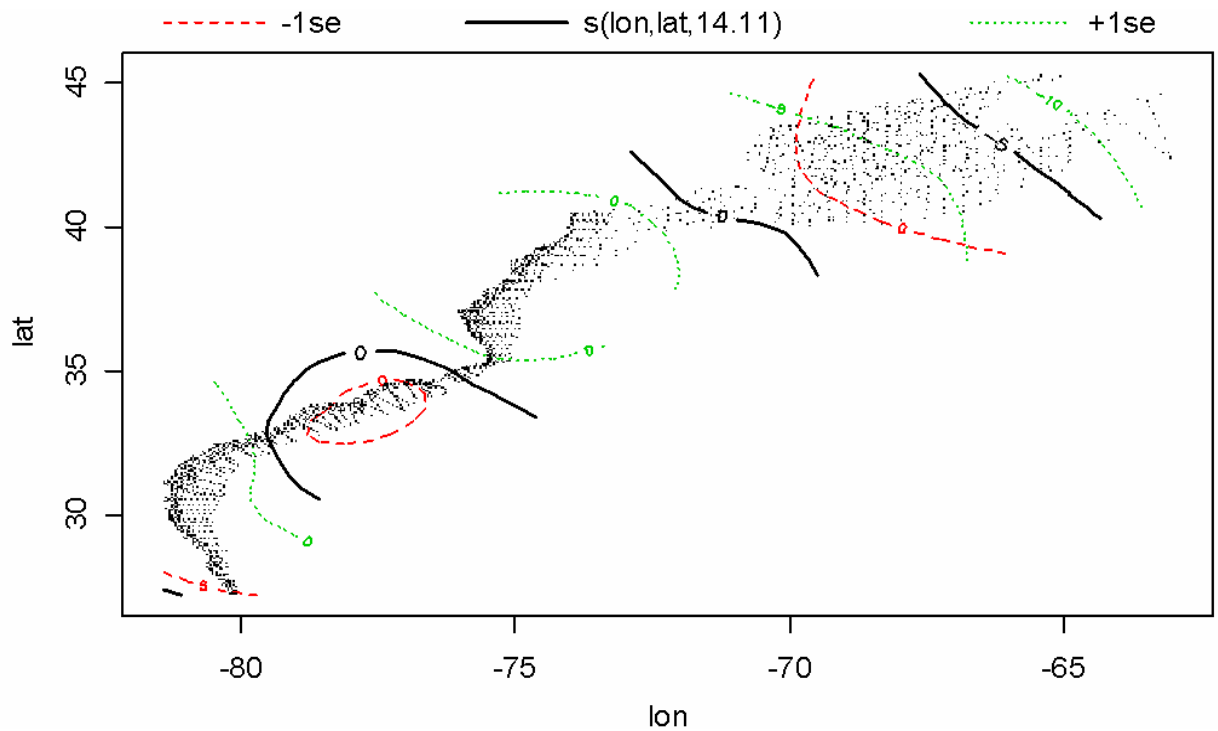


Figure A-60. Plot of the Generalized Additive Model smooth fit depicting the interaction of the covariates *longitude* and *latitude* selected for Hardshell Turtles during summer in the Northeast study area. Solid lines represent the best fit, dashed green lines represent the -1 SE confidence limit, and dashed red lines represent the +1 SE confidence limit.

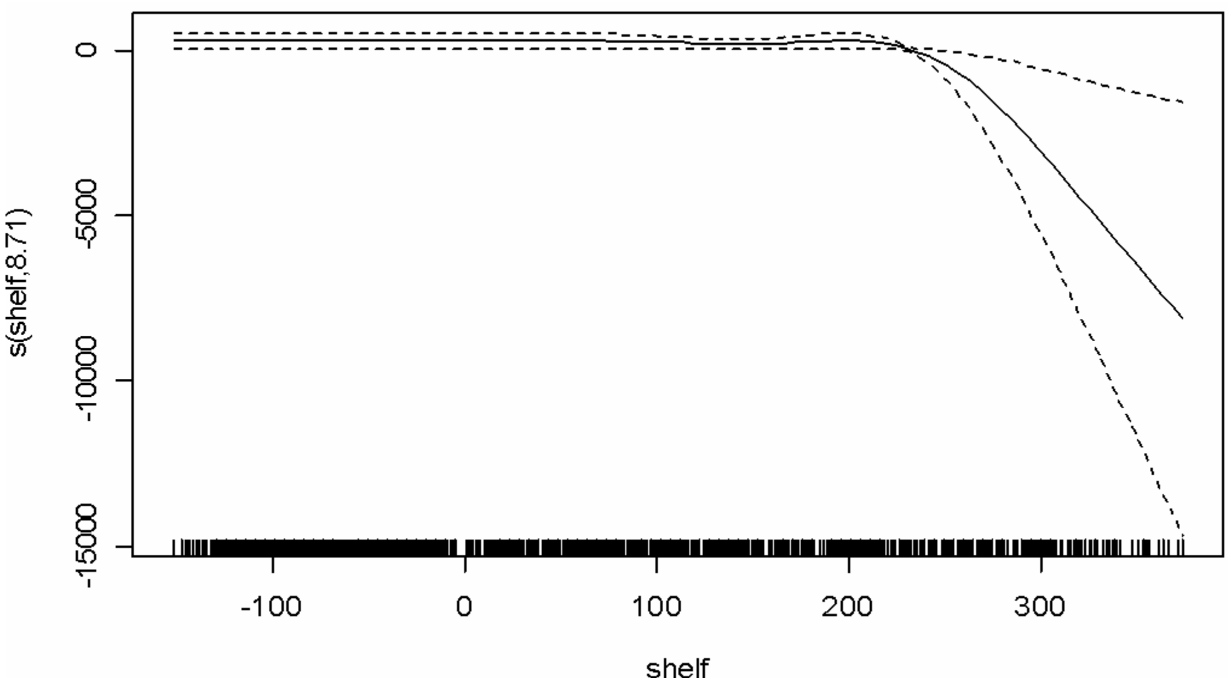


Figure A-61. Plot of the Generalized Additive Model smooth fit of the environmental covariate *shelf* selected for Hardshell Turtles during summer in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

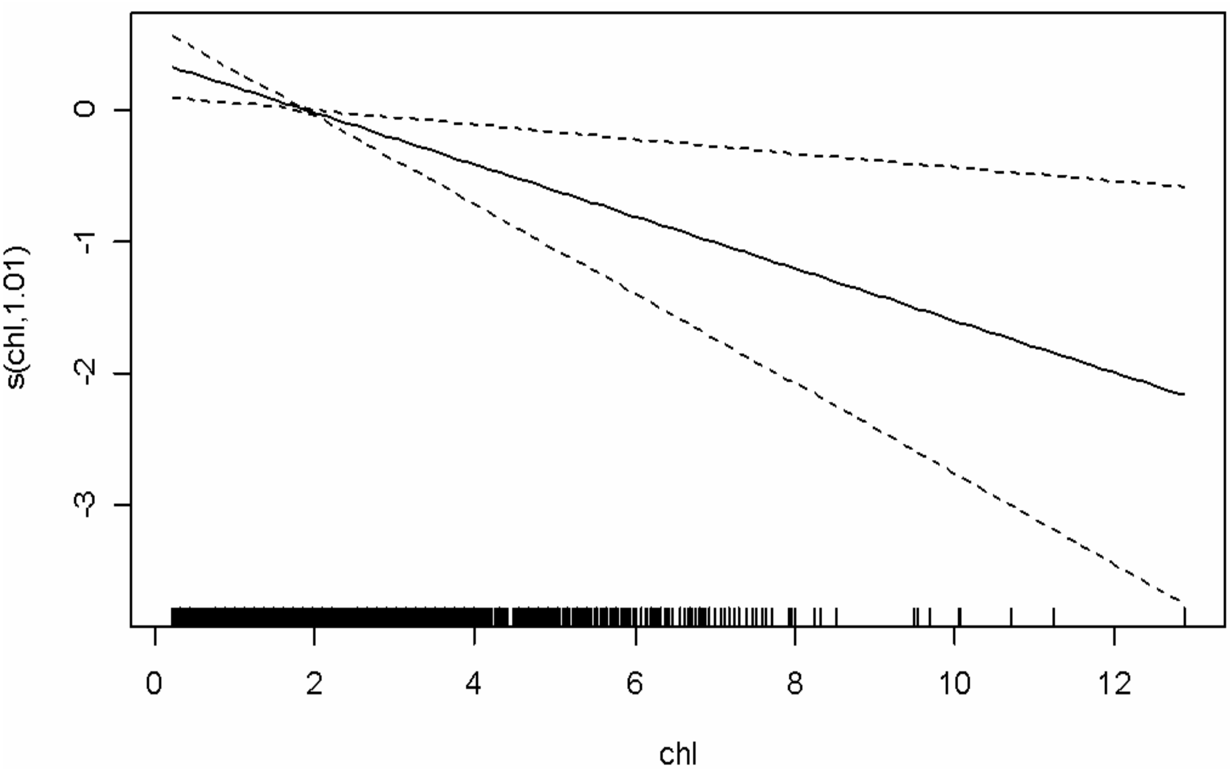


Figure A-62. Plot of the Generalized Additive Model smooth fit of the environmental covariate *chl a* selected for Hardshell Turtles during summer in the Northeast study area. Solid lines represent the best fit, dashed lines represent the 2 SE confidence limits, and vertical lines on the x-axis are the observed data values.

Table A-42. Variance estimate model results for Hardshell Turtles during all summer in the Northeast study area.

Variance	
Legitimate values	419
Non-legitimate bootstrap replicates	80
Infinites	0
NAs	0
NaNs	0
Percentile method computed 95% CI	10111.86 - 12680.08
Point estimate	10918.15
SE of bootstraps	624.283
Est. CV for density surface model	0.0572
CV in detection probability	0.0447
CV in overall estimate including density surface model and detection probability	0.0726
Confidence interval incorporating detection function uncertainty	9471.762, 12585.4

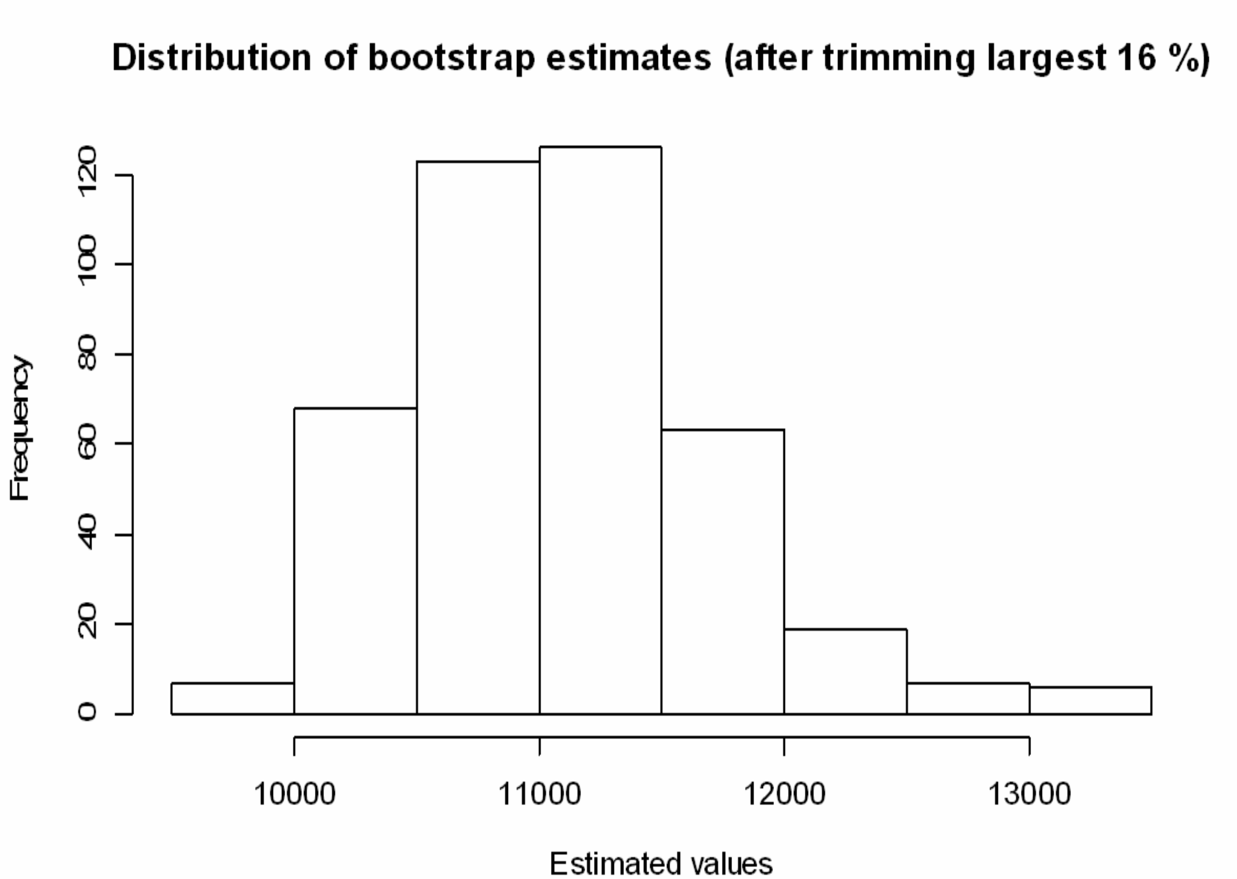


Figure A-63. Distribution of bootstrap estimates (after trimming largest 16%) for pooled sightings of Hardshell Turtles during summer in the Northeast study area.

APPENDIX B: DEPARTMENT OF NAVY NORTHEAST NODE REPORT (2006) – METHODS AND RESULTS

Figures are not included (see DoN 2006 for greater detail)

Species **Page**

2.0 METHODOLOGY

2.1 DESCRIPTION OF NAVY STRATA

As discussed in **Chapter 1**, the spatial strata were defined based on five of the six original biogeographic habitats determined by the NMFS-NEFSC. These habitats were further sub-divided, based on the marine mammal and sea turtle sightings per unit effort (SPUE) results from the NE OPAREAs MRA (DoN 2005; **Figure 2-1**). These SPUE results indicated that within the original biogeographical habitats defined above, some species (or groups) had greater concentrations in certain areas and were sparser in others (DoN 2005). The refinement of the original biogeographic habitats into the smaller strata allowed the density estimation for each species to be investigated at a smaller scale, thereby allowing a more realistic representation of the marine mammal and sea turtle density and distribution in the region.

2.2 DESCRIPTION OF SURVEY EFFORT IN THE NORTHEAST OPERATING AREAS

Aerial and shipboard line-transect surveys conducted by the NMFS-NEFSC in the NE OPAREAs study area provided the on-effort marine mammal and sea turtle sighting data used in this report (**Table 2-1**). Summer was the only season that NMFS-NEFSC conducted surveys that provide data used in this report. For a complete description of the surveys, please refer to the source documents listed in **Table 2-1**, brief descriptions of the surveys are found in DoN (2005). Areas of coverage by each survey are depicted in **Figures 2-2** through **2-6.** Individual survey trackline coverage (km) and area (km^2) for each spatial stratum are shown in **Table 2.2**

Table 2-1. Aerial and shipboard surveys conducted by the National Marine Fisheries Service-Northeast Fisheries Science Center in the Northeast Operating Area study area.

Dates	Source	Platform	Location	Strata covered
1998 06 July to 04 August (**Figure 2-2**)	NMFS-NEFSC (1998a)	RV *Abel-J* 98-01 Shipboard Survey	Between Cape Cod, MA and Virginia	Waters between the 100 m isobath and the eastern boundary of the Gulf Stream
1998 18 July and 21 August (**Figure 2-2**)	NMFS-NEFSC (1998b)	NOAA Twin Otter Aerial Surveys	Cape Hatteras, NC to Cape Breton Island, Nova Scotia (with additional blocks in La Have/Emerald Basin and Emerald/Western Banks)	Nearshore waters from the coastline to the 73 m isobath
1998 08 August and 06 September (**Figure 2-2**)	NMFS-NEFSC (1998a)	RV *Abel-J* 98-02 Shipboard Survey	Cape Cod, MA to Halifax, Nova Scotia	Waters between the 100 m isobath and the eastern boundary of the Gulf Stream
1999 28 July to 31 August (**Figure 2-3**)	NMFS-NEFSC (1999a)	RV *Abel-J* 99-02 Shipboard Survey	Muscungus Bay, ME to Grand Naman Island, Nova Scotia and eastward to Liverpool, Nova Scotia	GOM, Georges Bank East
1999 10 to 29 August (**Figure 2-3**)	NMFS-NEFSC (1999b)	NOAA Twin Otter Aerial Surveys	Georges Bank north through the Gulf of Maine, south to Cape Breton Island, Nova Scotia	GOM, Georges Bank
2002 19 July and 16 August (**Figure 2-4**)	NMFS-NEFSC (2002)	NOAA Twin Otter Aerial Surveys	40°N (just south of Long Island, NY) to the Bay of Fundy (just north of St. John, New Brunswick) and out to 64.5°W	Mid-Atlantic, Georges Bank, GOM, and Scotian
2004 12 June to 12 July (**Figure 2-5**)	NMFS-NEFSC (2004a)	NOAA Twin Otter Aerial Surveys	State border between Virginia and North Carolina (36°N) to the Bay of Fundy (45°N) and from the US Atlantic shoreline to the entrance of the Gulf of St. Lawrence. (58°W)	Mid-Atlantic, Georges Bank, GOM, and Scotian
2004 23 June to 12 July & 16 July to 04 August (**Figure 2-5**)	NMFS-NEFSC (2004b)	R/V *Endeavor* EN-04-395 Shipboard Survey	Virginia to Cape Cod, MA	Mid-Atlantic, 100m isobath to the Gulf Stream

Table 2-2. The total area (square kilometers) of each of the spatial stratum and the trackline length (km) within each stratum that was covered during each survey (Palka 2005).

Strata	Area (km^2)	Trackline Length (km) 1998 Ship	1999 Ship	1999 Aerial	2002 Aerial	2004 Ship	2004 Aerial
GOM North	9,862	0.0	777.0	0.0	155.0	0.0	384.4
GOM Central	53,651	0.0	1200.3	1699.0	2467.0	0.0	1929.9
GOM South	24,504	0.0	0.0	776.5	1130.6	0.0	1234.4
Mid-Atlantic	48,593	0.0	0.0	0.0	0.0	0.0	1251.6
Georges West	28,214	0.0	0.0	0.0	967.1	0.0	1105.8
Georges Central	11,534	0.0	0.0	195.6	346.8	0.0	451.4
Georges East	31,041	0.0	0.0	712.8	1160.8	0.0	644.5
Shelf West	16,515	826.5	0.0	0.0	0.0	735.2	13.5
Shelf Central	15,791	824.0	0.0	0.0	204.0	749.9	38.6
Shelf East	21,471	1211.1	0.0	0.0	554.2	580.9	143.0
Offshore	139,237	1408.3	0.0	0.0	0.0	1924.7	0.0

2.3 SEASONAL DEFINITIONS

For the purposes of this report, the seasons are:

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

2.4 ABUNDANCE/DENSITY ESTIMATE CALCULATIONS FOR CETACEANS

All cetacean abundance estimates used in this report were calculated by the NMFS-NEFSC (Palka 2005) at the Navy's request for each of the strata listed in **Table 2-2**. Only summer abundance estimates were provided since all survey effort by this agency occurred during that period. Abundance estimates provided were either actual estimates (non-zero) or were estimates of zero (see **Step 1** below in **Section 2.5**). Abundance estimates provided were then converted to density estimates by dividing the original abundance estimate by the area of survey coverage from which the original estimate was calculated. Specifics of how these estimates were calculated can be found from two sections *Shipboard Analytical Methods* and *Aerial Analytical Methods*, provided by Palka (2005) and are included in the Appendix. For detailed information on the methodology and results concerning the development of the abundance estimates, refer to the Appendix and Palka (2005).

2.5 DATA LIMITATIONS/QUALIFIERS

Due to the lack of survey effort for specific spatial strata and/or seasons, it was unrealistic to expect to provide robust density estimates for every species that could potentially occur in the areas of interest. As a result, alternate approaches (or methods) were developed in order to provide realistic density estimates for as many species as possible, when normal density estimation was not feasible. The methods used to assign estimates are not exact and are based on expert knowledge of the behavioral and distributional ecology of the species in question. The approaches are utilized at the point when traditional methods are no longer applicable. These density estimates are to be considered “temporary” until Part Two of the density estimation project (spatial modeling) can be implemented. Density estimates provided here were determined using four basic steps (**Figure 2-6**):

- **Step 1** – Use the summer density estimates provided by the NMFS-NEFSC (Palka 2005) for each species (or group) (see above). If the provided density estimate is zero, see **Step 3**, **Step 4**, and **Section 2.8**. NMFS-NEFSC has suggested that zeros should not always be considered absolute (Palka, D., NMFS-NEFSC, pers. comm.). Zeros can occur due to a lack of sightings when there is survey effort (common with hard to sight species, such as cryptic or deep-diving animals) or as result of no survey effort in a specific season and/or spatial stratum. Therefore, zeros provided by NMFS-NEFSC were handled on a case by case basis.

- **Step 2** – Provided summer density estimates were used to proportionally calculate other seasonal estimates using SPUE (when available) and assigned to the appropriate season and/or spatial stratum (see **Sections 2.6** and **2.7**). This approach of dealing with seasons and/or spatial stratum lacking density estimates was agreed upon by the NMFS-NEFSC (Palka, D., NMFS-NEFSC. pers.comm.) In cases where SPUE was not available, other methods were used (discussed below in **Section 2.8**).

- **Step 3** – Determine appropriateness of all estimates (e.g., the species/species group is present or absent in the region) for the season and/or spatial stratum. For example, If species are known to occur in a specified region during a specific time frame, a density estimate of zero was considered to be questionable; therefore, further investigation would be needed. Alternatively, density estimates which were proportionally calculated from summer density estimates using SPUE values also required further scrutiny. Values generated in this way needed to make biological sense, and a given species was examined to ensure estimates were not out of the ordinary. That is, high density estimates in regions where the species is not common (e.g., bottlenose dolphins in GOM north; this is not common habitat for this species) were questioned and reevaluated.

- **Step 4** – If summer density estimates were not provided (e.g., zeros and therefore not available) and (or) it was not possible to use SPUE values to proportionally calculate a density estimate, other methods were used to derive estimates for missing seasons and or spatial strata. These methods are discussed in greater detail in **Section 2.8**.

2.6.1 Combination of Density Estimates for Cetaceans from Each Survey

To provide the Navy with a single overall density estimate for each species and stratum, the abundance estimates and their associated coefficients of variation (cv) provided by the NMFS-NEFSC for each year of surveys needed to be combined. To accomplish this, the annual abundance estimate for species l and stratum i was converted to an estimate of density (per 100 km^2) using the following equation:

$$D_{ily} = \frac{N_{ily}}{A_i} \cdot 100 \qquad \text{(Equation 2.1)}$$

where D = density, N = abundance, A = area (km^2), i = stratum, l = species, and y = year. The density estimates for each of the years were then averaged to obtain a single estimate of the mean density ($\overline{D}$) for species l and stratum i. For species that did not have a density estimate available for each year within a given stratum, only the years for which estimates existed were averaged together.

The newly calculated density estimates and their associated cv estimates for each species, stratum, and year were then used to calculate the overall cv for the mean density estimate using the following equation:

$$cv\left(\overline{D}_{il}\right) = \frac{\sqrt{\sum_{i=1}^{n}\left[D_{ily} \cdot cv\left(D_{ily}\right)\right]^2}}{\overline{D}_{il}} \qquad \text{(Equation 2.2)}$$

where $cv(D)$ = the coefficient of variation of the density estimate for species l, stratum i, and year y; and $cv(\overline{D})$ = the coefficient of variation of the mean density estimate for species l and stratum i.

2.6.2 Determination of Density Estimates for Cetaceans by Season

All of the line-transect surveys conducted for the purpose of obtaining abundance estimates within the past eight years by the NMFS-NEFSC were done during the summer (June through August). Therefore, all of the density estimates calculated based on the abundances provided by the NMFS-NEFSC for each species and stratum are representative of the summer only. As a result, a method needed to be developed for estimating the density for each species and stratum for the remaining three seasons: spring, fall, and winter.

To accomplish this, the SPUE values calculated as part of the MRA for the NE OPAREAs (DoN 2005) were used to assist in assigning density values to the other seasons. Rather than representing the number of sightings per unit of effort as is common of most SPUE estimates, the SPUE values calculated in the NE MRA were weighted by the number of animals observed at each sighting. Therefore, they instead reflect the number of animals sighted per 1,000 km of effort. In addition, the SPUE values were calculated by season for each cell in a 10-min by 10-min grid.

The first step in the process was to combine the seasonal SPUE values by species from the NE MRA into a single SPUE value for each season by spatial strata. This was achieved by summing all of the SPUE estimates contained within each of the Navy's stratum.

Next, within each stratum, ratios were calculated between the SPUE values of a particular season and that of summer using the formula:

$$R_{ils} = \frac{SPUE_{ils}}{SPUE_{il.summer}} \qquad \text{(Equation 2.3)}$$

where R = ratio of the seasonal SPUE value to the summer SPUE value; i = stratum; l = species; and s = season. For example, the ratio for the season of spring would be the SPUE value for spring divided by the SPUE value for summer. Summer was chosen as the denominator because that was the season for which the existing density values were estimated.

Once the ratios were calculated, the densities for species l, stratum i, and season s were estimated using the formula:

$$D_{ils} = D_{il.summer} \cdot R_{ils} \qquad \text{(Equation 2.4)}$$

where D_{summer} = the density estimate derived using Equation 2.1 for the summer from the surveys. It should be noted that these new density estimates are strictly serving as proxies for the other seasons in the absence of survey data from which to calculate true density estimates.

2.7 Handling Spatial Strata and Seasons of Known Occurrence in the Absence of Density Estimates

In some instances, density estimates were unavailable for a spatial strata and season in which a particular species is known to occur. Presence of a marine mammals or sea turtles in a particular spatial strata and season was determined primarily from the sightings and SPUE data generated as part of the NE MRA (DoN 2005). When this occurred, the density estimate from an adjacent stratum for the same species and season was used as a surrogate value. Rather than assuming the same density value as the adjacent stratum, however, the following formula was used to determine the new density estimate:

$$D_{als} = \frac{SPUE_{als} \cdot D_{bls}}{SPUE_{bls}} \qquad \text{(Equation 2.5)}$$

where D = density; a = stratum for which the density is being calculated; b = adjacent stratum containing the existing density estimate; l = species; and s = season. This estimate was then applied to the remaining seasons using the SPUE ratio calculated for the given species, stratum, and season following Equations 2.3 and 2.4.

2.8 Handling Spatial Strata in the Absence of SPUE Values

Following the above methods for allocating density estimates in **Section 2-6** and **Figure 2-6** still left spatial strata and seasons for many of the species (or groups) without estimates calculated for them (see **Step 4** above). This section is an elaboration of **Step 4** above. These methods are used when SPUE values were not available to aid in the calculation of density estimates for all seasons or spatial strata or when the density estimate calculated using the SPUE values appeared to be unrealistic. In such instances, several approaches were developed in an attempt to provide realistic density estimates. These methods were not applied in any hierarchical manner and the numbering below does not indicate any specific priority. Each species (or group), spatial stratum, and season were treated on a case-by-case basis and the approach taken was dependent upon the specifics of each case. For example, a more conservative approach was taken for ESA-listed species (e.g., North Atlantic right whale), than was used for some of the more abundant species (or groups) (e.g., spotted dolphins). The basic overall thought processes of these approaches are diagramed in **Figure 2-6**. These approaches included:

1. **Apply estimate from an adjacent season within the same spatial strata/stratum.**

   This approach was taken when the sightings between the season with no density estimate and an adjacent (i.e., spring's adjacent season would be either winter or summer) season within the same spatial stratum were similar in frequency. It was also employed when density estimates were only available for two adjacent seasons, but were absent for the other two. In this case, and assuming it made biological sense for the species (or group) in question, the value for the season that had an estimate available would be applied to the adjacent season that was missing an estimate (e.g., summer and spring estimates are available and are applied to fall and winter, respectively).

2. **Apply average of adjacent seasonal estimates to a missing season within the same spatial stratum.**

   When it was known that the species (or group) in question was demonstrating differential habitat usage (shifting in and out of spatial strata) during a particular season, then an average of the density estimates from the two adjacent seasons was used to represent the density for the season with the missing value. For example, (1) if the species in question was known to spend much of the summer in a particular spatial stratum, but then move out of the stratum to spend its time elsewhere during the winter, and (2) density estimates were available for both summer and winter, but not for fall, then (3) the summer and winter density values would be averaged to obtain a density estimate for the fall.

3. **Apply estimate to a missing season directly from the same season in an adjacent spatial strata/stratum.**

   In some instances, it was not appropriate to apply or calculate an estimate for a season based on the other seasons in the same spatial stratum, since doing so would not adequately reflect the species' (or group's) level of occurrence during that time period. In some of these cases, it was more appropriate to use a density estimate from the same season in an adjacent stratum (give an example to follow) that possessed similar patterns and levels of utilization.

4. **Collapse seasons and/or spatial strata/stratum within an area and apply as year-round estimate.**

   This approach involved removing the east/central/west boundaries from a spatial strata (i.e., GOM East/GOM Central/GOM West would be collapsed to just GOM) and/or considering all seasons to be the same with respect to distributions of the species (or group) and its respective densities.

   Alternatives include:

   a. When a summer density estimate was the only seasonal estimate available for a specific spatial stratum (e.g., summer estimate for Georges East, but no spring, winter or fall estimates) and no SPUE values were available to estimate a density, seasons were collapsed and the summer estimate was applied to all seasons within that specific stratum.. For example, a summer estimate for species X was available for Georges East, but not for the other seasons within Georges East. The seasonality is removed (collapsed) and the summer estimate is applied to Georges East, regardless of the time of year.

   b. Conversely, a summer estimate might be provided by the NMFS-NEFSC (Palka 2005) for one stratum (Georges East), but no other estimates could be derived for the other spatial strata (Georges Central and Georges West), since no other stratum-specific estimate was provided by the NMFS-NEFSC. Therefore, all the strata (Georges West, Georges Central, and Georges East) would be collapsed into the larger biogeographical stratum defined by the NMFS-NEFSC (Palka 2005) of Georges Bank. The seasonal estimates of Georges East would then be applied to the entire Georges Bank stratum.

   c. Additionally, all seasonal estimates (winter, spring, and fall) may have been calculated based on the summer density estimate provided by the NMFS-NEFSC (Palka 2005) using SPUE values for a specific stratum (Georges Central). However, if no other seasonal estimates were available for the other individual stratum within Georges, then the three individual stratum (Georges East, Georges Central, Georges West) of Georges were collapsed into the larger biogeographical stratum of Georges and all the seasonal estimates from Georges Central were applied to this Georges area.

   d. Alternatively, using the examples from above, perhaps only the summer estimate is provided by the NMFS-NEFSC for Georges East, and that is the only estimate for all seasons within all the remaining Georges Bank spatial strata. The spatial and seasonal components would be collapsed into the larger Georges Bank stratum (from Palka 2005) and the summer estimate available from Georges East would be applied to all seasons and spatial strata for Georges.

5. **Collapse seasons and/or spatial strata/stratum within an area and apply estimate from an adjacent spatial stratum.**

For example, collapse the three shelf edge strata (Shelf Edge East, Shelf Edge Central, and Shelf Edge West) and apply the density estimate from the Offshore stratum to the Shelf Edge region.

6. **Estimate derived from the most recent NOAA SAR.**

   This approach was used when no other ancillary sightings (do you mean off-effort sightings?) are available. (I don't like the term ancillary sightings, b/c for seals, you had no sightings from surveys, so we're not even talking on- vs. off-effort sightings) The NOAA SAR (Waring et al. 2004) provides abundance estimates for most marine mammal species occurring in the western North Atlantic (inshore of the EEZ). A density estimate derived from the abundance estimate found in the SAR is referred to herein as the SAR-derived estimate. The estimate provided is divided by 870,775 km^2 (~estimate of the area of the U.S. Atlantic Coast to the EEZ).

7. Finally, there were instances where all of the above instances were applied in some aspect. Again, these approaches were done species by species to avoid placing zeros or no information in regions where animals were known to occur. No survey design is perfect and the amount of resources needed to fully provide robust estimates of every species does not exist. This is a sound scientific approach which has taken into consideration the conservation of the individual species and yet provides the Navy with realistic density estimates needed to meet their operational needs.

1.1 DENSITY ESTIMATE CALCULATIONS FOR PINNIPEDS

Pinnipeds were rarely sighted during aerial or shipboard line-transect surveys. Consequently, it was not possible to calculate density estimates for pinnipeds using the survey data from the NMFS-NEFSC. Instead, the pinniped density estimates were derived from abundance estimates found in the NOAA SAR (Waring et al. 2004). The only two pinniped species for which abundance estimates had been calculated for in the U.S. were the harbor seal (*Phoca vitulina*) and the gray seal (*Halichoerus grypus*).

1.1.1 Harbor Seal

The NOAA SAR provided a land-based abundance estimate for harbor seals along the entire coast of Maine based on an aerial survey of haul-out sites conducted in May and June of 2001 (Waring et al. 2004). The GOM North and the GOM Central strata together cover the entire shoreline of Maine. To obtain a density estimate for the waters off the coast of Maine, the abundance estimate provided in the SAR was divided by the total combined area of both GOM North and GOM Central as illustrated in **Equation 2.1**. The resulting density estimate was applied to all seasons for these two spatial strata since there were no SPUE values to aid in the allocation of the estimate among the seasons.

1.1.2 Gray Seal

There are two separate abundance estimates provided for the gray seal in the NOAA SAR (Waring et al. 2004). The first is from aerial surveys of haul-out sites around Muskeget Island and Monomoy, MA conducted during Spring 1999. The second estimate is from an aerial survey of haul-out sites along the coast of Maine during May 2001.

It was assumed that gray seals from Muskaget Island and Monomoy, MA would most likely frequent the waters contained in the GOM South, Georges Central, and Georges West strata. Based on this assumption, the abundance estimate provided in the NOAA SAR was divided by the total combined area of these three spatial strata to obtain an estimate of the density as shown in **Equation 2.1**. This estimate was applied to all seasons of each of the three spatial strata due to the lack of SPUE values to help distribute the estimates proportionally among the seasons.

As with the harbor seal, the abundance estimate provided for the coast of Maine in the NOAA SAR was divided by the total combined area of the GOM North and the GOM Central strata. The resulting density estimate was applied to all seasons of both spatial strata.

2.9 DENSITY ESTIMATE CALCULATION FOR SEA TURTLES

Abundance estimates for sea turtles were not calculated as part of Palka (2005) based on the 1998, 1999, 2002, and 2004 surveys conducted by the NMFS-NEFSC. However, estimates were available for leatherback, loggerhead, and Kemp's ridley turtles based on the 1998 aerial survey (Palka et al. 2005). As part of that analysis, each species was assigned a single density and abundance estimate for an area equivalent to the combined spatial strata of the Gulf of Maine (all three spatial strata), Mid-Atlantic, Georges Bank (all three spatial strata), and the Scotian Shelf.

For the purpose of this report, the density estimate provided for each species in Palka et al. (2005) was applied to all seasons and spatial strata listed above (with the exception of the Scotian shelf which is outside the scope of this report).

3.0 DENSITY ESTIMATES

There are 40 marine mammal species with occurrence records in the area of interest: 33 cetacean species, 6 seal species, and 1 sirenian species (DoN 2005). Of these 40 species, only 14 species and 4 species groups (*Kogia* spp., beaked whales, spotted dolphins, and pilot whales) are covered within this report and have abundance/density estimates provided. This is due to the lack of sufficient survey data for abundance estimate calculations by the NMFS-NEFSC for the other species.

There are also five sea turtle species with occurrence records within the NE OPAREAs (DoN 2005); only three are covered within this report (**Table 3-1**). This is again due to the lack of sufficient data for abundance estimate calculations for individual species by the NMFS-NEFSC.

For a detailed description of the marine mammal species and groups, as well as the sea turtle species presented in this report, their status, habitat preferences, distribution, behavior and life history, and information on acoustics and hearing, please refer to DoN (2005). Basic habitat preference and distribution information is presented here for each species (or group) to provide relevant information as it relates to density estimation.

3.1 MARINE MAMMALS

All marine mammal species are afforded protection by the MMPA. Additionally, six of the 19 marine mammal species/species groups considered in this report are listed as endangered under the ESA: North Atlantic right, humpback, sei, fin, blue, and sperm whales. The report begins with threatened/endangered cetacean species, and then addresses the remaining cetacean species. Baleen whales are addressed first (in the order presented in **Table 3-1**) followed by toothed whales. Two pinniped species are then discussed.

3.1.1 Cetaceans

For most of the cetacean species (or groups), the density estimates were determined from the annual abundance estimates provided by the NMFS-NEFSC (Palka 2005) using SPUE values from the NE OPAREAs MRA (DoN 2005). However, there were many instances where, although a density estimate was available for the summer, there were no SPUE values to aid in determining an appropriate density estimate during the remainder of the year. In addition, there were also cases where species were known to occur within a particular strata and season, but for which there was no density estimate available. A description of how each species (or group) and stratum was handled, follows on a case-by case basis.

3.1.1.1 Endangered cetaceans

- North Atlantic Right Whale (*Eubalaena glacialis*)

Density estimates by strata

The NMFS-NEFSC provided density estimates for some seasons and spatial strata, mainly for the GOM. A conservative approach was then adopted, since all estimates except for the GOM were either lacking or equal to 0.00. Taking into consideration the critically endangered status of the species, the number of right whales for the western North Atlantic, provided in the NOAA SAR (Waring et al. 2004) was used. The number population size of 300 right whales based on photo-identification efforts, was divided by the entire area of the waters off the U.S. Atlantic Coast from the shoreline to the EEZ (870,775 km^2) to derive an estimate of density for the entire coast of the U.S. This value is herein referred to as the SAR-derived value of 0.034. This value was applied to all other seasons for each spatial stratum other than the GOM.

Gulf of Maine—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons and spatial strata were calculated from proportional SPUE calculations based upon those summer estimates with the exception of winter for GOM North and Central, which were SAR-derived.

- *Gulf of Maine (GOM) North*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate was a SAR-derived value.
- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate was a SAR-derived value.
- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The winter, spring, and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate.

Table 3-1. Density estimates for North Atlantic right whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.034	0.578	1.947	1.217
per 100 NM^2	0.117	1.981	6.678	4.175
GOM Central				
per 100 km^2	0.034	0.169	0.167	0.043
per 100 NM^2	0.117	0.578	0.573	0.147
GOM South				
per 100 km^2	0.219	1.788	0.738	0.007
per 100 NM^2	0.750	6.134	2.532	0.024
Mid-Atlantic				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Georges West				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Georges Central				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Georges East				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Shelf West				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Shelf Central				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Shelf East				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117
Offshore				
per 100 km^2	0.034	0.034	0.034	0.034
per 100 NM^2	0.117	0.117	0.117	0.117

➢ Humpback Whale (*Megaptera novaeangliae*)

Density estimates by strata

Gulf of Maine—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons and spatial strata were either calculated or assigned from proportional SPUE calculations based upon the summer estimates. The winter estimate for GOM North was assigned from the winter estimate for the adjacent GOM Central.

- *Gulf of Maine (GOM) North*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate for GOM North was assigned from the winter estimate for the adjacent GOM Central.

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter, spring, and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate.

- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The winter, spring, and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate.

Mid-Atlantic—There were no on-effort sightings of humpback whales in this stratum (Palka 2005); therefore, no density estimate was available. Since humpback whales are known occur in this region, the zero estimate provided by the NMFS-NEFSC (Palka 2005) was unrealistic. A conservative approach was adopted due to the endangered status of this species. The seasonal estimates from the adjacent Shelf West stratum were applied here.

Georges—Summer estimates of Georges East and Georges Central were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons and spatial strata were calculated from proportional SPUE calculations based upon those summer estimates. The Georges West winter and summer estimates were based on the winter and summer estimates for Georges East; spring and fall estimates were the average of the winter and summer estimates for Georges West.

- *Georges East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The estimates for fall, winter, and spring were calculated from proportional SPUE calculations based upon the summer estimate.

- *Georges Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from proportional SPUE calculations based upon the summer estimate.

- *Georges West*—The Georges West winter and summer estimates were based on the winter and summer estimates for Georges East. Spring and fall estimates were the average of the winter and summer estimates.

Shelf—Summer estimates for all spatial strata were provided by the NMFS-NEFSC (Palka 2005), however, given the endangered status of this species and the lack of sightings in Shelf Central (compared to the adjacent Shelf East and Shelf West), a conservative approach was adopted. The spatial strata were collapsed and seasonal estimates either provided by the NMFS-NEFSC (summer estimate for Shelf East) or calculated from proportional SPUE calculations (all others) were applied.

The winter and fall estimates were calculated from SPUE calculations from Shelf West using the summer estimate provided by the NMFS-NEFSC (Palka 2005). The spring and summer estimates were calculated from SPUE calculations from Shelf East using the summer estimate.

Offshore—There were no on-effort sightings of humpback whales in this stratum (Palka 2005); therefore, no density estimate was available. Since humpback whales are known occur in this region, the zero estimate provided by the NMFS-NEFSC (Palka 2005) seemed questionable. The conservative approach used here was to apply the seasonal estimates from the adjacent Shelf strata.

Table 3-2 Density estimates for humpback whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.011	0.123	0.548	0.188
per 100 NM^2	0.038	0.422	1.878	0.645
GOM Central				
per 100 km^2	0.011	0.229	0.346	0.168
per 100 NM^2	0.037	0.787	1.185	0.577
GOM South				
per 100 km^2	0.025	0.313	0.474	0.301
per 100 NM^2	0.085	1.074	1.624	1.033
Mid-Atlantic				
per 100 km^2	0.137	0.290	0.170	0.041
per 100 NM^2	0.470	0.995	0.583	0.141
Georges West				
per 100 km^2	0.067	0.044	0.021	0.044
per 100 NM^2	0.231	0.151	0.072	0.151
Georges Central				
per 100 km^2	0.073	2.117	1.853	1.020
per 100 NM^2	0.250	7.260	6.356	3.500
Georges East				
per 100 km^2	0.089	1.342	2.203	0.381
per 100 NM^2	0.306	4.601	7.555	1.307
Shelf West				
per 100 km^2	0.137	0.290	0.170	0.041
per 100 NM^2	0.470	0.994	0.585	0.141
Shelf Central				
per 100 km^2	0.137	0.290	0.170	0.041
per 100 NM^2	0.470	0.994	0.585	0.141
Shelf East				
per 100 km^2	0.137	0.290	0.170	0.041
per 100 NM^2	0.470	0.994	0.585	0.141
Offshore				
per 100 km^2	0.137	0.290	0.170	0.041
per 100 NM^2	0.470	0.994	0.585	0.141

- Fin Whale (*Balaenoptera physalus*)

Density estimates by strata

Gulf of Maine—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons were either calculated or assigned from proportional SPUE calculations based upon the summer estimates, with the exception of the winter estimate for the GOM North, which was assigned from the spring estimate from the GOM North.

- *Gulf of Maine (GOM) North*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate for GOM North was assigned from the spring estimate for the adjacent GOM North.

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter, spring, and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate.

- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The winter, spring, and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate.

Mid-Atlantic—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons were either calculated or assigned from proportional SPUE calculations based upon the summer estimate.

Georges—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons were calculated from proportional SPUE calculations based upon the summer estimate.

Shelf—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons were either calculated or assigned from proportional SPUE calculations based upon the summer estimate.

Offshore—The seasons were collapsed, and the summer estimate provided by the NMFS-NEFSC (Palka 2005) was applied.

Table 3-3. Density estimates for fin whales by spatial strata and season.

Stratum/Density	Season			
	Winter	Spring	Summer	Fall
GOM North				
per 100 km^2	0.353	0.353	1.785	2.333
per 100 NM^2	1.211	1.212	6.121	8.004
GOM Central				
per 100 km^2	0.160	0.587	0.723	0.438
per 100 NM^2	0.547	2.014	2.478	1.503
GOM South				
per 100 km^2	0.483	1.246	2.221	1.589
per 100 NM^2	1.655	4.274	7.619	5.450
Mid-Atlantic				
per 100 km^2	0.142	0.141	0.128	0.022
per 100 NM^2	0.486	0.484	0.438	0.076
Georges West				
per 100 km^2	0.161	0.201	0.370	0.015
per 100 NM^2	0.552	0.689	1.270	0.053
Georges Central				
per 100 km^2	0.184	7.583	6.433	7.407
per 100 NM^2	0.631	26.010	22.065	25.405
Georges East				
per 100 km^2	0.181	0.984	1.413	0.687
per 100 NM^2	0.621	3.376	4.847	2.356
Shelf West				
per 100 km^2	0.447	0.059	0.139	0.068
per 100 NM^2	1.535	0.201	0.478	0.233
Shelf Central				
per 100 km^2	0.954	0.133	1.767	0.409
per 100 NM^2	3.271	0.458	6.060	1.401
Shelf East				
per 100 km^2	0.023	0.474	0.501	0.098
per 100 NM^2	0.079	1.627	1.717	0.336
Offshore				
per 100 km^2	0.026	0.026	0.026	0.026
per 100 NM^2	0.089	0.089	0.089	0.089

- Sei Whale (*Balaenoptera borealis*)

Density estimates by strata

Gulf of Maine—Summer density estimates were provided by the NMFS-NEFSC (Palka 2005). Other seasonal estimates were either calculated or assigned from proportional SPUE calculations based upon the summer estimate for the respective spatial strata.

- *Gulf of Maine (GOM) North*—The summer density estimate was provided by the NMFS-NEFSC (Palka 2005). The spring estimate was calculated from the proportional SPUE calculations based upon the summer estimate. The spring estimate was applied to winter. The summer estimate was applied to fall.

- *Gulf of Maine (GOM) Central*—The summer density estimate was provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate.

- *Gulf of Maine (GOM) South*—The summer density estimate was provided by the NMFS-NEFSC (Palka 2005). The fall and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate. The winter estimate was an average of the spring and fall estimates.

Mid-Atlantic—Summer density estimates of 0.00 were provided for the Mid-Atlantic by the NMFS-NEFSC (Palka 2005). Due to the endangered status of this species, as well as known sightings in this stratum, a conservative approach was adopted. This approach was to apply the estimates provided by the NMFS-NEFSC for fin/sei whales to missing seasons and/or spatial strata for sei whales, thereby ensuring that a value other than zero was provided. Therefore, the summer estimate for sei whales came from the fin/sei whale estimate, which was calculated from the fin/sei whale summer estimate for the adjacent Shelf West provided by the NMFS-NEFSC (Palka 2005). Other seasonal estimates were calculated from proportional SPUE calculations based upon the fin/sei whale summer estimate for the Mid-Atlantic.

Georges—Summer density estimates of <0.5 for sei whales were provided by the NMFS-NEFSC (Palka 2005). Due to the endangered status of this species, as well as known sightings in this stratum, a conservative approach was adopted (see above for rational) and the seasonal estimates of fin/sei whale for the Georges were applied here to the respective spatial strata.

- *Georges East*—The fin/sei whale summer estimate for Georges East was provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate.

- *Georges Central*—All seasonal estimates for the fin/sei whale were calculated from the proportional SPUE calculations based upon the summer estimate for the adjacent Georges East.

- *Georges West*—All seasonal estimates for the fin/sei whale were calculated from the proportional SPUE calculations based upon the summer estimate for the Georges East.

Shelf—Very low (<0.04) seasonal estimates were provided by the NMFS-NEFSC for all Shelf strata. Due to the endangered status of this species, as well as known sightings in this stratum, a conservative approach was adopted (see above for rational). The fin/sei whale summer estimates for Shelf East, Shelf Central, and Shelf West were provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate for the respective spatial strata.

Offshore—Seasonal density estimates of 0.00 were provided by the NMFS-NEFSC (Palka 2005). Due to the endangered status of this species, as well as known sightings in this stratum, a conservative approach was adopted (see above for rational) and the summer estimate of fin/sei whale for the adjacent Shelf East was applied here.

Table 3-4. Density estimates for sei whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.498	0.498	0.953	0.953
per 100 NM^2	1.708	1.709	3.269	3.269
GOM Central				
per 100 km^2	0.073	0.346	0.175	0.004
per 100 NM^2	0.251	1.186	0.601	0.013
GOM South				
per 100 km^2	1.076	1.975	0.816	0.177
per 100 NM^2	3.691	6.773	2.799	0.607
Mid-Atlantic				
per 100 km^2	0.082	0.082	0.074	0.013
per 100 NM^2	0.281	0.281	0.254	0.045
Georges West				
per 100 km^2	0.126	0.202	0.290	0.012
per 100 NM^2	0.432	0.693	0.995	0.041
Georges Central				
per 100 km^2	0.008	0.386	0.282	0.323
per 100 NM^2	0.027	1.324	0.967	1.108
Georges East				
per 100 km^2	0.045	0.515	0.370	0.171
per 100 NM^2	0.154	1.766	1.269	0.587
Shelf West				
per 100 km^2	0.129	0.017	0.040	0.020
per 100 NM^2	0.442	0.058	0.137	0.069
Shelf Central				
per 100 km^2	0.126	0.062	0.234	0.054
per 100 NM^2	0.432	0.213	0.803	0.185
Shelf East				
per 100 km^2	0.027	1.916	0.699	0.113
per 100 NM^2	0.093	6.572	2.398	0.388
Offshore				
per 100 km^2	0.699	0.699	0.699	0.699
per 100 NM^2	2.398	2.398	2.398	2.398

- Sperm Whale (*Physeter macrocephalus*)

Density estimates by strata

Gulf of Maine—Seasons and spatial strata were collapsed. The GOM Central summer estimate provided by the NMFS-NEFSC (Palka 2005) was applied across all strata and seasons.

Mid-Atlantic—The only available estimate provided by the NMFS-NEFSC (Palka 2005) was a summer estimate of 0.00. Since sperm whales are known occur in this region, the zero estimate provided by the NMFS-NEFSC (Palka 2005) seemed questionable. The conservative approach used here took into consideration the endangered status of this species. All seasonal estimates for the sperm whale were calculated from the proportional SPUE calculations based upon the summer estimate for the adjacent Shelf West stratum.

Georges—Summer estimates for Georges East and Georges Central were provided by the NMFS-NEFSC (Palka 2005). All other seasonal and spatial estimates were either calculated or applied from the proportional SPUE calculations based upon the summer estimates.

- *Georges East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring estimate was calculated from the proportional SPUE calculations based upon the summer estimate. The fall estimate was applied from the fall estimate for Georges West. The winter estimate was the average of the fall and spring estimates.

- *Georges Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring estimate was calculated from the proportional SPUE calculations based upon the summer estimate. The fall estimate was applied from the fall estimate for the adjacent Georges West. The winter estimate was the average of the fall and spring estimates.

- *Georges West*—The summer estimate was calculated from the proportional SPUE calculations based upon the summer estimate from the adjacent Georges Central. Spring and fall estimates were calculated from the proportional SPUE calculations based upon the summer estimate for Georges West. The winter estimate was the average of the fall and spring estimates.

Shelf—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). Winter and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimates. The fall estimate for the Shelf West was applied to the fall estimates for Shelf East and Shelf Central.

- *Shelf East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Winter and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate. The fall estimate for the Shelf West was applied to the fall estimate.

- *Shelf Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Winter and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate. The fall estimate for the Shelf West was applied to the fall estimate.

- *Shelf West*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Fall, winter, and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate.

Offshore—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Fall and spring estimates were calculated from the proportional SPUE calculations based upon the summer estimate. The winter estimate from the adjacent Shelf Central was applied for the winter estimate.

Table 3-5. Density estimates for sperm whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.076	0.076	0.076	0.076
per 100 NM^2	0.261	0.261	0.261	0.261
GOM Central				
per 100 km^2	0.076	0.076	0.076	0.076
per 100 NM^2	0.260	0.260	0.260	0.260
GOM South				
per 100 km^2	0.076	0.076	0.076	0.076
per 100 NM^2	0.260	0.260	0.260	0.260
Mid-Atlantic				
per 100 km^2	0.018	0.551	1.707	0.259
per 100 NM^2	0.062	1.890	5.855	0.888
Georges West				
per 100 km^2	3.870	0.543	2.118	7.196
per 100 NM^2	13.274	1.861	7.263	24.683
Georges Central				
per 100 km^2	4.590	1.983	2.692	7.196
per 100 NM^2	15.743	6.800	9.233	24.682
Georges East				
per 100 km^2	3.608	0.020	0.161	7.196
per 100 NM^2	12.375	0.069	0.551	24.682
Shelf West				
per 100 km^2	0.018	0.551	1.707	0.259
per 100 NM^2	0.063	1.889	5.854	0.890
Shelf Central				
per 100 km^2	0.662	0.424	1.423	0.259
per 100 NM^2	2.271	1.455	4.880	0.888
Shelf East				
per 100 km^2	0.032	0.170	0.940	0.259
per 100 NM^2	0.109	0.582	3.224	0.888
Offshore				
per 100 km^2	0.662	0.296	1.576	0.029
per 100 NM^2	2.271	1.017	5.406	0.100

3.1.1.2 Non-Threatened and Non-Endangered Cetaceans

➢ Minke Whale (*Balaenoptera acutorostrata*)

Density estimates by strata

Gulf of Maine—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons and spatial strata were calculated from proportional SPUE calculations based upon those summer estimates.

- *Gulf of Maine (GOM) North*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate was the average of fall and spring estimates.

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Fall, winter, and spring estimates were calculated from proportional SPUE calculations based upon the summer estimate.

- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Fall, winter, and spring estimates were calculated from proportional SPUE calculations based upon the summer estimate.

Mid-Atlantic—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring estimate was calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate equals the spring estimate, while the fall estimate equals the summer estimate.

Georges—The summer estimate for Georges East was provided by the NMFS-NEFSC (Palka 2005). All other estimates calculated from proportional SPUE calculations based upon the summer estimate from Georges East.

- *Georges East*—The summer estimate for Georges East was provided by the NMFS-NEFSC (Palka 2005). Fall, winter, and spring estimates calculated from proportional SPUE calculations based upon the summer estimate.

- *Georges Central*—All seasonal estimates calculated from proportional SPUE calculations based upon the summer estimate from Georges East.

- *Georges West*—Spring, summer, and fall estimates calculated from proportional SPUE calculations based upon the summer estimate from Georges East. The winter estimate is an average of the estimates for spring and fall.

Shelf—Seasons and spatial strata were collapsed. The highest summer estimate (Shelf East) provided by the NMFS-NEFSC (Palka 2005) was applied.

Offshore—Seasons and spatial strata were collapsed. The summer estimate from the adjacent Shelf East (the highest estimate for the Shelf strata) provided by the NMFS-NEFSC (Palka 2005) was applied. This took into consideration the low survey effort in this stratum and known occurrence of the species here.

Table 3-6. Density estimates for minke whales by spatial strata and season.

	Season			
Stratum/Density	Winter	Spring	Summer	Fall
GOM North				
per 100 km^2	3.675	4.913	5.136	2.436
per 100 NM^2	12.605	16.851	17.617	8.355
GOM Central				
per 100 km^2	0.008	0.233	0.500	0.066
per 100 NM^2	0.028	0.801	1.716	0.227
GOM South				
per 100 km^2	0.007	0.273	0.189	0.082
per 100 NM^2	0.024	0.938	0.649	0.280
Mid-Atlantic				
per 100 km^2	0.167	0.167	0.113	0.113
per 100 NM^2	0.573	0.572	0.388	0.388
Georges West				
per 100 km^2	0.028	0.473	0.053	0.087
per 100 NM^2	0.096	1.624	0.180	0.299
Georges Central				
per 100 km^2	0.051	0.791	0.342	0.250
per 100 NM^2	0.173	2.714	1.175	0.856
Georges East				
per 100 km^2	0.052	0.865	0.129	0.173
per 100 NM^2	0.177	2.967	0.441	0.595
Shelf West				
per 100 km^2	0.989	0.989	0.989	0.989
per 100 NM^2	3.392	3.392	3.393	3.392
Shelf Central				
per 100 km^2	0.989	0.989	0.989	0.989
per 100 NM^2	3.392	3.392	3.393	3.392
Shelf East				
per 100 km^2	0.989	0.989	0.989	0.989
per 100 NM^2	3.392	3.392	3.393	3.392
Offshore				
per 100 km^2	0.989	0.989	0.989	0.989
per 100 NM^2	3.392	3.392	3.393	3.392

- *Kogia* spp.

There are two species that make up this category: pygmy sperm whale (*Kogia breviceps*) and dwarf sperm whale (*Kogia sima*).

Density estimates by strata

Gulf of Maine, Georges, and Mid-Atlantic strata were combined, and seasonally collapsed. The summer estimate from Shelf Central provided by the NMFS-NEFSC (Palka 2005) was applied to this region. Density estimates of 0.00 provided by the NMFS-NEFSC did not seem realistic, when taking into consideration the cryptic behavior and off-effort sightings of this group of species in these spatial strata.

Shelf—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). Seasons were collapsed and the summer estimate applied for each spatial strata.

Offshore—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). Seasons were collapsed and the summer estimate applied.

Table 3-7. Density estimates for *Kogia* spp. whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
GOM Central				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
GOM South				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
Mid-Atlantic				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
Georges West				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
Georges Central				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
Georges East				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.151	0.151	0.151	0.151
Shelf West				
per 100 km^2	1.363	1.363	1.363	1.363
per 100 NM^2	4.675	4.675	4.675	4.675
Shelf Central				
per 100 km^2	0.044	0.044	0.044	0.044
per 100 NM^2	0.152	0.152	0.152	0.152
Shelf East				
per 100 km^2	0.088	0.088	0.088	0.088
per 100 NM^2	0.304	0.304	0.304	0.304
Offshore				
per 100 km^2	0.080	0.080	0.080	0.080
per 100 NM^2	0.273	0.273	0.273	0.273

- Beaked Whales (Family Ziphiidae)

The beaked whales category encompasses species belonging to the Family Ziphiidae occurring in the NE OPAREAS; these are the Cuvier's beaked whale, True's beaked whale, Gervais' beaked whale, Sowerby's beaked whale, and Blainville's beaked whale.

Density estimates by strata

Gulf of Maine—A summer estimate for only GOM Central was provided by the NMFS-NEFSC (Palka 2005). No SPUE data were available for use in proportionally calculating densities for the other seasons (DoN 2005). Therefore, taking the conservative approach and understanding the cryptic behavior of this group of species, seasons and spatial strata were collapsed. The summer estimate was applied.

Mid-Atlantic—There were no on-effort sightings of beaked whales in this stratum; therefore, a density estimate of 0.00 was provided by the NMFS-NEFSC (Palka 2005). Using a conservative approach and understanding the cryptic behavior of this group of species, seasons were collapsed and density estimates were calculated using summer SPUE values based on the estimate for the adjacent Shelf West stratum and applied.

Georges—There were no on-effort sightings of beaked whales in this stratum, so density estimates of 0.00 were provided by the NMFS-NEFSC (Palka 2005). Since beaked whales are known to occur in this region, these estimates seemed questionable. The conservative approach used here took into consideration the cryptic behavior of this group of species; spatial and seasonal estimates from the adjacent Shelf strata were applied.

- *Georges East*—Seasonal estimates from the adjacent Shelf East stratum were applied.
- *Georges Central*—Seasonal estimates from the adjacent Shelf Central stratum were applied.
- *Georges West*—Seasonal estimates from the adjacent Shelf Central stratum were applied.

Shelf—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for winter, spring, and fall for each strata were calculated proportionately from SPUE values from the summer for each strata when available.

- *Shelf East*—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for spring and fall were calculated proportionately from SPUE values using the summer density estimate. The winter estimate for Shelf West was applied.
- *Shelf Central*—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for spring were calculated proportionately from SPUE values using the summer density estimate. The winter estimate for Shelf West was applied. The fall estimate was applied from the fall estimate for Shelf East.
- *Shelf West*—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for spring and winter were calculated proportionately from SPUE values using the summer density estimate. The fall estimate from Shelf East was applied.

Offshore—Seasons were collapsed, and the summer estimate provided by the NMFS-NEFSC (Palka 2005) was applied.

Table 3-8. Density estimates for beaked whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.274	0.274	0.274	0.274
per 100 NM^2	0.939	0.939	0.939	0.939
GOM Central				
per 100 km^2	0.274	0.274	0.274	0.274
per 100 NM^2	0.940	0.940	0.940	0.940
GOM South				
per 100 km^2	0.274	0.274	0.274	0.274
per 100 NM^2	0.939	0.939	0.939	0.939
Mid-Atlantic				
per 100 km^2	0.057	0.057	0.057	0.057
per 100 NM^2	0.196	0.196	0.196	0.196
Georges West				
per 100 km^2	0.095	0.003	0.050	0.078
per 100 NM^2	0.326	0.010	0.171	0.268
Georges Central				
per 100 km^2	0.095	0.003	0.050	0.078
per 100 NM^2	0.326	0.010	0.171	0.268
Georges East				
per 100 km^2	0.095	0.222	3.032	0.078
per 100 NM^2	0.326	0.761	10.399	0.268
Shelf West				
per 100 km^2	0.095	1.204	1.421	0.078
per 100 NM^2	0.326	4.130	4.874	0.268
Shelf Central				
per 100 km^2	0.095	0.003	0.050	0.078
per 100 NM^2	0.326	0.010	0.171	0.268
Shelf East				
per 100 km^2	0.095	0.222	3.032	0.078
per 100 NM^2	0.326	0.761	10.399	0.268
Offshore				
per 100 km^2	1.317	1.317	1.317	1.317
per 100 NM^2	4.517	4.517	4.517	4.517

- Bottlenose Dolphin (*Tursiops truncatus*)

The category for bottlenose dolphins includes both the coastal (nearshore) and the offshore forms.

Density estimates by strata

Gulf of Maine—The bottlenose dolphin is rare north of Long Island, New York. Spatial and temporal strata were collapsed. The summer estimate for GOM Central provided by the NMFS-NEFSC (Palka 2005) was applied for the entire region, which is a conservative approach.

Mid-Atlantic—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Spring and winter estimates were derived from SPUE values. The fall estimate is based on the fall estimate for the adjacent Shelf West.

Georges—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The estimates for each seasons were either calculated or assigned from proportional SPUE calculations, see each stratum below for specific details.

- *Georges West*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The winter and spring estimates were calculated based upon SPUE values. The fall estimate was applied from the fall estimate for Georges Central.
- *Georges Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated based upon SPUE values. The winter estimate for the adjacent Georges West was applied here for the winter.
- *Georges East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were calculated based upon SPUE values. The winter estimate for the adjacent Georges West was applied here for the winter.

Shelf—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). All other seasonal estimates for each stratum were calculated proportionately from SPUE values.

Offshore—Seasons were collapsed, and the summer estimate was provided by the NMFS-NEFSC (Palka 2005) was applied.

Table 3-9. Density estimates for bottlenose dolphins by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.850	0.850	0.850	0.850
per 100 NM^2	2.915	2.915	2.915	2.915
GOM Central				
per 100 km^2	0.850	0.850	0.850	0.850
per 100 NM^2	2.915	2.915	2.915	2.915
GOM South				
per 100 km^2	0.850	0.850	0.850	0.850
per 100 NM^2	2.915	2.915	2.915	2.915
Mid-Atlantic				
per 100 km^2	0.207	8.140	26.905	3.696
per 100 NM^2	0.709	27.919	92.282	12.677
Georges West				
per 100 km^2	0.618	1.068	2.418	0.351
per 100 NM^2	2.118	3.665	8.295	1.204
Georges Central				
per 100 km^2	0.618	2.815	11.078	0.351
per 100 NM^2	2.120	9.656	37.995	1.205
Georges East				
per 100 km^2	0.618	1.079	1.727	0.384
per 100 NM^2	2.120	3.700	5.923	1.318
Shelf West				
per 100 km^2	3.450	7.587	10.541	1.780
per 100 NM^2	11.833	26.022	36.155	6.105
Shelf Central				
per 100 km^2	0.525	11.840	15.492	3.696
per 100 NM^2	1.801	40.609	53.135	12.678
Shelf East				
per 100 km^2	3.723	6.648	8.101	3.812
per 100 NM^2	12.769	22.804	27.785	13.074
Offshore				
per 100 km^2	1.178	1.178	1.178	1.178
per 100 NM^2	4.040	4.040	4.040	4.040

- Spotted Dolphins

There are two species of spotted dolphins in the western North Atlantic: the pantropical spotted dolphin and the Atlantic spotted dolphin. The NMFS-NEFSC did not delineate the two spotted dolphins and provided density estimates for spotted dolphins as a species group. Sightings of the Atlantic spotted dolphin and the pantropical spotted dolphin in northeast U.S. waters are not always differentiated due to difficulty in distinguishing the two species at sea (Waring et al. 2004). It should be noted that two distinct morphotypes of the Atlantic spotted dolphin are described for the western North Atlantic: a larger, more heavily spotted form found in waters over the continental shelf, and a smaller, less spotted form found in more pelagic offshore waters. It is the latter that is the most frequently sighted of the two forms in the NE OPAREAs study area.

Density estimates by strata

Density estimates provided by the NMFS-NEFSC were a combination of the two spotted dolphin species; separate estimates for each spotted dolphin species were not available.

Gulf of Maine—All seasons and spatial strata were collapsed. Density estimates of 0.00 provided by the NMFS-NEFSC (Palka 2005) are reasonable, since this group of species prefer warmer waters than those in this area.

Mid-Atlantic—All seasons and spatial strata were collapsed. The summer estimate for the adjacent Shelf West was applied.

Georges—All seasons and spatial strata were collapsed. The summer estimate for the adjacent Shelf West was applied.

Shelf—Due to difficulties in species identification and an overlap in habitat use here by the two spotted dolphin species, as well as that NMFS-NEFSC did not provide separate density estimates for the two spotted dolphin species, the conservative approach was to collapse the seasons and spatial strata and apply the summer estimate for Shelf West provided by the NMFS-NEFSC (Palka 2005).

Offshore—Seasons were collapsed. The summer estimate was provided by the NMFS-NEFSC (Palka 2005).

Table 3-10. Density estimates for spotted dolphins by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
GOM Central				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
GOM South				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Mid-Atlantic				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Georges West				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Georges Central				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Georges East				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Shelf West				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Shelf Central				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Shelf East				
per 100 km^2	8.730	8.730	8.730	8.730
per 100 NM^2	29.943	29.943	29.943	29.943
Offshore				
per 100 km^2	11.928	11.928	11.928	11.928
per 100 NM^2	40.910	40.910	40.910	40.912

➢ Striped Dolphin (*Stenella coeruleoalba*)

Density estimates by strata

Summer density estimates of 0.00 were provided for the GOM or Mid-Atlantic regions by the NMFS-NEFSC (Palka 2005). These regions are not preferred habitat for the striped dolphin, so these are realistic estimates.

Georges—Seasons and spatial strata were collapsed. Summer estimates of 0.00 were provided by the NMFS-NEFSC (Palka 2005) were questionable. Therefore, a conservative approach was adopted since this species does occur in this region. The estimate used was a SPUE-derived calculation from the summer estimate for the adjacent Shelf East stratum.

Shelf—Summer density estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for each seasons were either calculated or assigned from proportional SPUE calculations, see each stratum below for specific details.

- *Shelf East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring estimate was calculated from proportional SPUE calculations based upon the summer estimate. The fall estimate for Shelf West was applied to the fall estimate. The winter estimate for the adjacent Shelf Central was applied to the winter estimate.

- *Shelf Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The winter and spring estimates were calculated from proportional SPUE calculations based upon the summer estimate. The fall estimate for the adjacent Shelf West was applied to the fall estimate.

- *Shelf West*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from proportional SPUE calculations based upon the summer estimate.

Offshore—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall and spring estimates were calculated from proportional SPUE calculations based upon the summer estimate. The winter estimate was an average of the spring and fall estimates.

Table 3-11. Density estimates for striped dolphins by spatial strata and season.

Stratum/Density	Season			
	Winter	Spring	Summer	Fall
GOM North				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
GOM Central				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
GOM South				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Mid-Atlantic				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Georges West				
per 100 km^2	0.144	0.144	0.144	0.144
per 100 NM^2	0.494	0.494	0.494	0.494
Georges Central				
per 100 km^2	0.144	0.144	0.144	0.144
per 100 NM^2	0.494	0.494	0.494	0.494
Georges East				
per 100 km^2	0.144	0.144	0.144	0.144
per 100 NM^2	0.494	0.494	0.494	0.494
Shelf West				
per 100 km^2	2.813	6.862	21.715	4.228
per 100 NM^2	9.649	23.537	74.480	14.500
Shelf Central				
per 100 km^2	6.884	37.161	11.664	4.228
per 100 NM^2	23.611	127.458	40.006	14.502
Shelf East				
per 100 km^2	6.884	1.651	10.830	4.228
per 100 NM^2	23.611	5.664	37.145	14.502
Offshore				
per 100 km^2	2.778	4.976	28.124	0.580
per 100 NM^2	9.528	17.066	96.462	1.989

- Common Dolphins

The NMFS-NEFSC provided estimates for the species group called common dolphins. There are two species of common dolphin: the long-beaked common dolphin (*Delphinus capensis*) and short-beaked common dolphin (*Delphinus delphis*). Only the short-beaked common dolphin is expected to occur in the NE OPAREAs.

Density estimates by strata

Gulf of Maine

- *Gulf of Maine (GOM) North*—Collapsed seasons and applied the summer estimate from GOM Central provided by the NMFS-NEFSC (Palka 2005).

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Spring and fall estimates were derived from SPUE calculations for the summer estimate. The winter estimate was applied from the spring estimate.

- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). All other seasonal estimates were derived from SPUE calculations for the summer estimate.

Mid-Atlantic—There were no density estimates available for this stratum (Palka 2005). The density estimates for each season were derived from proportional SPUE calculations taken from the summer density estimate for the adjacent Shelf West stratum. The winter estimate was an average of the spring and fall estimates.

Georges—The summer estimates were provided by the NMFS-NEFSC (Palka 2005). All other seasonal estimates were derived from proportional SPUE calculations taken from the summer density estimate.

Shelf—The summer estimates were provided by the NMFS-NEFSC (Palka 2005). All other seasonal estimates were derived from proportional SPUE calculations taken from the summer density estimate.

Offshore—Seasons were collapsed and the summer estimate provided by the NMFS-NEFSC (Palka 2005) was applied.

Table 3-12. Density estimates for common dolphins by spatial strata and season.

Stratum/Density	Season: Winter	Spring	Summer	Fall
GOM North				
per 100 km^2	0.028	0.028	0.028	0.028
per 100 NM^2	0.096	0.096	0.096	0.096
GOM Central				
per 100 km^2	0.077	0.077	7.069	5.701
per 100 NM^2	0.264	0.263	24.246	19.555
GOM South				
per 100 km^2	2.005	2.269	18.315	21.874
per 100 NM^2	6.875	7.781	62.818	75.025
Mid-Atlantic				
per 100 km^2	145.347	1.908	3.590	5.275
per 100 NM^2	498.527	6.543	12.313	18.093
Georges West				
per 100 km^2	3.783	19.098	18.652	4.892
per 100 NM^2	12.977	65.504	63.975	16.777
Georges Central				
per 100 km^2	238.123	35.716	56.543	360.962
per 100 NM^2	816.740	122.503	193.937	1,238.065
Georges East				
per 100 km^2	15.523	5.356	25.153	65.881
per 100 NM^2	53.242	18.370	86.273	225.965
Shelf West				
per 100 km^2	100.359	548.770	40.242	1.218
per 100 NM^2	344.221	1,882.229	138.026	4.176
Shelf Central				
per 100 km^2	359.535	49.726	40.281	611.659
per 100 NM^2	1,233.172	170.555	138.159	2,097.934
Shelf East				
per 100 km^2	13.283	50.216	27.919	43.984
per 100 NM^2	45.561	172.238	95.759	150.862
Offshore				
per 100 km^2	2.340	2.340	2.340	2.340
per 100 NM^2	8.026	8.026	8.027	8.026

➢ Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

Density estimates by strata

Gulf of Maine—The summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for each season were calculated from proportional SPUE calculations using the summer estimates.

- *Gulf of Maine (GOM) North*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Winter and spring estimates were applied from the winter and spring estimates for GOM Central. The fall estimate was derived from SPUE calculations using the summer estimate.

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Winter, spring, and fall estimates were derived from SPUE calculations using the summer estimate.

- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Winter, spring, and fall estimates were derived from SPUE calculations using the summer estimate.

Mid-Atlantic—Seasons were collapsed. The summer estimate was provided by the NMFS-NEFSC (Palka 2005) was applied to all the other seasons is a conservative approach.

Georges—The only available density estimate provided by the NMFS-NEFSC for the Atlantic white-sided dolphin is for the summer in Georges East (Palka 2005). The estimates for all other seasons and spatial strata were either calculated or assigned from proportional SPUE calculations, see each stratum below for specific details.

- *Georges West*—The spring and summer estimates were derived from SPUE calculations based upon the summer estimate provided by the NMFS-NEFSC (Palka 2005) for Georges East. The fall and winter estimates from the adjacent Georges Central were applied.

- *Georges Central*—All seasonal estimates were derived from SPUE calculations based upon the summer estimate provided by the NMFS-NEFSC (Palka 2005) for Georges East.

- *Georges East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were derived from SPUE calculations based upon the summer estimate. The winter estimate is from the adjacent Georges Central.

Shelf—The summer estimate for Shelf East was provided by the NMFS-NEFSC (Palka 2005). No other density estimates were available. The estimates for all other seasons and spatial strata were either calculated or assigned from proportional SPUE calculations based on the Shelf East summer estimate.

- *Shelf East*—The summer estimate was derived from SPUE calculations for the summer estimate for Shelf East provided by the NMFS-NEFSC (Palka 2005). The fall estimate was applied from the fall estimate from the adjacent Shelf Central. The winter estimate was an average of the estimates for spring and fall.

- *Shelf Central*—Spring, summer, and fall estimates were derived from SPUE calculations for the summer in Shelf East provided by the NMFS-NEFSC (Palka 2005). The winter estimate was an average of the estimates for spring and fall.

- *Shelf West*—All seasonal estimates were applied from the adjacent Shelf Central stratum.

Offshore—Since no estimates were available, a conservative approach was taken by applying the Shelf Central estimates to this region.

Table 3-13. Density estimates for Atlantic white-sided dolphins by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.466	8.827	58.041	51.358
per 100 NM^2	1.598	30.276	199.075	176.153
GOM Central				
per 100 km^2	0.466	8.827	21.815	16.837
per 100 NM^2	1.598	30.275	74.824	57.751
GOM South				
per 100 km^2	4.912	21.956	13.140	10.700
per 100 NM^2	16.848	75.307	45.070	36.698
Mid-Atlantic				
per 100 km^2	0.410	0.410	0.410	0.410
per 100 NM^2	1.406	1.406	1.405	1.406
Georges West				
per 100 km^2	0.472	19.409	5.789	7.364
per 100 NM^2	1.619	66.571	19.857	25.258
Georges Central				
per 100 km^2	0.472	13.811	10.074	7.364
per 100 NM^2	1.619	47.369	34.551	25.259
Georges East				
per 100 km^2	0.472	23.959	14.819	8.815
per 100 NM^2	1.619	82.176	50.829	30.234
Shelf West				
per 100 km^2	4.811	3.173	0.797	6.448
per 100 NM^2	16.501	10.883	2.734	22.116
Shelf Central				
per 100 km^2	4.811	3.173	0.797	6.448
per 100 NM^2	16.501	10.884	2.734	22.117
Shelf East				
per 100 km^2	4.811	63.311	124.899	6.448
per 100 NM^2	16.501	217.151	428.392	22.116
Offshore				
per 100 km^2	4.811	3.173	0.797	6.448
per 100 NM^2	16.501	10.883	2.734	22.116

- Risso's Dolphin (*Grampus griseus*)

Density estimates by strata

Gulf of Maine—Summer density estimates were provided by the NMFS-NEFSC (Palka 2005). The only stratum during the summer with a density estimate of greater than 0.00 was the GOM Central. The conservative approach was to take into consideration the known occurrence of this species throughout the GOM. Therefore, the seasons and spatial strata were collapsed, and the summer estimate from the GOM Central was applied.

Mid-Atlantic—No density estimates were provided by the NMFS-NEFSC (Palka 2005). The summer estimate for the Mid-Atlantic stratum was calculated from the proportional SPUE calculations using the summer estimate for the adjacent Shelf West stratum. The seasons were collapsed and this estimate was applied.

Georges—The summer estimate was provided by the NMFS-NEFSC for Georges East (Palka 2005). No other estimates were available, and all seasons and spatial strata were collapsed. The summer estimate was applied.

Shelf—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). All other estimates were either calculated or assigned from the proportional SPUE calculations from the summer estimate for the respective spatial stratum. The winter estimate for the Shelf Central was applied to the winter estimate for Shelf East.

- *Shelf East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall and spring estimates were calculated from the proportional SPUE calculations from the summer estimate. The winter estimate for the Shelf Central was applied to the winter estimate for Shelf East.

- *Shelf Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from the proportional SPUE calculations from the summer estimate.

- *Shelf West*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall, winter, and spring estimates were calculated from the proportional SPUE calculations from the summer estimate.

Offshore—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall estimate was calculated from the proportional SPUE calculations from this estimate. The winter and spring estimates were applied from the winter and spring estimates for the adjacent Shelf Central.

Table 3-14. Density estimates for Risso's dolphins by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	6.258	6.258	6.258	6.258
per 100 NM^2	21.464	21.464	21.464	21.464
GOM Central				
per 100 km^2	6.258	6.258	6.258	6.258
per 100 NM^2	21.464	21.464	21.464	21.464
GOM South				
per 100 km^2	6.258	6.258	6.258	6.258
per 100 NM^2	21.464	21.464	21.464	21.464
Mid-Atlantic				
per 100 km^2	3.288	3.288	3.288	3.288
per 100 NM^2	11.278	11.278	11.278	11.278
Georges West				
per 100 km^2	1.663	1.663	1.663	1.663
per 100 NM^2	5.703	5.703	5.703	5.703
Georges Central				
per 100 km^2	1.663	1.663	1.663	1.663
per 100 NM^2	5.703	5.703	5.703	5.703
Georges East				
per 100 km^2	1.663	1.663	1.663	1.663
per 100 NM^2	5.703	5.703	5.703	5.703
Shelf West				
per 100 km^2	7.425	11.021	22.163	13.363
per 100 NM^2	25.468	37.802	76.017	45.833
Shelf Central				
per 100 km^2	0.364	2.843	24.188	1.982
per 100 NM^2	1.250	9.752	82.962	6.798
Shelf East				
per 100 km^2	0.364	1.099	12.853	12.978
per 100 NM^2	1.248	3.769	44.086	44.514
Offshore				
per 100 km^2	0.364	0.284	3.137	6.807
per 100 NM^2	1.248	0.975	10.759	23.346

➢ Pilot Whales (*Globicephala* spp.)

The long-finned pilot whale (*Globicephala melas*) and the short-finned pilot whale (*Globicephala macrorhynchus*) comprise this category. These species can be difficult to distinguish from one another in the field.

Density estimates by strata

Gulf of Maine—Summer estimates were provided for GOM Central and GOM South by the NMFS-NEFSC (Palka 2005). The summer estimate for GOM North was calculated from proportional SPUE calculations based upon the summer estimate for the GOM Central. Other seasonal estimates were either calculated or assigned from proportional SPUE calculations based upon the summer estimate for the respective spatial strata.

- *Gulf of Maine (GOM) North*—The summer estimate for GOM North was calculated from proportional SPUE calculations based upon the summer estimate for the GOM Central. The fall estimate was calculated from the proportional SPUE calculations based on this summer estimate. The winter and spring estimates equal the summer estimate for this stratum.

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Spring and fall estimates were calculated from the proportional SPUE calculations based on this summer estimate. The winter estimate was the average of the estimates for fall and spring.

- *Gulf of Maine (GOM) South*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Winter, spring, and fall estimates were calculated from the proportional SPUE calculations based on this summer estimate.

Mid-Atlantic—No density estimates were provided by the NMFS-NEFSC (Palka 2005). The summer estimate was calculated from the proportional SPUE calculations based on the summer estimate from the adjacent Shelf West. Winter and spring estimates were calculated from the proportional SPUE calculations based on this summer estimate for the Mid-Atlantic. The fall estimate is an average of the winter and spring estimates for this stratum.

Georges—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons and spatial strata were calculated or assigned from proportional SPUE calculations based upon those summer estimates.

- *Georges East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The fall and spring estimates were calculated from the proportional SPUE calculations based on this summer estimate. The winter estimate equals the summer estimate.

- *Georges Central*—The summer estimates was provided by the NMFS-NEFSC (Palka 2005). The fall estimate equals this summer estimate. The winter and spring estimates were calculated from the proportional SPUE calculations based on the summer estimate.

- *Georges West*—A summer density estimate of 0.00 was provided by the NMFS-NEFSC (Palka 2005). Since pilot whales are known occur in this region, this estimate seemed questionable, and a conservative approach to apply the summer estimate from the adjacent Georges Central to both summer and fall for this stratum was used. The winter and spring estimates were calculated from the proportional SPUE calculations based on the summer estimate for the adjacent Georges Central.

Shelf—Summer estimates were provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons and spatial strata were calculated from proportional SPUE calculations based upon these summer estimates.

Offshore—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring estimate was calculated from proportional SPUE calculations based upon the summer estimate. The summer estimate was applied to winter and fall.

Table 3-15. Density estimates for pilot whales by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.106	0.106	0.106	0.032
per 100 NM^2	0.364	0.364	0.365	0.110
GOM Central				
per 100 km^2	2.285	2.290	3.305	2.167
per 100 NM^2	7.837	7.855	11.336	7.434
GOM South				
per 100 km^2	0.176	0.788	4.261	7.757
per 100 NM^2	0.605	2.702	14.615	26.605
Mid-Atlantic				
per 100 km^2	3.348	0.818	0.044	1.696
per 100 NM^2	11.482	2.806	0.152	5.817
Georges West				
per 100 km^2	16.180	75.248	23.365	23.365
per 100 NM^2	55.496	258.095	80.140	80.140
Georges Central				
per 100 km^2	0.218	63.318	23.365	23.365
per 100 NM^2	0.749	217.174	80.141	80.140
Georges East				
per 100 km^2	9.237	17.722	9.237	4.687
per 100 NM^2	31.682	60.785	31.681	16.076
Shelf West				
per 100 km^2	10.278	4.240	3.721	9.725
per 100 NM^2	35.251	14.543	12.764	33.356
Shelf Central				
per 100 km^2	1.850	6.042	3.801	2.463
per 100 NM^2	6.344	20.725	13.037	8.449
Shelf East				
per 100 km^2	1.317	9.289	8.289	3.612
per 100 NM^2	4.516	31.860	28.431	12.387
Offshore				
per 100 km^2	1.169	1.665	1.169	1.169
per 100 NM^2	4.010	5.711	4.011	4.010

➢ Harbor Porpoise (*Phocoena phocoena*)

Density estimates by strata

Gulf of Maine—Summer estimates were provided by the NMFS-NEFSC for GOM North and GOM Central (Palka 2005). The summer estimate for GOM South was calculated proportionately from SPUE values of the summer estimate from the adjacent Georges East provided by the NMFS-NEFSC (Palka 2005). The estimates for the other seasons were calculated from proportional SPUE calculations based upon the summer estimate.

- *Gulf of Maine (GOM) North*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The spring and fall estimates were based on proportional SPUE calculations based upon this summer estimate. The winter estimate was an average of the spring and fall estimates.

- *Gulf of Maine (GOM) Central*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). Fall, winter, and spring estimates were based on proportional SPUE calculations based upon this summer estimate.

- *Gulf of Maine (GOM) South*—The summer estimate for GOM South was based on proportional SPUE calculations of the summer estimate from the adjacent Georges East. The fall, winter, and spring estimates were based on proportional SPUE calculations based upon this summer estimate.

Mid-Atlantic—No seasonal density estimates for this stratum were available from the NMFS-NEFSC (Palka 2005). The harbor porpoise does not commonly occur in this stratum during the summer, therefore the estimate of 0.00 is reasonable. Winter and spring estimates were based on the spring estimate from the adjacent Georges West. The fall estimate is an average of the winter and summer estimates for this stratum.

Georges—The only summer estimate provided by the NMFS-NEFSC (Palka 2005) was for Georges East. The estimates for the other seasons and spatial strata were calculated proportionately from SPUE values based upon the summer estimate.

- *Georges East*—The summer estimate was provided by the NMFS-NEFSC (Palka 2005). The winter and spring estimates were calculated proportionately from SPUE values based upon the summer estimate. The fall estimate was an average of winter and summer estimates.

- *Georges Central*—The winter and summer estimates were calculated proportionately from SPUE values based upon the summer estimate for Georges East provided by the NMFS-NEFSC (Palka 2005). The fall estimate was an average of winter and summer estimates.

- *Georges West*—All estimates were calculated proportionately from SPUE values based upon the summer estimate for Georges East provided by the NMFS-NEFSC (Palka 2005).

Shelf—Seasons and spatial strata were collapsed. The summer estimate from Shelf East was applied.

Offshore—Seasons were collapsed and the summer estimate from Shelf East was applied.

Table 3-16. Density estimates for harbor porpoises by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	48.900	24.313	205.493	73.569
per 100 NM^2	167.722	83.391	704.823	252.335
GOM Central				
per 100 km^2	1.036	5.260	45.350	5.782
per 100 NM^2	3.553	18.042	155.546	19.830
GOM South				
per 100 km^2	18.359	34.955	8.920	6.591
per 100 NM^2	62.970	119.892	30.594	22.608
Mid-Atlantic				
per 100 km^2	6.404	19.895	0.000	3.200
per 100 NM^2	21.965	68.237	0.000	10.976
Georges West				
per 100 km^2	11.924	37.041	3.152	0.957
per 100 NM^2	40.896	127.048	10.811	3.284
Georges Central				
per 100 km^2	5.256	29.252	3.441	4.400
per 100 NM^2	18.029	100.331	11.801	15.092
Georges East				
per 100 km^2	2.029	88.105	5.571	3.800
per 100 NM^2	6.958	302.191	19.108	13.034
Shelf West				
per 100 km^2	0.700	0.700	0.700	0.700
per 100 NM^2	2.401	2.401	2.401	2.401
Shelf Central				
per 100 km^2	0.700	0.700	0.700	0.700
per 100 NM^2	2.401	2.401	2.401	2.401
Shelf East				
per 100 km^2	0.700	0.700	0.700	0.700
per 100 NM^2	2.401	2.401	2.401	2.401
Offshore				
per 100 km^2	0.700	0.700	0.700	0.700
per 100 NM^2	2.401	2.401	2.401	2.401

3.2 PINNIPEDS

The density estimates for the pinnipeds were derived for the summer from the 2003 marine mammal stock assessment (Waring et al. 2004) and distributed amongst the remaining seasons using the SPUE values from the NE MRA (DoN 2005). However, as with the cetaceans, there were instances where this method was not possible either due to a lack of SPUE values to assign the density estimates or to the absence of a density estimate for an area and season in which the pinniped is know to occur. Following is a description of how these cases were handled according to species and strata:

➢ <u>Gray Seal</u> (*Halichoerus grypus*)

Density estimates by strata

No density estimates were provided by the NMFS-NEFSC (Palka 2005). Estimates provided below are SAR-derived and based on spring and summer abundance estimates found in the NOAA SAR (Waring et al. 2004) and applied to appropriate strata.

<u>Gulf of Maine</u>—The gray seal can be found year-round on the continental shelf in the GOM. Density estimates were SAR-derived and based on spring abundance estimates found in Waring et al. (2004).

- *Gulf of Maine (GOM) North*—Seasons were collapsed. The densities for summer, fall, and winter are SAR-derived and based on the spring abundance estimate in the NOAA SAR (Waring et al. 2004).

- *Gulf of Maine (GOM) Central*—Seasons were collapsed. The densities for summer, fall, and winter are SAR-derived and based on the spring abundance estimate in the NOAA SAR (Waring et al. 2004).

- *Gulf of Maine (GOM) South*—Seasons were collapsed. The densities for summer, fall, and winter are SAR-derived and based on the spring abundance estimate in the NOAA SAR (Waring et al. 2004).

<u>Mid-Atlantic</u>—The gray seal rarely occurs in this region.

<u>Georges</u>—Density estimates were SAR-derived and based on spring abundance estimates found in Waring et al. (2004). Seasons and spatial strata were collapsed.

<u>Shelf</u>—The gray seal rarely occurs in this region.

<u>Offshore</u>—The gray seal rarely occurs in this region.

Table 3-17. Density estimates for gray seals by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	2.519	2.519	2.519	2.519
per 100 NM^2	8.641	8.641	8.641	8.641
GOM Central				
per 100 km^2	2.519	2.519	2.519	2.519
per 100 NM^2	8.641	8.641	8.641	8.641
GOM South				
per 100 km^2	8.733	8.733	8.733	8.733
per 100 NM^2	29.953	29.953	29.953	29.953
Mid-Atlantic				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Georges West				
per 100 km^2	8.733	8.733	8.733	8.733
per 100 NM^2	29.953	29.953	29.953	29.953
Georges Central				
per 100 km^2	8.733	8.733	8.733	8.733
per 100 NM^2	29.953	29.953	29.953	29.953
Georges East				
per 100 km^2	8.733	8.733	8.733	8.733
per 100 NM^2	29.953	29.953	29.953	29.953
Shelf West				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Shelf Central				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Shelf East				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Offshore				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000

- Harbor Seal (*Phoca vitulina*)

Density estimates by strata

No density estimates were provided by the NMFS-NEFSC (Palka 2005). Estimates provided below are SAR-derived and based on spring and summer abundance estimates found in the NOAA SAR (Waring et al. 2004) and applied to appropriate strata.

Gulf of Maine—The harbor seal is a year-round resident of eastern Canada and coastal Maine. Density estimates were SAR-derived and based on spring and summer abundance estimates found in Waring et al. (2004). Seasons and spatial strata were collapsed.

Mid-Atlantic—The harbor seal is concentrated further north in the GOM region. Since about 1994, increasing numbers (primarily, subadults) are occupying a northern New Jersey haulout site during late fall through late spring (Slocum et al. 1999); however, this habitat is considered to be suboptimal for the species as a whole. Consequently, no density estimates are provided for this stratum during any season.

Georges—The harbor seal is a year-round resident of eastern Canada and coastal Maine. Density estimates were SAR-derived and based on spring and summer abundance estimates found in Waring et al. (2004). Seasons and spatial strata were collapsed.

Shelf—The harbor seal prefers more shallow waters than the Shelf region.

Offshore—The harbor seal prefers more shallow waters than the Offshore region.

Table 3-18. Density estimates for harbor seals by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
GOM Central				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
GOM South				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
Mid-Atlantic				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
Georges West				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
Georges Central				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
Georges East				
per 100 km^2	156.409	156.409	156.409	156.409
per 100 NM^2	536.468	536.468	536.468	536.468
Shelf West				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Shelf Central				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Shelf East				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000
Offshore				
per 100 km^2	0.000	0.000	0.000	0.000
per 100 NM^2	0.000	0.000	0.000	0.000

3.3 SEA TURTLES

All sea turtle species are listed as threatened or endangered under the ESA.

The NMFS-NEFSC provided density estimates for only the Kemp's ridley, leatherback, and loggerhead sea turtles. The estimates are based on the NMFS-NEFSC 1998 aerial survey (Palka et al. 2005).

- Kemp's Ridley Turtle (*Lepidochelys kempii*)

  Density estimates by strata

  All seasons and spatial strata were collapsed. The summer estimate provided by the NMFS-NEFSC (Palka et al. 2005) was applied.

Table 3-19. Density estimates for Kemp's ridley turtles by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
GOM Central				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
GOM South				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Mid-Atlantic				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Georges West				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Georges Central				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Georges East				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Shelf West				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Shelf Central				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Shelf East				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607
Offshore				
per 100 km^2	0.760	0.760	0.760	0.760
per 100 NM^2	2.607	2.607	2.607	2.607

➢ Leatherback Turtle (*Dermochelys coriacea*)

Density estimates by strata

All seasons and spatial strata were collapsed. The summer estimate provided by the NMFS-NEFSC (Palka et al. 2005) was applied.

Table 3-20. Density estimates for leatherback turtles by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
GOM Central				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
GOM South				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Mid-Atlantic				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Georges West				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Georges Central				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Georges East				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Shelf West				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Shelf Central				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Shelf East				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338
Offshore				
per 100 km^2	0.390	0.390	0.390	0.390
per 100 NM^2	1.338	1.338	1.338	1.338

➢ Loggerhead Turtle (*Caretta caretta*)

Density estimates by strata

All seasons and spatial strata were collapsed. The summer estimate provided by the NMFS-NEFSC (Palka et al. 2005) was applied.

Table 3-21. Density estimates for loggerhead turtles by spatial strata and season.

	Season			
Stratum/Density	**Winter**	**Spring**	**Summer**	**Fall**
GOM North				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
GOM Central				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
GOM South				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Mid-Atlantic				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Georges West				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Georges Central				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Georges East				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Shelf West				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Shelf Central				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Shelf East				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894
Offshore				
per 100 km^2	2.010	2.010	2.010	2.010
per 100 NM^2	6.894	6.894	6.894	6.894

This page intentionally left blank