U.S. Navy Marine Species Density Database Phase III for the Atlantic Fleet Training and Testing Area

Final Technical Report

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U.S. Navy Marine Species Density Database Phase III for the Atlantic Fleet Training and Testing Area

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Final Technical Report

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EXECUTIVE SUMMARY

The purpose of the United States (U.S.) Navy's Marine Species Density Database (NMSDD) Technical Report is to document the process used to derive density estimates for marine mammal and sea turtle species occurring in the Atlantic Fleet Training and Testing (AFTT) Study Area, and to provide a summary of species-specific and area-specific density estimates incorporated into the NMSDD. The following discussion summarizes improvements that have been made in the density estimation process for Phase III of the Navy's Tactical Training Theater Assessment and Planning Program (TAP) process. The availability of additional systematic survey data as well as improvements to habitat modeling methods used to estimate species density have resulted in substantial improvements to the NMSDD Phase III as summarized below.

East Coast. New survey data (relative to density models used in TAP Phase II) incorporated into density models included the following: North Atlantic Right Whale Surveys (aerial, updated years), New Jersey Department of Environmental Protection environmental baseline aerial and shipboard surveys, University of North Carolina Wilmington (UNCW) aerial surveys sponsored by the Navy, and Virginia Aquarium and Marine Science Center Virginia Wind Energy Area aerial surveys. The additional sightings data, particularly the non-summer sightings from the UNCW surveys, allowed for finer scale temporal prediction and more species models than the previous generation of models. Models for all taxa regularly present off the East Coast of the U.S. were produced, whereas five taxa were excluded in the previous generation of models. Additionally, fewer stratified models were utilized thanks to more sightings of species. Methodological improvements were incorporated as well, including a new framework for pooling detection functions for disparate surveys based on survey platform similarity, updated covariates for density spatial models, restricted maximum likelihood optimization of covariates to aid selection, and a comparison of models produced using both contemporaneous and climatological covariates.

Gulf of Mexico. No new survey data were available in the Gulf of Mexico relative to the last generation of models. However, all the methodological updates applied to the East Coast stratum were applied to the Gulf of Mexico resulting in important updates to species present there.

Broader AFTT. A completely new set of models were generated for the broader AFTT stratum, outside of the U.S. Exclusive Economic Zone (EEZ), which is largely unsurveyed. The models relied on all the new and old survey data from the East Coast and Gulf of Mexico, as well as incorporated shipboard and aerial surveys from the Caribbean, shipboard surveys from the European Atlantic, and a shipboard survey from the mid-Atlantic Ridge. These additional surveys provided additional sightings data, and allowed for extrapolative models to be fit to multiple regions within a species range. These models were kept parsimonious in order to avoid over-prediction where surveys had not occurred while closely linking these models to data within or near the region of interest. Where possible, methodological improvements from models in surveyed regions were carried over. These models were produced for all taxa regularly found in the East Coast and Gulf of Mexico and represent a significant improvement over global scale relative environmental suitability (RES) models. This allowed for the replacement of almost all global scale RES models, which in the past have performed poorly at regional and sub-regional scales.

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ACRONYMS AND ABBREVIATIONS

°	degree
AFTT	Atlantic Fleet Training and Testing
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AOR	Areas of Responsibility
CI	confidence interval
CREEM	Center for Research into Ecological & Environmental Modelling
CV	coefficient of variation
EEZ	Economic Exclusion Zone
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
GAM	Generalized Additive Model

GIS	Geographic Information System
GOM	Gulf of Mexico
HIS	Habitat Suitability Index
ICW	Inter Coastal Waterway
km	kilometer(s)
km^2	square kilometer(s)
LSJR	Lower Saint Johns River
MMPA	Marine Mammal Protection Act
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMSDD	Navy Marine Species Density Database
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy OPAREA Density Estimates
NUWC	Naval Undersea Warfare Center
OPARAEA	Operating Area
RES	relative environmental suitability
SAR	stock assessment report
SD	standard deviation
SEFSC	Southeast Fisheries Science Center
SMRU	Sea Mammal Research Unit
SMRU Ltd.	Sea Mammal Research Unit Limited
SST	sea surface temperature
SYSCOMS	Systems Commands

TAP	Tactical Training Theater Assessment and Planning Program
U.S.	United States
UNCW	University of North Carolina Wilmington

1 BACKGROUND

To ensure compliance with United States (U.S.) regulations including the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the National Environmental Policy Act (NEPA), and Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions), the U.S. Navy (Navy) takes responsibility for reviewing and evaluating the potential environmental impacts of conducting at-sea training and testing. All marine mammals in the U.S. are protected under the MMPA, and some species receive additional protection under the ESA. As stipulated by the MMPA and ESA, information on the species and numbers of protected marine species is required in order to estimate the number of animals that might be affected by a specific activity. The Navy performs quantitative analyses to estimate the number of marine mammals and sea turtles that could be affected by at-sea training and testing activities. A key element of this quantitative impact analysis is knowledge of the abundance and concentration (density) of the species in specific areas where those activities will occur. The most appropriate unit of metric for this type of analysis is density, which is the number of animals present per unit area. This report includes a description of the currently available density data used in the quantitative impact analysis for each marine mammal and sea turtle species present in the Atlantic Fleet Training and Testing (AFTT) Study Area. Phase III is the third implementation of the Navy's Tactical Training Theater Assessment and Planning Program (TAP). TAP is a comprehensive, integrated process to preserve access to and use of Navy training ranges, testing ranges, and operating areas by addressing encroachment and environmental compliance issues.

A significant amount of effort is required to collect and analyze survey data in order to produce a marine species density estimate. Unlike surveys for terrestrial wildlife, many marine species spend much of their time submerged, and are not easily observed on the surface. Therefore the computed density of marine species must also take into account an estimate of the number of animals likely to be present but not observed, as compared to the animals that are actually spotted on these surveys. The uncertainty of such estimates decreases with an increasing number of observations. In order to collect enough sighting data to make reasonable density estimates, multiple observations are required, often in areas that are not easily accessible (e.g., far offshore). The National Marine Fisheries Service (NMFS) is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Economic Exclusion Zone (EEZ). Other independent researchers often publish density data or data that can be used to calculate densities for key species in specific areas of interest. For example, manatee abundance data is collected by state agencies. The amount of effort required to estimate density for the Navy's Areas of Responsibility (AOR) is beyond the scope of any single organization or beyond any feasible means for the Navy to collect the amount of data required to support. Therefore, the Navy compiled existing, publically available density data, as well as supporting density model development for use in the quantitative acoustic impact analysis.

For most cetacean and sea turtle species, abundance is estimated using line-transect surveys or mark-recapture studies (e.g., Barlow and Forney 2007; Calambokidis et al. 2008; Barlow 2010). These methods usually produce a single value for density that is an averaged estimate across very large geographical areas, such as waters within the U.S. EEZ (referred to as a "uniform" density estimate). This is the general approach applied in estimating cetacean abundance in the NMFS stock assessment reports (SARs). The disadvantage of these methods is that it does not provide information on varied concentrations of species in sub-regions of these very large areas, and does not estimate density for other seasons or timeframes that were not surveyed. More recently, a newer method called spatial habitat modeling has been used to estimate cetacean densities that address some of these shortcomings (e.g., Ferguson et al. 2006; Redfern et al. 2006; Barlow et al. 2009; Becker et al. 2010, 2012a, 2014, 2016; Forney et al. 2012, 2015) (Note that spatial habitat models are also referred to as “species distribution models” or “habitat-based density models”). These models estimate density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus within the study area that was modeled, densities can be predicted at all locations where these habitat variables can be measured or estimated. Spatial habitat models therefore allow estimates of cetacean densities on finer scales than traditional line-transect or mark-recapture analyses.

Uncertainty in published density estimates is typically large because of the low number of sightings available for their derivation. Uncertainty is typically expressed by the coefficient of variation of the estimate, which is derived using standard statistical methods and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. When the coefficient of variation exceeds 1.0, the estimate is very uncertain. For example, a coefficient of variation of 0.85 would indicate high uncertainty in the population estimate. The coefficient of variation does not capture the full extent of uncertainty in an estimate. For example, since cetacean distributions often shift in response to oceanic variability (Becker et al. 2012a), the uncertainty associated with movements of animals into or out of an area due to changing environmental conditions is much larger than is indicated by the coefficient of variation.

The methods used to estimate pinniped densities may differ from those used for cetaceans, particularly in inland waters, because pinnipeds are not limited to the water and spend a significant amount of time on land (e.g., at rookeries). Pinniped abundance is generally estimated via shore counts of animals on land at known haul-out sites or by counting number of pups weaned at rookeries and applying a correction factor to estimate the abundance of the population. Estimating in-water densities from land-based counts is difficult given the variability in foraging ranges, migration, and haul-out behavior between species and within each species, and is driven by factors such as age class, sex class, breeding cycles, and seasonal variation. Data such as age class, sex class, and seasonal variation can be used in conjunction with abundance estimates from known haul-out sites to assign an in-water abundance estimate for a given area. The total abundance divided by the area of the region provides a representative in-water density estimate for each species in inland waters, which enables analyses of in-water stressors resulting from at-sea Navy testing or training activities. Most areas in AFTT are offshore areas. As such, a habitat-based density model derived from line-transect data is used, as opposed to haul-out counts and telemetry data which are more appropriate in areas constrained by land and close to haul-out sites.

Ideally, density data would be available for all species for all areas in all seasons of the year, in order to best estimate the impacts of Navy activities on marine species. However, in many places poor weather conditions and high sea states prevent the completion of comprehensive year-round surveys. Even with surveys that are completed, poor conditions may result in lower sighting rates for species that would typically be sighted with greater frequency under favorable conditions. Lower sighting rates preclude having an acceptably low uncertainty in the density estimates. A high level of uncertainty, indicating a low level of confidence in the density estimate, is typically the case for species that are rare or difficult to sight. In areas where survey data are limited or non-existent, known or inferred associations between marine habitat features and (the likelihood of) the presence of specific species are sometimes used to predict densities in the absence of actual animal sightings. Consequently, there is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, to characterize marine species density for large oceanic regions such as the Navy's study areas, the Navy needed to review, critically assess, and prioritize existing density estimates from multiple sources, requiring the development of a systematic method for selecting the most appropriate density estimate for each combination of species, area, and season. The resulting compilation and structure of the selected marine species density data resulted in the Navy Marine Species Density Database (NMSDD).

Uncertainty as used here is an indication of variation in an estimate that is unique to each data source and is dependent on how the values were derived. Each source of data may use different methods to estimate density, of which, uncertainty in the estimate can be directly related to the method applied. Uncertainty in published density estimates is typically large because of the low number of sightings collected during large survey efforts. Uncertainty characterization is an important consideration in marine mammal and sea turtle density estimation and some methods inherently result in greater uncertainty than others. Therefore, in selecting the best density estimate for a species, area, and time, it is important to select the data source that used a method that provides the most certainty for the geographic area.

The next section provides a summary of the protocol that the Navy developed to evaluate possible density data sources, compare data sources to each other, and to provide guidance on the most appropriate density data source to use in Navy study areas. For the AFTT Study Area, these data are compiled by Naval Facilities Engineering Command Atlantic (NAVFAC) into the NMSDD and are used for Navy acoustic effects analysis. The Navy compiled the first version of the NMSDD and published a final report describing the density data used in the "Phase II" AFTT Environmental Impact Statement (EIS) quantitative impact analysis for each marine mammal and sea turtle species present in the AFTT Study Area. This report provides an update on the data used in the same area for the "Phase III" AFTT EIS analysis.

2 NAVY MARINE SPECIES DENSTIY DATABASE (NMSDD) OVERARCHING PROTOCOL AND GUIDANCE

2.1 DENSITY ESTIMATION METHODS AND RELATIVE UNCERTAINTY BASED ON METHODS APPLIED

For every region and species there is a broad range of data that the Navy evaluated in order to select the best available density values for incorporation into the NMSDD. Assessing the quality of the data available and their associated level of uncertainty was key to the Navy's approach for selecting the best sources of marine species density data, as described below.

Marine species density is the number of individuals that are present per unit area, typically per square kilometer. Density estimation of marine species, in particular, marine mammals and sea turtles, is very difficult to do because of the large amount of survey effort required, often spanning several years, and the resulting low number of sightings observed. ”Distance sampling” describes methods that are used to estimate the density or abundance of biological populations given the assumption that many of the target species will not be detected during a survey (Buckland et al. 2001). The most common type of “distance sampling” is line-transect sampling, which characterizes the probability of visually detecting an animal or group of animals from a survey transect line to quantify and estimate the number of individuals missed. The result provides one single density estimate value, for each species, for the entire survey coverage extent, and usually represents a specific timeframe or season. This is the general method applied in estimating marine mammal abundance (number of individuals in a defined area) in the NMFS SARs. Though the single value provides a good average estimate of abundance (total number of individuals) for a specified area, it does not provide information of the species distribution or concentrations within that area, and does not estimate density for other timeframes/seasons that were not surveyed.

To quantify how the species' density estimates varies geographically requires breaking up the survey effort into smaller segments. There are several methods that can be applied to accomplish this and each will affect the uncertainty in the estimate differently. Three commonly used methods of density estimation using direct survey sighting data and distance sampling theory are considered here: (1) They are designed-based density estimates, (2) stratified-designed based density estimates, and (3) spatial models. Another suite of models, RES models (also known as Environmental Envelope or Habitat Suitability Index models), use known or inferred habitat associations to predict densities, typically in areas where direct survey sighting data are limited or non-existent. In some cases, extrapolation from neighboring regional density estimates or population/stock assessments into areas with no density estimates is appropriate based on expert opinion. In many cases, this may be preferred over using RES models because of discrepancies identified by local expert knowledge, and results in more certainty in the extrapolated estimates. This includes an extrapolation of no occurrence based on other sources of data, such as the NMFS SARs or expert judgment. Extrapolation of nearby density models into unsurveyed regions is another option that may perform better than global scale RES models as this type of extrapolation is closely linked to nearby survey data. Following is a short summary of each of the density estimation methods.

Designed-Based Density Estimate

One example of designed-based density estimation uses line-transect survey data and usually involves distance sampling theory (Buckland et al. 2001) to estimate density for the entire survey extent (strata). Systematic line-transect surveys can be conducted from both ships and aircraft; however, the time period available for sighting an animal is much shorter for aerial surveys as compared to ship surveys, and therefore more aerial survey effort may be required in order to obtain enough sightings to estimate densities. Conversely, aerial surveys can cover a much larger area in a shorter period of time than ship surveys. Line-transect methods can also rely on passive acoustic detections of animals typically obtained from a towed hydrophone during a concurrent visual survey (e.g., Barlow and Taylor 2005). Line-transect surveys are typically designed from the ground up with intent to survey and estimate density for a specific geographic area, hence the term "designed-based." This is the method of abundance estimation typically used for the NMFS marine mammal SARs. Values in the literature may be reported as abundance for the survey area, for which a density estimate can be inferred if the area is specified.

Stratified Design-Based Density Models

Stratified density estimates use the same survey data and methods as the designed-based method, but the study area is stratified into sub-regions and densities estimated are specific to each sub-region. The advantage of this method is that geographically stratified density estimates provide a better indication of a species' distribution within the study area, because it generates one density estimate for each stratum. The disadvantage is that the uncertainty is typically high compared to the designed-based estimate because each sub-region estimate is based on a smaller stratified segment of the overall survey effort. For impact assessments that are geographically specific, the benefits of understanding the species geographic variability generally outweighs the increased uncertainty in the estimate.

Spatial Models

This method of density estimation yields the best value estimation with the least uncertainty and is the preferred data source when available. Spatial models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature [SST], seafloor depth, etc.) and thus allow density predictions on finer spatial scales than designed-based or stratified designed-based methods. Spatial density models, also referred to as 'species distribution models' or 'habitat-based density models', are developed using line-transect survey data collected in accordance with NMFS protocol and standards, and density estimates derived for divided segments in accordance with distance sampling theory (Buckland et al. 2001). These segments are fitted to environmental explanatory variables typically using a Generalized Additive Model (GAM). The advantage of this method is that the resulting density estimate is spatially defined, typically at the resolution of the environmental data used for model development, and thus shows variation in species density and distribution. For geographically specific impacts assessment, this is the most preferred method of density estimation. This is the method applied for the majority of the species in the Roberts et al. (2016) and Navy OPAREA Density Estimates (NODE) models used in the AFTT study area.

Density Based on Relative Environmental Suitability Models

The three methods described above estimate density directly from survey sighting data in conjunction with distance sampling theory. However, the majority of the world's oceans have not been surveyed in a manner that supports quantifiable density estimation of marine mammals and sea turtles. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and (the likelihood of) the presence of specific species have been used to predict densities using model-based approaches. These habitat suitability models include RES models. Habitat suitability models can be used to understand the possible extent and relative expected concentration of a marine species distribution. These models are derived from an assessment of the species occurrence in association with evaluated environmental explanatory variables that results in defining the RES suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated for each RES value based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed.

Two recognized methods and sources of density estimation for marine mammals are considered here: the Kaschner et al. (2006) global density estimates and the Sea Mammal Research Unit, Limited at University of St. Andrews (SMRU Ltd.) global density estimates (SMRU Ltd, 2012), hereafter referred to as the Kaschner et al. RES model or Kaschner et al. marine mammal density models, and the SMRU Ltd. model. The SMRU Ltd. model is ranked higher than the Kaschner et al. model because the SMRU Ltd. version used separately derived population abundance estimates to constrain the global density estimates from the RES model. Given that uncertainty is very high, results can substantially diverge from adjacent empirically-based results (or do not correspond to densities measured from surveyed areas), this method of density estimation is the least preferred type of data source.

Density Based on Extrapolative Models

Estimating cetacean densities using extrapolative models generally involves predicting beyond surveyed regions (geographical extrapolation) and, in some cases, predicting beyond the range of environmental covariates sampled within the surveyed areas; this second type of ‘environmental’ extrapolation is more speculative (Mannocci et al. 2016). To increase the reliability of extrapolations in the area, survey data from various regions may be incorporated and carefully selected candidate environmental covariates are used to develop parsimonious habitat models. To reduce the amount of environmental extrapolation, candidate environmental covariates with a broad range of values covered by the surveys (e.g., avoiding distances from the coast or isobaths) are selected.

In many cases it may be more appropriate to extrapolate models from surveyed regions than use RES models. These extrapolative models are more closely linked to regional survey areas and may predict more realistic distribution and abundances than global models, though there is no assumed cap on abundance when performing the extrapolation. This could lead to overestimation of animals or a prediction of animals outside their normal range if similar environmental conditions exist in the surveys areas than the extrapolation is based on.

A note on mean densities and uncertainty

The Navy is required to use best available science in support of its analyses and strives to accurately characterize the size and scope of its potential environmental impacts. The current convention in density modeling is to report the mean abundance estimate produced by a model as well as some associated uncertainty value. Uncertainty values commonly take the form of coefficient of variation (CV), confidence interval (CI), standard deviation (SD), and qualitative measures, though others are available.

It has been suggested by public reviewers that the Navy account for uncertainty explicitly in its effect analysis. In the case of density models, a suggestion put forth as an example was to use the upper 95%

confidence limit of a model's predicted abundance as a conservative measure for estimating takes. The Navy feels that this is at odds with the use of best available science as this is not how species abundance is reported by resource agencies (which would misrepresent the proportion of Navy takes relative to a species' population size) and a mean value is generally considered to be the 'best' or most likely estimate of how many animals are present in a given population. As such, mean predicted abundances are used and reported here, unless otherwise noted, so as to not mischaracterize the scope of the Navy's impacts.

While uncertainty is an important consideration in assessing environmental consequences, simply taking the highest population estimate and using it as the basis to model takes is an unrealistic approach to generating takes and distorts the ratio of takes to population, given how population abundance is reported by trustee agencies (e.g. SARs). Additionally, using a conservatively high population estimate is not how the NMFS approaches take authorizations for other consultations. For the Navy's analysis, uncertainty is taken into consideration by using the uncertainty in a density model to perform the take analysis many times over a range of possible density estimates around the mean, akin to bootstrapping, to generate a mean estimate of takes. See the Navy Acoustic Effects Model technical report (DON 2017) for details on how the Navy estimates takes from animal density models.

2.2 OVERARCHING NMSDD DATA SOURCE SELECTION AND IMPLEMENTATION GUIDELINES

It is important to consider that even the best estimate of marine species density is really a model representation of the values of concentration where these animals might occur. Each model is limited to the variables and assumptions considered by the original data source provider. No mathematical model representation of any biological population is perfect and with regards to marine species biodiversity, any single model method will not completely explain the actual distribution and abundance of marine mammal species. It is expected that there would be anomalies in the results that need to be evaluated, with independent information for each case, to support if we might accept or reject a model or portions of the model.

The methods used to develop the density estimate directly affect the level of inherent uncertainty in the estimate. For example, if the density estimate for a geographic area is based on sighting data from a direct survey effort, the inherent uncertainty is comparatively low when compared to a RES-based estimate for a geographic area that has never been surveyed. It is important to understand that marine species surveys are often conducted during one or two seasons because the winter weather conditions can be too harsh to survey in many places. Therefore, one method of survey may provide a better density estimate for one season and possibly result in selecting a density estimate from another method for the other seasons. Understanding these methods and how they affect the quality of the resulting density estimate is important when making an informed decision about which species specific estimates are incorporated into the NMSDD for each geographic area and season.

2.2.1 NMSDD HIERARCHICAL APPROACH FOR RANKING DENSITY ESTIMATES

Some methods of density estimation can produce a more accurate estimate with decreased uncertainty. Therefore, when there are multiple data sources available, the data selection process can be driven largely by: 1) spatial resolution and 2) uncertainty in the estimate. Generally, a more recent estimate using a preferred methodology is used over an older estimate. **Figure 2-1** depicts how the ranking and data selection can be organized. Here is a ranking of density modeling methods:

A) Density estimates from spatial models will be used when available.

- For the U.S. EEZ on the East Coast and in the Gulf of Mexico, models produced by Roberts et al. (2016) are preferred.

- For species not covered by the Roberts et al. (2016) models, older NODE density estimates could be used.

B) If no density estimates from spatial models are available, the following can be used in order of preference:

1) Density estimates using design-based methods incorporating line-transect survey data and involving spatial stratification (e.g., estimates split by depth strata or survey sub-regions). Although stratified designed-based estimates typically have higher uncertainty due to fewer sightings available for the smaller strata, geographically stratified density estimates provide a better indication of a species' distribution within the study area.

2) Density estimates using design-based methods incorporating only line-transect survey data (i.e. regional density estimate, SAR)

3) Density estimates extrapolated (geographically or environmentally) from nearby surveyed areas, primarily from Mannocci et al. (2016) in the areas of the AFTT study area outside the U.S. EEZ.

4) Density estimates derived using a RES model in conjunction with survey data from SMRU Ltd. (primary) or in conjunction with a global population estimate from Kaschner's density data.

C) In some cases, extrapolation of values from neighboring regional density estimates or population/stock assessments into areas with no density estimates (or only estimates from RES models) is appropriate based on expert opinion. In many cases this may be preferred over using RES models because of discrepancies identified by local expert knowledge. It is important to distinguish between extrapolation and extrapolative models. Extrapolative density models estimate density in an unsurveyed areas based on relationships to environmental covariates in a surveyed region, creating a new prediction in the unsurveyed region. The extrapolations referenced here simply carry values from one area into another with no modeling process involved and there can be no estimation of uncertainty, making extrapolative models preferable.

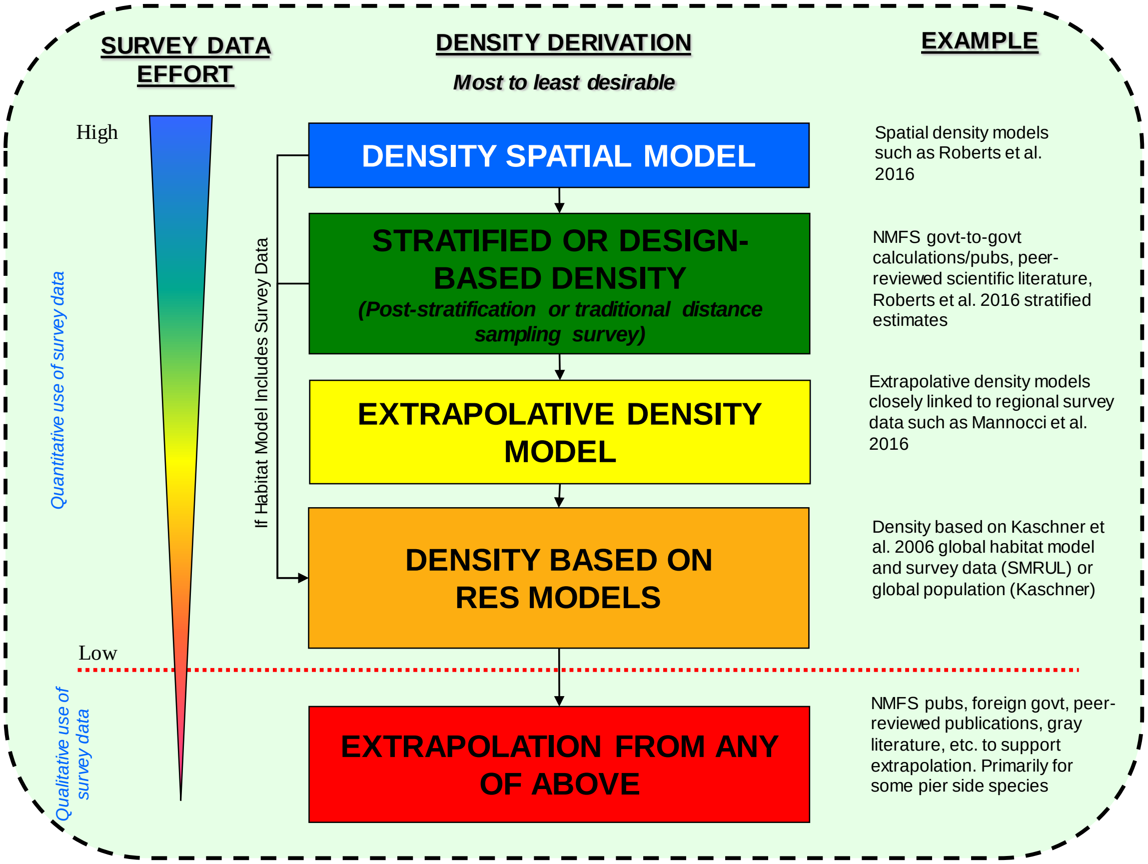


Figure 2-1 Graphical depiction of methods for density data derivation and how they rank in guilding in the determination of what density data to include in the NMSDD.

2.2.2 NMSDD DENSITY DATA COMPILATION AND INTEGRATION

The density data for input to the Navy effects analysis model is compiled and centrally managed for inclusion in Navy modeling at NAVFAC Atlantic and made publically available via web services from Duke University at https://seamap.env.duke.edu/models.

In an effort to coordinate across the Navy's OPAREAs and establish a consistent approach to select the best available density estimates, data for each species is compiled to include the best available estimate of density for each specific area by season using the hierarchical approached outlined in **Figure 2-1** as a guideline for selection.

For example, the density data file for fin whale (*Balaenoptera physalus*) in the Atlantic during June:

Density data sources are ranked in order based on the methods outlined in ***Section 2.2.1*** *and* ***Figure 2-1****. They are:*

1) *Roberts et al. (2016) density spatial model in the U.S. Atlantic EEZ*
2) *Roberts et al. (2016) stratified density estimates in the U.S. Gulf of Mexico EEZ*

3) *Mannocci et al. (2016) extrapolative density spatial model everywhere else*

The resulting density data file in **Figure 2-2** shows the designated geographic location of density integrated from sources chosen. Since the density spatial model is more desirable, for the geographic area where it is available, these data are used in lieu of the extrapolative density model for this species and month. Using a Geographic Information System (GIS), the data are stitched together using the most appropriate source to create a continuous layer of density estimates covering the entire AFTT study area. This ensures that there is only one representative density value for each geographic location. The results are species specific density data files that are compilations of density data from potentially multiple sources, defined seasonally where possible, and that provide a single density value for each geographic area of interest.

The numerical values from each source were used as given by the provider and were not modified, preserving the original value. The only exception is any modification by deletion if it was deemed that the predicted distribution of the density values did not match with what is expected based on NMFS survey effort.

If species specific density data are not available, the density value of a surrogate species or season can be used as a proxy value. A surrogate species is a species with similar morphology, behavior, and habitat preferences. A surrogate season is a season that best represents the expected distribution and density for that species.

In some cases, ambiguous sightings or difficult to distinguish species (e.g., beak whales) resulted in species being modeled as a combined guild. For example, all beaked whale sightings in the AFTT Study Area are combined into a single guild and, therefore a single density model for all species present in the study area. See **Table 3-1** for a detailed breakdown of which species were modeled as guilds. Outputs from the Navy acoustic effects analysis are analyzed post hoc to partition effects to individual species. This is discussed in the Navy Acoustic Effects Analysis Technical Report (DON 2017).

The Navy Fleets and Systems Commands (SYSCOMS) are each responsible for seeking and acquiring the best available density data for their AOR and providing the data in an ArcGIS compatible format with associated metadata for inclusion into the master Atlantic and Pacific datasets. There is continual coordination between Pacific Fleet, Atlantic Fleet, and SYSCOMS to ensure consistency between regional environmental analyses (e.g., Pacific and Atlantic EISs) and commands across the Navy. The Navy Fleets and SYSCOMS are each responsible for developing the supporting documentation on the methods of implementation for data included in the NMSDD. The Navy invests directly in the development of density models such as those produced in Roberts et al. (2016) and Mannocci et al. (2016).

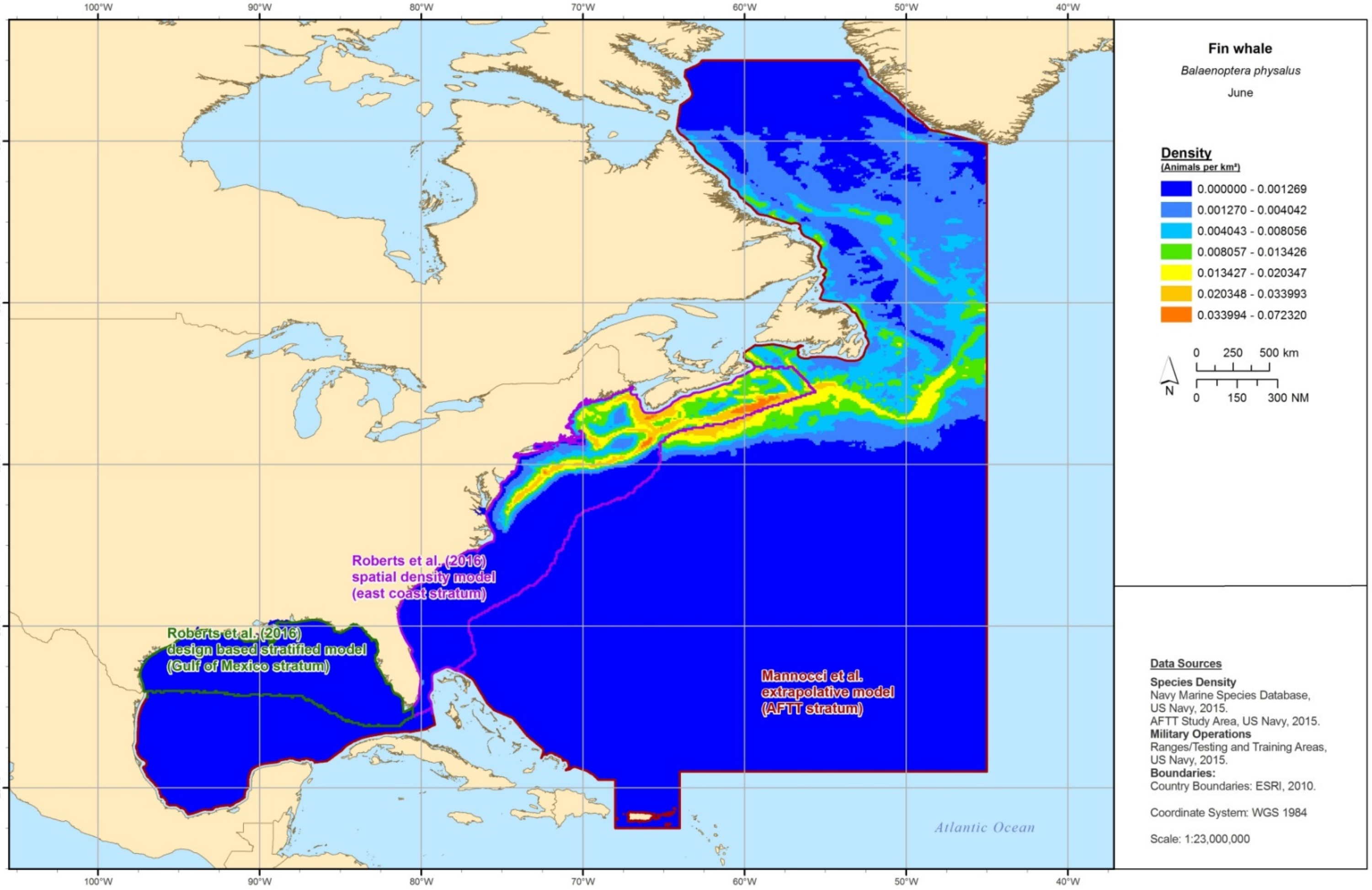


Figure 2-2. Example of a Combined NMSDD Density Data.

2.2.3 METHODS FOR SEASONAL INTEGRATION

Seasons are defined by the available data and the minimum number of timeframes that characterize the species distribution over one year. The number of timeframe designations could vary based on the detail of the available data. This could be designated by the traditional four seasons, warm and cold seasons, breeding and feeding seasons, monthly or smaller increments.

The dataset with the most seasonal classifications determines the number of seasonal density data files that need to be developed. A separate density data file is required for each season designation. In instances of combining a species for which there is an annual density estimate and a seasonally parsed density estimate, multiple density data files may be developed based on the seasonal category. For example, a species density dataset with four seasonal classifications is merged with a density dataset with an annual classification. The annual data need to be repeated for all four seasons and each repeated value must have the same season start and end dates as the season classification. There should be no overlapping time frames or geographic areas represented by the density data within the combination of the multiple datasets.

The ultimate result is a series of density data files that spatially and temporally have density values that span the species expected distribution for the entire year. The number of density data files for a given species are defined by the data region of greatest detail (i.e., the greatest number of seasonal timeframe designations) and may result in geographic partitioning and multiple density data files for a single species if seasonal definitions differ for oceanic areas. For the AFTT Study Area, 12 monthly files were developed for each species as that was the finest temporal resolution at which predictions were made for any species.

2.2.4 FILE FORMAT AND MANAGEMENT

All density estimates need to be in an ArcGIS compatible format for integration with the Navy effects analysis model. All data are clipped to the AFTT Study Area boundary which is maintained by United States Fleet Forces Command. At a minimum, the metadata fields listed in Appendix A are to be included in the database file (.dbf) for all density values in the density data files.

The file format and structure standards are managed by the Naval Undersea Warfare Center (NUWC) modeling team in collaboration with NAVFAC Atlantic. By keeping the data in the same file format, new data can easily be added to future iterations of the species density data files. All density data files are available via web service from the OBIS-SEAMAP website (https://seamap.env.duke.edu/models) for distribution and file management. This central location will ensure that the end user is using the correct, most up-to-date file available.

Uncertainty may be characterized in many different ways by the original density data provider, and are cataloged and preserved in the NMSDD database for potential later use. Additional metadata fields other than the ones listed in Appendix A may be used to incorporate and retain these values.

3 NMSDD AFTT REGION- OVERALL METHODS AND SOURCES IMPLEMENTED

The following sections describe the AFTT Study Area for which density data have been compiled and incorporated into the NMSDD Phase III. Available density data sources are also described.

3.1 ATLANTIC FLEET TRAINING AND TESTING STUDY AREA

The AFTT Study Area consists of multiple operating areas, organized into range complexes, all of which are contained within the U.S. EEZ and within the broader AFTT Study Area (**Figure 3-1**).

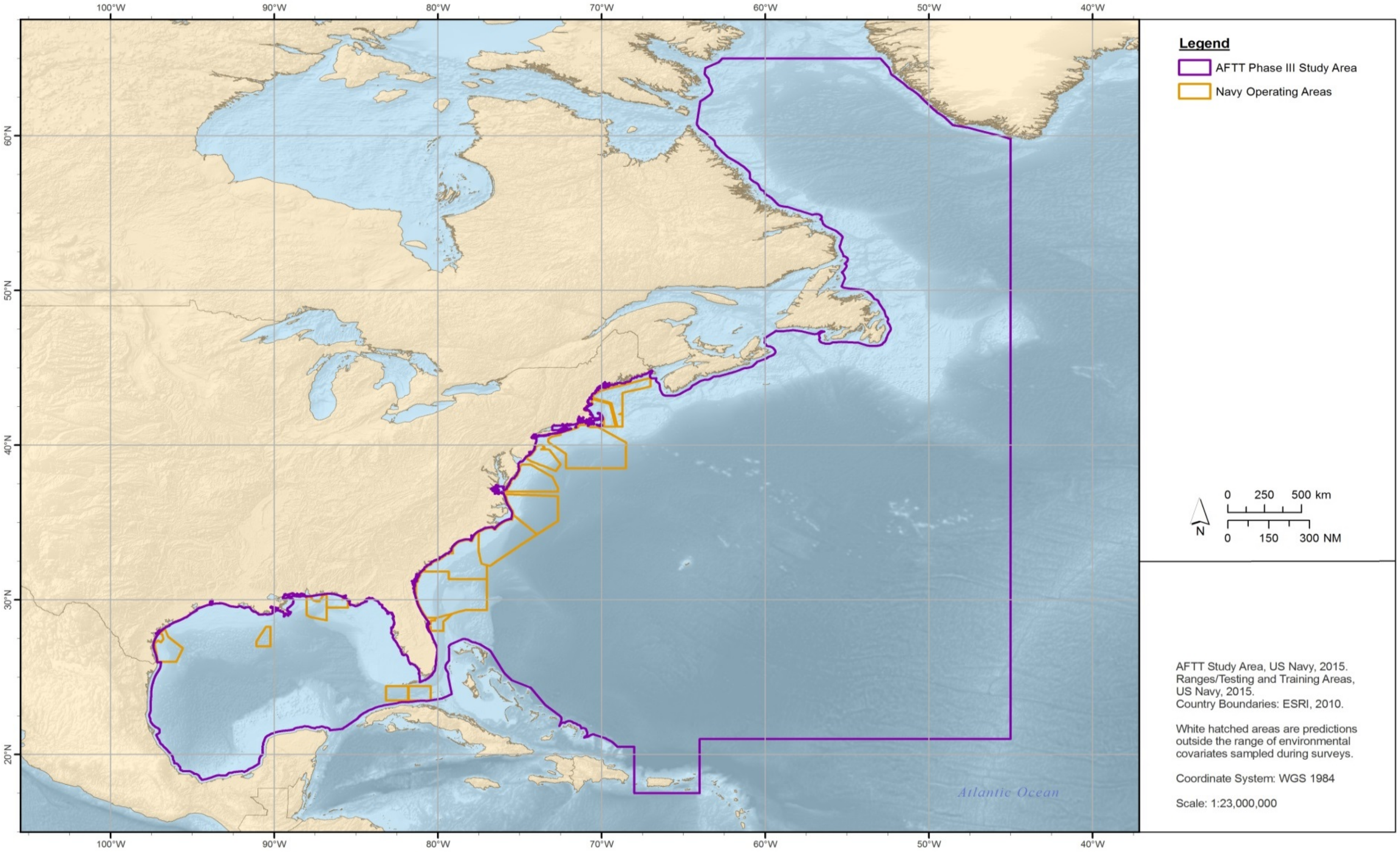


Figure 3-1. Atlantic Fleet Training and Testing Area and Navy Operating Areas.

3.2 APPLICATION OF THE NMSDD PROTOCOL

NMSDD layers for the AFTT Study Area are currently stratified monthly as this was the finest temporal resolution amongst all utilized density models.

However, not all density data were available at this temporal resolution. Marine mammal surveys are typically conducted during fair weather seasons because rough weather conditions in winter/spring make it difficult to collect shipboard line-transect data. Off the U.S. East Coast survey conditions in the winter are very poor with sea states unamenable to broad scale survey efforts and animal sightings. Data for winter months were extremely limited for some species leading to higher uncertainty for predictions in these months. See **Table 3-1** for a summary of data sources and temporal resolution of models used for each species. For data limited species a seasonal or annual model may have been fitted. In the case of an annual density estimate, it will be repeated for all twelve months.

For each area and season, the Navy's goal is to identify the best available density estimate, and thus may rely on different data sources. As described in **Section 2.2.1**, extrapolation from neighboring regional density estimates or population/stock assessments is appropriate based on expert opinion and is preferred over using RES models because of discrepancies identified by local expert knowledge. The different data sources are described in more detail in the following sections.

The NMSDD protocol was applied when selecting the best available marine species density for each study area. For the AFTT Study Area, Level 1 data (habitat-based density models, see **Table 3-1**) were available for multiple species/species groups within the U.S. EEZ (the furthest extent of most available survey data). For most remaining species, seasons, and areas within the U.S. EEZ, stratified line-transect density estimates (i.e., Level 2 data) were available. For all marine mammal species except the more northern associated seals, extrapolative density models were used in the broader AFTT study area. For more northerly distributed seal species (e.g., hooded seals), RES data was utilized. Sea turtle species did not have updated habitat models available except for limited instances and utilized older density spatial models and extrapolations thereof with the exception of loggerhead turtles in the mid-Atlantic region.

Information on the data density sources available for the AFTT Study Area is included in the next section but density estimates come from four main sources: Roberts et al. (2016), Mannocci et al. (2016), the Kaschner RES models, and the NODES density estimates. Their selection, seasonality, and temporal resolution are summarized by species in **Table 3-1**. This table is also organized by the three most commonly used spatial strata in the AFTT Study Area; the east coast U.S. EEZ (East Coast) the Gulf of Mexico U.S. EEZ (Gulf of Mexico) and the broader AFTT Study Area (AFTT).

Table 3-1. Density estimate source, seasonality, and temporal resolution by species.

Group	Species Common Name	Notes	Selected Model(s)			Season Definition			Temporal Resolution of Prediction		
			East Coast	Gulf of Mexico	AFTT	East Coast	Gulf of Mexico	AFTT	East Coast	Gulf of Mexico	AFTT
Baleen whales	blue whale	assumed absent in the Gulf of Mexico	Mannocci et al. 2016 stratified density estimate	NA	Mannocci et al. 2016 stratified density estimate	none	NA	none	annual	NA	annual
	bowhead whale	assessed qualitatively	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Bryde's whale		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	fin whale		Roberts et al. 2016 density spatial model	Roberts et al. 2016 stratified density estimate	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	monthly	annual	monthly
	humpback whale	assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 extrapolative density spatial model	winter/ summer	NA	winter /summer	seasonal	NA	seasonal
	minke whale	assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 extrapolative density spatial model	winter/ summer	NA	none	monthly	NA	annual
	North Atlantic right whale	assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 stratified density model	4 seasons	NA	none	monthly	NA	annual
	sei whale	assumed absent in the Gulf of Mexico	Roberts et al. 2016 stratified and density spatial model	NA	Mannocci et al. 2016 stratified and extrapolative density spatial model	4 seasons	NA	winter/ summer	monthly	NA	seasonal
Beaked whales	Blainville's beaked whale	modeled as a guild (beaked whales)	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	Cuvier's beaked whale	modeled as a guild (beaked whales)	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual

	Gervais' beaked whale	modeled as a guild (beaked whales)	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	northern bottlenose whale	assumed absent in the Gulf of Mexico	Roberts et al. 2016 stratified density estimate	NA	Mannocci et al. 2016 stratified density estimate	none	NA	none	annual	NA	annual
	Sowerby's beaked whale	modeled as a guild (beaked whales)	Roberts et al 2016 density spatial model	Roberts et al 2016 density spatial model	Mannocci et al 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	True's beaked whale	modeled as a guild (beaked whales)	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
Delphinids	Atlantic spotted dolphin		Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	Atlantic white-sided dolphin	assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 extrapolative density spatial model	none	NA	none	monthly	NA	annual
	bottlenose dolphin	estuarine estimates derived from literature	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	monthly	annual	annual
	clymene dolphin		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	false killer whale		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 stratified density model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	Fraser's dolphin	species assumed absent in some regions	Roberts et al. 2016 stratified density estimate	Roberts et al. 2016 stratified density estimate	Mannocci et al. 2016 stratified density estimate	none	none	none	annual	annual	annual
	killer whale		Mannocci et al. 2016 stratified density estimate	Roberts et al 2016 density spatial model	Mannocci et al. 2016 stratified density estimate	none	none	none	annual	annual	annual
	long-finned pilot whale	modeled as a guild (pilot whales)	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	melon-headed whale		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual

	pantropical spotted dolphin		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	pygmy killer whale		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	Risso's dolphin		Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	monthly	annual	annual
	rough-toothed dolphin		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	short-beaked common dolphin	assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 extrapolative density spatial model	none	NA	none	monthly	NA	annual
	short-finned pilot whale	modeled as a guild (pilot whales)	Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	spinner dolphin		Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	striped dolphin		Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	white-beaked dolphin	assumed absent in the Gulf of Mexico	Mannocci et al. 2016 extrapolative density spatial model	NA	Mannocci et al. 2016 extrapolative density spatial model	none	NA	none	annual	NA	annual
Porpoises	harbor porpoise	assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 extrapolative density spatial model	winter/ summer	NA	none	monthly	NA	annual
Small whales	beluga whale	assessed qualitatively	NA	NA	NA	NA	NA	NA	NA	NA	NA
	narwhal	assessed qualitatively	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sperm whales	dwarf sperm whale	modeled as a guild (Kogia species)	Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual

	pygmy sperm whale	modeled as a guild (Kogia species)	Mannocci et al. 2016 extrapolative density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	annual	annual	annual
	sperm whale		Roberts et al. 2016 density spatial model	Roberts et al. 2016 density spatial model	Mannocci et al. 2016 extrapolative density spatial model	none	none	none	monthly	annual	annual
Sirenians	West Indian manatee	literature derived estimate in estuarine waters	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pinnipeds	bearded seal	assumed absent in the Gulf of Mexico	Kaschner RES model	NA	Kaschner RES model	4 seasons	NA	4 seasons	seasonal	NA	seasonal
	gray seal	modeled as a guild (seals); assumed absent in the Gulf of Mexico	Roberts et al. 2016 density spatial model	NA	Mannocci et al. 2016 stratified density estimate	winter/summer	NA	none	seasonal	NA	annual
	harbor seal	modeled as a guild (seals); assumed absent in the Gulf of Mexico	Roberts et al.2016 density spatial model	NA	Mannocci et al. 2016 stratified density estimate	winter/summer	NA	none	seasonal	NA	annual
	harp seal	assumed absent in the Gulf of Mexico	Kaschner RES model	NA	Kaschner RES model	4 seasons	NA	4 seasons	seasonal	NA	seasonal
	hooded seal	assumed absent in the Gulf of Mexico	Kaschner RES model	NA	Kaschner RES model	4 seasons	NA	4 seasons	seasonal	NA	seasonal
	ringed seal	assumed absent in the Gulf of Mexico	Kaschner RES model	NA	Kaschner RES model	4 seasons	NA	4 seasons	seasonal	NA	seasonal
	walrus	assessed qualitatively	NA	NA	NA	NA	NA	NA	NA	NA	NA
Polar bear	polar bear	assessed qualitatively	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sea turtles	green turtle	Modeled as a guild (hardshell turtles); AFTT not fully covered	NODES density spatial model	NODES density spatial model	extrapolation from NODES	4 seasons	4 seasons	4 seasons	seasonal	seasonal	seasonal
	hawksbill turtle	modeled as a guild (hardshell turtles); AFTT not fully covered	NODES density spatial model	NODES density spatial model	extrapolation from NODES	4 seasons	4 seasons	4 seasons	seasonal	seasonal	seasonal

	Kemp's ridley turtle	modeled as a guild (hardshell turtles); AFTT not fully covered	NODES density spatial model	NODES density spatial model	extrapolation from NODES	4 seasons	4 seasons	4 seasons	seasonal	seasonal	seasonal
	leatherback turtle	AFTT not fully covered	NODES density spatial model	NODES density spatial model	extrapolation from NODES	4 seasons	4 seasons	4 seasons	seasonal	seasonal	seasonal
	loggerhead turtle	modeled as a guild (hardshell turtles) and as a single species; AFTT not fully covered	NODES density spatial model; Virginia Aquarium density spatial model in the mid-Atlantic	NODES density spatial model	extrapolation from NODES	4 seasons	4 seasons	4 seasons	seasonal	seasonal	seasonal

Taxa considered but not included

Spatially explicit, absolute density estimates of the type needed for quantitative analysis of impacts are not available in the AFTT Study Area for several taxa of concern to the Navy and trustee agencies – ESA-listed sea birds and marine fish.

While the Navy has been actively involved in telemetry-based tagging and tracking efforts involving Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish, these efforts do not yield data appropriate for estimation of population size nor the estimation of densities in the absence of population estimates given current best available science. Though the Navy is not directly involved in similar research, the same can be said for ESA-listed salmonid species. To the Navy's knowledge, the data needed to create spatially explicit, absolute density estimates for ESA-listed fish species at-sea in the AFTT Study Area (total population estimates and distribution data) do not exist nor could they be readily created. As such, they are not included in this technical report.

Little or no telemetry data are available for the two ESA-listed sea birds expected to be in offshore areas of the study area, the Bermuda petrel and the roseate tern, though population estimates do exist for these species. Even with population estimates, without robust information on distribution patterns too many assumptions would need to be made to produce reasonable density estimates for these species and as such they are excluded from this report. U.S. Fish and Wildlife Service has produced relative density models (Kinlan et al. 2016) for guilds of sea birds but these relative abundance models cannot be used for quantitative take estimation.

There are also four species of marine mammal that are assessed qualitatively in the AFTT EIS given their unlikelihood of being found in the AFTT Study Area. They are the narwhal, beluga whale, walrus, and polar bear.

3.3 INFORMATION ON DENSITY SOURCES CONSIDERED

Roberts et al. 2016 and Mannocci et al. 2016

In an effort to expand and improve on the NODE effort, the Navy funded density modeling efforts at Duke University, culminating in the two papers citied above. The intent of these projects was to update density models in the U.S. EEZ with newer data and methods. Another aim was to produce extrapolative models in the broader AFTT area that are more closely linked to survey data in the U.S. EEZ that could replace the globally scaled Kaschner and SMRU data sets, which were predominantly used in that area in the AFTT Phase II EIS.

In the U.S. EEZ the NMFS bears responsibility for defining marine mammal stocks and has placed many species that occur in both the North Atlantic and Gulf of Mexico into separate stocks. Pursuant to the need for per-stock estimates when calculating takes, and to allow for the possibility that species-environment relationships differ between stocks, two strata were defined to which separate density models could be fit; the Gulf of Mexico and East Coast. The area outside these two strata was defined as the AFTT analysis region where extrapolative models would be fit. In the East Coast and Gulf of Mexico analysis regions—the well-surveyed portions of the AFTT— relatively complex models were fitted designed to closely reproduce spatiotemporal patterns in cetacean density. Beyond these areas, in the

AFTT analysis region, where there was very little survey effort—parsimonious models were fitted, designed to produce plausible extrapolations of marine mammal density.

Multiple aerial and shipboard surveys were combined to provide data for all models. The details of how data were standardized and combined into a common density modeling framework are beyond the scope of this report but are detailed in the associated peer reviewed article. Data sources included surveys from NMFS, the Navy, and other state, federal, and not for profit agencies. Notably, the NMFS Atlantic Marine Assessment Program for Protected Species (AMAPPS) aerial and shipboard survey data, which represent the most recent and comprehensive set of line-transect data on the U.S. East Coast are not included in these density models. These data were not released to the Navy or Duke University until the spring of 2016, at which point the acoustic impacts analysis for the AFTT Phase III EIS was already well underway. It takes significant time and effort to incorporate new survey data into a modeling framework and to produce, review, and publish updated models. While efforts are currently underway to incorporate AMAPPS data into Navy density models, they are not currently available, and no NMFS density spatial models incorporating these data are available. As such, the Roberts et al. (2016) and Mannocci et al. (2016) models represent the most recent and best available science in the AFTT Study Area.

Most of the surveys available for density modeling only used one observer team, meaning that perception bias of observers could not be accounted for. If analysis was restricted to only dual-team surveys, at least 80% of the survey effort would have to be discarded. This would severely limit the number of density spatial models that could be fit, providing little improvement over the Navy's NODE studies. For surveys that used two teams, only the sightings from the primary team were incorporated. To address perception and availability bias, literature estimates were used for of the value of g(0) that incorporated these biases. The supplemental information for the publications contain taxon-specific reports for the East Coast, Gulf of Mexico, and AFTT regions that document the g(0) values and sources (Roberts et al. 2016 and Mannocci et al. 2016).

In the East Coast and Gulf of Mexico, the goal was to closely reproduce the spatiotemporal patterns in marine mammal density revealed by the surveys. In the AFTT, the goal was to produce plausible extrapolations of marine mammal density where little or no surveying was performed. The models for the East Coast and Gulf of Mexico regions utilized a different suite of covariates than the models for the AFTT region (rationale described below). Seasonal models were defined when all of the following were true: 1) The literature suggested that the taxon exhibits seasonality in which its relationship to the environment is expected to be different during different parts of the year. 2) Sufficient survey coverage and sightings existed to model at least one of the seasons effectively. 3) The spatial pattern in the sightings resembled the expectation described by the literature. For convenience, monthly boundaries were used; higher precision might be possible for some taxa (e.g., they might initiate migration to feeding grounds within the same two-week period) but detecting this was beyond the scope of this project. If any of these conditions were false, a single "year-round" model was used (Roberts et al. 2016 and Mannocci et al. 2016).

In the East Coast and Gulf of Mexico regions the modeling team split the data into seasonal and sub-regional strata, as appropriate and fitted GAMs to the data in each stratum. When a relatively large number of sightings were available for a stratum, a multivariate model that considered a full suite of candidate covariates was implemented. When a moderate number of sightings were available (typically

20-40) the modeling team fitted a univariate model. For some taxa where only a single covariate was to be fit, many covariates were tested and the one that explained the most deviance was selected; for others, a specific covariate based on the ecology of the taxon was utilized based on information in the literature. Finally, when few sightings were available (typically less than 20), a stratified model was used, similar to the estimates used in the SARs, but covering a broader ranges of surveys. In the more complex models, models using both contemporaneous and climatological covariates were tested. Various arguments exist supporting the use of one type of covariate or another, beyond the scope of this technical report. In this case, the modeling team used a parsimonious approach and used the model (climatological or contemporaneous environmental covariates) that explained the most deviance (Roberts et al. 2016).

Estimating cetacean densities in the AFTT area required predicting beyond the surveyed regions (geographical extrapolation) and, in some cases, predicting beyond the range of environmental covariates; this second type of ‘environmental’ extrapolation is more speculative (Mannocci et al. 2016). To increase the reliability of our extrapolations in the AFTT area the modeling team (1) incorporated survey data from various regions of the North Atlantic, (2) carefully selected candidate environmental covariates and (3) designed parsimonious habitat models. A qualitative index of uncertainty to differentiate geographical versus environmental extrapolation in the AFTT area was developed. Within these caveats, the process was very similar to the one undertaken for the East Coast and Gulf of Mexico. To reduce the amount of environmental interpolation, covariates with a broad range of values covered by the surveys were favored (e.g., avoided distances from the coast or isobaths) and only biological covariates with direct effects on cetacean distributions we considered. In the AFTT models, all covariates were monthly climatologies and consequently only climatological models were developed. This was decided in part to make models more parsimonious given the speculative nature of these models and included limiting models to four predictor variables (Mannocci et al. 2016).

In tandem with the final density and abundance predictions, uncertainty estimates were produced, including standard error and CV. To estimate CVs that expressed how close total abundance estimates were to the actual abundance of the modeled taxa, the modeling team applied the “delta method” described by Miller et al. (2013). The CVs presented in the taxon specific documentation of Roberts et al. (2016) and Mannocci et al. (2016) supporting information likely underestimate the true uncertainty of the models, as they only reflect the uncertainty of the spatial modeling (GAM). Traditionally, uncertainty estimates for cetacean density models also incorporate the uncertainty of the detection functions and the g(0) estimates. For the models here, which incorporated two platforms types, many disparate surveys, and several g(0) estimates per model, the only viable method described in the literature for integrating these additional sources of uncertainty was bootstrapping, which was computationally prohibitive with the time and resources available (Roberts et al. 2016 and Mannocci et al. 2016). More detail on the g(0) estimates used and other methodological details can be found in the aforementioned publications.

Navy OPAREA Density Estimates (NODE)

NODE (DON 2007a, 2007b, 2007c) was an effort to estimate and compile all marine mammal and sea turtle density data available for the Northeast, Southeast, and Gulf of Mexico coasts of the U.S., undertaken to be used in the AFTT for TAP Phase II. The grid cell resolution of the data varies from 10km^2 to 40 km^2 depending on the species. Spatial density models were developed from NMFS shipboard and aerial survey data available at the time, where possible. Each species data file is comprised of literature derived or spatially modeled density data depending on the quality of data available and using a hierarchical approach described in **Section 2.2.1**. NODE density spatial models were considered as the best available data within the U.S. EEZ and were applied for the appropriate season but have since been largely replaced by the recent Roberts et al. (2016) models. NODE data were used for all sea turtle species with limited exceptions as no more recent, broad scale density models were available for that taxa.

Sea turtle density estimates for NODE were generated only from aerial surveys conducted by NMFS available at the time. Densities were calculated for the leatherback turtle, the loggerhead turtle, the Kemp's ridley turtle, and the group Hardshell turtles. The species incorporated into the Hardshell turtle category include green, hawksbill, and unidentified hardshell turtles (which could include olive ridley turtles though their occurrence in the AFTT Study Area would be considered extralimital), which were pooled together since the number of sightings for each species or group was not sufficient to allow for spatial modeling. Given what is known about sea turtle occurrence in and along the eastern seaboard of the U.S. and the Gulf of Mexico, it is likely that a majority of the unidentified hardshell sightings were green or Kemp's ridley turtles, given that loggerheads are usually identified. Density estimates were all based on density spatial models and were corrected to account for availability bias g(0). All g(0) values were selected from published aerial survey and tag data (Benson et al. 2007; Cardona et al 2005; Eguchi et al. 2007; Mansfield and Musick 2005; Southwood et al. 2003).

Sea Mammal Research Unit Limited (SMRU Ltd.) – University of Saint Andrews, Scotland Global Density Models

SMRU Ltd. developed global, seasonal, density models for 45 marine mammal species (SMRU Ltd. 2012). Seasonal RES values were produced on a 0.5 degree (°) grid cell resolution based on SST, bathymetry and distance to land or ice edge data, and a literature review relating to seasonal habitat preferences, requirements, and known occurrences of the species of interest. A relationship between RES and empirical density data then had to be established in order to generate predictions of density for locations where no surveys have been conducted. A thorough literature search for survey data was undertaken to identify ship-based and/or aerial surveys of marine mammals. Survey data were collated on a global level and included surveys since 1980 up through the time when the models were created, although most surveys included in the analysis were post-1990. Models relating density (from surveys) to RES values were constructed using Generalized Linear Models. Initial model fitting utilized only the summer season data for the Northern and Southern hemispheres. The summer RES values were passed through the fitted equations to give predicted densities for all 0.5° grid-cells. This, coupled with database values for the area of water within each cell, gave a 'global abundance' estimate. Seasonal predictions were made by distributing this global abundance in accordance with the seasonal RES values and the model coefficients. This approach ensured that the global abundance of a species did not change between seasons. Predictions were confined to Food and Agriculture Organization areas so as to not over extrapolate. For Food and Agriculture Organization areas with no survey data, a global mean population was used as in the Kaschner model (see below).

The data are presented in a 0.5° squared cell size based on the C-Squares global spatial indexing system (Rees 2013). These data were reformatted into ArcGIS compatible files for the purpose of Navy environmental effects modeling. The NMFS SARs available at the time were used to evaluate the extent of distribution within the U.S. EEZ and if there were any significant discrepancies, we adjusted the distribution of the SMRU Ltd. data to match the expected distribution based on the NMFS stock assessment.

These data are considered secondary to the Roberts et al. (2016), Mannocci et al. (2016), and NODE density spatial model data in the hierarchy evaluation and would only be applied to areas or seasons where there were no seasonal density spatial models available. SMRU Ltd. density data are preferred to literature derived models because of the greater spatial and temporal resolution/evaluation.

Though the modeled density estimates include areas up to and including inland waters of the U.S. coastline, for the Navy's evaluation purposes, these estimates should be considered as an extrapolation of data further from shore. The methods applied and the origin of the data should be considered when evaluating the degree of accuracy in the coastal values. This was noted when some erroneous deep water species were showing up in Navy port locations. Post-analysis evaluation of the results should be performed to correct for any unexpected species occurrence, especially in pier side and port locations.

These models were utilized as a significant data source in the analysis of the TAP Phase II AFTT EIS. However, the species represented in this data set were fully replaced with models from the Roberts et al. (2016) and Mannocci et al. (2016) data sources for the TAP Phase III EIS.

Kristen Kaschner et al. Global Density Model

For species not included in the SMRU Ltd. effort, global density estimates developed by Kristin Kaschner were available. Dr. Kaschner produced RES values (Kaschner et al. 2006) on a 0.5° grid cell resolution based on SST, bathymetry and distance to land or ice edge data, and a literature review relating to seasonal habitat preferences, requirements and known occurrences of the species of interest. This characterized each species distribution and relative concentration on a global oceanic scale based on suitable habitat where the species could occur. To transform the RES values to estimate density, mean annual global population abundance was calculated from published estimates (Kaschner 2004). She then distributed the abundance based on using the RES values as an index of relative concentration so that if one was to sum up all of the cells, the result would be the mean global population. The advantage of this method versus distributing the global abundance estimate uniformly is that you are only dividing the abundance of the species by the geographic area where they might occur. This results in a lower risk of underestimating the density when trying to infer density from a global population estimate. The disadvantage with this method is that it is difficult to validate the results because much of the area covered has never been surveyed and uncertainty was qualitatively assessed. Also, habitat suitability may not represent the current species' actual distribution and the density estimate is only as good as the population estimate, which is based on limited, typically coastal survey coverage.

The data are presented in a 0.5° squared cell size based on C-Squares. These data were reformatted into ArcGIS compatible files for the purpose of Navy environmental effects modeling. The NMFS SARs were used to evaluate the extent of distribution within the U.S EEZ and if there were any significant discrepancies, we adjusted the distribution of the Kaschner data to match the expected distribution based on the NMFS stock assessment.

These data were considered tertiary to the various density spatial models and secondary to the SMRU Ltd. data in the hierarchy evaluation and were only applied to areas where there were no density spatial models or SMRU Ltd. data were available. Though the modeled density estimates include areas up to and including inland waters of the U.S. coastline, for the Navy's evaluation purposes, these estimates should be considered as an extrapolation of data further from shore. The methods applied and the origin of the data should be considered when evaluating the degree of accuracy in the coastal values. This was noted when some erroneous deep water species were showing up in Navy port locations. Post-analysis evaluation of the results should be performed to correct for any unexpected species occurrence, especially in pier side and port locations.

Kaschner RES data were used predominately for more northerly associated species (relative to the U.S. Atlantic coast EEZ) where sightings in U.S. waters where either extremely limited or not available at all. See **Table 3-1** for a detailed breakdown by species on which data sources were used.

Analysis of Aerial Surveys Conducted in Coastal Waters of Maryland and Virginia, including Chesapeake Bay, 2011–2013

Aerial surveys of marine animals were conducted by the Virginia Aquarium in the coastal waters of Maryland and Virginia, including Chesapeake Bay, in 2011 (spring, summer, and fall) and 2012 (spring and summer). A survey limited to Chesapeake Bay was conducted in summer 2013. Though other species were detected, loggerhead turtles and bottlenose dolphins were the most frequently detected species and density for other species was not modeled from these surveys (Burt et al. 2014). Mark-recapture distance-sampling methods were used to take account of observer perception bias.

The availability of loggerhead turtles was modeled using data recorded on tags attached to turtles, and these models were incorporated in the density surface estimates to give estimates that accounted for both observer perception bias and availability bias (Scott-Hayward et al. 2014). Turtles were considered to be available (to be detected) when they were at the surface within Chesapeake Bay and within 2 meters of the surface when they were in the Atlantic Ocean (Burt et al. 2014). Explanatory variables for the density spatial model included water depth, sea surface temperature, sea bottom temperature, and Chlorophyll a. Seasonal predications (2 spring, 3 summer, 1 fall) were made on a set of 10 kilometer (km) grid cells. For incorporation into the NMSDD, individual seasonal predictions were averaged. The average densities for each season were inserted into the NMSDD replacing the previous NODE data for sea turtles. As no new density data was available for winter, NODE winter data was used for loggerhead turtles. These density models are preferable to NODE models as they incorporate more recent survey data and are also a top tier data source according to the NMSDD hierarchy. NODE data for the spring, summer, and fall outside the new survey area was kept as no newer data sources exist.

For bottlenose dolphin, a similar process was followed except that all seasonal predictions were averaged into a single year round prediction by Duke University based on the criteria applied to other species in their study.

Published estimates

In sounds and estuaries of interest to the Navy, traditional density estimates are often unavailable (lack of survey data, only non-line-transect data available). In these situations, an estimate of the population divided by the area of the body of water in question is often the only available means to generate a reasonable density estimate. Population estimates may come from mark recapture studies or other means.

These are considered literature derived estimates in the NMSDD hierarchy. These types of estimates were used for manatees and bottlenose dolphins in some inland waters and estuaries. See the species specific information in Section 4.0 for more detail.

NMFS Stock Assessment Reports (SARs)

No SAR derived density estimates were included in the AFTT portion of the NMSDD. Though for some species more recent data were available than was included in the Roberts et al. (2016) models, the SARs were generally limited to a single season, single value stratified estimate. As such, the SARs are lower in the NMSDD hierarchy and do not represent the best available science for the purposes of take estimation. However, the stock assessments are used qualitatively for comparison with the Roberts et al. (2016) models, though any comparison must be taken cautiously given the vastly different survey data sources and methodologies incorporated. SARs are also used to assess the range of some of the RES data. See **Section 4.0** for additional detail.

4 SPECIES AND GUILD DENSITY PROFILES

The remainder of this document provides the density profiles that are being used by the Navy for modelling the potential exposure of each species to Navy sound sources in the AFTT Study Area based on the data sources and selection methods described in **Sections 2** and **3**. Species are presented in groups of related taxa: baleen whales, beaked whales, delphinids, porpoises, sperm whales, small whales, sirenians, pinnipeds, polar bear, and sea turtles. Within each group, species and guilds are presented in alphabetical order by their common name; hence the common name is presented before their scientific name. This organization scheme keeps closely-related species together. Information on which species are found in the AFTT Study Area is provided in **Table 3-1**.

There are three elements in each species profile: (1) information of the specific data used for the AFTT study area and seasonality, (2) comparison to other available density estimates, and (3) maps of the estimated species density in the Study Area. In a few cases, one of the elements may be expanded or removed based on special circumstances for that species.

4.1 BALEEN WHALES

Blue whale (*Balaenoptera musculus*)

Data Sources and Seasonality:
All density data incorporated into the NMSDD for this species comes from stratified density estimates developed by Mannocci et al. (2016). A stratified density estimate for the entire AFTT was produced. Given the low number of sightings in the East Coast, the modelers felt that the AFTT stratified density estimate better represented this species' presence in the East Coast stratum. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region. No seasons were delineated for this migratory species in any stratum given the lack of sightings of this species overall. There is no temporal resolution for these density predictions as a lack of sightings meant that any data, regardless of season, needed to be used to produce even a basic estimate of abundance.

Survey Data and Selected Models:
In the East Coast stratum, data from NEFSC and SEFSC aerial and shipboard surveys, Navy-sponsored University of North Carolina Wilmington (UNCW) surveys, Virginia Aquarium aerial surveys, and the New Jersey Department of Environmental Protection surveys spanning 1995-2014 were used with eight total sightings. Because of the extremely limited sightings in the East Coast stratum, only a stratified density estimate could be produced (used the AFTT estimate). No environmental covariates were used to produce this density estimate.

The model for the AFTT stratum used the eight East Coast stratum sightings, as well as one from the European Atlantic, and four from the Mid-Atlantic Ridge. Because of the low number of sightings available in all regions, only a stratified density model could be fit for the AFTT strata. No environmental covariates were used to generate the density estimate so no environmental extrapolation occurred.

Other Density Estimates:
An abundance estimate of 11 individuals can be derived looking only at the East Coast portion of the broader AFTT prediction (Mannoci et al. 2016). The most recent estimate from the NOAA SAR is 440 individuals based on a 30 year photo identification census in the Gulf of St. Lawrence, which is entirely

outside of the East Coast stratum. In TAP Phase II, the Kaschner RES data was used with an estimate of 26 individuals (annual prediction). Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the SAR estimate and the estimate from the East Coast portion of the AFTT prediction cover entirely different spatial extents and are not directly comparable. Because the SAR estimate does not cover the same spatial extent it is not appropriate for use in modeling acoustic effects in the East Coast stratum, although it may provide a better estimate of the total population in the broader AFTT area. The Mannocci et al. (2016) estimate was chosen over the Kaschner RES model as it incorporates more recent data, which are more closely linked to the study area and because the stratified density estimate is still higher in the NMSDD hierarchy.

An abundance estimate of 104 individuals (CV=0.35) was derived for the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast stratum than global density estimates used in the past (such as the SMRU and Kaschner RES data) and, as such, is expected to provide more realistic density estimates than those datasets. Data from the census used in the SAR report was not appropriate for density modeling and, therefore, is not incorporated, which has likely led to an underestimation of abundance within the broader AFTT Study Area. Navy activity outside the East Coast stratum drops off considerably as distance increases, which is where most of the population of this animal is expected to occur.

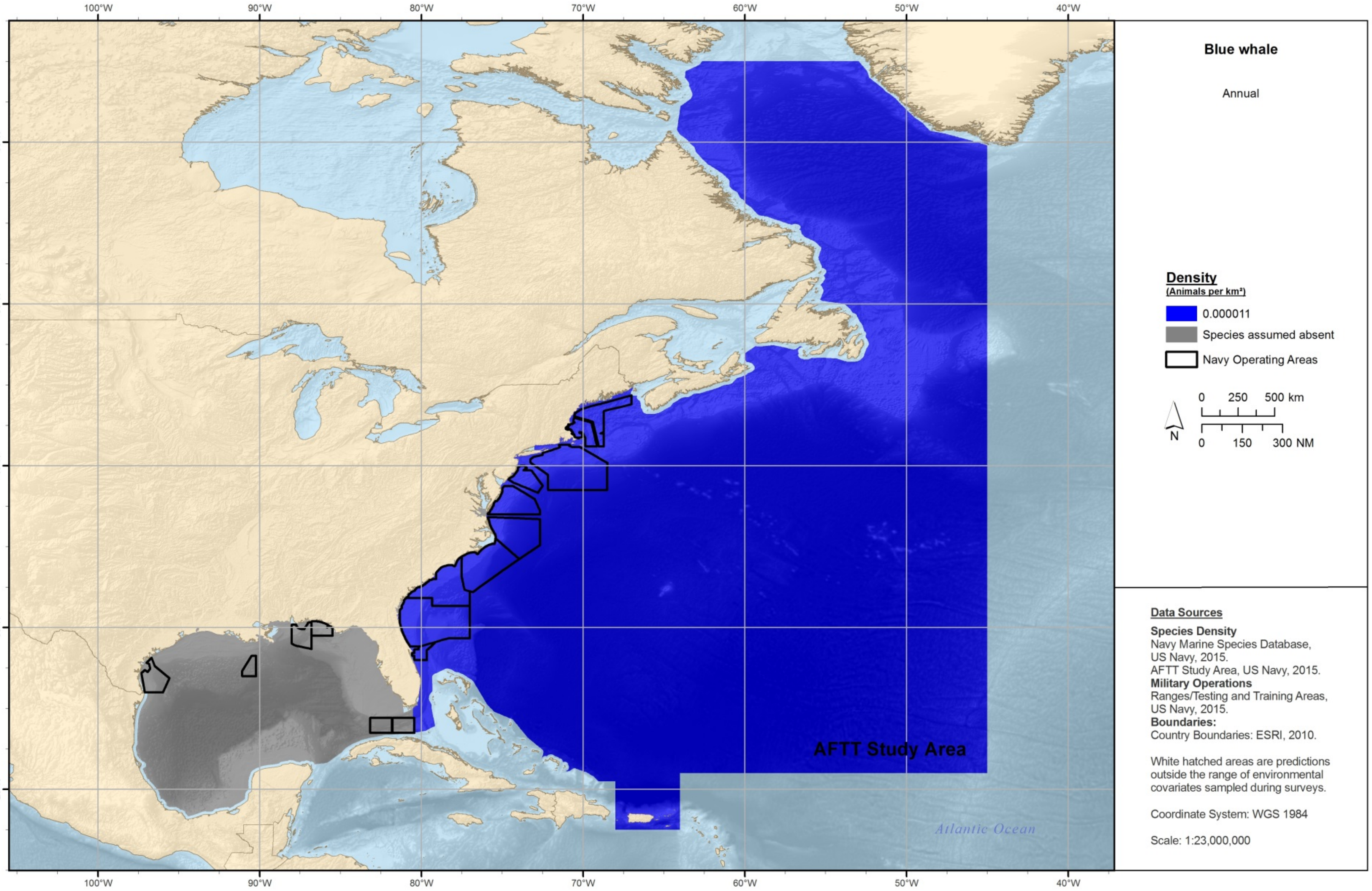


Figure 4-1. Annual density prediction for blue whales for the East Coast and AFTT strata.

Bowhead whale (*Balaena mysticetus*)

Because of their extremely limited distribution within the AFTT Study Area, impacts to bowhead whales are assessed qualitatively in the document. As such, no density data for bowhead whales were analyzed.

Bryde's whale (*Balaenoptera edeni*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. An extremely low number of sightings in the East Coast stratum (N=4) meant that a separate East Coast stratum model could not be fit and the AFTT model was used in the East Coast stratum. Four ambiguous sightings reported as either sei or Bryde's whale that could not be classified were incorporated into both the sei and Bryde's models as a conservative measure (see supplementary material from Roberts et al. (2016) for a more detailed discussion). No seasons were defined for this species given the low number of sightings and lack of described seasonal movement patterns for this species. Density spatial models were developed for both the AFTT and Gulf of Mexico strata though both used a small number of explanatory variables. The temporal resolution of the density predictions was annual for both the AFTT and Gulf of Mexico strata.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1994-2009 were used with 22 total sightings. The sightings were limited to the shelf break in the eastern portion of the Gulf of Mexico and as such a spatial smooth of coordinates and depth were selected as covariates for the Gulf of Mexico model. No dynamic covariates were used in the development of this model so there is no need to distinguish between climatological and contemporaneous variables.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as five sightings from the Caribbean, four from the European Atlantic, and one from the Mid-Atlantic Ridge. The best fitting model included only SST as a predictor. Given the small number of sightings an extremely parsimonious model needed to be fit. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Bryde's whales are generally not expected to be seen north of 40 degrees latitude (Jefferson et al. 2008) and the AFTT model predicts very few individuals north of that latitude.

Other Density Estimates:

No SAR exists for the East Coast stratum and NMFS does not recognize a northwestern Atlantic stock. Annual Kaschner RES data were used in TAP Phase II and predicted 241 individuals in the East Coast stratum. The portion of the AFTT model that falls within the East Coast stratum predicts 59 individuals in that region. Because of the small number of sightings in the East Coast stratum, a stratified density model could not be fit and the AFTT model should be considered speculative. However, the Mannocci et al. (2016) model is more closely tied to regional data than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Given its simplicity and the few historical sightings in the East Coast stratum, the

AFTT model may be over-predicting the number of individuals in the region but appears to perform better than the RES data and is higher in the NMSDD hierarchy.

An abundance estimate of 44 individuals (CV=0.27) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent NOAA SAR estimate is 36 individuals (CV=1.07) (NOAA 2013) based on 2009 shipboard surveys performed in oceanic waters. In TAP Phase II, a value was used based on the NOAA SAR. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the SAR estimate and the estimate from the Roberts et al. (2016) are not statistically different. The Roberts et al. (2016) estimate was chosen over the SAR as it is a density spatial model versus a single density estimate and as such is higher in the NMSDD hierarchy.

An abundance estimate of 677 individuals (CV=0.21) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

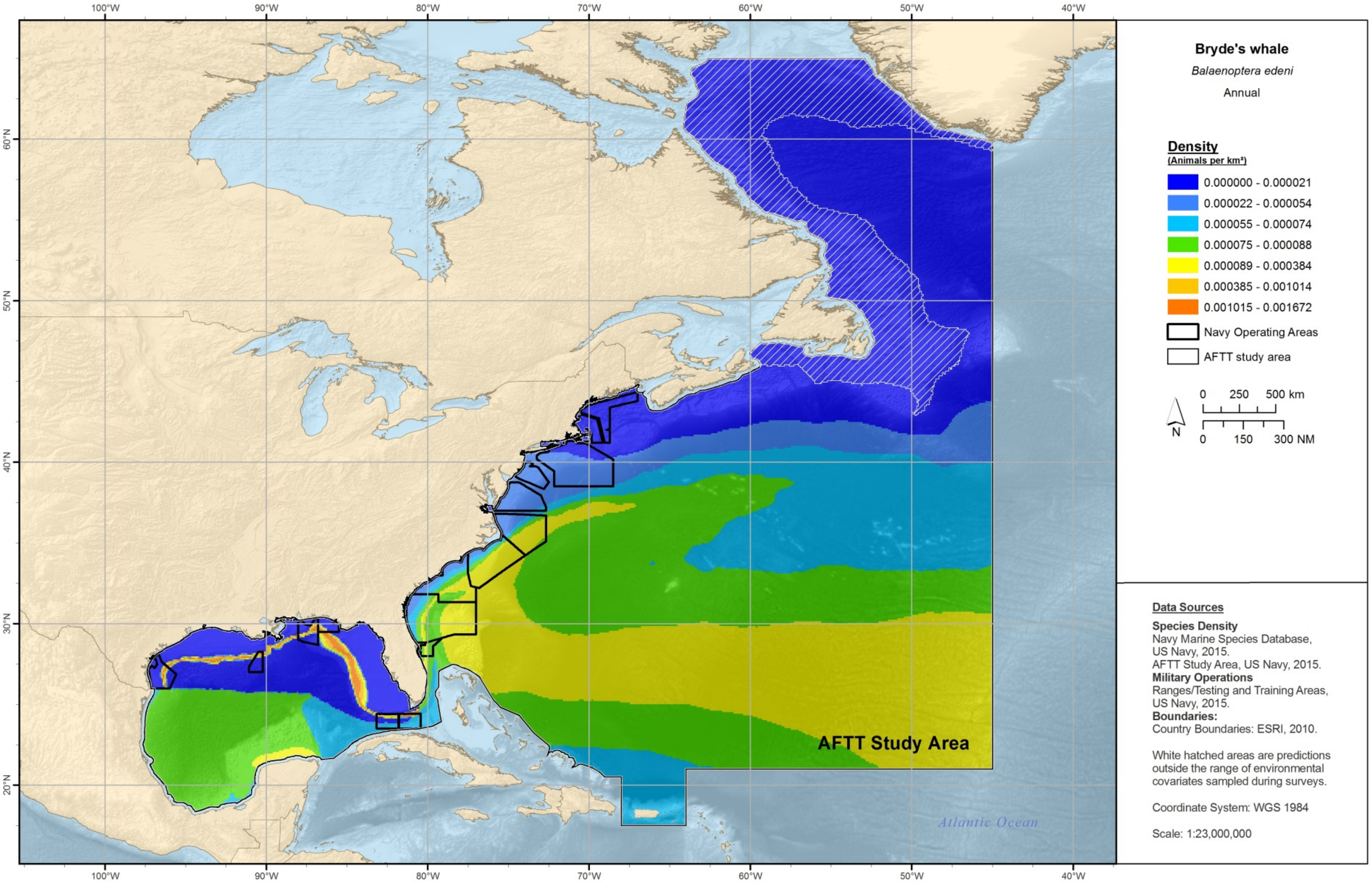


Figure 4-2. Annual density prediction for Bryde's whales for the Gulf of Mexico and AFTT strata.

Fin whale (*Balaenoptera physalus*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from density spatial models and stratified designed- based density models developed by Roberts et al. (2016), and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum and an extrapolative density spatial model was fit for the AFTT stratum. A stratified density estimate was produced for the Gulf of Mexico stratum given the lack of sightings. No seasons were delineated as migration patterns of this species are poorly defined in the literature. Some seasonal movement is captured in the East Coast and AFTT strata where the temporal resolution of predictions was monthly. The temporal resolution of the density predictions was annual in the Gulf of Mexico stratum.

Survey Data and Selected Models:

In the East Coast stratum, a total of 2,100 sightings from the combined survey data were used for model development. Ambiguous sightings reported as either fin or sei whales were classified into one species or another with the sei whale classified sightings being incorporated into this model (see supplementary material from Roberts et al. (2016) for a more detailed discussion). The climatological models consistently explained more deviance than models fitted with contemporaneous covariates. However, the best climatological models and the best contemporaneous model predicted very similar spatial distributions and mean abundances (Roberts et al. 2016).

In the Gulf of Mexico stratum, only one sighting was available from the combined survey data, making a spatial model infeasible. The sighting was on the shelf break in the western Gulf of Mexico, therefore the model was allowed to cover the entire Gulf of Mexico stratum.

The model for the AFTT stratum used the same sightings from the East Coast and Gulf of Mexico models, as well as 192 sightings from Europe, 12 sightings from the mid-Atlantic ridge, and three sightings from the Caribbean. The best fitting model included slope, distance to fronts, epipelagic micronekton primary productivity, and SST as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of the species.

Other Density Estimates:

An abundance estimate of 4,633 individuals (CV=0.08) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 1,618 individuals (CV=0.33) based on summer 2011 NEFSC and SEFSC aerial surveys (Waring et al. 2013). Note that these data were not available to the modeling team that produced the Robert et al. (2016) and Mannoci et al. (2016) models at the time of release. In TAP Phase II, the NODES estimate of 2,746 individuals (summer season, no CV available) based on survey day for the summer season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population is within the same order of magnitude as the SAR and seems more realistic than the Phase II data, which included RES data in non-summer seasons.

The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also preferable to the SAR estimate which uses only a single season of one year of survey data and provides only a single density value estimate for the southern east coast of the Atlantic, which is less desirable in the NMSDD data hierarchy. The higher predicted abundance for the Roberts et al. (2016) model is largely attributable to the use of different g(0) estimates than the SAR estimate.

An abundance estimate of nine individuals (CV=1.01) was derived for the Gulf of Mexico stratum model (Roberts et al. 2016). No other density estimates for this species exist in the Gulf of Mexico stratum.

An abundance estimate of 15,429 individuals (CV=0.06) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

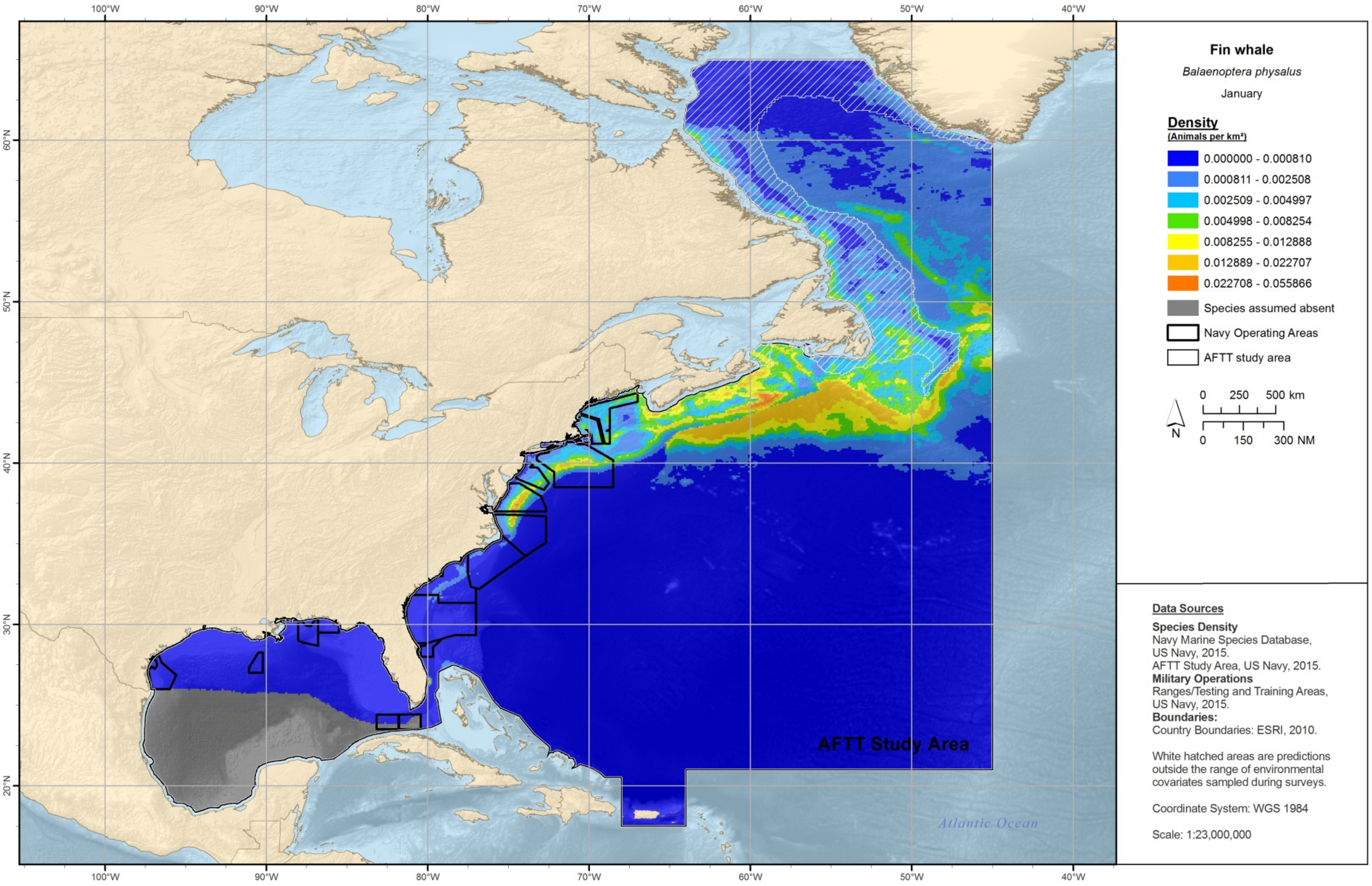


Figure 4-3. January prediction for fin whales for the East Coast, Gulf of Mexico and AFTT strata.

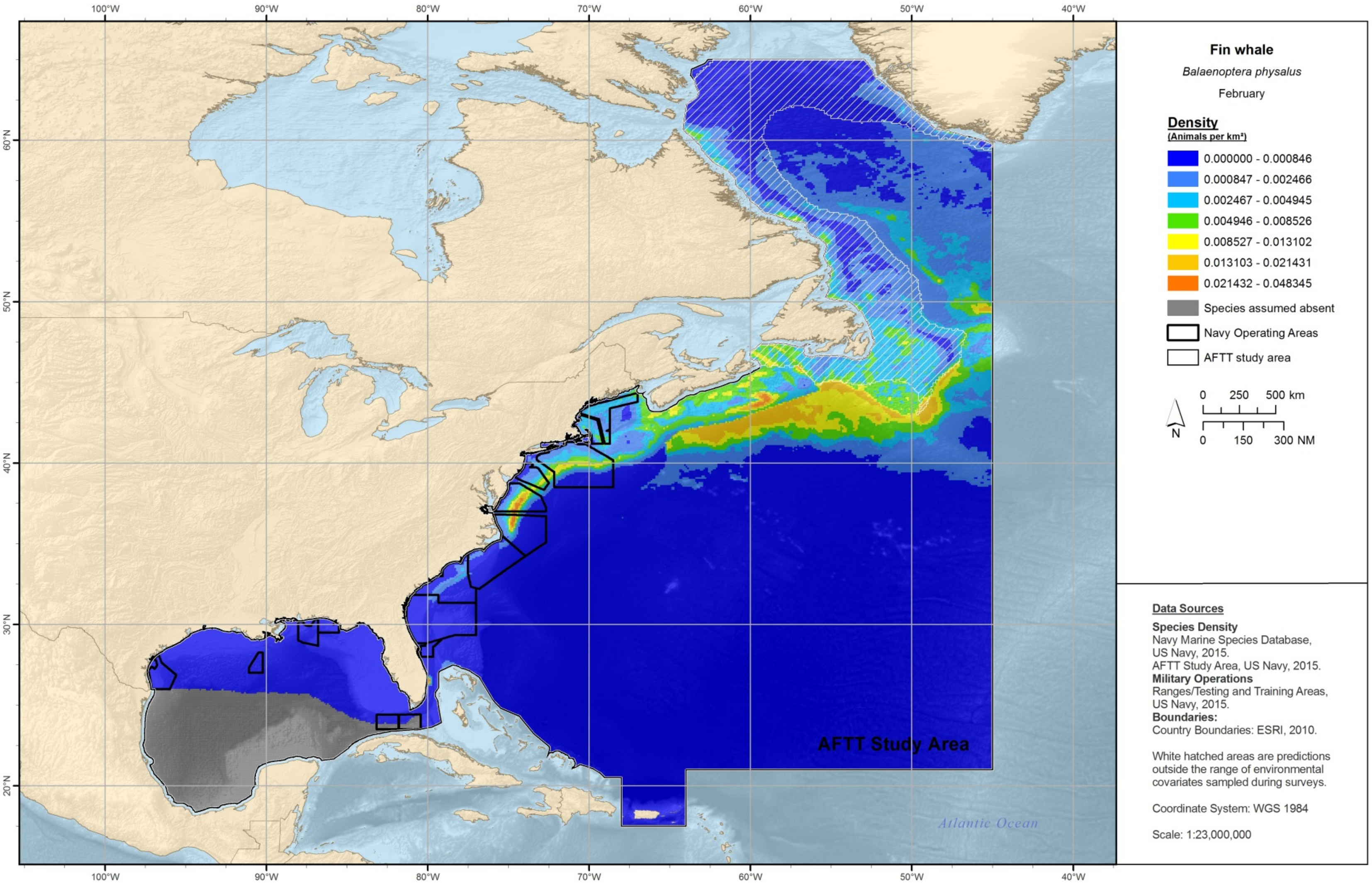


Figure 4-4. February density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

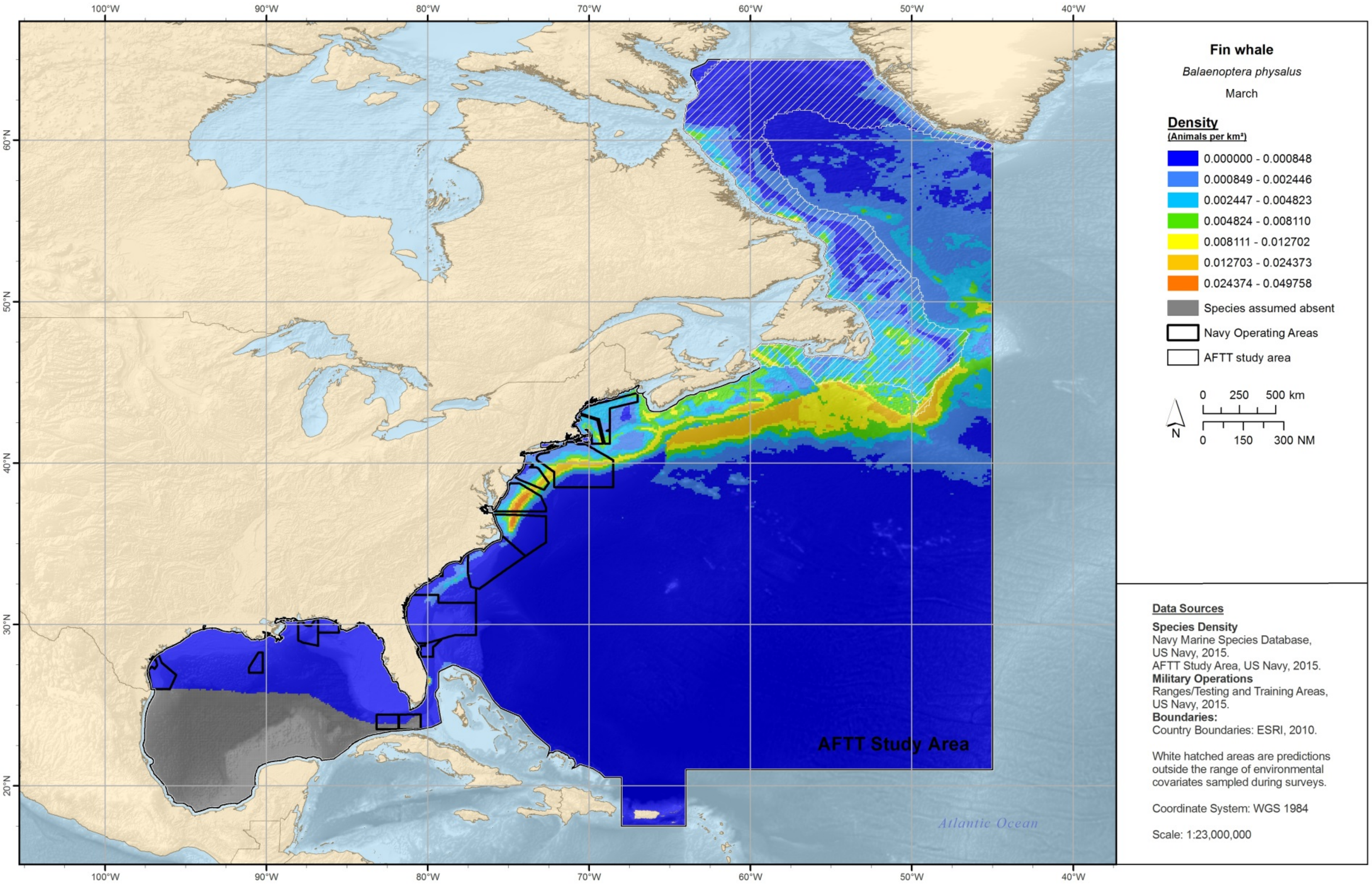


Figure 4-5. March density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

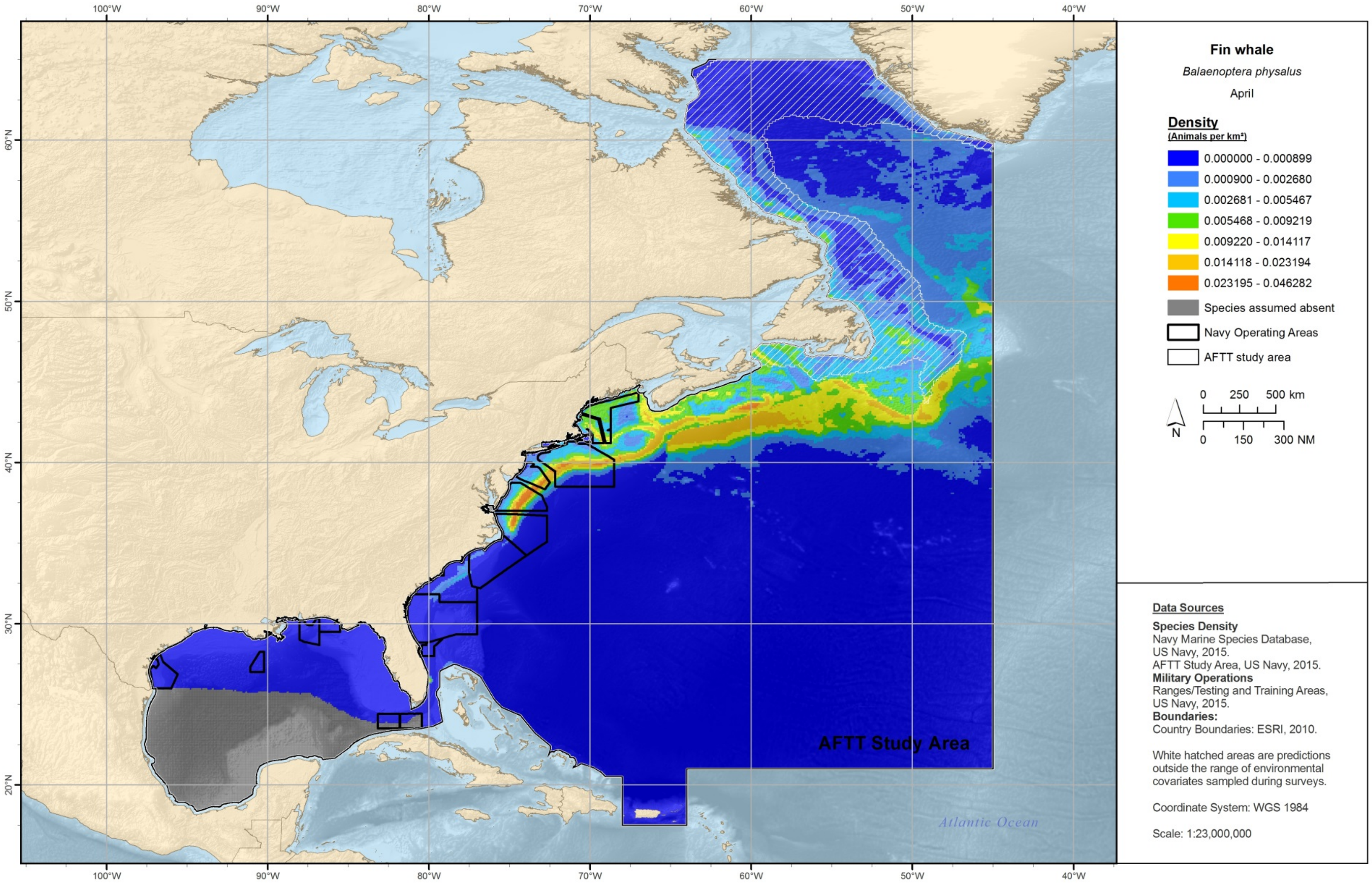
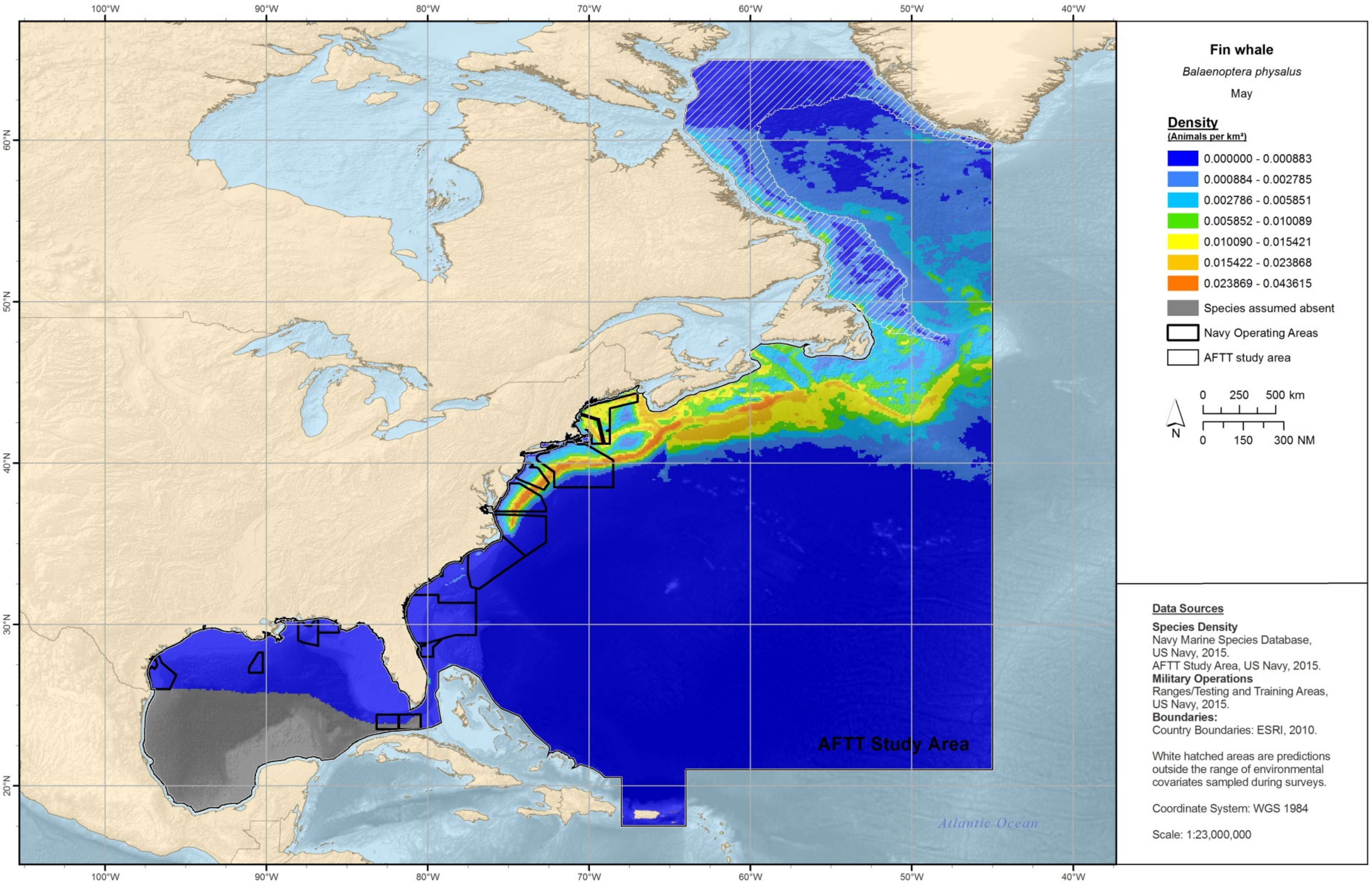


Figure 4-6. April density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-7. May density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

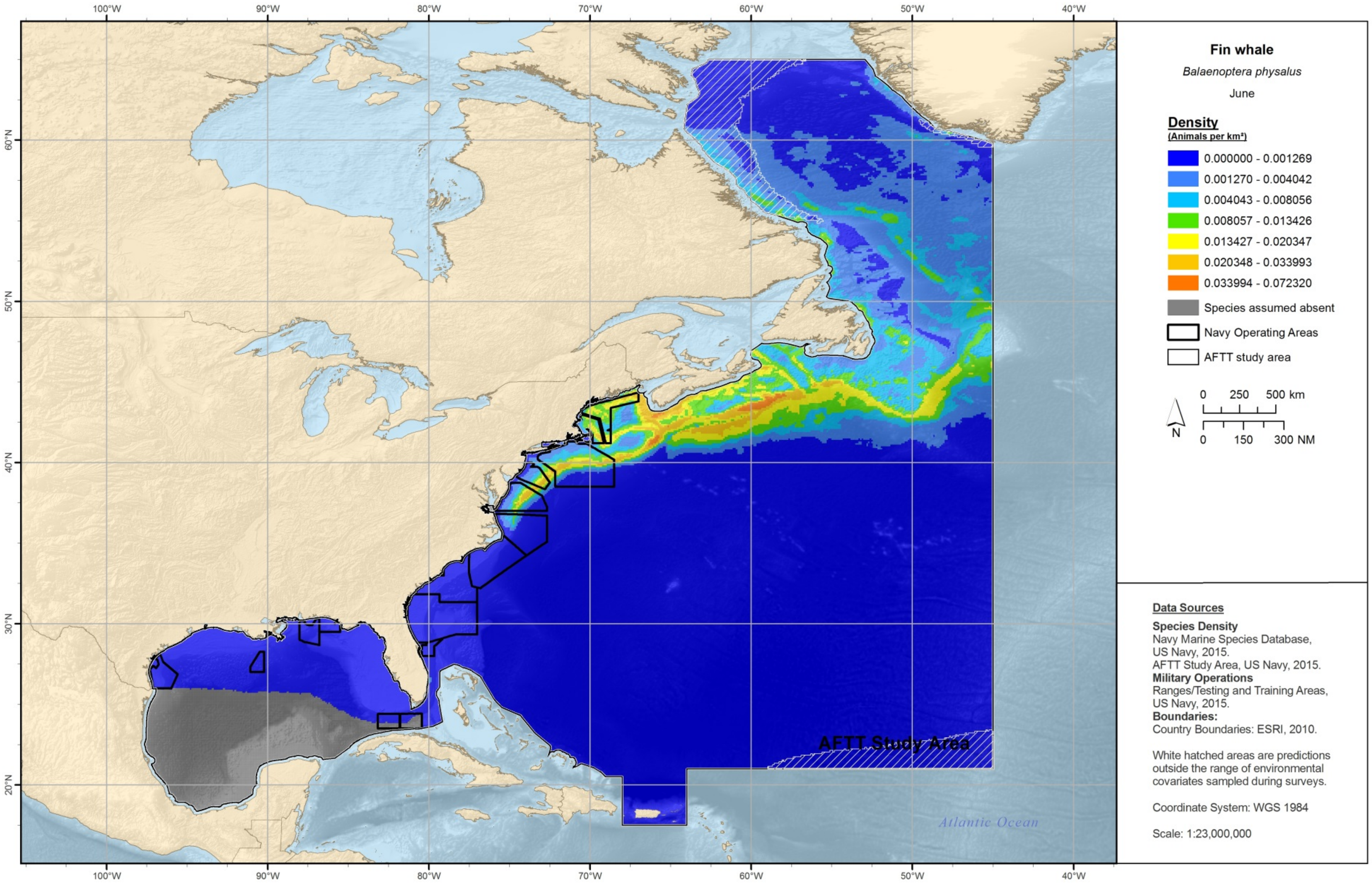


Figure 4-8. June density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

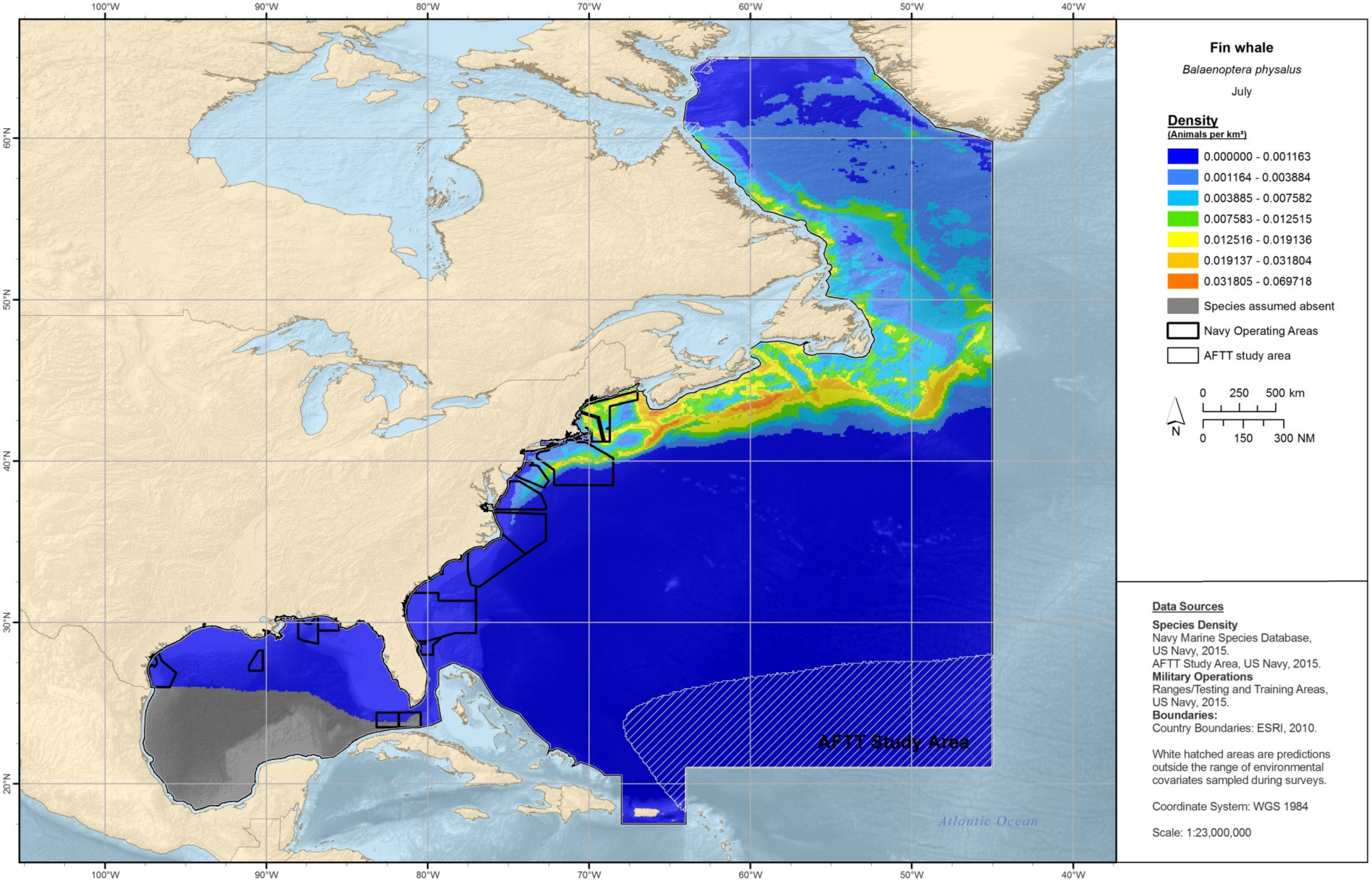


Figure 4-9. July density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

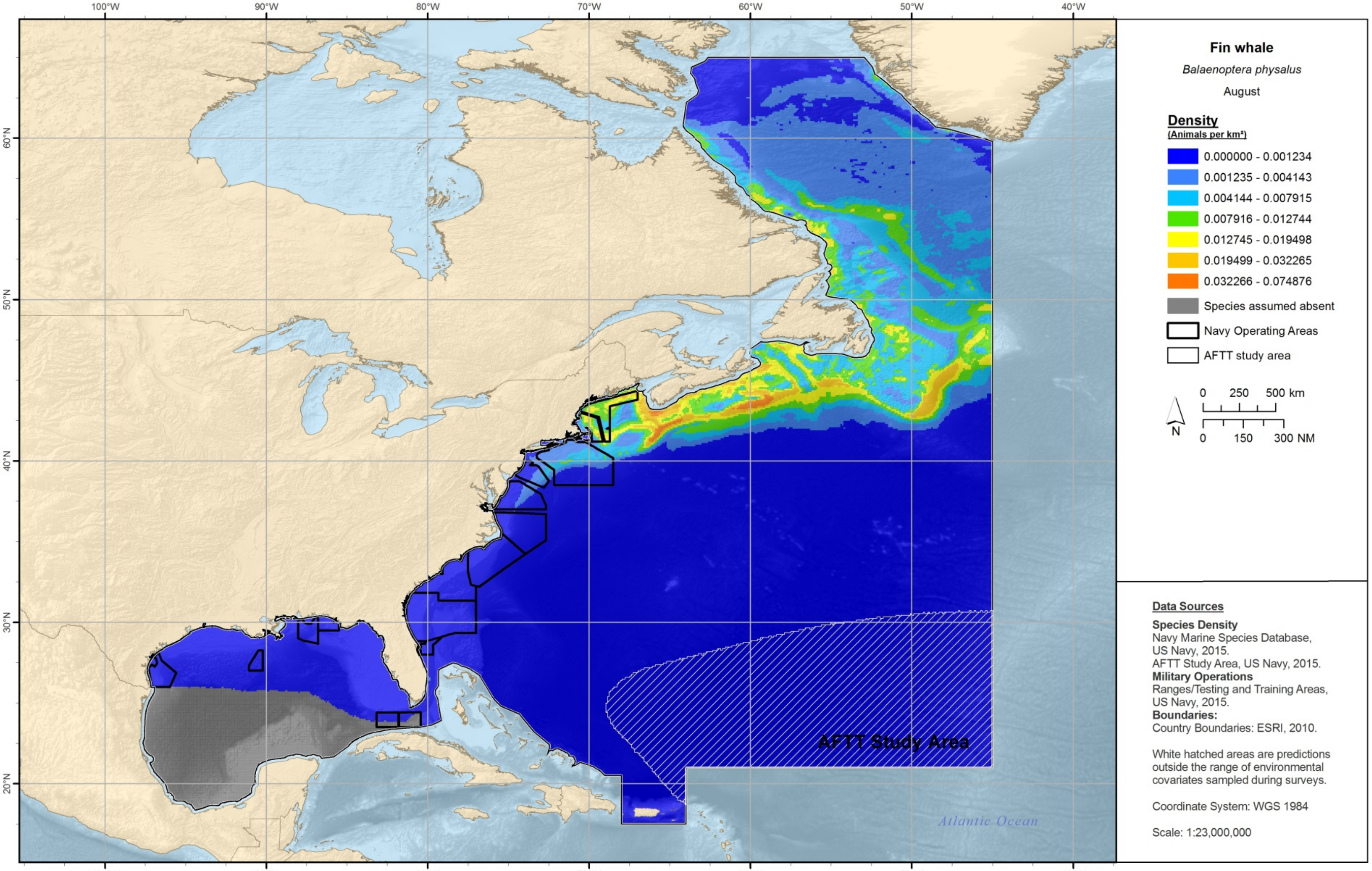


Figure 4-10. August density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

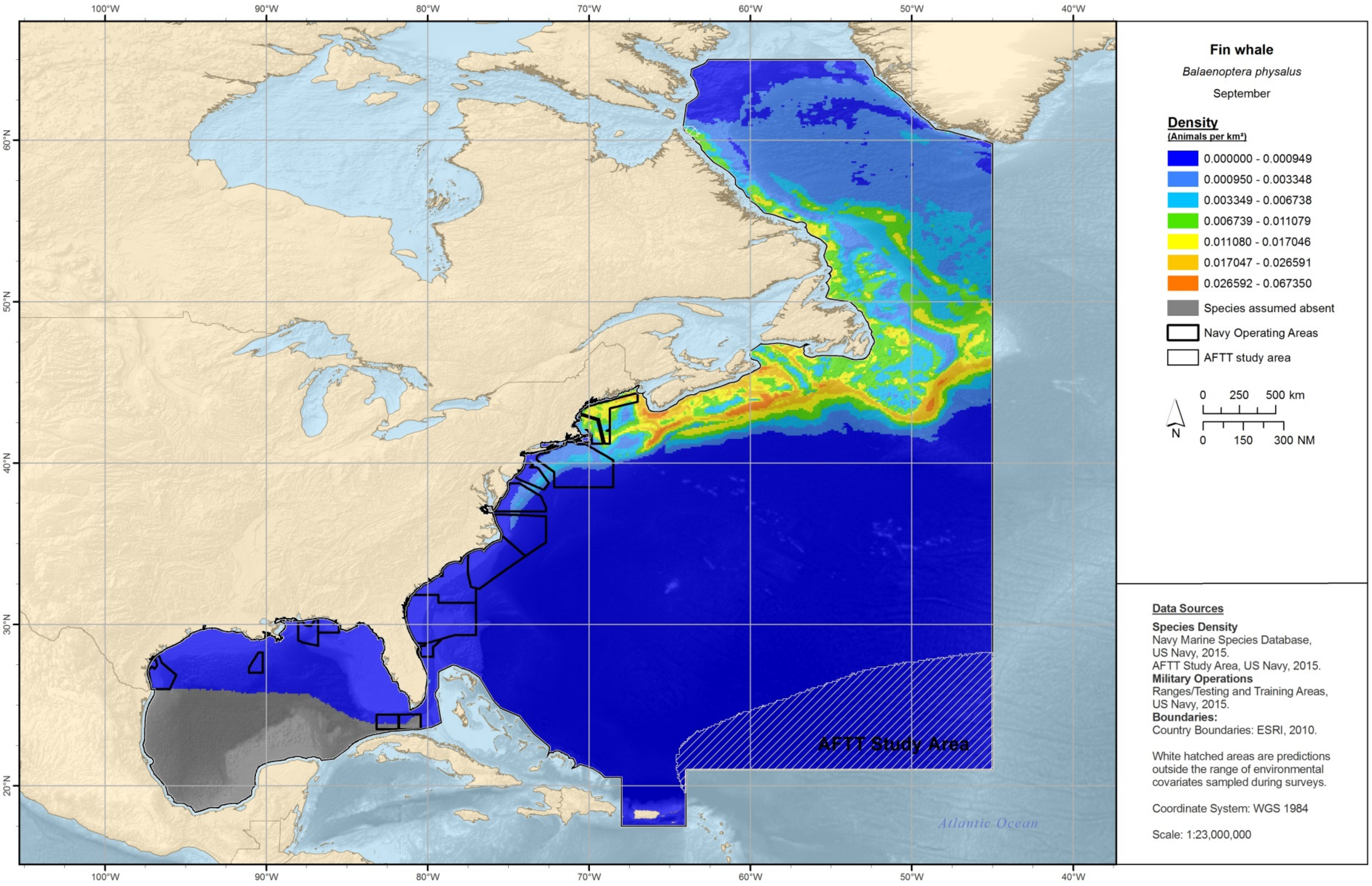


Figure 4-11. September density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

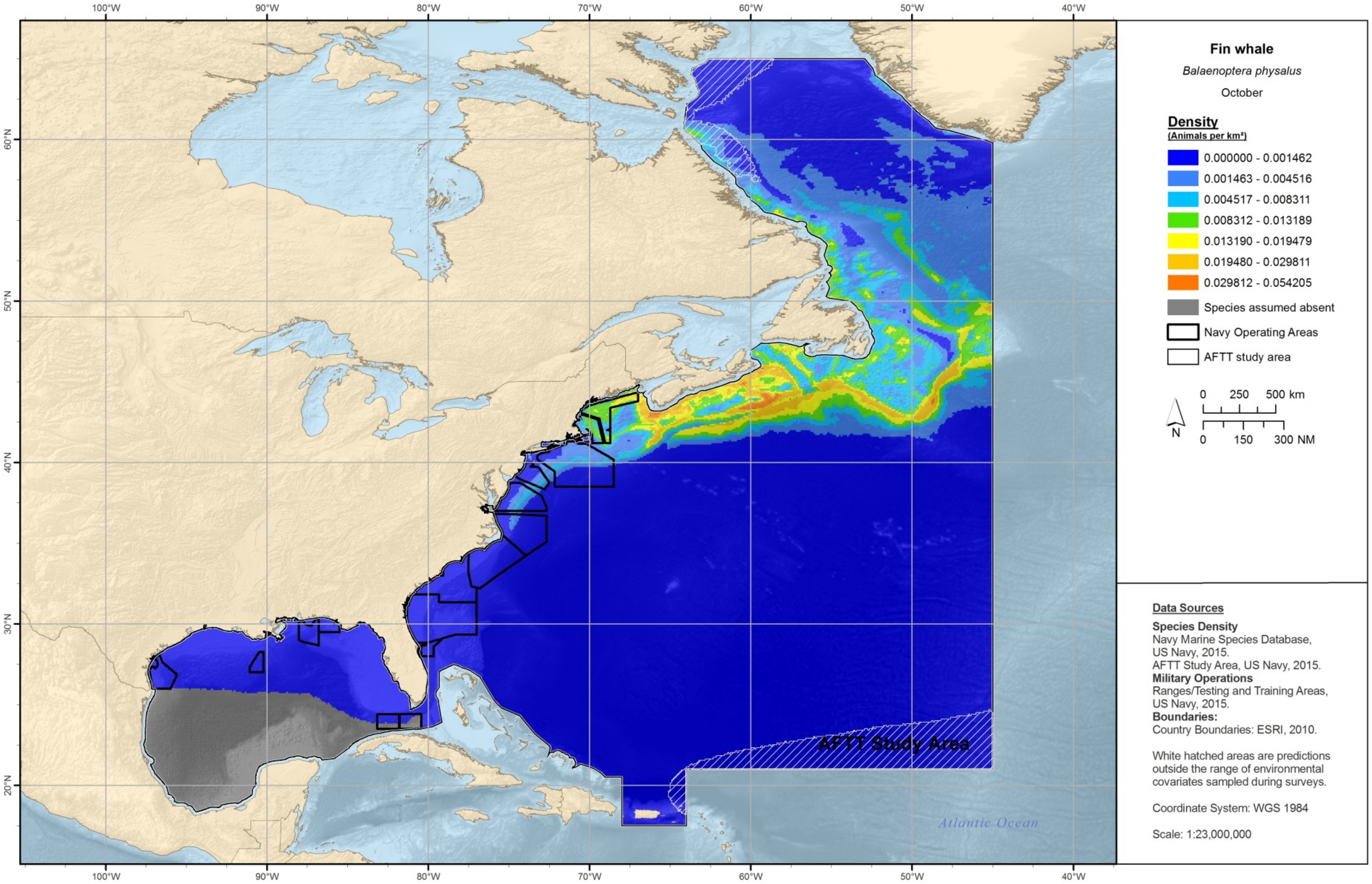
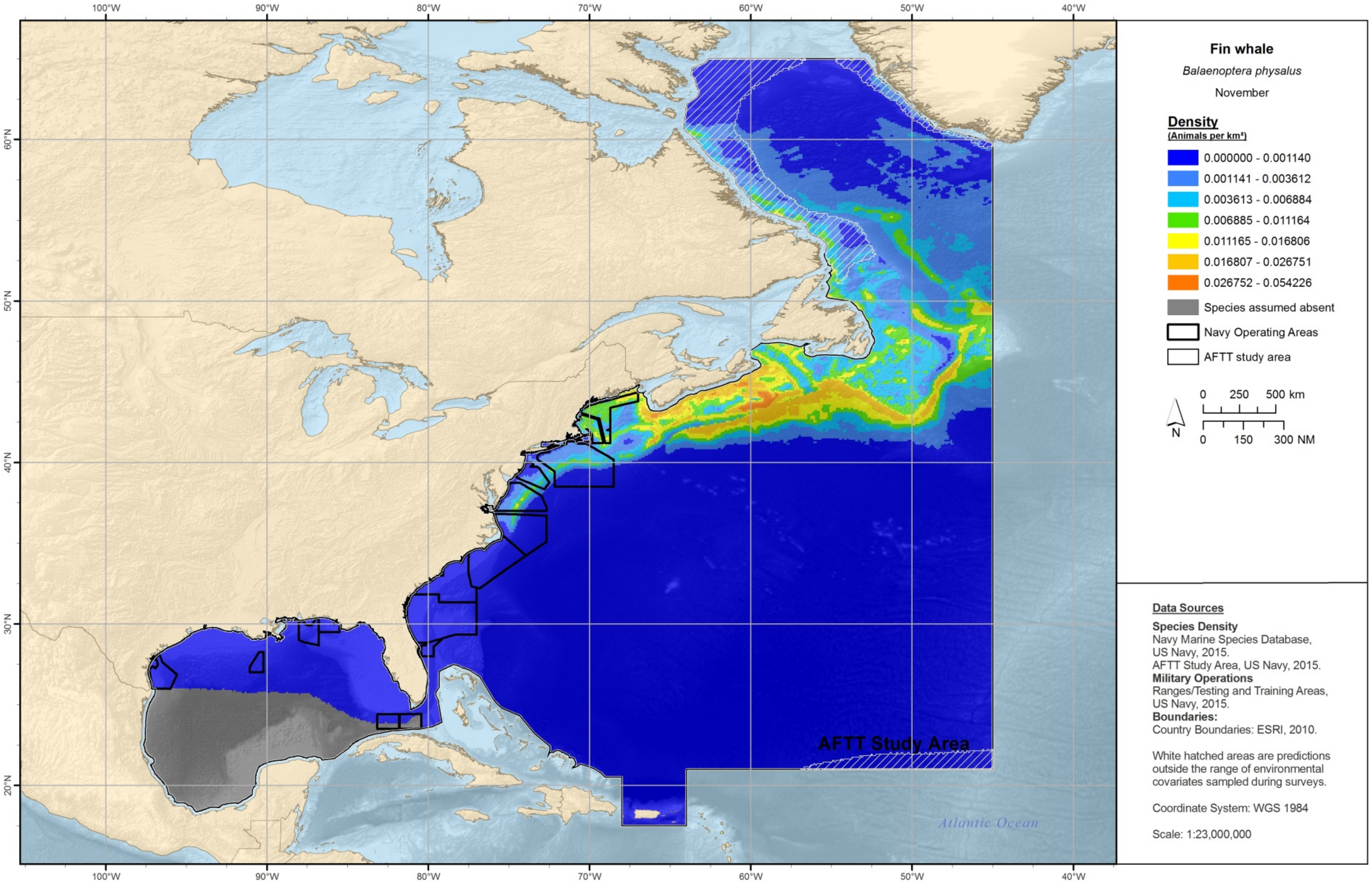


Figure 4-12. October density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.



Data Sources

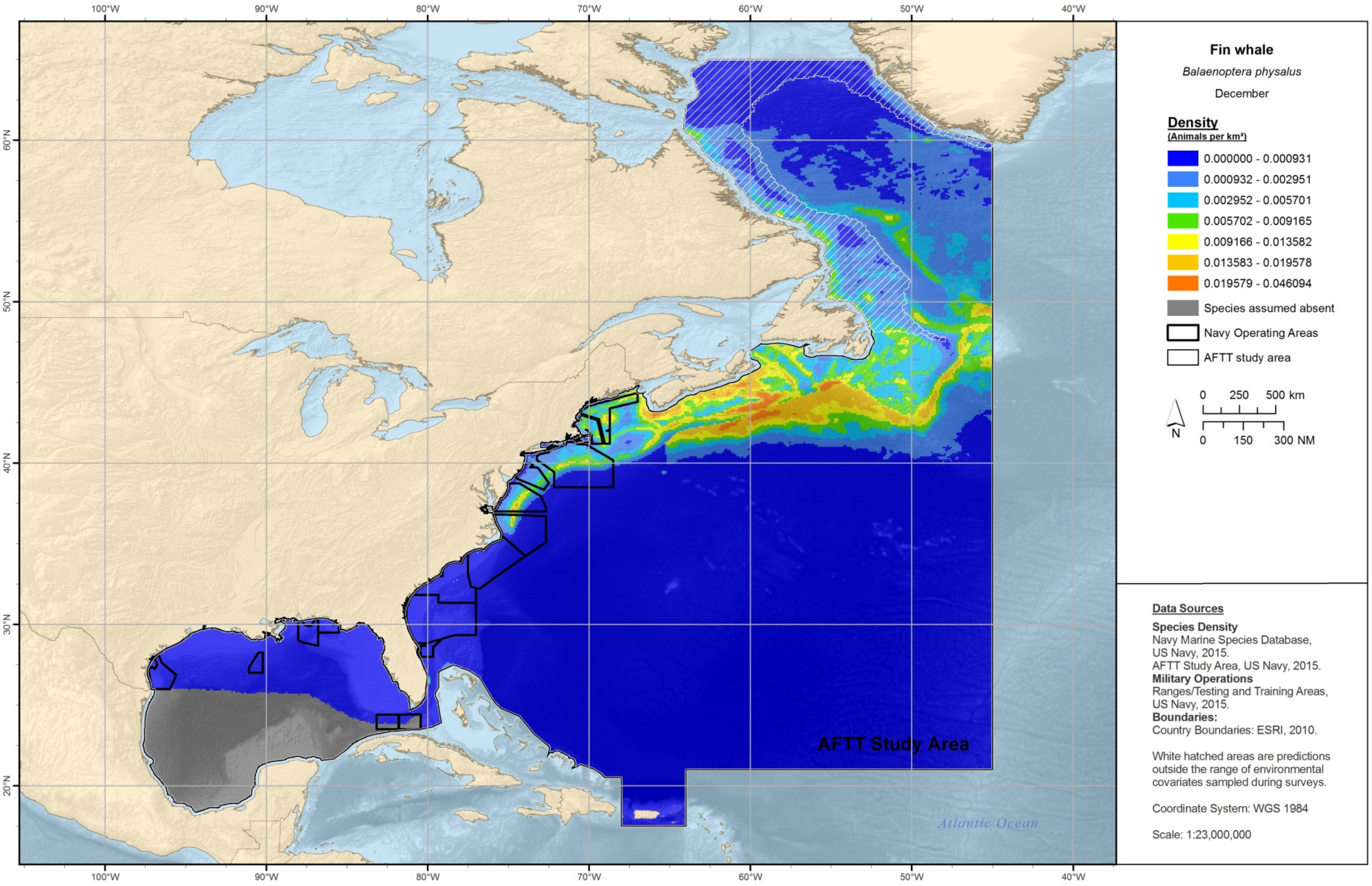
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-13. November density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-14. December density prediction for fin whales for the East Coast, Gulf of Mexico, and AFTT strata.

Humpback whale (*Megaptera novaeangliae*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial was fit for the East Coast stratum. An extrapolative density spatial model was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico. This species has well-researched migration patterns (Mattila et al. 1989). A four season model showed strong similarities in spring, summer, and fall, so a two season, summer/winter model was used in both the East Coast and AFTT strata. Summer was defined as April-November and winter as December-March based on timing of migration. The temporal resolution of the density predictions was seasonal in both strata.

Survey Data and Selected Models:

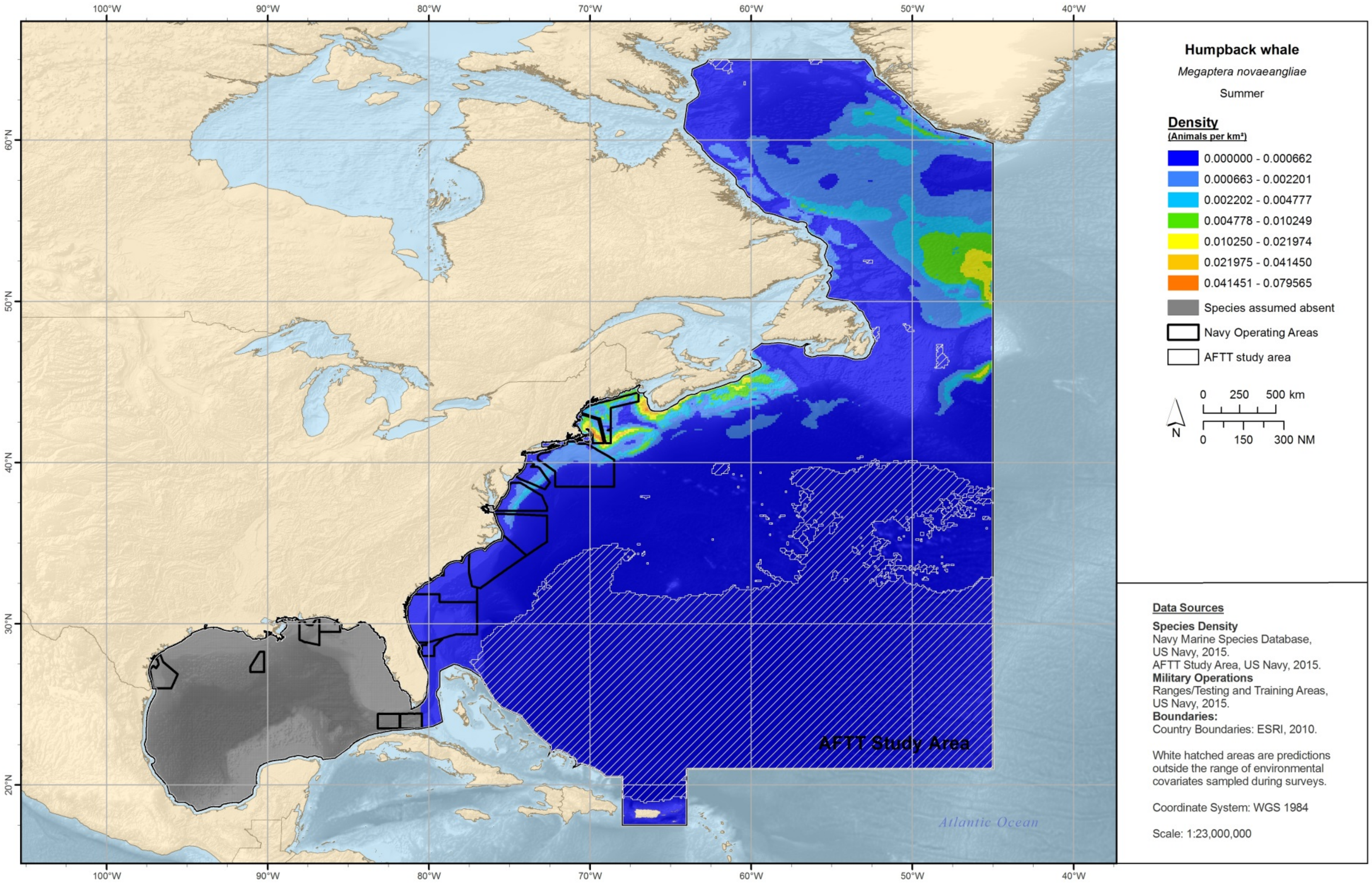
In the East Coast stratum, a total of 2,732 sightings from the combined survey data were used for model development (149 in winter, 2583 in summer). The climatological models explained more deviance than models fitted with contemporaneous covariates, particularly when ocean current and primary productivity predictors were included. The contemporaneous and climatological models predicted different densities in the Scotian Shelf area (see supplementary material from Roberts et al. (2016) for a more detailed discussion).

The model for the AFTT stratum used the same sightings from the East Coast and Gulf of Mexico models, as well as one sighting from the mid-Atlantic ridge (summer) and 41 sightings from the Caribbean (winter). The best fitting summer model included depth, distance to fronts, chlorophyll concentration, and sea surface height anomaly as predictors. The winter model used a single predictor (sea surface temperature) given the lower number of sightings. Density predictions from both of the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of the species.

Other Density Estimate:

An abundance estimate of 205 individuals (CV=0.16) in winter and 1,637 indivuduals (CV=0.07) in summer were derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 335 individuals (CV=0.42). This estimate was based on summer 2011 NEFSC and SEFSC aerial surveys and does not include the Bay of Fundy (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al and Mannocci et al. (2016) models at the time of release. In TAP Phase II, the NODES estimate of 1,230 individuals (summer season, no CV available) based on survey data for the summer season was used, with SMRU RES data used elsewhere. A photo ID study of the Gulf of Maine and Bay of Fundy identified 823 individuals but did not include the Scotian Shelf (Robbins 2007). While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population is reasonable if animals in Canadian waters not accounted for in the US surveys are considered. Data in Canadian waters were unavailable to the modeling team despite repeated requests for access. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also preferable to the SAR estimate which uses only a single season of one year of survey data and does not cover the species' full range which is less desirable in the NMSDD data hierarchy. The higher predicted abundance for the Roberts et al. 2016 model is largely attributable to the differences in spatial coverage of the predictions.

An abundance estimate of 6,217 individuals (CV=0.15) was derived from the AFTT stratum model in the winter and 4,270 individuals (CV=0.31) in the summer (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-15. Summer density prediction for humpback whales for the East Coast and AFTT strata.

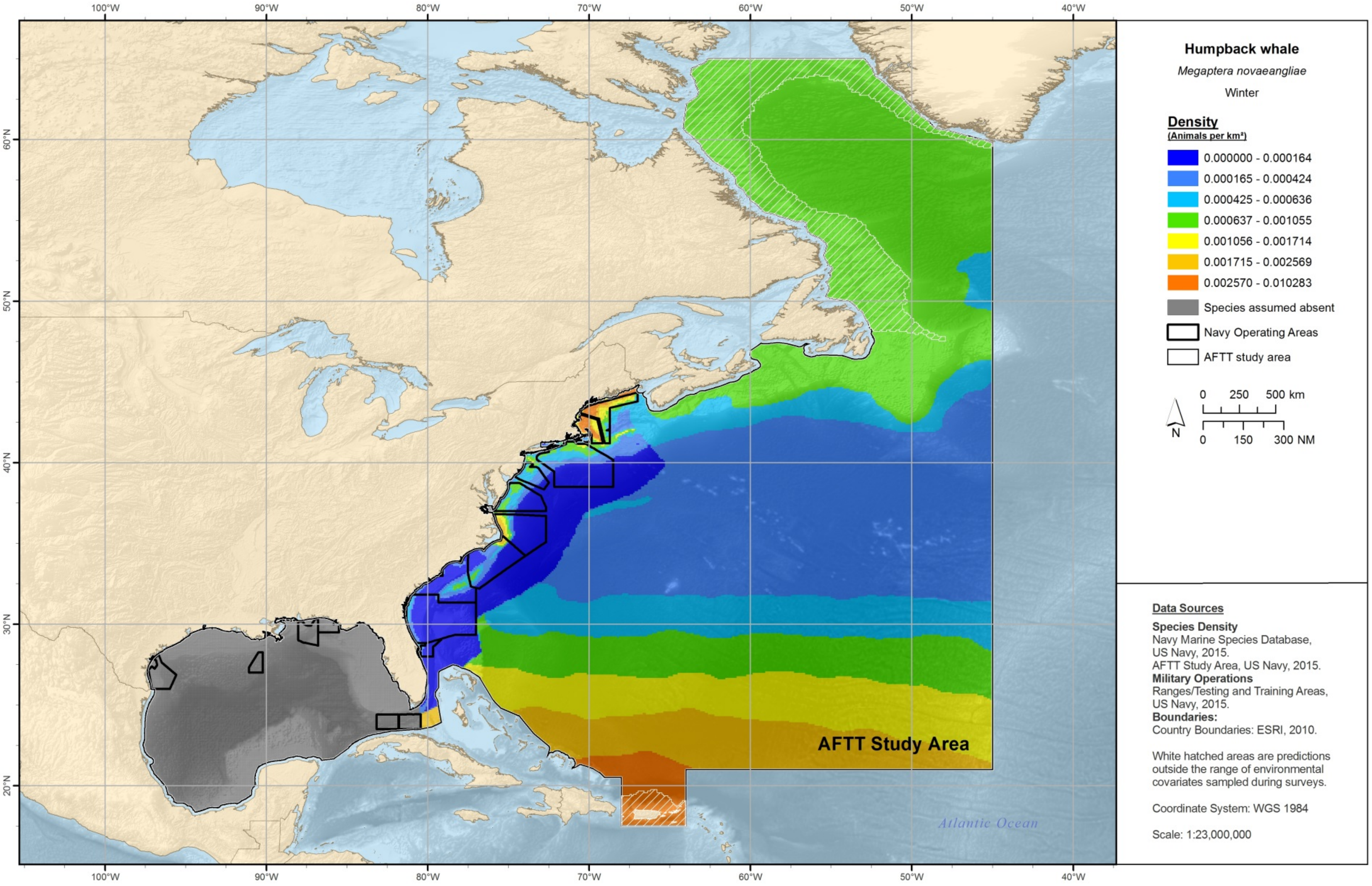


Figure 4-16. Winter density prediction for humpback whales for the East Coast and AFTT strata.

Minke whale (*Balaenoptera acutorostrata*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species come from density spatial density models developed by Roberts et al. (2016) and extrapolative density spatial density models developed by Mannocci et al. (2016). A density spatial model was fit for the East Coast stratum. An extrapolative density spatial model was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region. The sightings record for this species shows clear seasonal movement to higher latitudes in summer and lower latitudes in winter. Two seasonal models were fit in the East Coast with transitions between summer and winter defined at October/November and March/April based on visual and acoustic sightings records. A separate winter model was not fit in the AFTT given the lack of sightings in that season over the broader region. The temporal resolution of the density predictions was monthly in the East Coast and annual in the AFTT.

Survey Data and Selected Models:

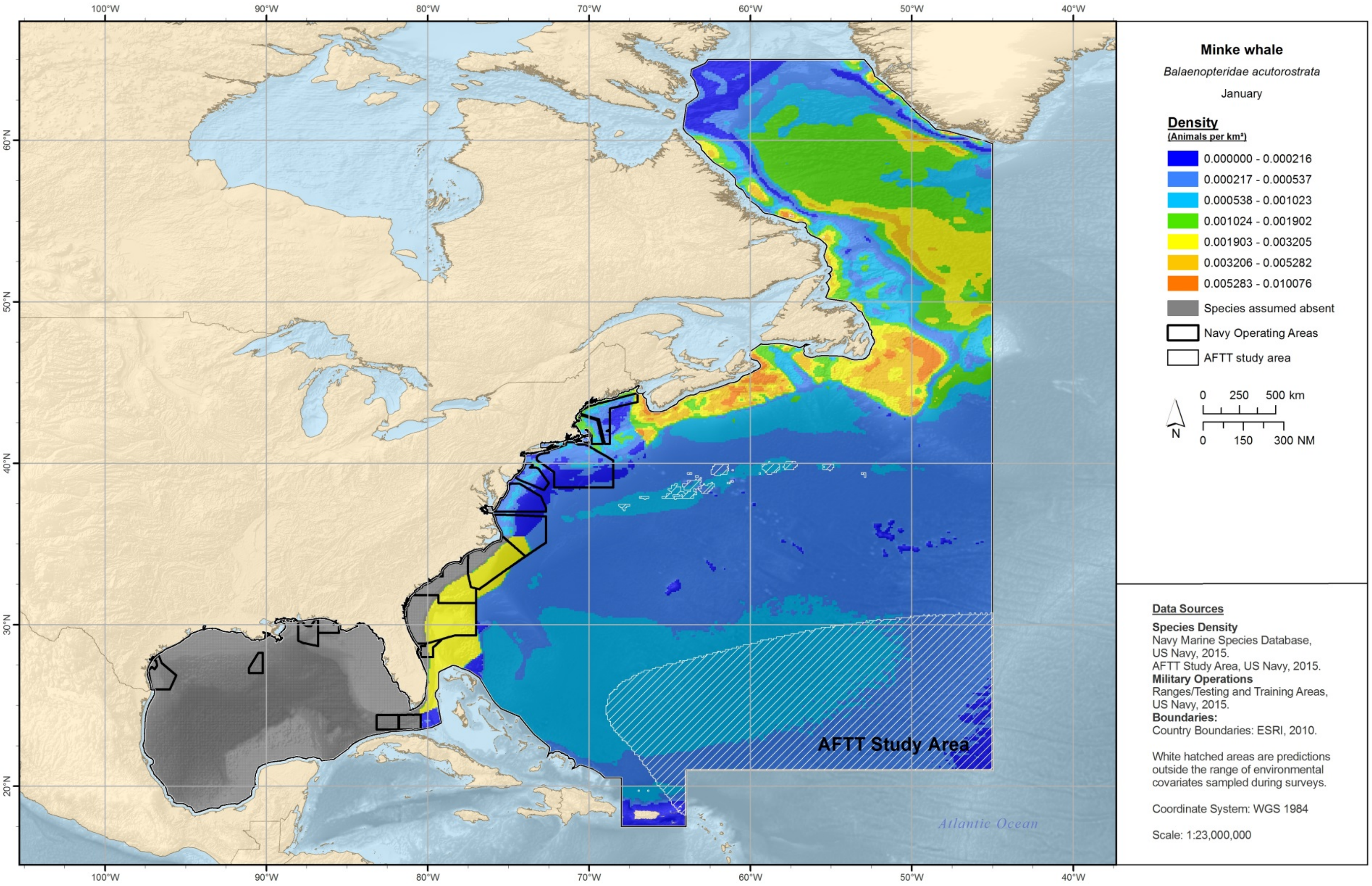
In the East Coast stratum, data from the combined survey data were used with 1,031 total sightings. The months covered by the seasonal spatial models were based on the reduced presence of animals in the Gulf of Maine in November-March and sightings of minke whales in each month of December-March between Cape Hatteras and Florida that were not present in other months (Roberts et al. 2015). Within the East Coast stratum during the winter season, the model was split into two geographic subregions based on suspected foraging and calving grounds (Waring et al. 2014). In both subregions, climatological environmental variables explained more deviance than contemporaneous ones and so the climatological models were chosen.

The model for the AFTT stratum used the 1,030 East Coast stratum sightings, as well as two sightings from the Caribbean, 76 sightings from the European Atlantic, and 1sighting from the Mid-Atlantic Ridge. The best fitting model included depth, distance to front, and zooplankton potential biomass as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. The non-zero density extent of the predicted model is consistent with the assumed extent of this species' range (Riley et al. 2008).

Other Density Estimates:

An abundance estimate of 2,112 individuals was derived from the East Coast stratum model (Roberts et al. 2016). The most recent NOAA SAR is 20,741 individuals (CV=0.81) based on 2007 surveys performed in Canadian waters only (Waring et al. 2014). For TAP Phase II, a NODES estimate of 24,545 individuals (summer season, no CV available) based on survey data for the summer season in the northeast only was used, with SMRU RES data used elsewhere. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the SAR estimate and the estimate from the Roberts et al. (2016) East Coast stratum model cover entirely different spatial extents and are not comparable. Because the SAR estimate does not cover the same spatial extent it is not appropriate for use in modeling acoustic effects in the East Coast stratum. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed and replaces global RES data in the southeast which is lower in the NMSDD hierarchy.

An abundance estimate of 7,617 individuals (CV=0.19) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Given its good model performance metrics, the Mannocci et al. (2016) model is expected to predict overall minke whale distribution reasonably well, though density appears to be underestimated in northern waters based on Canadian surveys. Unfortunately, data from these surveys were not available to the modelers despite repeated attempts to acquire the data. Navy activity outside the East Coast stratum drops off considerably as distance increases.



Data Sources

Species Density
Navy Marine Species Database,
US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas,
US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-17. January density prediction for minke whales for the East Coast and AFTT strata.

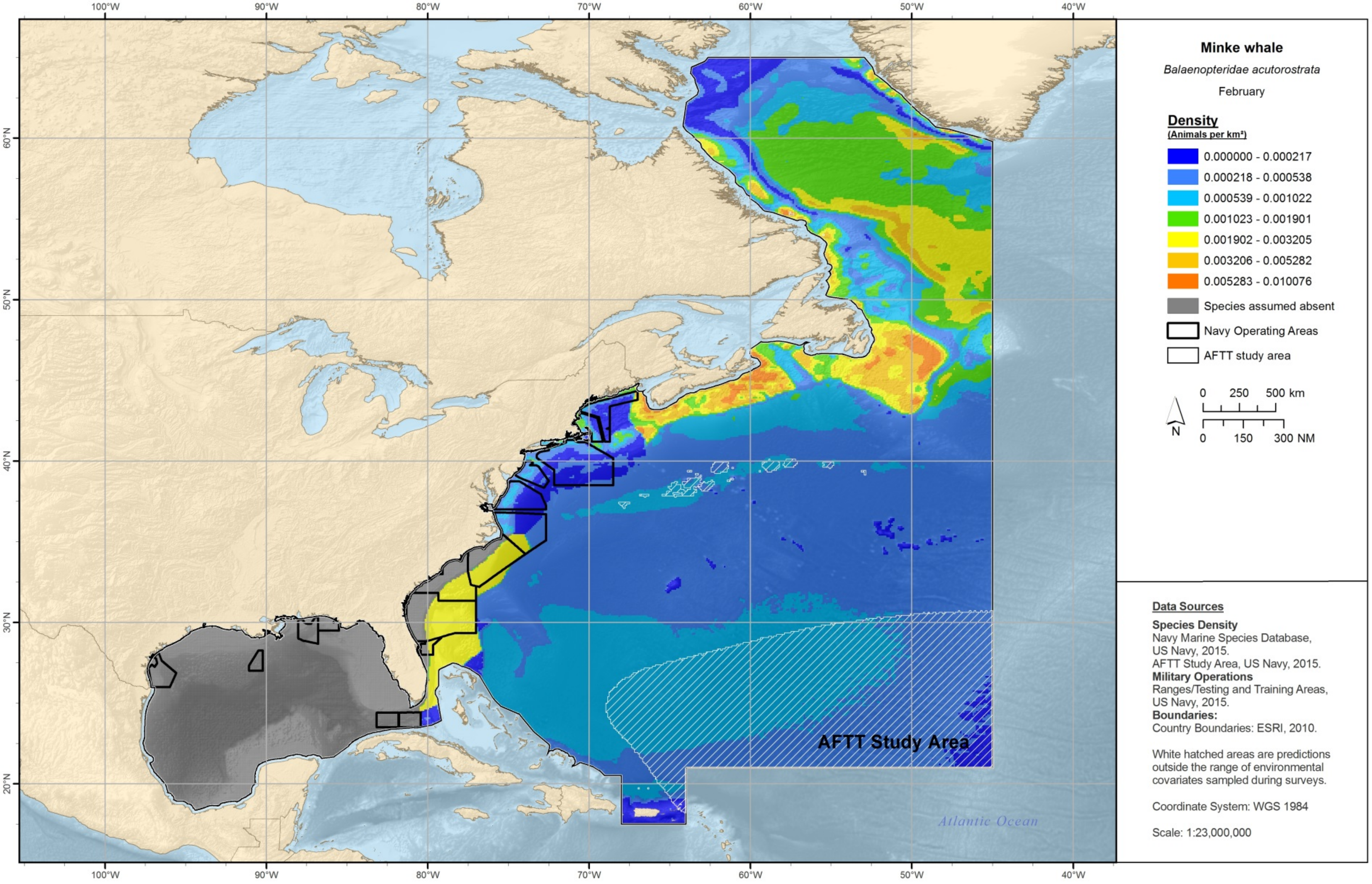


Figure 4-18. February density prediction for minke whales for the East Coast and AFTT strata.

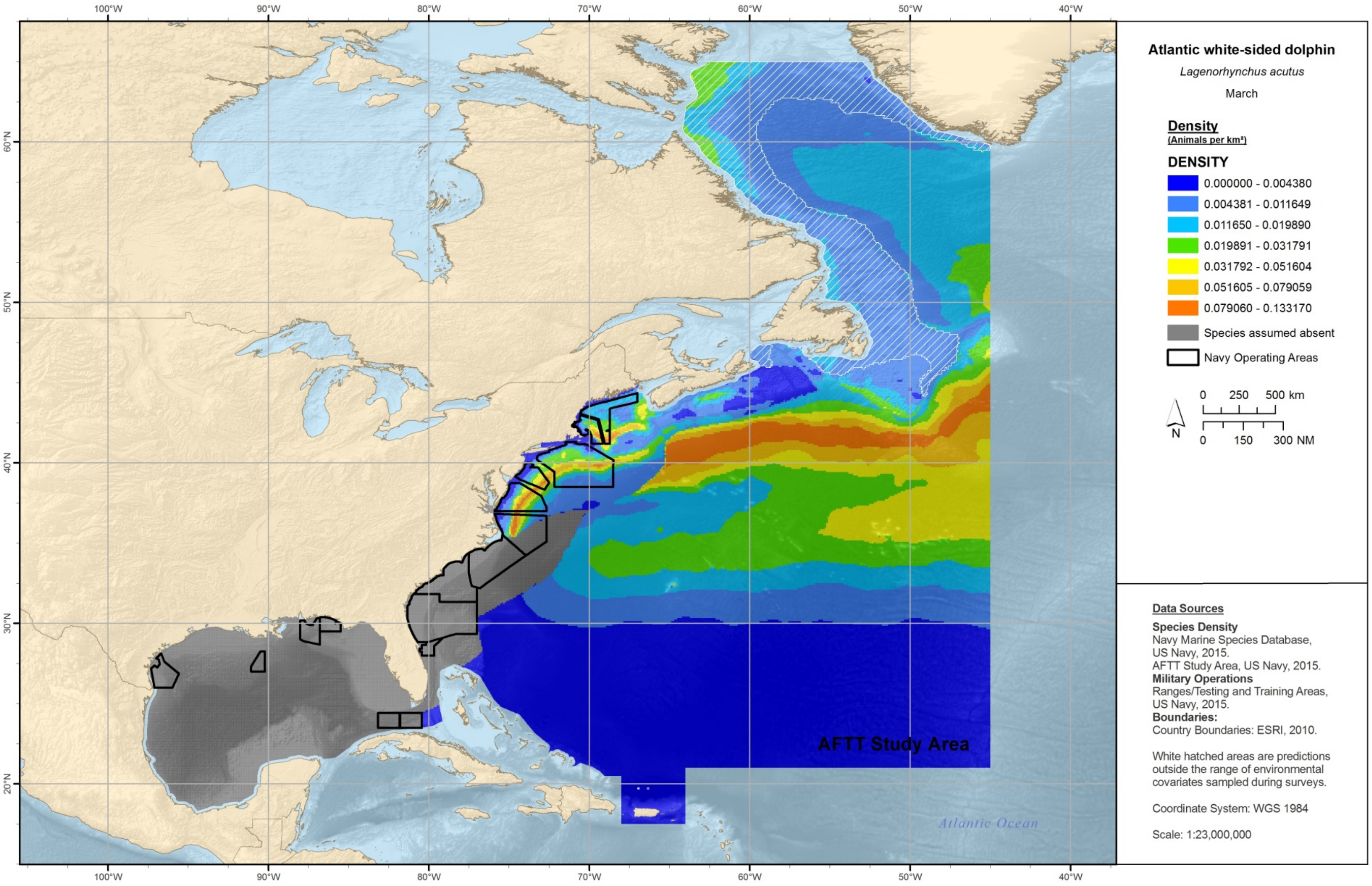


Figure 4-19. March density prediction for minke whale for the East Coast and AFTT strata.

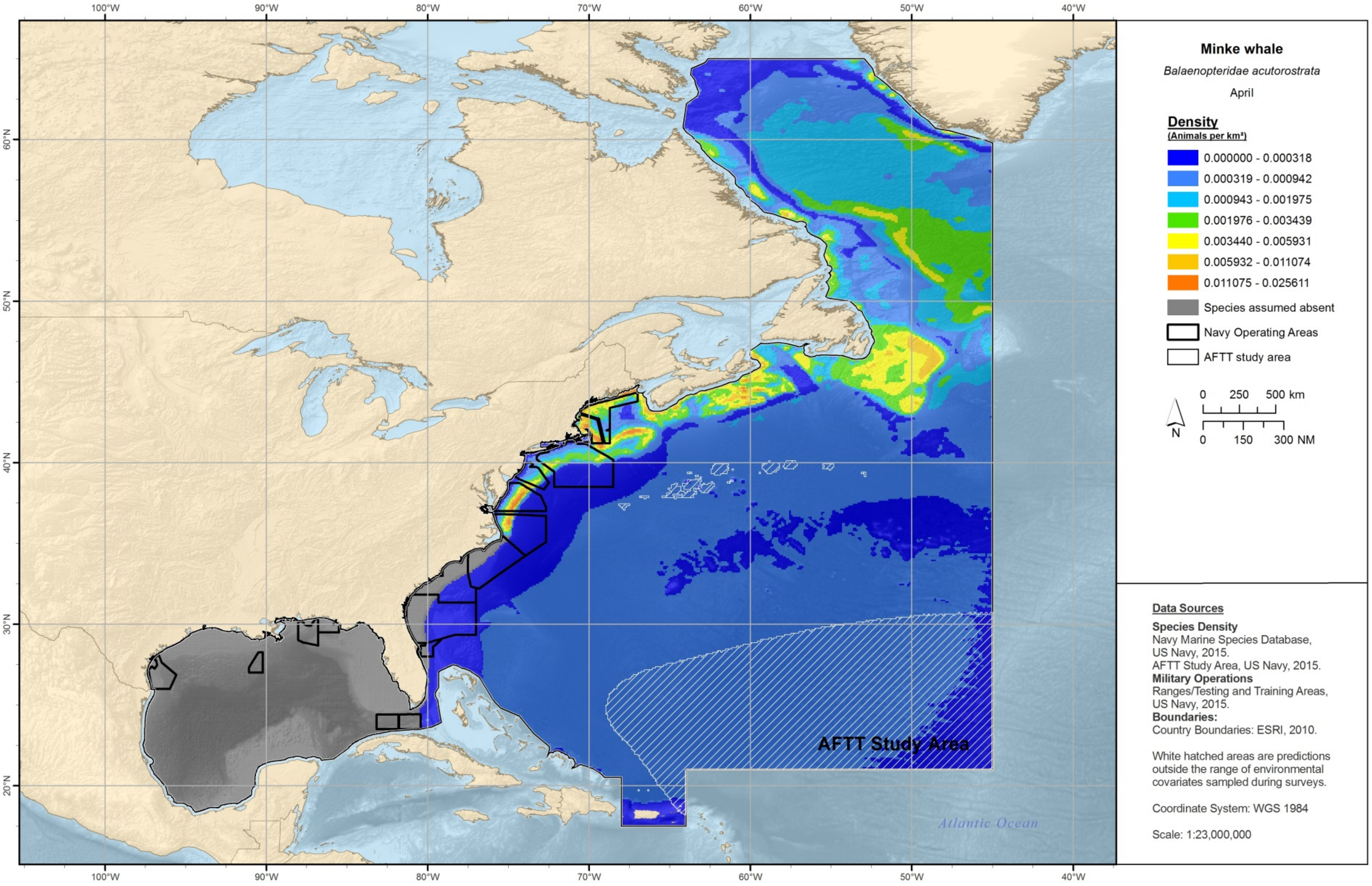


Figure 4-20. April density prediction for minke whales for the East Coast and AFTT strata.

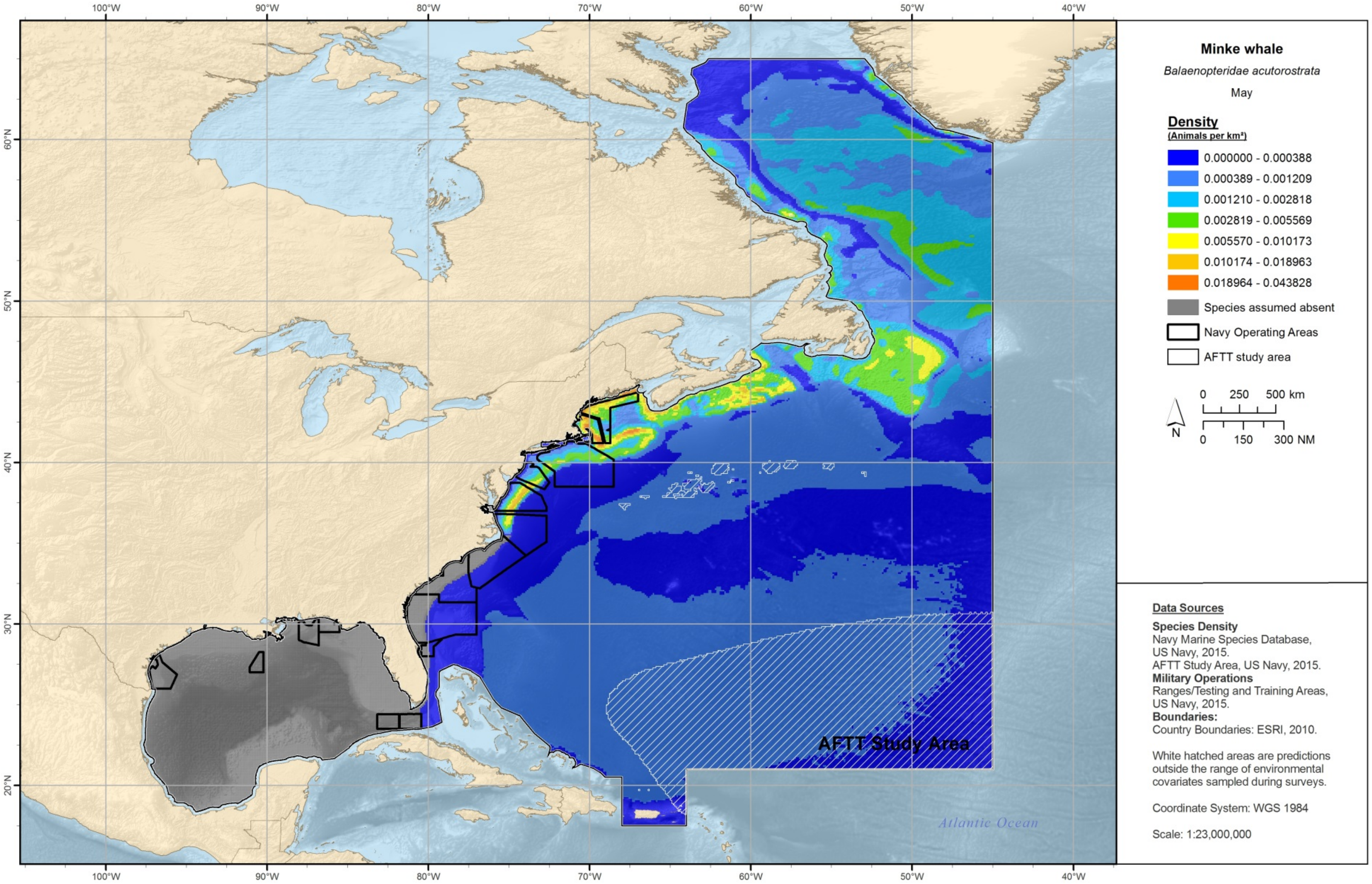
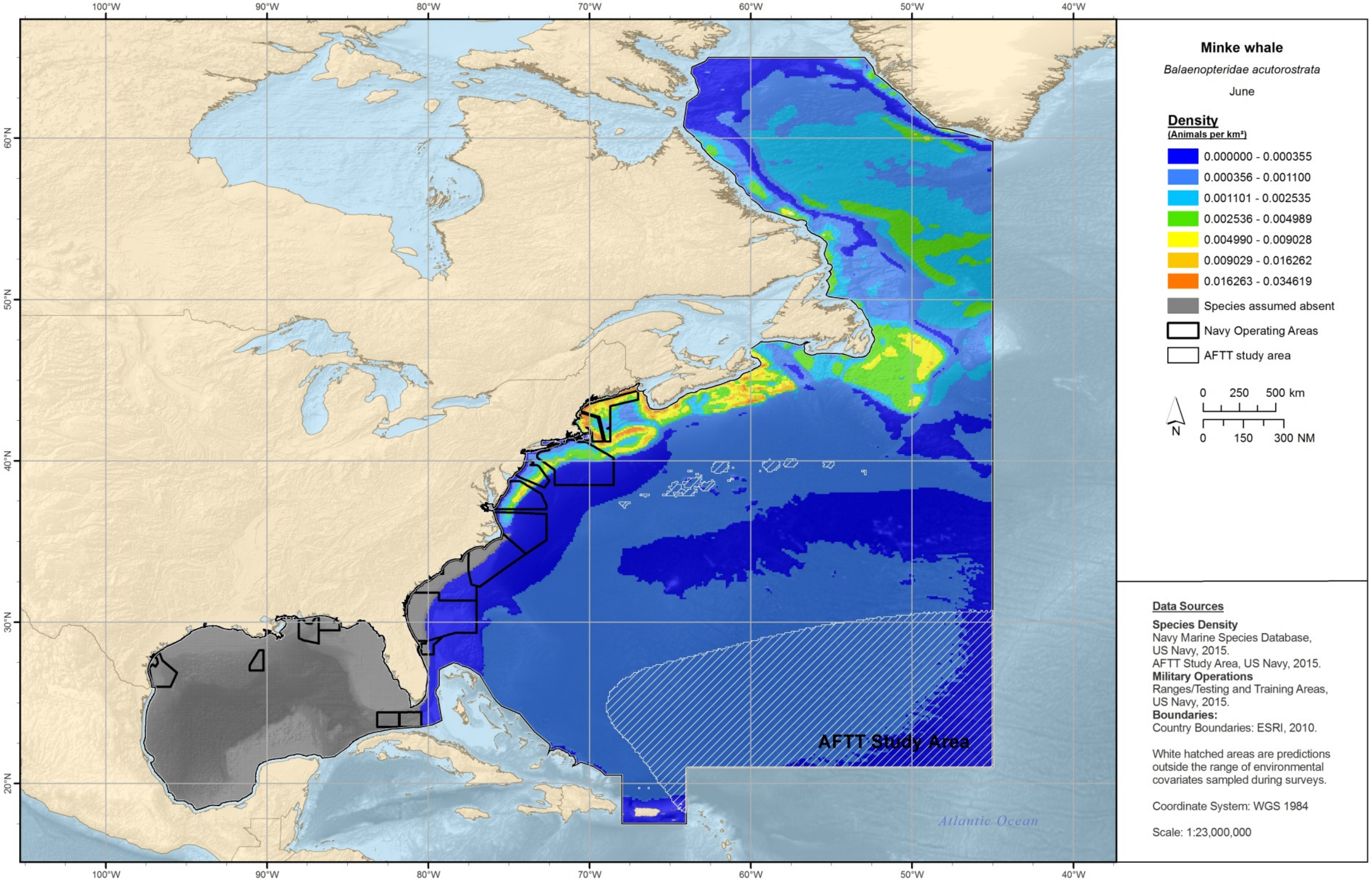


Figure 4-21. May density prediction for minke whales for the East Coast and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-22. June density prediction for minke whales for the East Coast and AFTT strata.

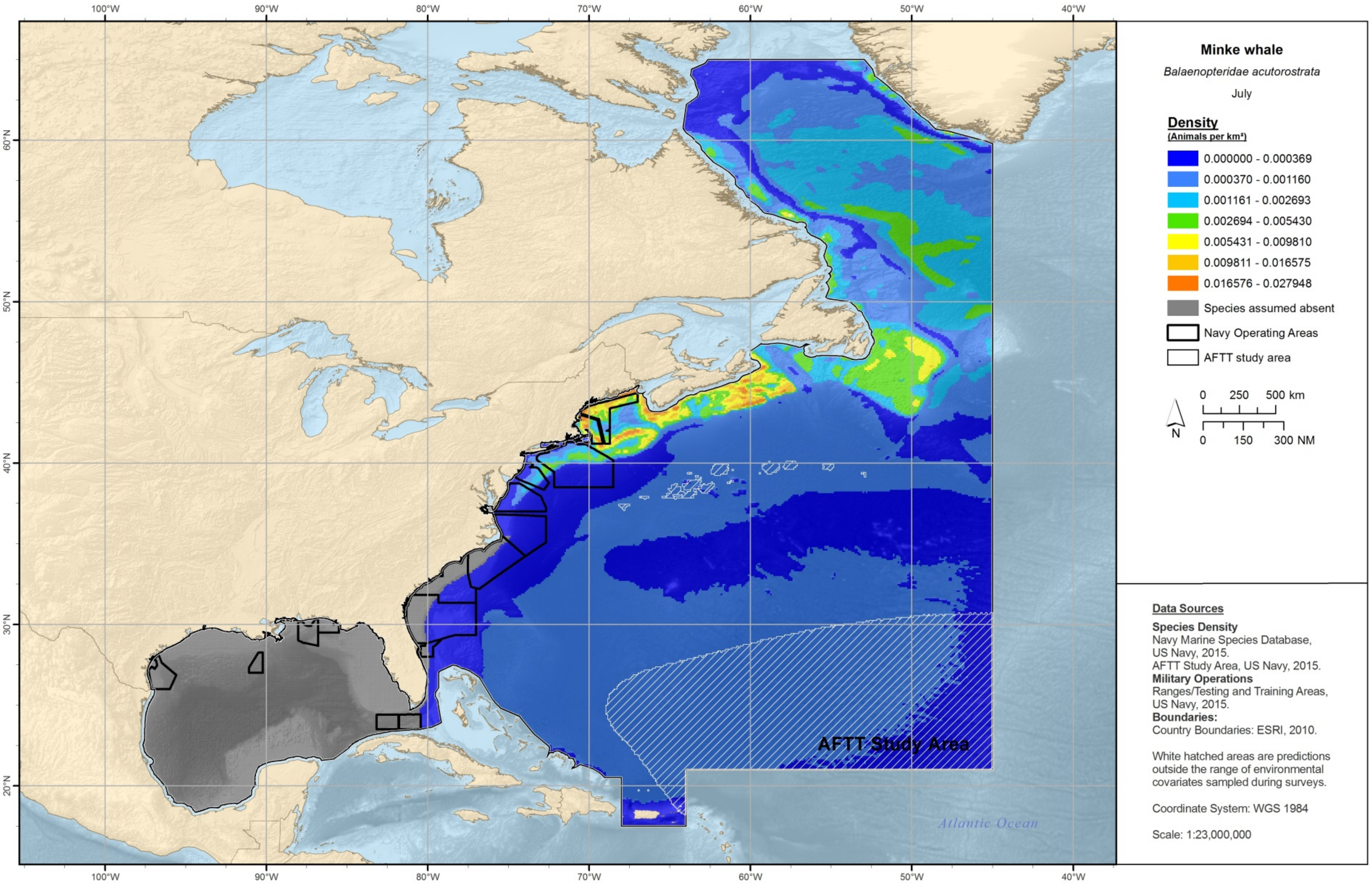


Figure 4-23. July density prediction for minke whales for the East Coast and AFTT strata.

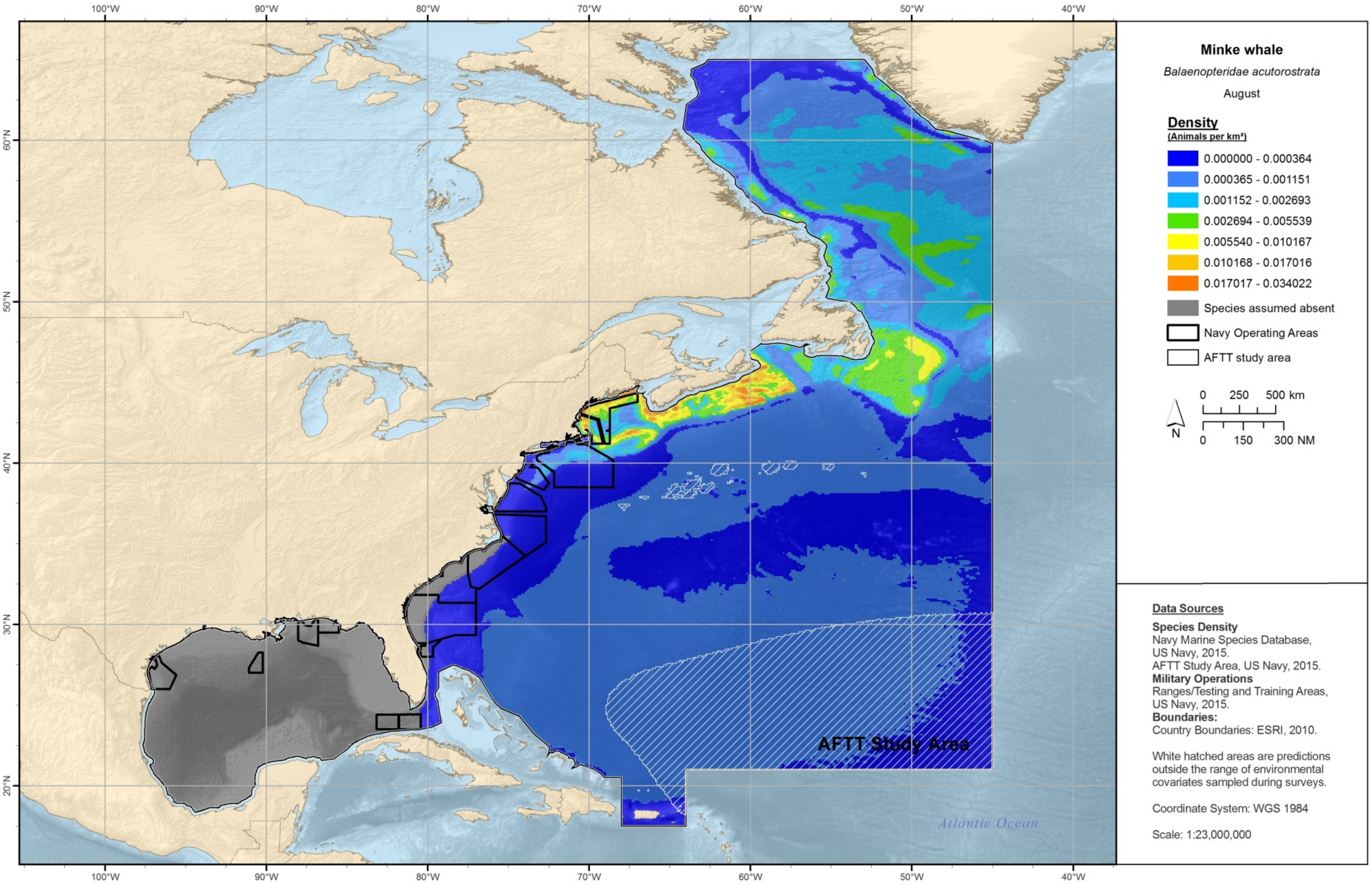


Figure 4-24. August density prediction for minke whales for the East Coast and AFTT strata.

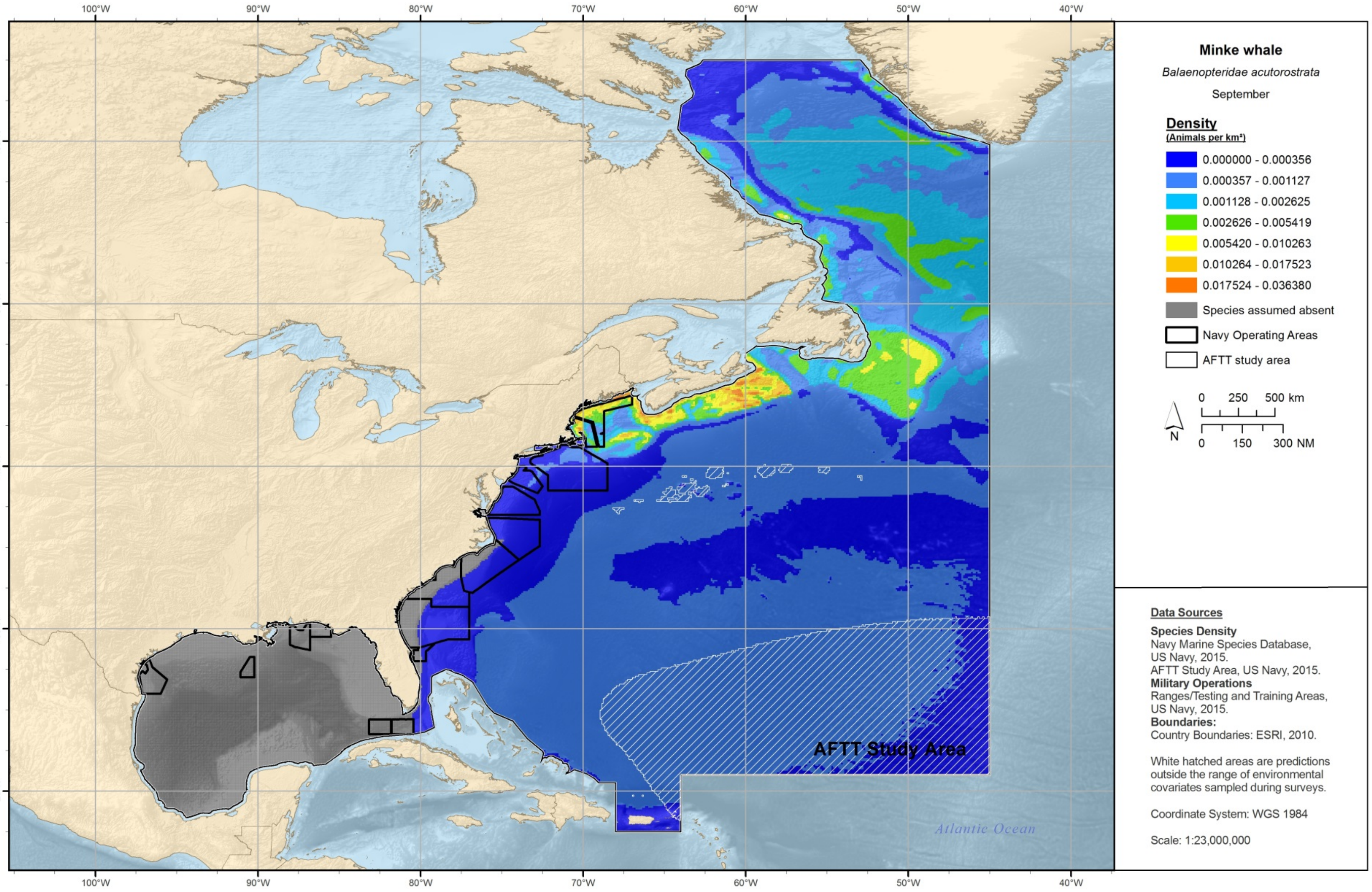
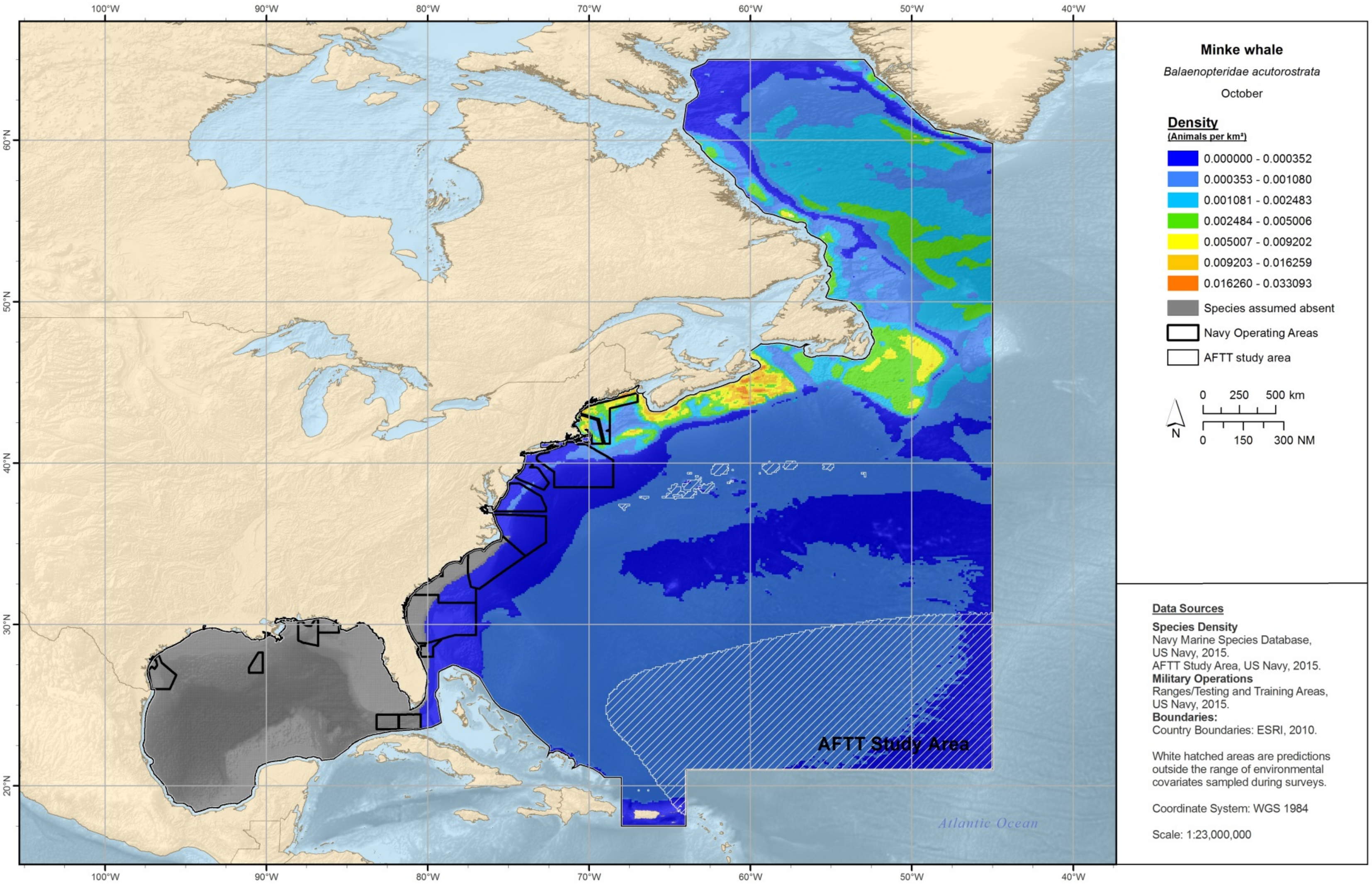


Figure 4-25. September density prediction for minke whales for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-26. October density prediction for minke whales for the East Coast and AFTT strata.

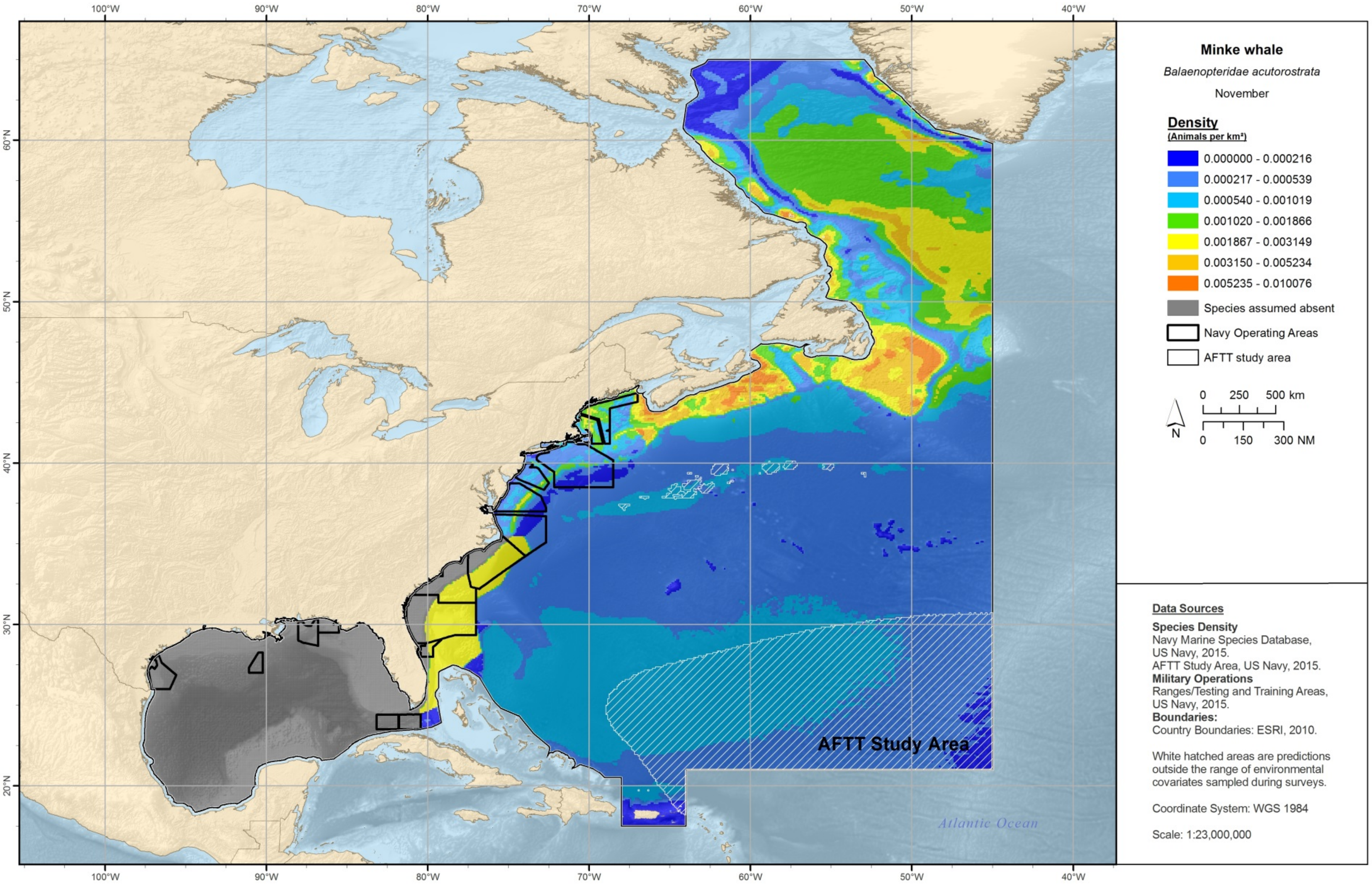
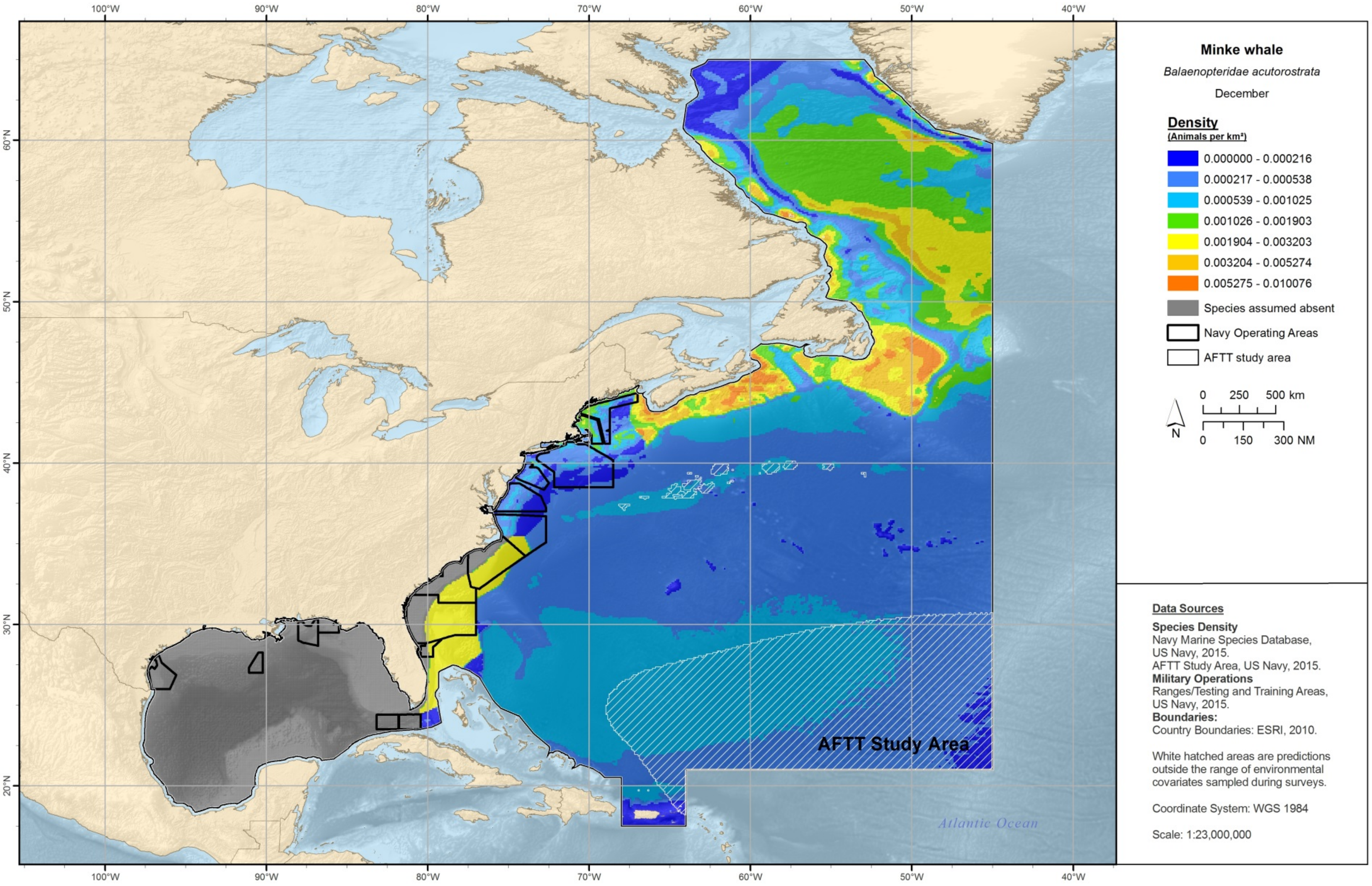


Figure 4-27. November density prediction for minke whales for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-28. December density prediction for minke whales for the East Coast and AFTT strata.

North Atlantic right whale (*Eubalaena glacialis*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and stratified density models developed by Mannocci et al. (2016). A density spatial model was fit for the East Coast stratum. A stratified density model was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region. This species has a complex life cycle with six phases described (Winn et al. 1986). The Roberts et al. (2016) modeling team did not feel confident in the spatiotemporal coverage of the survey data to fit a six season model and so fit a four season model, defined as follows: Winter (November-February), Spring (March-April), Summer (May-July, and Fall (August-October). See the supplemental material from Roberts et al. (2016) for a detailed rationale for these break points. A seasonal model was not fit for the AFTT Study Area given the paucity of sightings and the uncertainty of this species' distribution outside of surveyed regions. The temporal resolution of the density predictions was monthly in for East Coast stratum and annual for the AFTT stratum.

Survey Data and Selected Models:

In the East Coast stratum, a total of 1,634 sightings from the combined survey data were used for model development (371 in winter, 326 in spring, 845 in summer, and 176 in fall). The climatological models explained more deviance than models fitted with contemporaneous covariates in winter. The contemporaneous models were selected for all seasons except winter where the climatological model explained more deviance and was more in line with existing estimates of the Gulf of Maine population at that time of the year (see supplementary material from Roberts et al. 2016 for a more detailed discussion).

The model for the AFTT stratum used the same sightings from the East Coast model. No sightings data were available from other regions. A stratified model was selected because this species' current range is restricted and fitting an extrapolative habitat model throughout the entirety of the AFTT Study Area would be extremely unrealistic. The extent of the stratified model was based in depth to deepest sighting (500m) and from Florida to Nova Scotia where the populations is believed to be distributed (Kenney 2009).

Other Density Estimates:

An abundance estimate of 416 individuals (spring average value, CV=0.12) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent population estimate from a NOAA SAR is 465 individuals based on confirmed photo IDs and should be considered a minimum population estimate (Pettis and Hamilton 2014). In TAP Phase II, the NODES estimate of 165 individuals (July, no CV available) was used based on literature derived estimates. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the SAR estimate and the estimate from the Roberts et al. (2016) are in reasonable agreement. The Roberts et al. (2016) models do vary between seasons and months, reflecting movement of the species within and outside the East Coast stratum. The Roberts et al. (2016) estimate was chosen over the NODES model and SAR literature derived estimates as it is higher in the NMSDD hierarchy.

An abundance estimate of 1,721 individuals (CV=0.04) was derived from the AFTT stratum model (Mannocci et al. 2016). This seems unreasonably high given the expected population of this species and as such the East Coast model should be used wherever possible. The AFTT model assumed a density of zero for most of the AFTT Study Area and should only be used for those areas off of Nova Scotia not covered by the East Coast stratum model. No other density estimates exist for these regions.

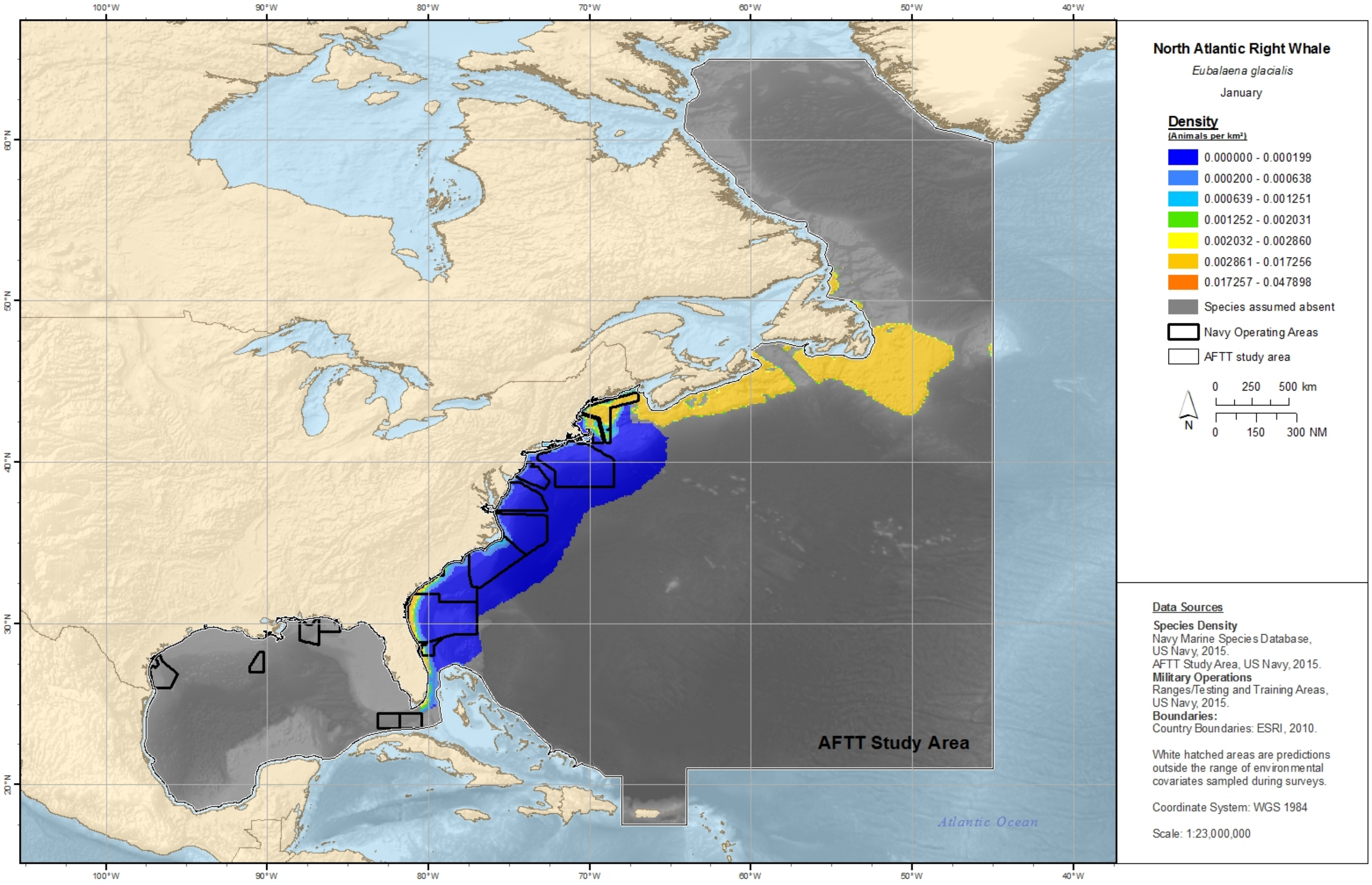


Figure 4-29. January density prediction for North Atlantic right whales for the East Coast and AFTT strata.

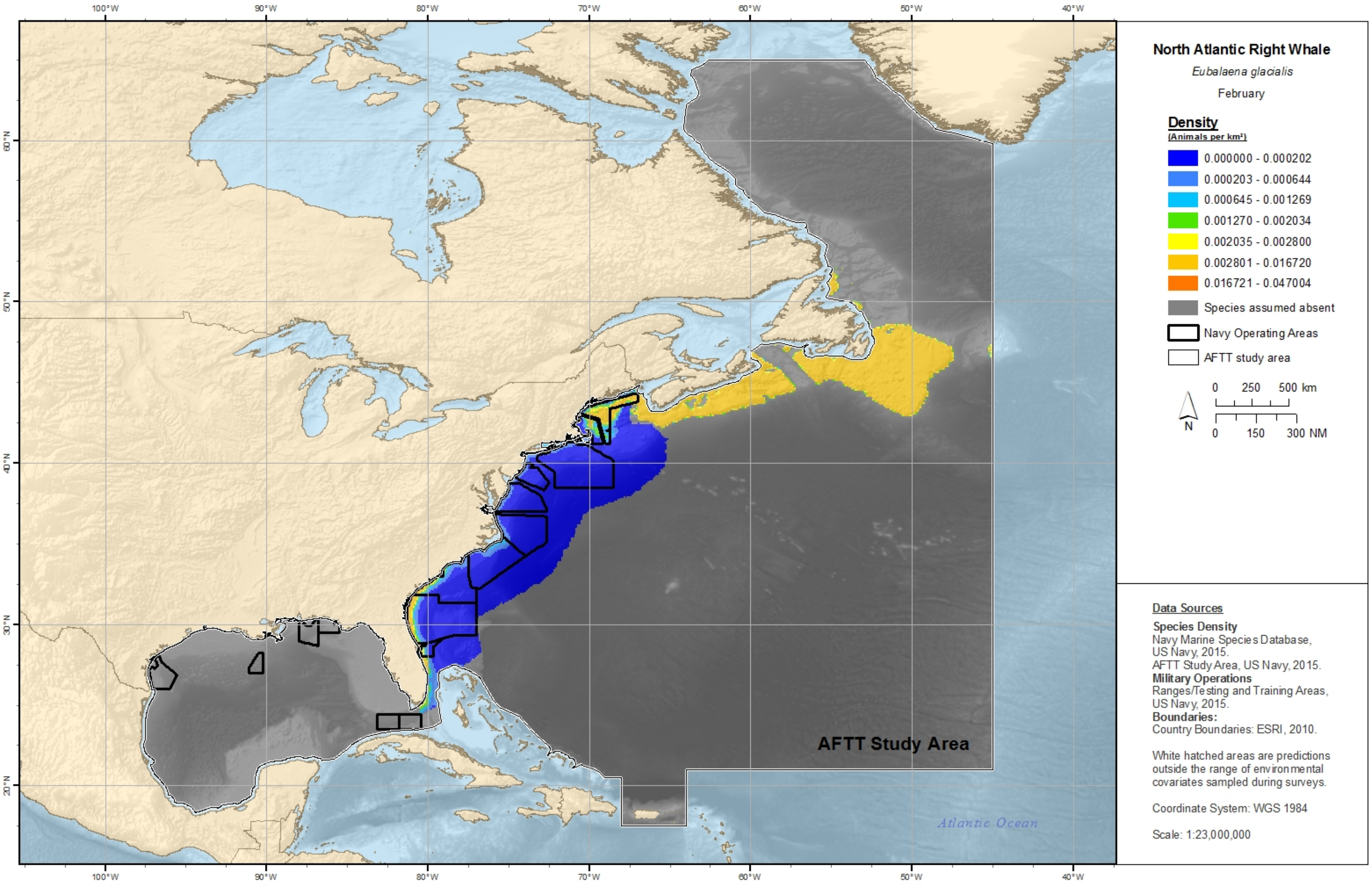
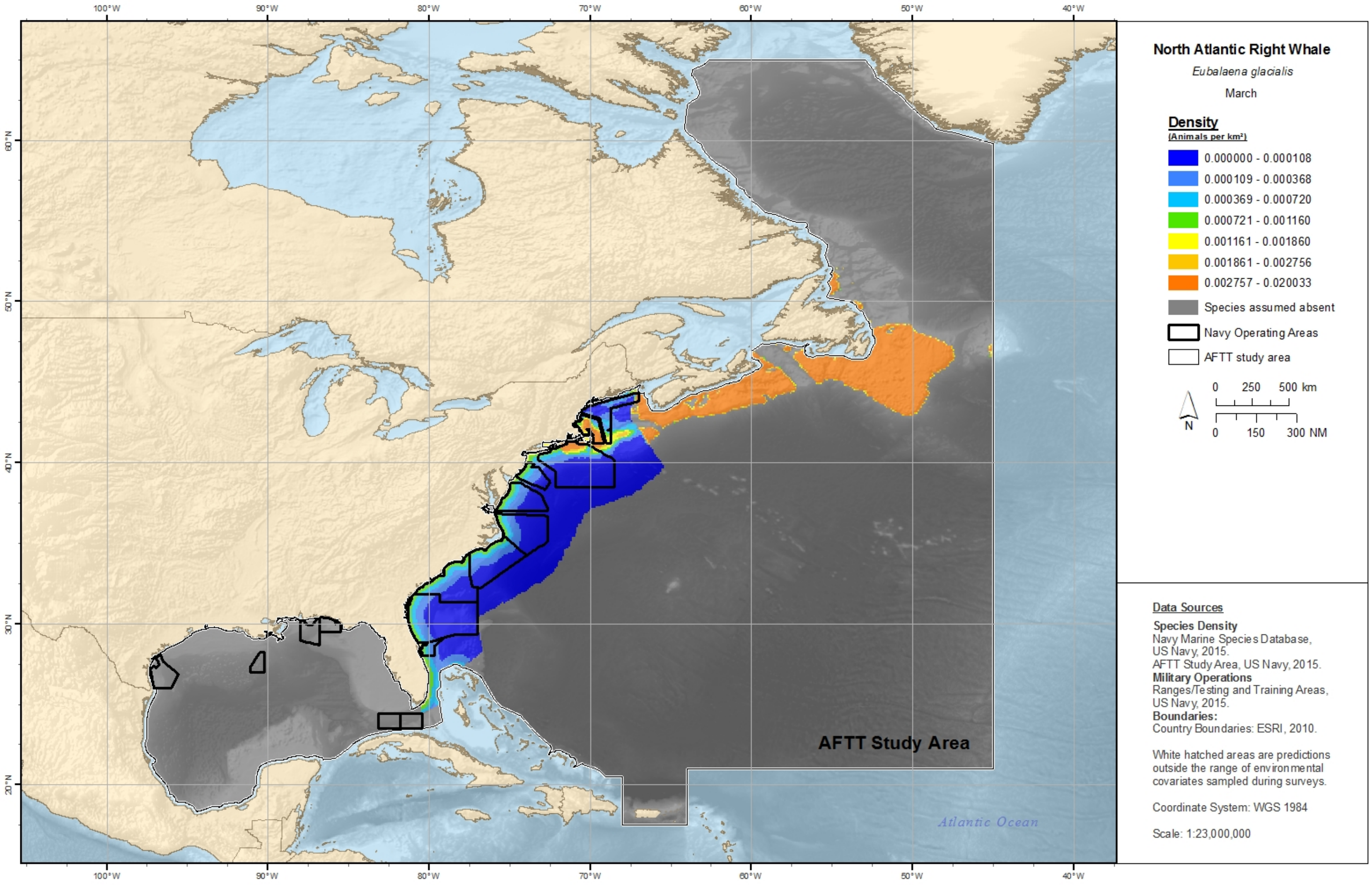


Figure 4-30. February density prediction for North Atlantic right whales for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-31. March density prediction for North Atlantic right whales for the East Coast and AFTT strata.

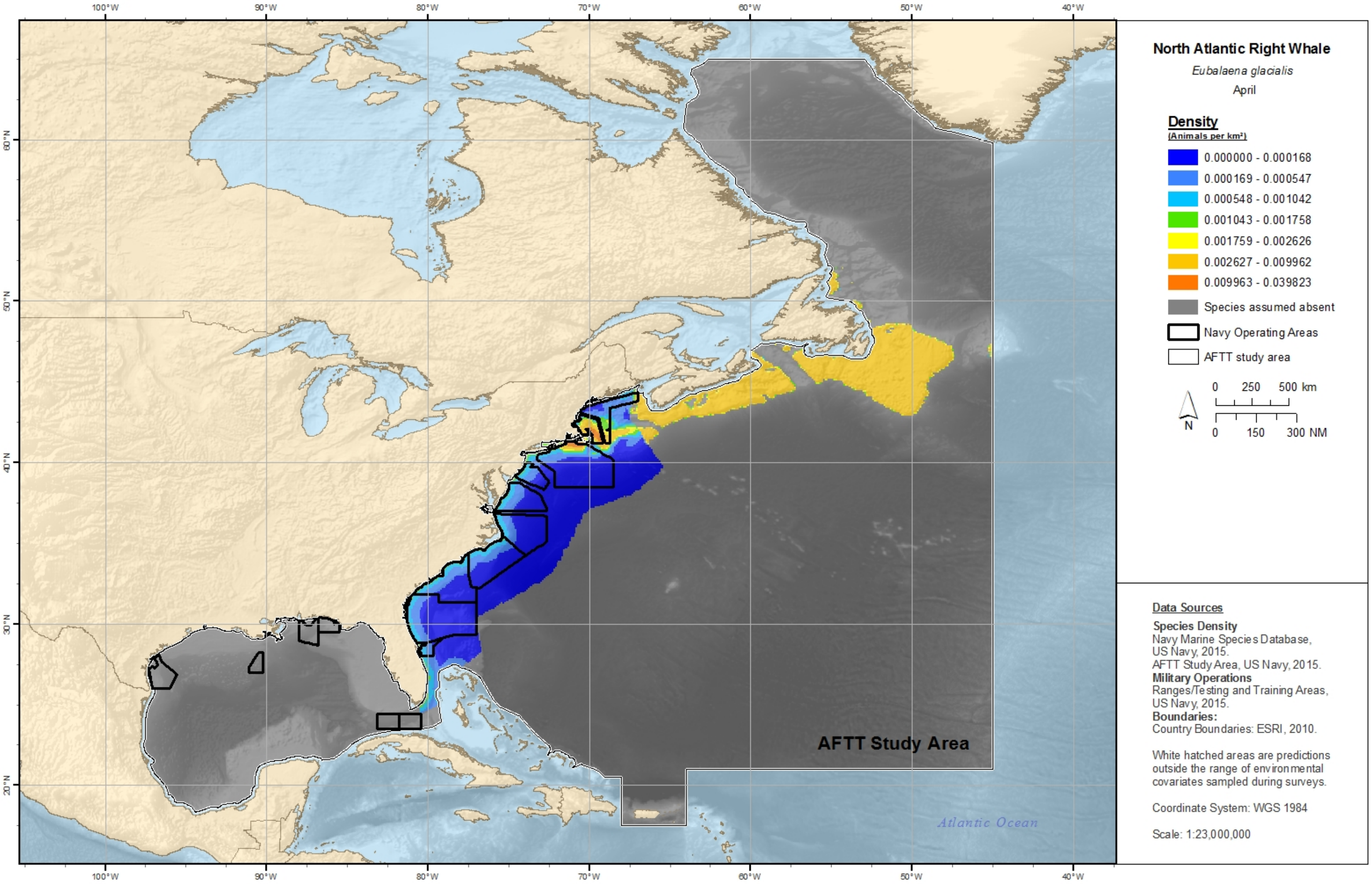


Figure 4-32. April density prediction for North Atlantic right whales for the East Coast and AFTT strata.

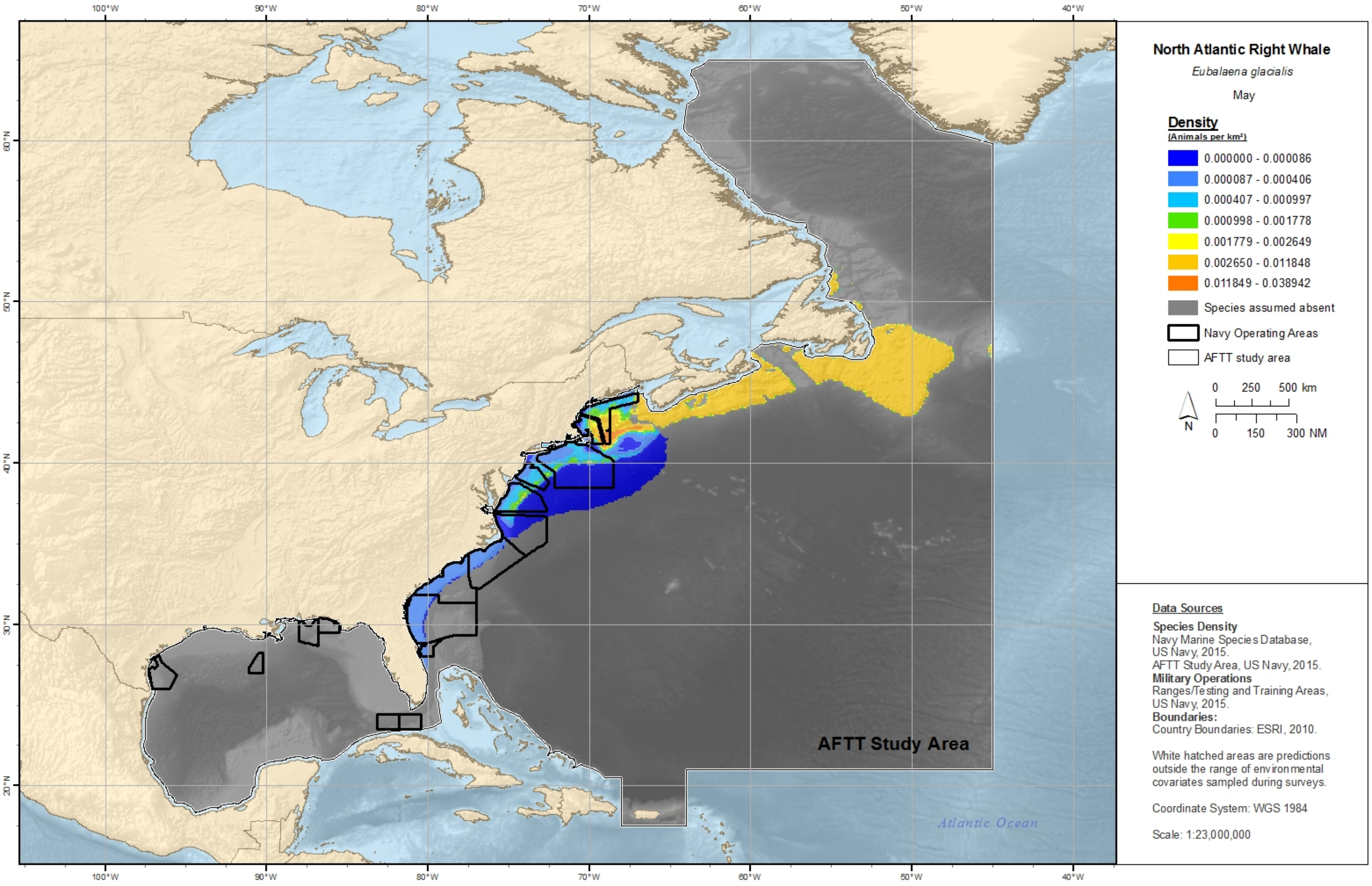


Figure 4-33. May density prediction for the North Atlantic right whales for the East Coast and AFTT strata.

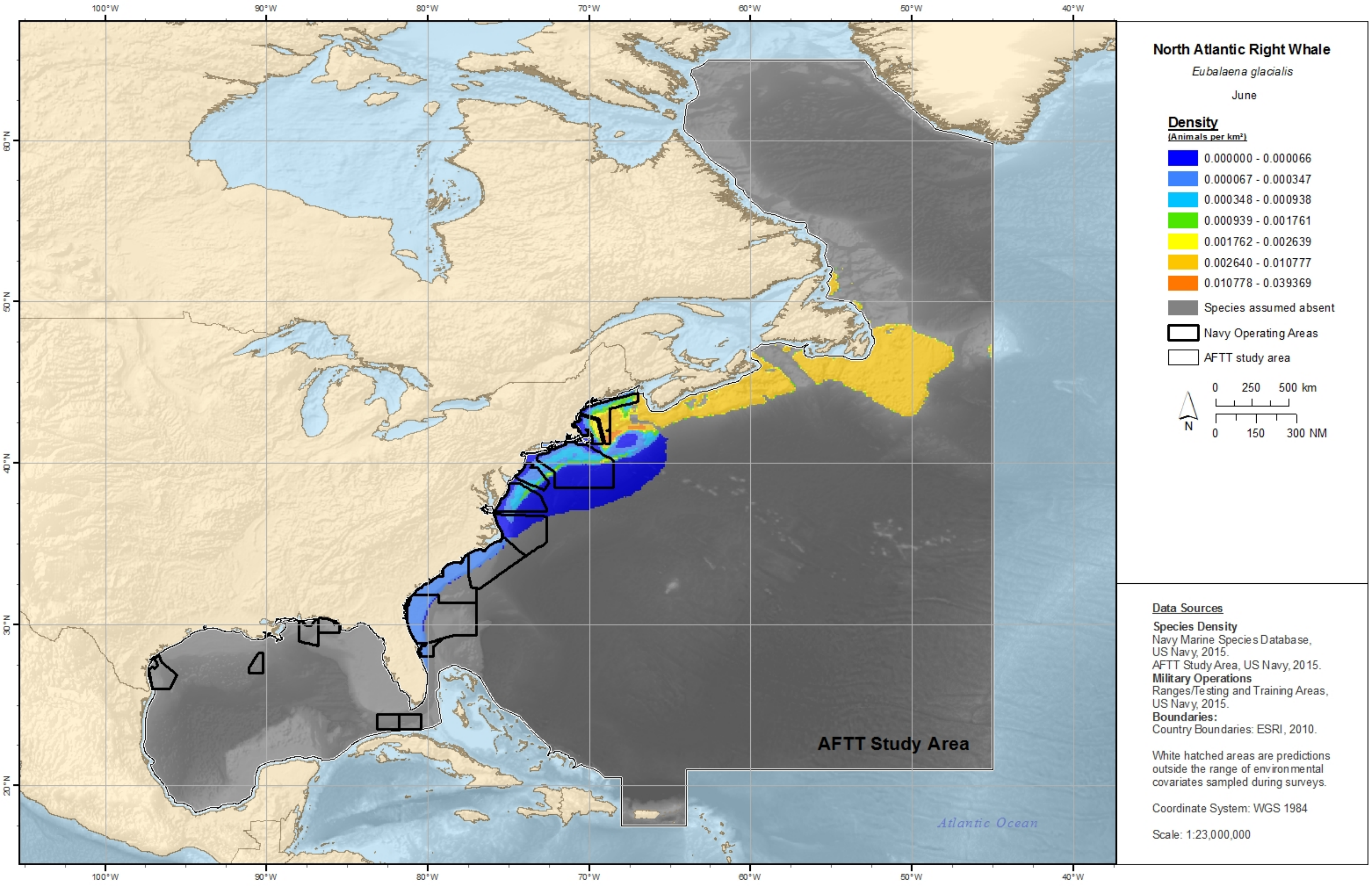


Figure 4-34. June density prediction for North Atlantic right whale for the East Coast and AFTT strata.

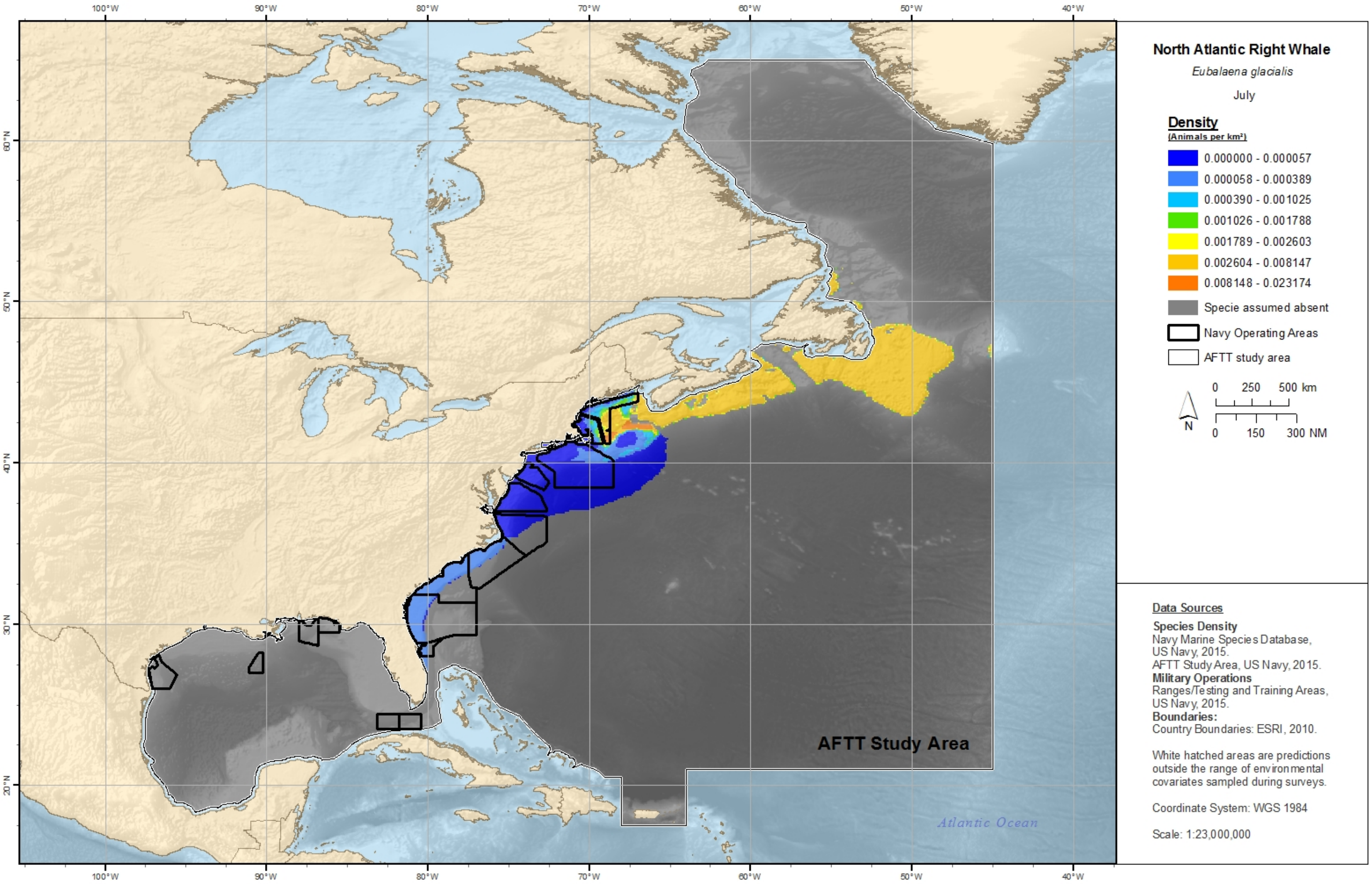


Figure 4-35. July density prediction for North Atlantic right whales for the East Coast and AFTT strata.

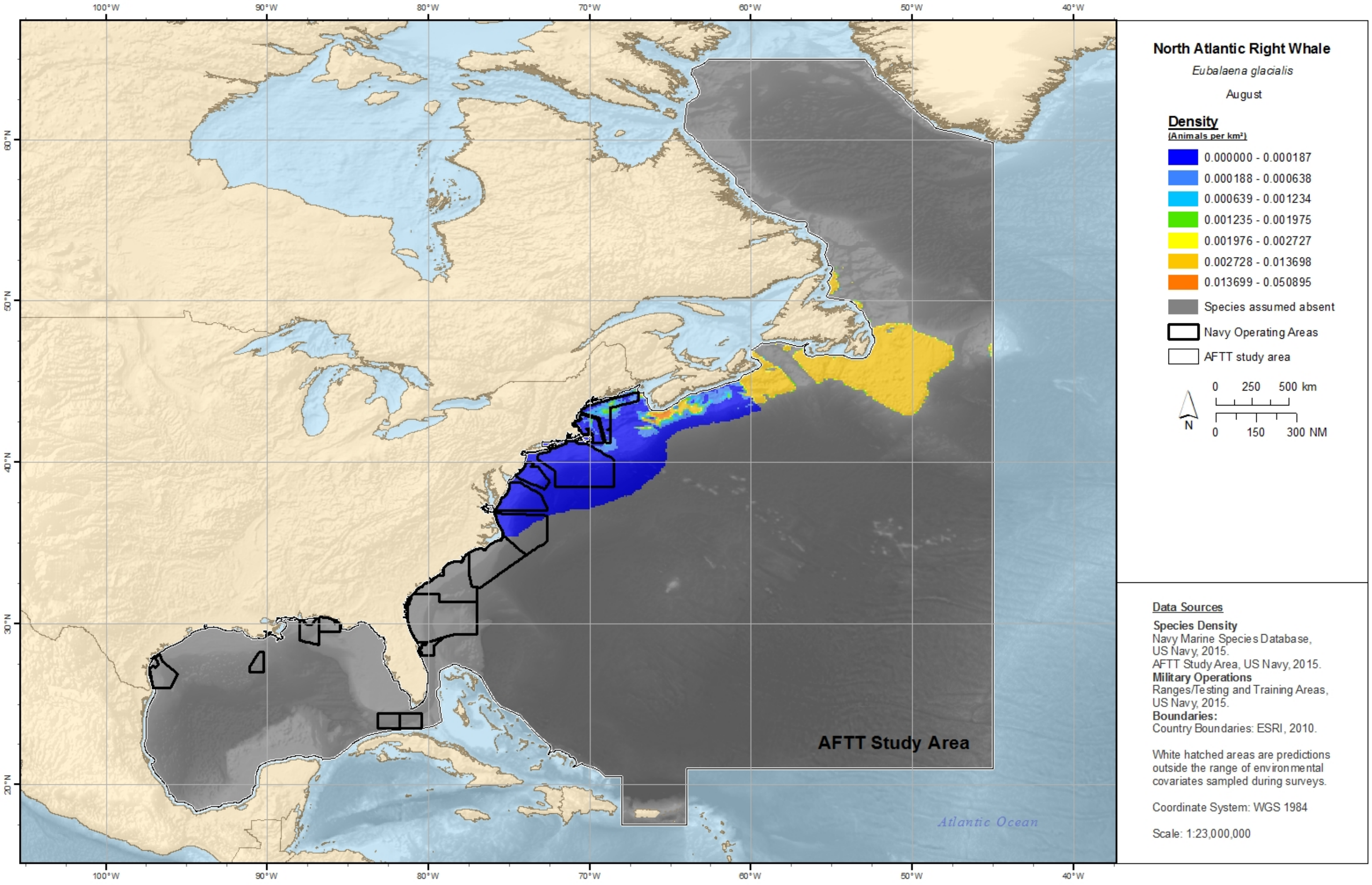


Figure 4-36. August density prediction for North Atlantic right whales for the East Coast and AFTT strata.

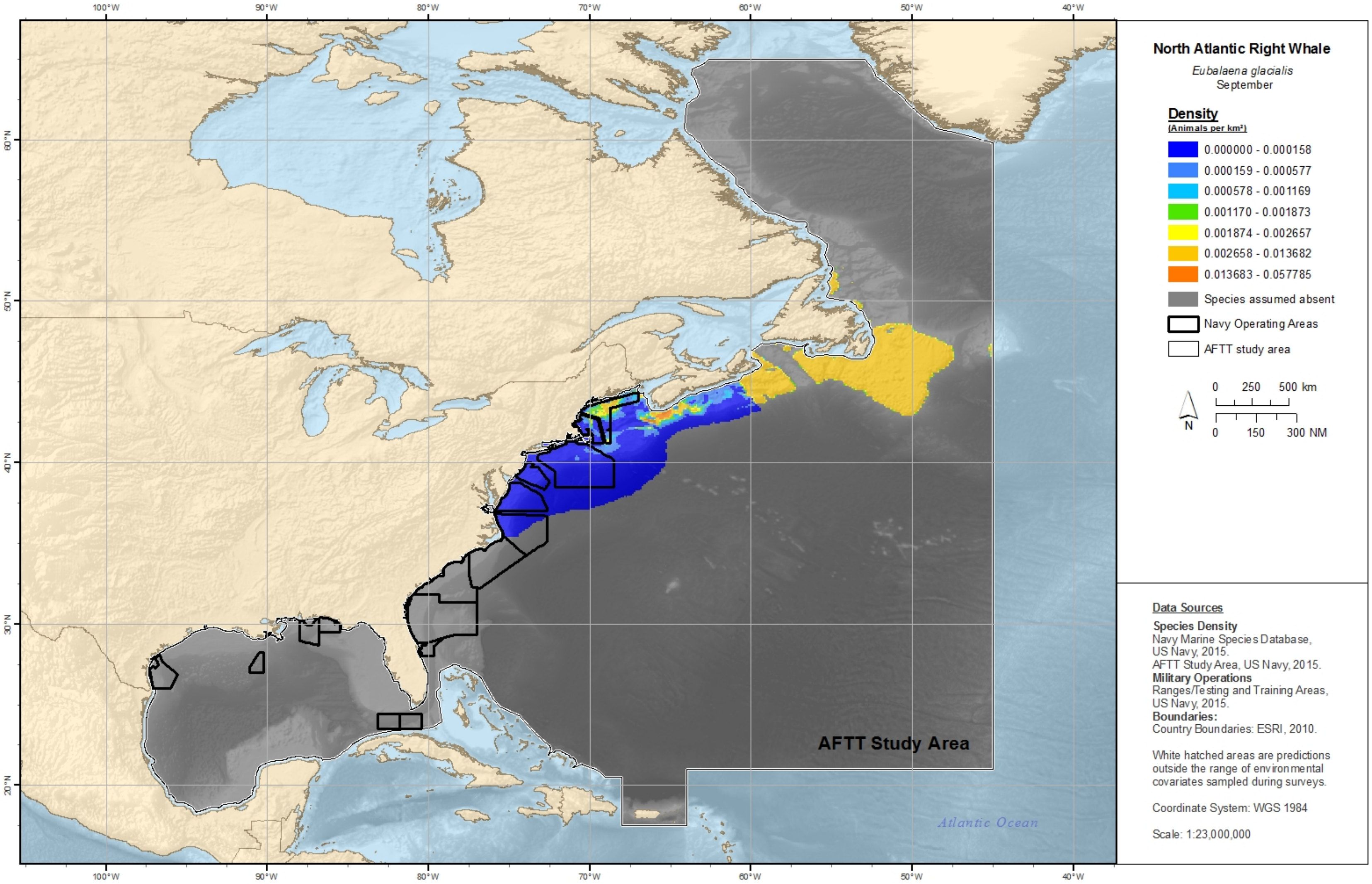


Figure 4-37. September density prediction for North Atlantic right whales for the East Coast and AFTT strata.

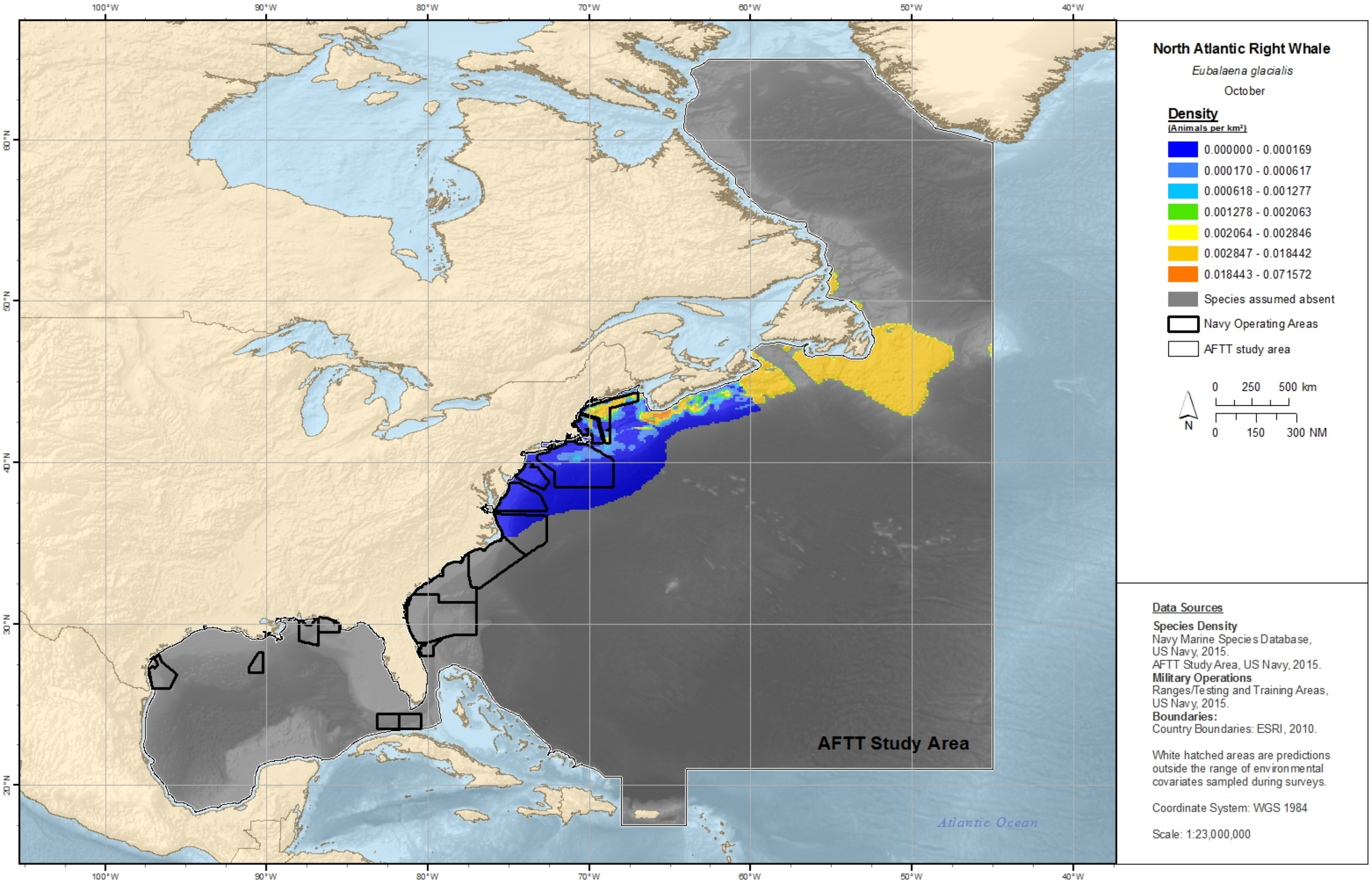


Figure 4-38. October density prediction for North Atlantic right whales for the East Coast and AFTT strata.

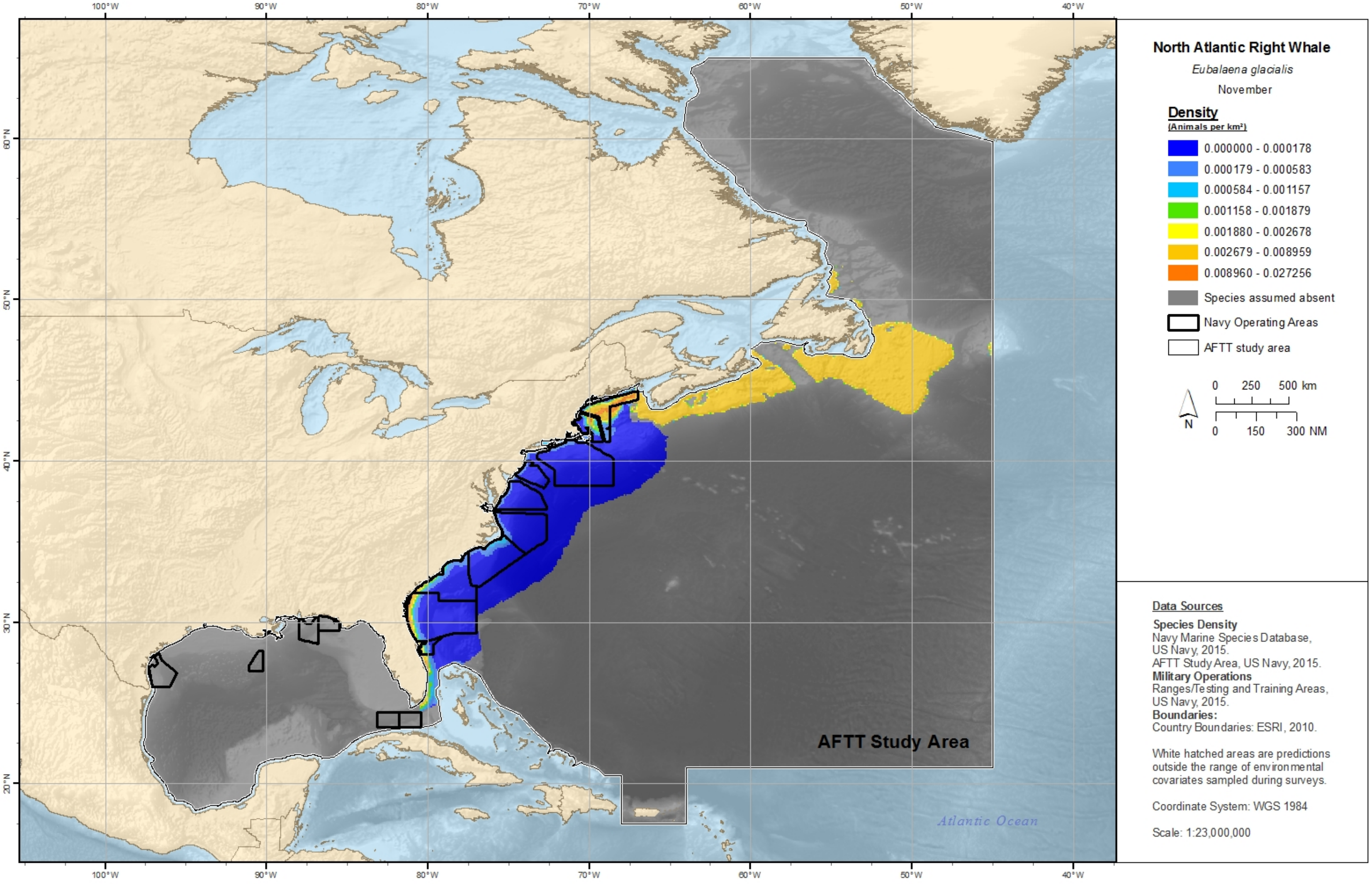


Figure 4-39. November density prediction for North Atlantic right whales for the East Coast and AFTT strata.

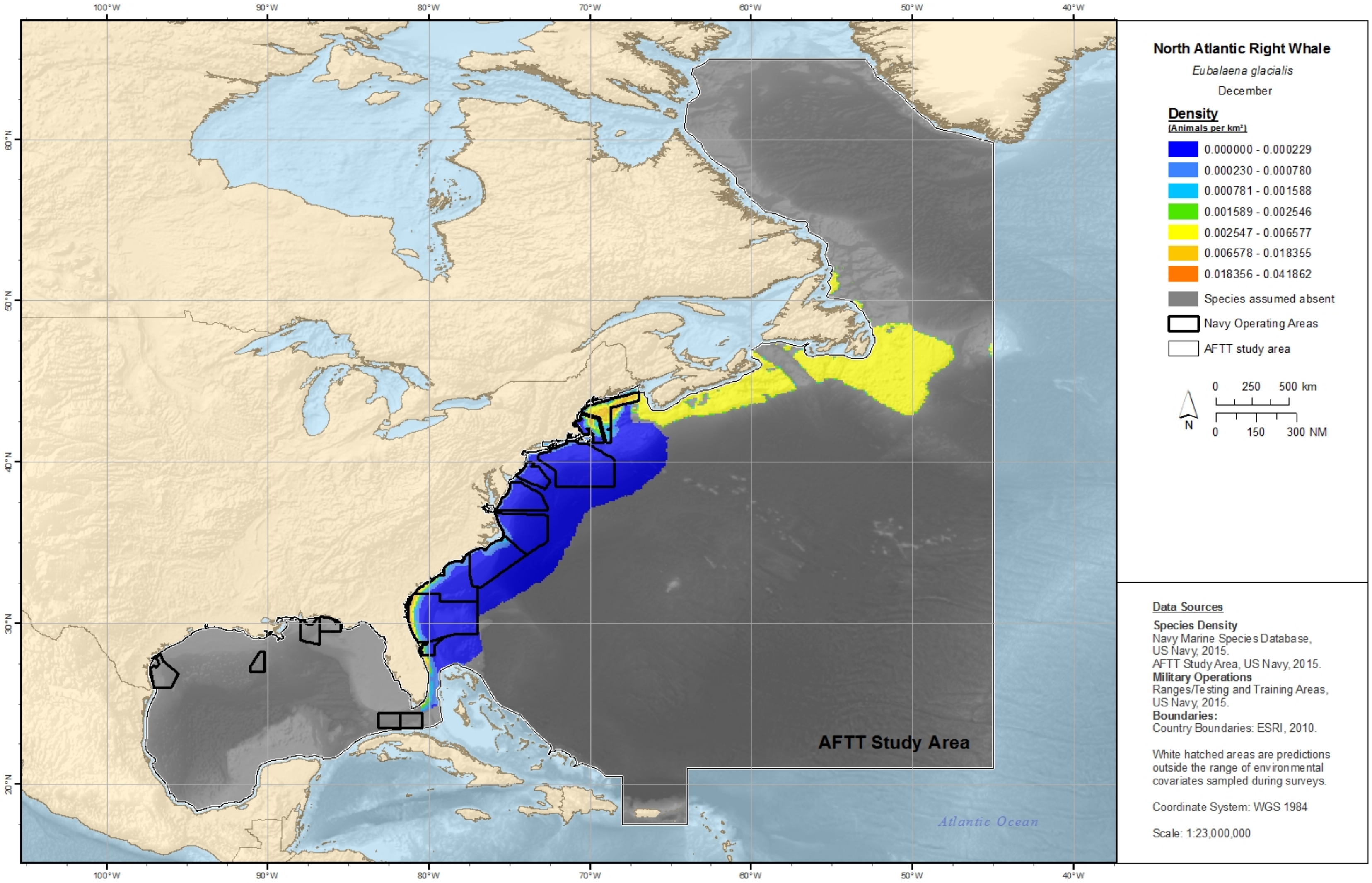


Figure 4-40. December density prediction for North Atlantic right whales for the East Coast and AFTT strata.

Sei whale (*Balaenoptera borealis*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from stratified density models and density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models and stratified density models developed by Mannocci et al. (2016). This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region. The sightings record for this species shows clear seasonal movement to higher latitudes in summer and lower latitudes in winter, with the migration occurring in several stages (Mitchell 1975). As such, four seasonal models were fit in the East Coast with transitions set at March/April, June/July, September/October, and November/December. In the East Coast in the winter, only a stratified model could be fit given the low number of sightings. Only winter and summer models were fit in the AFTT given the need for a more parsimonious model over a broader region. Given the lower number of sightings in the winter, a stratified model was fit to the expected range of the species. An extrapolative density spatial model was fit in the summer for the AFTT stratum. The temporal resolution of the density predictions was monthly in the East Coast and seasonal in the AFTT strata.

Survey Data and Selected Models:

In the East Coast stratum, a total of 821 sightings from the combined survey data were used for model development (20 in winter, 659 in spring, 99 in summer, and 43 in fall). The climatological models explained more deviance than models fitted with contemporaneous covariates in summer. In spring the contemporaneous predictors performed better and were selected. In fall only static predictors were selected by the model (see supplementary material from Roberts et al. (2016) for a more detailed discussion). Ambiguous sightings reported as either fin or sei whale were classified into one species or another with the sei whale classified sightings being incorporated into this model. Four ambiguous sightings reported as either sei or Bryde’s whale that could not be classified were incorporated into both the sei and Bryde’s models as a conservative measure. (See supplementary material from Roberts et al. (2016) for a more detailed discussion).

The models for the AFTT stratum used the same sightings from the East Coast model, as well as 54 sighting from the mid-Atlantic ridge (summer). The best fitting summer model included depth, SST, sea surface height anomalies and SEAPODYM epipelagic micronekton primary productivity as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of the species.

Other Density Estimates:

An abundance estimate of 717 (CV=0.30) individuals was derived from the East Coast stratum model in summer (Roberts et al. 2016). The most recent estimate from the NOAA SAR is 357 individuals (CV=0.52) based on NEFSC and SEFSC 2011 aerial surveys from the Gulf of Maine to central Virginia (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. The SMRU RES model predicted 4,490 individuals (summer, CV not available) in TAP Phase II. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the SAR estimate and the estimate from the Roberts et al. (2016) East Coast stratum model are within the same order of magnitude but are not statistically similar. No SAR estimates exist for other seasons for comparison. The Roberts et al. (2016) estimate was chosen over the SAR and SMRU RES models as it is higher in the NMSDD hierarchy than both.

An abundance estimate of 20,069 individuals (CV=0.23) was derived from the AFTT stratum summer model and 1,170 individuals (CV=0.19) in the winter (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) models are more closely tied to data in the East Coast stratum than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such are expected to provide more realistic density estimates than those datasets. Data from waters in Canadian and Greenland waters (Lawson and Gosselin 2009) were unavailable to the modelers, which may have helped with accuracy in those regions. The Mannocci et al. (2016) model is considered higher in the NMSDD hierarchy than these literature-derived, stratified estimates.

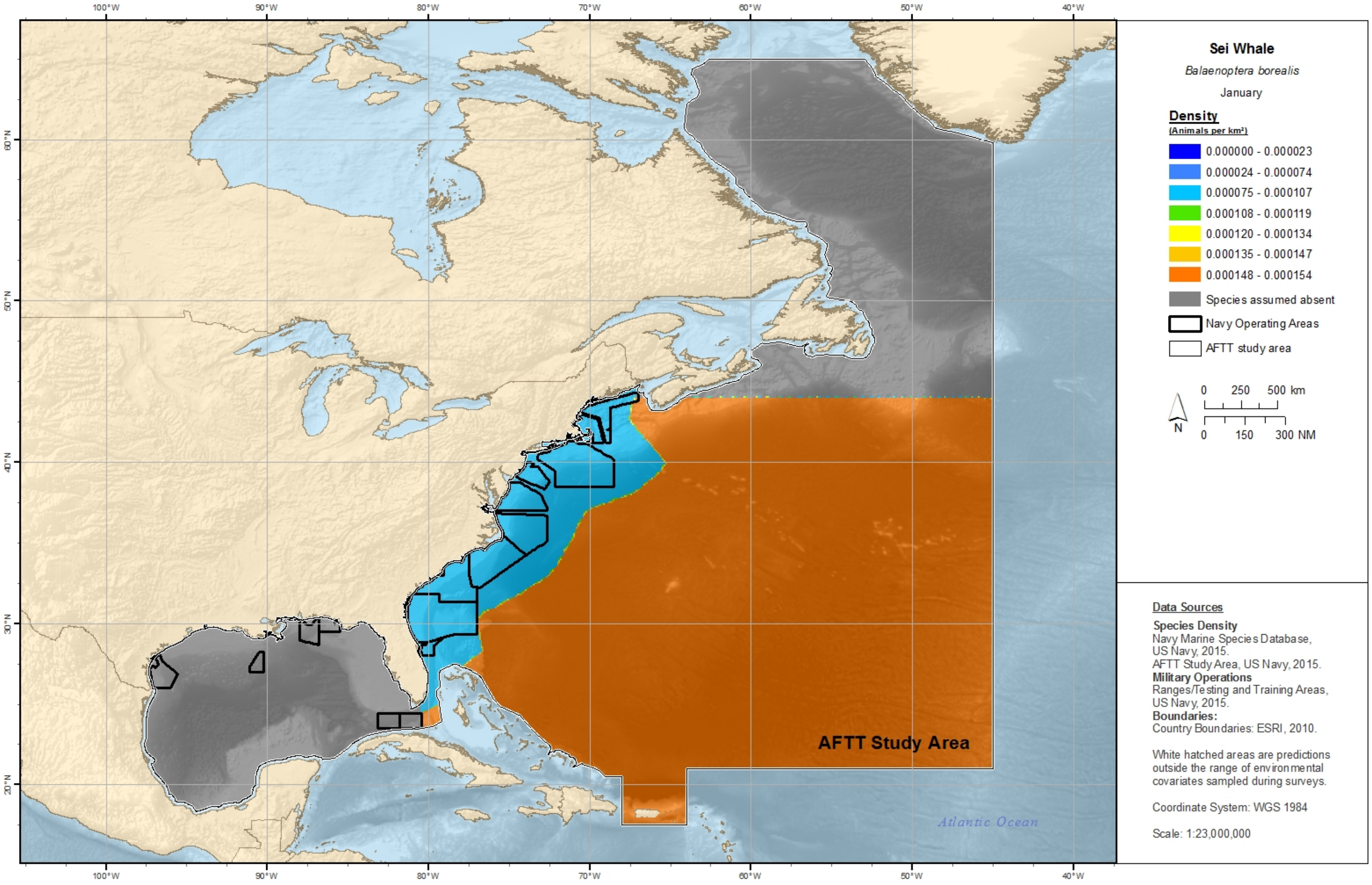


Figure 4-41. January density prediction for sei whales for the East Coast and AFTT strata.

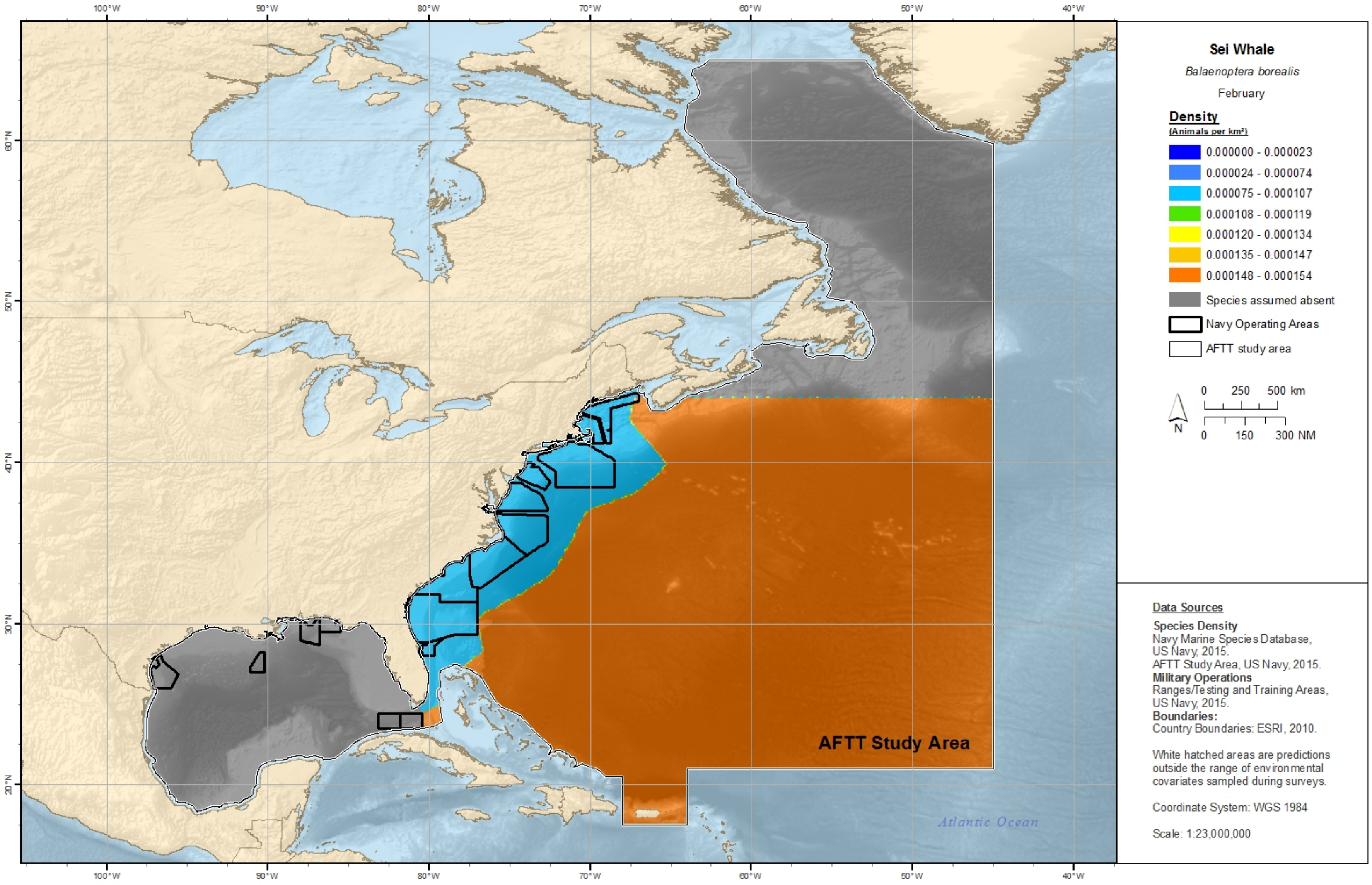
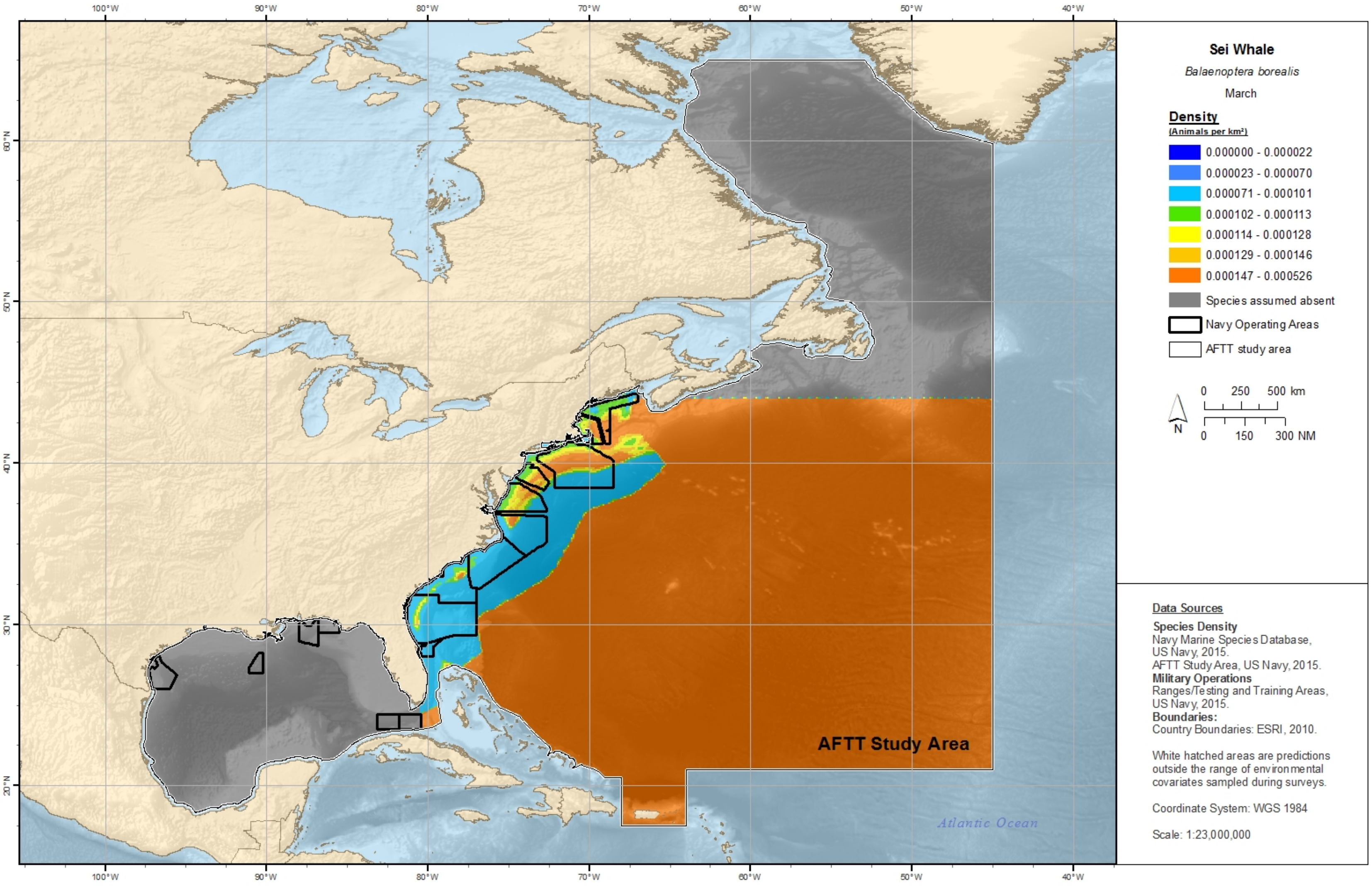


Figure 4-42. February density prediction for sei whales for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-43. March density prediction for sei whales for the East Coast and AFTT strata.

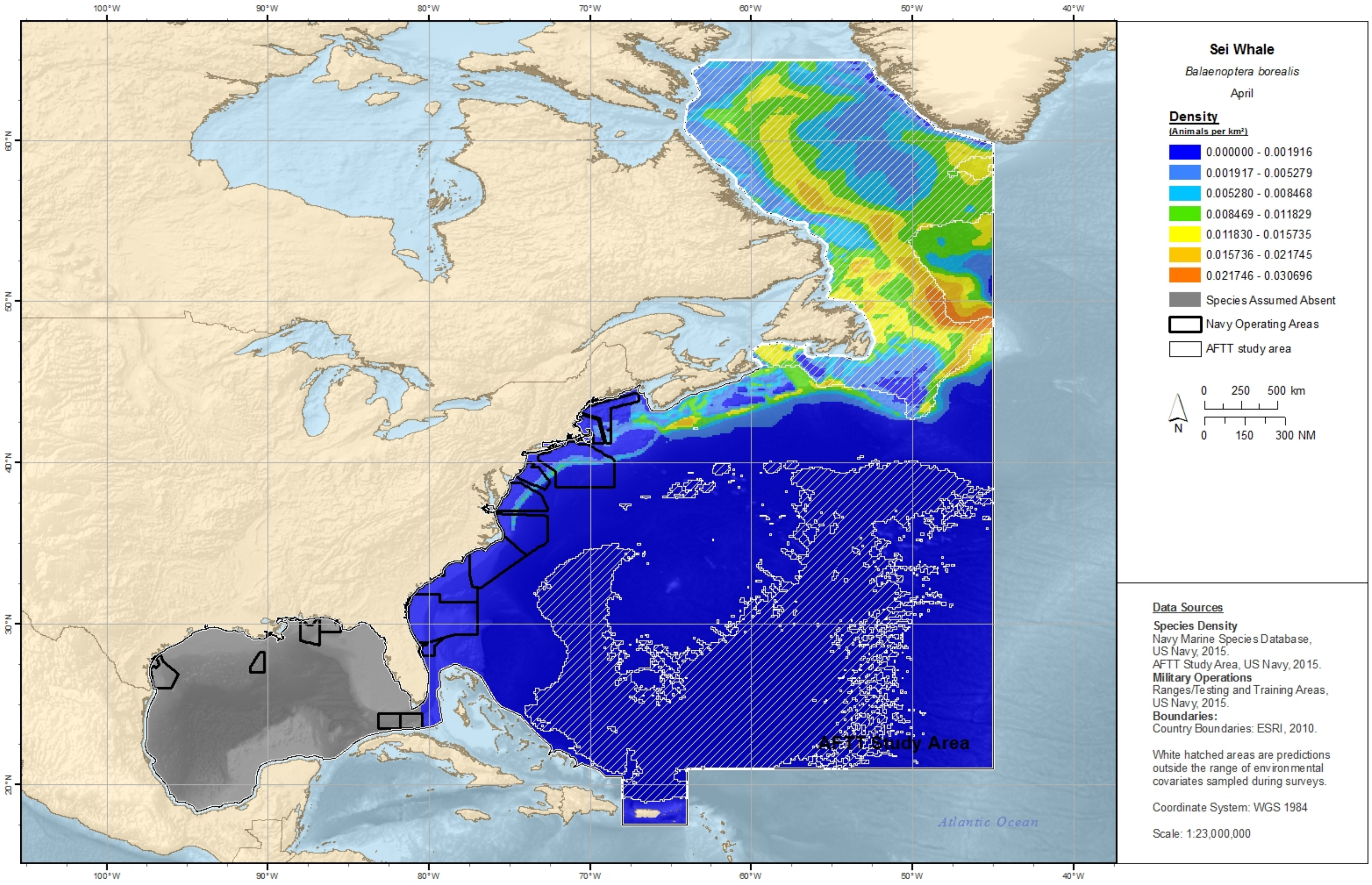


Figure 4-44. April density prediction for sei whales for the East Coast and AFTT strata.

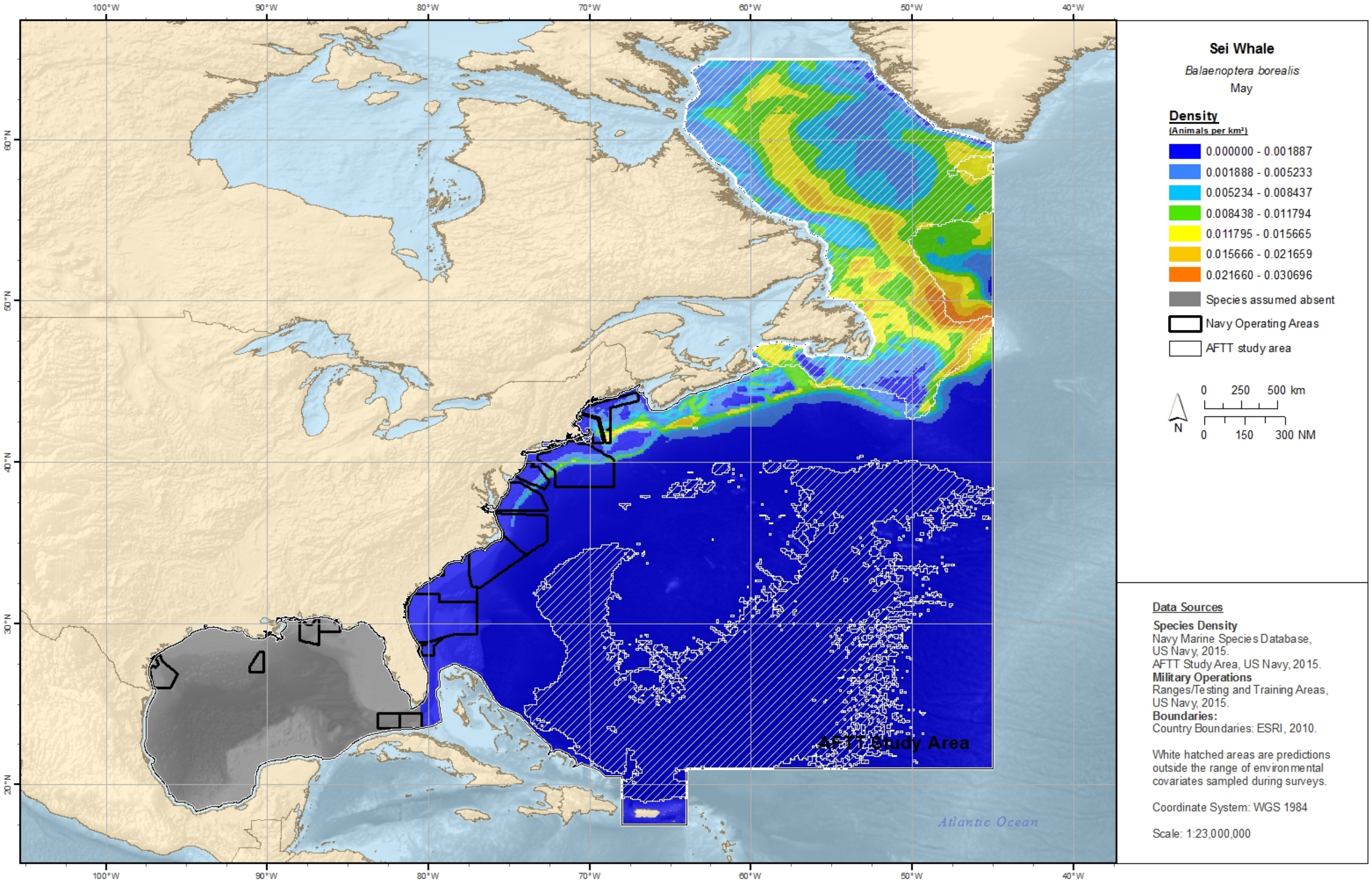
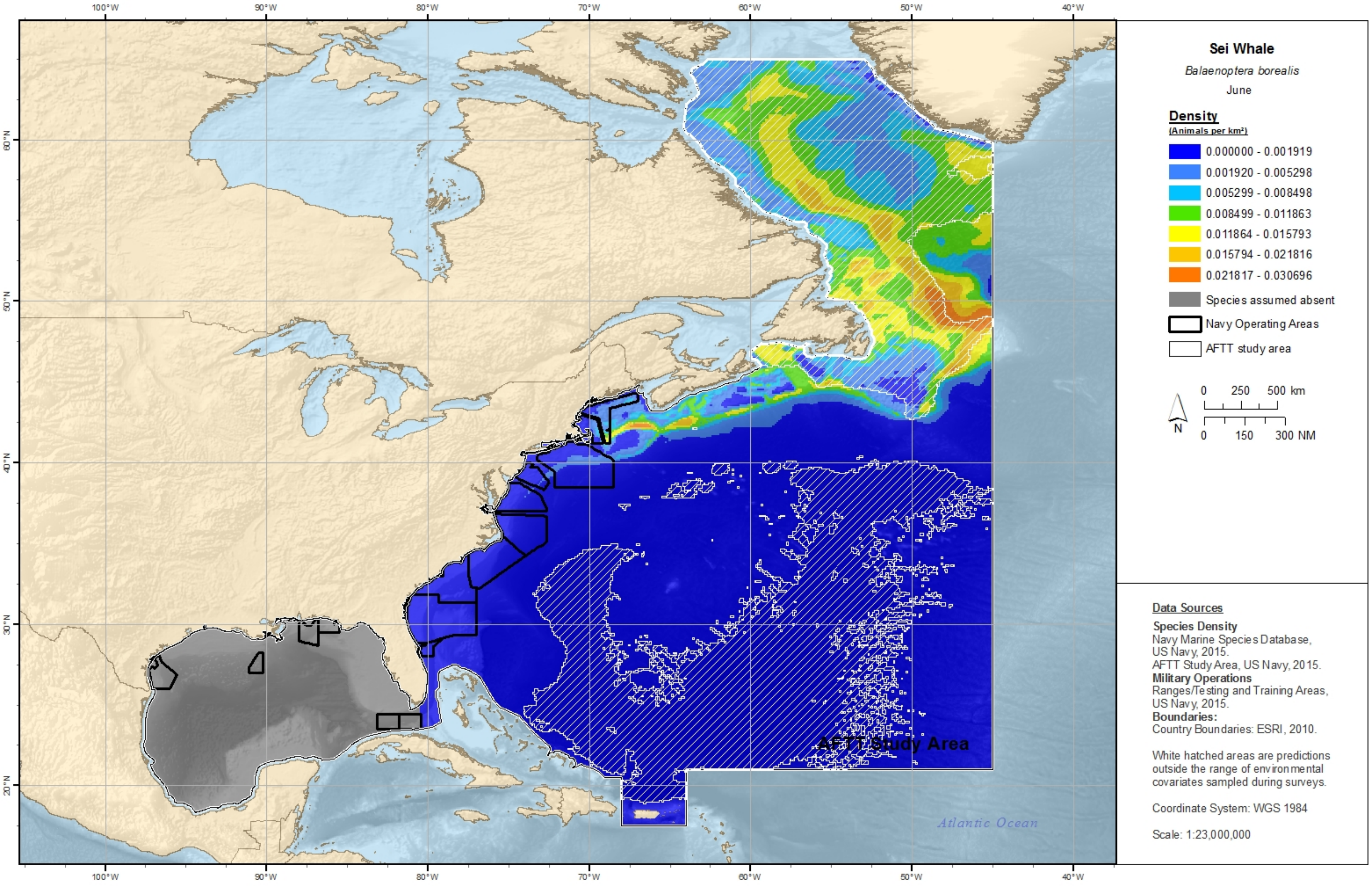


Figure 4-45. May density prediction for sei whales for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-46. June density prediction for sei whales for the East Coast and AFTT strata.

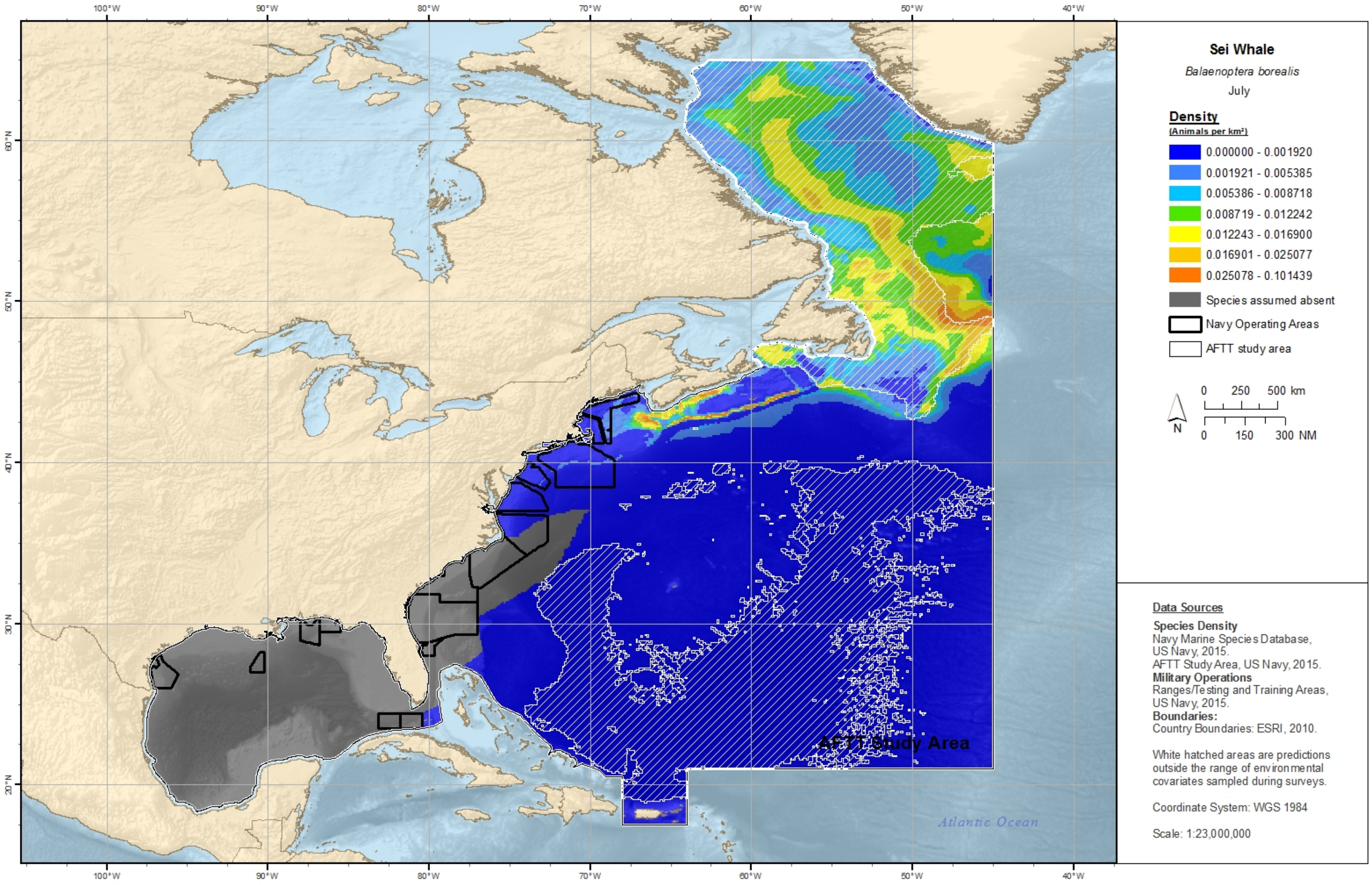


Figure 4-47. July density prediction for sei whales for the East Coast and AFTT strata.

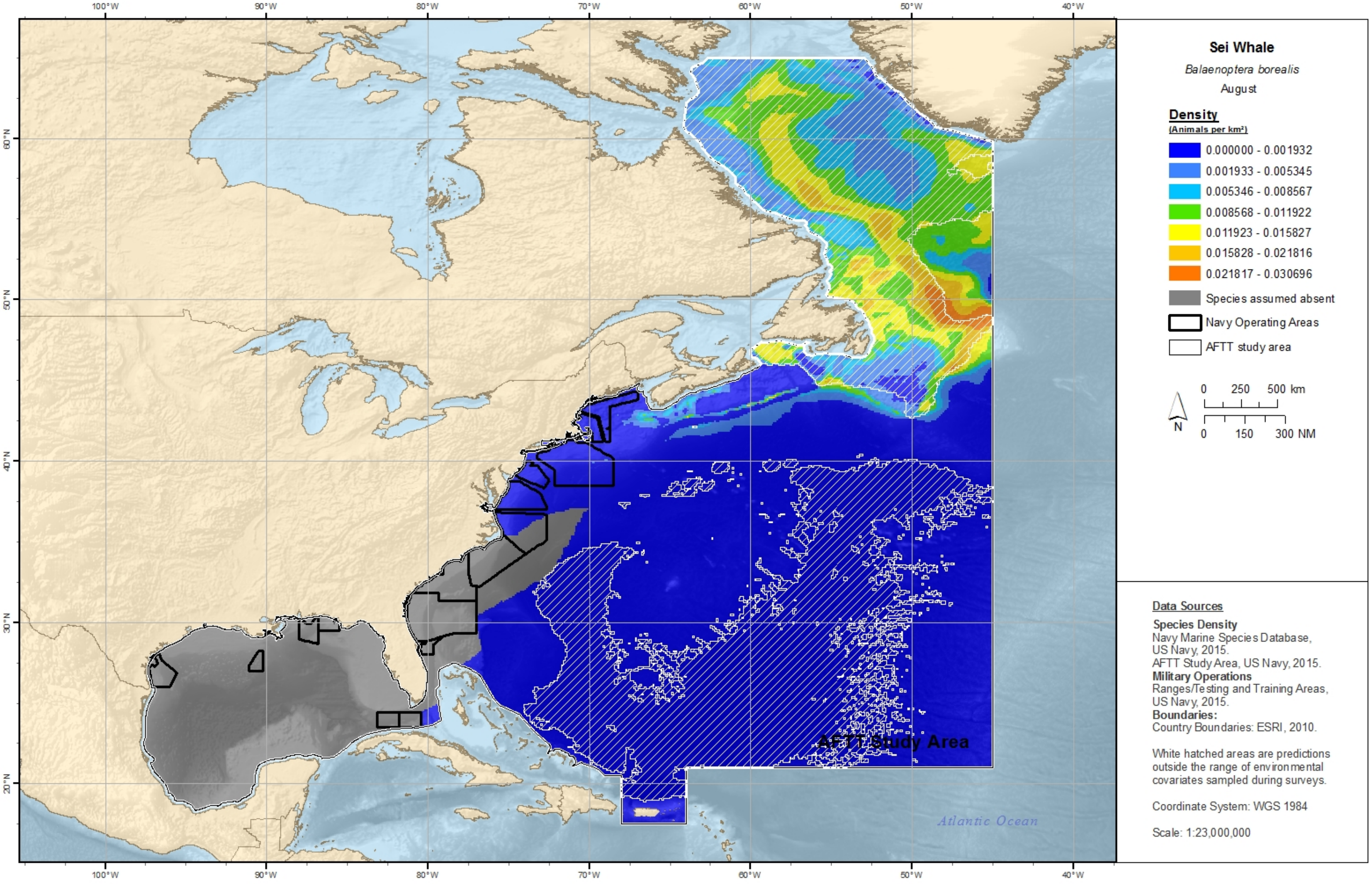


Figure 4-48. August density prediction for sei whales for the East Coast and AFTT strata.

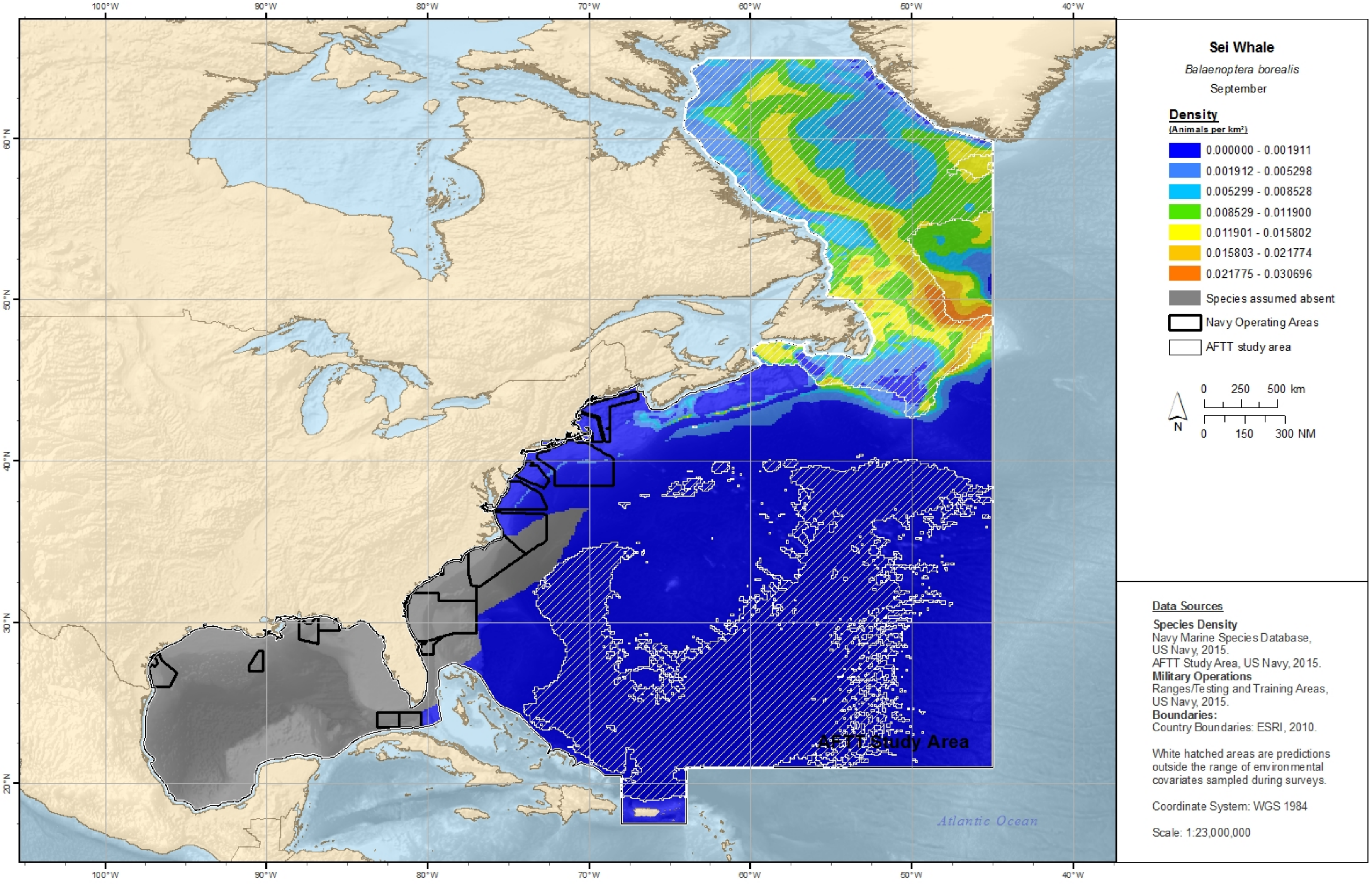
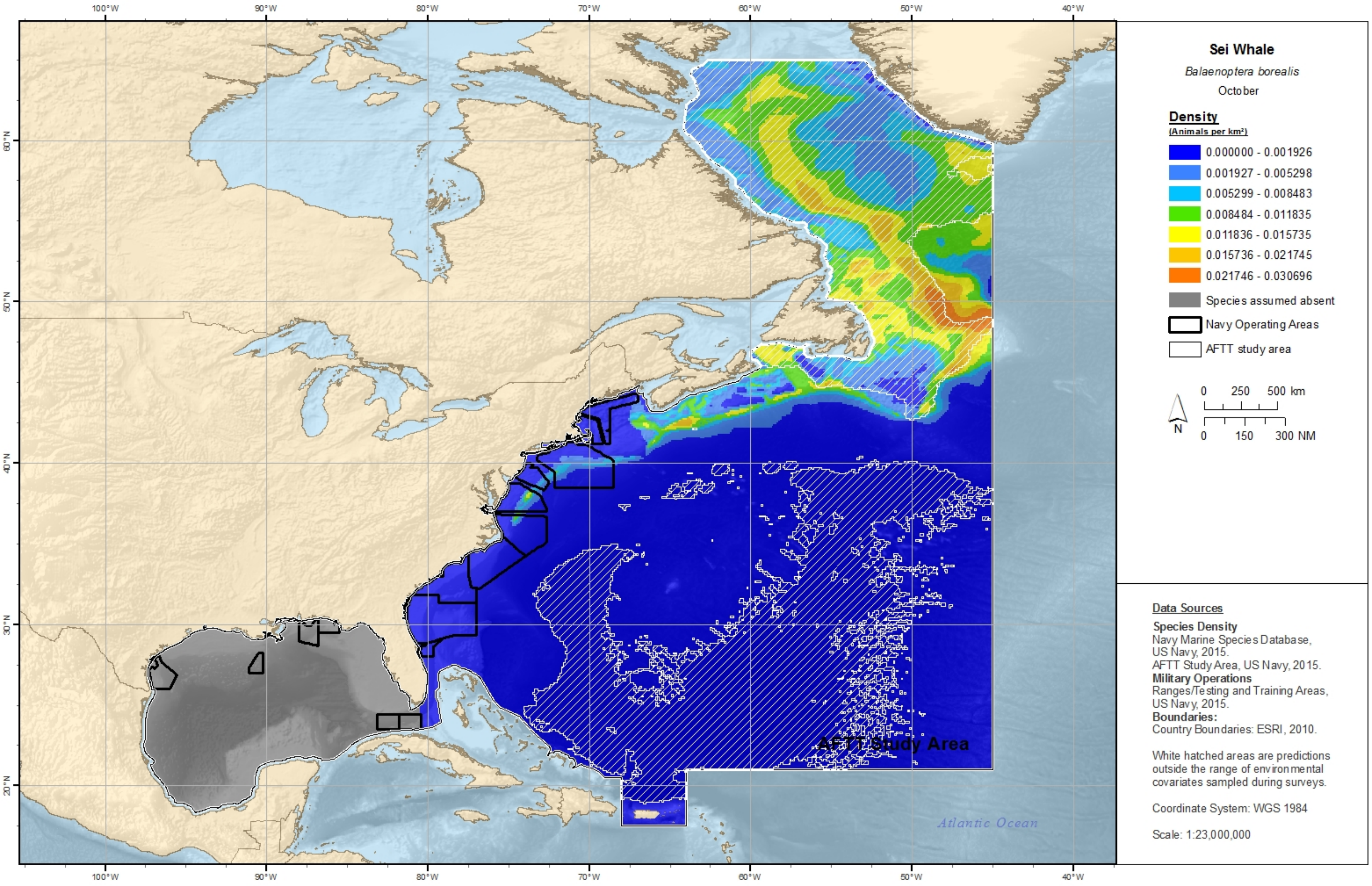


Figure 4-49. September density prediction for sei whales for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-50. October density prediction for sei whales for the East Coast and AFTT strata.

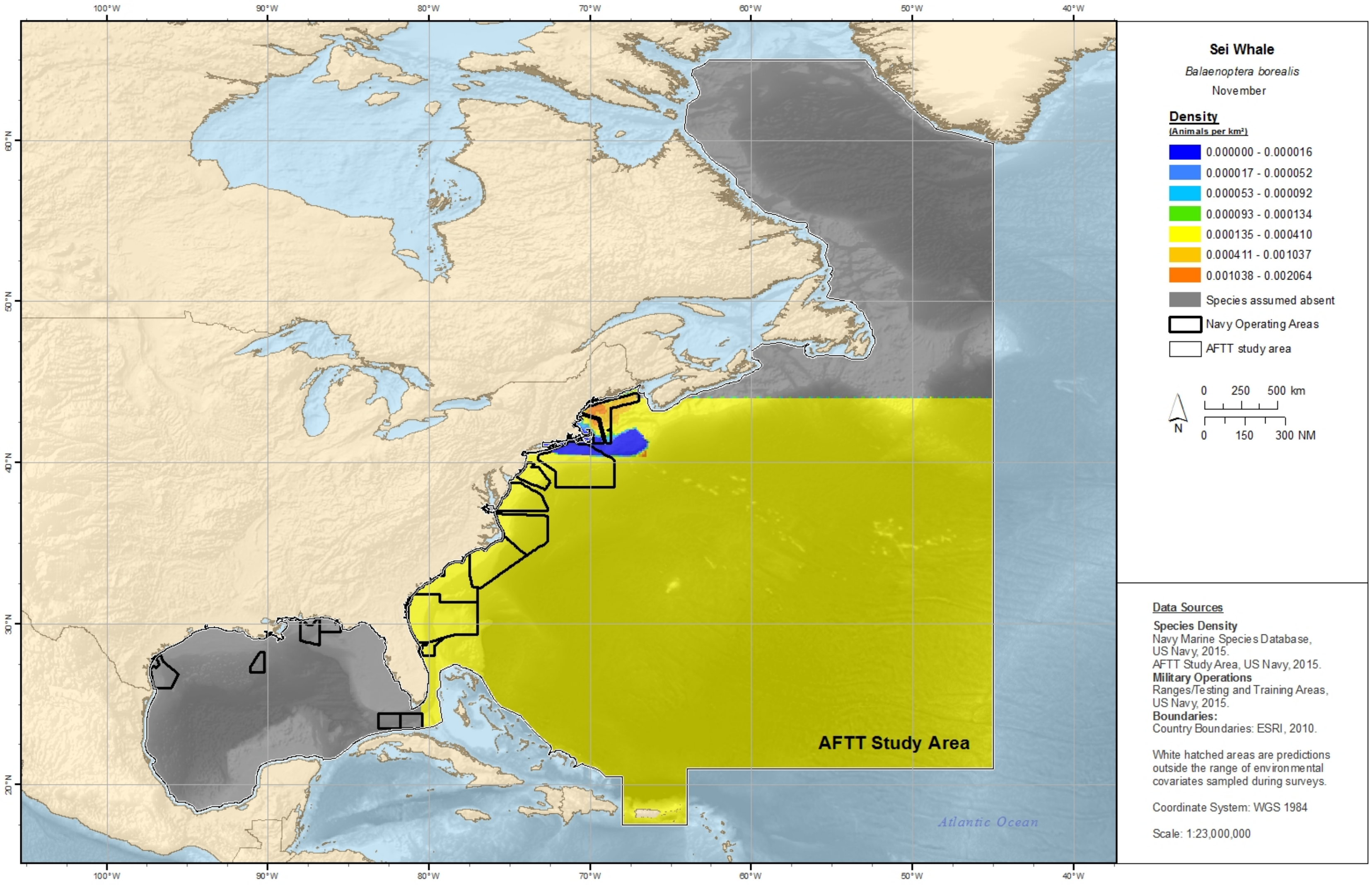


Figure 4-51. November density prediction for sei whales for the East Coast and AFTT strata.

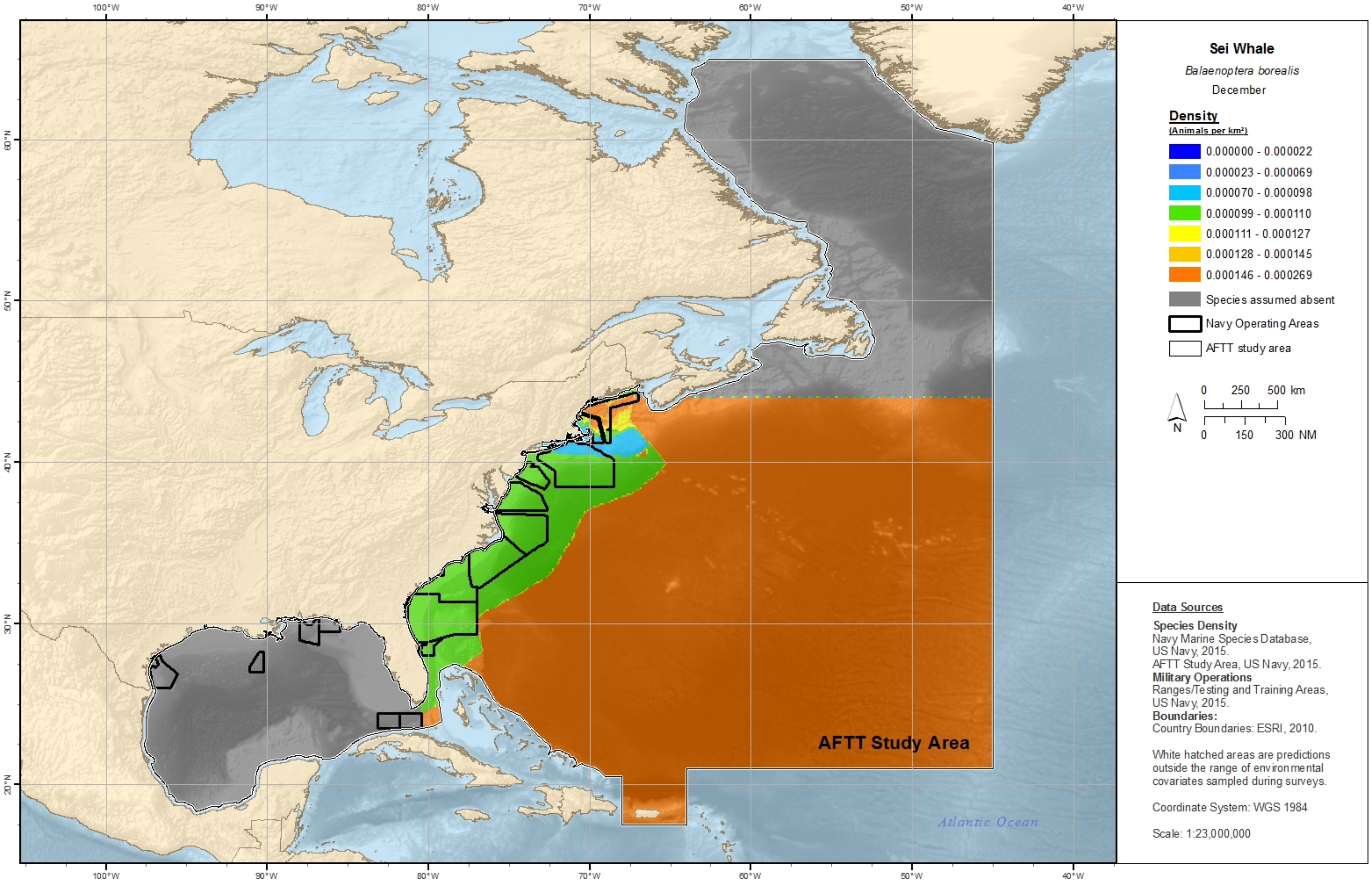


Figure 4-52. December density prediction for sei whales for the East Coast and AFTT strata.

4.2 BEAKED WHALES

Beaked whales (Ziphiidae)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). Species included in the beaked whale guild include Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, Sowerby's beaked whale, True's beaked whale, and unidentified beaked whale sightings. Discussions with survey data providers indicated that northern bottlenose whales could be reliably identified; therefore a separate model was fit for the northern bottlenose whale (discussed in its own section) as there were enough confirmed sightings to support modeling. Density spatial models were fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. No seasons were delineated as important environmental predictors for these individuals tend not to vary seasonally, and no seasonal migrations are described in the literature in addition to generally low number of sightings. The temporal resolution of the density predictions for all three models was annual.

Survey Data and Selected Models:

In the East Coast stratum, a total of 226 sightings from the combined survey data were used for model development. Contemporaneous environmental variables explained more deviance than climatological ones and was selected for the East Coast stratum.

In the Gulf of Mexico stratum, a total of 116 sightings from the combined survey data were used for model development. Climatological environmental variables explained more deviance than contemporaneous ones and was selected for the Gulf of Mexico stratum. This differs from the East Coast stratum but the climatological models performed significantly better than the contemporaneous ones in the Gulf of Mexico. However, all Gulf of Mexico models explained less deviance than the East Coast models.

The model for the AFTT stratum used the 226 and 116 sightings from the East Coast and Gulf of Mexico strata, respectively, as well as 16 sightings from the Caribbean, 29 sightings from Europe, and eight sightings from the mid-Atlantic ridge for a total of 395 sightings. The best fitting model included depth, distance to canyon, chlorophyll, and current speed as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. The non-zero density extent of the predicted model is consistent with the assumed extent of this species' range (MacLeod 2000, MacLeod et al. 2006).

Other Density Estimates:

An abundance estimate of 14,491 individuals (CV=0.17) was derived for the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 13, 624 individuals (CV not available for combined estimate) (Palka 2012) based on summer 2011 NEFSC and SEFSC aerial surveys. This estimate comes from the combined estimate for Mesoplodon and Ziphius species. Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. A comparable NODES estimate was not available. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population estimate is close to the estimate of the recent SAR population estimate, though no CV was available for the combined SAR estimate (CVs were available for subsets of the data only). The Roberts et al. (2016) estimate is preferable to the SAR estimate, which uses estimates for several beaked whale species guilds, broken into northeast and southeast strata (essentially several large stratified estimates), which are less desirable in the NMSDD data hierarchy.

An abundance estimate of 2,910 individuals (CV=0.16) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). In the Gulf of Mexico stratum, the most recent NOAA SAR estimate is 466 individuals (combined estimate, CV unavailable) (Waring et al. 2014), based on a summer 2009 outer-continental shelf survey. A comparable estimate from Phase II is not available as SMRU RES data were used for individual species. While direct comparisons between models are difficult due to factors such as different spatial and temporal extent, different environmental covariates considered, different modeling frameworks, and different survey data used, the Gulf of Mexico stratum population estimate by Roberts et al. (2016) appears higher than the SAR report. The SAR report did not cover the entire Gulf of Mexico and did not account for g(0), which may in part explain the apparent discrepancy. The Roberts et al. (2016) estimate was chosen over the SMRU data as it represents significant advances in methodology and is better linked to regional data. The Roberts et al. (2016) estimate is preferable to the SAR estimate, which uses estimates for several beaked whale species guilds (essentially several large stratified estimates), and those estimates are less desirable in the NMSDD data hierarchy.

An abundance estimate of 123,588 individuals (CV=0.17) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

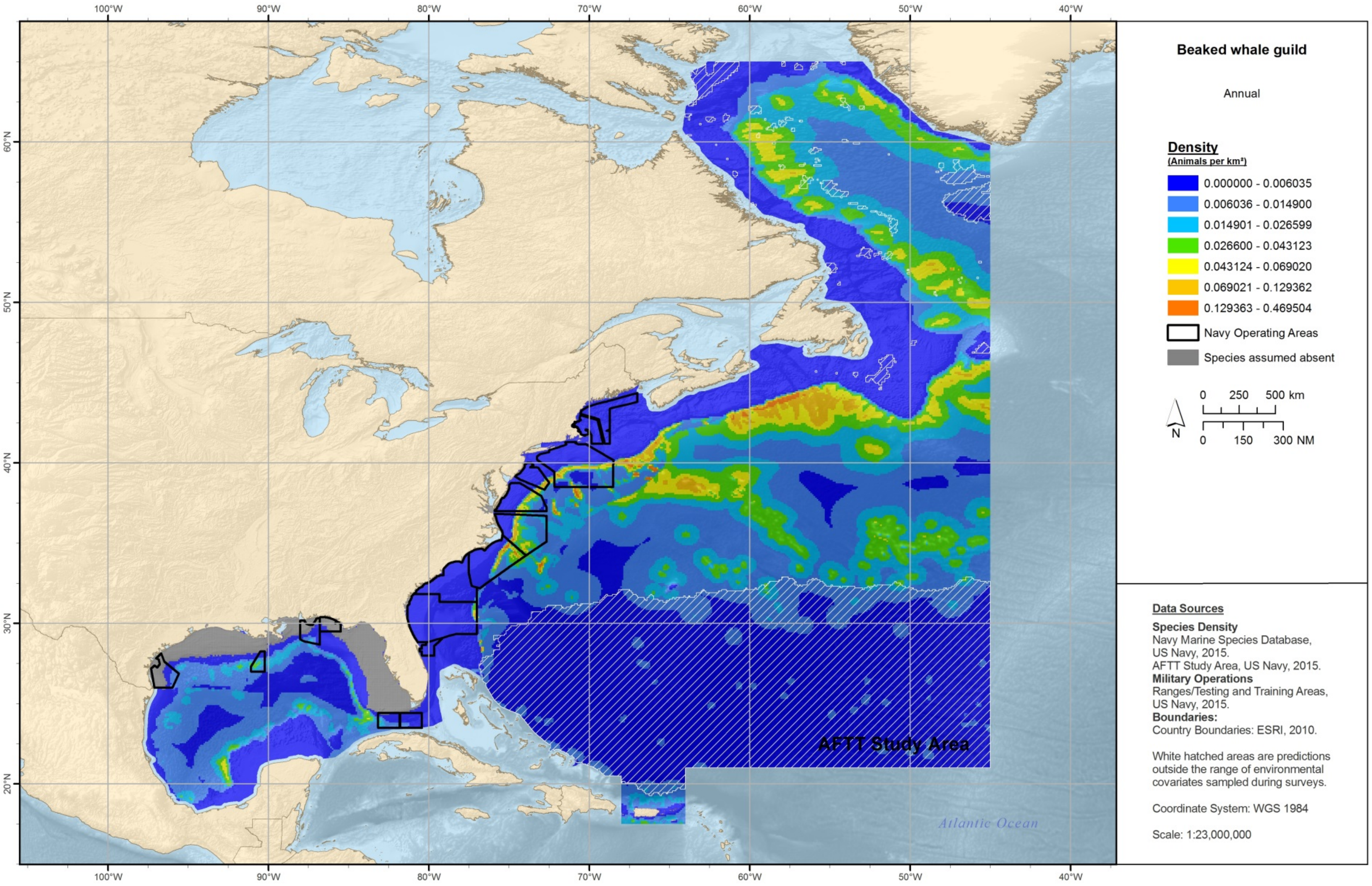


Figure 4-53. Annual density prediction for beaked whales for the East Coast, Gulf of Mexico, and AFTT strata.

Northern bottlenose whale (*Hyperoodon ampullatus*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from stratified density models developed by Roberts et al. (2016) and Mannocci et al. (2016). A stratified density model developed by Roberts et al. (2016) was fit for the East Coast stratum. A stratified density model developed by Mannocci et al. (2016) was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region. Very few sightings were available anywhere for this species. No seasons were defined for this species given a paucity of sightings and a lack of clearly defined seasonality. The temporal resolution of the density predictions was annual for all models.

Survey Data and Selected Models:

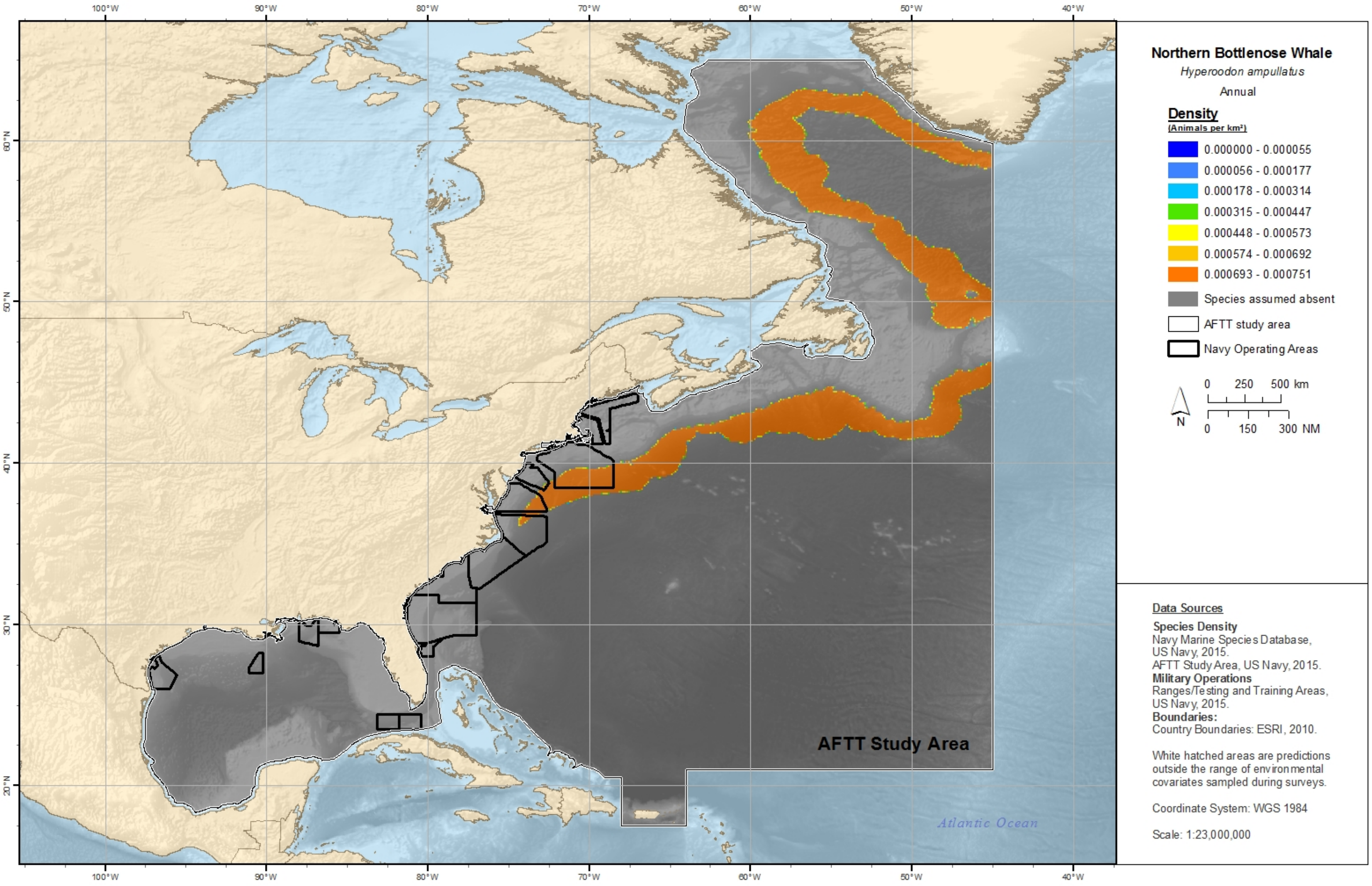
In the East Coast stratum, a total of four sightings from the combined survey data were used for model development. Estimates were limited to areas deeper than 500m and north of the center of the Gulf Stream based on a review of the literature available for the species (Wimmer and Whitehead 2004) and the Gulf Stream being the dominant ecological feature in the region. A spatial model was not practicable given the number of sightings; therefore a stratified estimate was produced.

The model for the AFTT stratum used the East Coast stratum sightings. No other sightings were available. Northern bottlenose whales were assumed present in waters characterized by cold temperatures, depth greater than 2000 m and distances to submarine canyons <less than100 km, based on descriptions in the literature (Wimmer and Whitehead 2004).

Other Density Estimates:

The Roberts et al. (2016) AFTT model predicts 90 individuals (CV=0.63) in the East Coast stratum. The most recent NOAA SAR (Waring et al. 2014) for this species does not try to estimate population levels given the low number of sightings. SMRU RES data were used in TAP Phase II, predicting 3,726 individuals in the East Coast stratum. Meaningful comparison is difficult given the absence of a CV for the SMRU RES data and other factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The Roberts et al. (2016) estimate was chosen over the SMRU model as it is higher in the NMSDD hierarchy.

An abundance estimate of 689 individuals (CV=0.63) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-54. Annual density prediction for northern bottlenose whales for the East Coast and AFTT strata.

4.3 DELPHINIDS

Atlantic spotted dolphin (*Stenella frontalis*)

Data Sources and Seasonality:
All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). Density spatial models were fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. No seasons were delineated as movement patterns for this species are poorly understood. The temporal resolution of the density predictions for all three models was annual.

Survey Data and Selected Models:
In the East Coast stratum, a total of 838 sightings from the combined survey data were used for model development. Based on the clustering of data and evidence that there may be two populations of Atlantic spotted dolphin, the East Coast stratum was split into two subregions which were modeled separately (Baron et al. 2008 and Viricel and Rosel 2014). In both subregions, climatological environmental variables explained more deviance than contemporaneous ones and was selected for the East Coast stratum.

In the Gulf of Mexico stratum, a total of 347 sightings from the combined survey data were used for model development. Climatological environmental variables explained more deviance than contemporaneous ones and was selected for the Gulf of Mexico stratum..

The model for the AFTT stratum used the 838 and 347 sightings from the East Coast and Gulf of Mexico strata, respectively, as well as 11 sightings from the Caribbean. The best fitting model included depth, eddy kinetic energy, zooplankton potential production, and SST as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. The non-zero density extent of the predicted model is consistent with the assumed extent of this species' range (Hammond et al. 2012).

Other Density Estimates:
An abundance estimate of 55, 346 individuals (CV=0.32) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from the National Oceanic and Atmospheric Association (NOAA) SAR is 44, 715 individuals (CV=0.43) (Waring et al. 2013) based on summer 2011 NOAA Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) aerial surveys. Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In Tap Phase II, the NODES estimate of 186,581 individuals (summer season, no CV available) based on survey data for the summer season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered different modeling frameworks, and different survey data used. The East Coast stratum population estimate is within the range of values given by the 0.43 CV of the recent SAR population estimate. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and

methods not available when the NODES model was developed. It is also preferable to the SAR estimate as the SAR used only a single season of one year of survey data and only provides a single density value for the entire Gulf of Mexico, which is less desirable in the NMSDD data hierarchy.

An abundance estimate of 47,488 individuals (CV=0.13) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent NOAA SAR estimate is 37, 611 individuals (CV=0.28) (NOAA 2012) based on summer 2000-2001 outer-continental shelf surveys and 2003-2004 offshore shipboard surveys. In TAP Phase II, a NODES estimate of 79, 880 individuals (CV not available) based on survey data for the spring season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extent, different environmental covariates considered, different modeling frameworks, and different survey data used, the Gulf of Mexico stratum population estimate is within range of values given by the 0.28 CV of the most recent SAR population estimate. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates methods not available when the NODES model was developed. It is also preferable to the SAR estimate as the SAR only provides a single density value for the entire Gulf of Mexico, which is less desirable in the NMSDD data hierarchy.

An abundance estimate of 306,113 individuals (CV=0.13) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

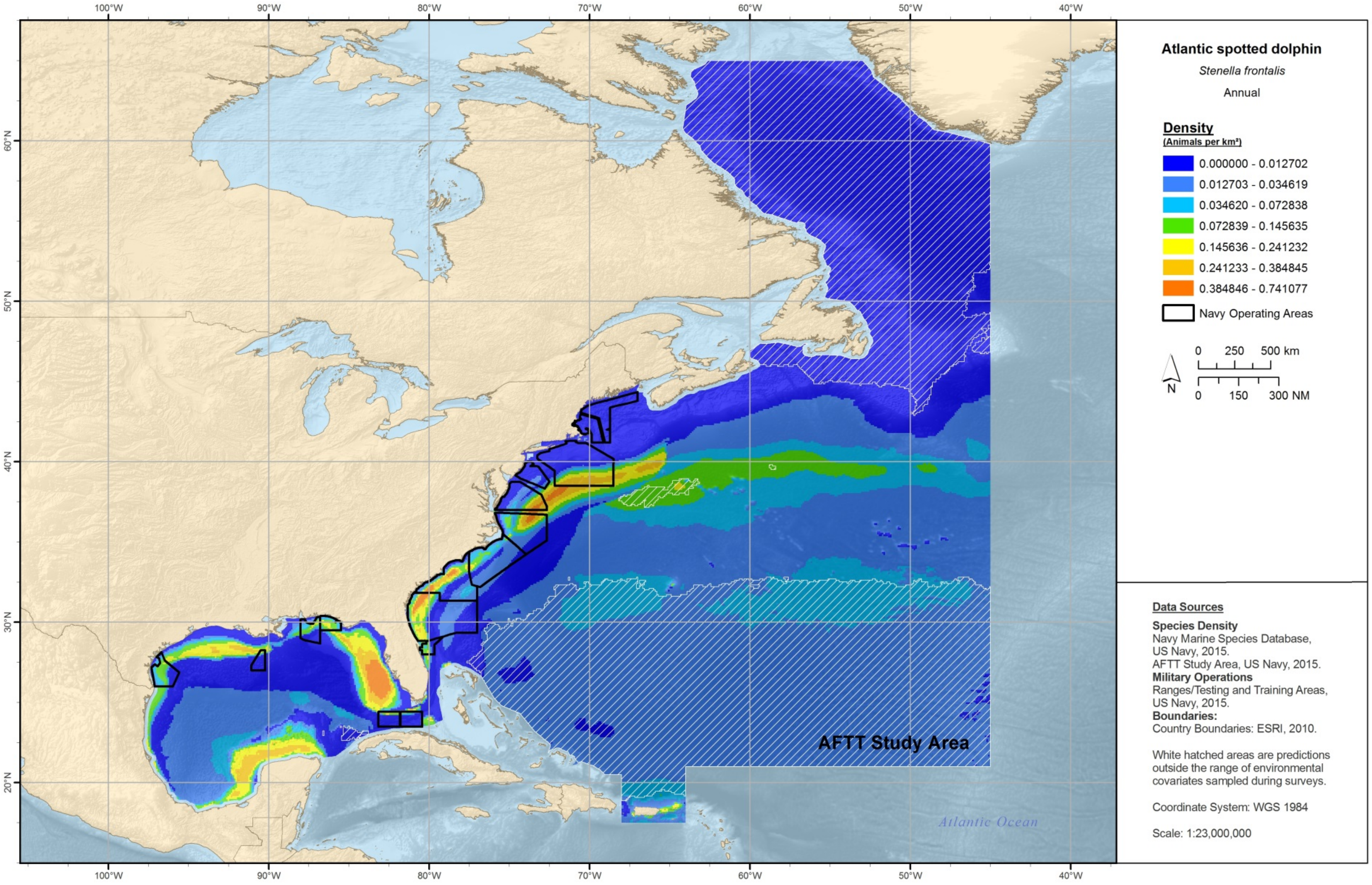


Figure 4-55. Annual density prediction for Atlantic spotted dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

Atlantic white-sided dolphin (*Lagenorhynchus acutus*)

Data Sources and Seasonality:
All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed Mannocci et al. (2016). A density spatial model was fit for the East Coast stratum. An extrapolative density spatial model was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico stratum given a historical lack of sightings data in that region. No seasons were delineated though some temporal north/south shifts in distribution have been noted (Palka et al. 1997). The temporal resolution of the density predictions for the East Coast was monthly and roughly captured this north/south shift in distribution. An annual model was fitted for the AFTT region.

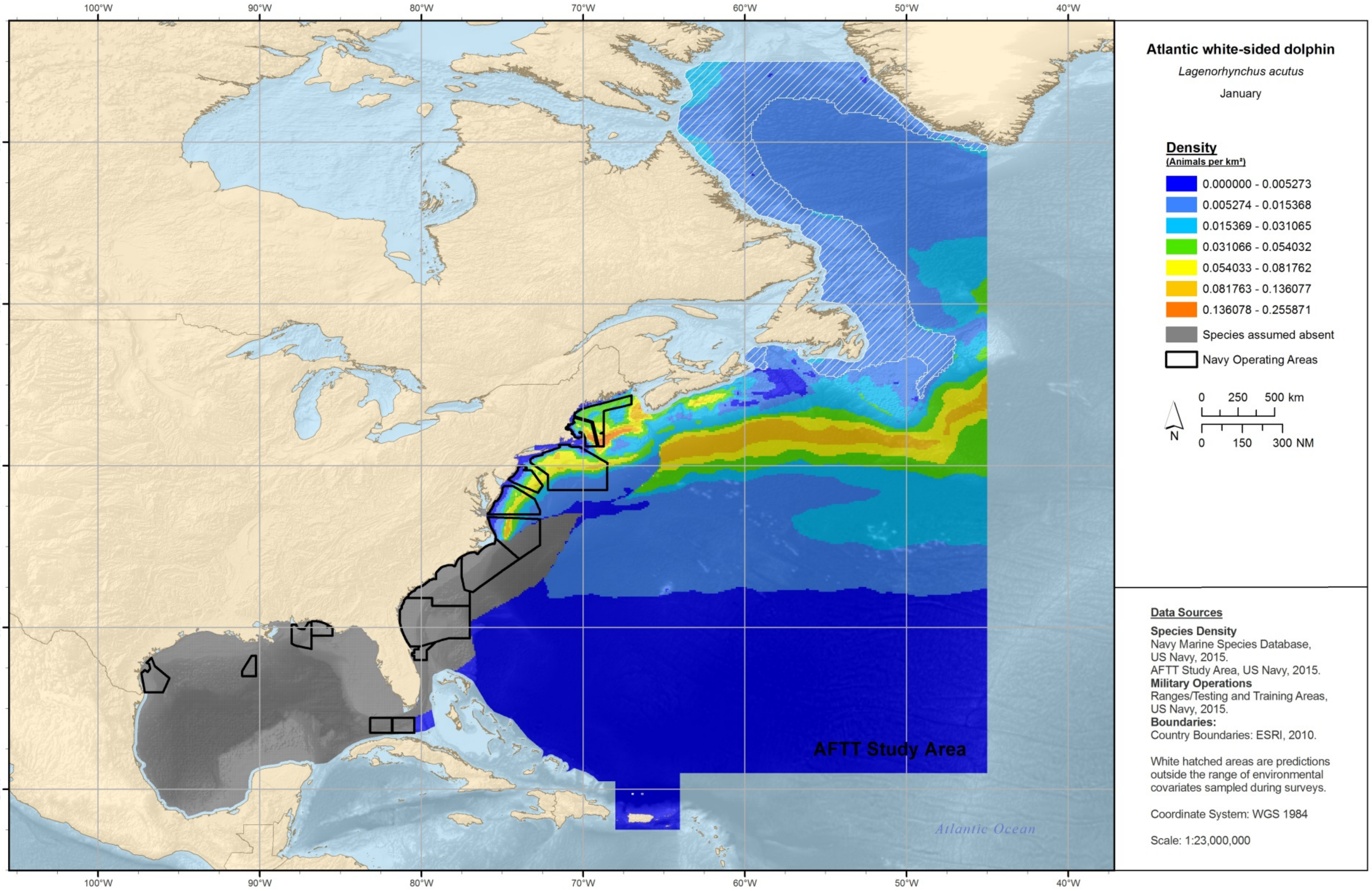
Survey Data and Selected Models:
In the East Coast stratum, a total of 2,266 sightings from the combined survey data were used for model development. These include ambiguous sightings that were recorded as being either Atlantic white-sided dolphin or common dolphin. A reclassification model was successfully applied to these ambiguous sightings and only sightings definitely confirmed as Atlantic white-sided dolphin or identified as such by the reclassification model were used in the model. See the taxon specific documentation associated with Roberts et al. (2016) for details. The climatological environmental variables explained more deviance than contemporaneous ones but showed some spurious predictions and had unusually high CVs. Therefore, the contemporaneous model was chosen for the East Coast stratum.

The model for the AFTT stratum used the same sightings from the East Coast model, as well as 56 sightings from Europe and 11 sightings from the mid-Atlantic ridge. The best fitting model included depth, distance to fronts, epipelagic primary productivity, and SST as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of Atlantic white-sided dolphin in temperate and sub-polar waters of the western North Atlantic, from North Carolina to Greenland and from the continental shelf to deep oceanic waters (as evidenced from bycatch records in pelagic fisheries) (Palka et al 1997, Cipriano 2009).

Other Density Estimates:
An abundance estimate of 37,180 individuals (CV=0.07) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR report is 48, 819 individuals (CV=0.61) (NOAA 2014) based on summer 2011 SEFSC aerial surveys. Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In TAP Phase II, the NODES estimate of 105, 355 individuals (summer season, no CV available) based on survey data for the summer season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population is within the same order of magnitude as the SAR and seems more realistic than the Phase II data, which included RES data. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also preferable to the SAR estimate, which uses

only a single season of one year of survey data and provides only a single density value estimate for the southern east coast of the Atlantic, which is less desirable in the NMSDD data hierarchy.

An abundance estimate of 142,933 individuals (CV=0.17) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-56. January density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.

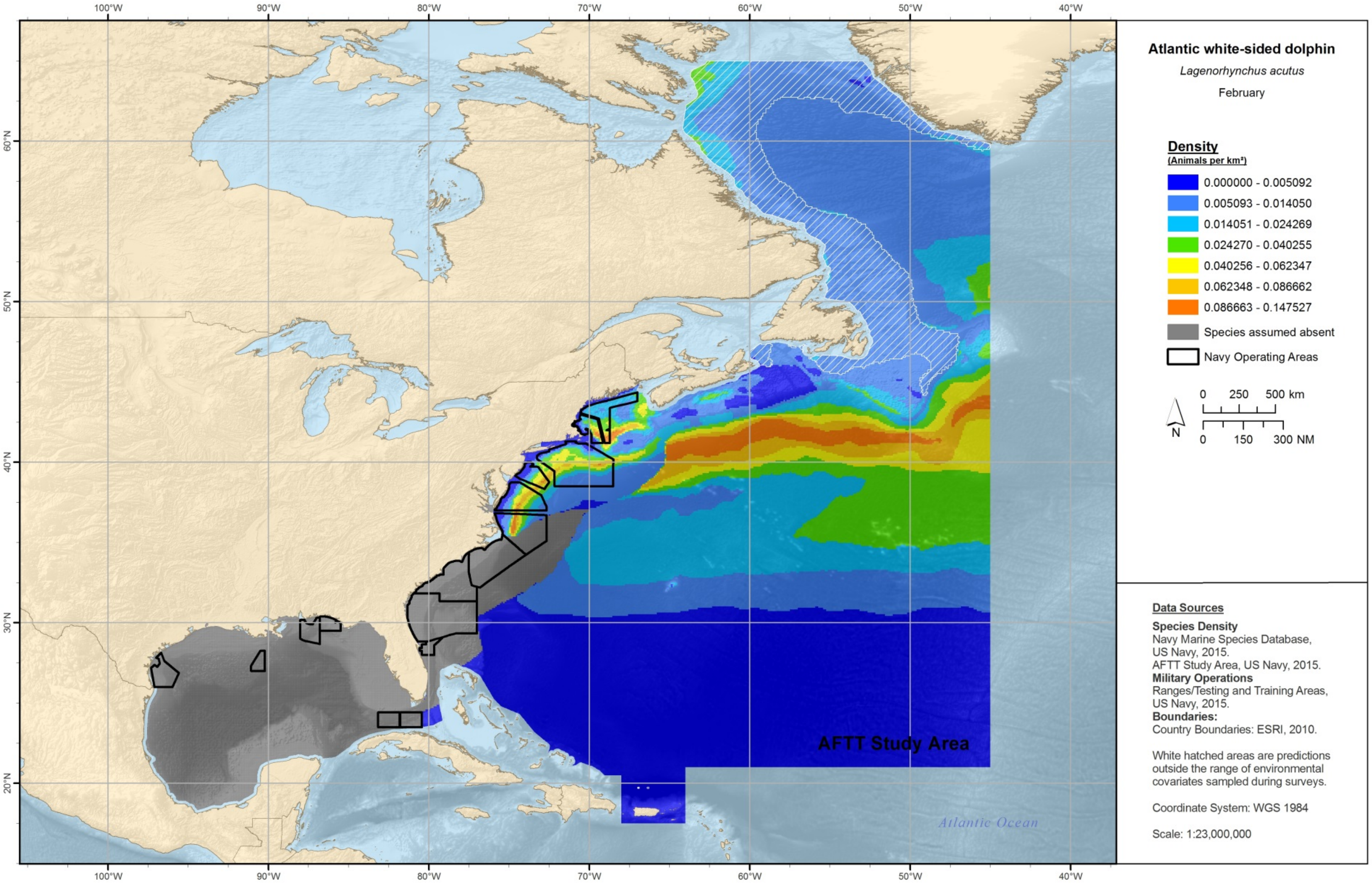


Figure 4-57. February density prediction for Atlantic white-sided dolphin for the East Coast and AFTT strata.

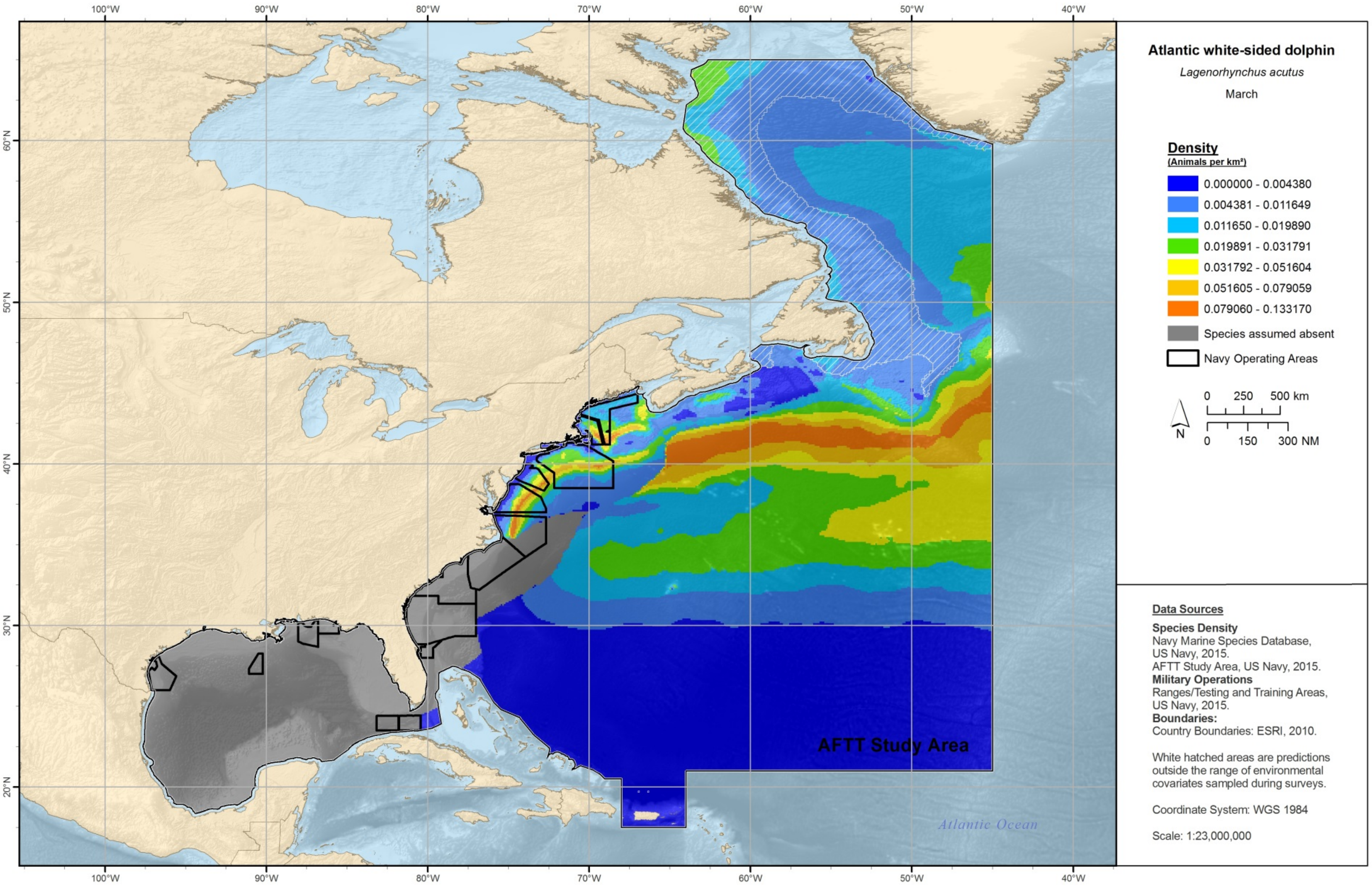


Figure 4-58. March density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.

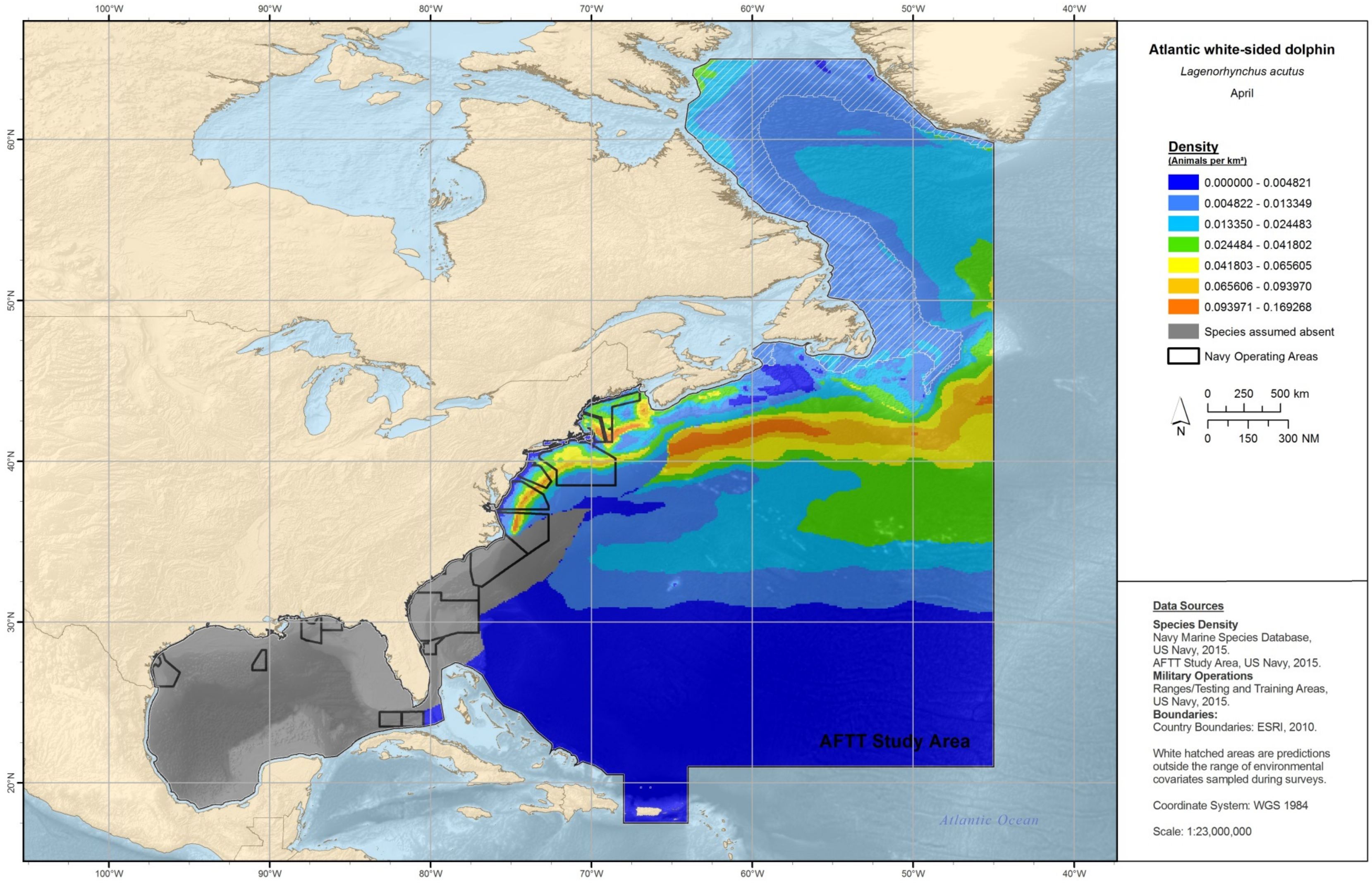
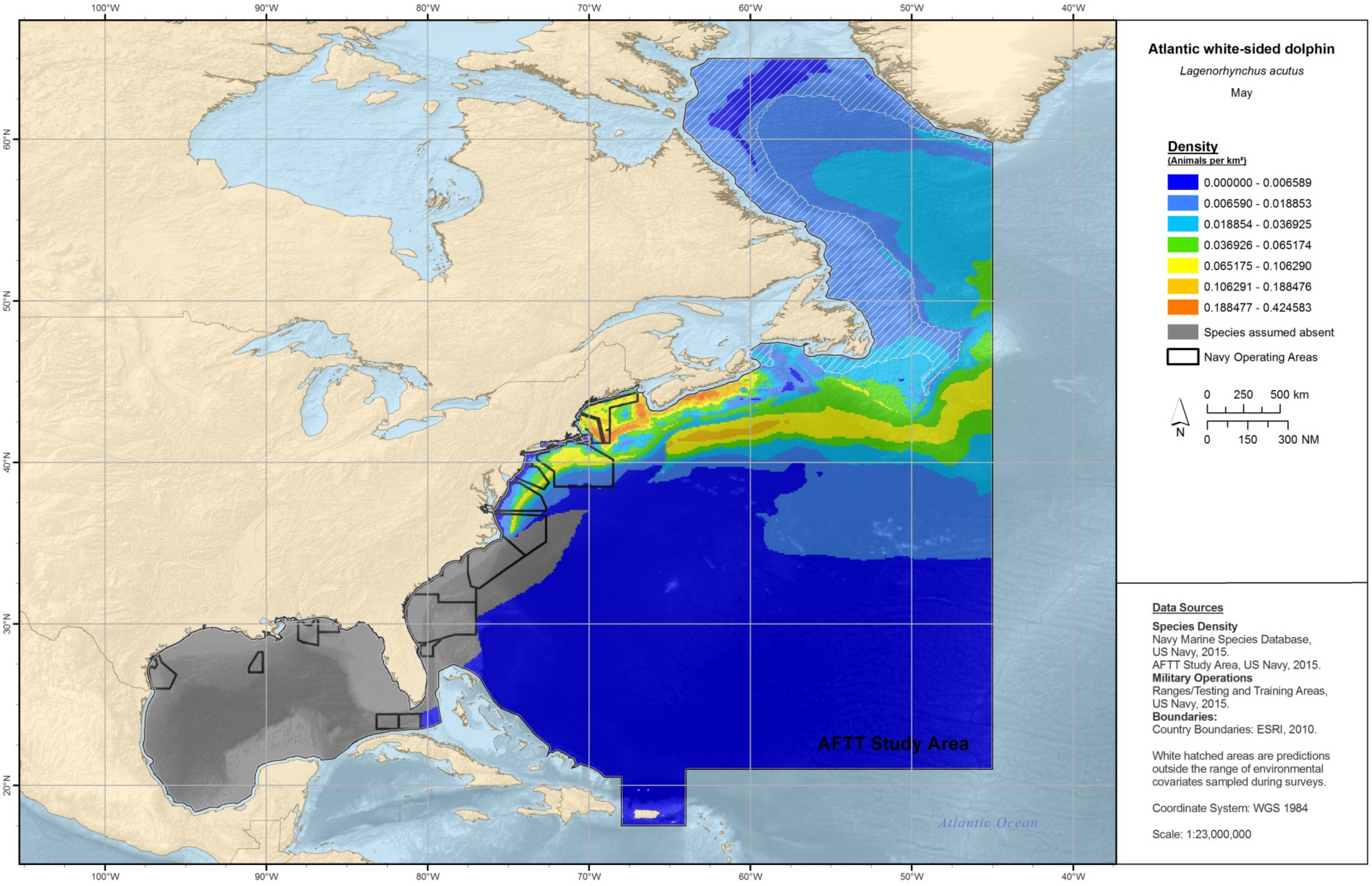


Figure 4-59. April density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.



Data Sources

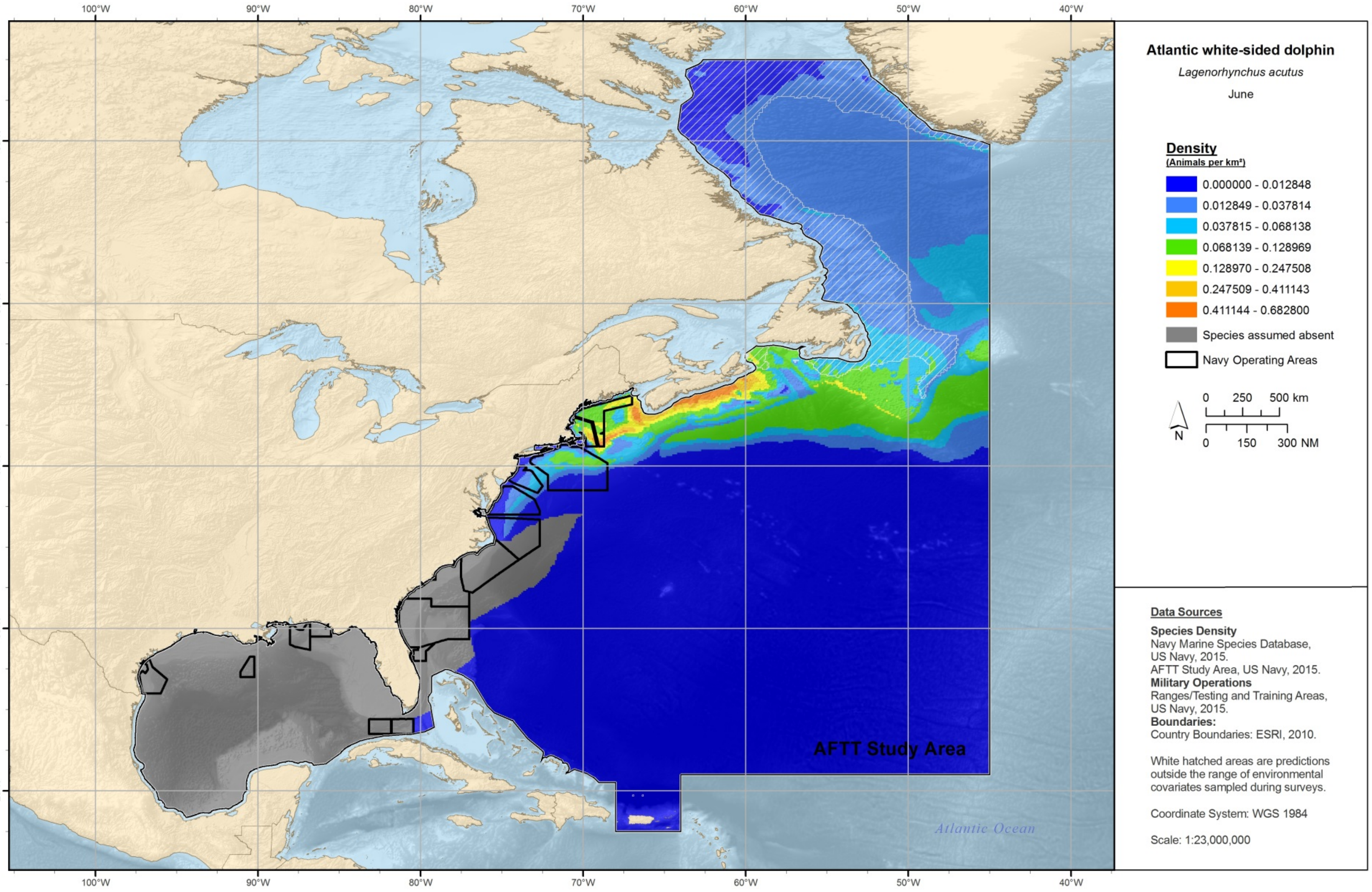
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-60. May density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-61. June density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.

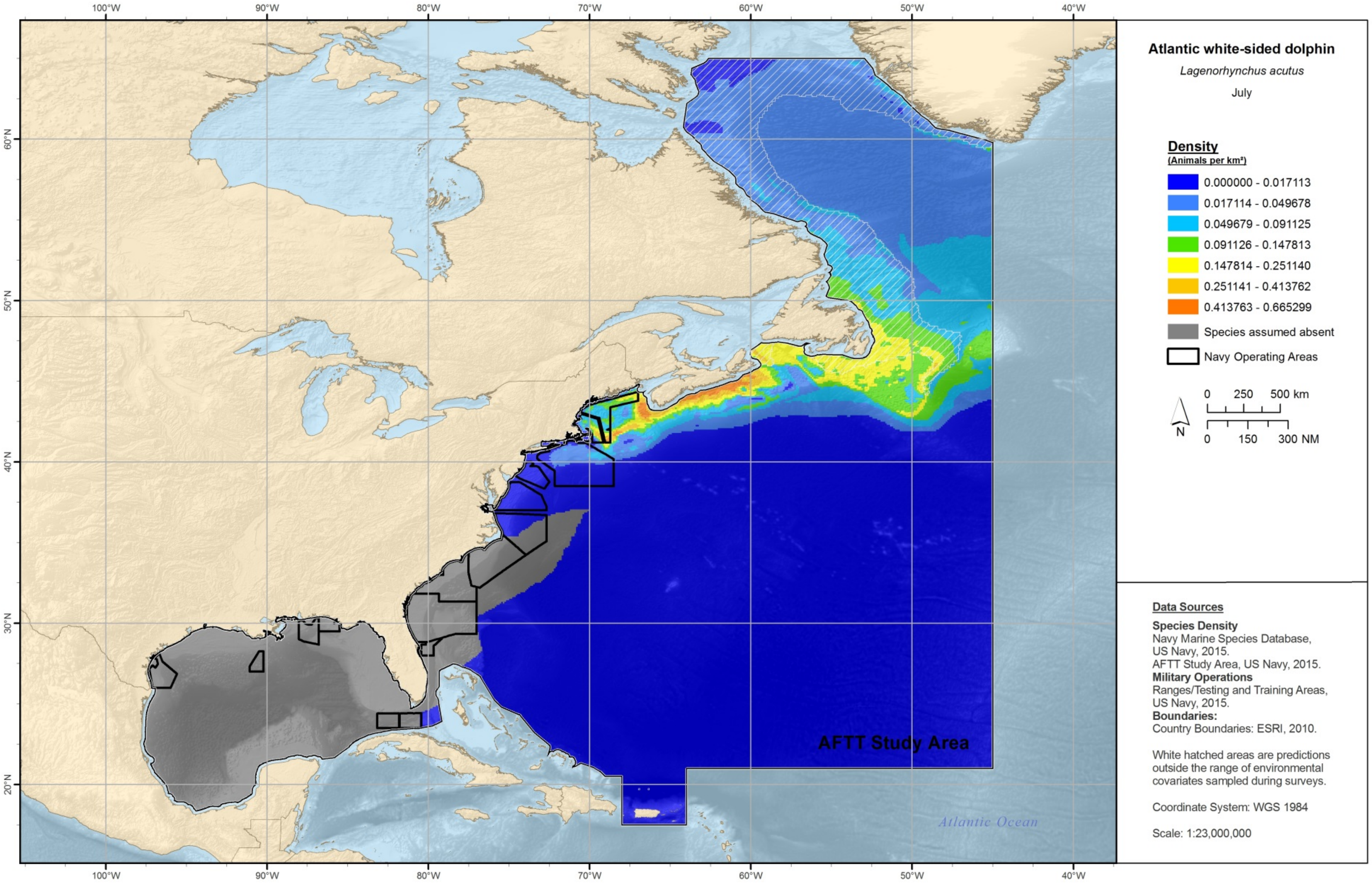


Figure 4-62. July density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.

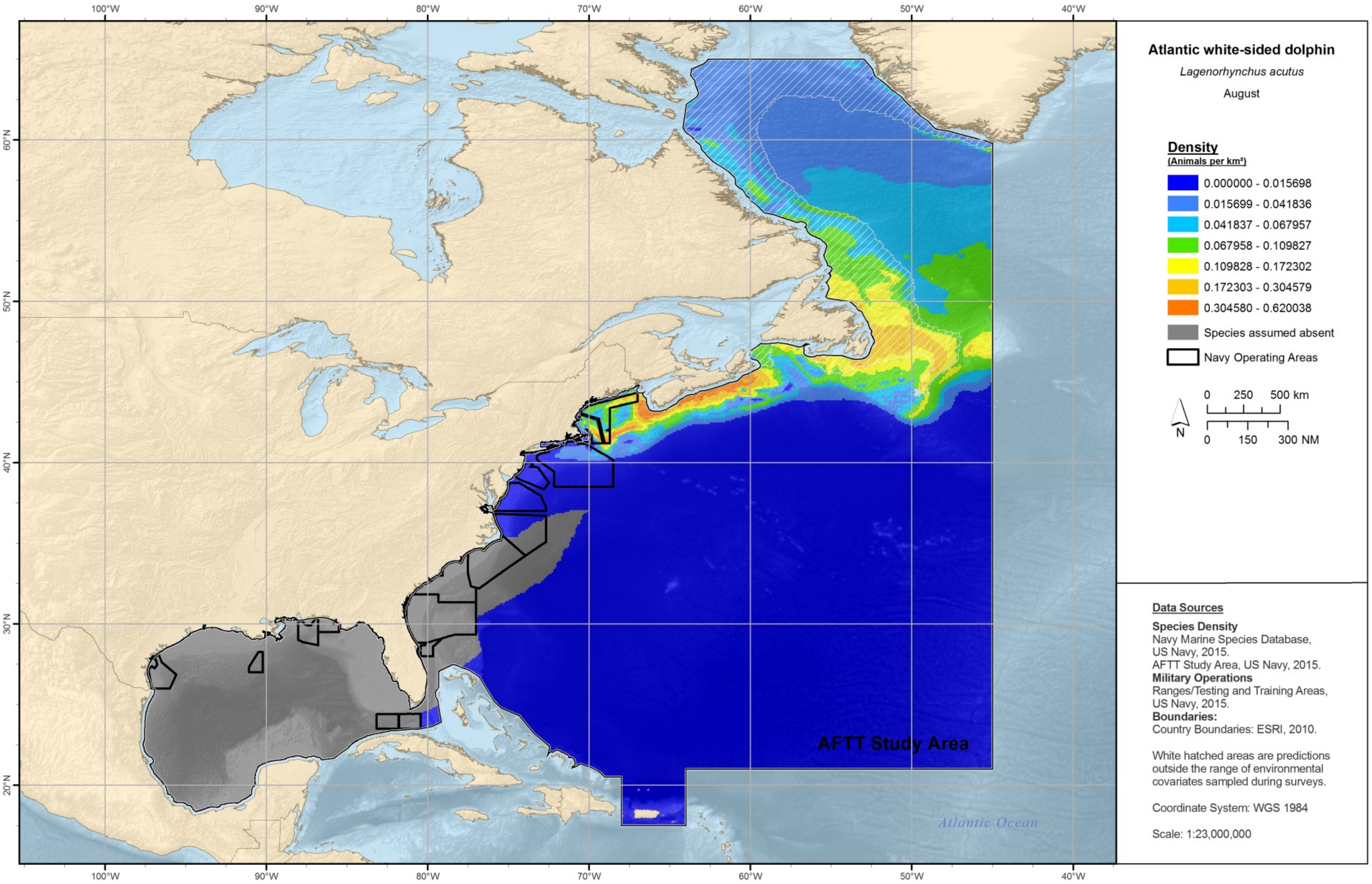


Figure 4-63. August density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.

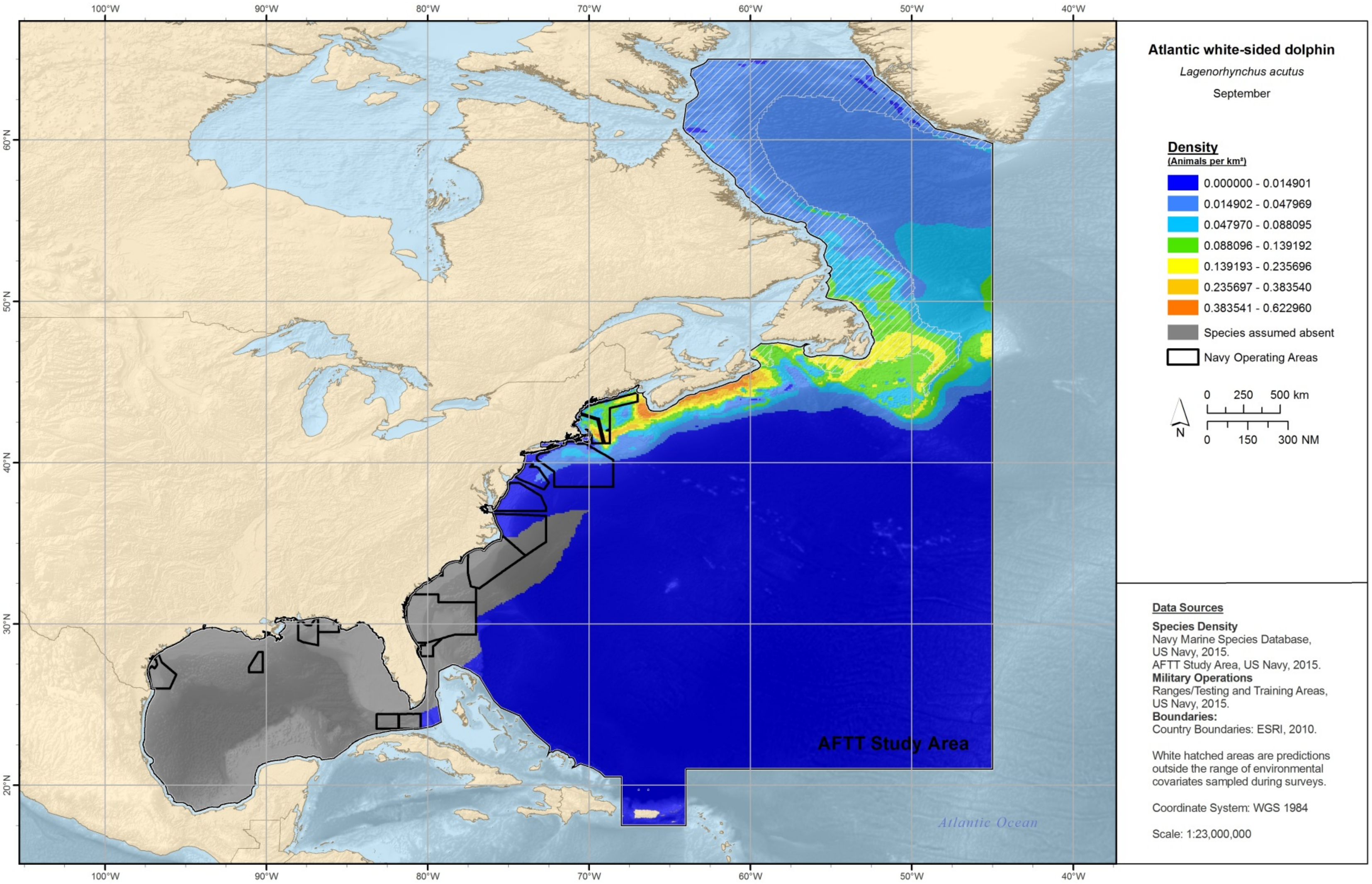
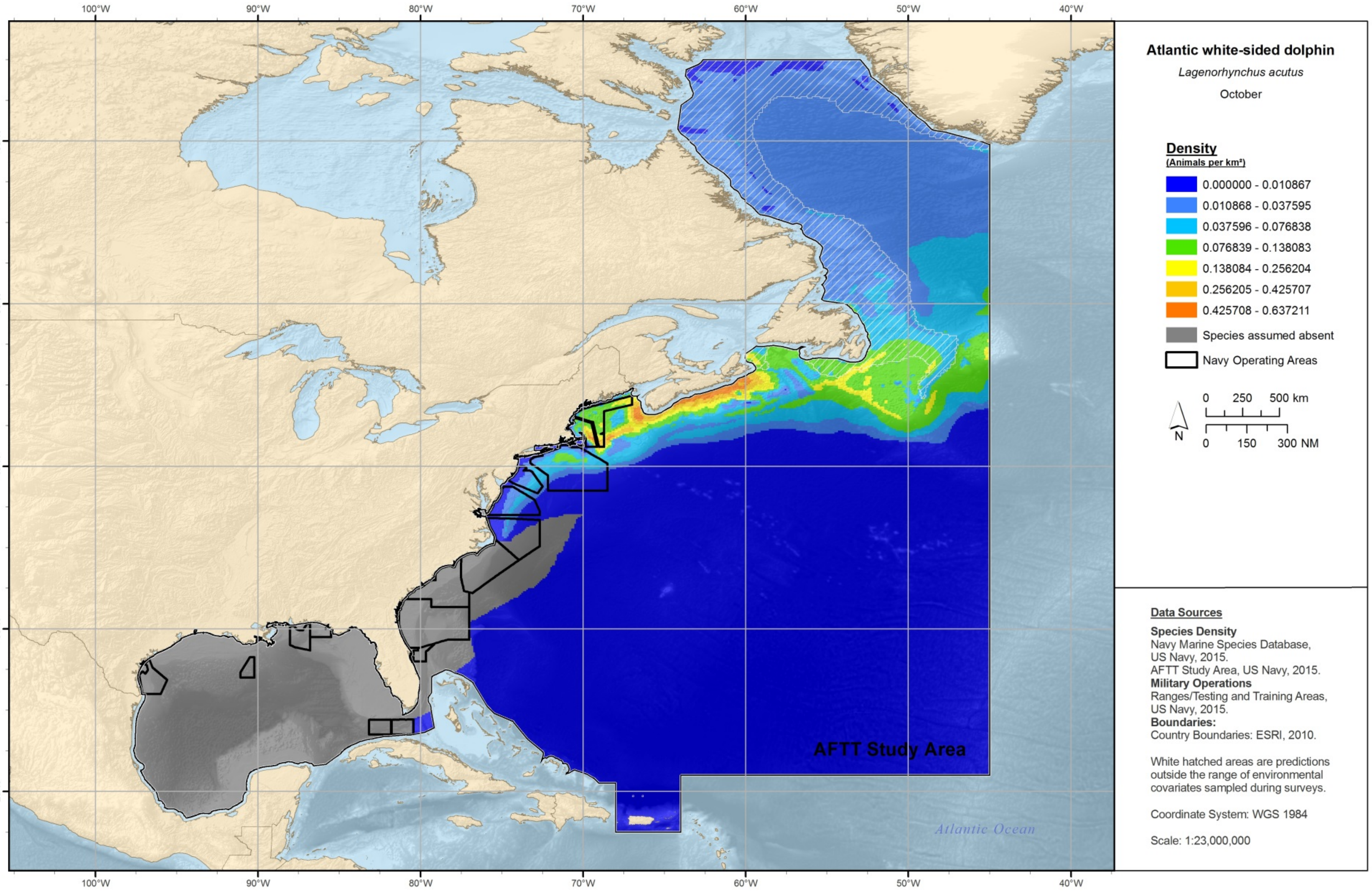


Figure 4-64. September density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.



Data Sources

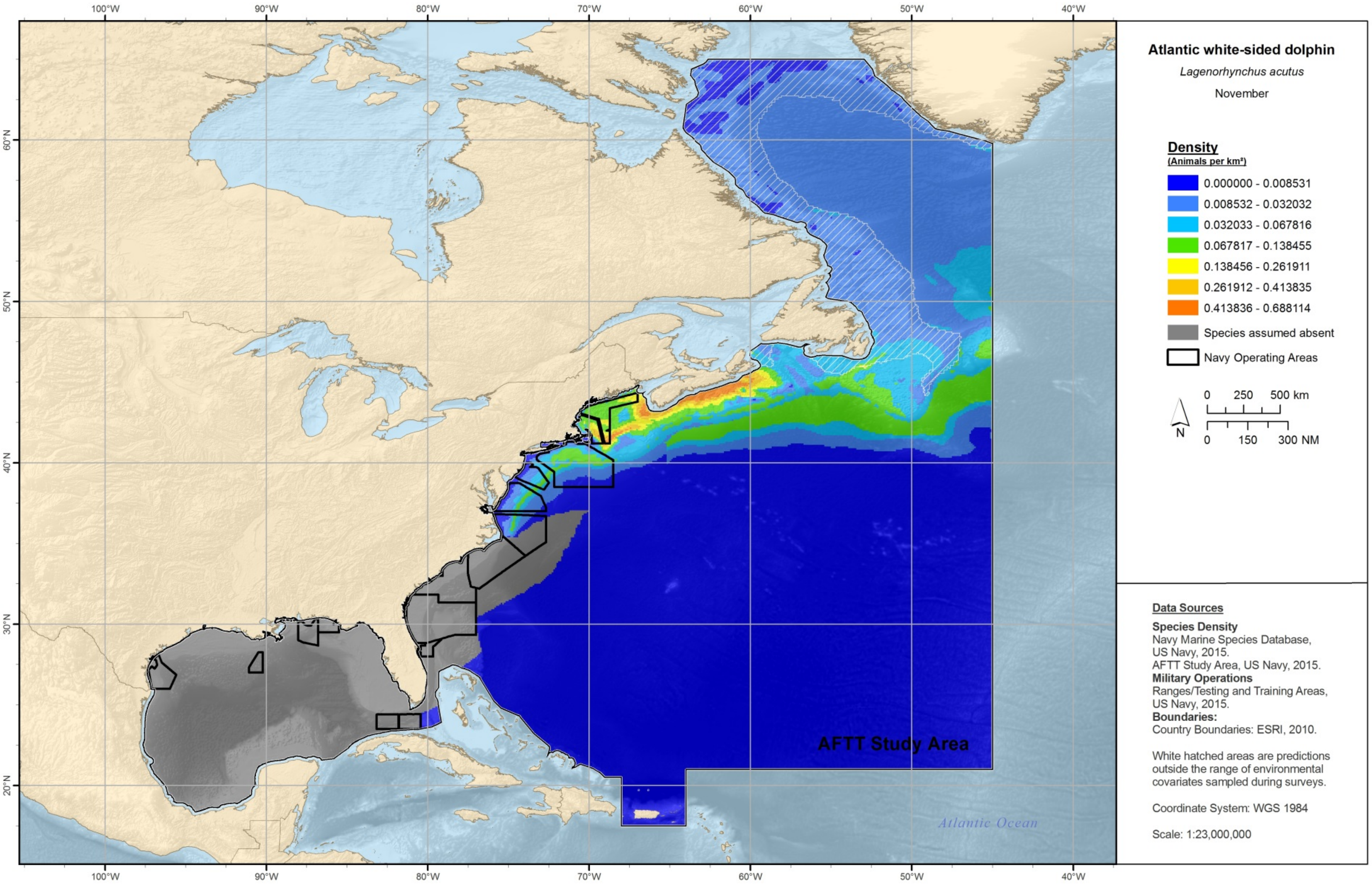
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-65. October density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.



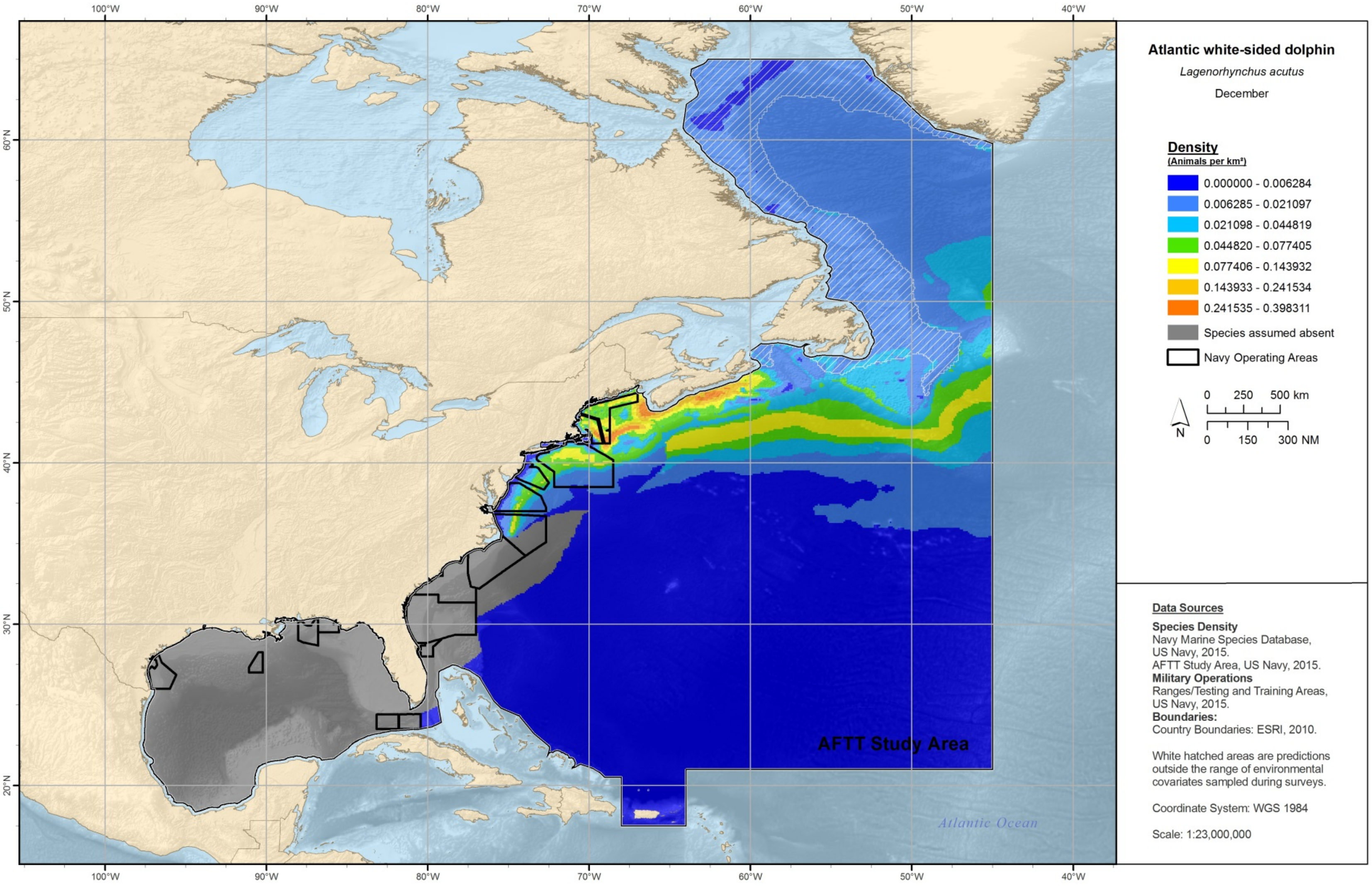
Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-66. November density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-67. December density prediction for Atlantic white-sided dolphins for the East Coast and AFTT strata.

Bottlenose dolphin (*Tursiops truncatus*)

Data Sources and Seasonality:
The majority of density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). Density spatial models were fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. No seasons were delineated though some temporal north/south shifts described in the literature (Waring et al. 2013) were accurately captured by the monthly predictions in the East Coast stratum, indicating that the selected model covariates predicted these shifts without the need to fit separate models. The temporal resolution of the density predictions was monthly for the East Coast stratum only. Annual models were fit in the Gulf of Mexico and AFTT strata. These models are intended for broad scale density predictions in the open ocean and nearshore environment. Bottlenose dolphins are also the most prevalent marine mammal species in estuarine waters in the study area, where these models do not perform as well (limited by the performance of remotely sensed environmental covariates in estuarine environments). As such, other data sources were incorporated to produce area specific density estimates in estuaries throughout the study area. Data sources included mark recapture models, estuarine specific aerial surveys, and extrapolation from offshore density models where no other data sources were available. **Table 4-1** provides a list of estuaries where density estimates were given, their source, and the type of estimate. With the exception of the Chesapeake Bay density model, those data sources will not be discussed in further detail below though detailed justification for the selection of individual estimates can be found in the supporting documentation of the Roberts et al. (2016) density spatial models for bottlenose dolphins.

In the Chesapeake Bay, the largest estuarine environment in the study area, dedicated aerial surveys have been conducted by Virginia Aquarium and single season density models produced by the University of St. Andrews Center for Research into Ecological & Environmental Modelling (CREEM) were based off those data (Burt et al. 2014). Those seasonal models were combined into an annual density model as part of the Roberts et al. (2016) effort (decision based on being consistent with modeling for other species) and were used in the AFTT portion of the Chesapeake Bay. See **Section 3.3** and the cited report for more detail on the underlying surveys used for these models. These surveys and associated density estimate represent the only recent estuarine aerial survey of a bottlenose dolphin population in an estuarine environment.

Table 4-1. Estuaries with area specific density estimates in the NMSDD for bottlenose dolphins.

Estuarine Area	**Density Data Source**	**Type of Density Estimate**
East Coast Estuaries (north to south)		
Chesapeake Bay	Virginia Aquarium / CREEM	density spatial model
James River	Virginia Aquarium / CREEM	density spatial model
Mobjack Bay	Virginia Aquarium / CREEM	density spatial model
York River	Virginia Aquarium / CREEM	density spatial model
Beaufort Inlet	Robert's et al. 2016 density spatial model	extrapolation from the closest cell of the density spatial model
Cape Fear River	Robert's et al 2016. density spatial model	extrapolation from the closest cell of the density spatial model
Sapelo Sound	Balmer et al. 2013	generated from mark recapture estimate and study area
Doboy Sound	Balmer et al. 2013	extrapolated from mark recapture estimate
Altamaha River	Balmer et al. 2013	generated from mark recapture estimate and study area

Hampton River	Balmer et al. 2013	generated from mark recapture estimate and study area
St. Simons Sound	Balmer et al. 2013	generated from mark recapture estimate and study area
St. Andrew Sound	Balmer et al. 2013	extrapolated from mark recapture estimate
Cumberland Sound	Balmer et al. 2013	extrapolated from mark recapture estimate
Nassau Sound	Gubbins et al. 2013	generated from mark recapture estimate and study area
St. John River	Gubbins et al. 2013	generated from mark recapture estimate and study area
Indian River	Durden et al. 2011	seasonal uniform density estimates derived from aerial line-transect data
Banana Rover	Durden et al. 2011	seasonal uniform density estimates derived from aerial line-transect data
Ponce de Leon Inlet	Durden et al. 2011	seasonal uniform density estimates derived from aerial line-transect data
Gulf of Mexico Estuaries (west to east)		
Corpus Christi Bay	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Redfish Bay	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Aransas Bay	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Mesquite Bay	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Sabine Lake	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Calcasieu Lake	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Bataria Bay	Miller 2003	generated from mark recapture estimate and assumed area
Caminada Bay	Miller 2003	generated from mark recapture estimate and assumed area
Bastian Bay	Roberts et al. 2016	extrapolation from the closest cell of the density spatial model
Shell Island Bay	Roberts et al. 2016	extrapolation from the closest cell of the density spatial model
Bay Coquette	Roberts et al. 2016	extrapolation from the closest cell of the density spatial model
Scott Bay	Roberts et al. 2016	extrapolation from the closest cell of the density spatial model
Dixon Bay	Roberts et al. 2016	extrapolation from the closest cell of the density spatial model
Southwest Pass	Roberts et al. 2016	extrapolation from the closest cell of the density spatial model
Mississippi Sound	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Lake Borgne	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
St. Andrew Bay	Bouveroux 2010	average annual estimate generated from seasonal mark recapture surveys and study area
Gullivan Bay	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys
Ten Thousand Islands	Blaylock and Hoggard 1994	uniform density estimate generated by Duke University from the referenced aerial surveys

Survey Data and Selected Models:

In the East Coast stratum, a total of 1,849 sightings from the combined survey data were used for model development. The climatological models consistently explained more deviance than models fitted with contemporaneous covariates. However, the best climatological models and the best contemporaneous model predicted very similar spatial distributions and mean abundances (Roberts et al. 2016).

In the Gulf of Mexico stratum, a total of 4,657 sightings from the combined survey data were used for model development. The climatological models consistently explained more deviance than models fitted with contemporaneous covariates. However, the best climatological models and the best contemporaneous model predicted very similar spatial distributions and mean abundances (Roberts et al. 2016).

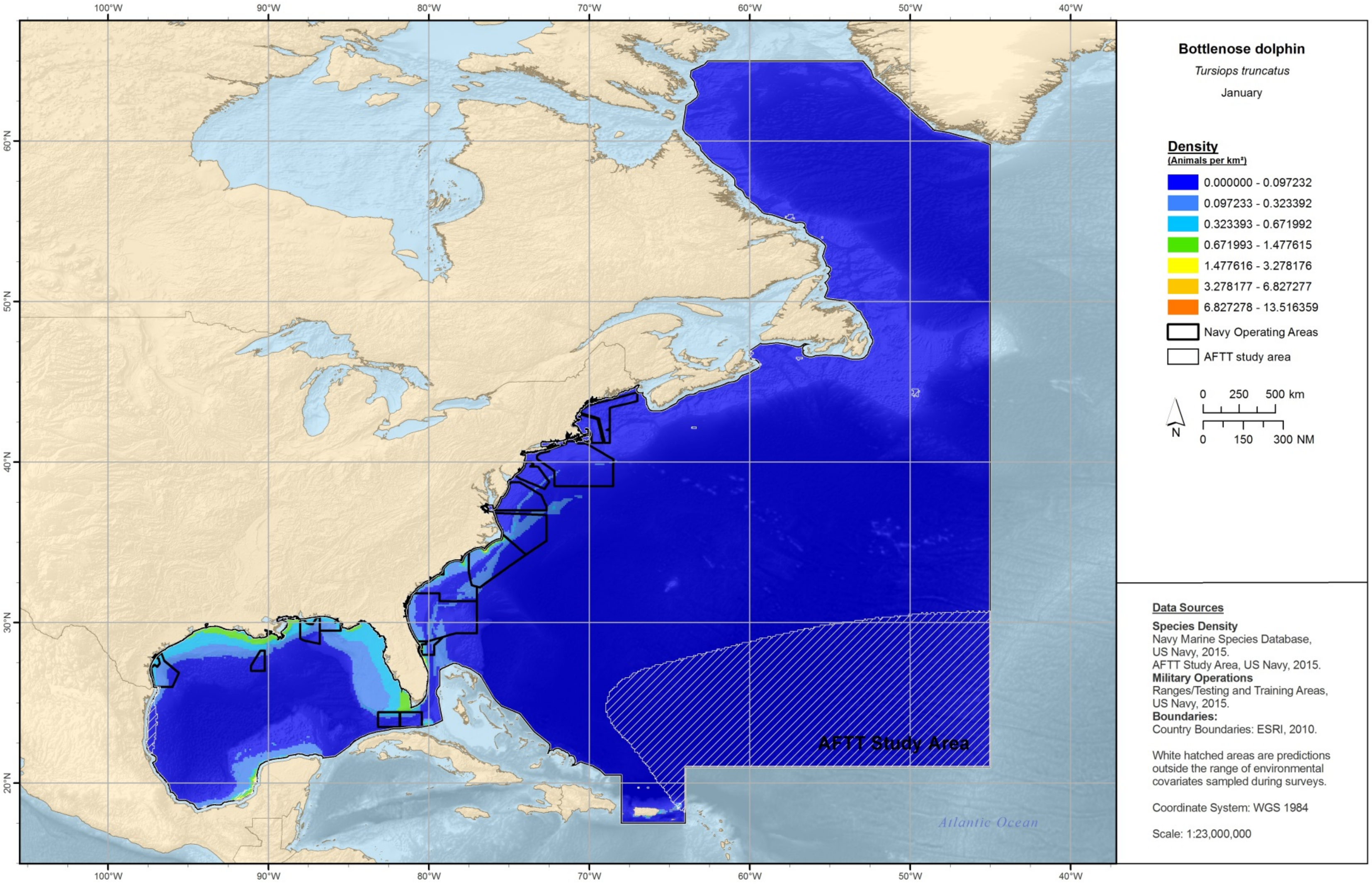
The model for the AFTT stratum used the same sightings from the East Coast and Gulf of Mexico models, as well as 41 sightings from Europe and 84 sightings from the Caribbean. The best fitting model included depth, distance to fronts, epipelagic micronekton primary productivity, and zooplankton potential production as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of the species.

Other Density Estimates:

An abundance estimate of 97,476 individuals (CV=0.06) was derived from the East Coast stratum model (Roberts et al. 2016). The more recent estimate from a NOAA SAR is 108, 744 individuals (no CV available as this combines multiple estimates of various coastal and offshore stocks) (NOAA 2014) based on summer 2011 NEFSC and SEFSC aerial surveys. Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In TAP Phase II, the NODES estimate of 117, 956 individuals (summer season, CV not available) based on survey data for the summer season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population is within the same order of magnitude as the SAR and seems more realistic than the Phase II data which included RES data in non-summer seasons. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also preferable to the SAR estimate, which uses only a single season of one year of survey data and provides only a single density value estimate for the southern east coast of the Atlantic which is less desirable in the NMSDD data hierarchy.

An abundance estimate of 138,602 individuals (CV=0.06) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016).The most recent NOAA SAR estimate is 96,732 individuals (CV=0.07) for all stocks (NOAA 2014) based on oceanic shipboard surveys in 2009 and aerial surveys in 2011/2012. In TAP Phase II, a NODES estimate of 130, 971 individuals (summer season, season not available) based on survey data for the summer season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the Gulf of Mexico stratum population estimate seems more realistic than the Phase II data, which included RES data in non-summer seasons. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also preferable to the SAR estimate which uses only a single season of one year of survey data and provides only a single density value estimate for the southern east coast of the Atlantic, which is less desirable in the NMSDD data hierarchy.

An abundance estimate of 432,046 individuals (CV=0.06) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-68. January density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

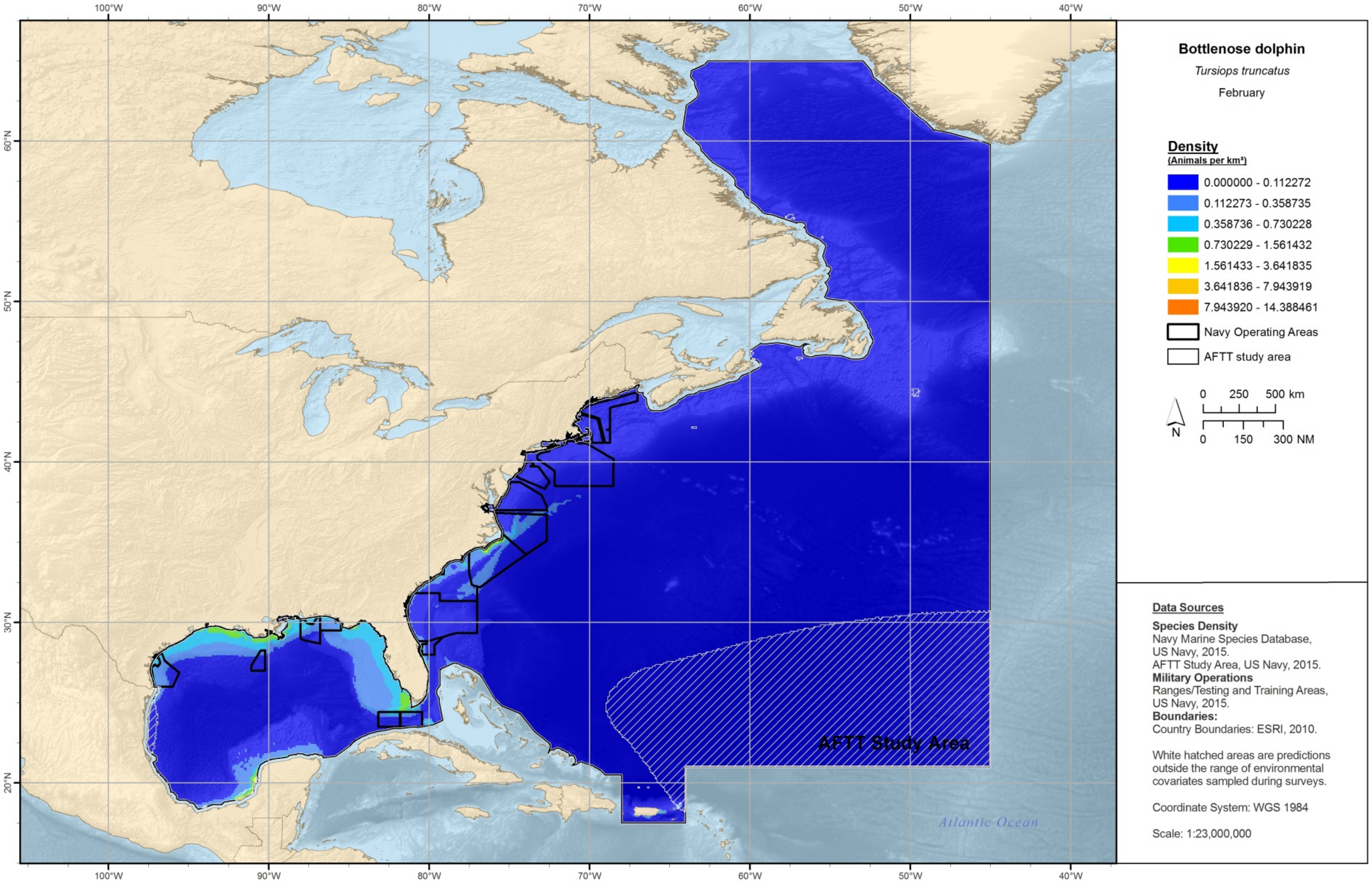


Figure 4-69. February density prediction for bottlenose dolphins for East Coast, Gulf of Mexico and AFTT strata.

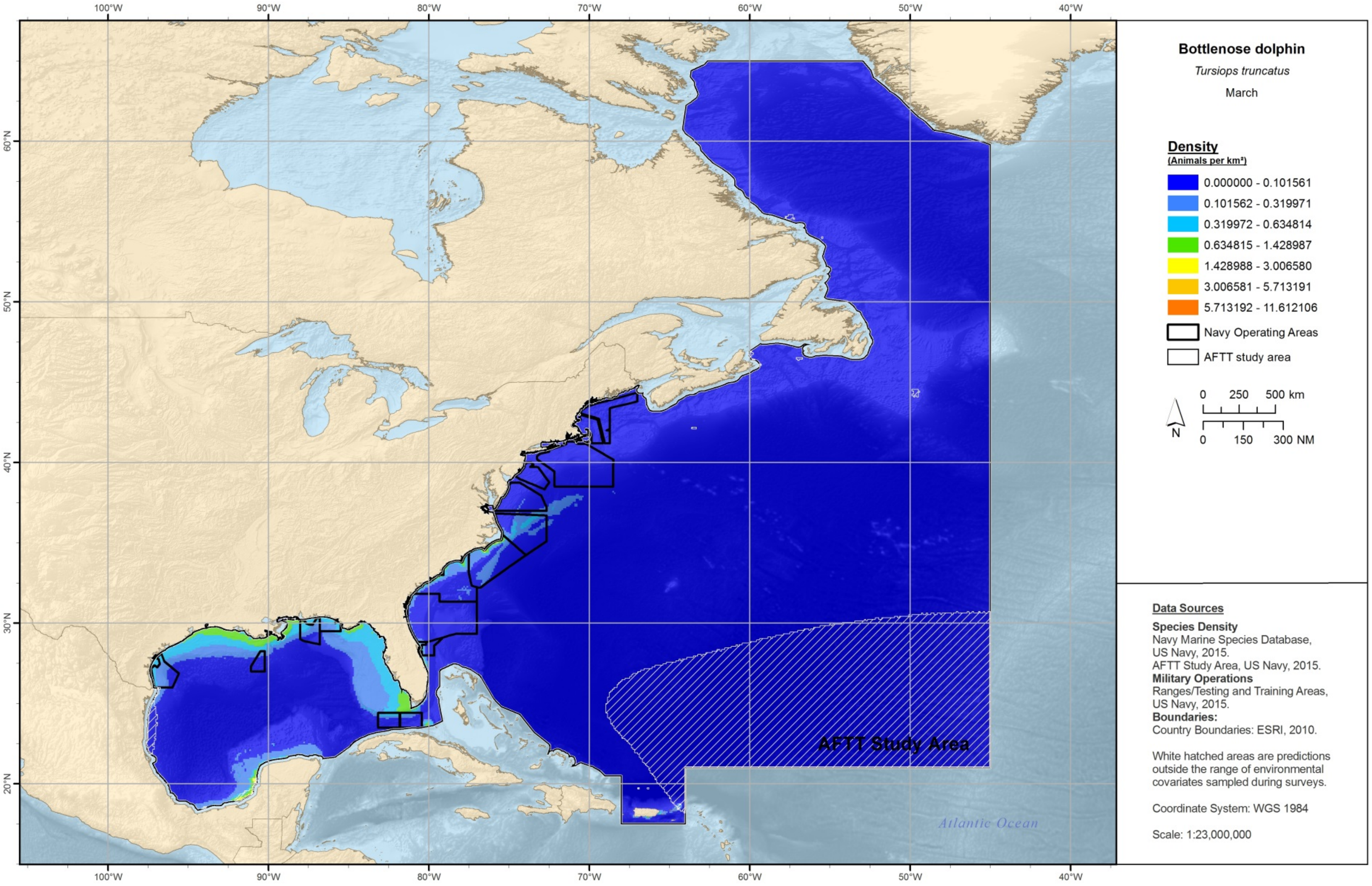
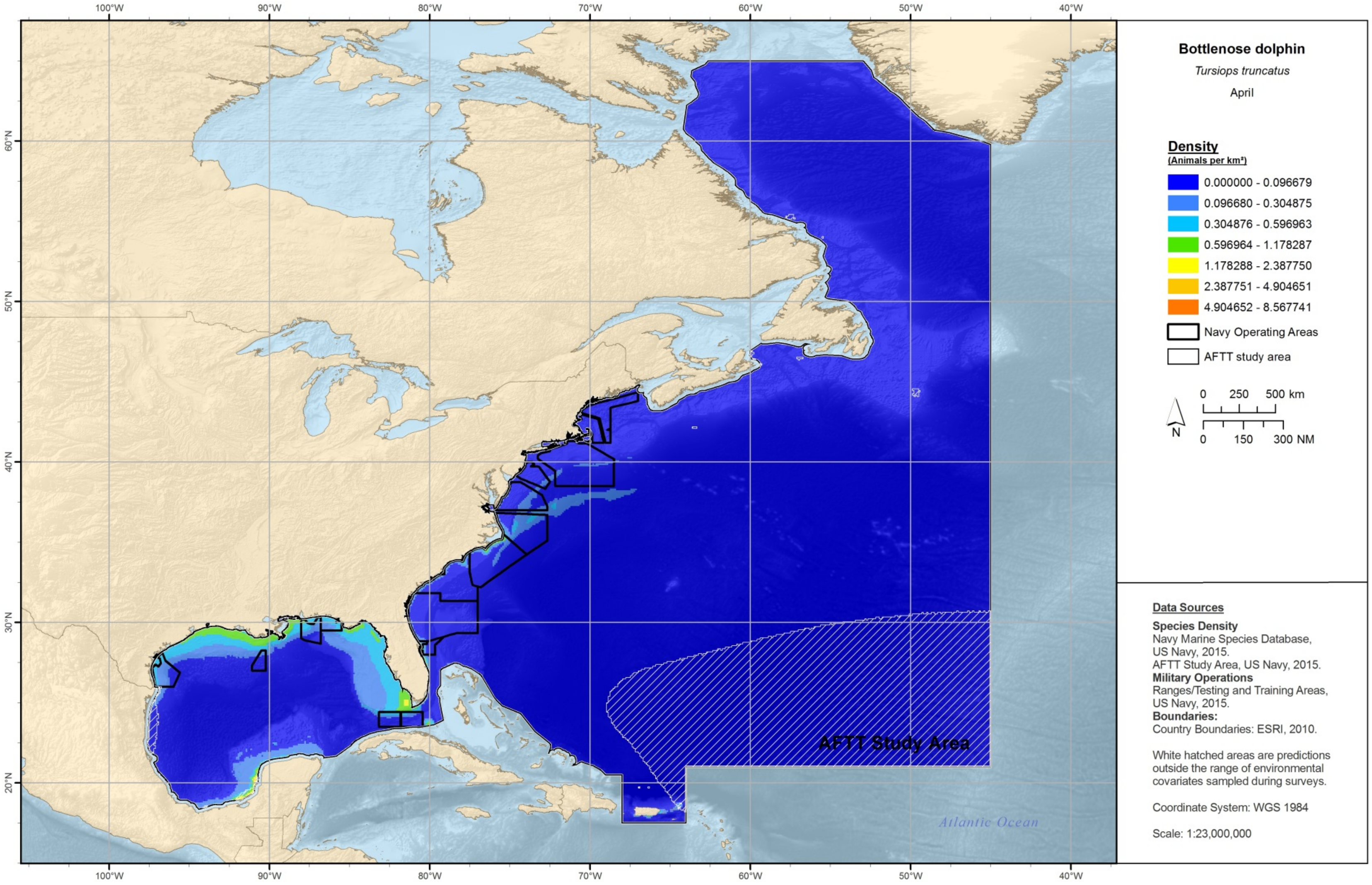


Figure 4-70. March density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-71. April density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

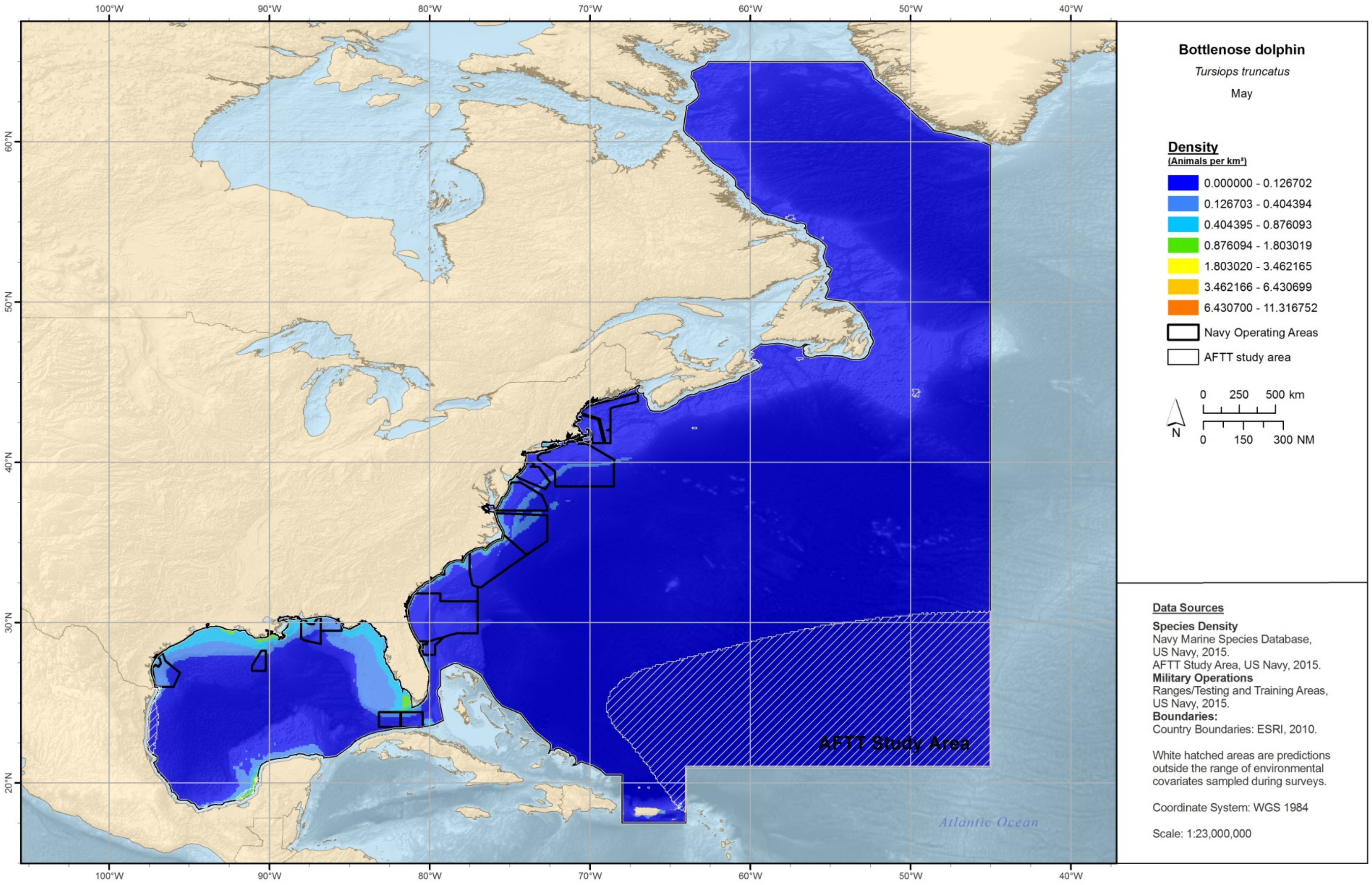


Figure 4-72. May density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

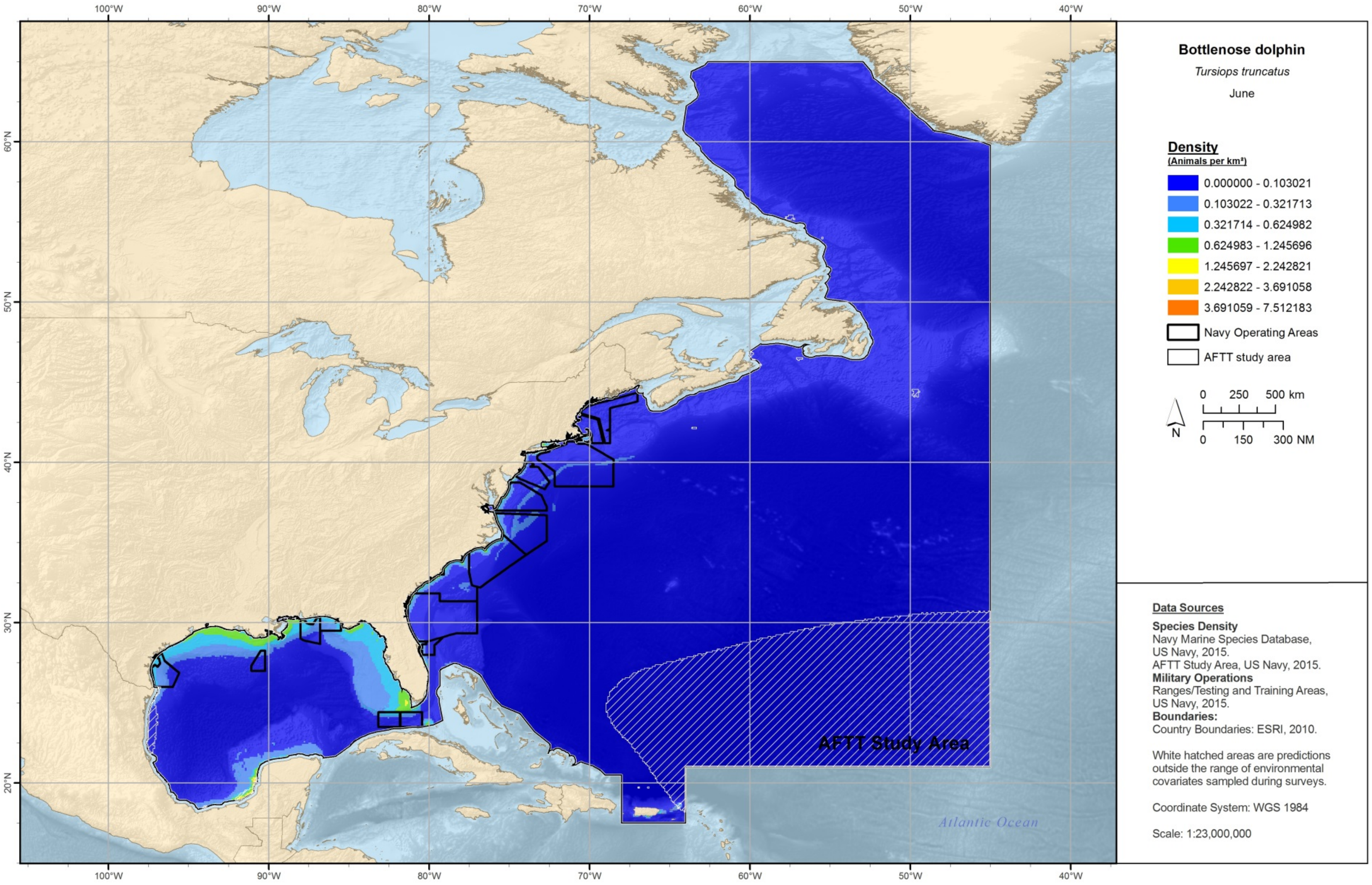


Figure 4-73. June density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

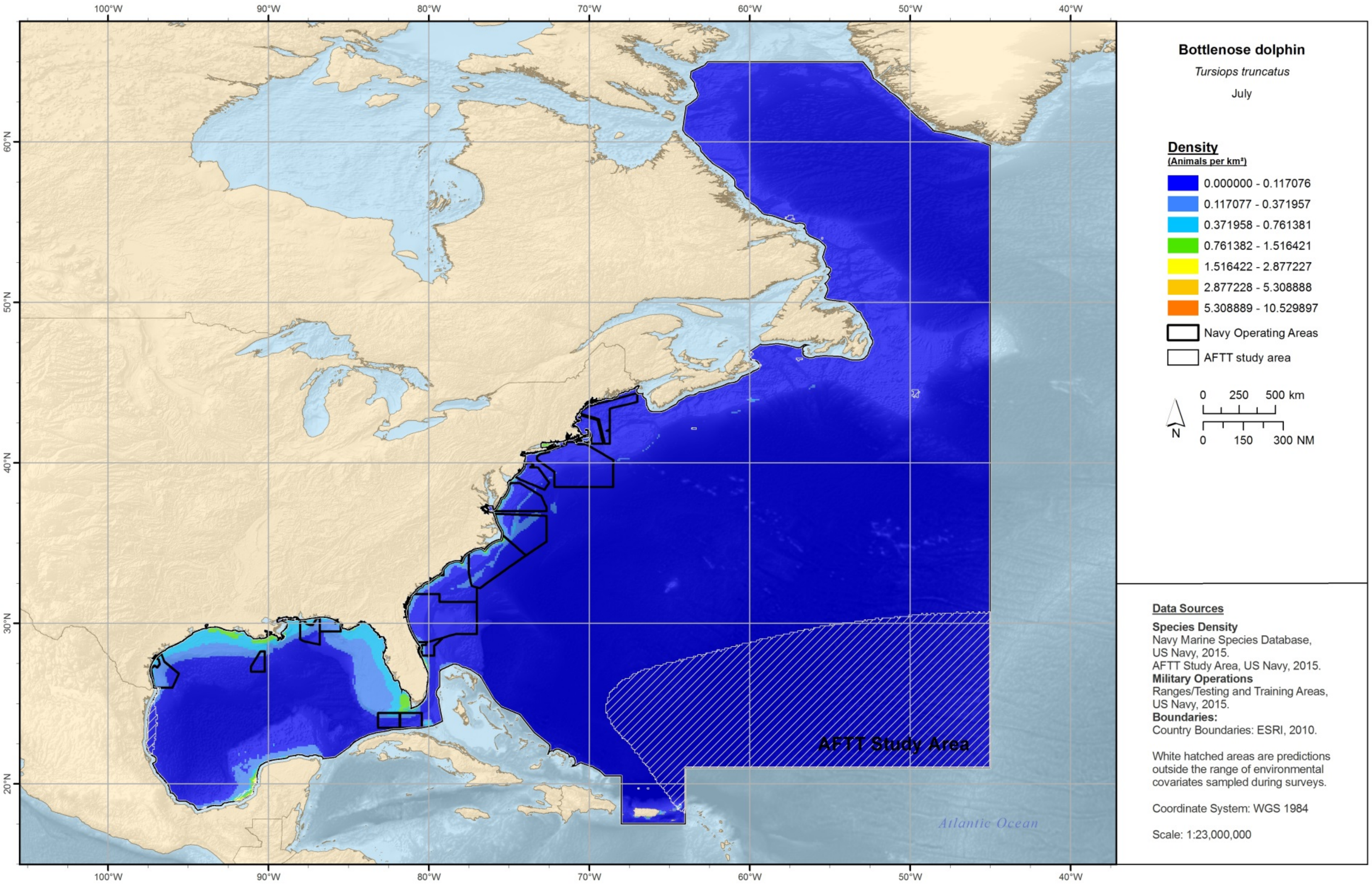


Figure 4-74. July density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

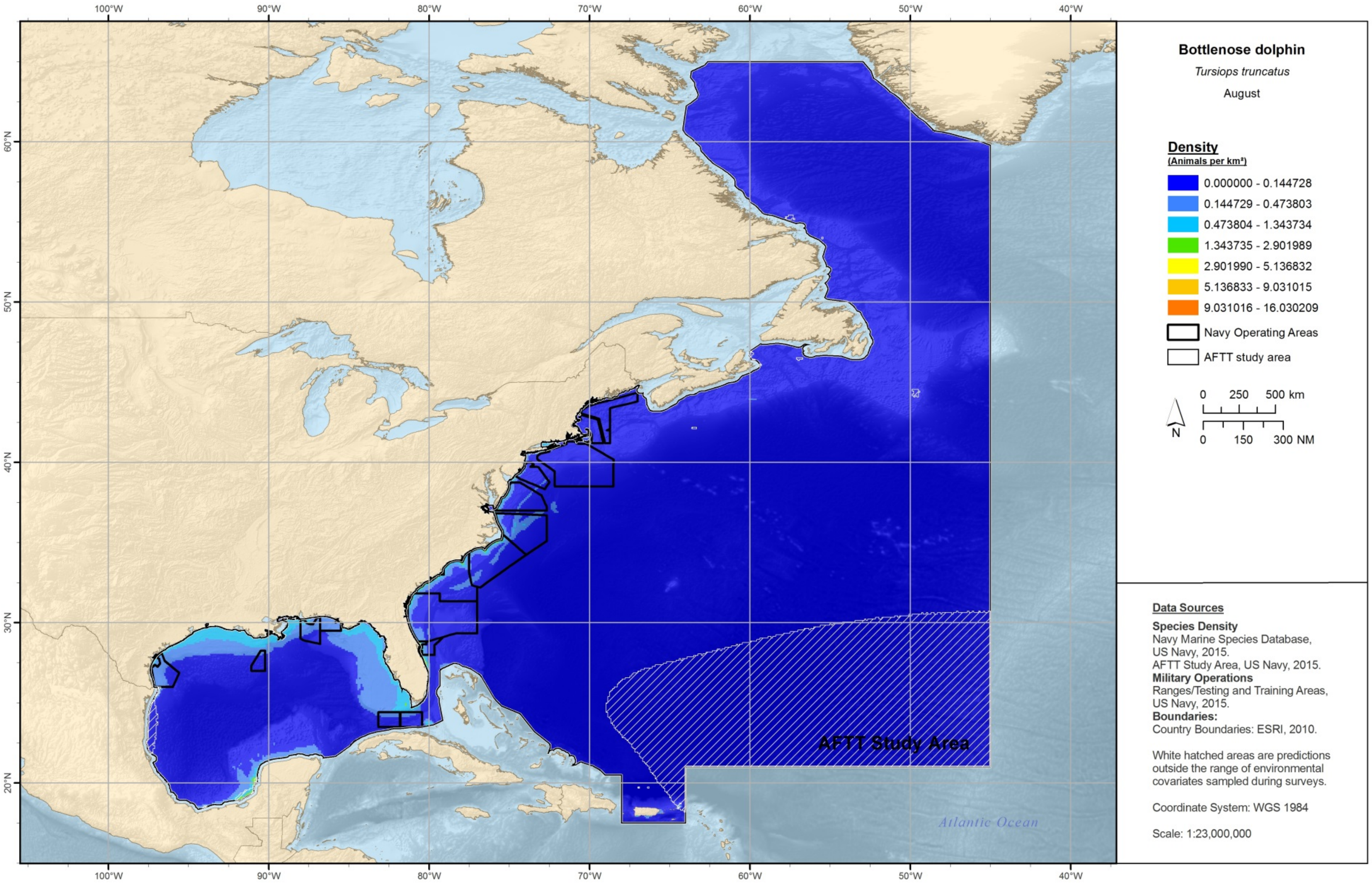
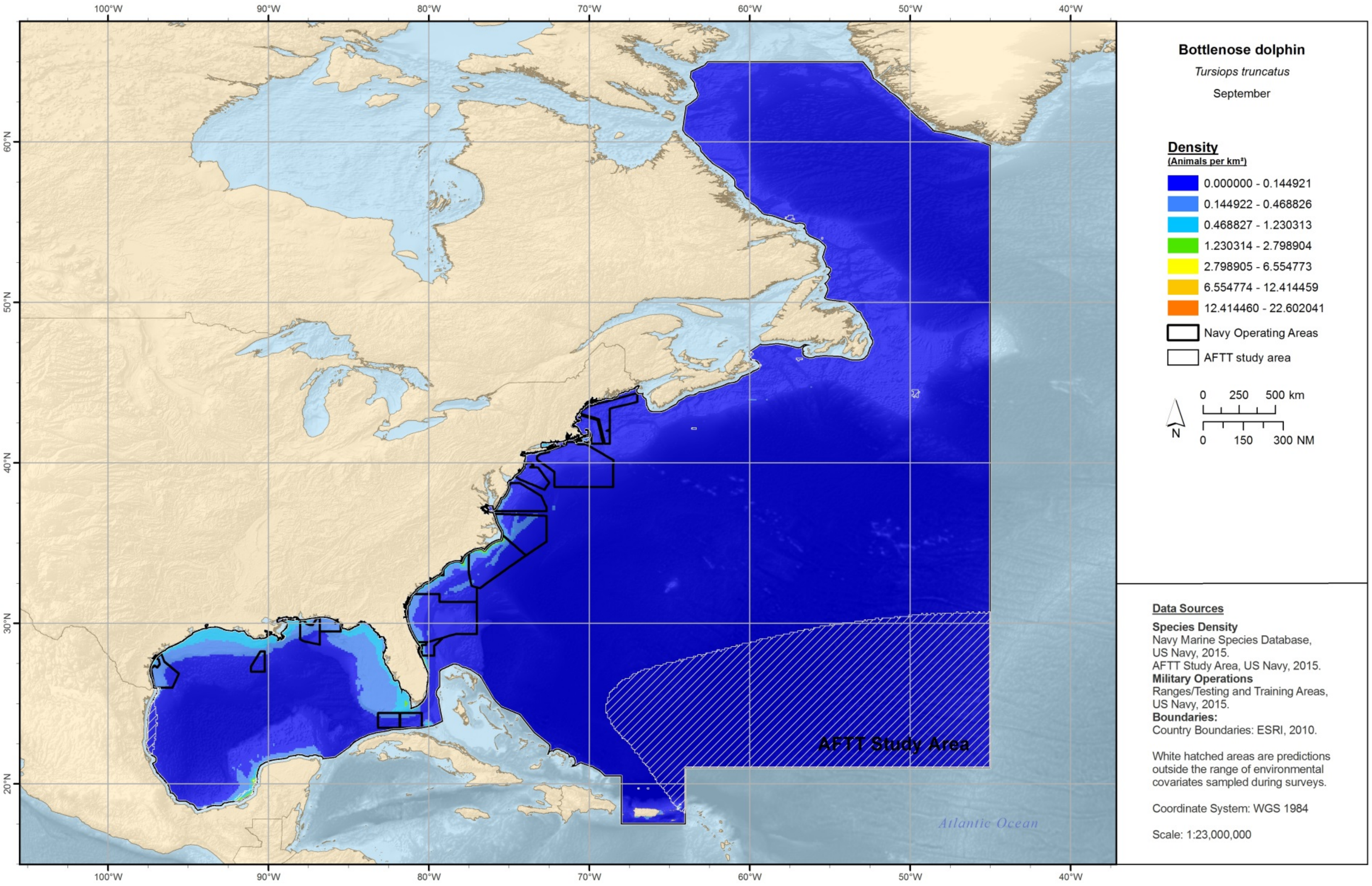


Figure 4-75. August density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-76. September density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

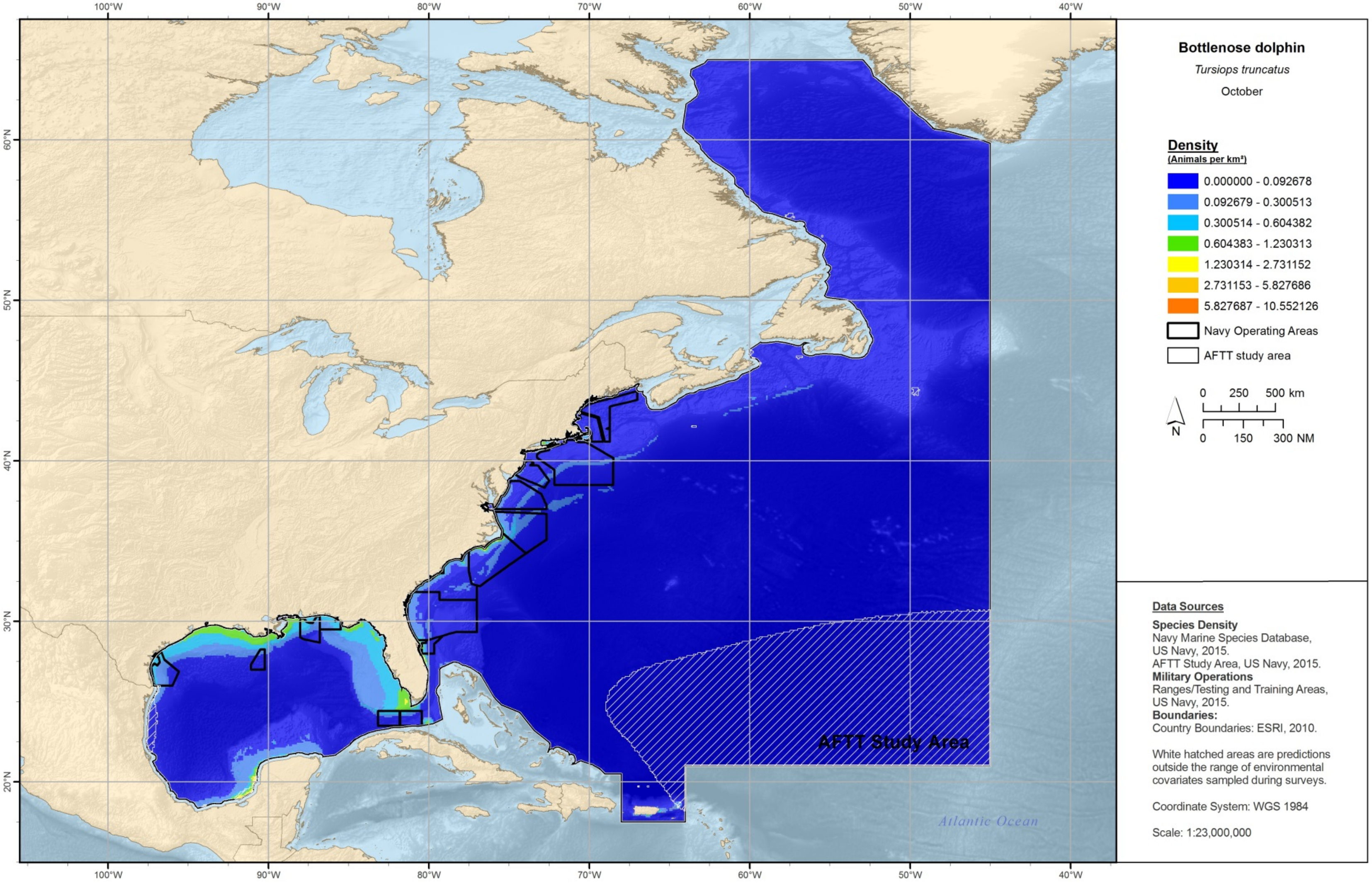


Figure 4-77. October density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

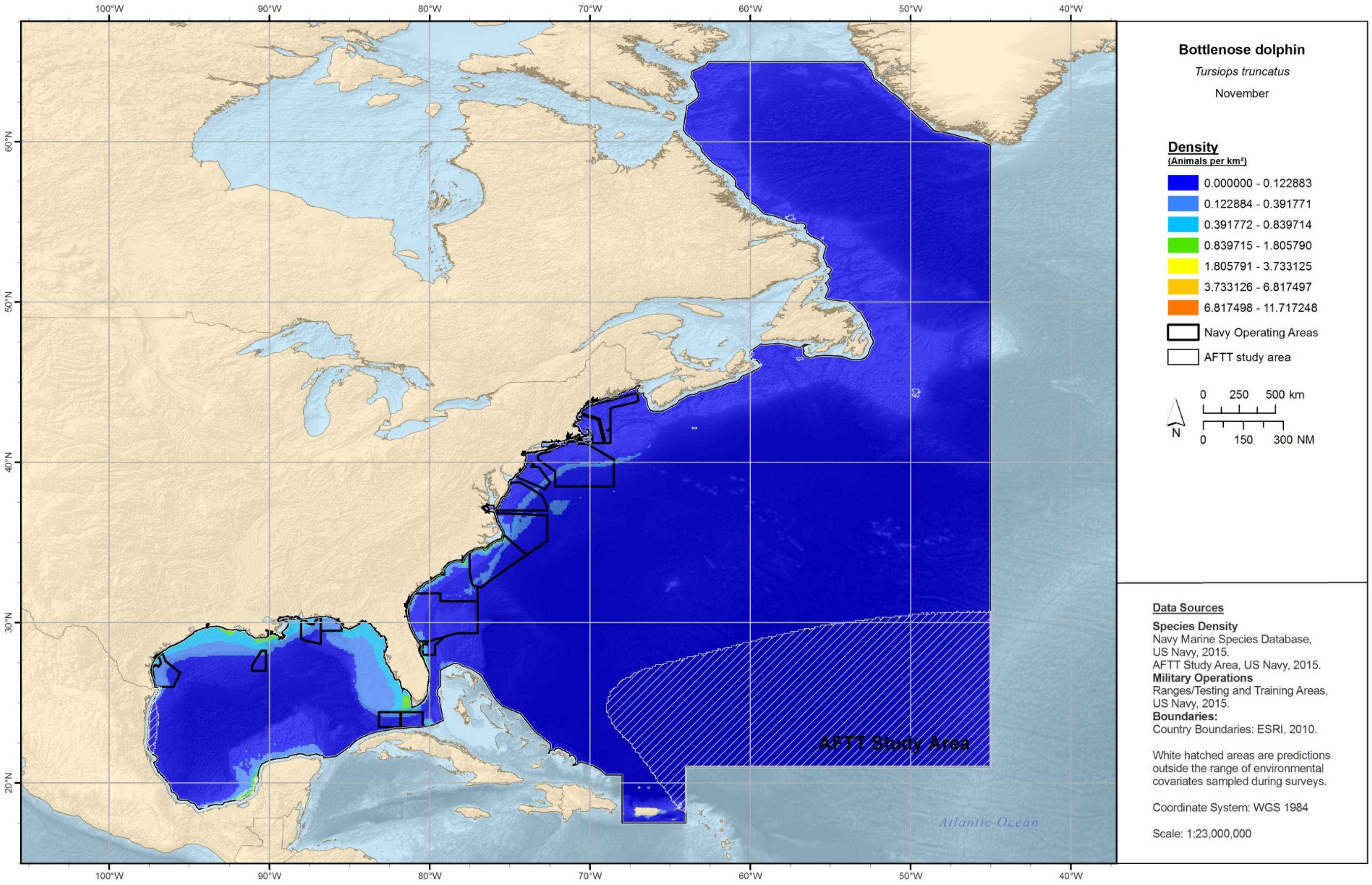
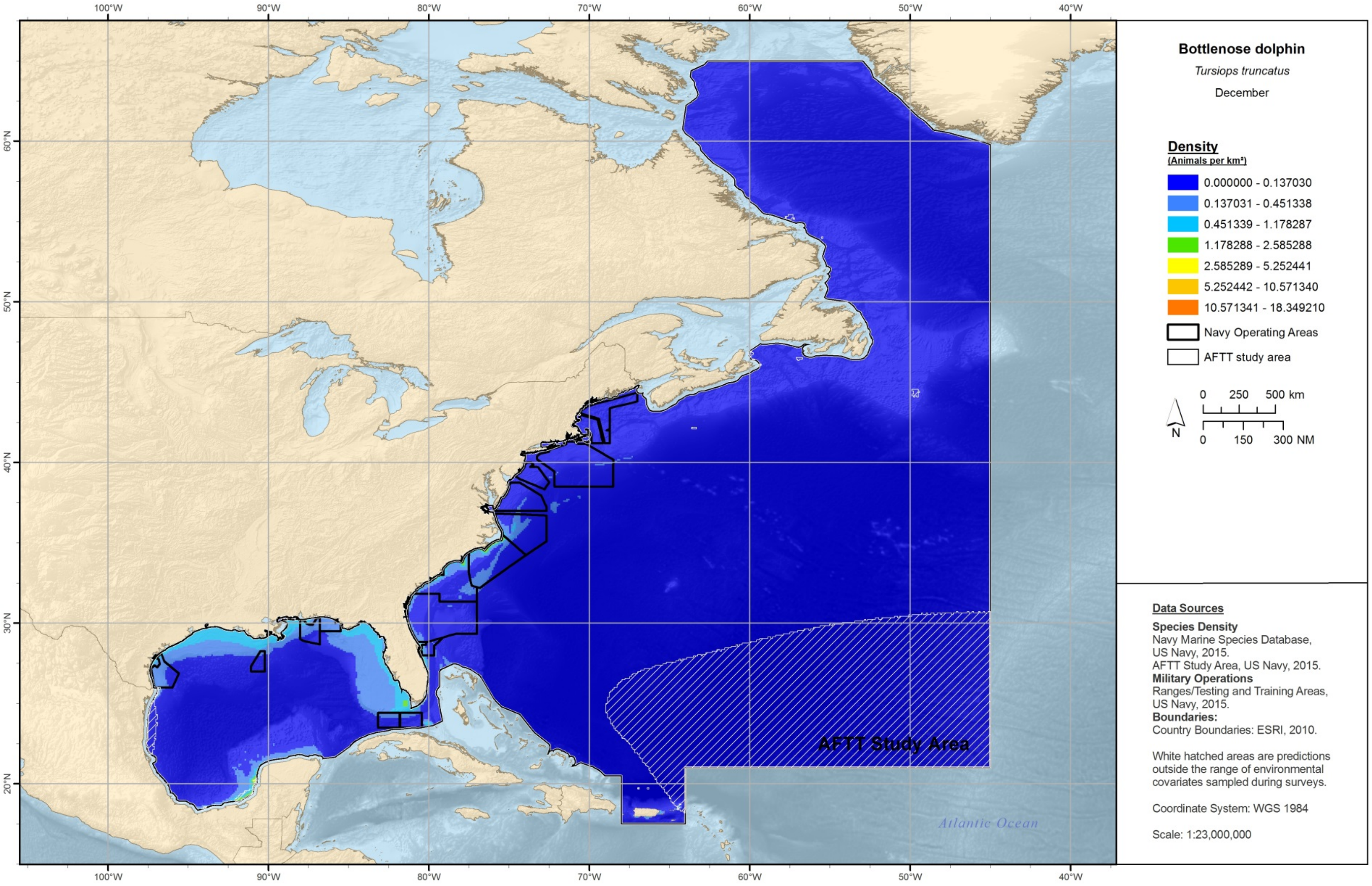


Figure 4-78. November density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-79. December density prediction for bottlenose dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

Clymene dolphin (*Stenella clymene*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. An extremely low number of sightings in the East Coast stratum (N=11) meant that a separate East Coast stratum model could not be fit and the AFTT model was used in the East Coast stratum. No seasons were defined for this species given the low number of sightings and lack of described seasonal movement patterns for this species. Density spatial models were developed for both the AFTT and Gulf of Mexico strata though both used a small number of explanatory variables. The temporal resolution of the density predictions was annual for both the AFTT and Gulf of Mexico strata.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1994-2009 were used with 78 total sightings. This species is limited almost exclusively to regions off the shelf and as such the model was limited to areas deeper than the 100m isobaths. A parsimonious model was fit given the relatively low number of sightings but it did include one dynamic covariate (distance to eddy). The contemporaneous model explained more deviation than the contemporaneous model and was selected for the Gulf of Mexico stratum.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as 11 sightings from the East Coast. No sightings from other regions were available. The best fitting model included only SST as a predictor. Given the small number of sightings an extremely parsimonious model needed to be fit. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the reported distribution of Clymene dolphins throughout tropical and warm temperate waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico (Fertl et al. 2003).

Other Density Estimates:

The most recent NOAA SAR estimate predicts 6,086 individuals (CV=0.93) in the East Coast stratum. (Waring et al. 2013). However, this estimate is based on data from a 1998 shipboard survey and is considered by the NMFS to be deprecated. A literature derived value was used in the summer in the southeast portion of the East Coast and seasonal Kaschner RES data were used in TAP Phase II and predicted a summer estimate of 8,302 individuals in the East Coast stratum. The portion of the AFTT model that falls within the East Coast stratum predicts 18,316 individuals in that region. Because of the small number of sightings in the East Coast stratum, a stratified model could not be fit and the AFTT model should be considered speculative. However, the Mannocci et al. (2016) model is more closely tied to regional data than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Given its simplicity and the few historical sightings in the East Coast stratum, the AFTT model may be over-predicting the number of individuals in the region but appears to perform better than the RES data and is higher in the NMSDD hierarchy.

An abundance estimate of 11,000 individuals (CV=0.16) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The NOAA SAR estimates in recent years has varied between 17,355 and 129, with 129 individuals being the most recent, based on a 2009 shipboard survey of oceanic waters (Waring et al. 2013). In TAP Phase II, a value was used based on the NOAA SAR. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) falls between various SAR estimates though is very different from the most recent estimate. This may be because clymene dolphins in the Gulf of Mexico are usually sighted in large groups and few groups were detected in the most recent NOAA survey on which the most recent SAR is based. Despite this, the Roberts et al. (2016) estimate was chosen over the SAR as it is a spatial density model versus a single density estimate and as such is higher in the NMSDD hierarchy in addition to more closely tracking past SAR predicted abundances.

An abundance estimate of 203,211 individuals (CV=0.17) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

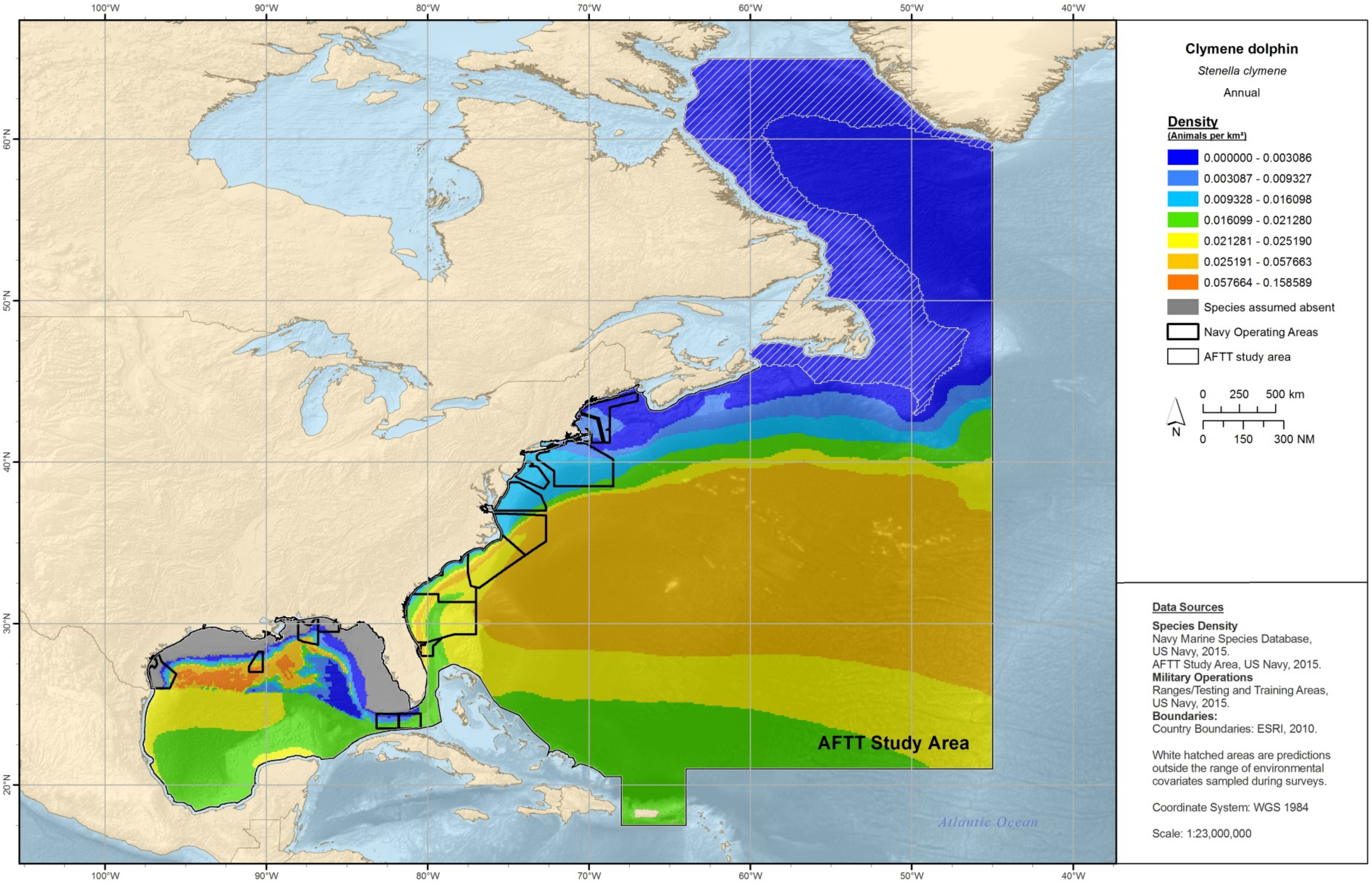


Figure 4-80. Annual density prediction for clymene dolphins for the Gulf of Mexico and AFTT strata.

False killer whale (*Pseudorca crassidens*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from stratified density estimates developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A stratified density estimate was produced for the Gulf of Mexico stratum given the lack of sightings. An extrapolative density spatial model was fit for the AFTT stratum. Very few (N=2) sightings were available in the East Coast stratum and the researchers felt the AFTT model was more representative of this species in that stratum than a designed-based density estimate. No seasons were defined for this species given a paucity of sightings and a lack of clearly defined seasonality. This estimate was limited to offshore areas given the lack of sightings on the shelf and the generally pelagic nature of this species (Baird 2002). The temporal resolution of the density predictions was annual for both models.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 19 total sightings. This species is limited almost exclusively to regions off the shelf and as such the model was limited to areas deeper than the 100m isobaths. A spatial model was not practicable given the number of sightings and a stratified density estimate was produced.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as two sightings from the East Coast and three from the Caribbean. The best fitting model included only SST as a predictor. A single environmental covariate was used given the lack of sightings data. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the described range of false killer whales in tropical and warm temperate waters, with preferences for the deeper waters (Baird 2002).

Other Density Estimates

The Mannocci et al. (2016) AFTT model predicts 1,479 individuals in the East Coast stratum. The most recent estimate from a NOAA SAR estimate is 442 individuals (CV=1.06 [Waring et al. 2013]). This estimate is based on 2011 aerial surveys that were conducted from the lower Bay of Fundy to central Florida. Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. It is possible that the Mannocci et al. (2016) model overestimates abundance in the East Coast but meaningful comparison is difficult given factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used.

An abundance estimate of 3,204 individuals (CV=0.36) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 777 (CV=0.56) individuals being the most recent, based on a 2003/2004 shipboard survey of oceanic waters (Mullin 2007). In TAP Phase II, a NODE SAR derived estimate was used with an estimate of 995 individuals (summer value, CV not available). Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) is much higher than

SAR and NODE estimates used in Phase II. The most likely reasons for the discrepancy between the Roberts et al. (2016) value and the SAR is that the SAR estimate assumed g(0)=1 whereas in the model used g(0) was assumed to be 0.856, which is likely a more accurate representation of availability for this species, and because of differences in the detection function used by Roberts et al (2016). The Roberts et al. (2016) and SAR estimates are the same level in the NMSDD hierarchy, but the Roberts et al. (2016) estimate was chosen over the SAR because it incorporated an estimate of g(0).

An abundance estimate of 19,855 individuals (CV=0.33) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

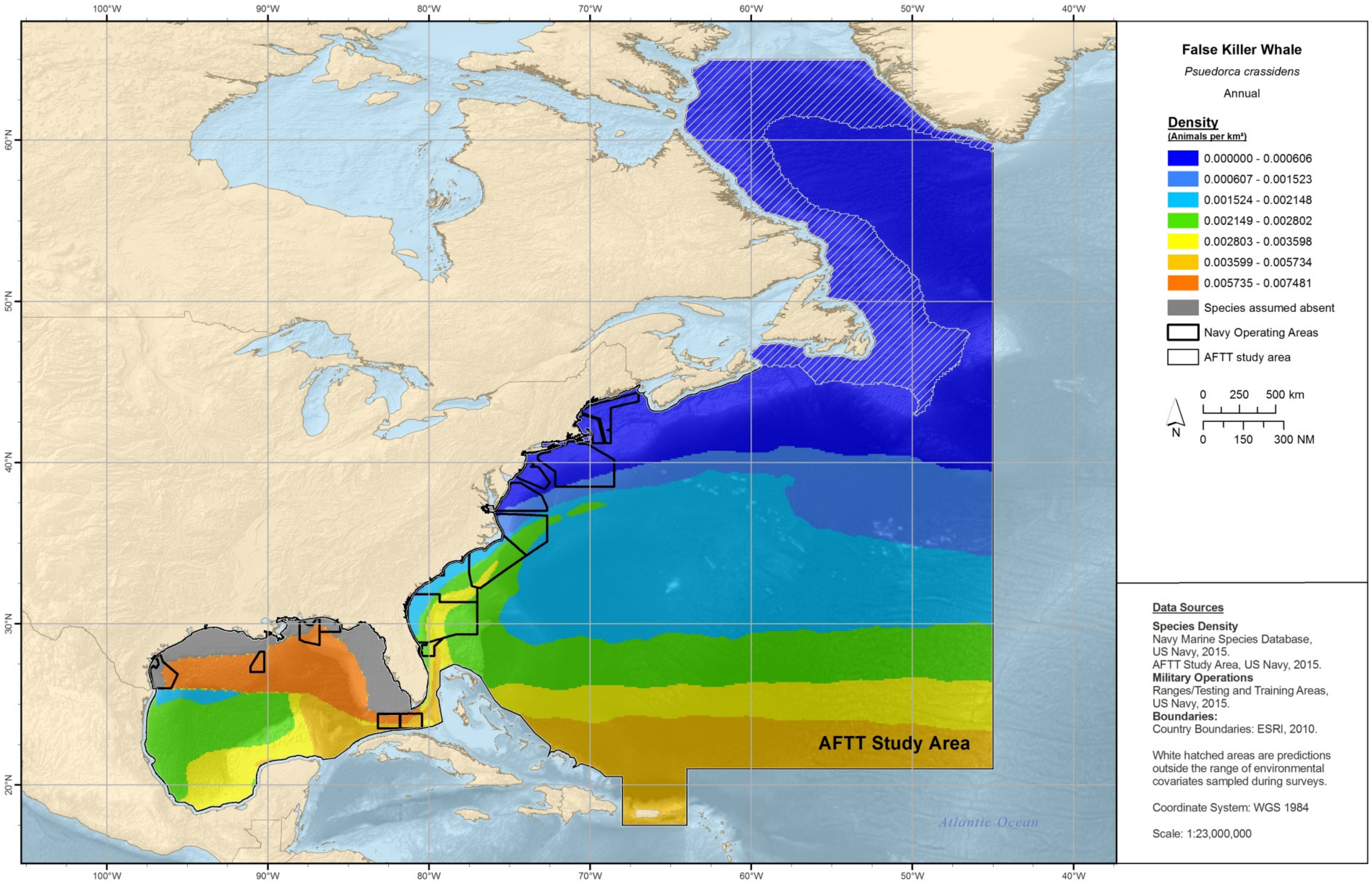


Figure 4-81. Annual density prediction for false killer whales for the Gulf of Mexico and AFTT strata.

Fraser's dolphin (*Lagenodelphis hosei*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from stratified density models developed by Roberts et al. (2016) and Mannocci et al. (2016). Separate models were fit for the Gulf of Mexico, East Coast, and AFTT strata. Very few sightings were available anywhere for this species. No seasons were defined for this species given a paucity of sightings and a lack of clearly defined seasonality. Estimates were limited to offshore areas given the lack of sightings on the shelf and the high seas distribution of this animal (Jefferson and Schiro1997). The temporal resolution of the density predictions was annual for all models.

Survey Data and Selected Models:

In the East Coast stratum, a total of two sightings from the combined survey data were used for model development. This species is limited almost exclusively to warm waters off the shelf and as such the model was limited to areas off the shelf break and south of the northern limit of the Gulf Stream. A spatial model was not practicable given the number of sightings and, therefore, a stratified density estimate was produced.

In the Gulf of Mexico stratum, a total of five sightings from the combined survey data were used for model development. This species is limited almost exclusively to warm waters off the shelf and as such the model was limited to areas off the shelf break. A spatial model was not practicable given the number of sightings and, therefore, a stratified density estimate was produced.

The model for the AFTT stratum used the Gulf of Mexico and East Coast strata sightings, as well as four from the Caribbean. A stratified density model was produced.

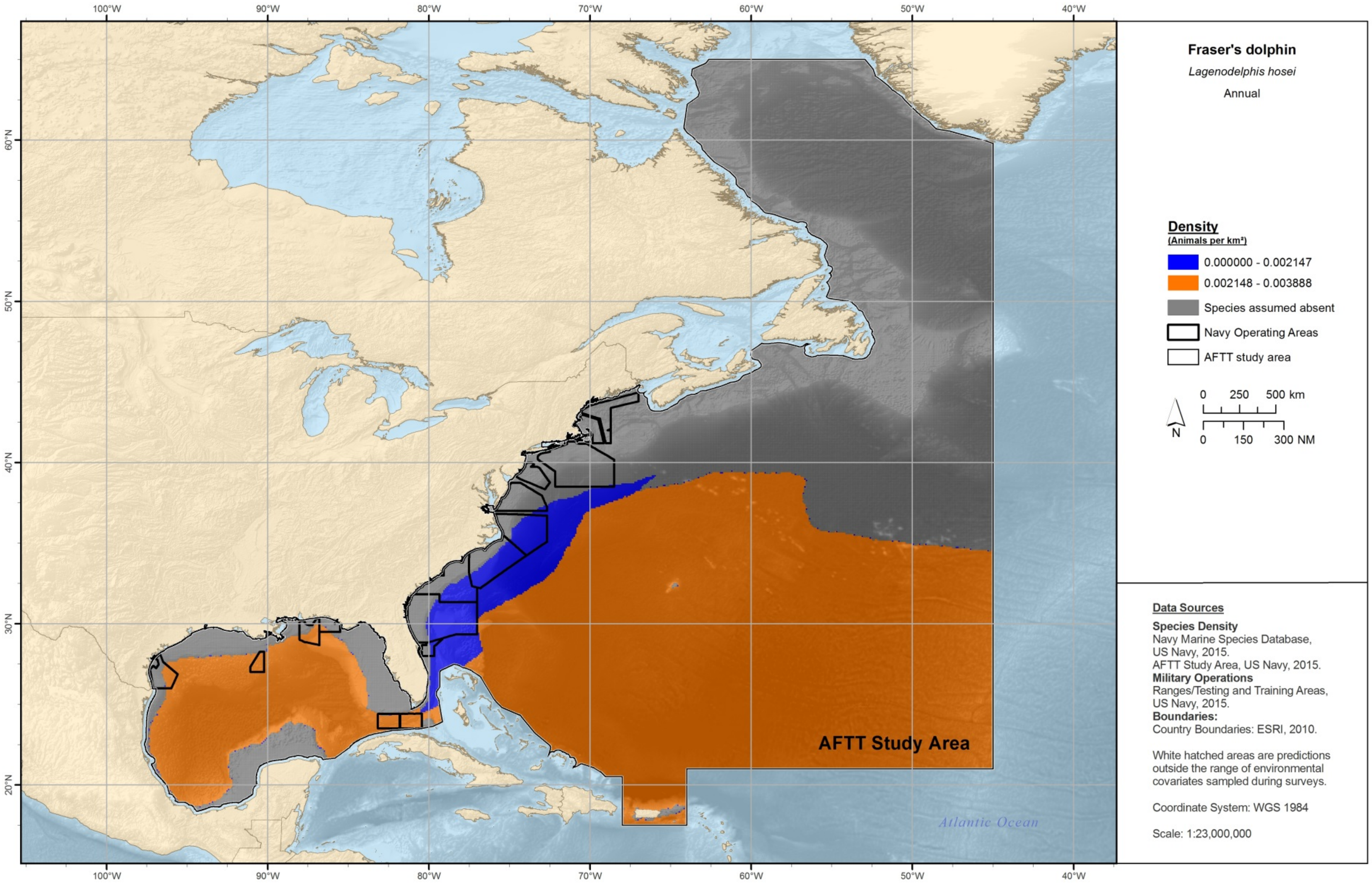
Other Density Estimates:

The Roberts et al. (2016) AFTT model predicts 492 individuals (CV=0.76) in the East Coast stratum. There is no NOAA SAR estimate for this species in the East Coast stratum. Kaschner RES data were used in TAP Phase II, predicting 690 individuals in the East Coast stratum. Meaningful comparison is difficult given the absence of a CV for the Kaschner RES data and other factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The Roberts et al. (2016) estimate was chosen over the Kaschner model as it is higher in the NMSDD hierarchy.

An abundance estimate of 1,665 individuals (CV 0.73) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 726 individuals (CV=0.70) based on a shipboard survey of oceanic waters through the early 2000s (Mullin and Fulling 2004). In TAP Phase II, a NODE SAR derived estimate was used with an estimate of 747 individuals (summer value, CV not available). Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) is higher than SAR and NODE estimates used in Phase II. The most likely reasons for the discrepancy between the Roberts et al. value and the SAR is because of differences in the detection function used by Roberts et al (2016). The

Roberts et al. (2016) and SAR estimates are the same level in the NMSDD hierarchy but the Roberts et al. (2016) estimate was chosen over the SAR because it incorporated an estimate of g(0) and the SAR did not.

An abundance estimate of 21,821 individuals (CV=0.49) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-82. Annual density prediction for Fraser's dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

Killer whale (*Orcinus Orca*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from density spatial models designed by Roberts et al. (2016) and stratified density models developed Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. A stratified density model was fit for the AFTT stratum. Very few (N=4) sightings were available in the East Coast stratum and the researchers felt the AFTT stratified model was more representative of this species in that stratum than an East Coast specific model. No seasons were defined for this species given a paucity of sightings and a lack of clearly defined seasonality. The temporal resolution of the density predictions was annual for both models

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 16 total sightings. A spatial model with a single explanatory variable (depth) was fit given the limited number of sighting and lack of sightings on the shelf break. The relationship with depth was linear and should be treated cautiously. As no dynamic variables were used, the decision between contemporaneous and dynamic variables was not a factor.

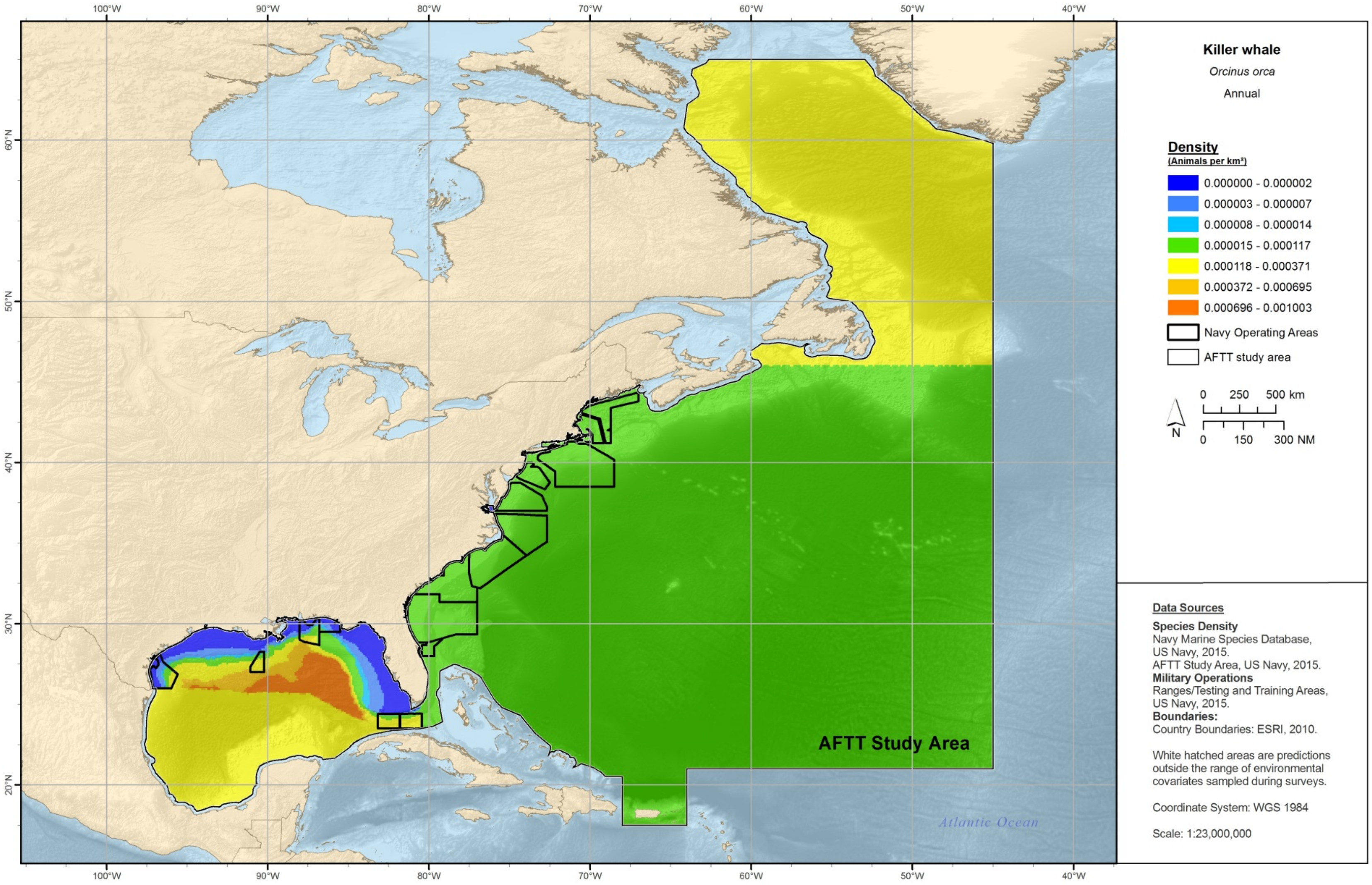
The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as four sightings from the East Coast, one from Europe and one from the mid-Atlantic ridge. The modeling team felt the small number of sightings were not enough to fit a spatial model for such a broadly distributed species (Forney and Wade 2007). Several strata were defined based on the assumed higher concentration of killer whales north of Nova Scotia and in the Gulf of Mexico (Lawson and Stevens 2014).

Other Density Estimates:

The Mannocci et al. (2016) AFTT model predicts 20 individuals in the East Coast stratum. There is no NOAA SAR estimate for killer whales in the East Coast stratum given the low number of sightings. SMRU RES data was used for all seasons in TAP Phase II with a predicted abundance of 7,459 individuals (summer estimate, CV not available). Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The Mannocci et al. (2016) is higher in the NMSDD hierarchy than the RES data and as such was selected for this stratum.

An abundance estimate of 185 individuals (CV=0.41) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 28 individuals (CV=1.02), based on a 2009 shipboard survey of oceanic waters (Waring et al. 2013). In TAP Phase II, a SMRU RES derived estimate was used with an estimate of 4,095 individuals (summer value, CV not available). Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) is higher than SAR estimates but an order of magnitude lower than the RES data estimate used in Phase II. The most likely reason for the discrepancy between the Roberts et al. (2016) value and the SAR is that the SAR estimate was based on a single year of survey data and the Roberts et al. model used many years of survey data. Older SAR estimates show population estimates much closer to the Roberts et al. (2016) estimate. The Roberts et al. (2016) is higher in the NMSDD hierarchy than the SAR or RES models and as such was selected for use.

An abundance estimate of 849 individuals (CV=0.52) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-83. Annual density prediction for killer whales for the Gulf of Mexico and AFTT strata.

Melon-headed whale (*Peponocephala electra*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. An extremely low number of sightings in the East Coast stratum (N=4) meant that a separate East Coast stratum model could not be fit and the AFTT model was used in the East Coast stratum. No seasons were defined for this species given the low number of sightings and lack of described seasonal movement patterns for this species. Density spatial models were developed for both the AFTT and Gulf of Mexico strata though both used a small number of explanatory variables (one for the AFTT models and two for the Gulf of Mexico model). The temporal resolution of the density predictions was annual for both the AFTT and Gulf of Mexico strata.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1994-2009 were used with 29 total sightings. The sightings were limited to the shelf break so the model prediction was limited to areas beyond the 100m isobath. A contemporaneous model explained more deviance than the climatological models and was selected for the Gulf of Mexico stratum.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as one sighting from the Caribbean and four from the East Coast. The best fitting model included only SST as a predictor. Given the small number of sightings an extremely parsimonious model needed to be fit. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions were consistent with the expected extent of the species, largely off the shelf break (Perryman 2009).

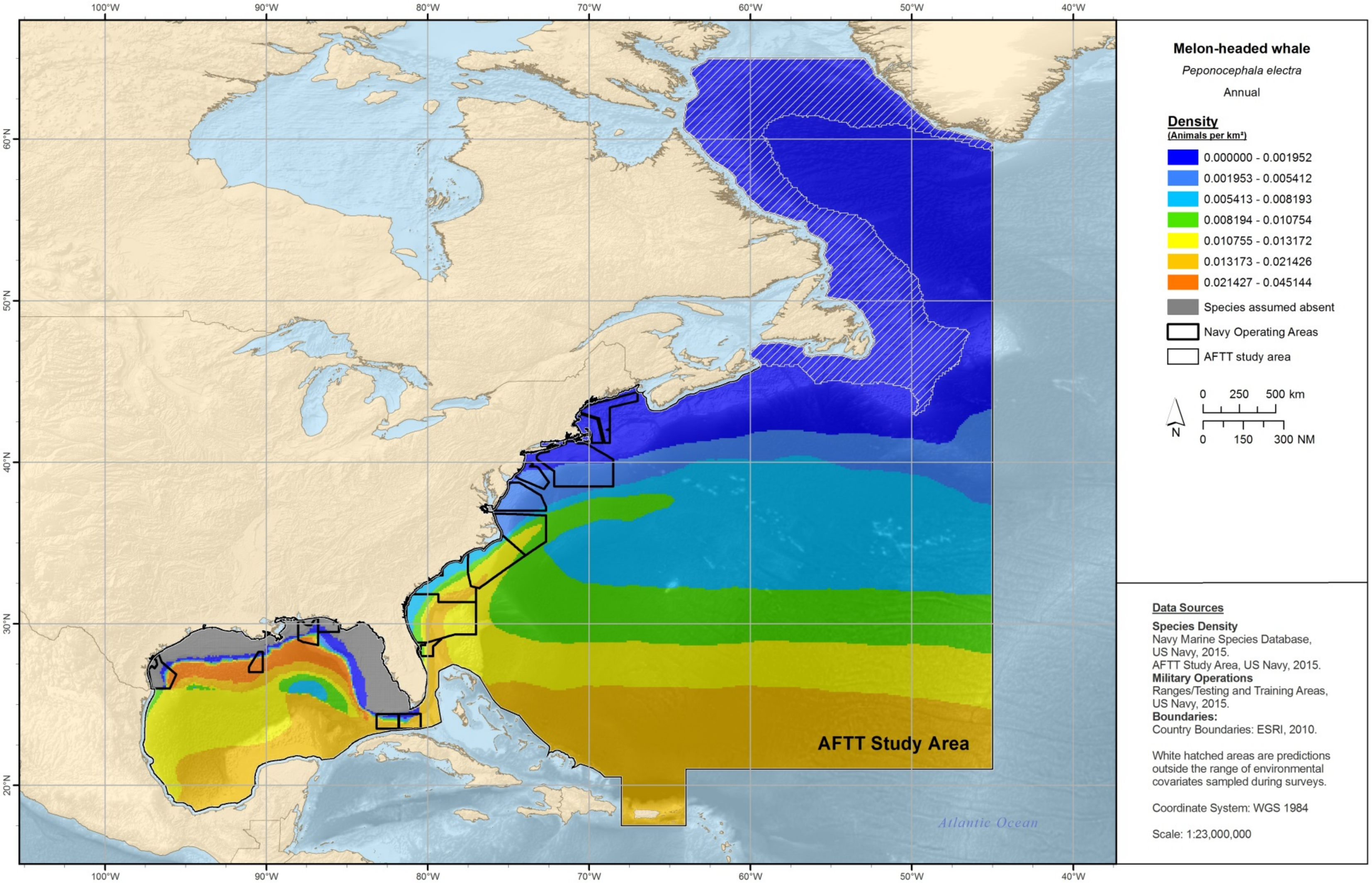
Other Density Estimates

The most recent SAR is from 2007 and did not contain enough sightings to estimate population abundance. Annual SMRU RES data were used in TAP Phase II and predicted 10,172 individuals (CV not available) individuals in the East Coast stratum. The portion of the AFTT model that falls within the East Coast stratum predicts 6,881 individuals in that region (region specific CV not available). Because of the lack of sightings in the East Coast stratum, a stratified model could not be fit and the AFTT model should be considered speculative. However, the Mannocci et al. (2016) model is more closely tied to regional data than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Given its simplicity and the few historical sightings in the East Coast stratum, the AFTT model may be over-predicting the number of animals in the region but appears to perform better than the RES data and is higher in the NMSDD hierarchy.

An abundance estimate of 6,733 individuals (CV 0.30) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate NOAA SAR estimate is 2,235 individuals

(CV=0.75) based on 2009 shipboard survey performed in oceanic waters (Waring et al. 2013). In TAP Phase II, SMRU RES data was used for all seasons and predicted 8,773 individuals in the summer. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the difference between the Roberts et al. (2016) estimate and the SAR can largely be attributed to distances in the detection function used in each estimate. See model documentation for details. The Roberts et al. (2016) estimate was chosen over the SAR as it is density spatial model versus a single density estimate and as such is higher in the NMSDD hierarchy.

An abundance estimate of 87,334 individuals (CV=0.23) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-84. Annual density prediction for melon-headed whales for the Gulf of Mexico and AFTT strata.

Pantropical spotted dolphin (*Stenella attenuata*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by d Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. Very few (N=17) sightings were available in the East Coast stratum and the researchers felt the AFTT model was more representative of this species in that stratum than a stratified density estimate. No seasons were defined for this species given a paucity of sightings and a lack of clearly defined seasonality. The Gulf of Mexico density spatial model was limited to offshore areas given the lack of sightings on the shelf and the generally pelagic nature of this species (Jefferson and Schiro 1997). The temporal resolution of the density predictions was annual for both models.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 719 total sightings. This species is limited almost exclusively to regions off the shelf and as such the model was limited to areas deeper than the 100m isobaths. The climatological model was chosen over the contemporaneous even though it explained slightly less deviance because the contemporaneous model resulted in unacceptable levels of data loss (productivity predictors not available for older data). Both models predicted roughly the same abundance.

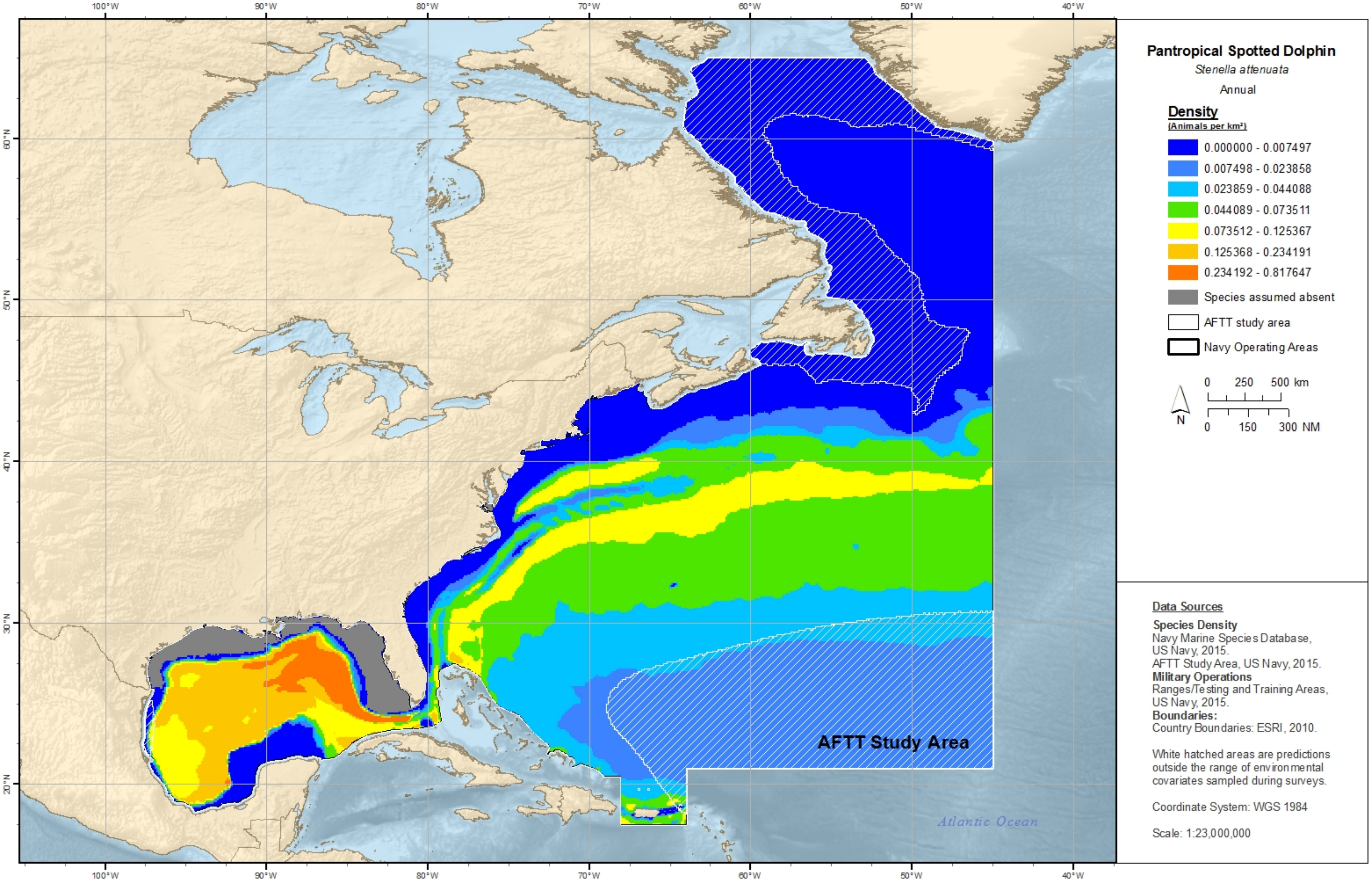
The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as 17 sightings from the East Coast and 19 from the Caribbean. The best fitted model included SST, depth, distance to fronts and epipelagic micronekton productivity as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the described range of pantropical spotted dolphins in tropical and subtropical waters (Perrin 2009).

Other Density Estimates:

The Mannocci et al. (2016) AFTT model predicts 37,087 individuals in the East Coast stratum (CV for East Coast stratum alone not available).The 2007 NOAA SAR estimate is 4,439 individuals (CV=0.49) based on summer 2004 shipboard surveys from the lower Bay of Fundy to central Florida. It is possible that the Mannocci et al. (2016) model overestimates abundance in the East Coast but meaningful comparison is difficult given factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The SAR used only summer sightings and abundance may be different in other seasons given differing environmental conditions. The Mannocci et al. (2016) model is an annual prediction.

An abundance estimate of 84,014 individuals (CV= 0.06) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR in the Gulf of Mexico is 50,880 individuals (CV=0.27) individuals, based on a 2009 shipboard survey of oceanic waters (Waring et al. 2013). In TAP Phase II, a NODE estimate of 98,932 individuals (summer value, CV not available) was used. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) model is somewhat higher than the SAR estimate and a little lower than the NODE estimate used in Phase II. The most likely reasons for the discrepancy between the Roberts et al. (2016) value and the SAR is because of differences in the detection function used by Roberts et al. (2016). The Roberts et al. (2016) and NODES estimate are the same level in the NMSDD hierarchy, but the Roberts et al. (2016) estimate was chosen because it incorporated more data and updated techniques. The Roberts et al. (2016) model is higher in the NMSDD hierarchy than the SAR estimate and was, therefore, selected over it.

An abundance estimate of 411,078 individuals (CV=0.11) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-85. Annual density prediction for pantropical spotted dolphins for the Gulf of Mexico and AFTT strata.

Pilot whales (Globicephala)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016).While the ranges of these species have some differentiation (Waring et al. 2014), they have significant overlap in the AFTT Study Area. Most sightings available for these species were ambiguous. As such, they were modeled as a guild. Density spatial models were fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. . No seasons were defined for this species given the lack of described seasonal movement patterns for this species. The temporal resolution of the density predictions was annual for all models.

Survey Data and Selected Models:

In the East Coast stratum, a total of 909 sightings from the combined survey data were used for model development. Two separate models were fit in the East Coast stratum, one on the shelf break, which were all in the northern extent of the stratum, and an offshore model. Based on confirmed sightings and an initial classification model, it appears that all animals on the shelf are long-finned pilot whales (Waring et al. 2014). The off the shelf sightings are expected to be mixed between the two species. The climatological model explained more variance than the contemporaneous model and was selected for the East Coast stratum.

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 50 total sightings. This species is limited to regions off the shelf and as such the model was limited to areas deeper than the 100m isobath. It is expected that all sightings in the Gulf of Mexico stratum are short-finned pilot whales given the more northerly distribution of long-finned pilot whales (Olson 2008). The climatological model explained more deviation than the contemporaneous model and was selected for the Gulf of Mexico stratum.

The model for the AFTT stratum used the East Coast and Gulf of Mexico strata sightings, as well as 57 sightings from Europe, 15 sightings from the mid-Atlantic ridge, and 28 sightings from the Caribbean. The best fitting model included depth, epipelagic micronekton primary productivity, primary productivity, and sea surface height anomaly as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the described range of pilot whales and sightings of this species.

Other Density Estimates:

An abundance estimate of 18,977 individuals (CV=0.11) was derived for the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 27,151 individuals (CV=0.31) based on summer 2011 NEFSC and SEFSC aerial surveys (Waring et al. 2014). This estimate comes from the combined estimate for both long-finned and short-finned species. Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In TAP Phase II, a combined NODE and SMRU estimate of 125,939 individuals (summer value, CV not available) was used. Combined species NODE data was used in the southeast Atlantic in the summer with RES data for separate species used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the

East Coast stratum population estimate is statistically similar to the estimate of the recent SAR population estimate. The Roberts et al. (2016) estimate is preferable to the stratified SAR estimate and the TAP Phase II combined estimate which contains RES data as it is higher in the NMSDD data hierarchy.

An abundance estimate of 1,981 individuals (CV=0.18) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). In the Gulf of Mexico stratum, the most recent NOAA SAR estimate is 2,415 individuals (CV=0.66) based on a summer 2009 outer-continental shelf survey (Waring et al. 2013. In TAP Phase II, a SMRU estimate of 25,552 individuals (summer value, CV not available) was used. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population estimate is statistically similar to the estimate of the recent SAR population estimate. The Roberts et al. (2016) estimate was chosen over the SMRU data as it represents significant advances in methodology and is better linked to regional data. The Roberts et al. (2016) estimate is preferable to the SAR estimate as it is higher in the NMSDD data hierarchy.

An abundance estimate of 477,659 individuals (CV=0.16) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

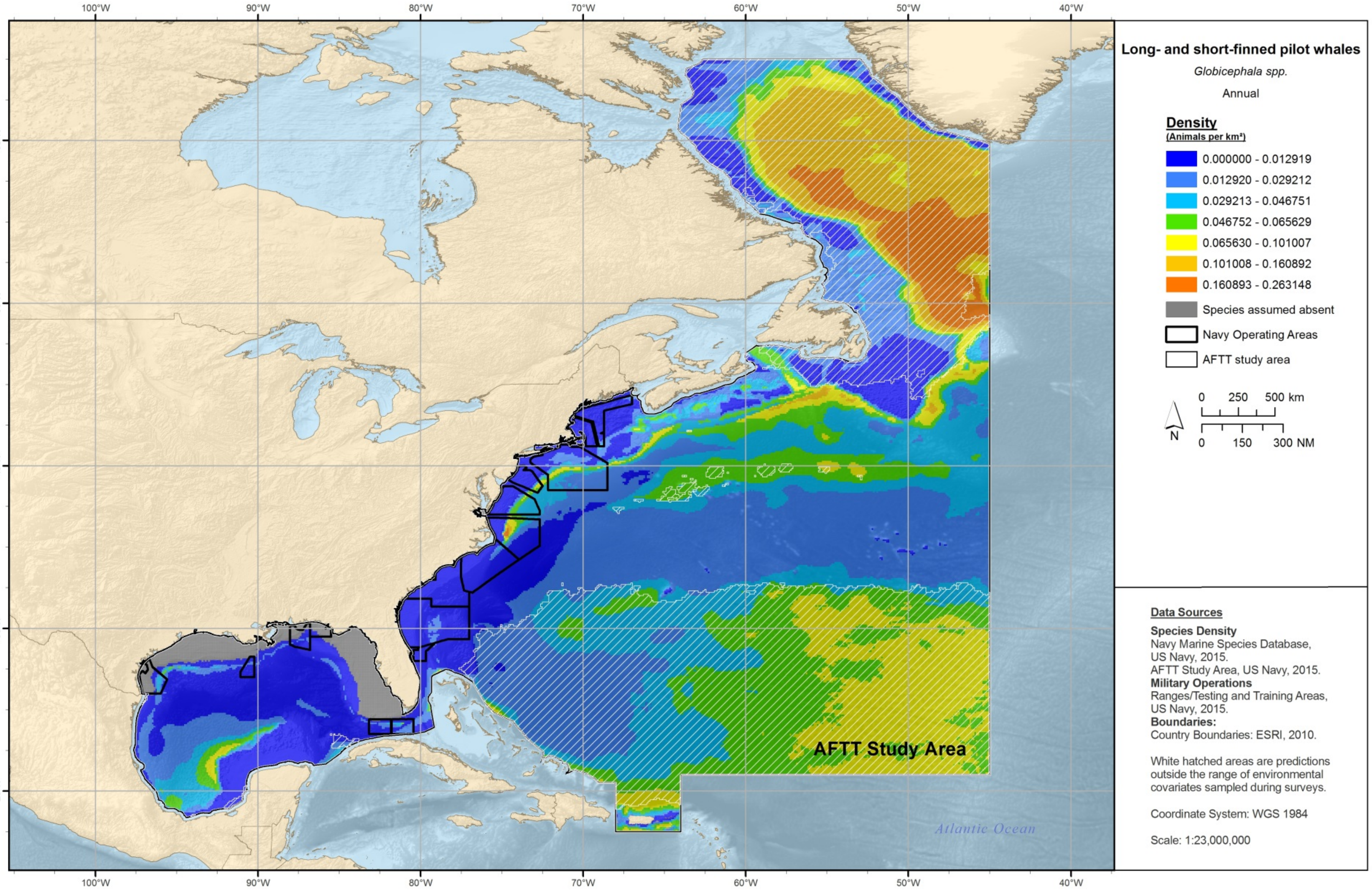


Figure 4-86. Annual density prediction for pilot whales for the East Coast, Gulf of Mexico and AFTT strata.

Pygmy killer whale (*Feresa attenuata*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial density models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. An extremely low number of sightings in the East Coast stratum (N=4) meant that a separate East Coast stratum model could not be fit and the AFTT model was used in the East Coast stratum. No seasons were defined for this species given the low number of sightings and lack of described seasonal movement patterns for this species. Density spatial models were developed for both the AFTT and Gulf of Mexico strata though both used a small number of explanatory variables because of a low number of sightings (one for each model). The temporal resolution of the density predictions was annual for both the AFTT and Gulf of Mexico strata.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 27 total sightings. The sightings were limited to the shelf break so the model prediction was limited to areas beyond the 100m isobath. Depth was the only covariate selected by the model.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as four sightings from the Caribbean and four from the East Coast. The best fitting model included only SST as a predictor. Given the small number of sightings an extremely parsimonious model needed to be fit. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions were consistent with the expected extent of the species in tropical and subtropical waters (Donahue and Perryman 2009).

Other Density Estimates:

The most recent SAR in the East Coast is from 2007 and did not contain enough sightings to estimate population abundance. Annual SMRU RES data were used in TAP Phase II and predicted 808 individuals (CV not available) in the East Coast stratum. The portion of the AFTT model that falls within the East Coast stratum predicts 1,246 individuals in in that region (region specific CV not available). Because of the lack of sightings in the East Coast stratum, the researchers felt that the AFTT model better represented there. The AFTT model should be considered speculative. However, the Mannocci et al. (2016) model is more closely tied to regional data than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Given its simplicity and the few historical sightings in the East Coast stratum, the AFTT model may be over-predicting the number of animals in the region but is higher in the NMSDD hierarchy than RES data.

An abundance estimate of 2,126 individuals (CV=0.30) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The more recent estimate from a NOAA SAR is 152 individuals (CV 1.023) based on 2009 shipboard survey performed in oceanic waters (Waring et al. 2013). In TAP Phase II, SMRU RES data was used for all seasons and predicted less than 1 animal in the summer. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the large difference between the Roberts et al.(2016) estimate and the SAR can largely be attributed to three factors distances in the detection function used in each estimate, Roberts et al. (2016) used 9 additional sightings than the SAR (classified from ambiguous sightings), and the SAR assumed g(0)=1 whereas Roberts et al. did not. Combined, these factors can account for the difference in estimates. See species specific model documentation from Roberts et al. (2016) for details. The Roberts et al. (2016) estimate was chosen over the SAR as it is a density spatial model versus a stratified estimate and as such is higher in the NMSDD hierarchy.

An abundance estimate of 15,268 individuals (CV=0.23) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

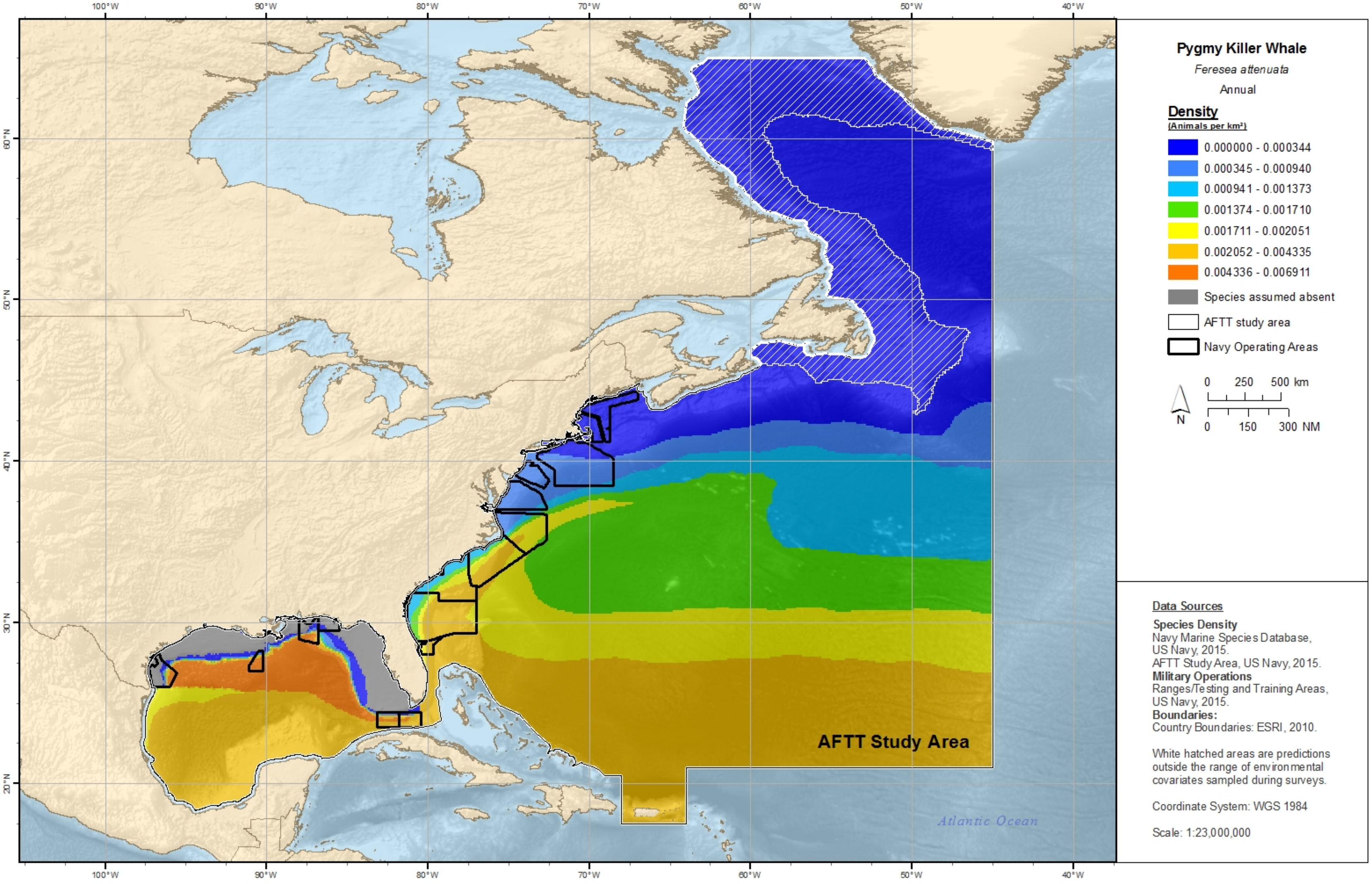


Figure 4-87. Annual density prediction for pygmy killer whales for the Gulf of Mexico and AFTT strata.

Risso's dolphin (*Grampus griseus*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. No seasons were defined for this species given the lack of described seasonal movement patterns for this species. Density spatial models were developed for both the East Coast and Gulf of Mexico and an extrapolative density spatial model was fit for the AFTT. The temporal resolution of the density predictions was monthly for the East Coast stratum and annual for the Gulf of Mexico and AFTT strata models.

Survey Data and Selected Models:

In the East Coast stratum, a total of 721 sightings from the combined survey data were used for model development. Two separate models were fit for the East Coast stratum, one on the shelf break and an offshore model, based on the assumption that different ecological processes may be driving the distribution of these animals in those regions. The climatological model explained more deviation than the contemporaneous model and was selected for both the East Coast stratum models.

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 282 total sightings. This species is limited to regions off the shelf and as such, the model was limited to areas deeper than the 100m isobath. The climatological model explained more variance than the contemporaneous model and was selected for the Gulf of Mexico stratum.

The model for the AFTT stratum used the East Coast and Gulf of Mexico strata sightings, as well as nine sightings from Europe and two from the Caribbean. The best fitting model included depth, epipelagic micronekton primary productivity, distance to fronts and SEAPODYM zooplankton potential biomass as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the described range of this species (Jefferson et al. 2014).

Other Density Estimates

An abundance estimate of 7,732 individuals (CV=0.09) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent NOAA SAR estimate is 18,250 (CV=0.46) individuals, based on NEFSC and SEFSC 2011 summer aerial surveys from central Florida to the lower Bay of Fundy (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In TAP Phase II, the NODE spatial density model was used with an estimate of 72,674 individuals (summer value, CV not available) with SMRU RES data used in seasons except for summer. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. Though the average abundance Roberts et al. (2016) predicted is lower than the SAR estimate, the Roberts et al. (2016) model varied widely in predicted abundance between months and closely matched the SAR in summer months when the data from the SAR were collected. A density spatial model versus a single density estimate is higher in the NMSDD hierarchy than a stratified estimate; therefore the Roberts et al. (2016) estimate was chosen over the SAR. Furthermore, since Roberts et al. (2016) data is more recent, it was chosen over the NODES estimate.

In the Gulf of Mexico stratum, an abundance estimate of 3,137 individuals (CV=0.10) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The NOAA SAR estimate is 2,442 (CV=0.57) individuals based on a 2009 shipboard survey of oceanic waters (Waring et al. 2013). In TAP Phase II, SMRU RES data were used in summer, fall, and winter with an estimate of 78,591 individuals (summer value, CV not available). A NODE spatial density model was used in spring. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) is statistically similar to the SAR estimate. A spatial density model versus a single density estimate is higher in the NMSDD hierarchy than a single estimate or RES data so the Roberts et al. (2016) estimate was chosen over the SAR and SMRU models.

An abundance estimate of 51,777 individuals (CV=0.09) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

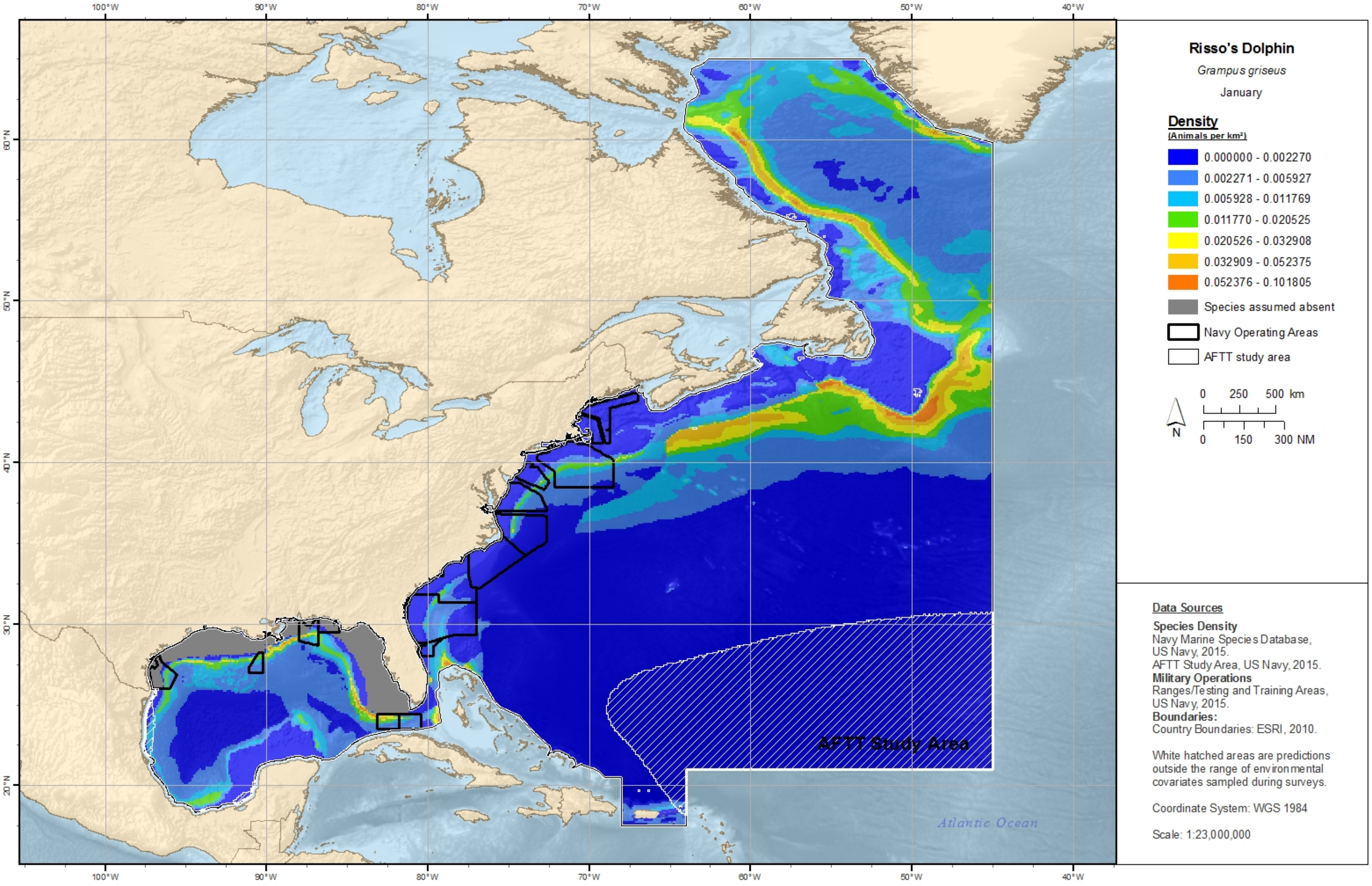


Figure 4-88. January density prediction for Risso's dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

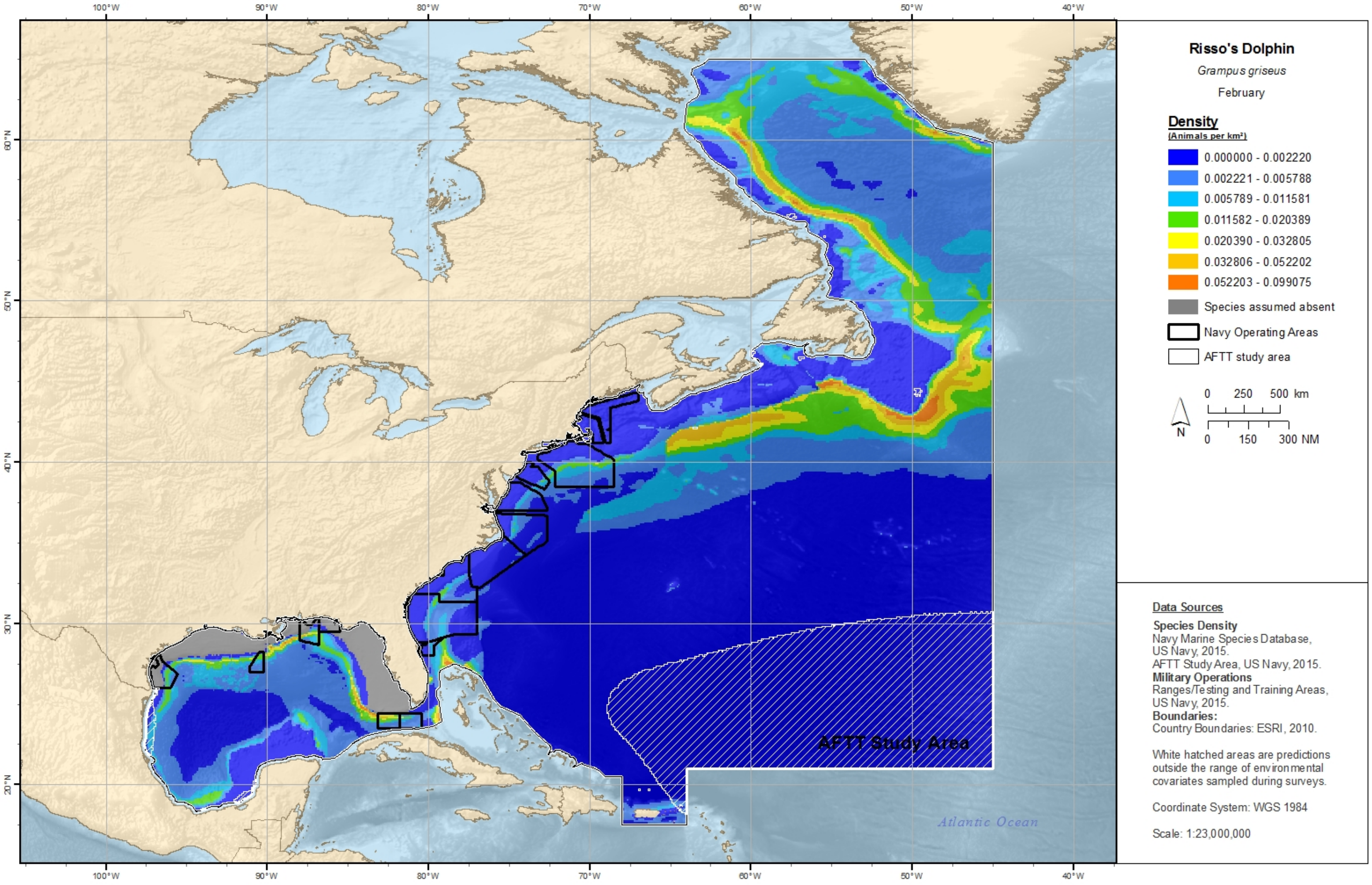


Figure 4-89. February density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

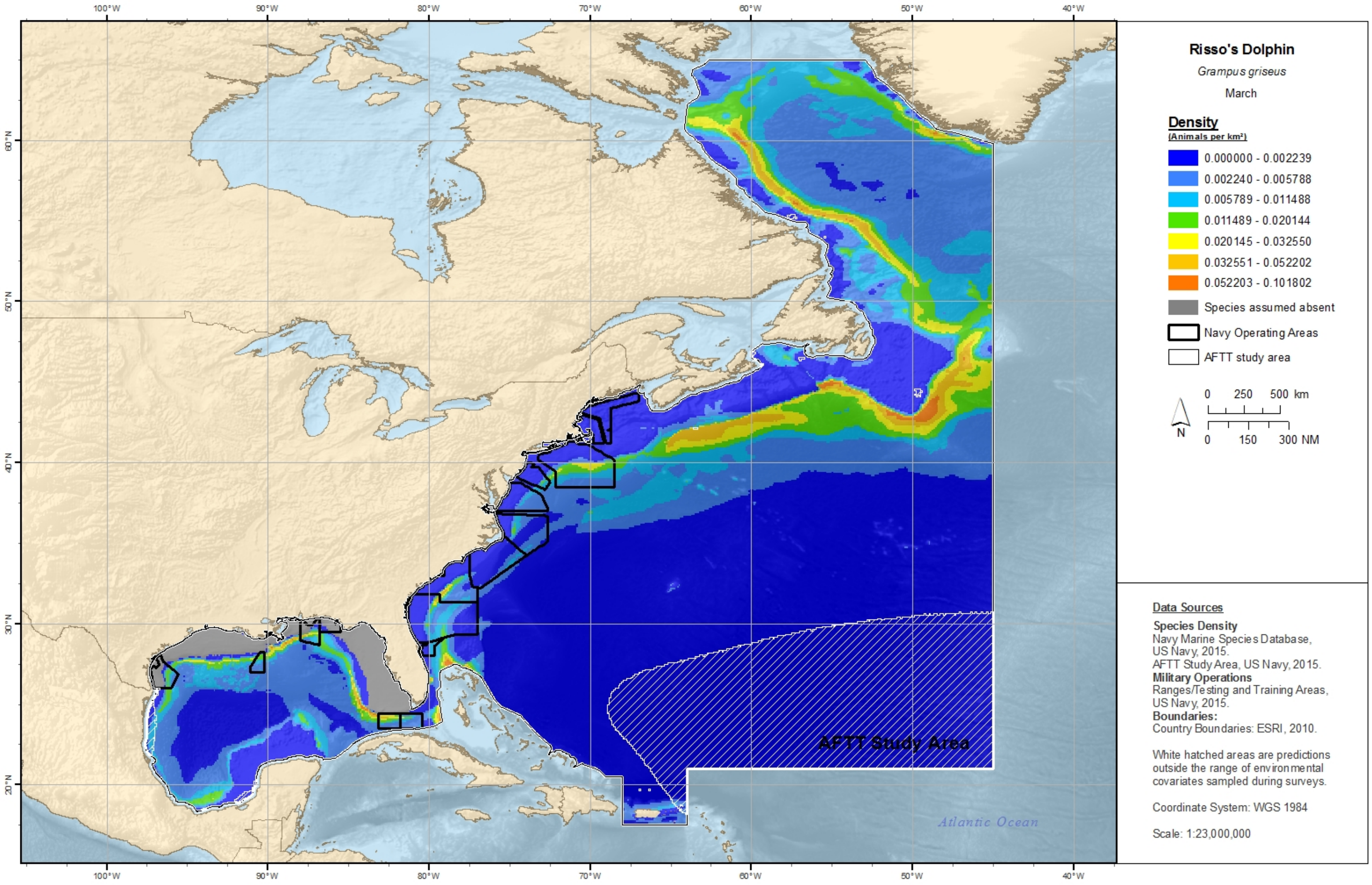


Figure 4-90. March density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

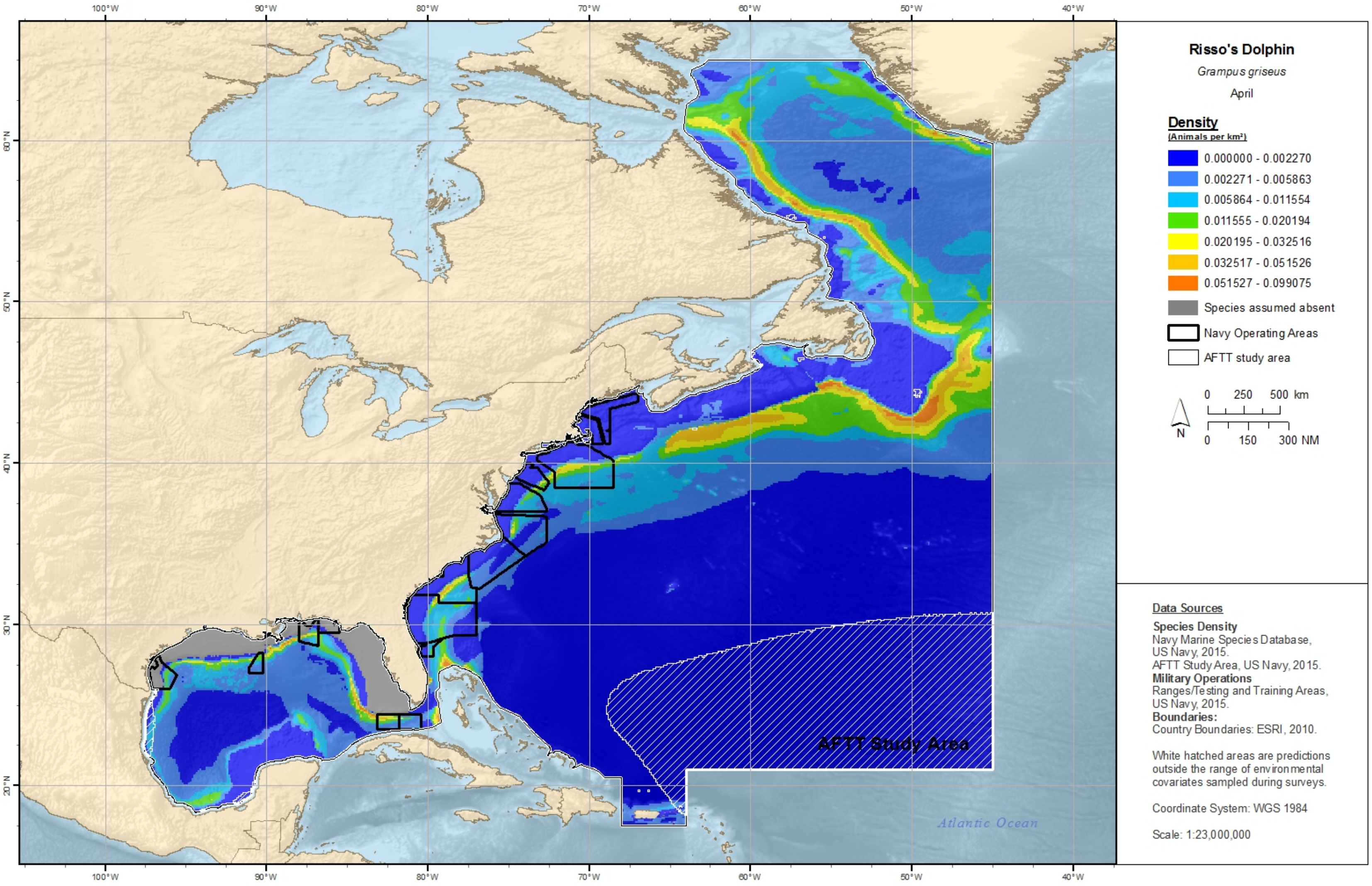


Figure 4-91. April density prediction for Risso's dolphins for the East Coast, Gulf of Mexico, and AFTT strata.

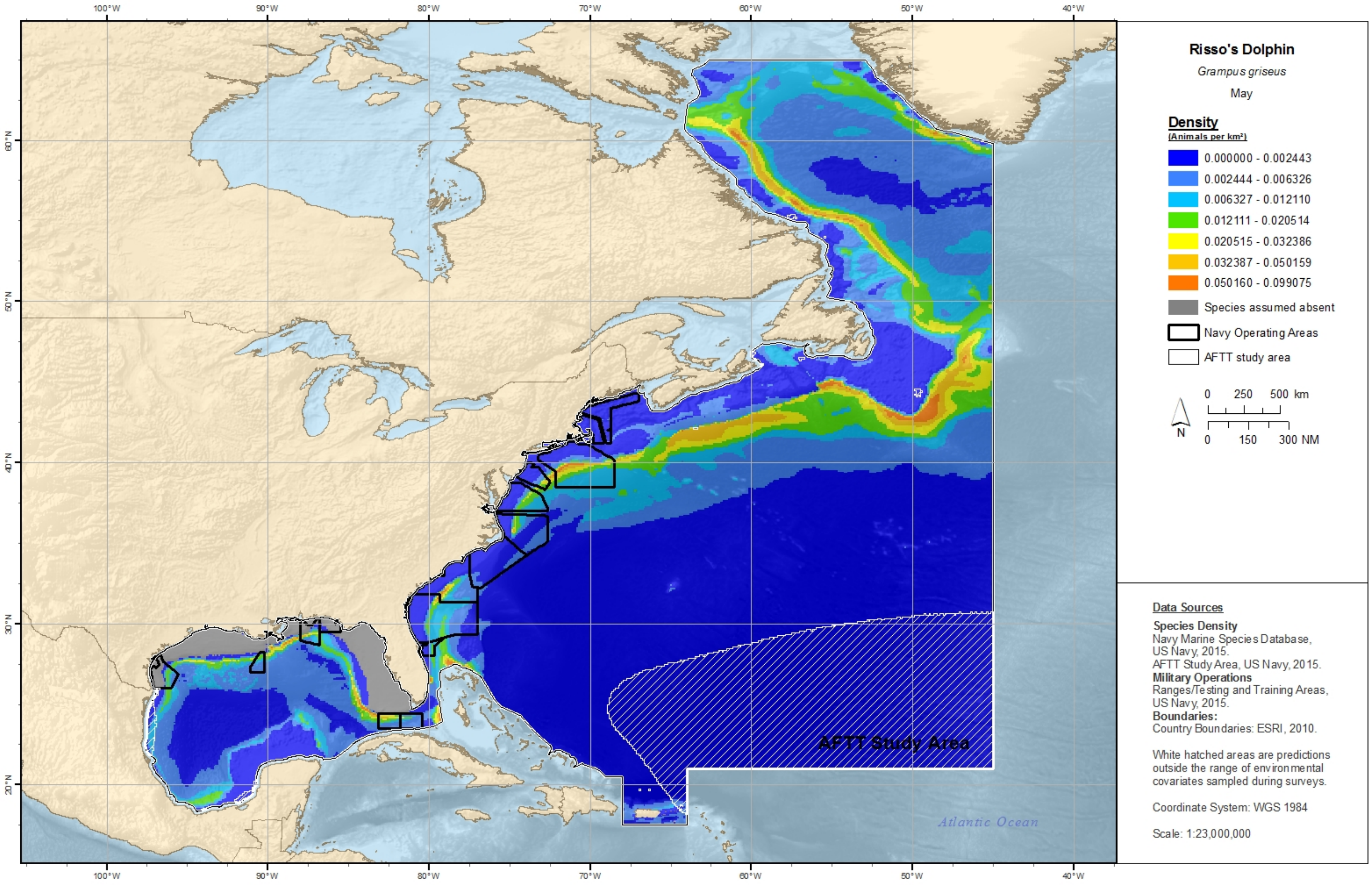


Figure 4-92. May density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

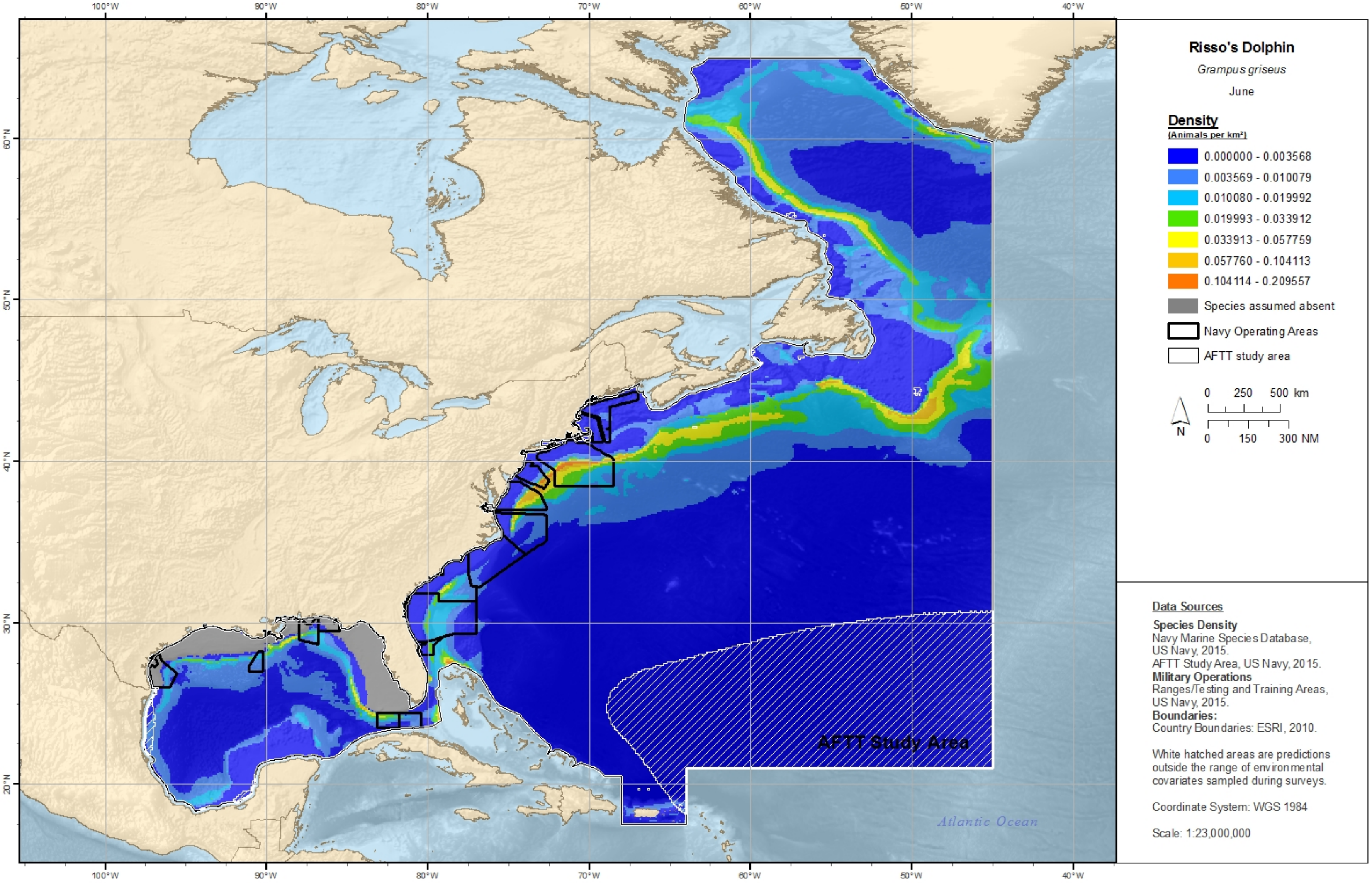


Figure 4-93. June density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

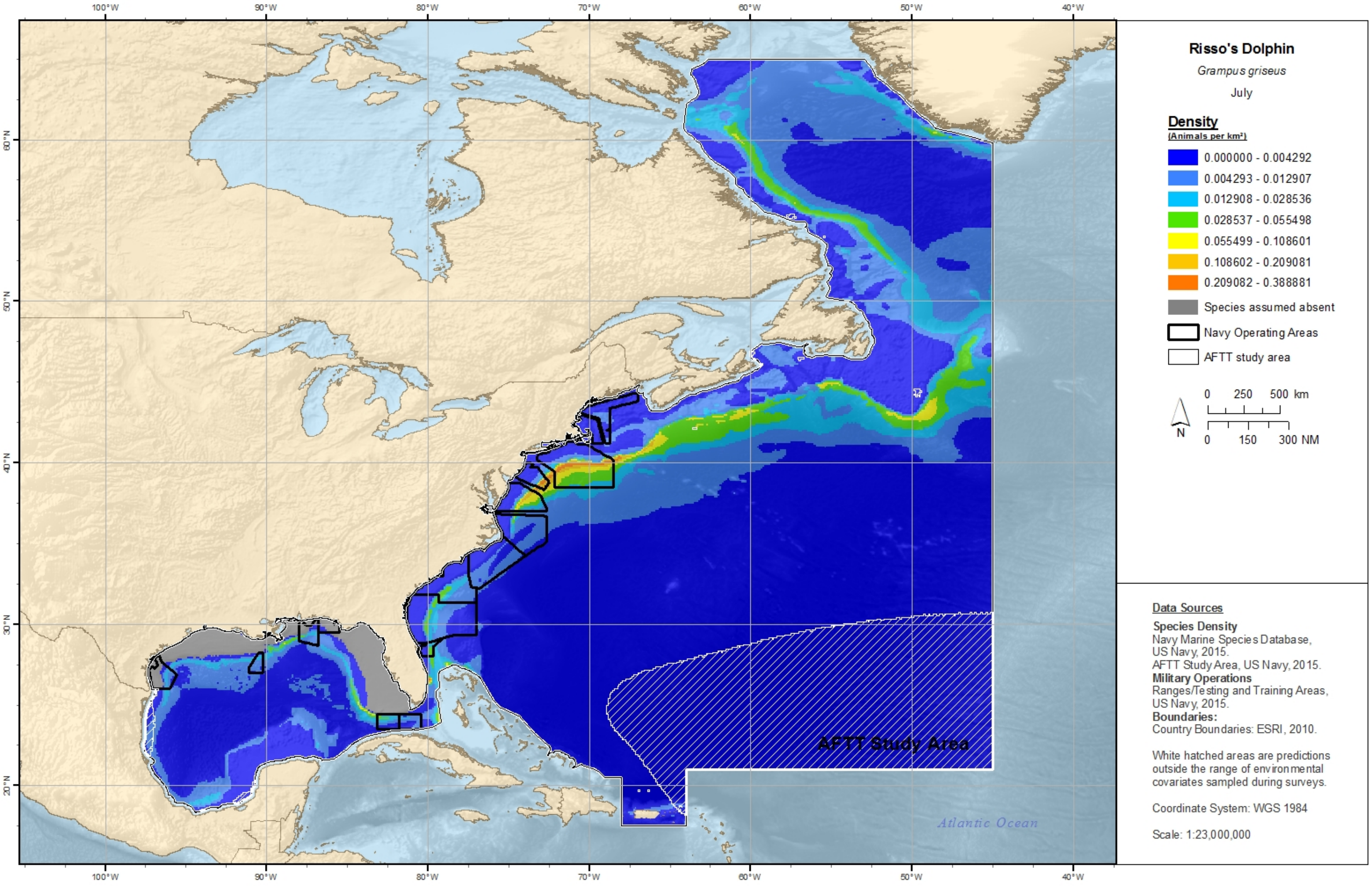


Figure 4-94. July density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

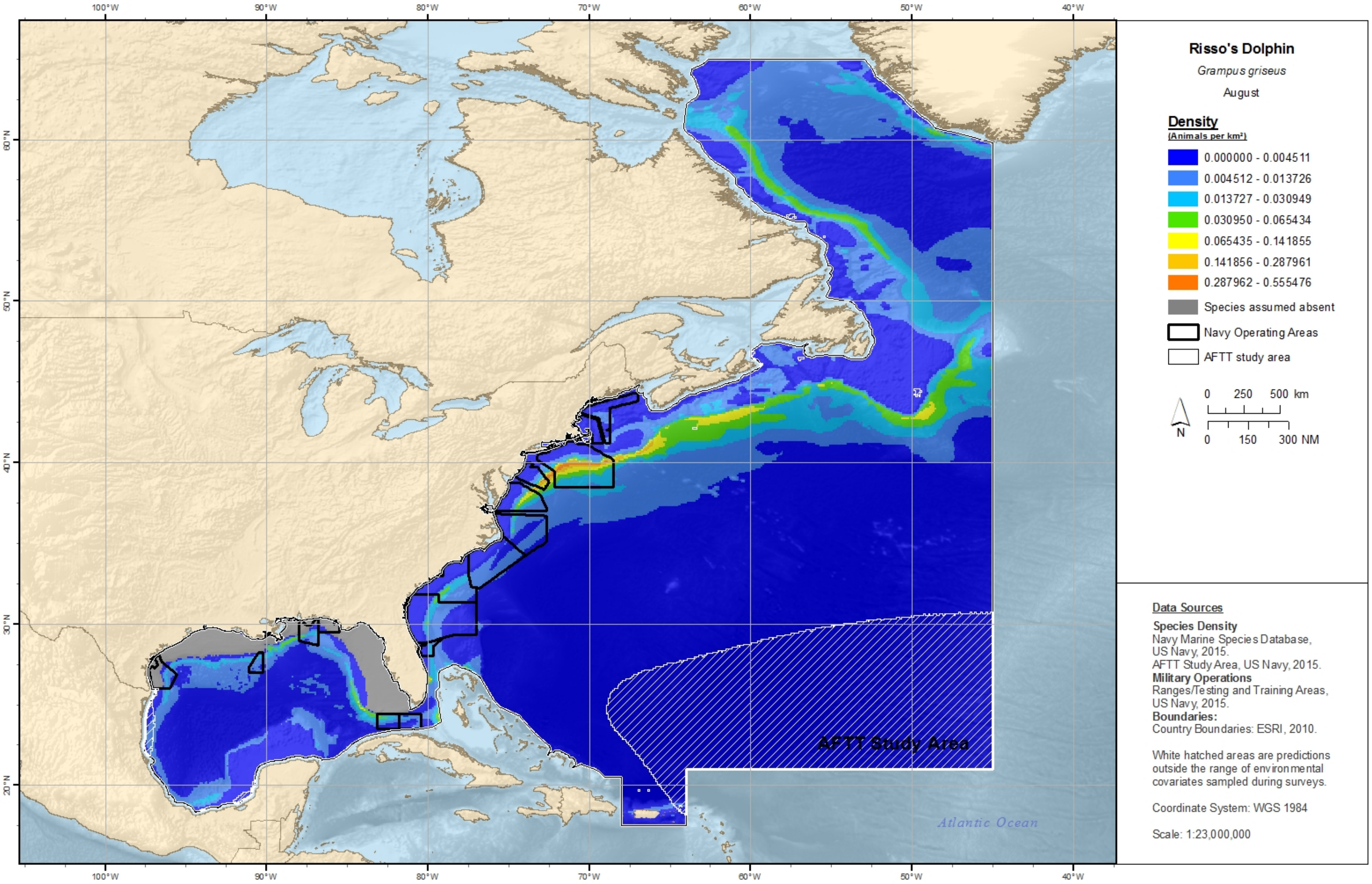


Figure 4-95. August density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

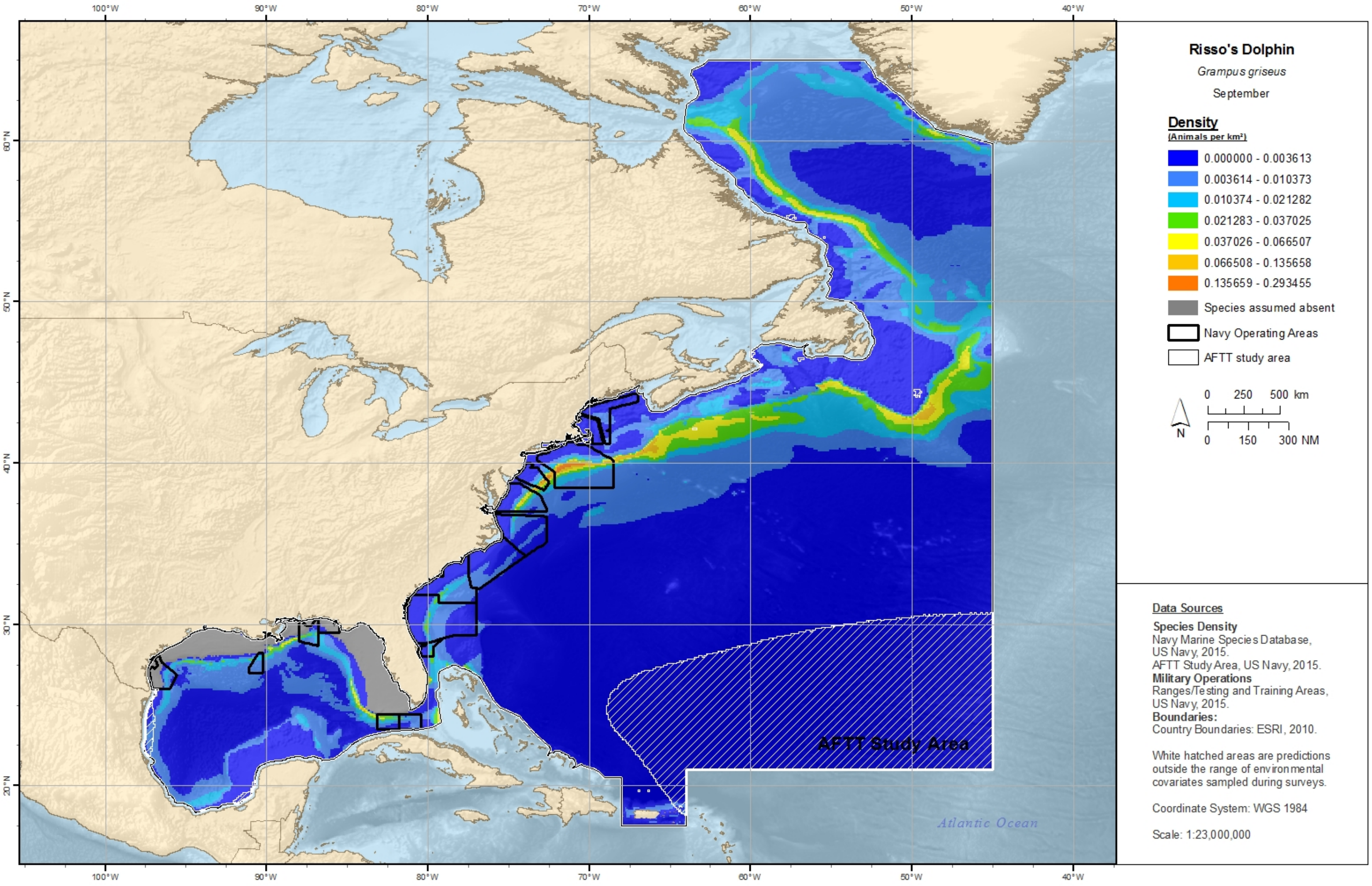


Figure 4-96. September density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

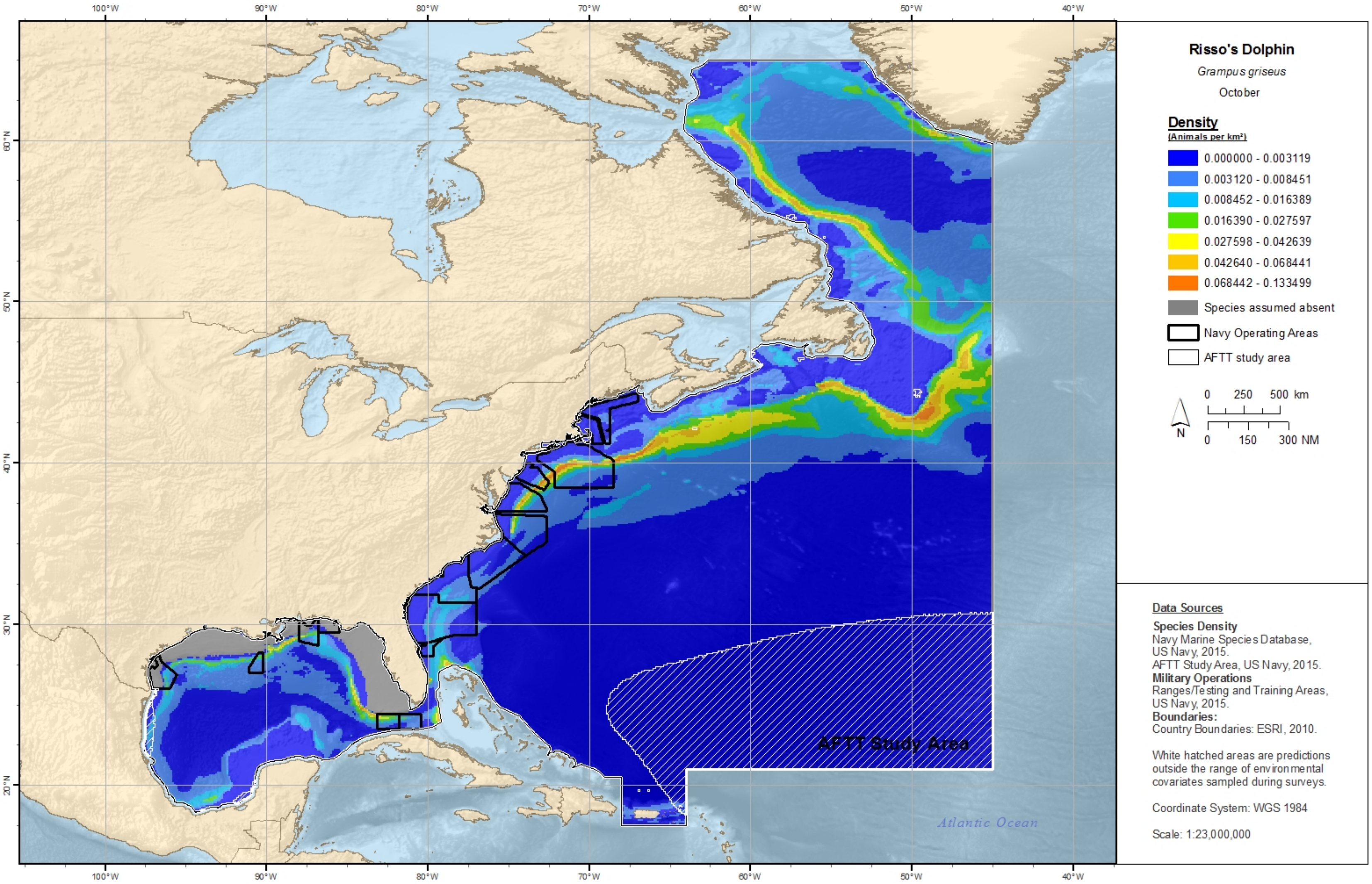


Figure 4-97. October density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

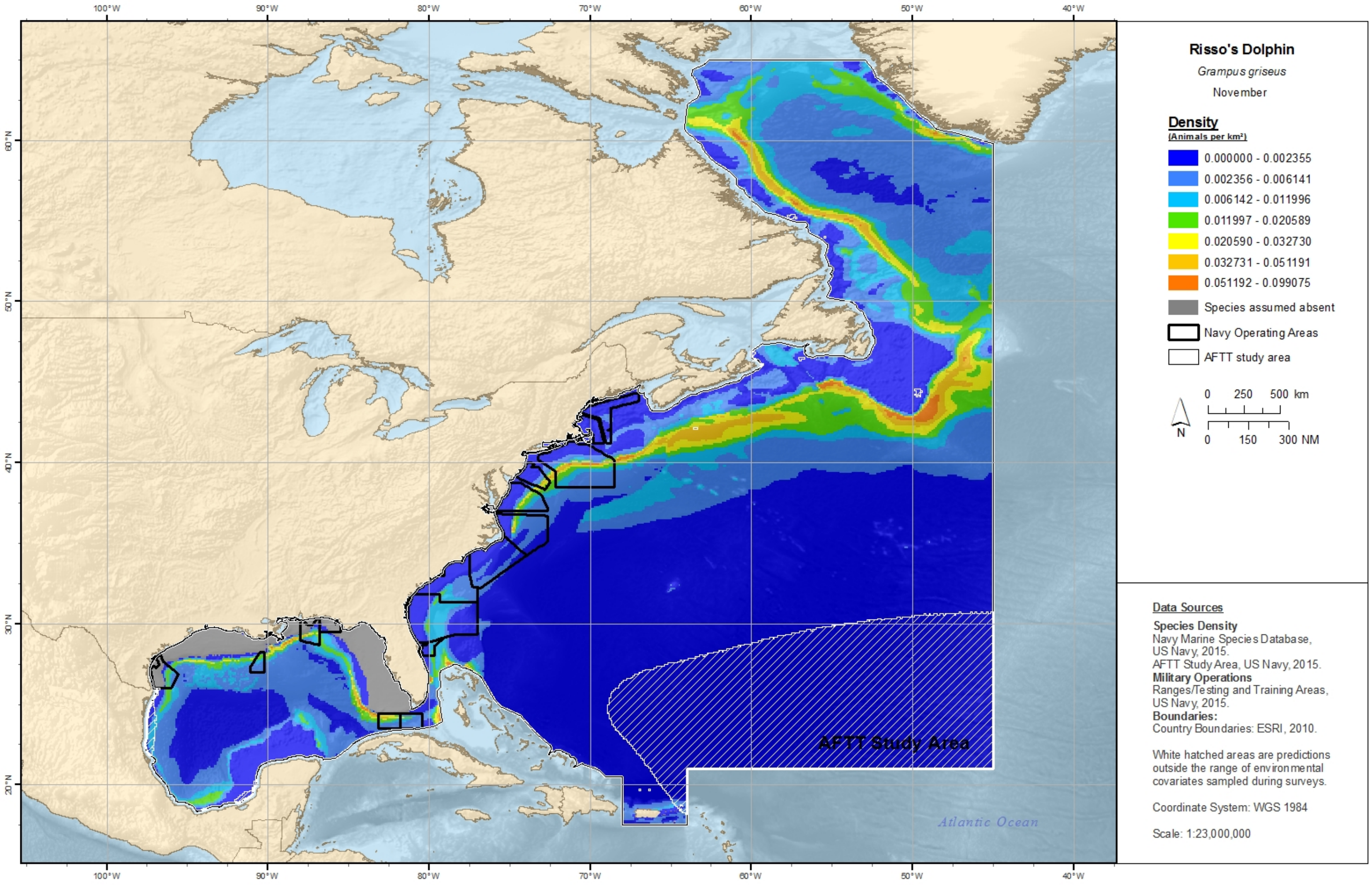


Figure 4-98. November density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFTT strata.

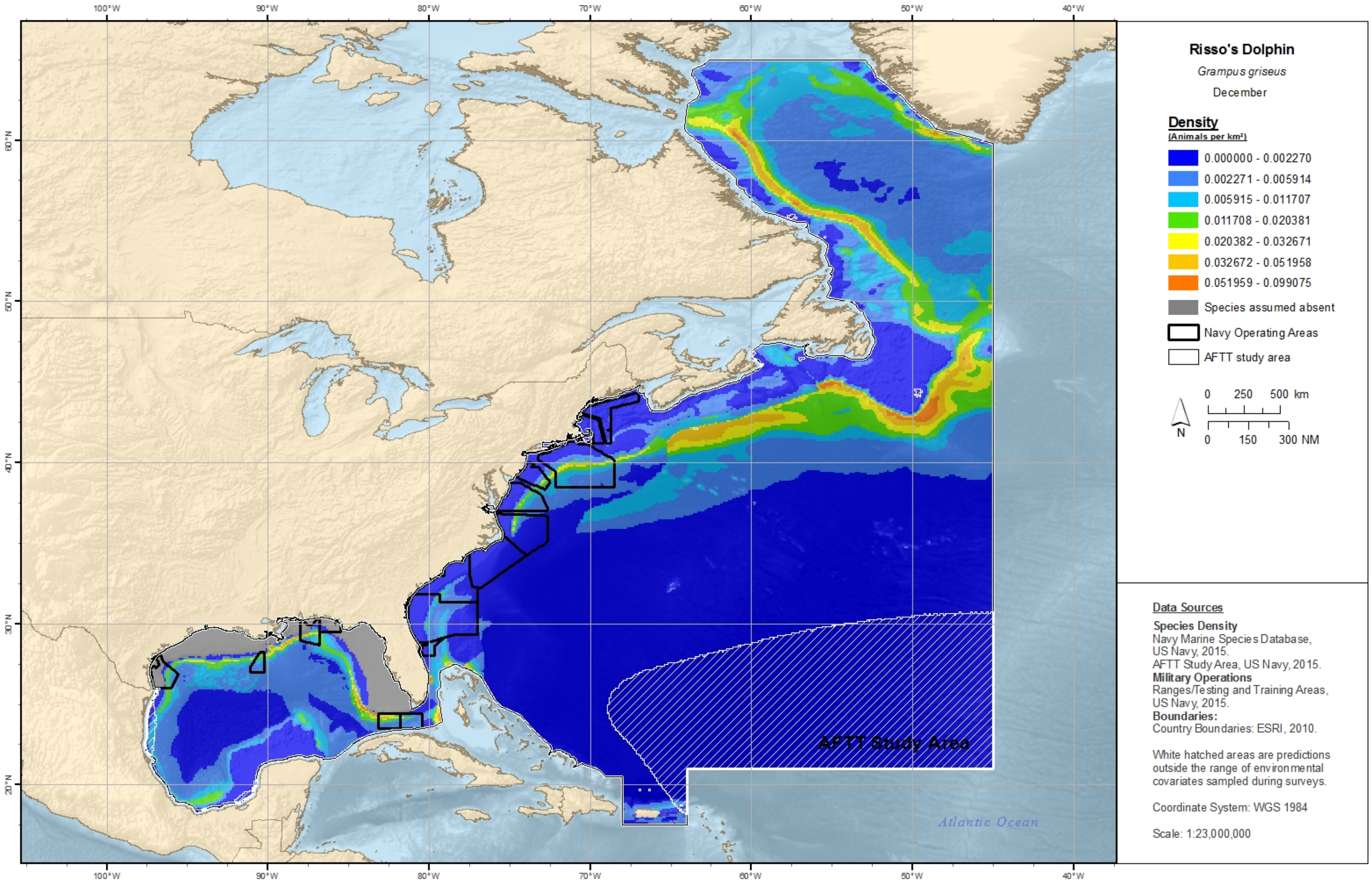


Figure 4-99. December density prediction for Risso's dolphins for the East Coast, Gulf of Mexico and AFFT strata

Rough-toothed dolphin (*Steno bredanensis*)

Data Source and Seasonality:

All density data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. Very few (N=11) sightings were available in the East Coast stratum and the researchers felt the AFTT model was more representative of this species in that stratum than a stratified density estimate. No seasons were defined for this species given a paucity of sightings and a lack of clearly defined seasonality. The temporal resolution of the density predictions was annual for both models.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 51 total sightings. Only a simple model could be fit given the low number of sightings and only one predictor, slope, was assessed as being marginally significant.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as 11 sightings from the East Coast and two from the Caribbean. Only a simple model could be fit given the low number of sightings and SST was selected as the only significant variable. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the described range of pantropical spotted dolphins (West et al. 2011).

Other Density Estimates:

The Mannocci et al. (2016) AFTT model predicts 3,314 individuals in the East Coast stratum (CV for East Coast stratum alone not available). The most recent NOAA SAR estimate is 271 individuals (CV=1.00) based on NEFSC and SEFSC summer 2011 aerial surveys from the lower Bay Fundy to central Florida (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In TAP Phase II, a literature derived estimate of 371 individuals was used for summer in the southeast Atlantic, with Kaschner RES data used in other areas/seasons. It is possible that the Mannocci et al. (2016) model overestimates abundance in the East Coast but meaningful comparison is difficult given factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The SAR used only summer sightings and abundance may be different in other seasons given differing environmental conditions. The Mannocci et al. (2016) model is an annual prediction.

An abundance estimate of 4,853 individuals (CV= 0.19) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR in the Gulf of Mexico is 624 (CV=0.99) individuals based on a 2009 shipboard survey of oceanic waters (Waring et al. 2013). In TAP Phase II, a NODES density spatial model was used with an estimate of 2,463 individuals (summer value, CV not available). Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) is somewhat higher than SAR estimate. The most likely reasons for the discrepancy between the Roberts et al. value and the SAR is because of the SAR covered only oceanic waters (the species is known to occur on the shelf and shelf break) and the SAR assumed that g(0)=1. The Roberts et al. (2016) and NODE are the same level in the NMSDD hierarchy but the Roberts et al. (2016) estimate was chosen over it because Roberts et al.(2016) incorporated more data and updated techniques. The Roberts et al. (2016) model is higher in the NMSDD hierarchy than the SAR estimate and covers more of the species' range and so was selected over it.

An abundance estimate of 44,746 individuals (CV=0.18) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

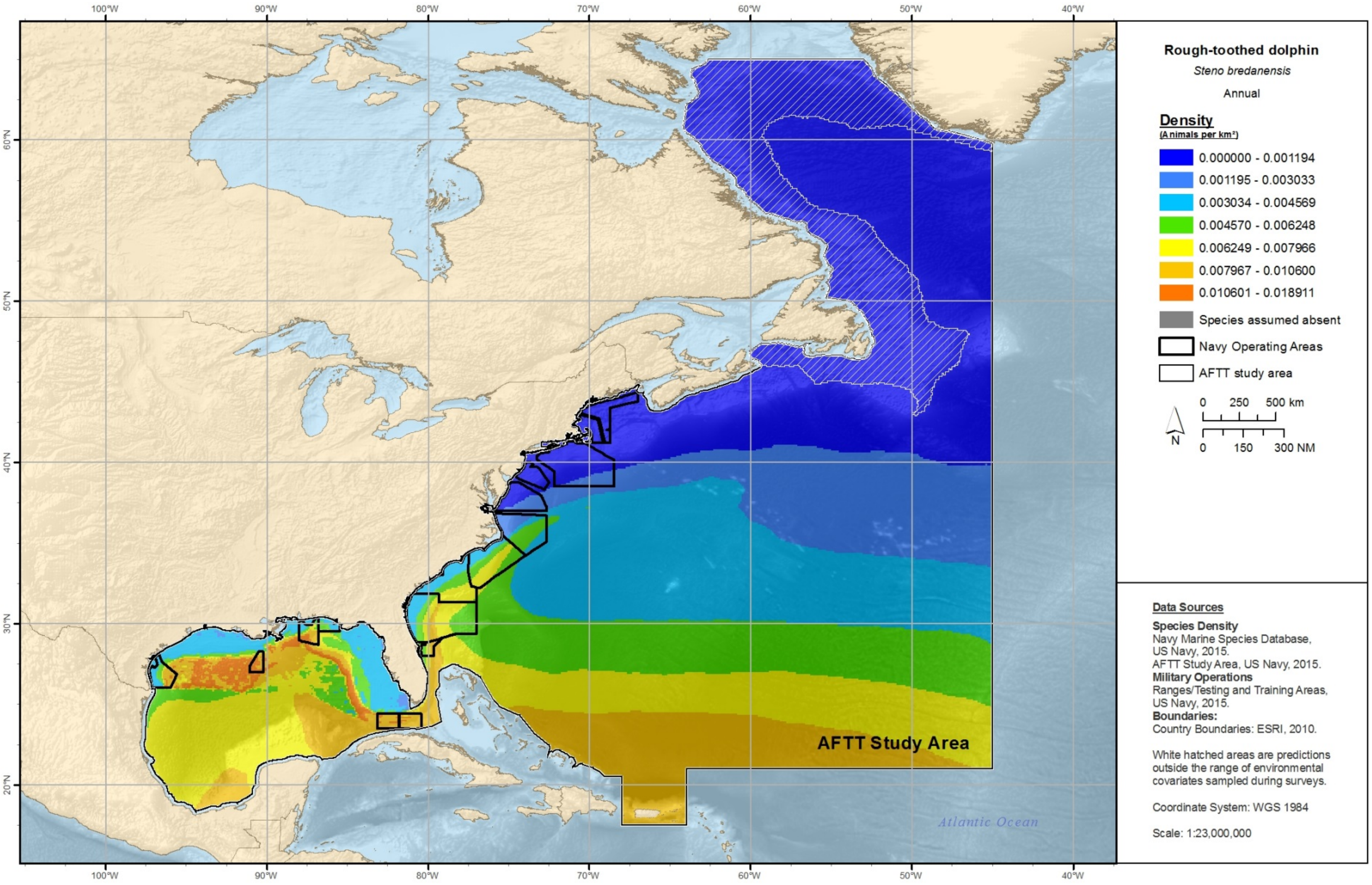


Figure 4-100. Annual density prediction for rough-toothed dolphins for the Gulf of Mexico and AFTT strata.

Short-beaked common dolphin (*Delphinus delphis*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species come from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the East Coast stratum. An extrapolative density spatial model was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region The temporal resolution of the density predictions was monthly in the East Coast and annual in the AFTT.

Survey Data and Selected Models:

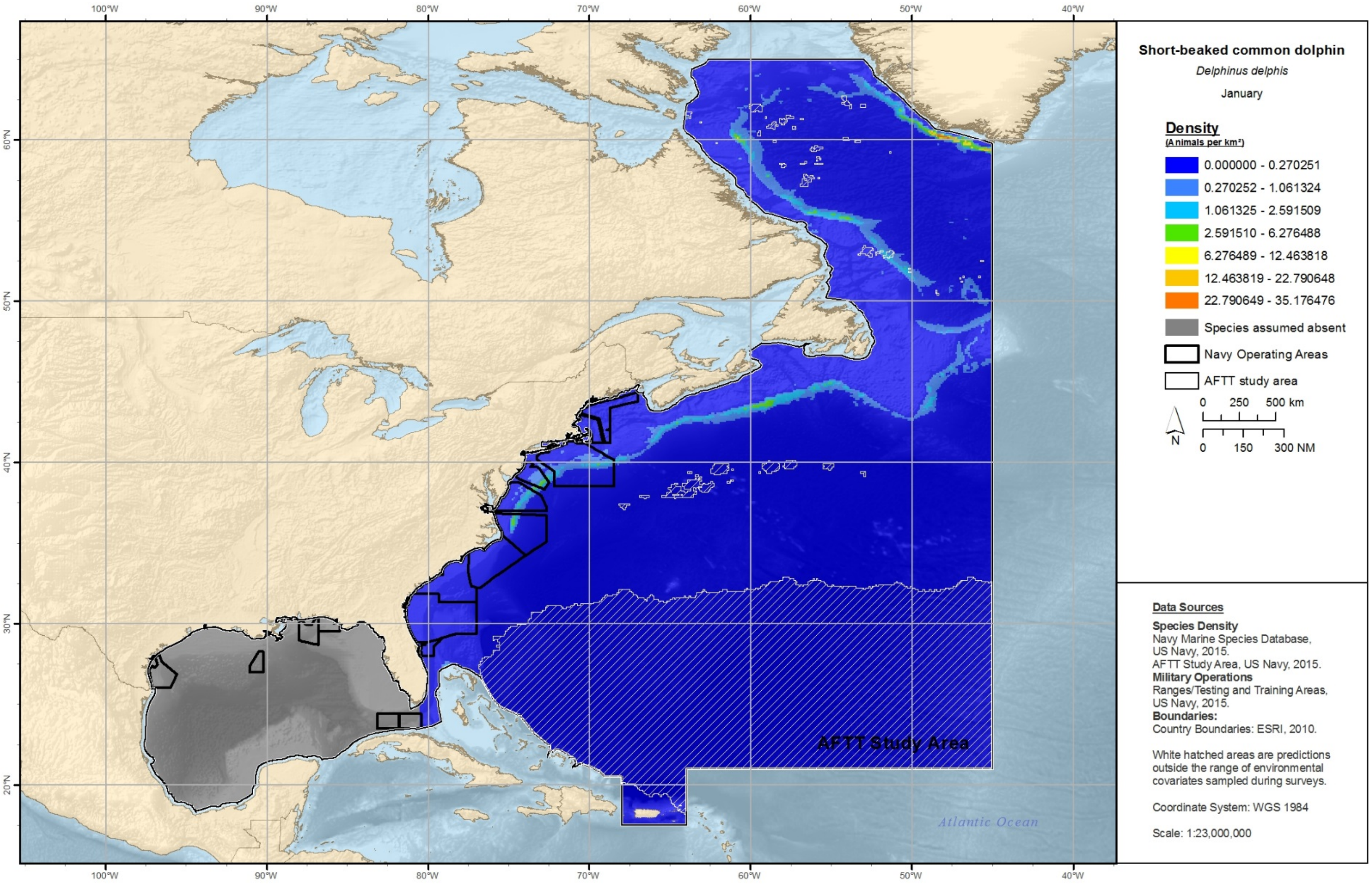
In the East Coast stratum, a total of 1,189 sightings from the combined survey data were used for model development. These include ambiguous sightings that were recorded as being either Atlantic white-sided dolphin or common dolphin. A reclassification model was successfully applied to these ambiguous sightings and only sightings definitely confirmed as common dolphin or identified as such by the reclassification model were used in the model. See the taxon-specific documentation associated with Roberts et al. (2016) for details. The climatological model explained more deviance than the contemporaneous model but exhibited high temporal variability in predicted abundance, suggesting that the climatological model may be over-fitted. As such the contemporaneous model was selected (see supplementary material from Roberts et al. (2016) for a more detailed discussion).

The model for the AFTT stratum used the same sightings from the East Coast model, as well as one sighting from the mid-Atlantic ridge (summer), 227 sightings from Europe, and 28 sightings from the mid-Atlantic ridge. The best fitting summer model included slope, chlorophyll a concentrations, distance to fronts, and climatological sea surface height anomalies as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are mostly consistent with the known occurrence of the species though may be providing an erroneous presence, albeit in low numbers, off of Florida (Jefferson et al. 2009).

Other Density Estimates:

An abundance estimate of 86,089 individuals (CV=0.12) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR report is 70,184 individuals (CV=0.28) based on NEFSC and SEFSC 2011 aerial surveys from the Gulf of Maine to central Virginia (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. There is also a 2007 estimate based on surveys performed in Canadian waters only that predicts 173,486 individuals (CV=0.55 [Lawson and Gosselin 2009]). In TAP Phase II, a NODE estimate of 123, 899 individuals (summer season, no CV available) based on survey data for the summer season in the northeast only was used, with SMRU RES data elsewhere. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case the SAR estimate and the estimate from the Roberts et al. (2016) East Coast stratum model are in relatively close agreement and are statistically comparable. Because the Canadian estimate does not cover the same spatial extent it is not appropriate for use in modeling acoustic effects in the East Coast stratum. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed and replaces global RES data in the southeast, which is lower in the NMSDD hierarchy. The Roberts et al. (2016) model was chosen over the SAR as it is higher in the NMSDD hierarchy.

An abundance estimate of 482,022 individuals (CV=0.11) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast stratum than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Data from waters in Canadian and Greenland waters (Lawson and Gosselin 2009) were unavailable to the modelers, which may have helped with accuracy in those regions. The Mannocci et al. (2016) model is considered higher in the NMSDD hierarchy than these literature-derived, stratified estimates.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-101. January density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

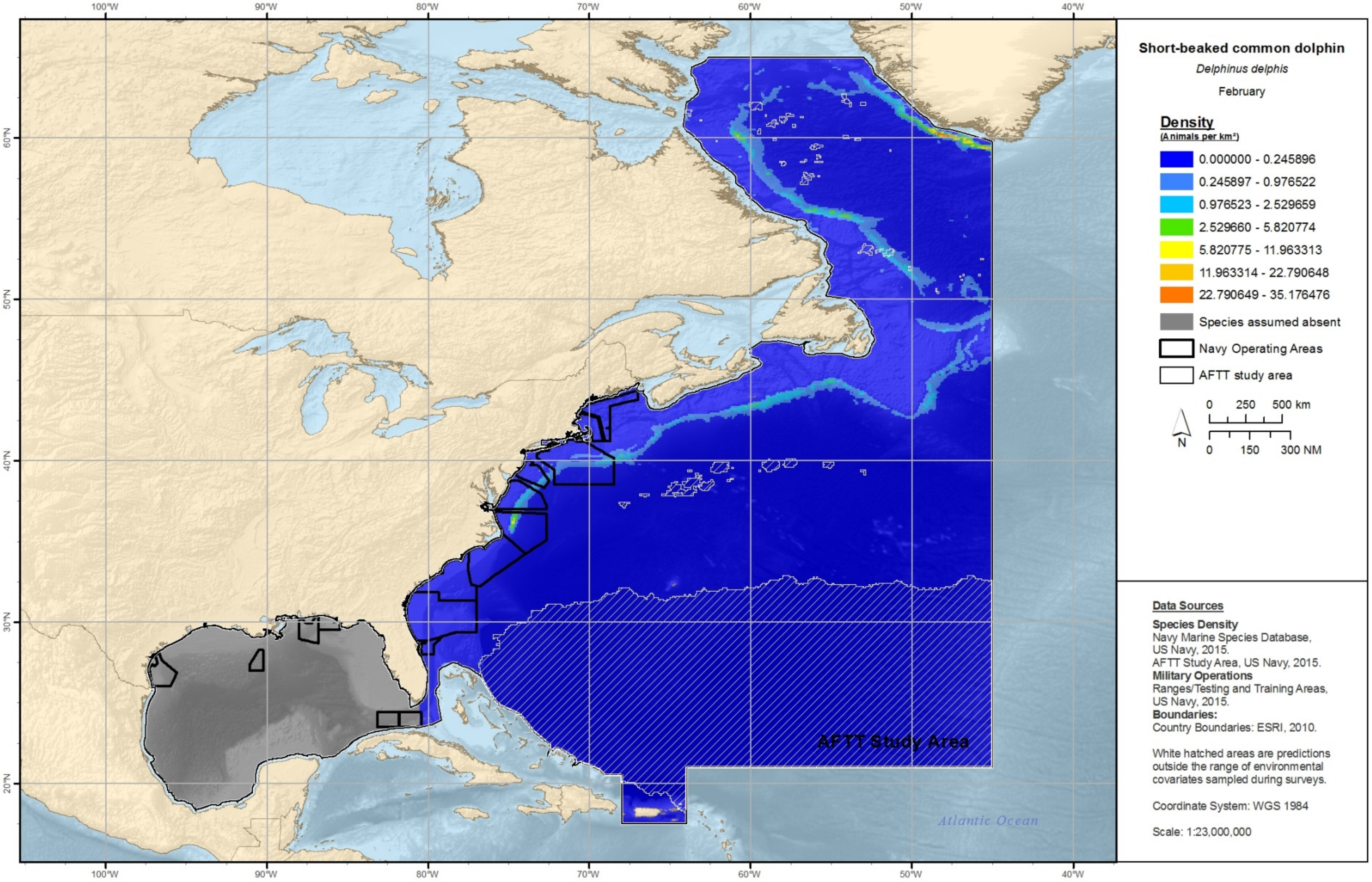


Figure 4-102. February density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

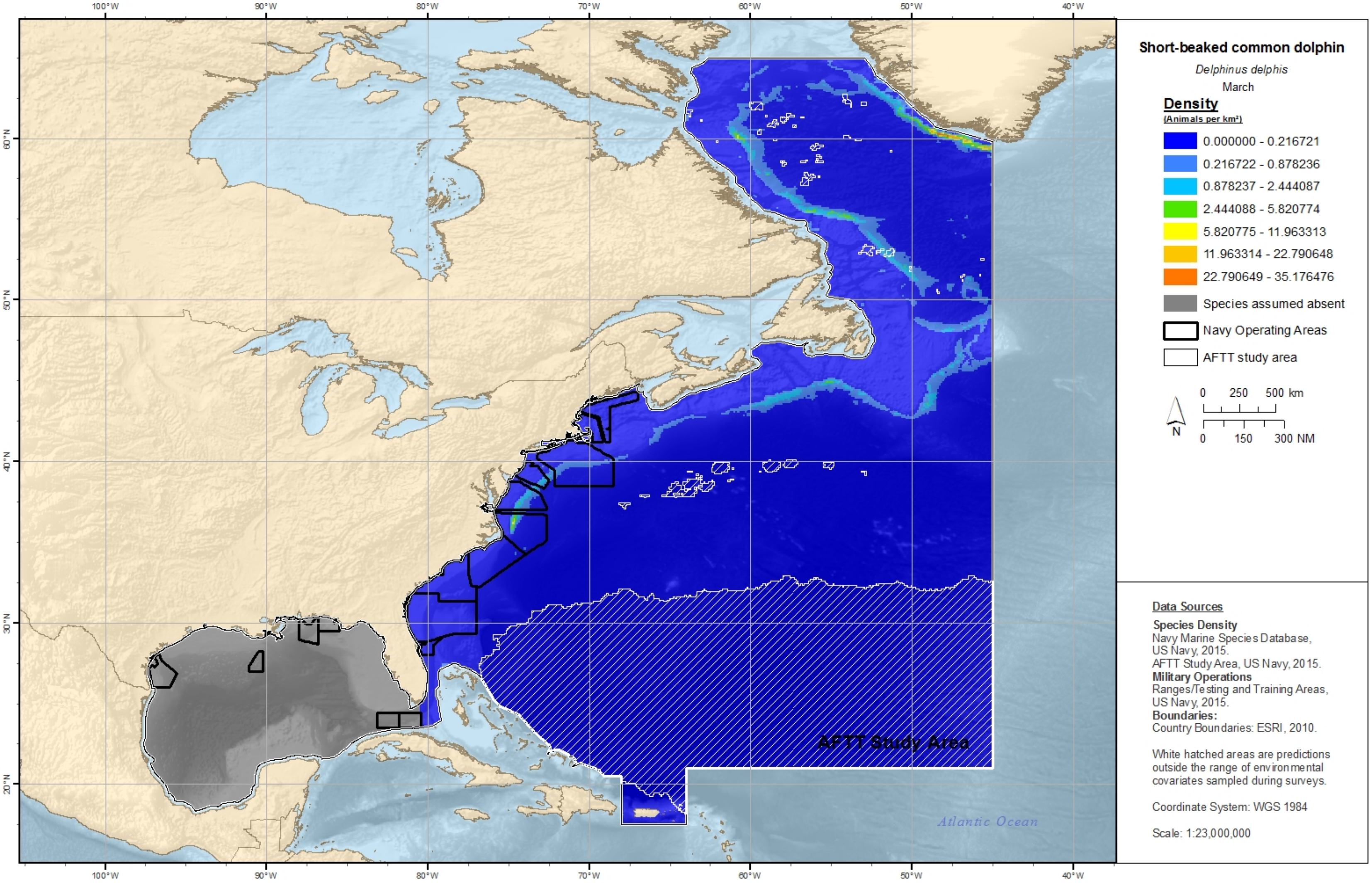
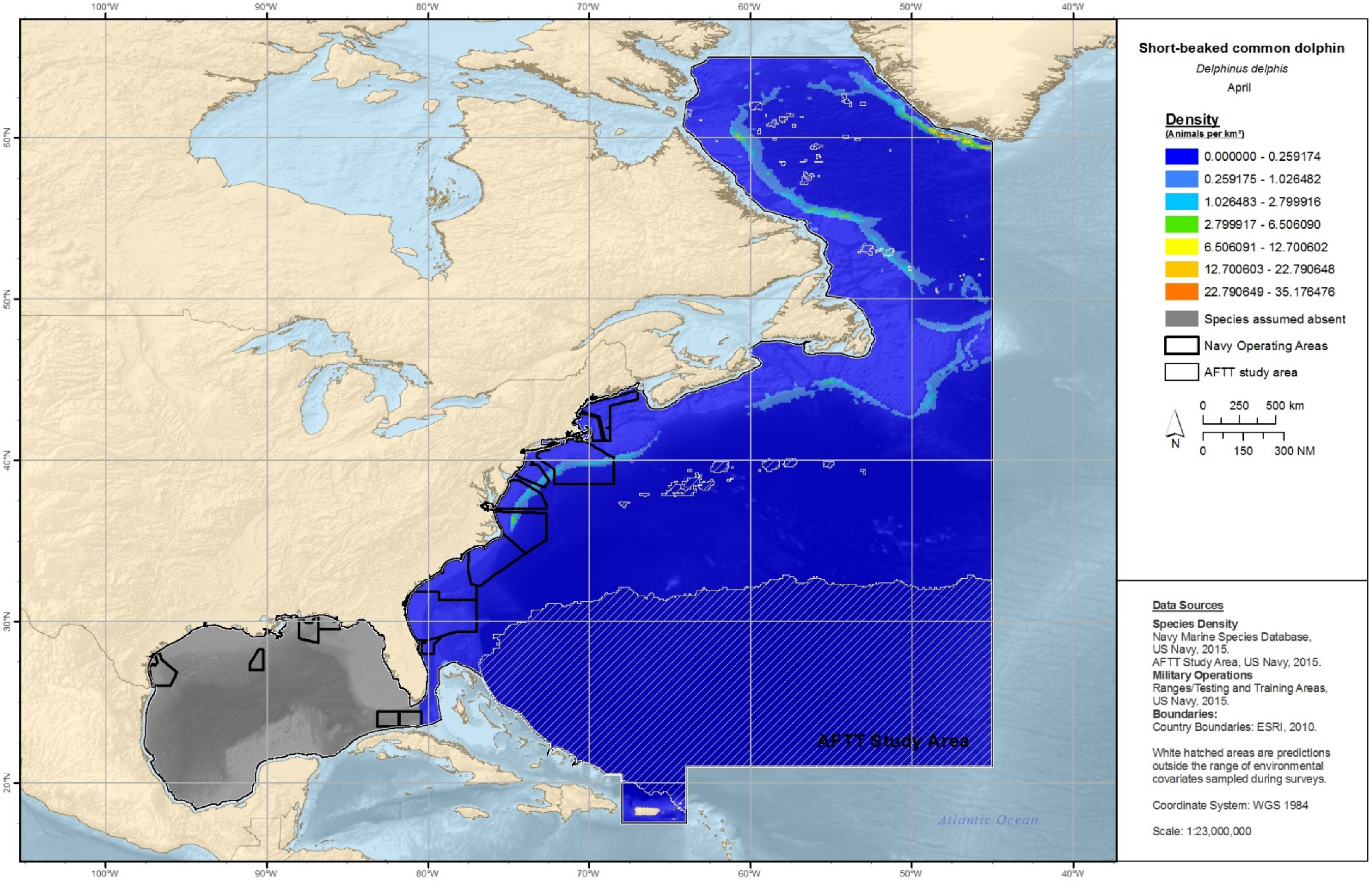


Figure 4-103. March Density prediction for short-beaked common dolphins for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-104. April density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

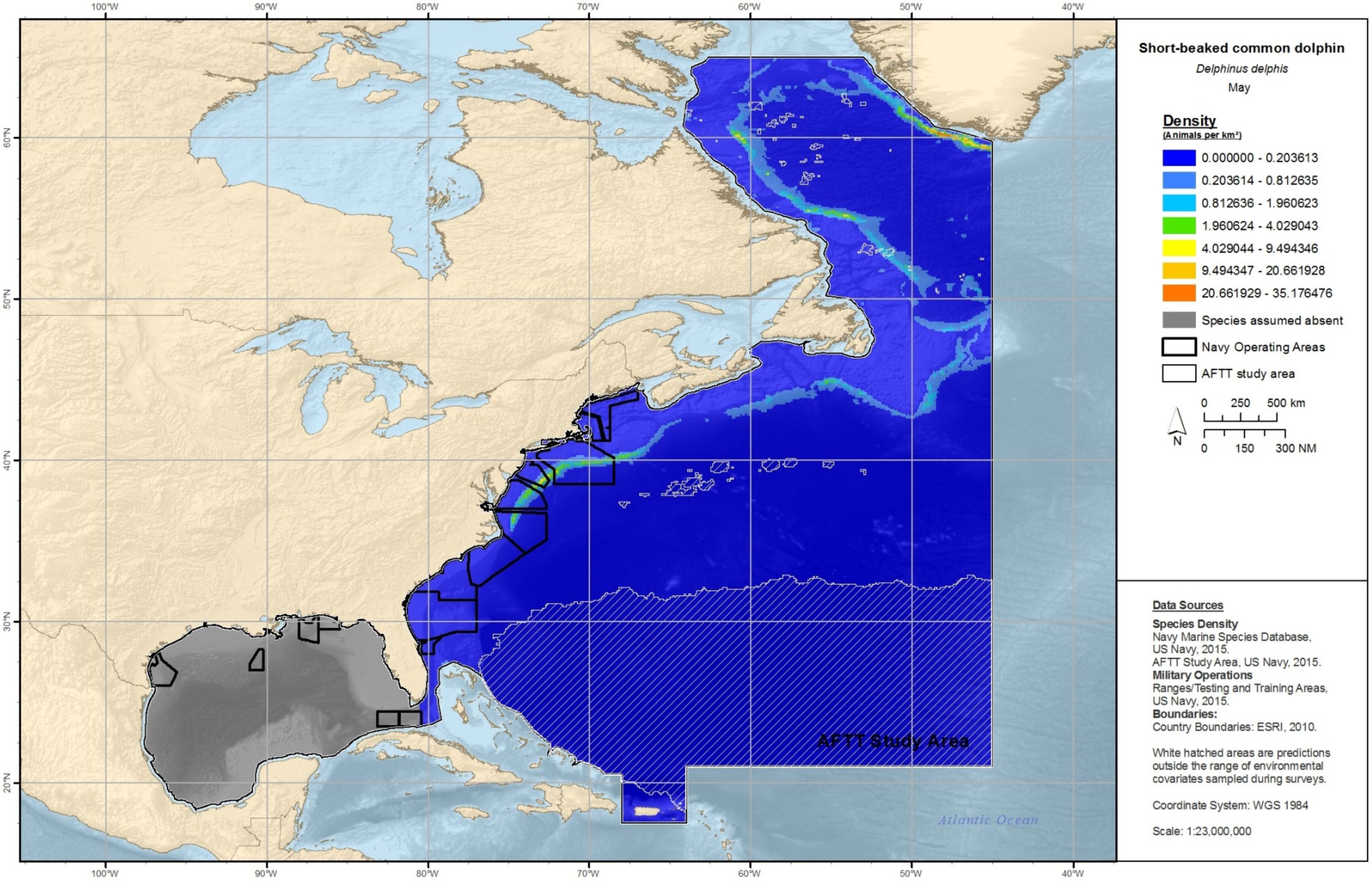


Figure 4-105. May density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

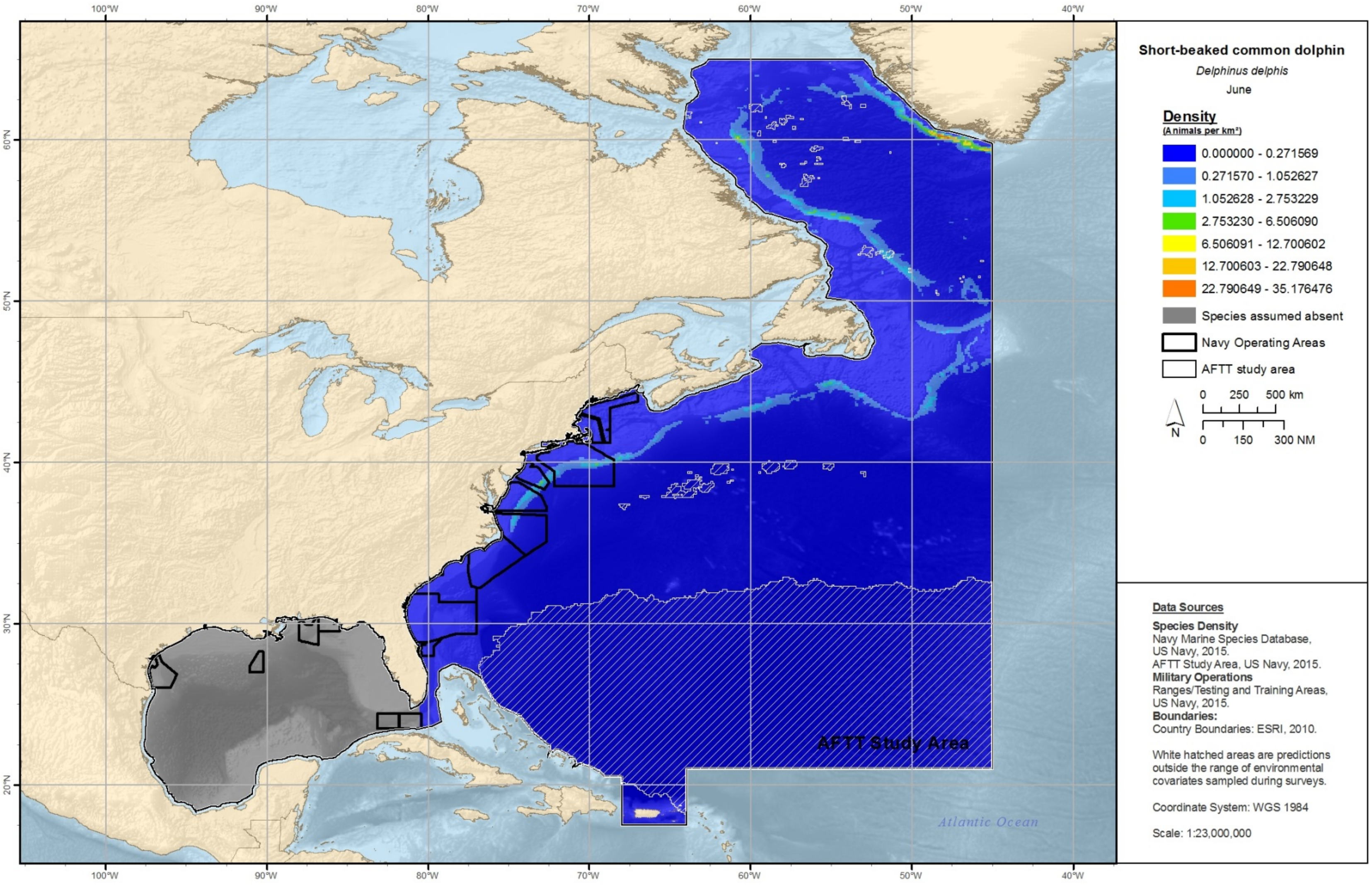


Figure 4-106. June density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

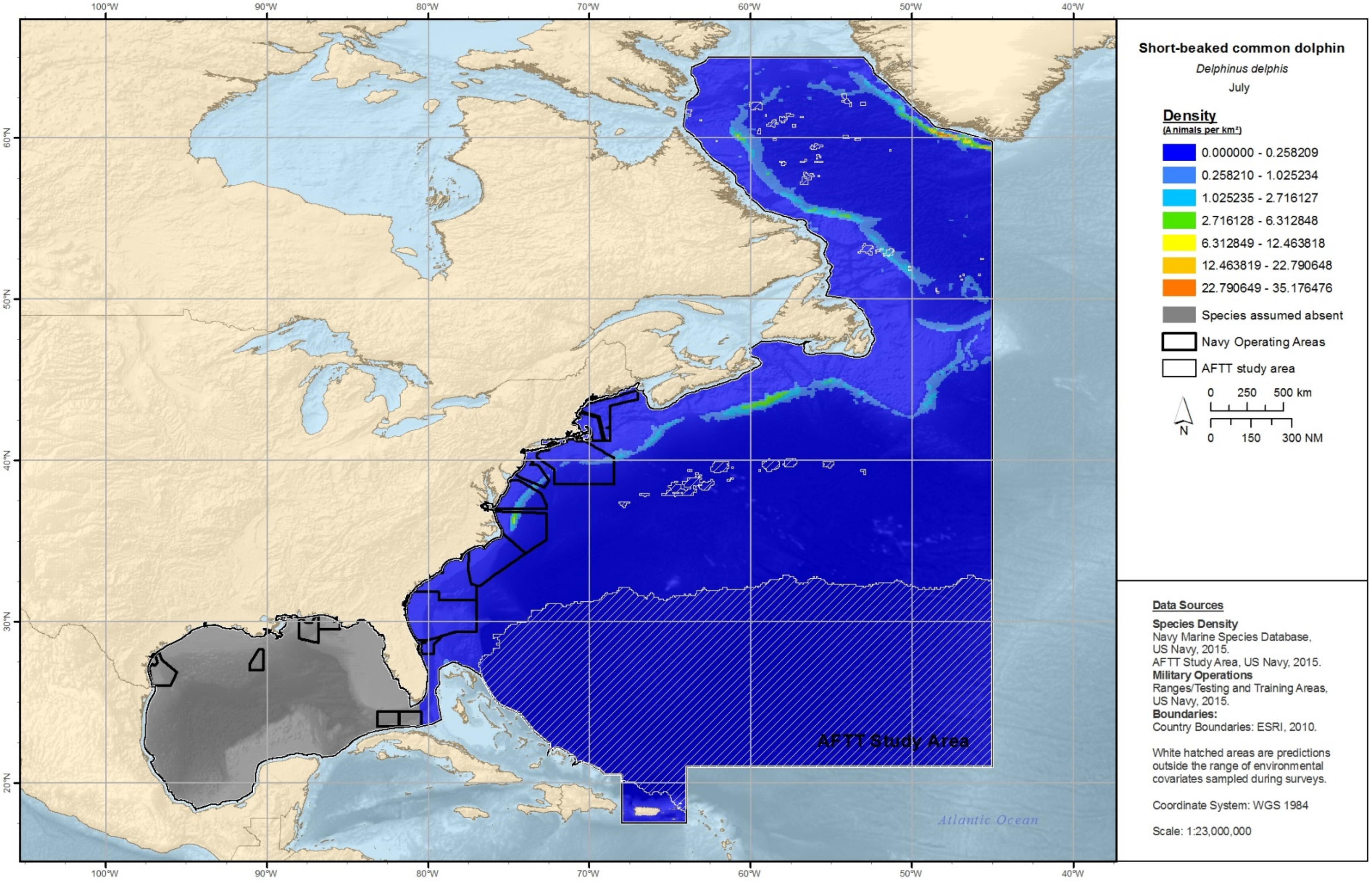


Figure 4-107. July density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

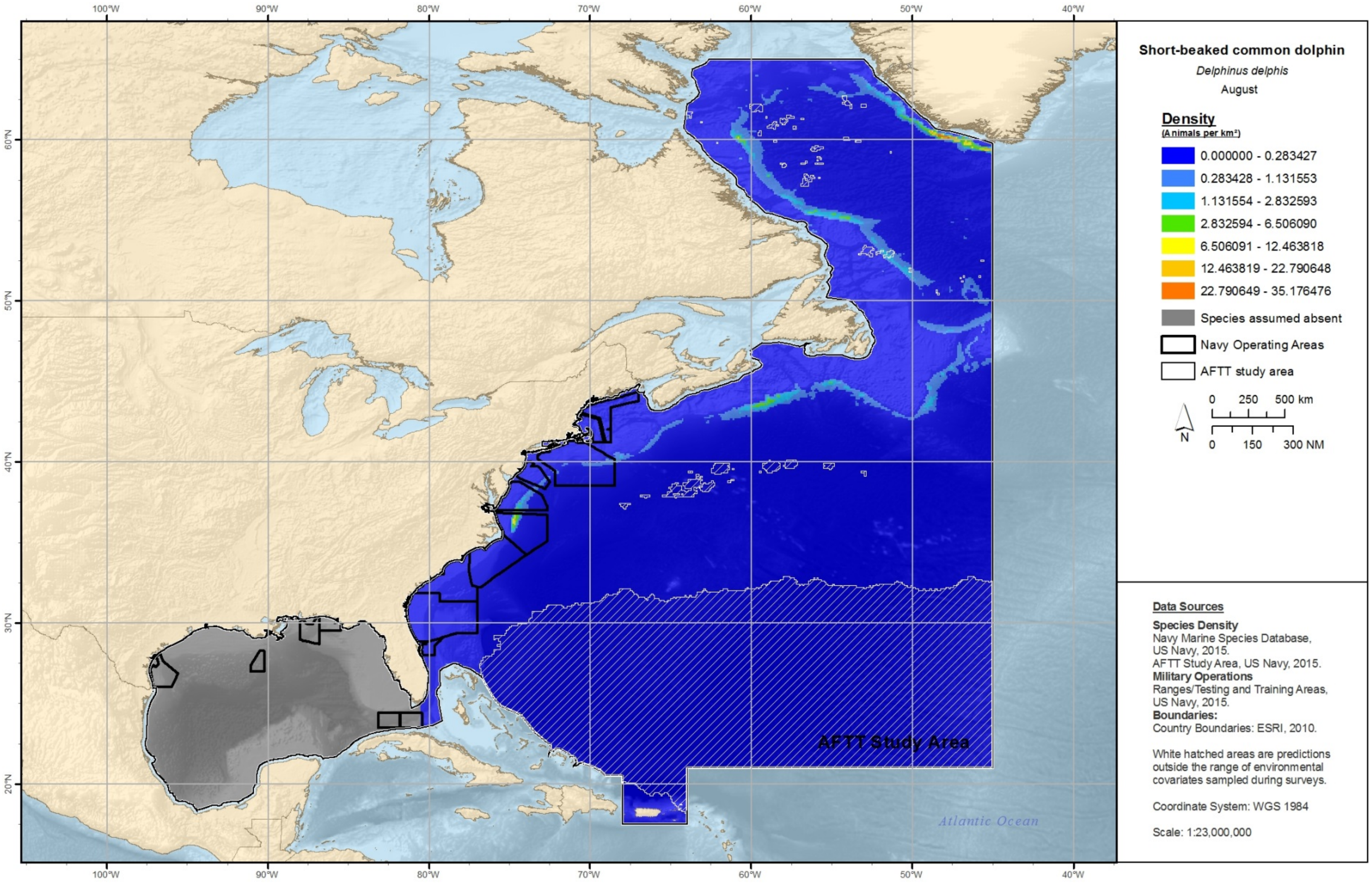


Figure 4-108. August density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

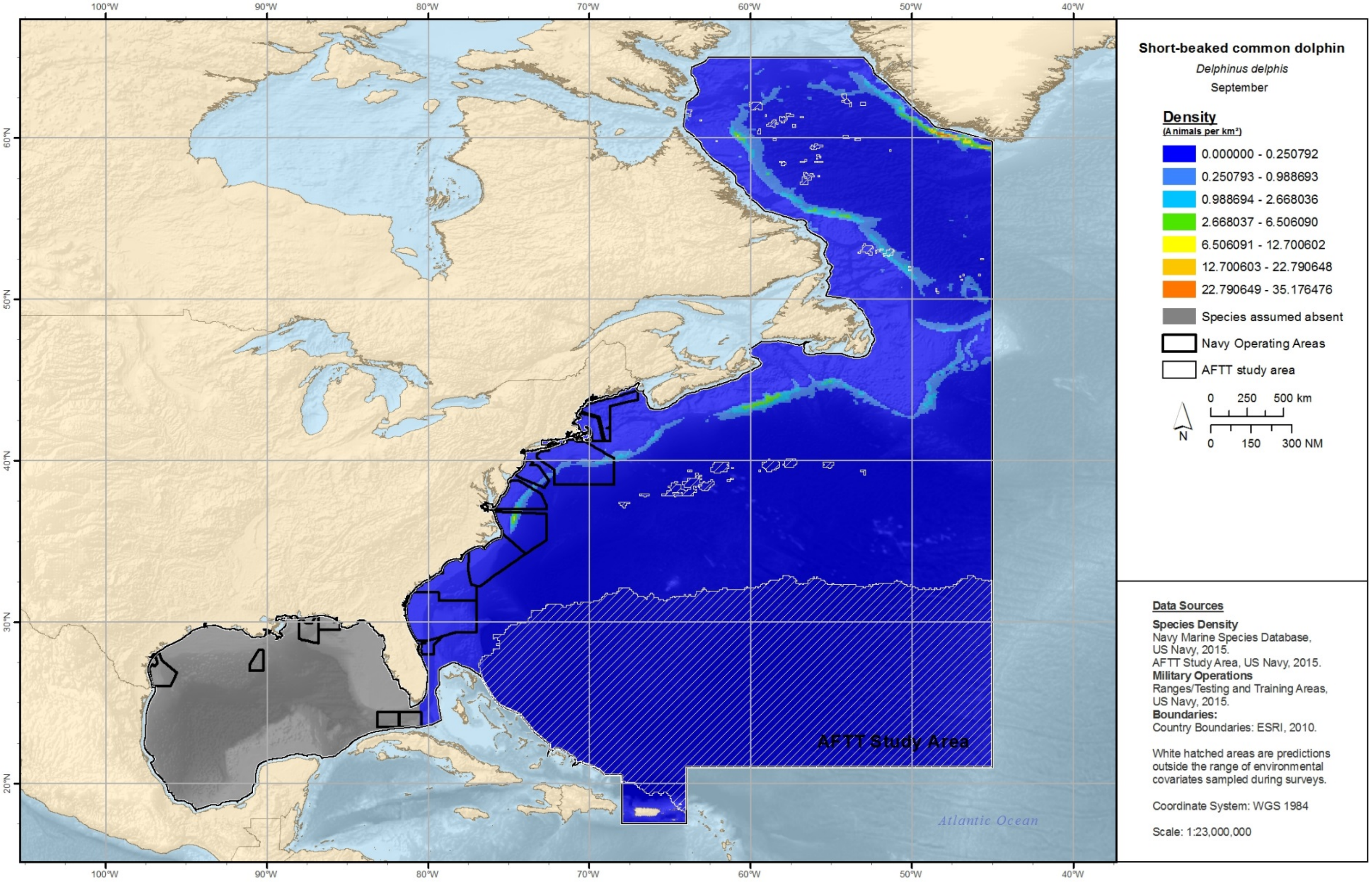


Figure 4-109. September density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

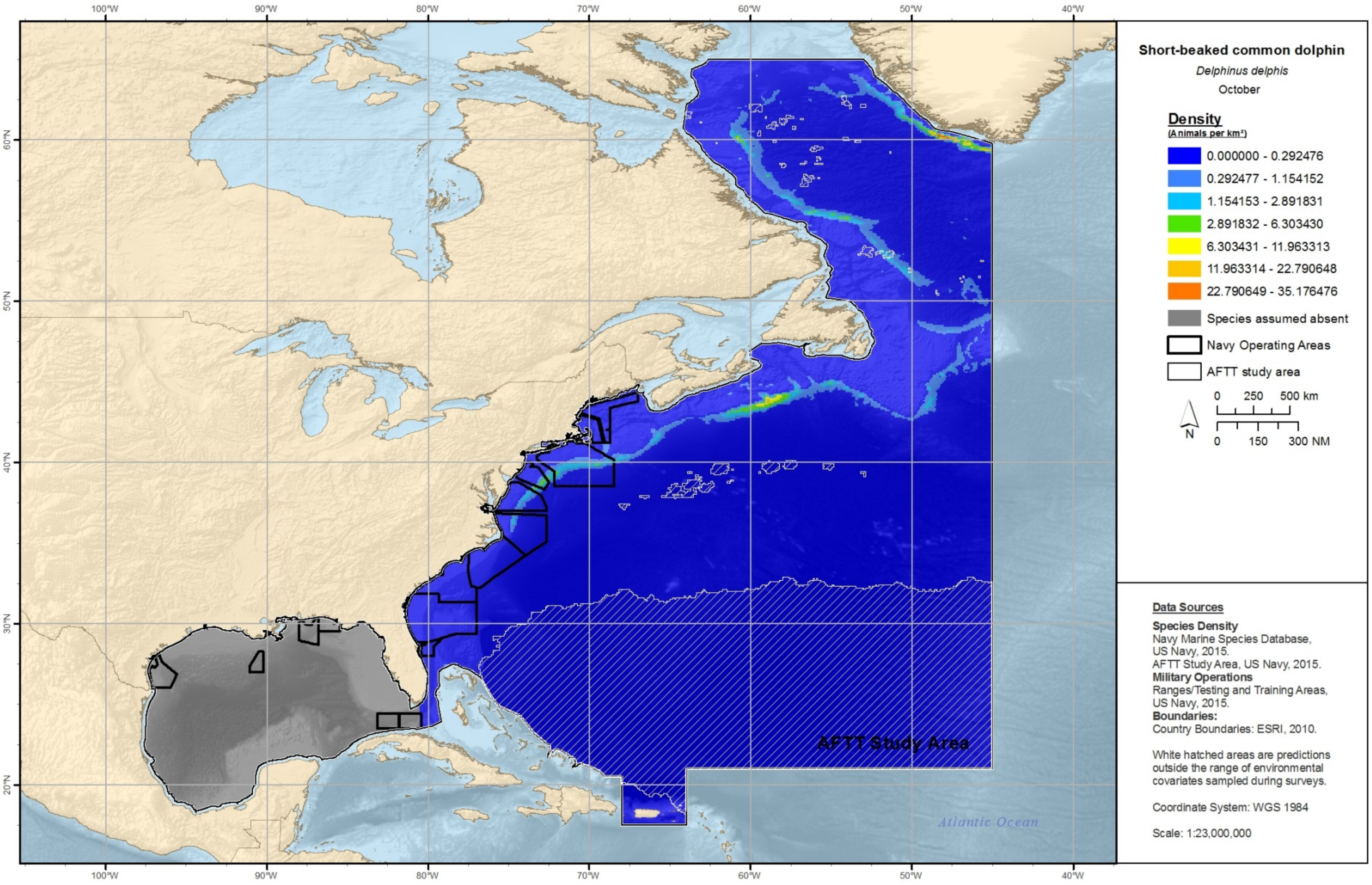


Figure 4-110. October density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

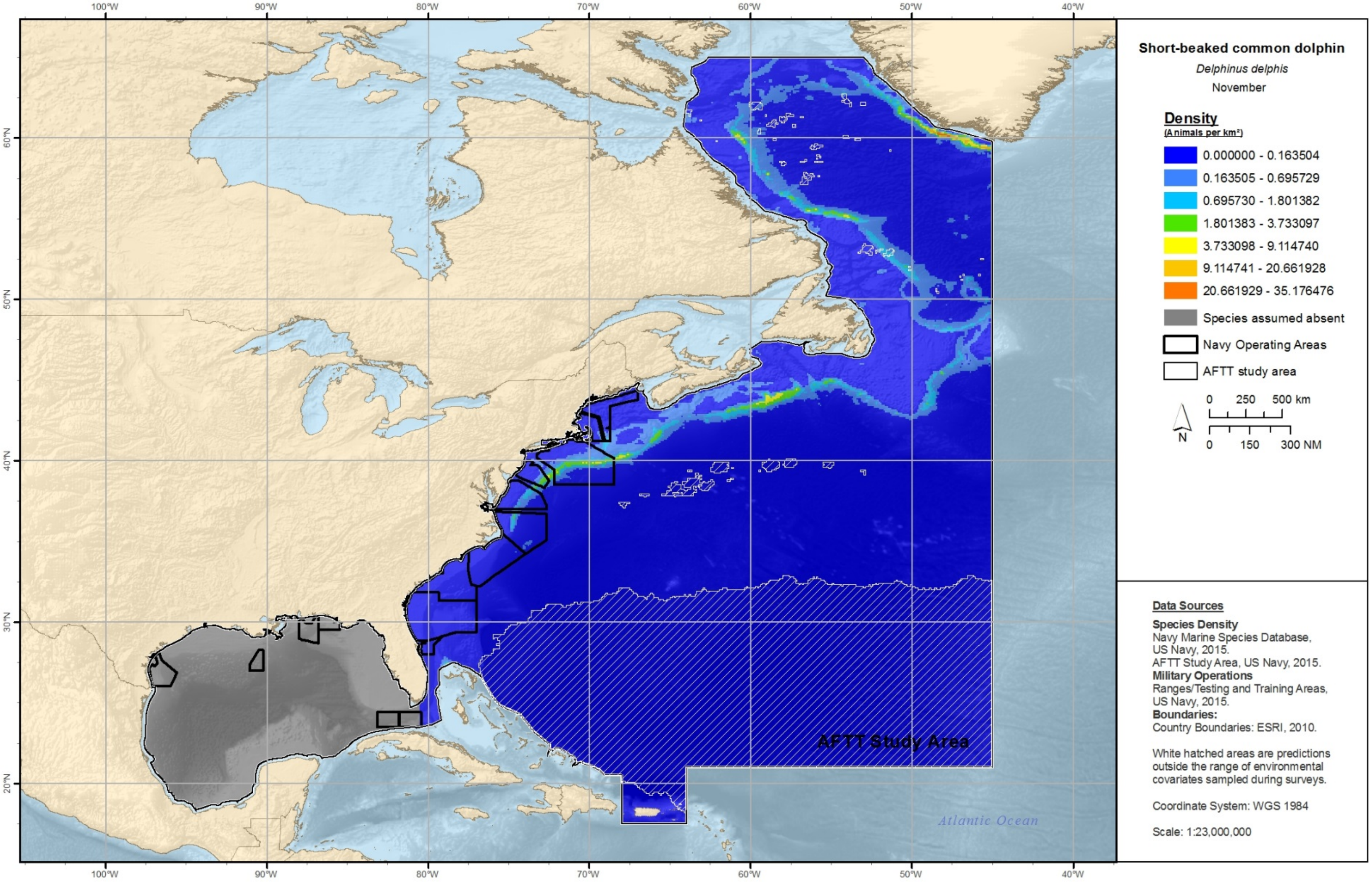
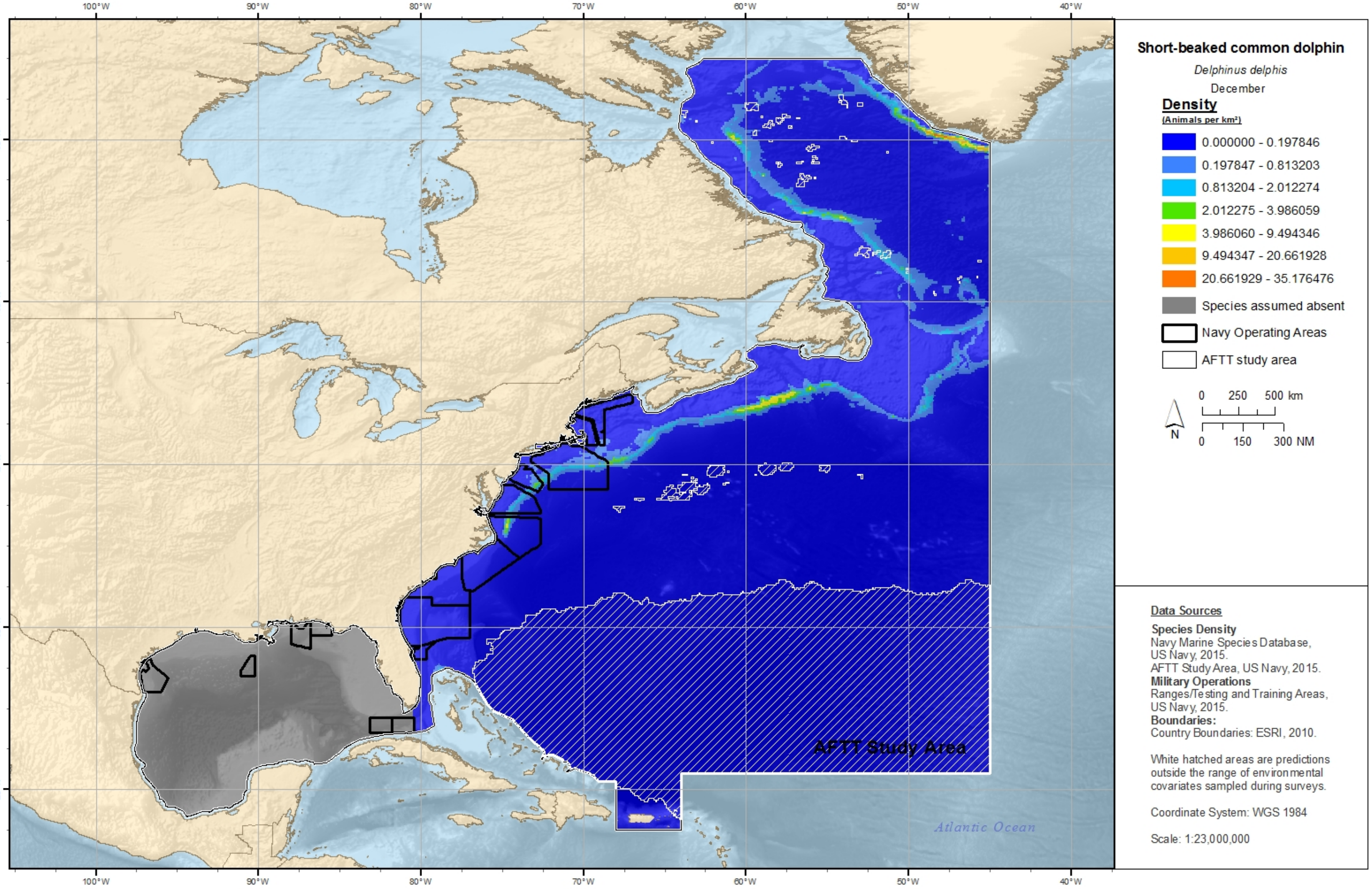


Figure 4-111. November density prediction for short-beaked common dolphins for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-112. December density prediction for short-beaked common dolphins for the East Coast and AFTT strata.

Spinner dolphin (*Stenella longirostris*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative spatial density models developed by Mannocci et al. (2016). A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. Very few (N=2) sightings were available in the East Coast stratum and the researchers felt the AFTT model was more representative of this species in that stratum than a stratified density estimate. No seasons were defined for this species given a lack of clearly defined seasonality. The temporal resolution of the density predictions was annual for both models.

Survey Data and Selected Models:

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 71 total sightings. The sightings were limited almost exclusively to regions beyond the continental shelf edge, at depths of 250-2600 m, and as such the model was limited to areas deeper than the 100m isobaths. The climatological models explained considerably more deviance than models fitted with contemporaneous covariates, and did not predict a large abundance in the western Gulf of Mexico, where only two sightings occurred, like the contemporaneous models did (Roberts et al. 2016).

The model for the AFTT stratum used the sightings from the Gulf of Mexico model, the East Coast stratum sightings (N=2), and two sightings from the Caribbean. The best fitting model included only SST as a predictor. A single environmental covariate was used given the lack of sightings data. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the apparent range of the species in global tropical waters, including both inshore and oceanic waters (Perrin and Gilpatrick 1998). Model predictions are also consistent with the known occurrence of the species based on sightings (Ortega-Ortiz 2002 and Mignucci-Giannoni 1998).

Other Density Estimates:

The Mannocci et al. (2016) AFTT density spatial model predicts 13,345 individuals (CV not available for East Coast stratum) in the East Coast stratum. The most recent NOAA SAR for the western North Atlantic stock is from 2013 and did not contain enough sightings to estimate population abundance (Waring et al. 2013). Annual Kaschner RES data were used in TAP Phase II and predicted 4,929 individuals (CV not available) in the East Coast stratum. Because of the lack of sightings in the East Coast stratum, the modeling team felt the AFTT model better represented the species' presence in the East Coast stratum than a stratified model. The AFTT model should be considered speculative; however, the Mannocci et al. (2016) model is more closely tied to regional data than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. Given its simplicity and the few historical sightings in the East Coast stratum, the AFTT model may be over-predicting the number of animals in the region, but the model appears to perform better than the RES data and is higher in the NMSDD hierarchy.

An abundance estimate of 13,485 individuals (CV=0.24) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 11,441 individuals (CV=0.83). This estimate is based on a summer 2009 oceanic shipboard survey (Waring et al. 2013). In TAP Phase II, a NODES estimate of 12,802 individuals (summer value, CV not available) was used. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) estimate was somewhat higher than NOAA's most recent estimate; however, it was within the confidence limits of NOAA's estimate. A spatial density model versus a single density estimate is higher in the NMSDD hierarchy than a single estimate and the Roberts et al. (2016) estimate incorporates more recent data, therefore, the Roberts et al. (2016) estimate was chosen over the SAR and NODES estimates.

An abundance estimate of 171,618 individuals (CV=0.17) was derived from the AFTT stratum model (Mannocci et al. 2016). Because the AFTT stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of this stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

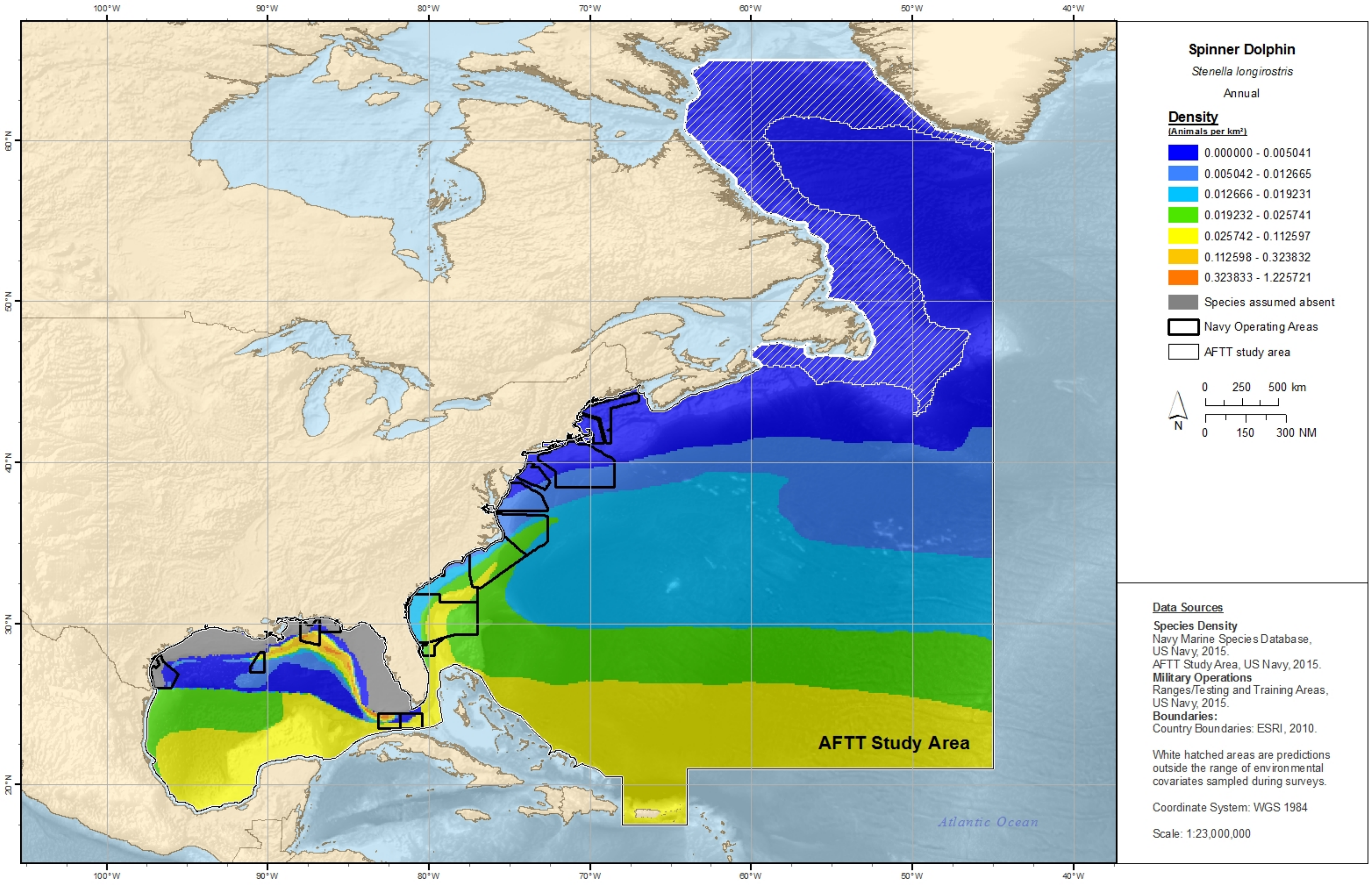


Figure 4-113. Annual density prediction for spinner dolphins for the East Coast, Gulf of Mexico and AFTT strata.

Striped dolphin (*Stenella coeruleolba*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). Density spatial models were fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. No seasons were defined for this species given a lack of clearly defined seasonality. The temporal resolution of the density predictions was annual for the East Coast, Gulf of Mexico, and AFTT strata.

Survey Data and Selected Models

In the East Coast stratum, a total of 195 sightings from the combined survey data were used for model development. A contemporaneous model explained more deviance than the climatological models and was selected for the East Coast stratum. The contemporaneous model was also selected as the best model because the model did not exhibit a large peak in abundance far offshore (between 33-37 N) in May like the climatological models exhibited for the species (Roberts et al. 2016).

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 92 total sightings. The sightings were limited almost exclusively to regions off the continental shelf and as such the model was limited to areas deeper than the 100m isobaths. The climatological models consistently explained more deviance than models fitted with contemporaneous covariates, had a higher explanatory power, and a more stable abundance prediction.

The model for the AFTT stratum used the same sightings from the East Coast and Gulf of Mexico models, as well as one sighting from the Caribbean, 36 sightings from Europe, and 12 sightings from the Mid-Atlantic ridge. The best fitting model included depth, chlorophyll concentration, distance to fronts and SEAPODYM potential epipelagic micronekton production as predictors (Mannocci et al. 2016). Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions in the northern offshore waters appear to be an underestimate given the species' preference for deep waters and strong currents (e.g. the Gulf Stream) (Archer 2009). However, model predictions in the southern Gulf of Mexico are consistent with the known occurrence of the species based on strandings (Ortega-Ortiz 2002).

Other Density Estimates:

A year-round abundance estimate of 75,657 individuals (CV=0.21) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 54,807 individuals (CV=0.30). This estimate is based on June-August NEFSC and SEFSC 2011 aerial and shipboard surveys that were conducted from the lower Bay of Fundy to central Florida (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. The CV of NOAA's abundance estimate indicates that the Roberts et al. (2016) estimate is within NOAA's confidence intervals. In TAP Phase II, a NODES estimate of 98,067 individuals (CV not available) based on survey data for the summer season from the southeast Atlantic was used, with SMRU RES data used elsewhere. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The East Coast stratum estimate is within the same order of magnitude and roughly comparable given the CV of the SAR estimate and seems more realistic than the Phase II data, which only covered a portion of the species range (southeast Atlantic). The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also higher in the NMSDD hierarchy than the SAR estimate, which used only a single season (June-August) of one year of survey data and produced a stratified estimate.

An abundance estimate of 4,914 individuals (CV=0.17) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). Other density estimates in or near the Gulf of Mexico stratum include: The NOAA SAR estimates of 1,849 individuals (CV=0.77) based on a 2009 oceanic shipboard survey and 6,506 individuals (CV=0.43) based on 1996-2001 oceanic shipboard surveys (Waring et al. 2013). In TAP Phase II, a NODES estimate of 80,180 individuals (CV not available) based on survey data for the spring season was used, with SMRU RES data used elsewhere. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) estimate falls within the range of the two most recent NOAA SAR estimates and both Roberts et al. (2016) and NOAA's estimates are much lower than the NODE estimate used in Phase II. A spatial density model versus a single density estimate is higher in the NMSDD hierarchy than a single estimate and the Roberts et al. (2016) estimate incorporates more recent data, so the Roberts et al. (2016) estimate was chosen over the SAR and NODES estimates.

An abundance estimate of 319,952 individuals (CV=0.16) was derived from the AFTT stratum model (Mannocci et al. 2016). Because the AFTT stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of this stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU RES data) and as such is expected to provide more realistic density estimates than those datasets.

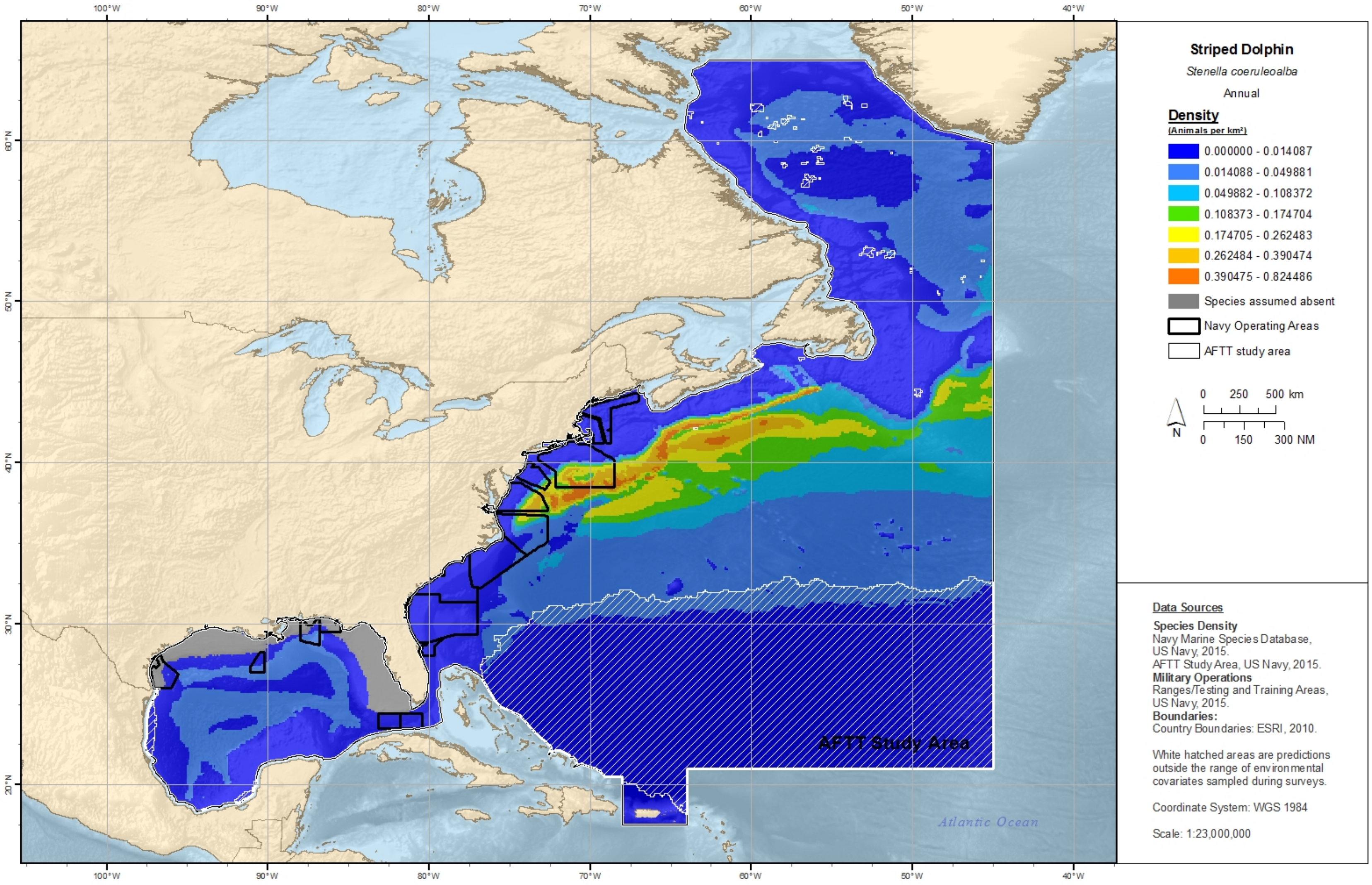


Figure 4-114. Annual density prediction for the striped dolphin for the East Coast, Gulf of Mexico and AFTT strata.

White-beaked dolphin (*Lagenorhynchus albirostris*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from extrapolative density spatial models developed by Mannocci et al. (2016). Few (N=12) sightings were available in the East Coast stratum and the researchers felt the AFTT model was more representative of this species in that stratum than a designed-based density estimate. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region. No seasons were defined in the AFTT extrapolative model given a lack of sightings and a lack of clearly defined seasonality. The temporal resolution of the density predictions was annual for the model.

Survey Data and Selected Models:

The model for the AFTT stratum used the East Coast stratum sightings (N=12). No sightings were available from other regions. The best fitting model included SEAPODYM potential zooplankton biomass and SEAPODYM potential epipelagic micronekton production as predictors (Mannocci et al. 2016). Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of the species based on sightings (Lawson and Gosselin 2009; Heide-Jørgensen et al. 2008, and Hansen and Heide-Jørgensen 2013).

Other Density Estimates:

The Mannocci et al. (2016) AFTT density spatial model predicts 39 individuals (CV not available) in the East Coast stratum. The most recent and only NOAA SAR estimate is 2,003 individuals (CV=0.94). This estimate is based on a 2006 aerial survey that only covered a portion of the species range (Southern Gulf of Maine to Bay of Fundy and Gulf of St. Lawrence), in which only five sightings were recorded (Waring et al. 2007). Stratified abundance estimates from the literature suggest that the Mannocci et al. (2016) model largely underestimates this species abundance in the northern waters of the AFTT area (Lawson and Gosselin 2009 and Hansen and Heide-Jørgensen 2013). However, a density spatial model versus a stratified estimate is higher in the NMSDD hierarchy. Annual SMRU RES data were used in TAP Phase II and predicted 6,310 individuals (summer value, CV not available) in the East Coast stratum. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Mannocci et al. (2016) is lower than SAR and SMRU RES estimates used in Phase II. The most likely reason for the discrepancy between the Mannocci et al. (2016) and the NOAA SAR estimates is that NOAA's estimate was based on a certain year that white-beaked dolphins were sighted, and did not account for their total absence in other years. Because of the lack of sightings in the East Coast stratum, a stratified model could not be fit and the AFTT model should be considered speculative. However, the Mannocci et al. (2016) model is more closely tied to regional data than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

An abundance estimate of 599 individuals (CV=0.27) was derived from the AFTT stratum model (Mannocci et al. 2016). Because the AFTT stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of this stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast stratum than global density estimates used in the past (such as the SMRU RES data) and as such is expected to provide more realistic density estimates than those datasets.

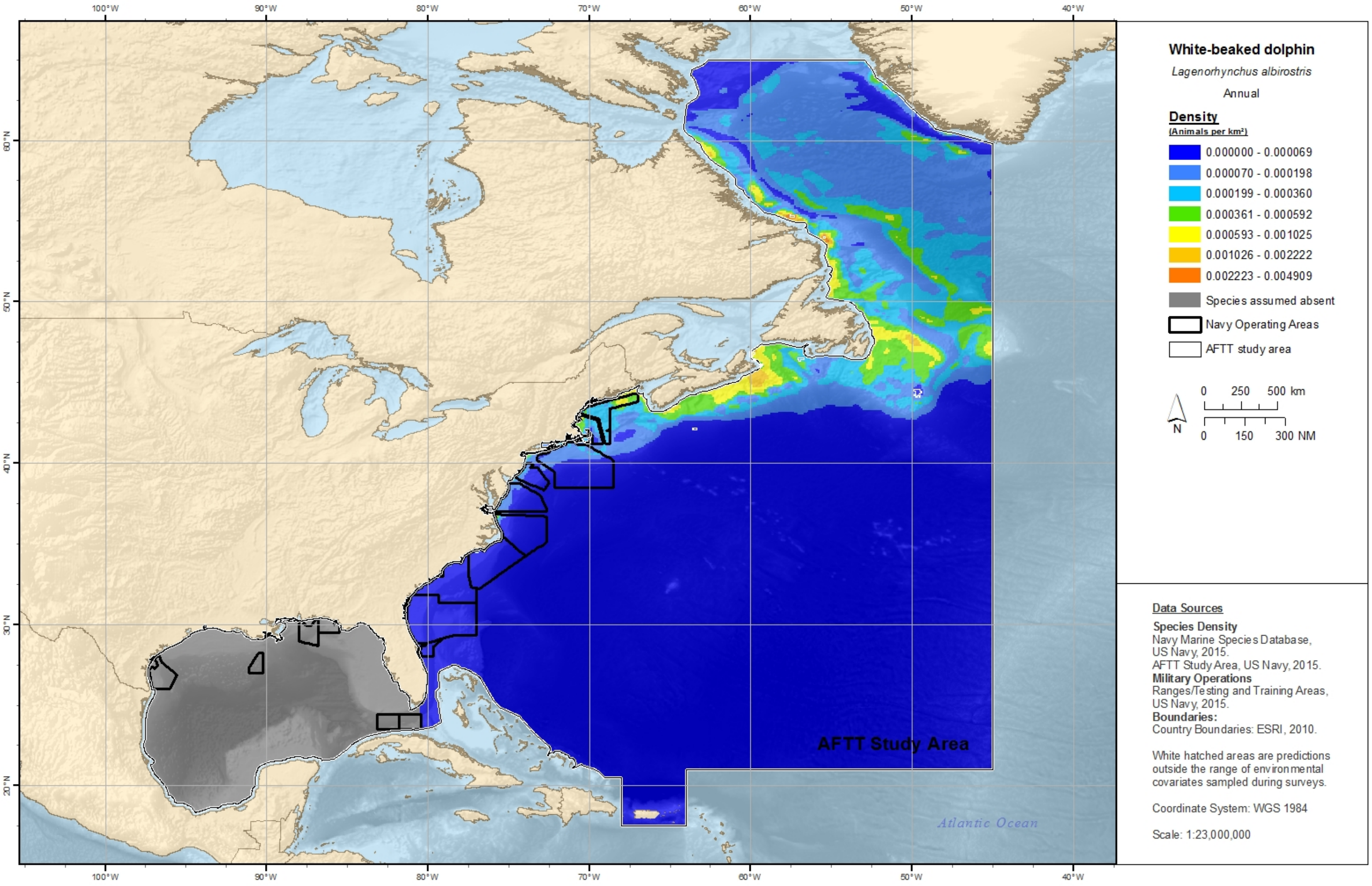


Figure 4-115. Annual density prediction for white-beaked dolphins in the East Coast and AFTT strata.

4.4 PORPOISES

Harbor porpoise (*Phocoena phocoena*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). A density spatial model was fit for the East Coast stratum. An extrapolative density spatial model was fit for the AFTT stratum. This species is assumed absent in the Gulf of Mexico stratum given a historical lack of sightings data in that region. In the East Coast, Roberts et al. (2016) defined seasons based on the seasonal variation in distribution summarized by Palka et al. (1996), and on patterns in sightings observed in the surveys, with winter spanning November through May and summer spanning June through October. No seasons were defined in the AFTT extrapolative model as seasonal patterns outside surveyed regions are not defined. The temporal resolution of the density predictions was monthly in the East Coast stratum and annual in the AFTT stratum.

Survey Data and Selected Models:

In the East Coast stratum, a total of 2,018 sightings from the combined survey data were used for model development. The climatological models consistently explained more deviance than models fitted with contemporaneous covariates in both seasons. However, the best climatological models and the best contemporaneous model predicted very similar spatial distributions and with differences primarily in abundance (Roberts et al. 2016).

The model for the AFTT stratum used the same sightings from the East Coast model, as well as 280 sightings from Europe. The best fitting model included slope, depth, SEAPODYM potential zooplankton and biomass production, and sea surface height anomalies as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the known occurrence of the species based on sightings and strandings (Bryd et al. 2014; Palka et al. 1996; Lawson and Gosselin 2009; and Hansen and Heide-Jørgensen 2013).

Other Density Estimates:

An abundance estimate of 45,089 individuals (summer season, CV=0.12) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 79, 883 individuals (CV=0.32). This estimate is based on summer 2011 NEFSC and SEFSC aerial surveys (Waring et al. 2013). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. In TAP Phase II, the NODES estimate of 142, 734 individuals (summer season, no CV available) based on survey data for the summer season was used, with SMRU RES data used elsewhere. While direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used, the East Coast stratum population is within the same order of magnitude and roughly comparable given the CVs as the SAR and seems more realistic than the Phase II data which included RES data in non-summer seasons. The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also preferable to the SAR estimate which uses only a single season of one year of survey data and provides only a single density value estimate for the northern east coast of the Atlantic which is less desirable in the NMSDD data hierarchy. The lower predicted abundance for the Roberts et al. (2016) model is largely attributable to the inclusion of surveys not particularly well suited for sighting harbor porpoises but that provided important temporal coverage (Roberts et al. 2016).

An abundance estimate of 207,907 individuals (CV=0.46) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

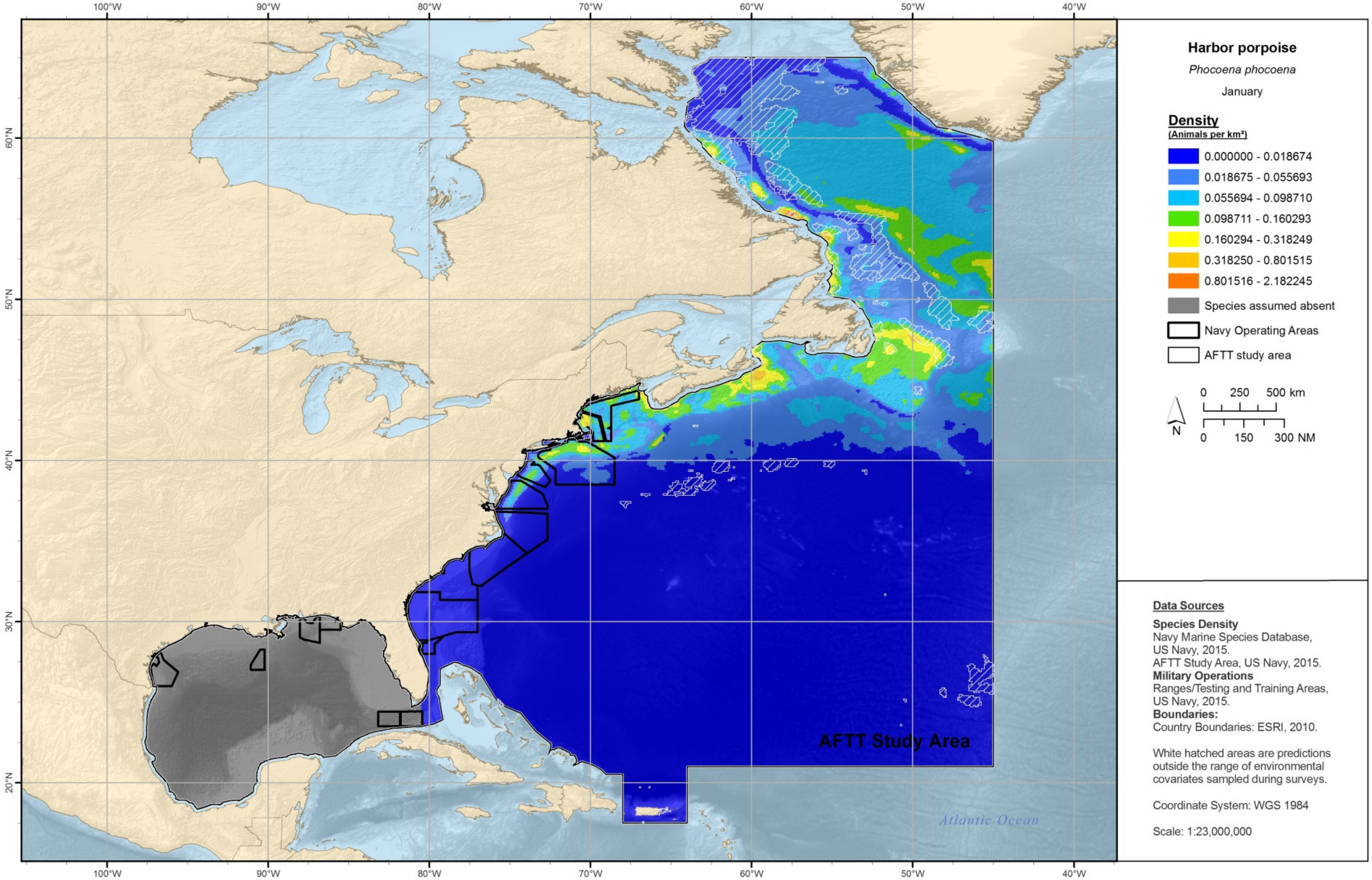


Figure 4-116. January density prediction for harbor porpoise for the East Coast and AFTT strata.

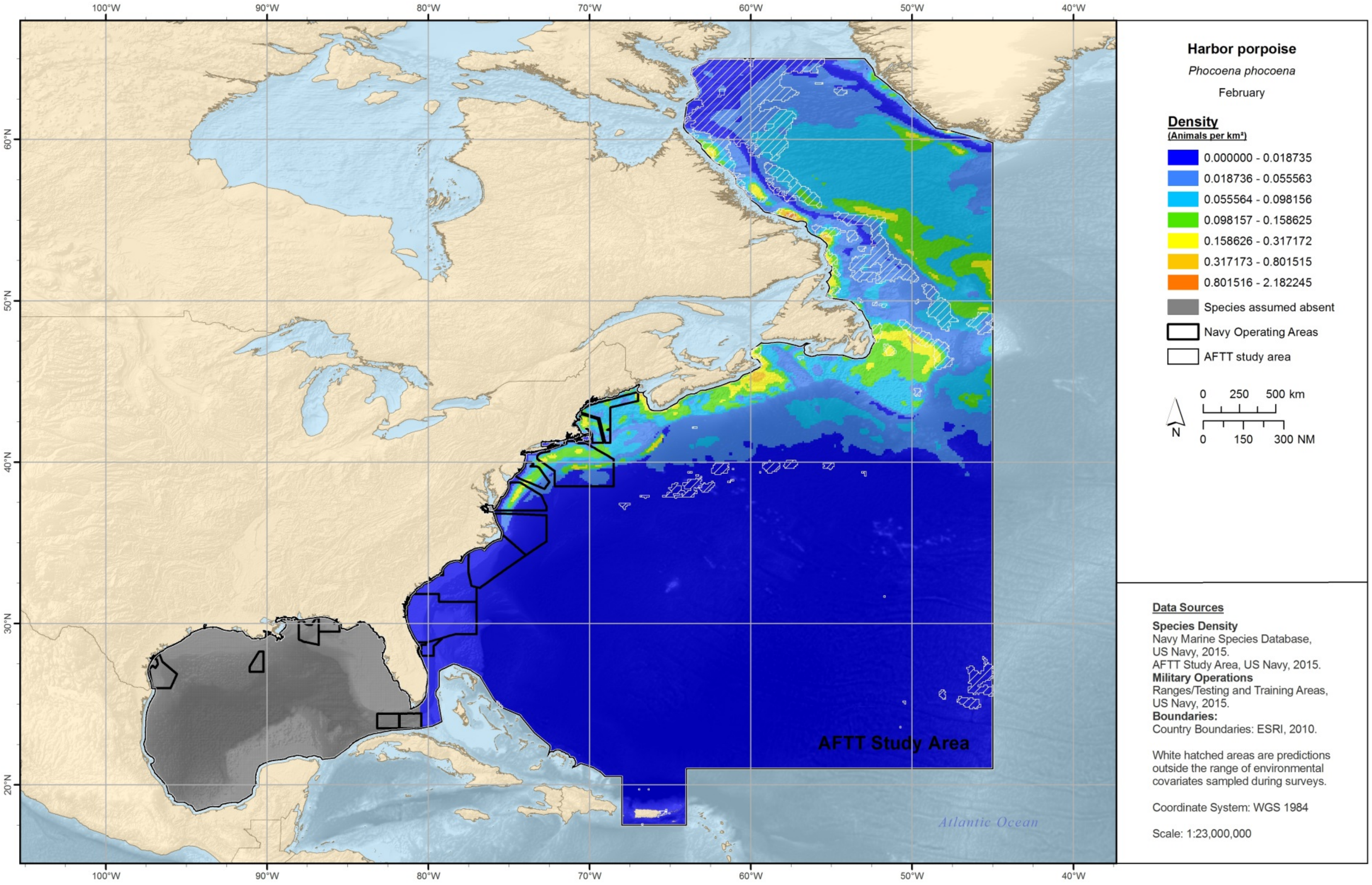


Figure 4-117. February density prediction for the harbor porpoise for the East Coast and AFTT strata.

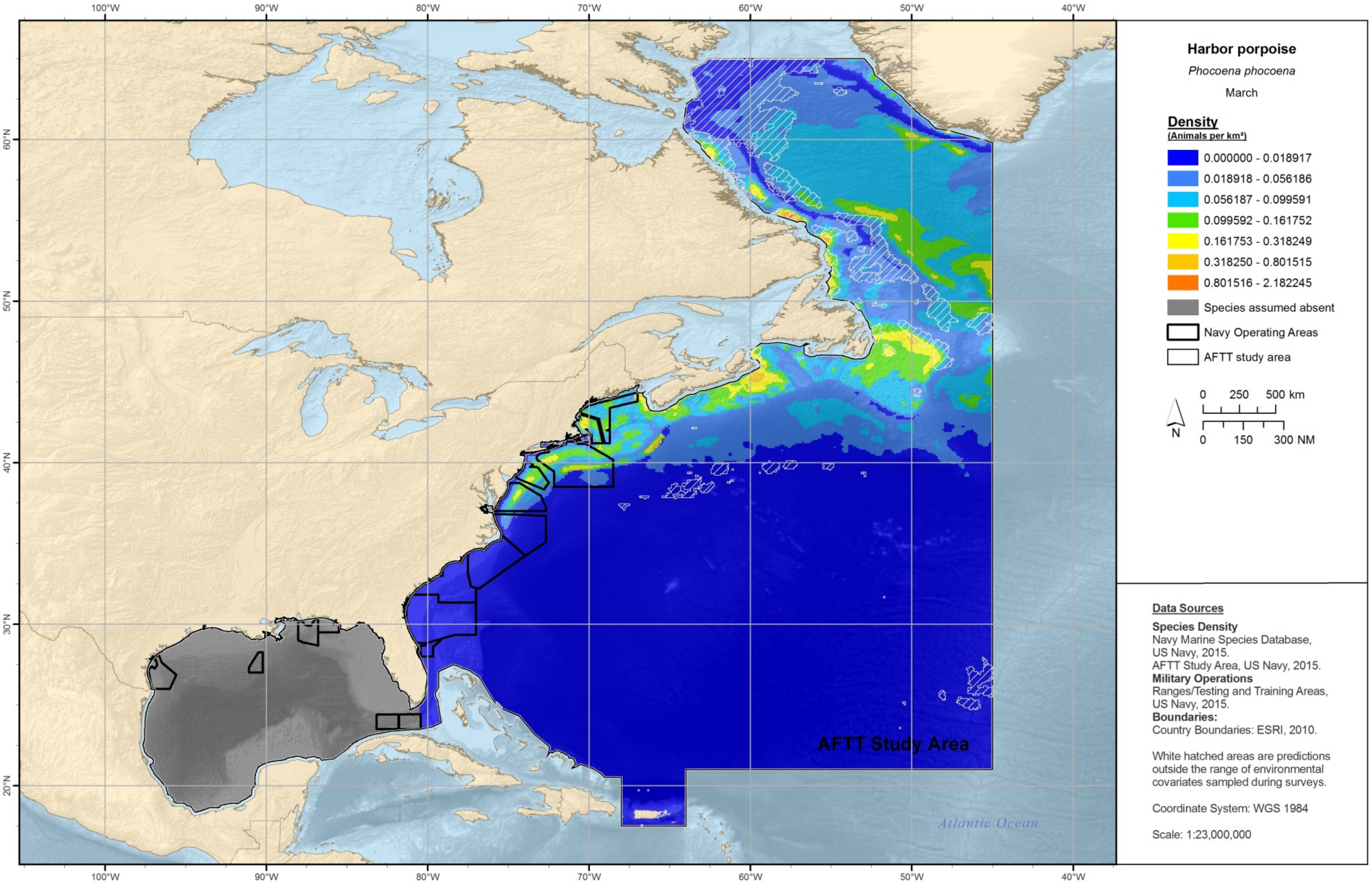


Figure 4-118. March density prediction for harbor porpoises for the East Coast and AFTT strata.

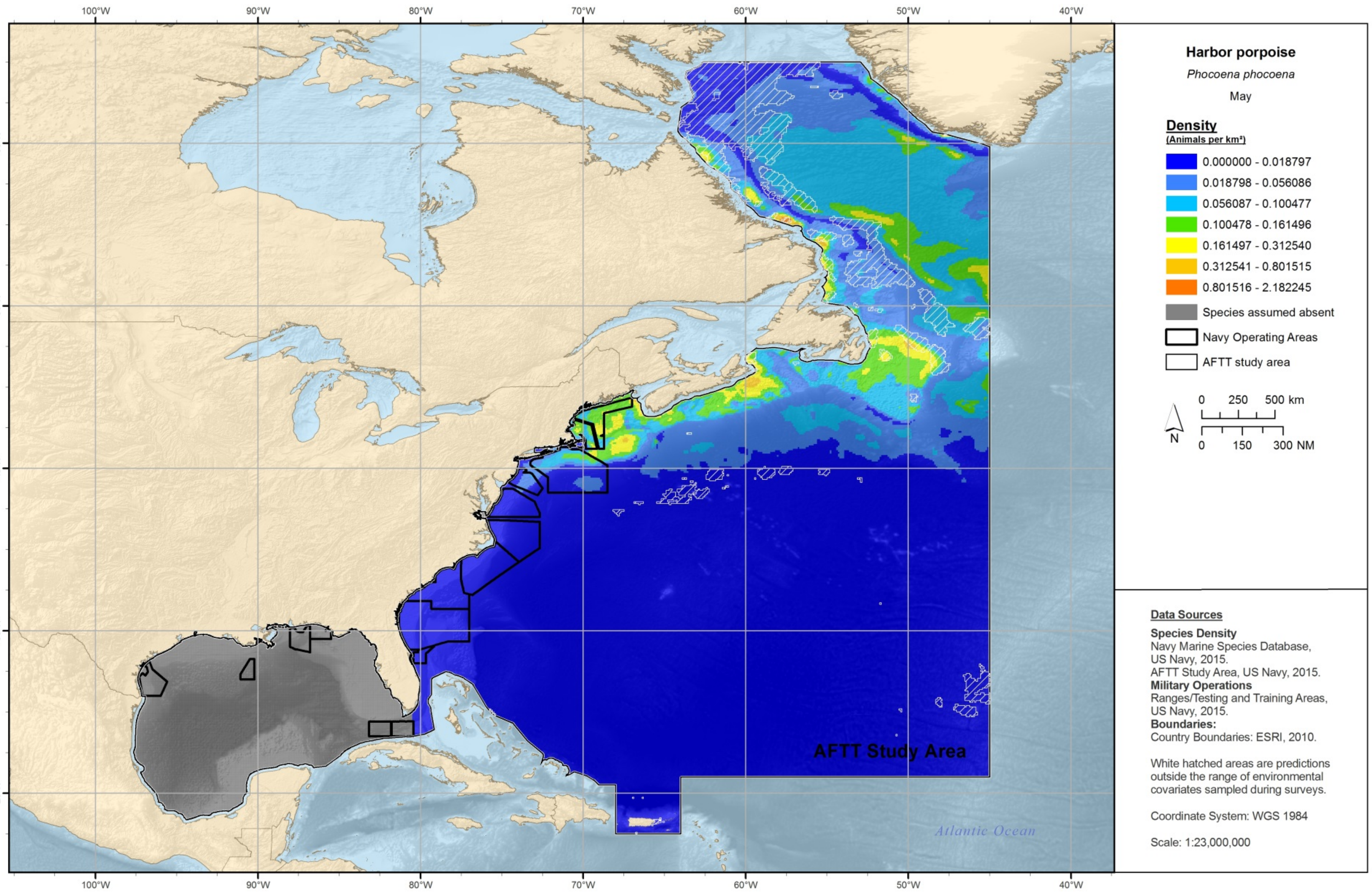


Figure 4-119. April density prediction for harbor porpoises for the East Coast and AFTT strata.

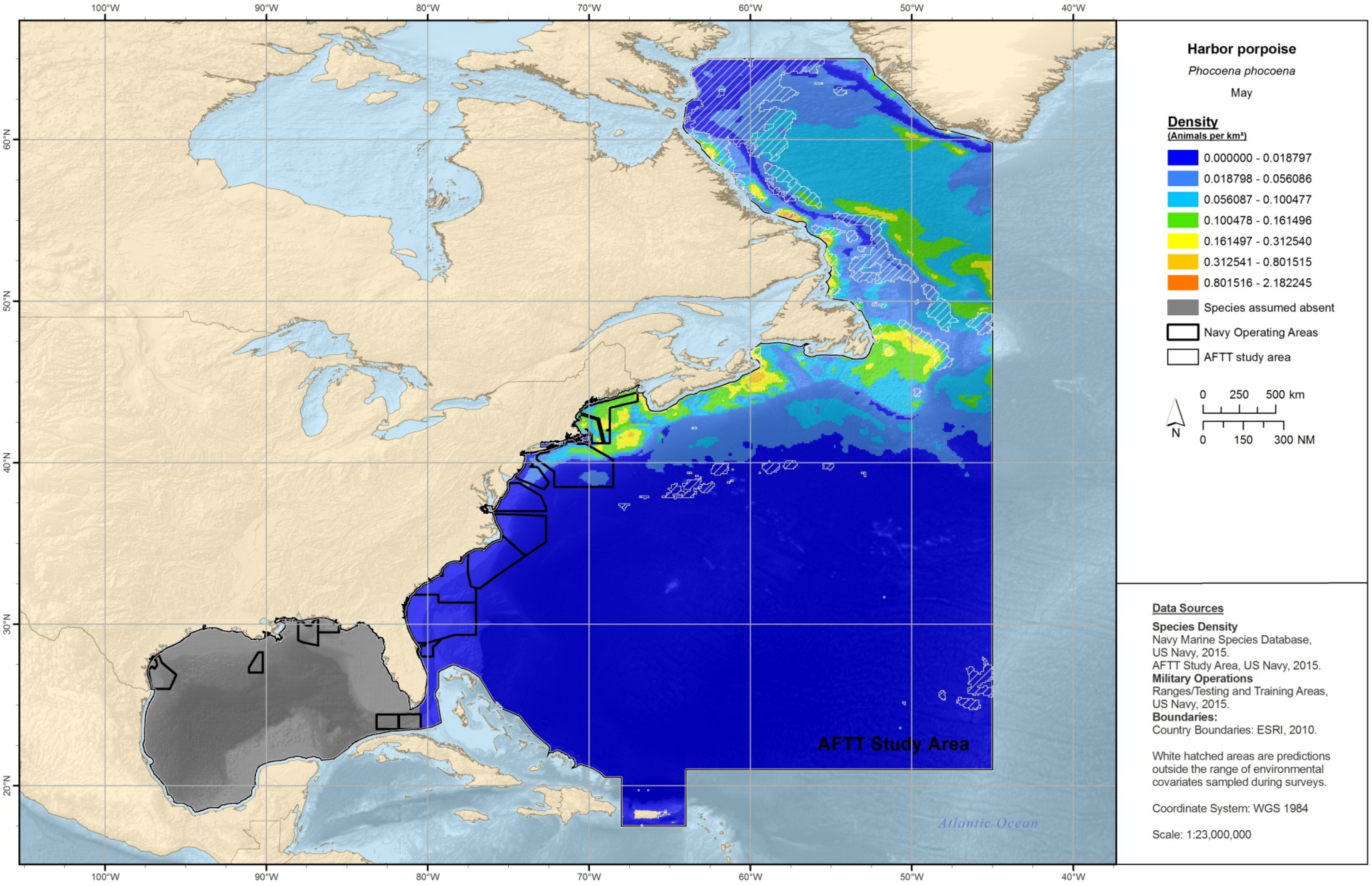


Figure 4-120. May density prediction for harbor porpoises for the East Coast and AFTT strata.

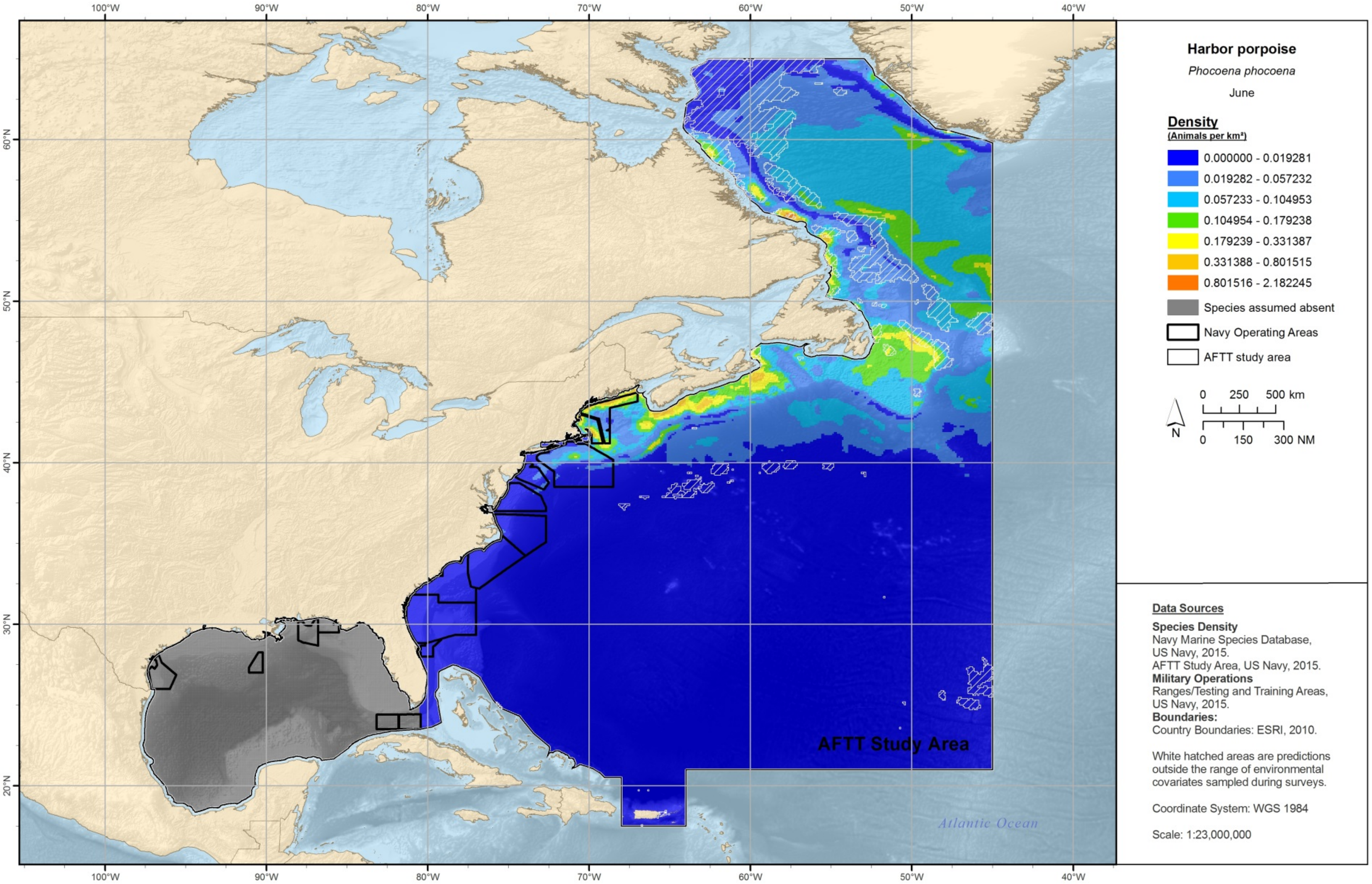
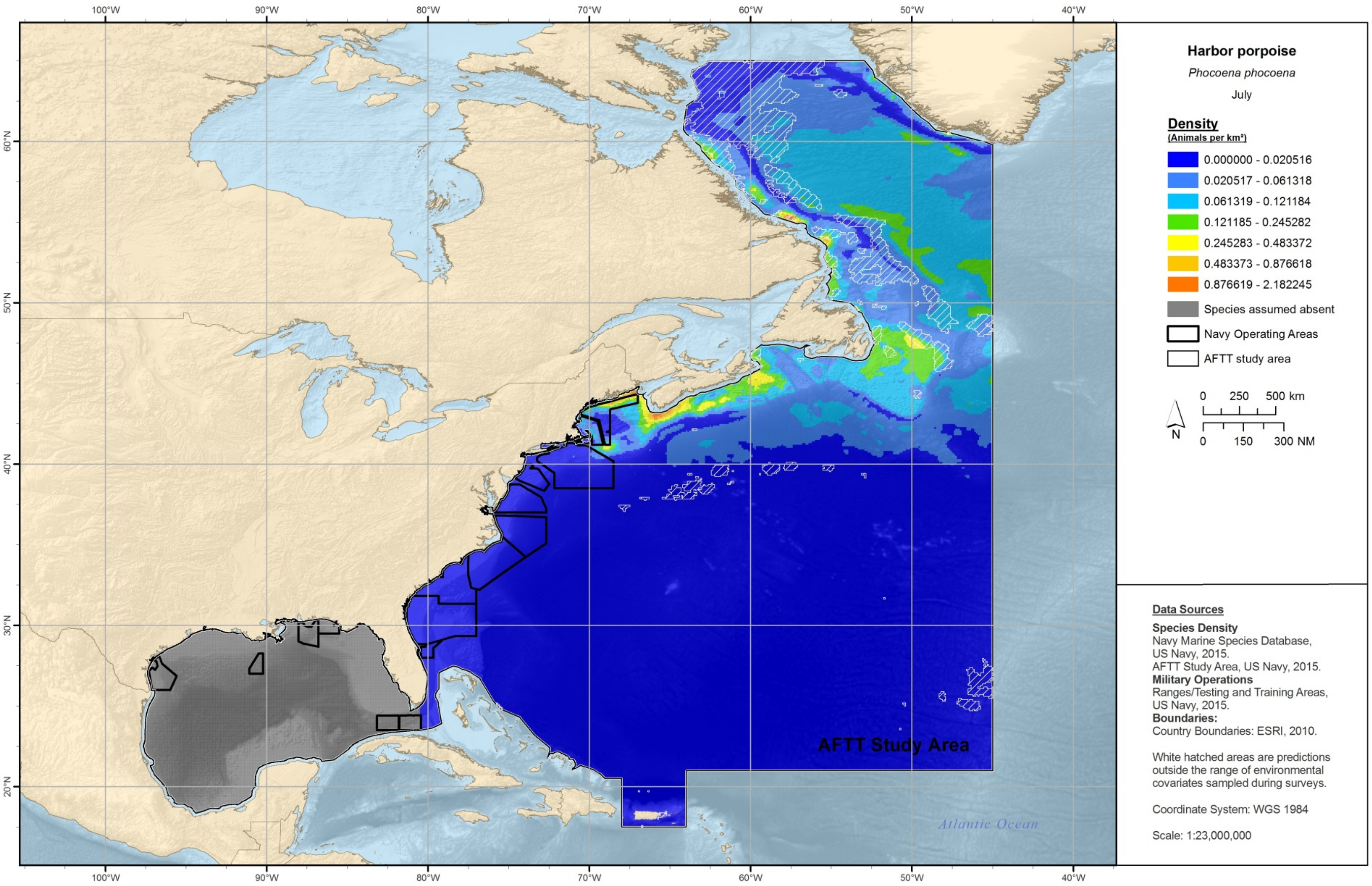


Figure 4-121. June density prediction for harbor porpoises for the East Coast and AFTT strata.



Data Sources

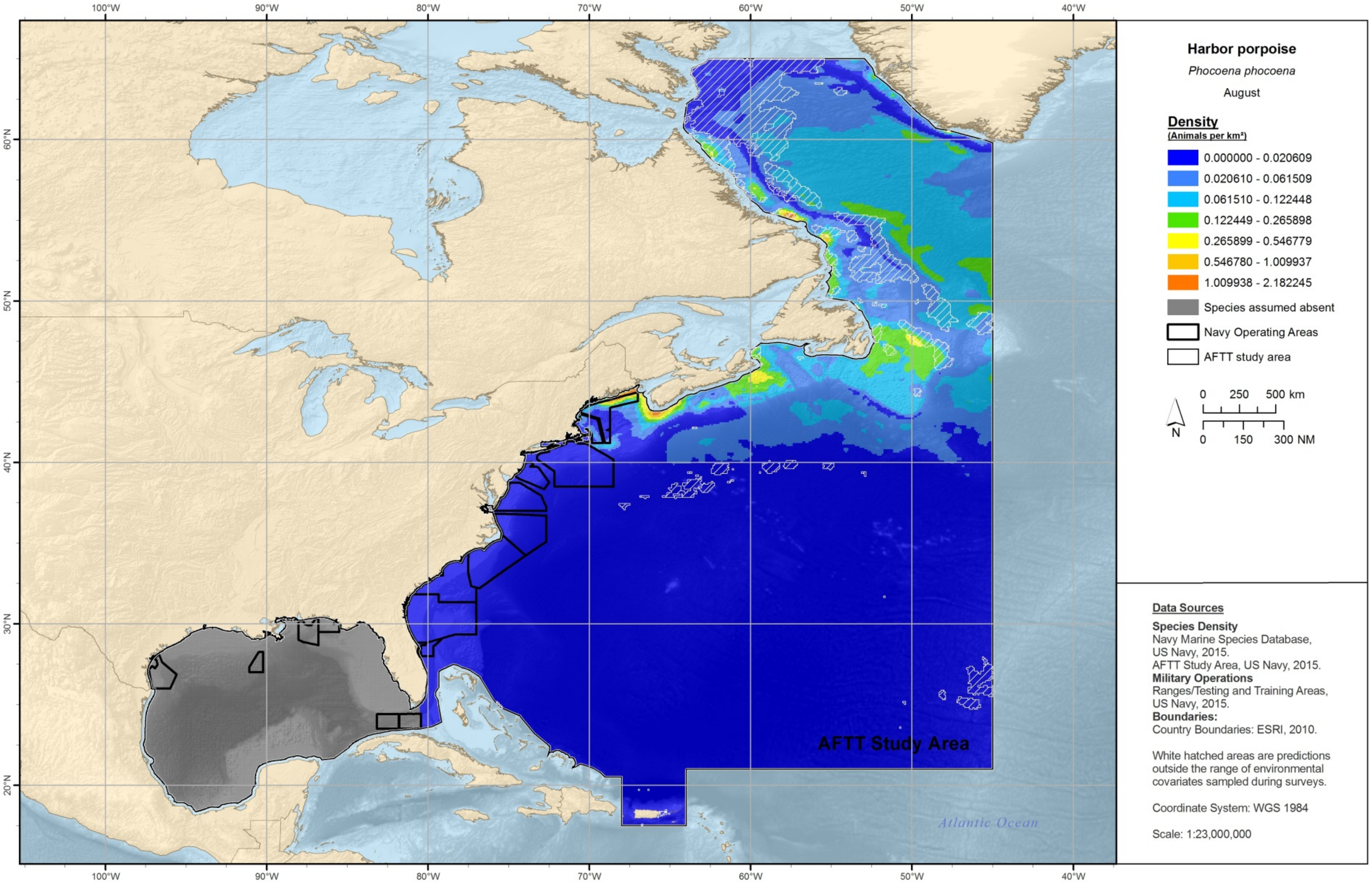
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-122. July density prediction for harbor porpoises for the East Coast and AFTT strata.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-123. August density prediction for harbor porpoises for the East Coast and AFTT strata.

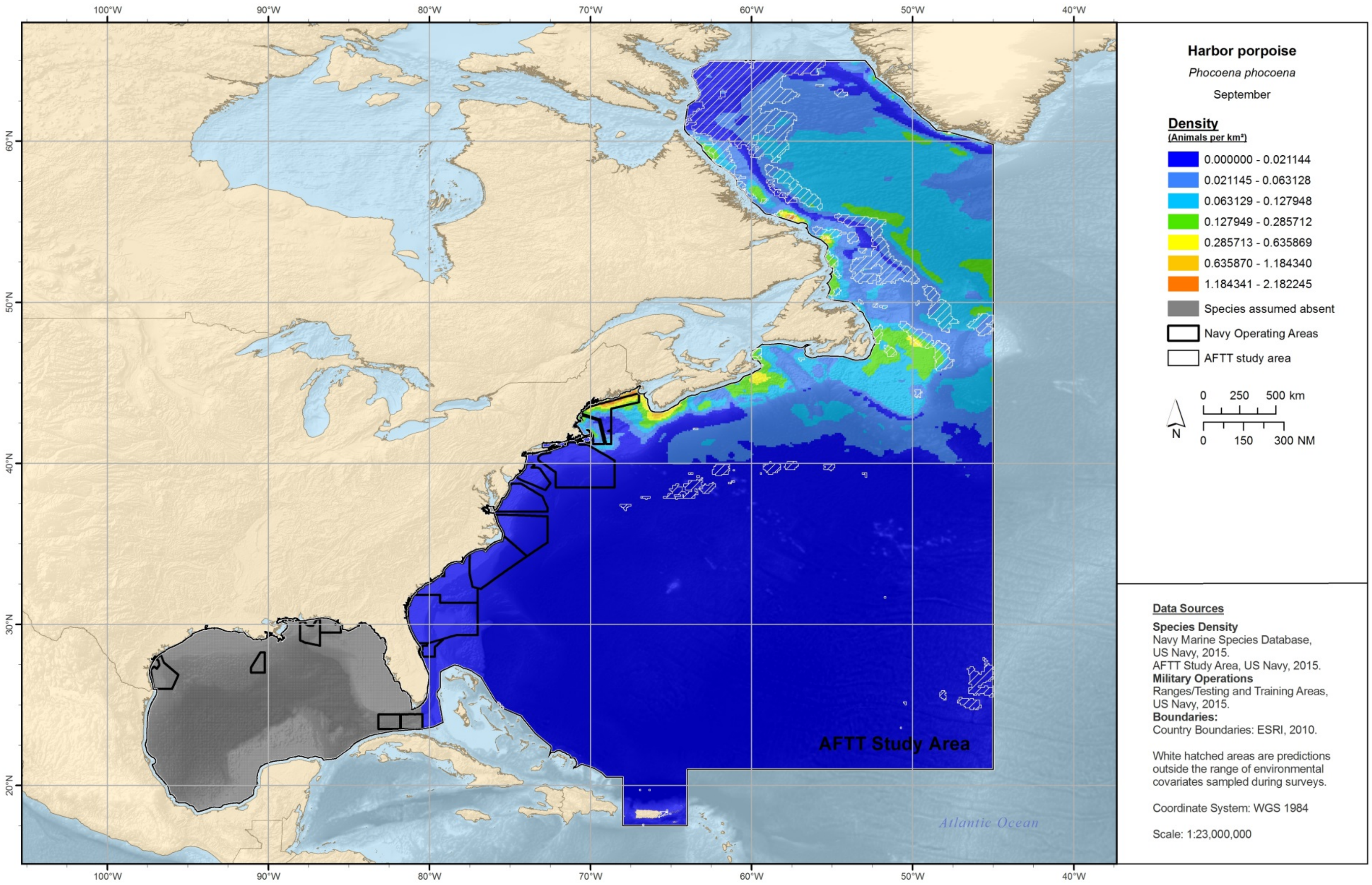


Figure 4-124. September density prediction for harbor porpoises for the East Coast and AFTT strata.

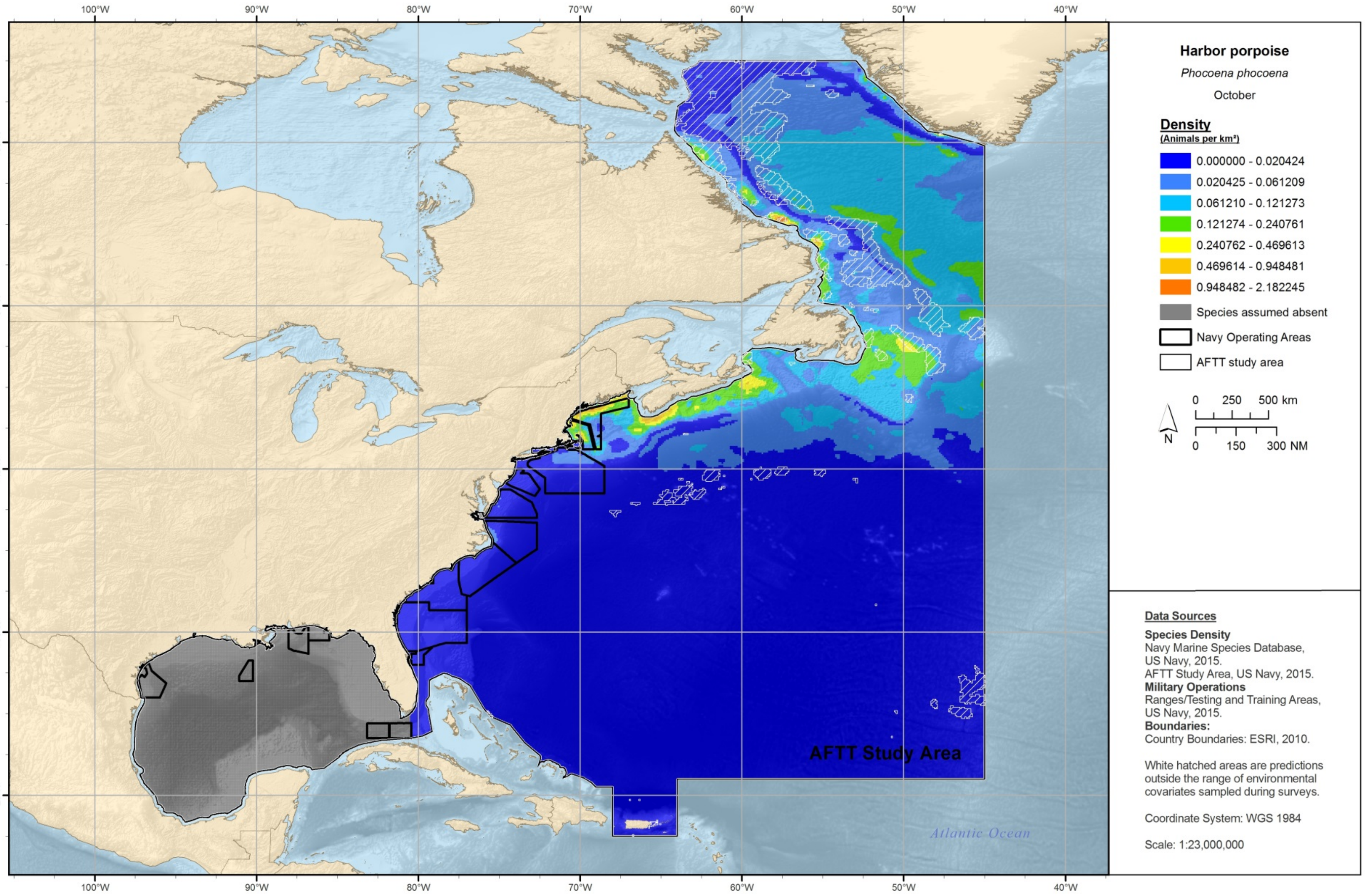


Figure 4-125. October density prediction for harbor porpoises for the East Coast and AFTT strata.

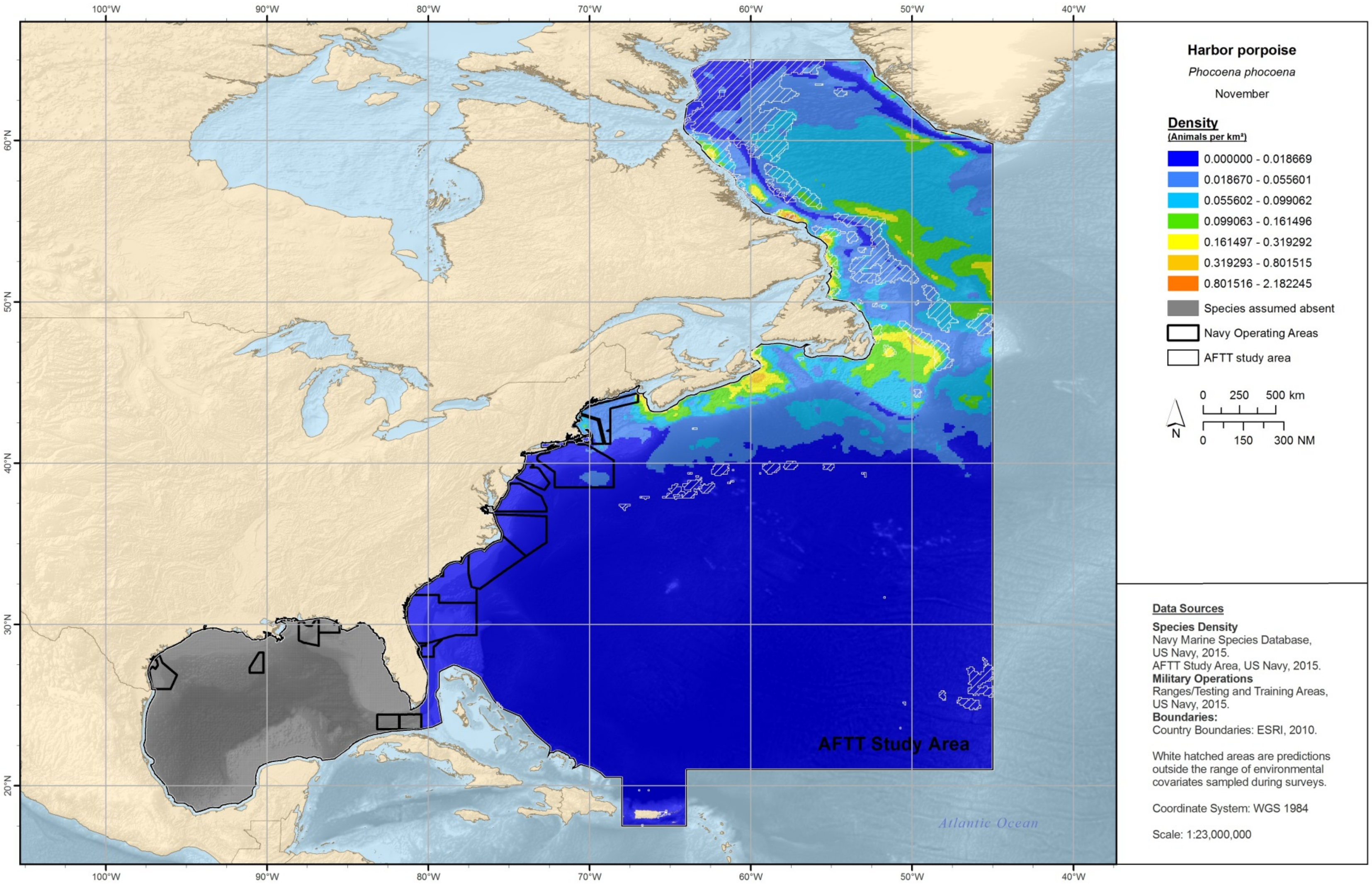


Figure 4-126. November density prediction for harbor porpoises for the East Coast and AFTT strata.

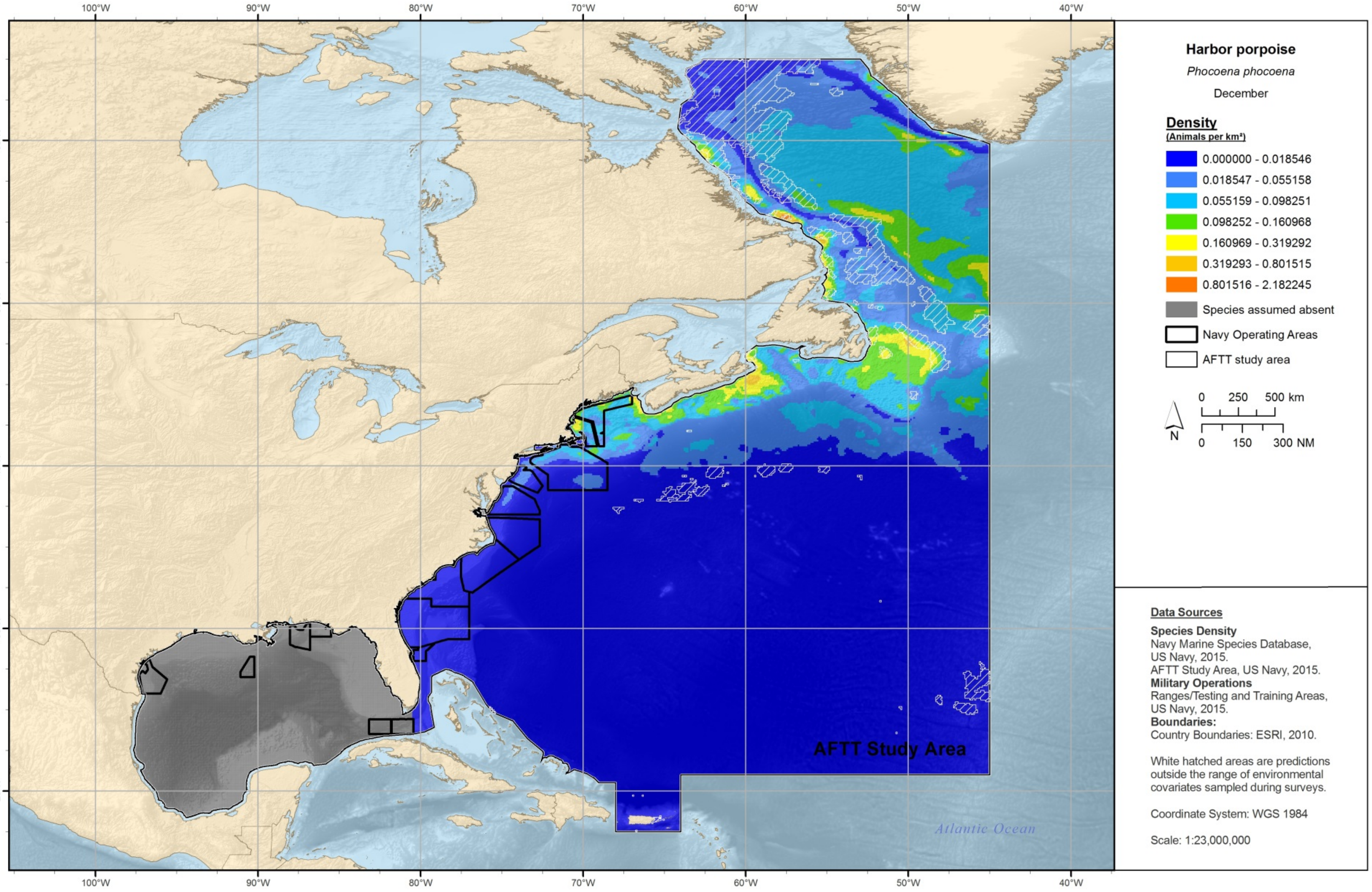


Figure 4-127. December density prediction for harbor porpoises for the East Coast and AFTT strata.

4.5 SMALL WHALES

Beluga whale (*Delphinapterus leucas*)

Because of their extremely limited distribution within the AFTT Study Area, impacts to beluga whales are assessed qualitatively in the document. As such, no density data for beluga whales were analyzed.

Narwhal (*Monodon monoceros*)

Because of their extremely limited distribution within the AFTTStudy Area, impacts to the narwhal are assessed qualitatively in the document. As such, no density data for the narwhal was analyzed.

4.6 SPERM WHALES

Kogia whales: dwarf sperm whale (*Kogia sima*) and pygmy sperm whale (*Kogia breviceps*)

Data Sources and Seasonality:
All density data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). These species are challenging to differentiate in the wild and share much of the same habitat (Jefferson and Shiro 1997). Most sightings available for these species were ambiguous. As such, they were modeled as a guild. A density spatial model was fit for the Gulf of Mexico stratum. An extrapolative density spatial model was fit for the AFTT stratum. Few sightings were available in the East Coast stratum and the researchers felt the AFTT model was more representative of this species in that stratum than a designed-based density estimate. No seasons were defined for this species given the lack of described seasonal movement patterns for this species. The temporal resolution of the density predictions was annual for both models.

Survey Data and Selected Models:
In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1992-2009 were used with 219 total sightings. This species is limited almost exclusively to regions off the shelf and as such the model was limited to areas deeper than the 100m isobaths. The climatological model explained more deviation than the contemporaneous model and was selected for the Gulf of Mexico stratum.

The model for the AFTT stratum used the Gulf of Mexico stratum sightings, as well as 31 sightings from the East Coast and 7 sightings from the Caribbean. The best fitting model included depth, epipelagic micronekton primary productivity, and SST as predictors. Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the described range of Kogia spp. in tropical and warm temperate waters, with preferences for the continental shelf and slope (McAlpine et al. 2009).

Other Density Estimates:
An abundance estimate of 2,234 individuals (CV=0.19) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The NOAA SAR estimates in recent years have varied between 742 and 186, with 186 (CV=1.04) individuals being the most recent, based on a 2009 shipboard survey of oceanic waters (Waring et al. 2013). In TAP Phase II, a NODES estimate of 2,458 individuals (summer value, CV

not available) was used. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) is much higher than SAR estimates and very similar to the NODE estimate used in Phase II. The most likely reason for the discrepancy between the Roberts et al. (2016) value and the SAR is that the SAR estimate assumed g(0)=1 whereas in the model used g(0) was assumed to be 0.35, which is likely a more accurate representation of availability for this species. Because of this, and because it is a spatial density model versus a single density estimate and as such is higher in the NMSDD hierarchy, the Roberts et al. (2016) estimate was chosen over the SAR.

An abundance estimate of 11,270 individuals (CV=0.17) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets.

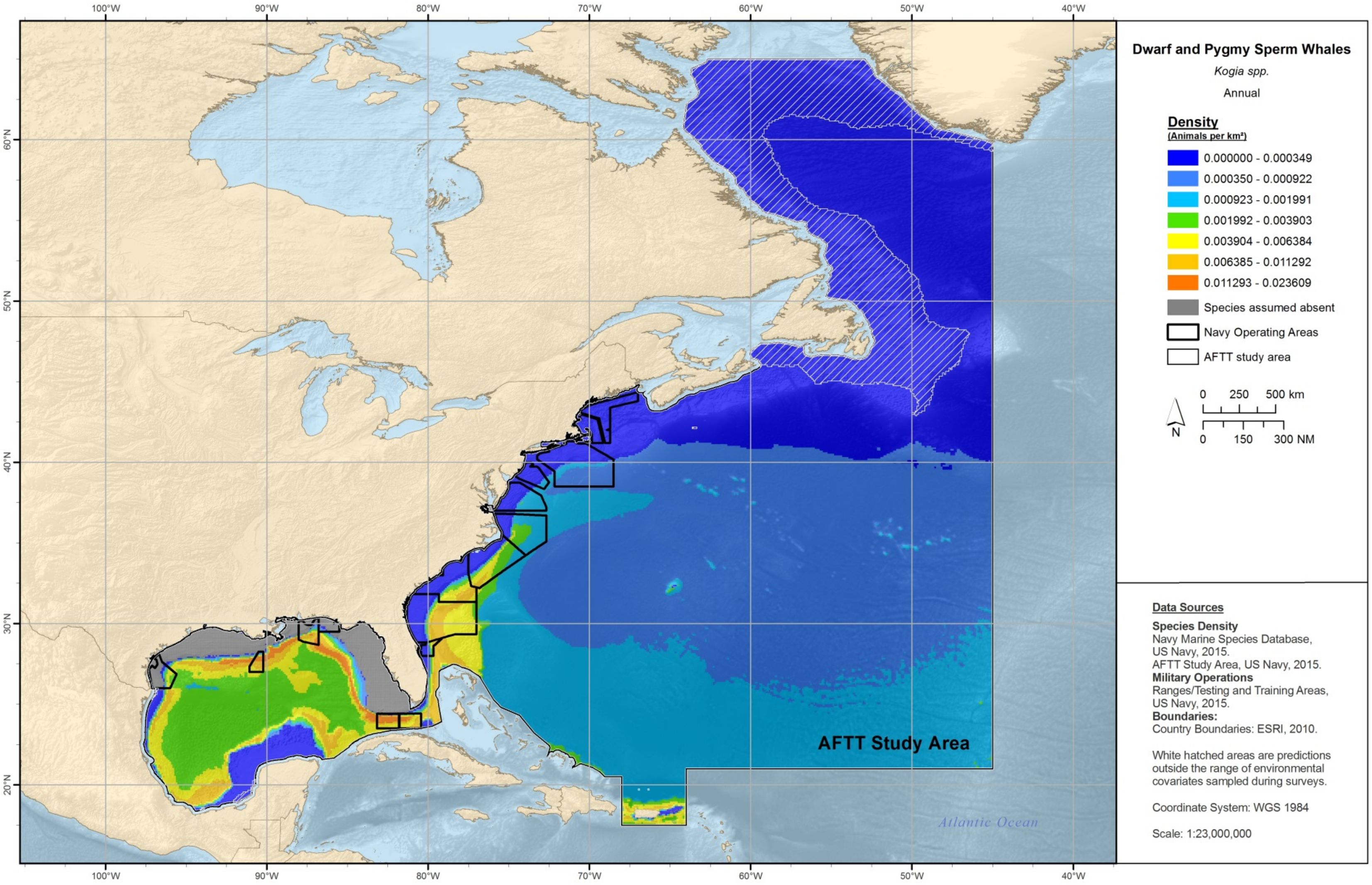


Figure 4-128. Annual density prediction for Kogia whales for the Gulf of Mexico and AFTT strata.

Sperm whale (*Physeter macrocephalus*)

Data Sources and Seasonality:

All data incorporated into the NMSDD for this species comes from density spatial models developed by Roberts et al. (2016) and extrapolative density spatial models developed by Mannocci et al. (2016). Density spatial models were fit for the East Coast and Gulf of Mexico strata. An extrapolative density spatial model was fit for the AFTT stratum. No seasons were defined for this species given a lack of clearly defined seasonality. The temporal resolution of the density predictions was monthly in the East Coast stratum and annual in the Gulf of Mexico and AFTT strata.

Survey Data and Selected Models:

In the East Coast stratum, a total of 501 sightings from the combined survey data were used for model development. The contemporaneous models explained more deviance than the climatological model and was selected for the East Coast stratum. The contemporaneous models did not predict a potentially spurious seasonal pattern off the shelf of Nova Scotia or exhibit a high standard error in that region as the climatological models did. The contemporaneous models predicted a high-in-summer, low-in-winter pattern, similar to the pattern suggested for the mid-Atlantic by Waring et al. (2014) (Roberts et al. 2016).

In the Gulf of Mexico stratum, data from SEFSC aerial and shipboard surveys spanning 1998-2009 were used with 222 total sightings. Roberts et al. (2016) assumed the species was always absent on the continental shelf due to the absence of sightings in this area; therefore, the model was fitted only to the off-shelf survey segments. The 100m isobath was used as the shelf break to ensure that the model included some segments that were shallower than the shallowest species sightings. The contemporaneous model explained more deviance than the climatological model and was selected for the Gulf of Mexico stratum. The contemporaneous model consistently outperformed the climatological model that considered the same survey segments, and the model results are consistent with former studies that confirmed important environmental factors (e.g. eddies and continental slope) for sperm whale distribution in this region (Biggs et al. 2005 and Jochens et al. 2008).

The model for the AFTT stratum used the same sightings from the East Coast and Gulf of Mexico strata sightings, as well as 34 sightings from the Caribbean, and 49 sightings from the Mid-Atlantic ridge. The best fitting model included depth, chlorophyll-a concentration, and distance to submarine canyon or seamount (Mannocci et al. 2016). Density predictions from the final model were made for regions where the range of environmental covariates were outside those sampled by the sighting data and thus predictions for these regions should be considered extremely speculative. Model predictions are consistent with the cosmopolitan distribution of the species and its preference for deep waters (Whitehead 2009). Model predictions are also consistent with the known occurrence of the species based on sightings (Whitehead et al. 1992; Hooker et al. 1999; Reeves and Whitehead 1998; Ortega-Ortiz 2002; and Mignucci-Giannoni 1998) and passive acoustic monitoring (Wong 2012).

Other Density Estimates:

An abundance estimate of 5,353 individuals (CV=0.12) was derived from the East Coast stratum model (Roberts et al. 2016). The most recent estimate from a NOAA SAR is 2,288 individuals (CV=0.28). This estimate is based on June-August 2011 aerial and shipboard surveys that were conducted from the lower Bay of Fundy to central Florida (Waring et al. 2014). Note that these data were not available to the modeling team that produced the Roberts et al. (2016) and Mannocci et al. (2016) models at the time of release. The SAR estimate was not corrected for dive-time and thus, not corrected for g(0), therefore, the estimate is likely downwardly biased and an underestimate of actual abundance (Waring et al. 2015). In TAP Phase II, the NODES estimate of 7,803 individuals (summer season, CV not available) based on survey data for the summer season from the southeast Atlantic was used, with SMRU RES data used elsewhere. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. The EC stratum estimate seems more realistic than the Phase II data, which only covered a portion of the species range (southeast Atlantic). The Roberts et al. (2016) estimate was chosen over the NODES model as it incorporates more recent data and methods not available when the NODES model was developed. It is also higher in the NMSDD hierarchy than the SAR estimate, which used only a single season (June-August) of one year of survey data and produced a stratified estimate without incorporating g(0).

In the Gulf of Mexico stratum, an abundance estimate of 2,128 individuals (CV=0.08) was derived from the Gulf of Mexico stratum model (Roberts et al. 2016). The most recent NOAA SAR estimate is 763 individuals (CV=0.38) based on a 2009 oceanic shipboard survey covering waters (Waring et al. 2013). In TAP Phase II, a NODES estimate of 4,981 individuals (CV not available) based on survey data for the spring season was used, with SMRU RES data used elsewhere. Direct comparisons between models are difficult due to factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. In this case, the Roberts et al. (2016) estimate is higher than earlier abundance estimates, which ranged from 763 individuals in 2009 (Waring et al. 2013) to 1,665 individuals in 2004 (Mullin 2007). These earlier estimates did not account for g(0), instead they assumed that g(0)=1. If these estimates were rescaled to the Roberts et al. (2016) g(0) estimate of 0.53, they would range from 1440-3142 and be very similar to the Roberts et al. (2016) estimate statistically. A spatial density model versus stratified estimate is higher in the NMSDD hierarchy than a single estimate or RES data and the Roberts et al. (2016) estimate incorporates more recent data, therefore, the Roberts et al. (2016) estimate was chosen over the SAR and NODES estimates.

An abundance estimate of 71,547 individuals (CV=0.09) was derived from the AFTT stratum model (Mannocci et al. 2016). Because the AFTT stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of this stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the East Coast and Gulf of Mexico strata than global density estimates used in the past (such as the SMRU RES data) and as such is expected to provide more realistic density estimates than those datasets.

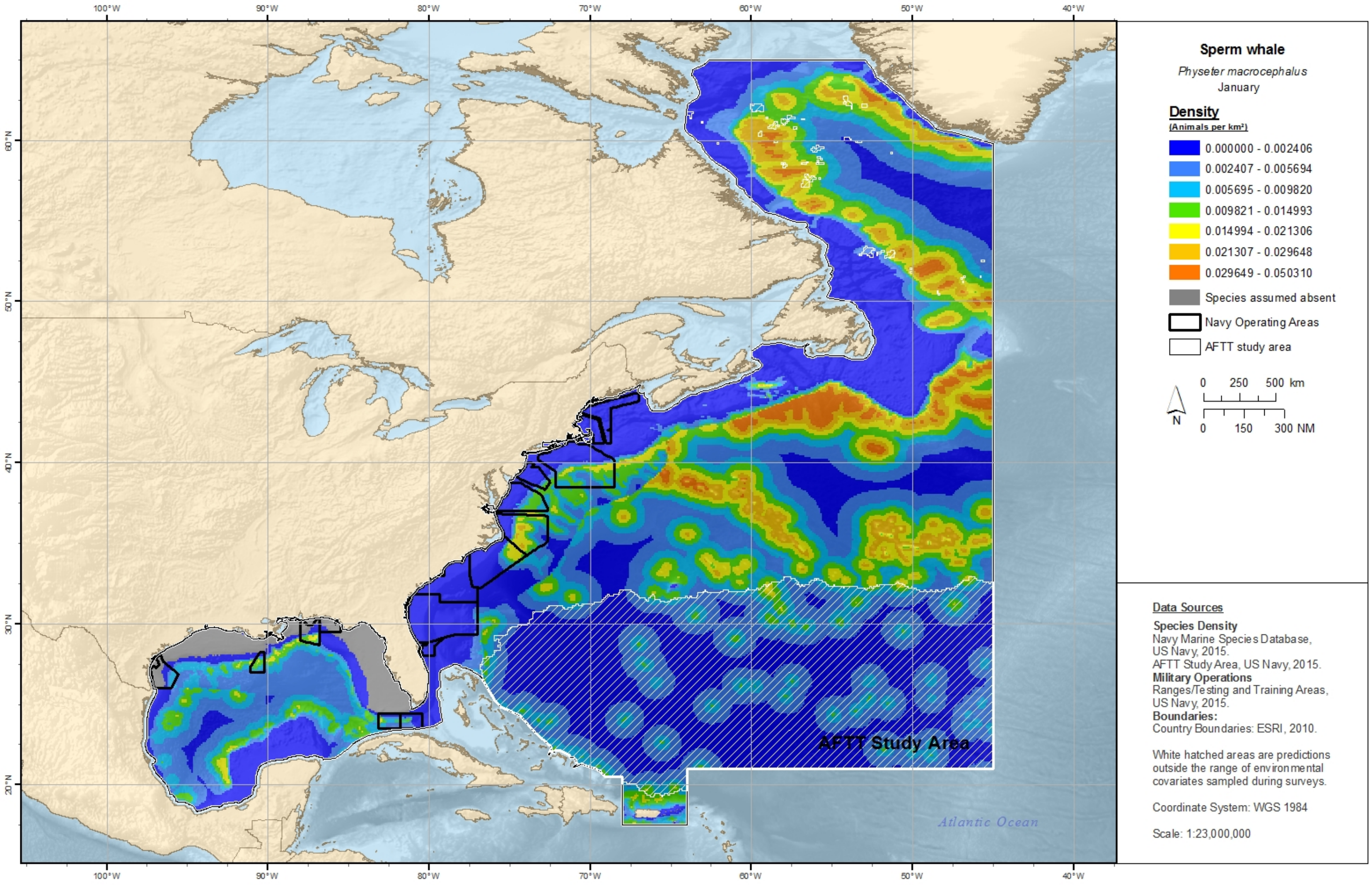


Figure 4-129. January density prediction for the sperm whale in the Gulf of Mexico, East Coast and AFTT strata.

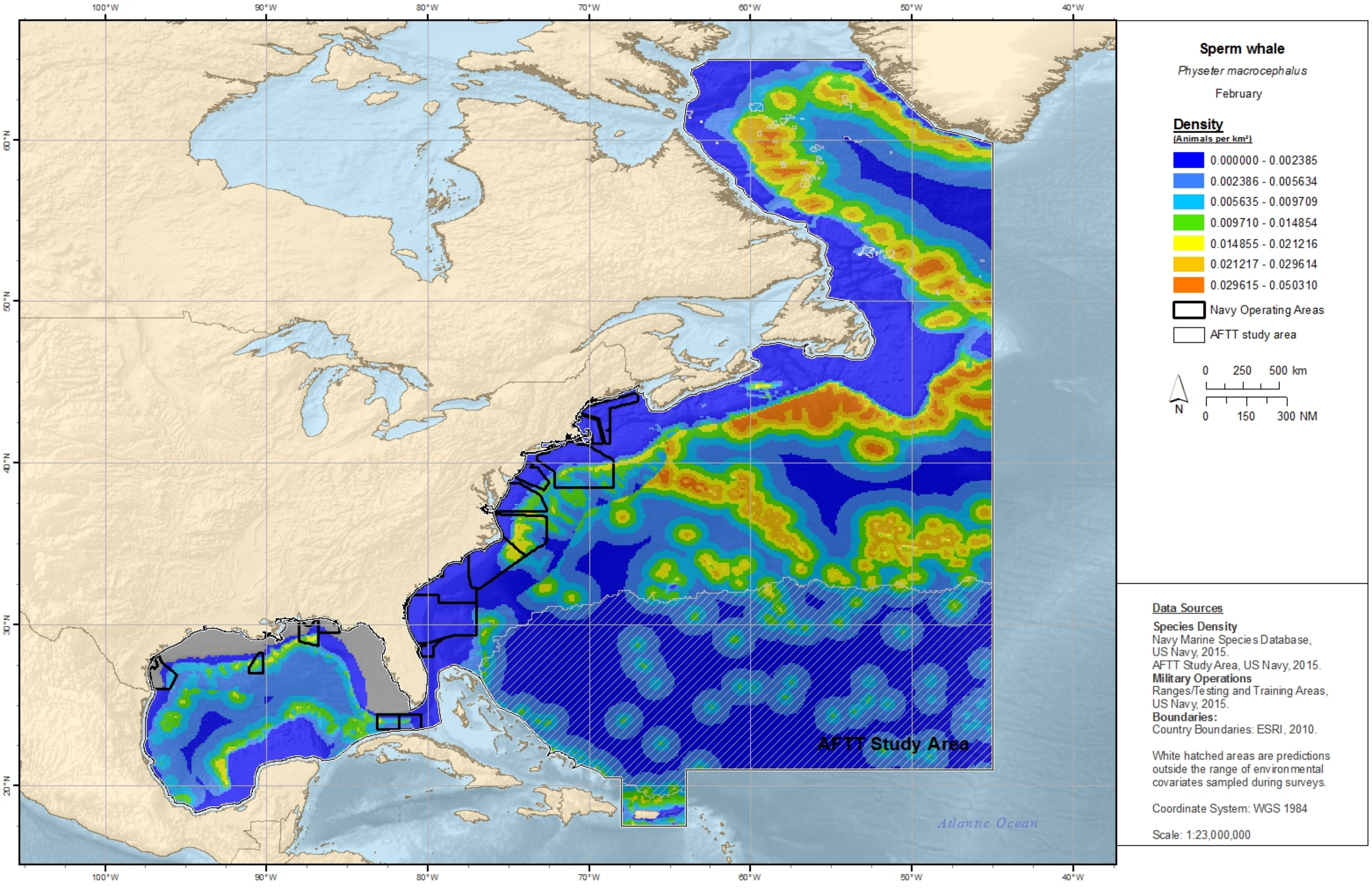


Figure 4-130. February density prediction for sperm whales in the Gulf of Mexico, East Coast, and AFTT strata.

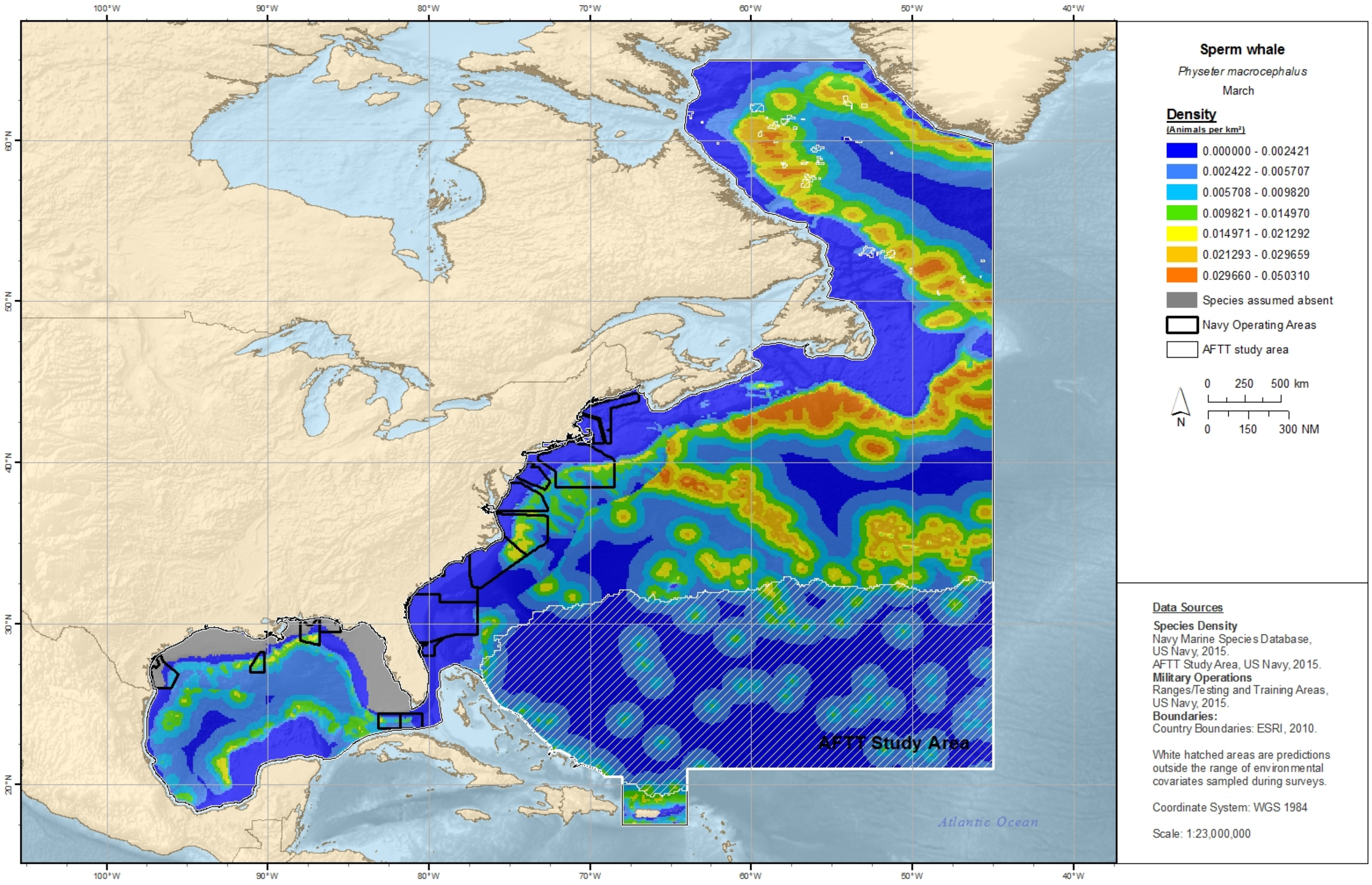


Figure 4-131. March density prediction for sperm whales in the Gulf of Mexico, East Coast, and AFTT Strata.

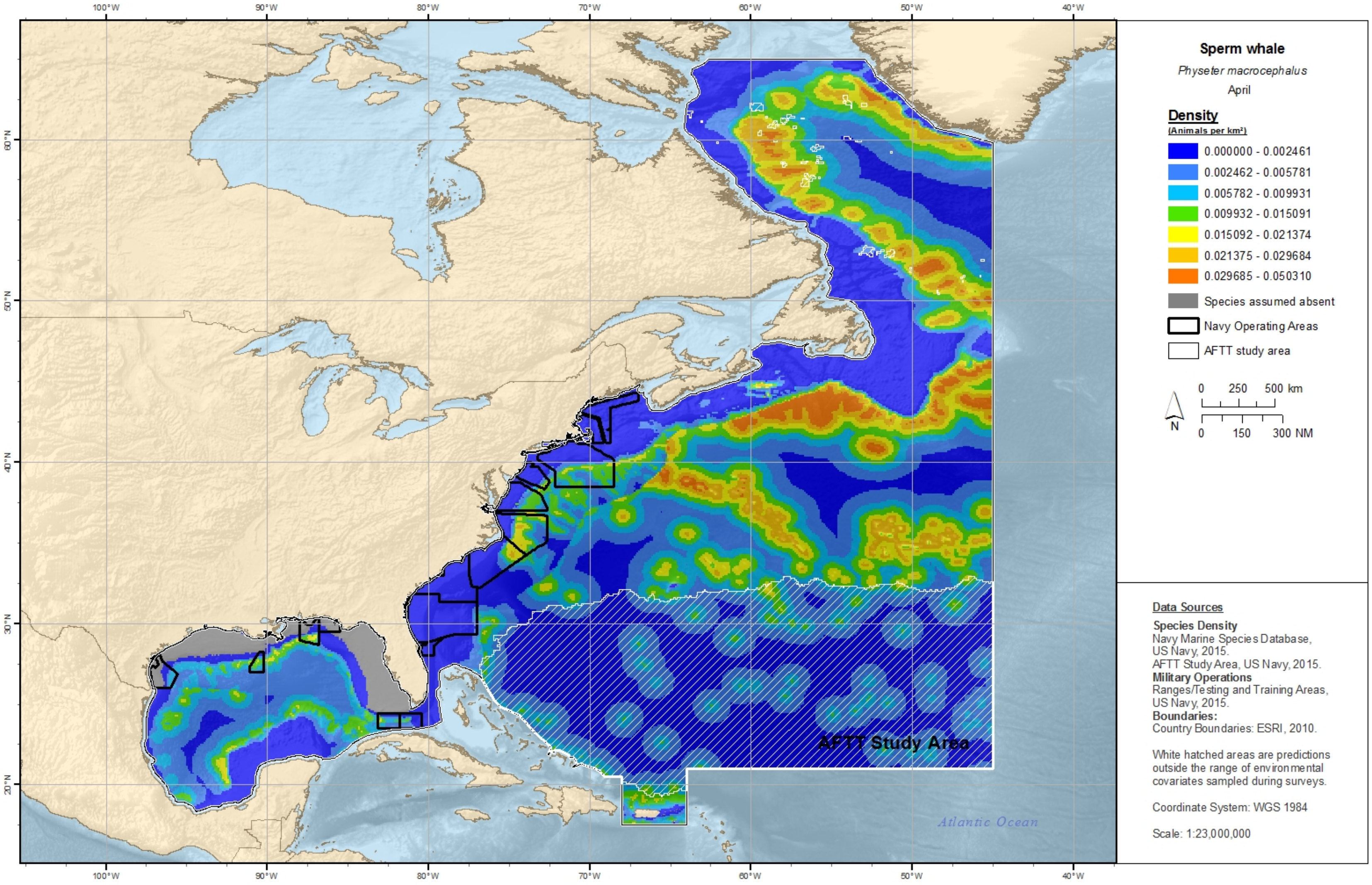
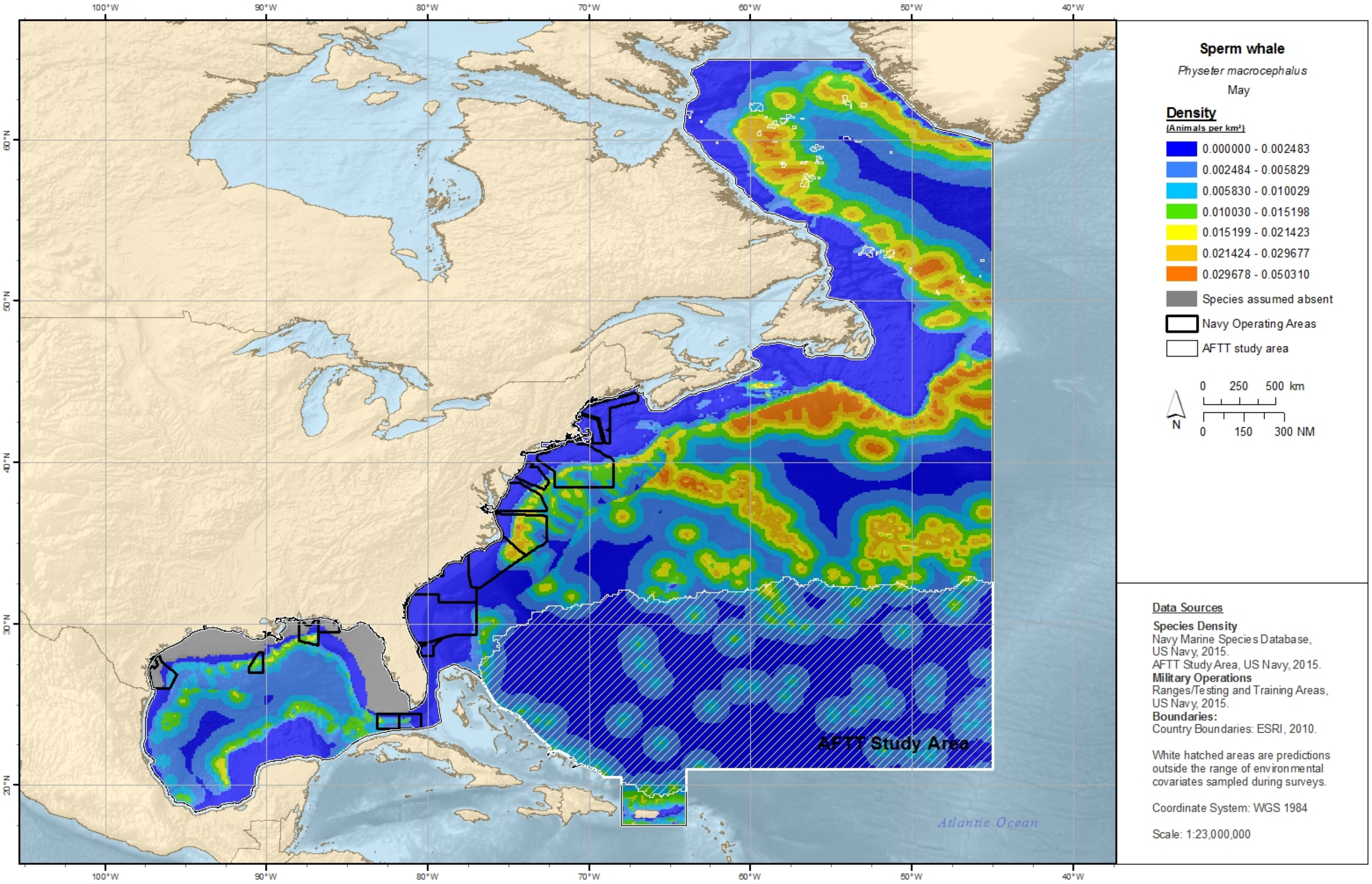


Figure 4-132. April density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.



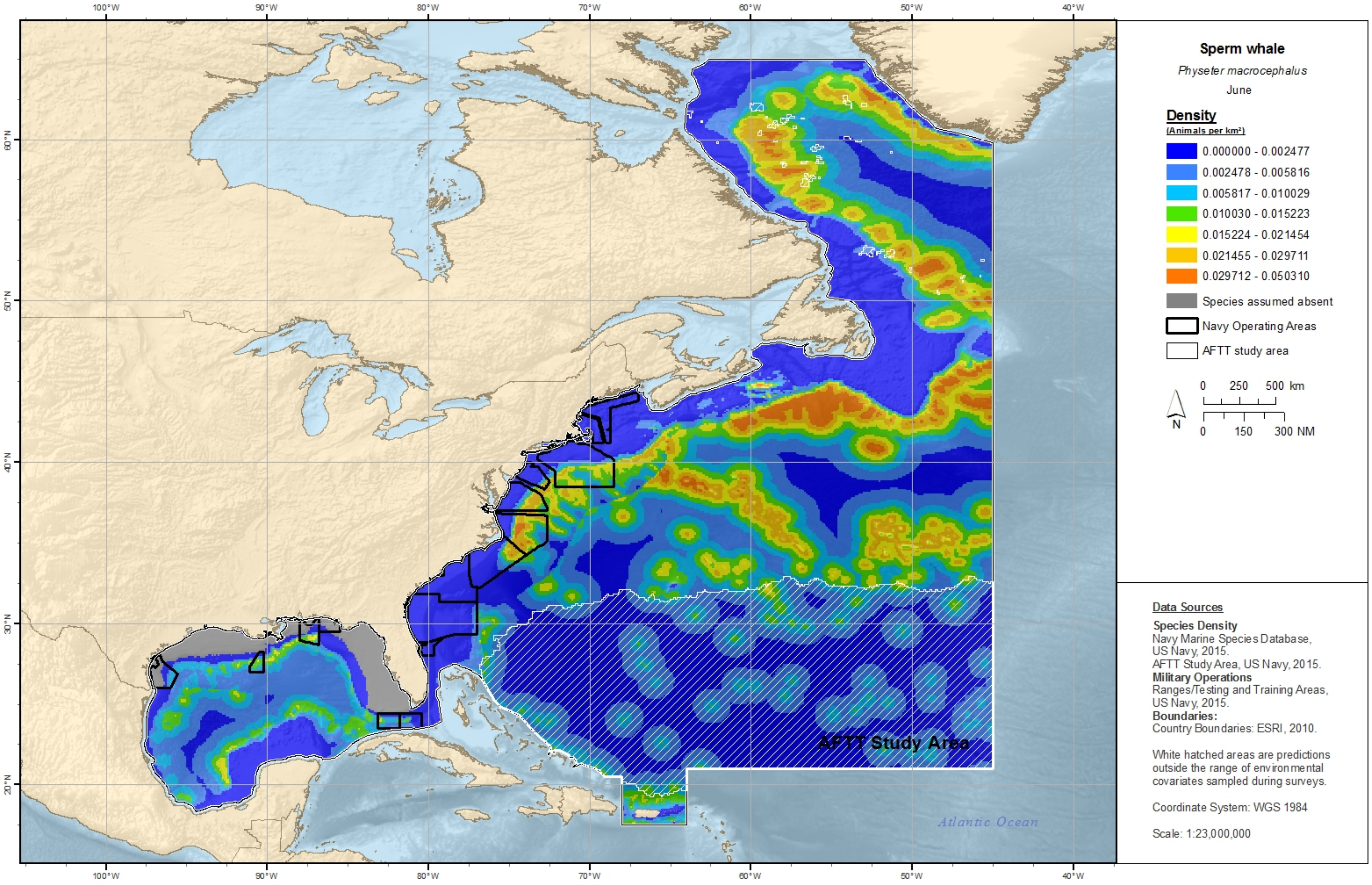
Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-133. May density prediction for sperm whales in the Gulf of Mexico, East Coast, and AFTT strata.



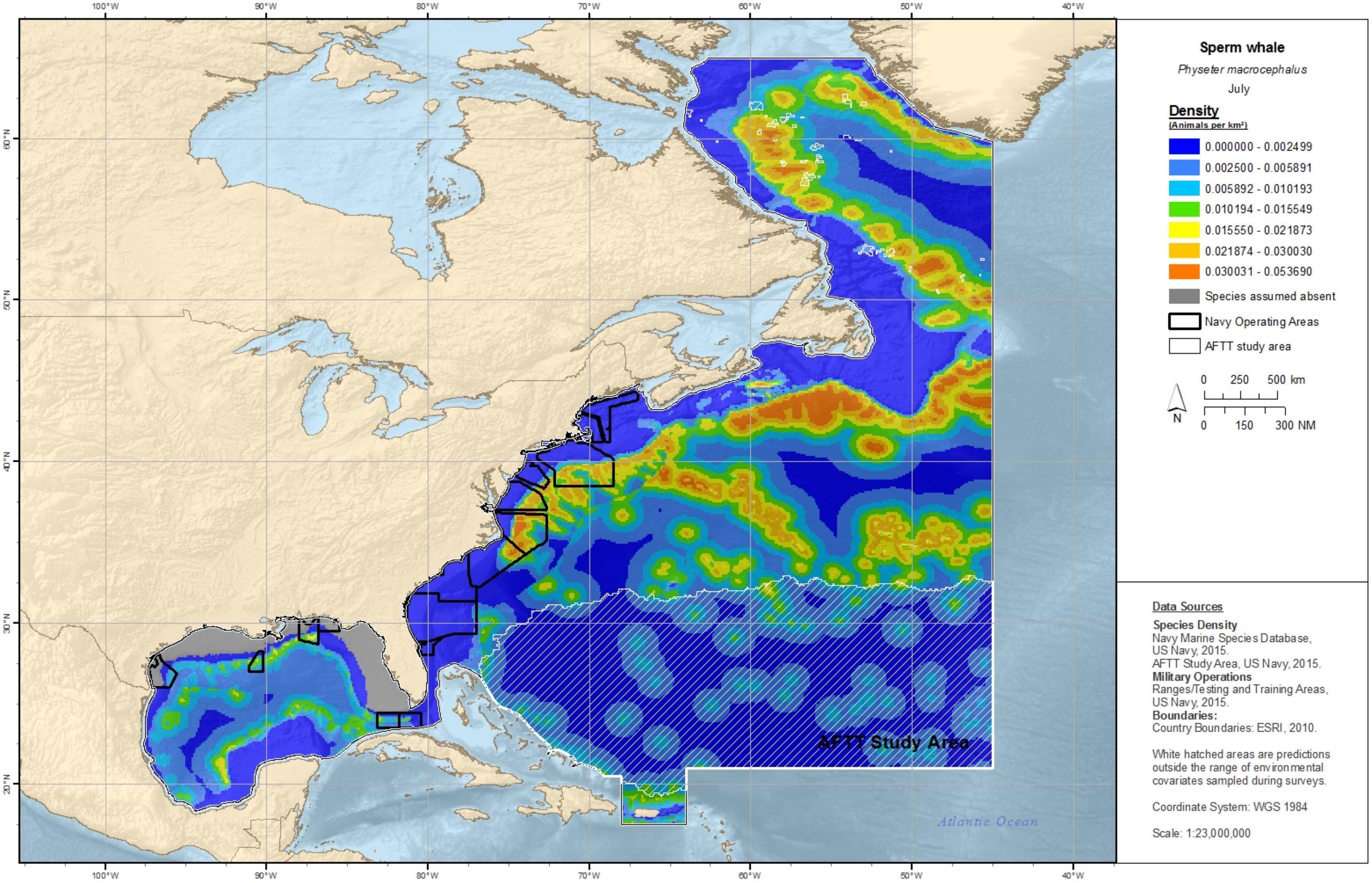
Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-134. June density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.



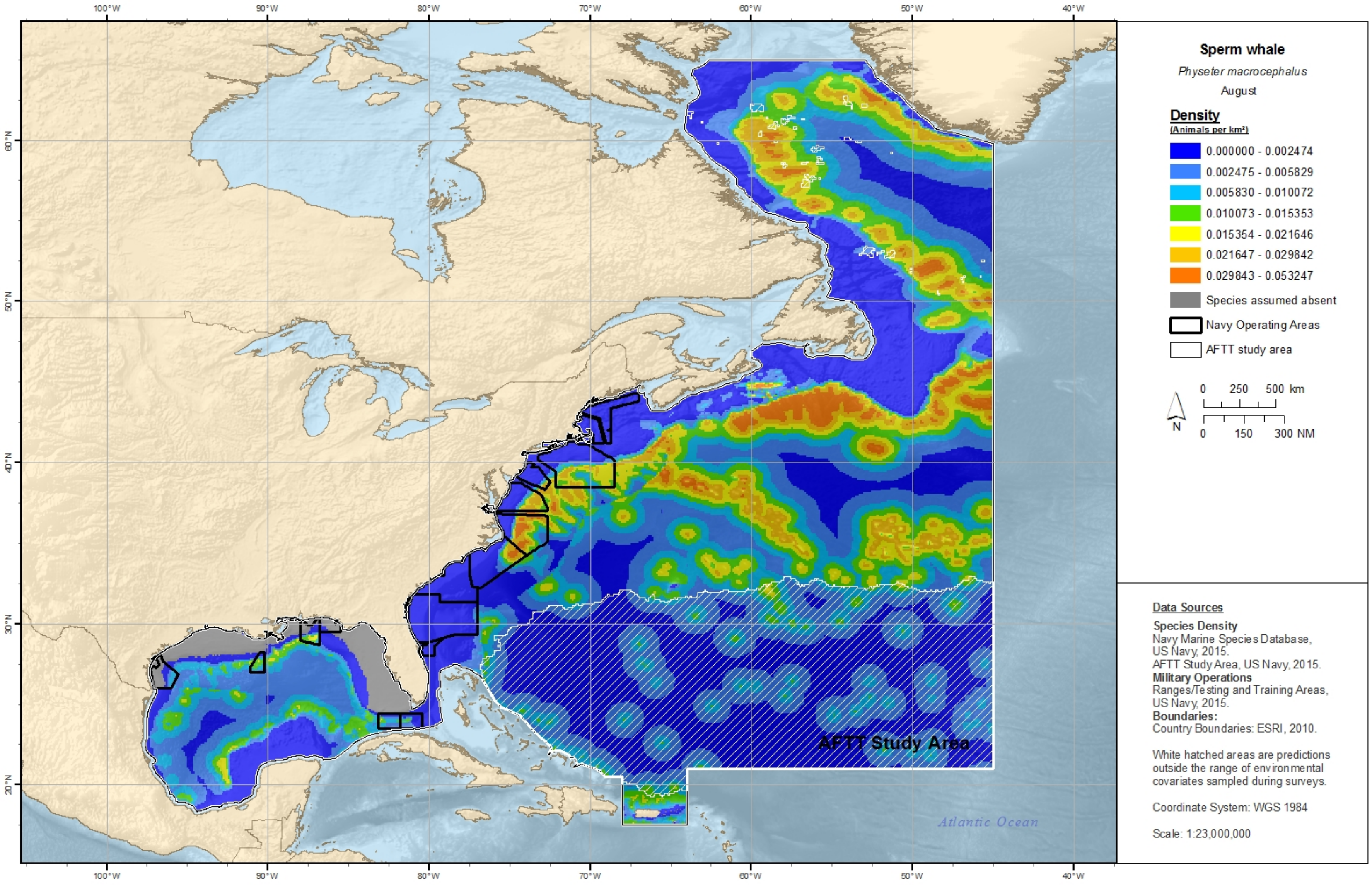
Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-135. July density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-136. August density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.

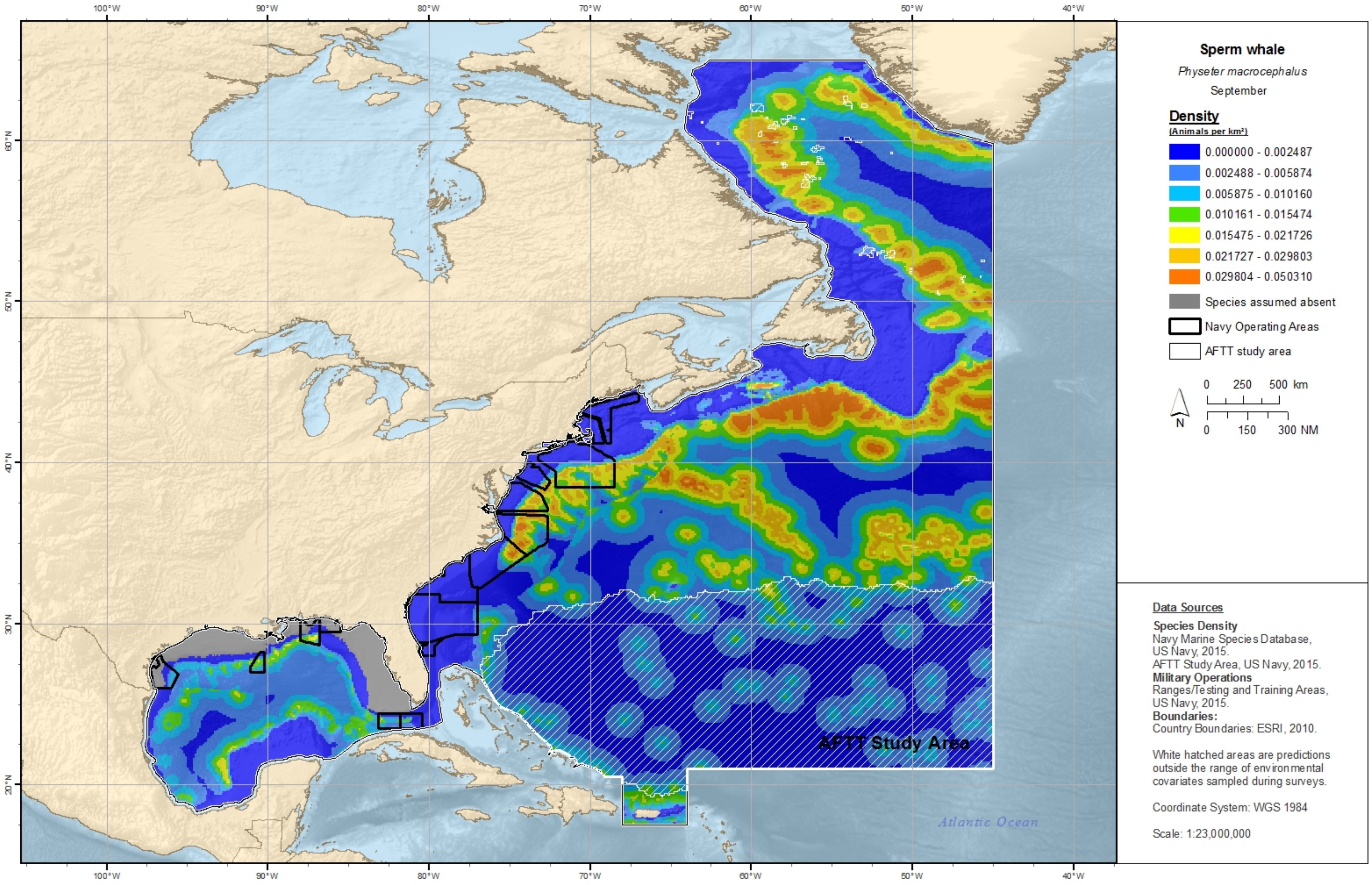


Figure 4-137. September density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.

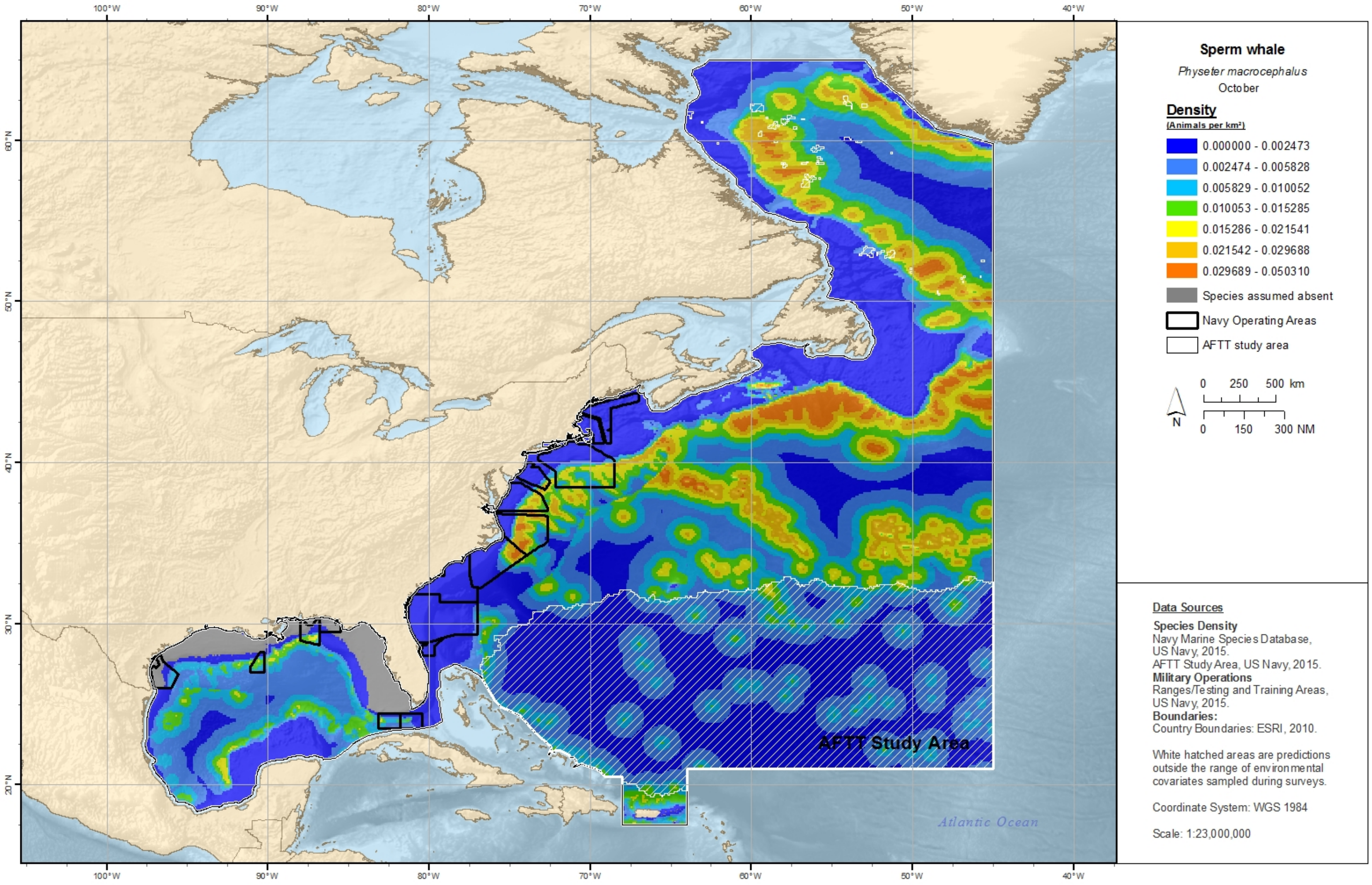


Figure 4-138. October density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.

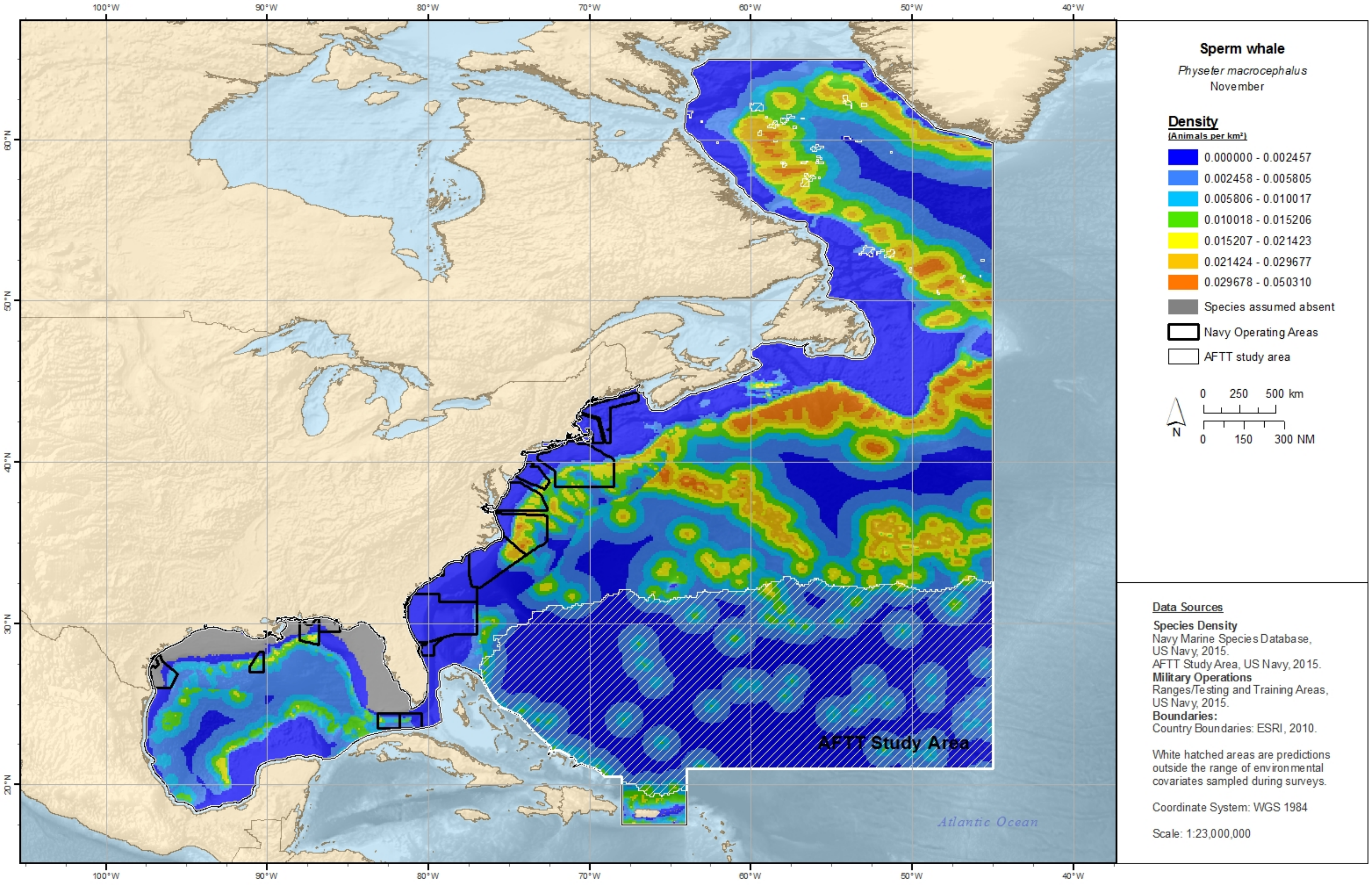
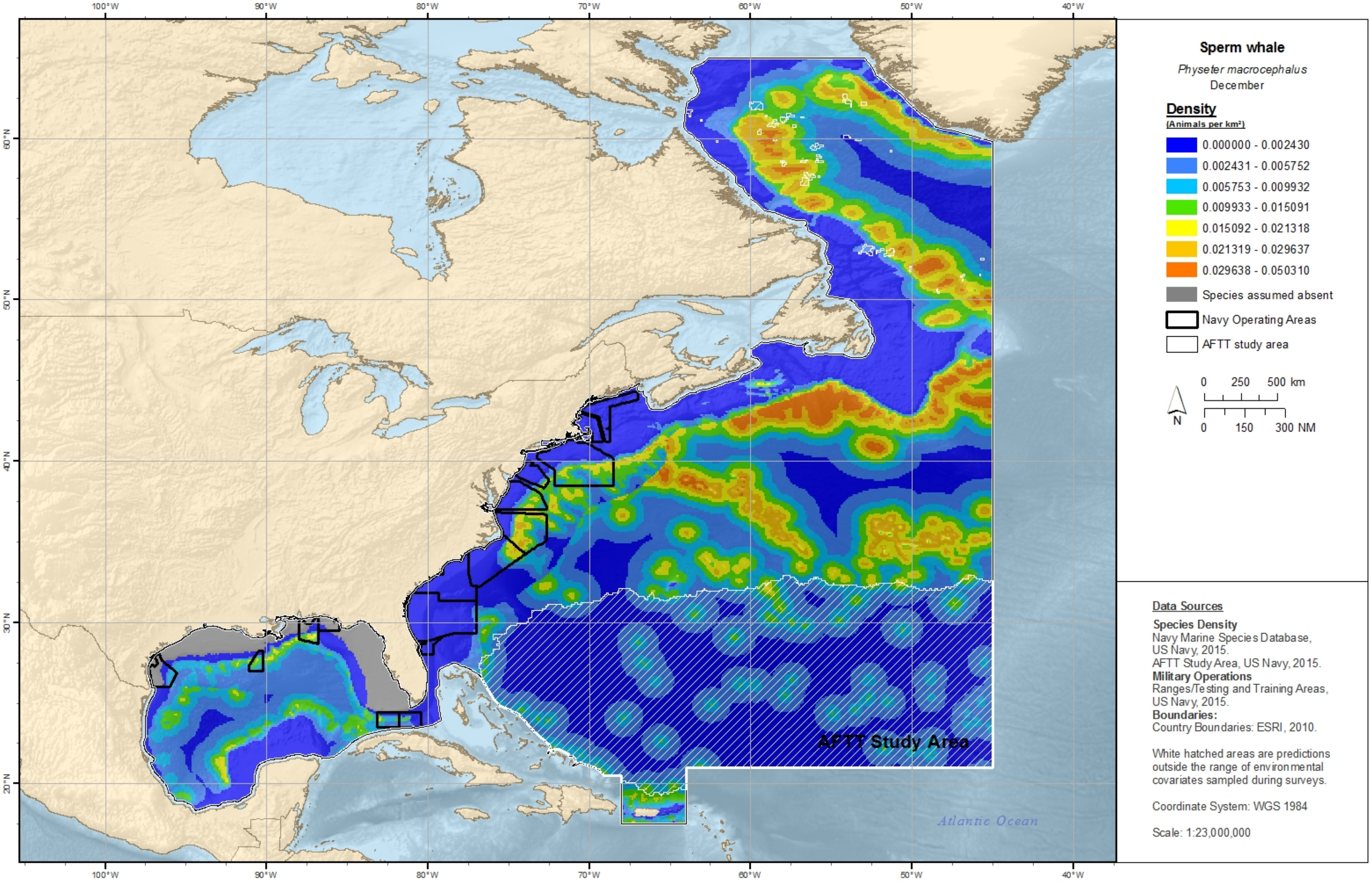


Figure 4-139. November density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-140. December density prediction for sperm whales in the Gulf of Mexico, East Coast and AFTT strata.

4.7 SIRENIANS

West Indian manatee *(Trichechus manatus)*

The density estimates for manatees were all derived from literature-based estimates of non-density estimation studies for pierside areas where manatees and naval training testing activities could be reasonably expected to co-occur. As such, this section is formatted differently from other sections where model based approached were used. No significant changes in manatee abundance were documented in recent years for the areas under consideration; therefore these data are not changed from TAP Phase II.

Pierside estimates in Kings Bay, Georgia were calculated from an abundance estimate obtained from the Georgia Department of Natural Resources (George 2009). Helicopter surveys were conducted in Cumberland Sound and its tributaries from spring through fall of 2006 and 2007. The study area was divided into 120 plots, with plots stratified by location and habitat (corridors or creeks). A subset of plots from each habitat type was randomly chosen for each survey. Pilots circled seven to ten minutes above each plot during the survey, and an observer collected data on the number of manatee groups, total number of manatees, group behavior, tide state, water clarity, and Beaufort sea state. Manatee abundance was estimated from each survey using a Bayesian hierarchical model that included the following variables: year, month, location category, habitat type, number of groups, group size, and the probability that manatees would be alone or in groups.

The freshwater and estuarine features of the National Wetlands Inventory water shapefile of Kings Bay were edited using GIS software to include only the areas overlapped by the survey plots. Using a spatial statistics tool in GIS, a study area of 14.6 nmi^2 (49.96 km^2) resulted. Estimated abundances for each survey were divided by the survey area and averaged over years. No surveys were conducted during winter, and while manatees are most frequently sighted in SUBASE Kings Bay waters April through October manatees occasionally have been sighted in winter. Fall density is used as a proxy for the winter density.

Manatee density data for the Lower Saint Johns River (LSJR) and Inter Coastal Waterway (ICW), including Mayport, FL were estimated from the Duval county Manatee Protection Plan (Jacksonville University 2009). The estimates come from average seasonal aerial survey counts of manatees from 1994-2009. Density was estimated from the total seasonal average counts (LSJR+ICW) divided by the total area of survey coverage (439 km^2). Updated data available in the 2014 plan would not significantly change this estimate (City of Jacksonville 2014).

Systematic manatee surveys, both aerial and opportunistic, were conducted within the Trident basin in Port Canaveral, FL from 2006 to 2010 (Pers. Comm 2010). Since there was no consistent survey sampling scheme, this analysis assumes that these were opportunistic total counts of abunance in a given area akin to strip transects. The total number of sightings (30 animals) were divided by the number of surveys (29 surveys) to get the average number of sightings from suveys conducted in 2006 -2010. This equates to an average number of 1.03448 animals seen in a 0.5 km^2 survey area of the Trident Basin. This estimate of density is assumed to be representative of all four seasons. This value was extrapolated to just outside the basin to the mouth of Port Canveral to cover the sonar testing area.

4.8 PINNIPEDS

Bearded seal *(Erignathus barbatus*)

Data Sources and Seasonality:
All density data incorporated into the NMSDD for this species comes from the Kaschner RES models. One model was used for the entire study area, covering portions of the AFTT and East Coast strata. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region and its expected distribution is limited to the northern reaches of the AFTT study area. Four seasons were defined for this species, based on human seasons for convenience, similar to other RES data. The temporal resolution of the density predictions was seasonal.

Survey Data and Selected Models:
Globally available line-transect survey data through 2005 were used in the creation of the Kaschner RES data. This is the only broad scale density estimate currently available for this species. See **Section 3.3** for a description of how the Kaschner RES models were made. The bearded seal model does not deviate from that general methodology.

Other Density Estimates:
No other broad scale density estimates for this species exist in the AFTT Study Area. There is no SAR as the NMFS only recognizes an Alaskan stock in U.S. waters. The primary distribution of this species in the AFTT Study Area is around Canada and Greenland.

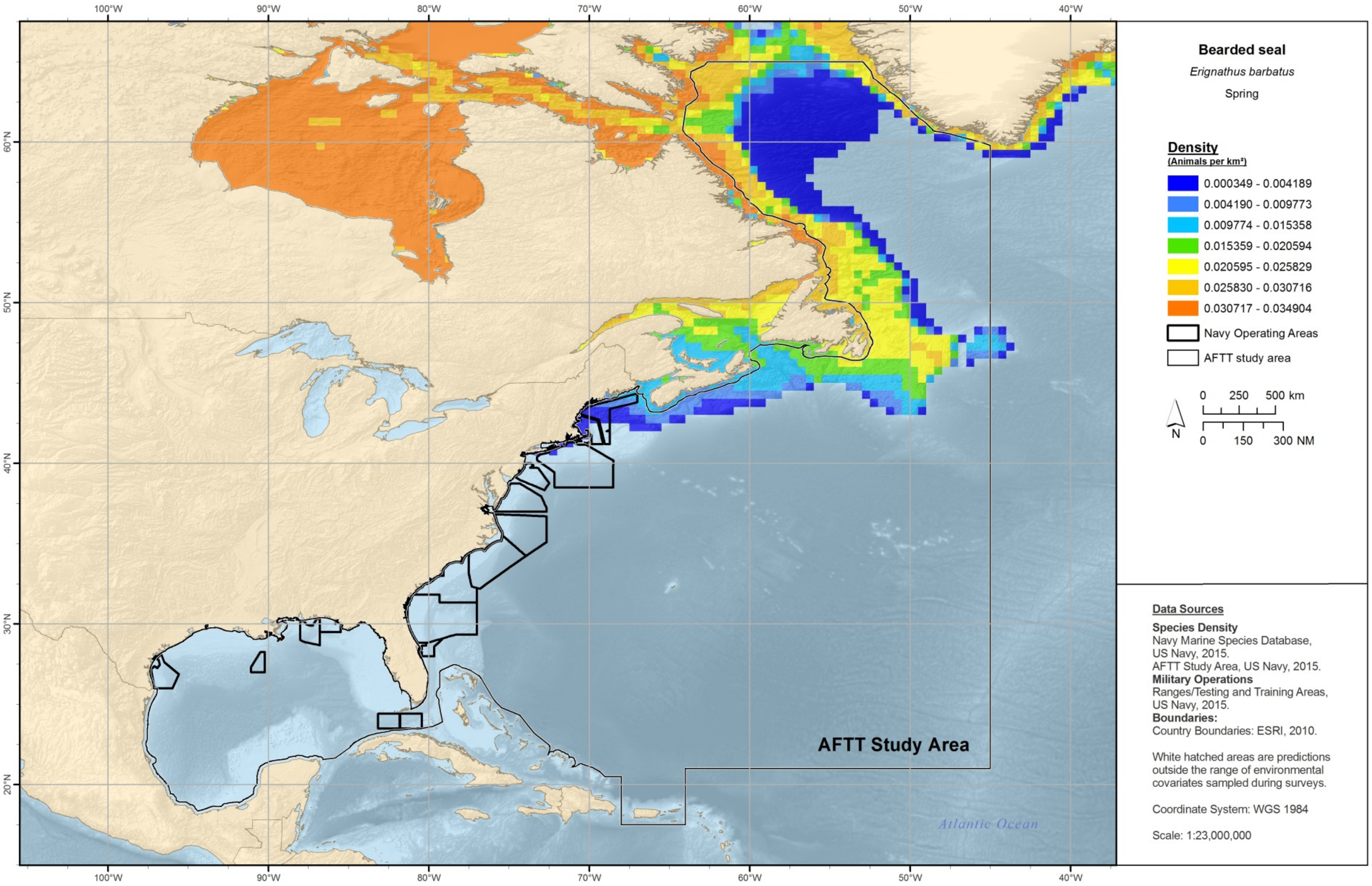


Figure 4-141. Spring RES density prediction for bearded seals.

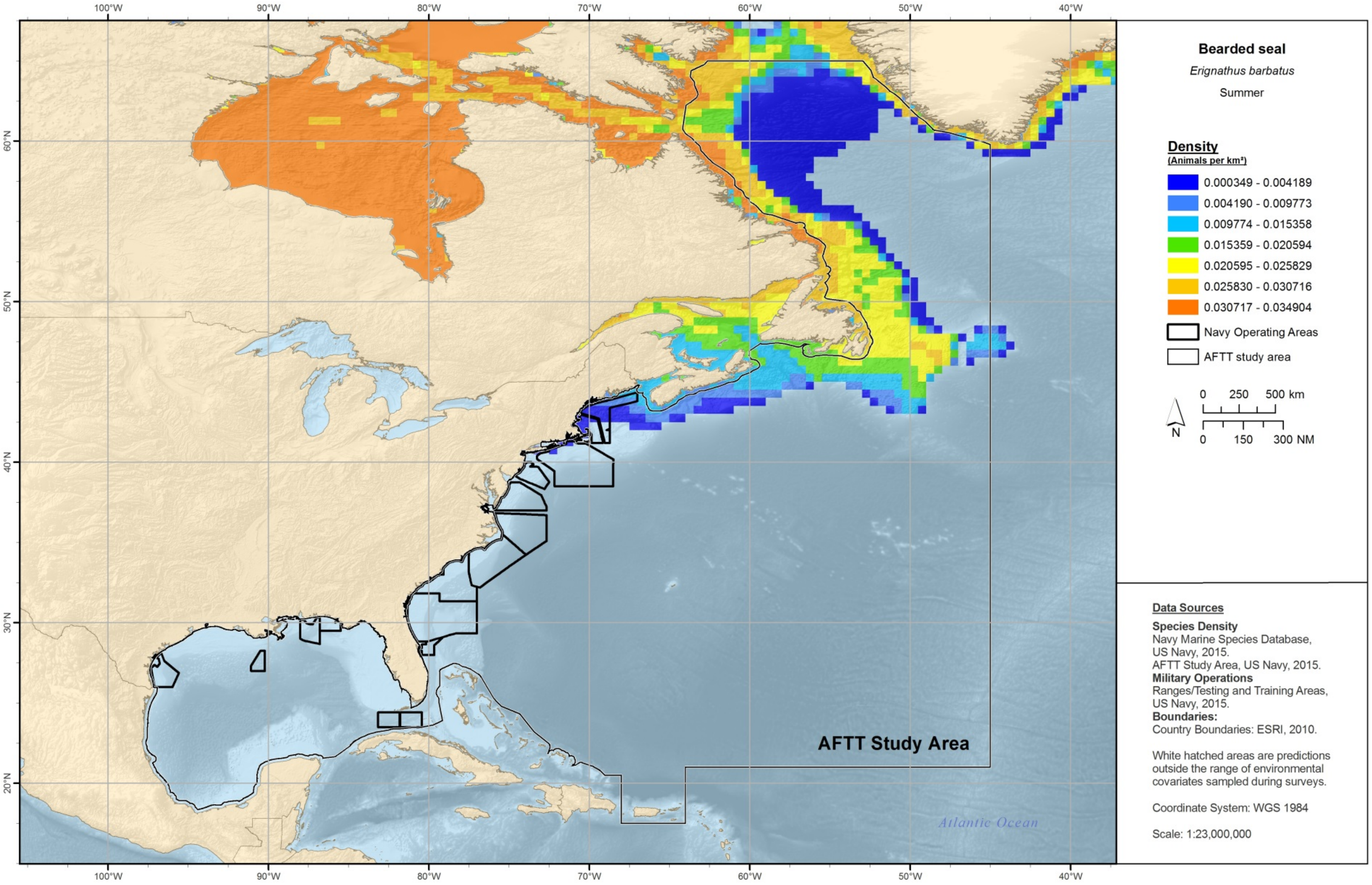


Figure 4-142. Summer RES density prediction for bearded seals.

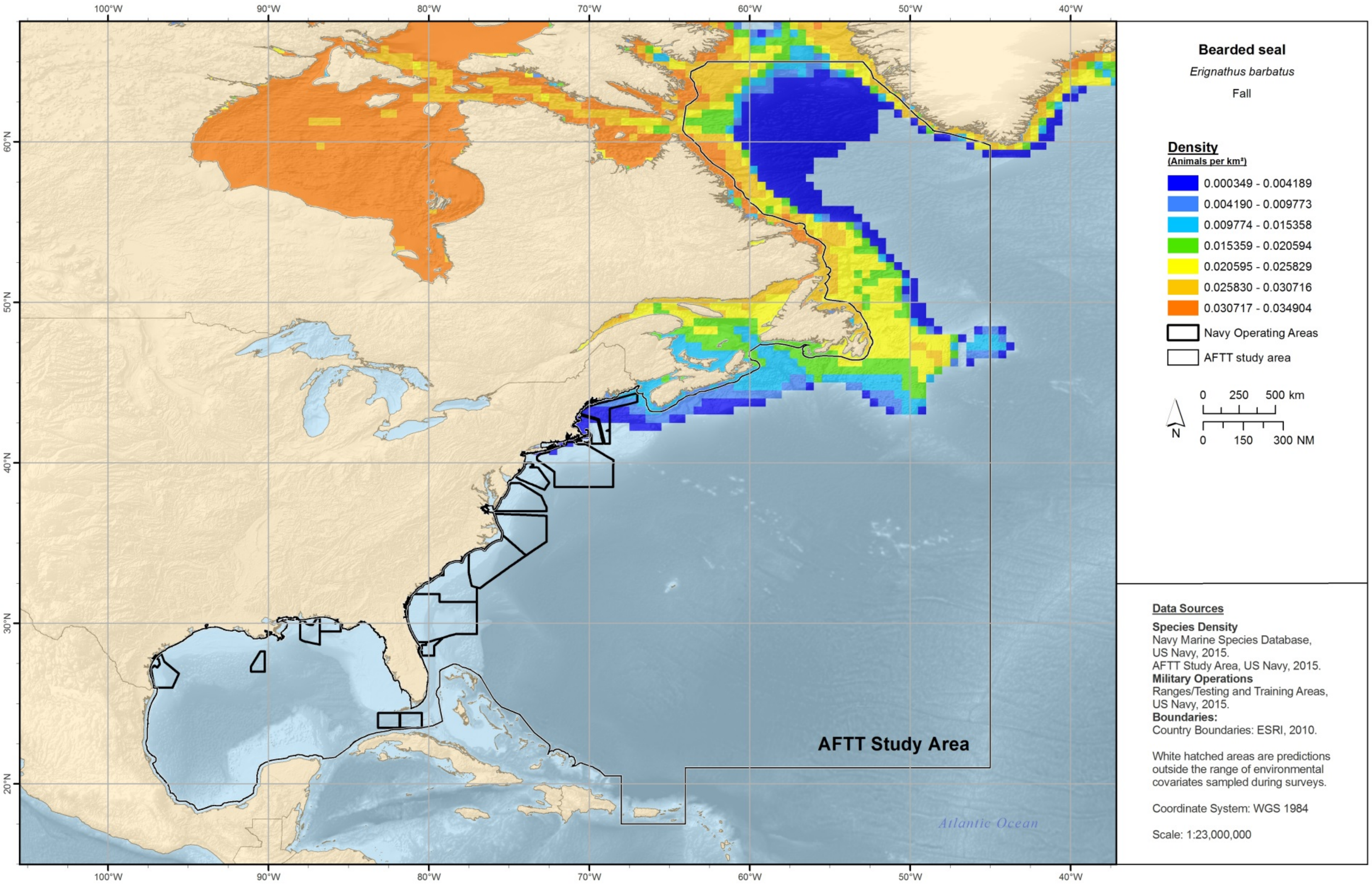


Figure 4-143. Fall RES density prediction for bearded seals.

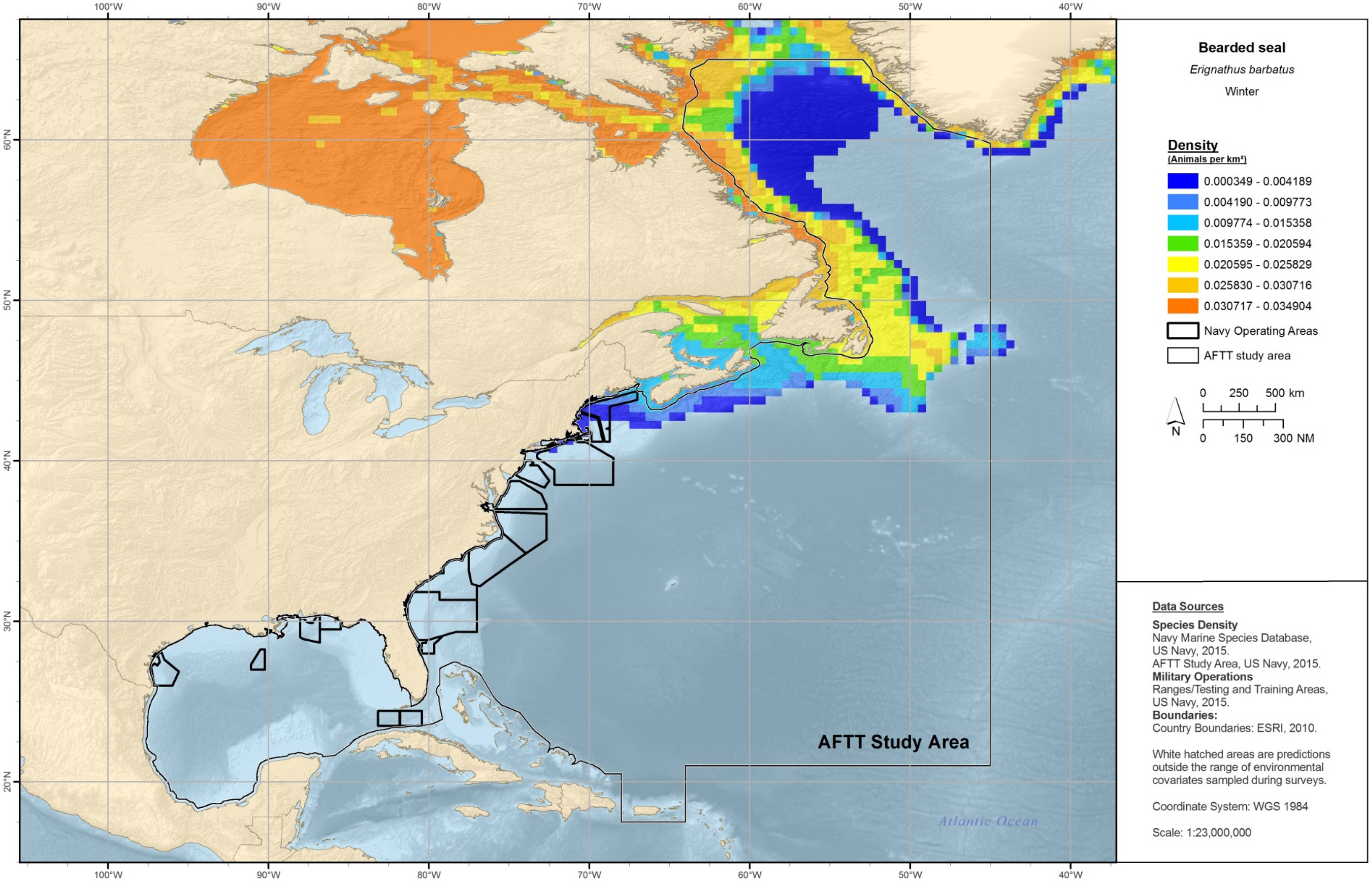


Figure 4-144. Winter RES density prediction for bearded seals.

Harp seal (*Pagophilus groenlandicus*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from the Kaschner RES models. One model was used for the entire study area, covering portions of the AFTT and East Coast strata. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region and its expected distribution is limited to the northern reaches of the AFTT Study Area. Four seasons were defined for this species, based on human seasons for convenience, similar to other RES data. The temporal resolution of the density predictions was seasonal.

Survey Data and Selected Models:

Globally available line-transect survey data through 2005 were used in the creation of the Kaschner RES data. This is the only broad scale density estimate currently available for this species. See **Section 3.3** for a description of how the Kaschner RES models were made. The harp seal model does not deviate from that general methodology.

Other Density Estimates:

No other broad scale in-water density estimates for this species exist in the AFTT Study Area. The SAR for the western north Atlantic stock relies entirely on aerial surveys of pupping locations in Canada and Greenland and populations models based on pup production. The most recent SAR (2013) estimates 7.1 million (95% CI=5.9-8.3 million) harp seals in Canadian waters but does not attempt to estimate those animals in U.S. waters (Waring et al. 2013). The primary distribution of this species in the AFTT is around Canada and Greenland.

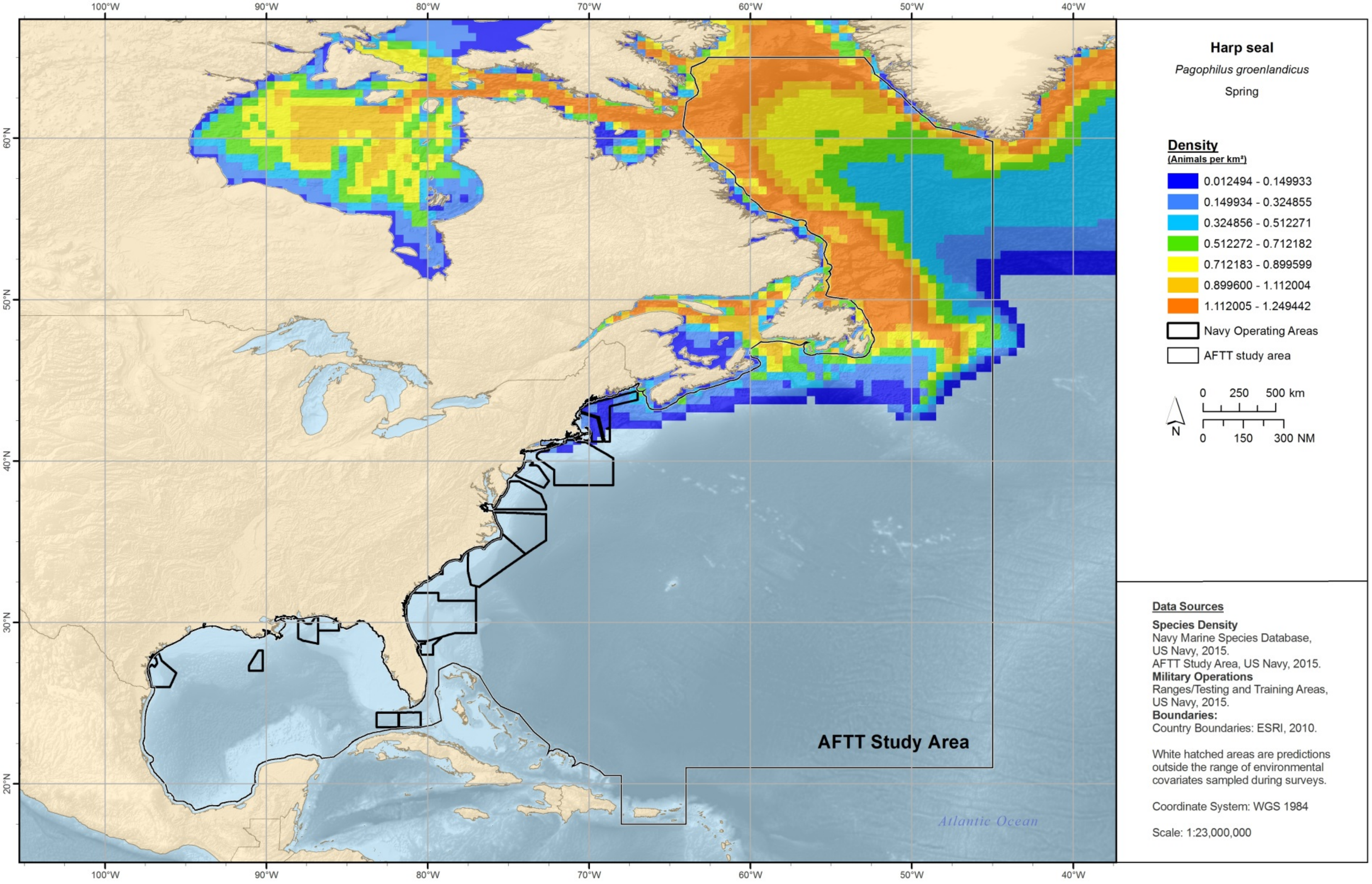


Figure 4-145. Spring RES density prediction for harp seals.

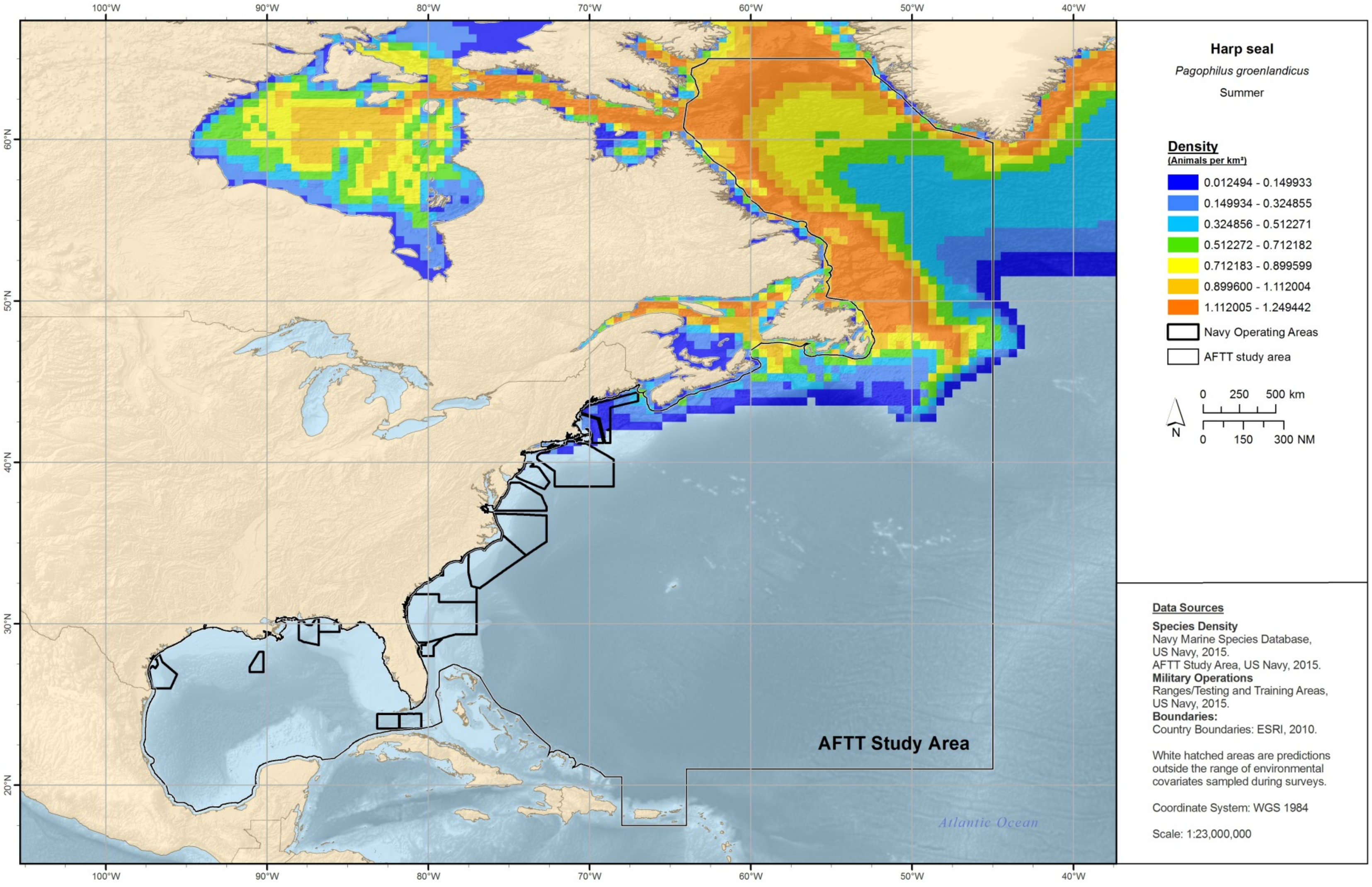


Figure 4-146. Summer RES density prediction for harp seals.

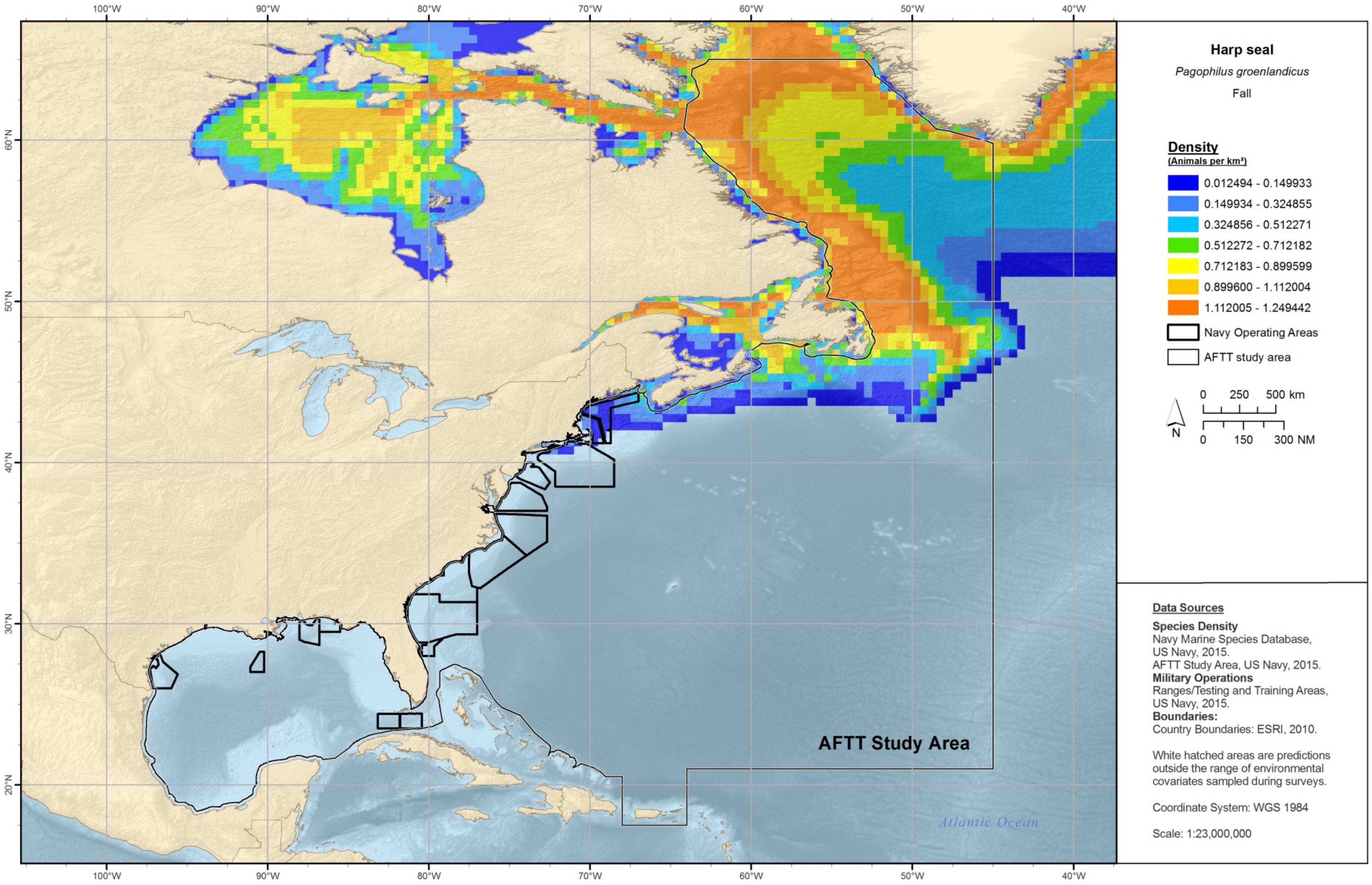
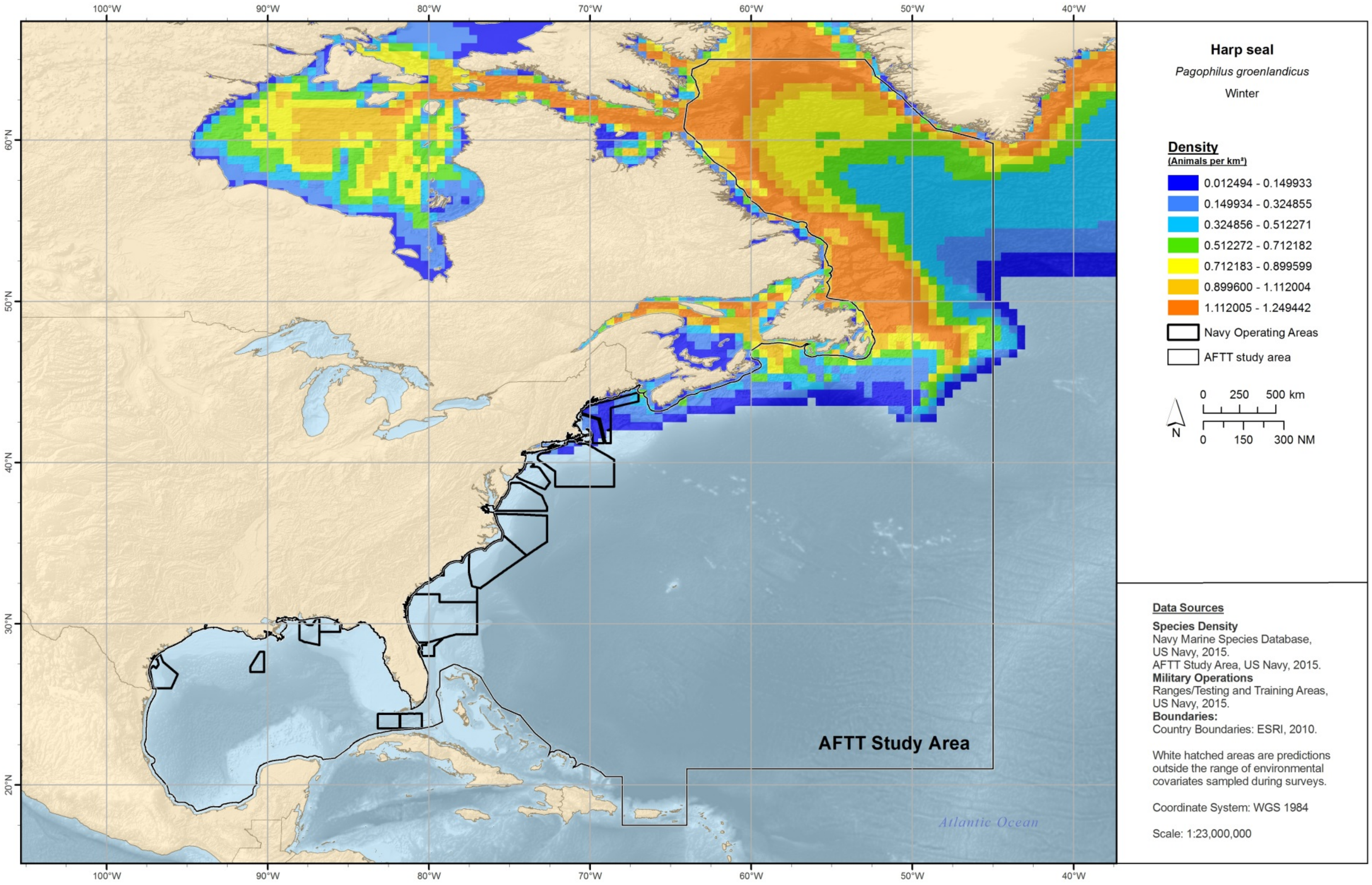


Figure 4-147. Fall RES density prediction for harp seals.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-148. Winter RES density prediction for harp seals.

Hooded seal (*Cystophora cristata*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from the Kaschner RES models. One model was used for the entire study area, covering portions of the AFTT and East Coast strata. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region and its expected distribution is limited to the northern reaches of the AFTT Study Area. Four seasons were defined for this species, based on human seasons for convenience, similar to other RES data. The temporal resolution of the density predictions was seasonal.

Survey Data and Selected Models:

Globally available line-transect survey data through 2005 were used in the creation of the Kaschner RES data. This is the only broad scale density estimate currently available for this species. See **Section 3.3** for a description of how the Kaschner RES models were made. The hooded seal model does not deviate from that general methodology.

Other Density Estimates

No other broad scale in-water density estimates for this species exist in the AFTT Study Area. The SAR for the western north Atlantic stock relies entirely on surveys of pupping locations outside of U.S. waters and population models based on pup production. The most recent SAR (Waring et al.2007) estimates 592,100 (95% CI 404,400-779,800) hooded seals for all whelping locations but does not attempt to estimate those animals in US waters. The primary distribution of this species in the AFTT is around Canada and Greenland.

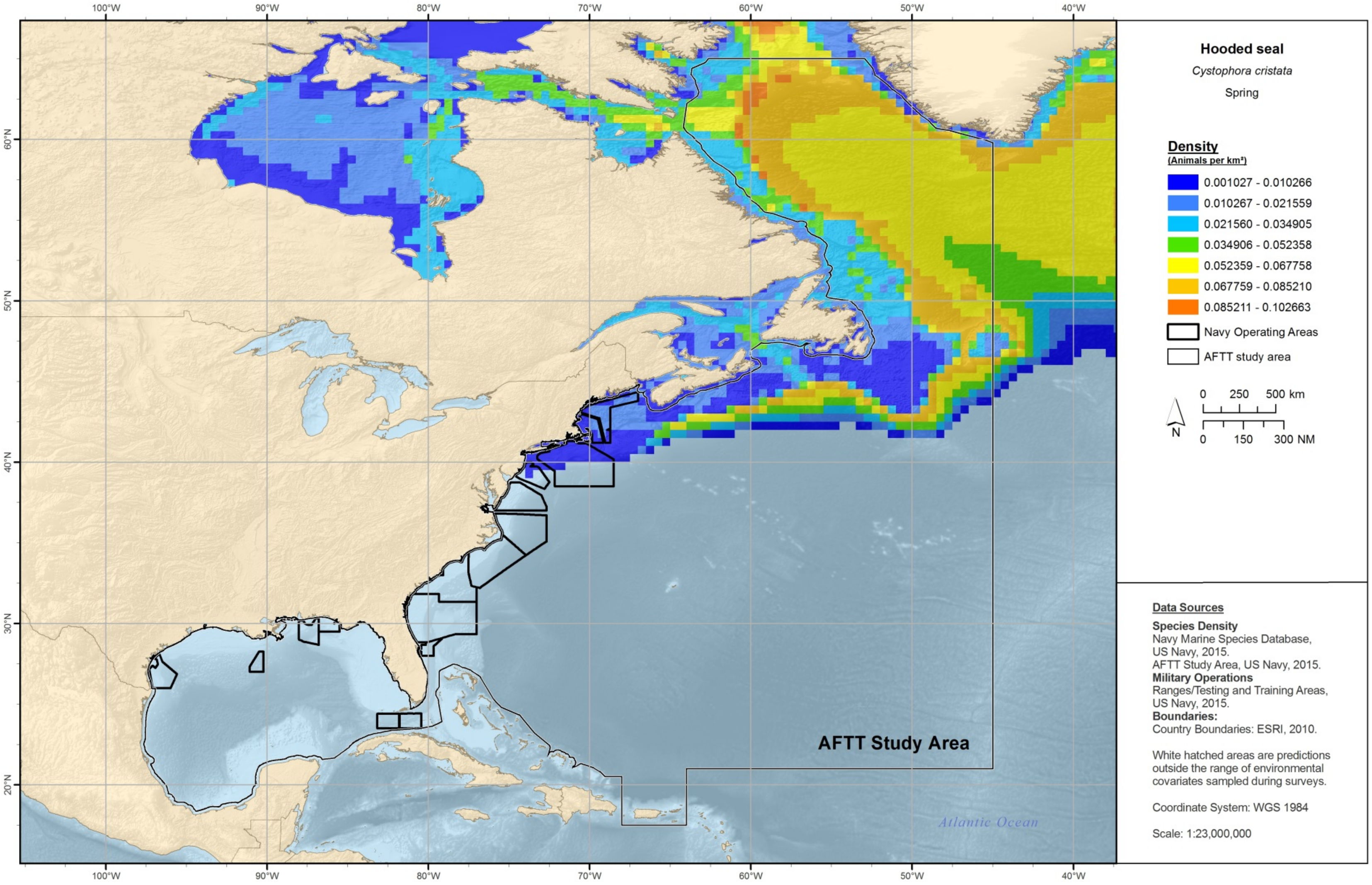
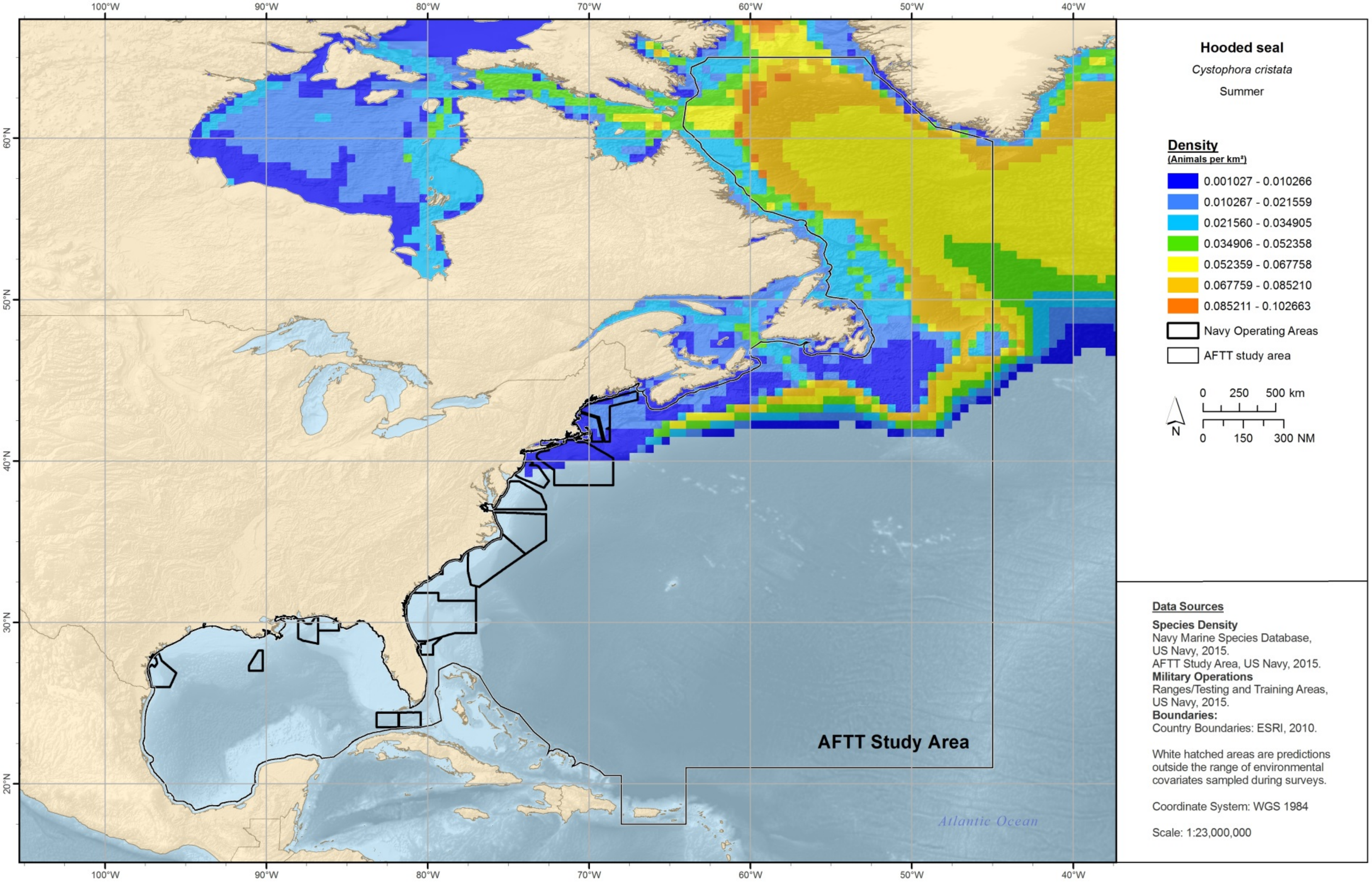


Figure 4-149. Spring RES density prediction for hooded seals.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-150. Summer RES density prediction for hooded seals.

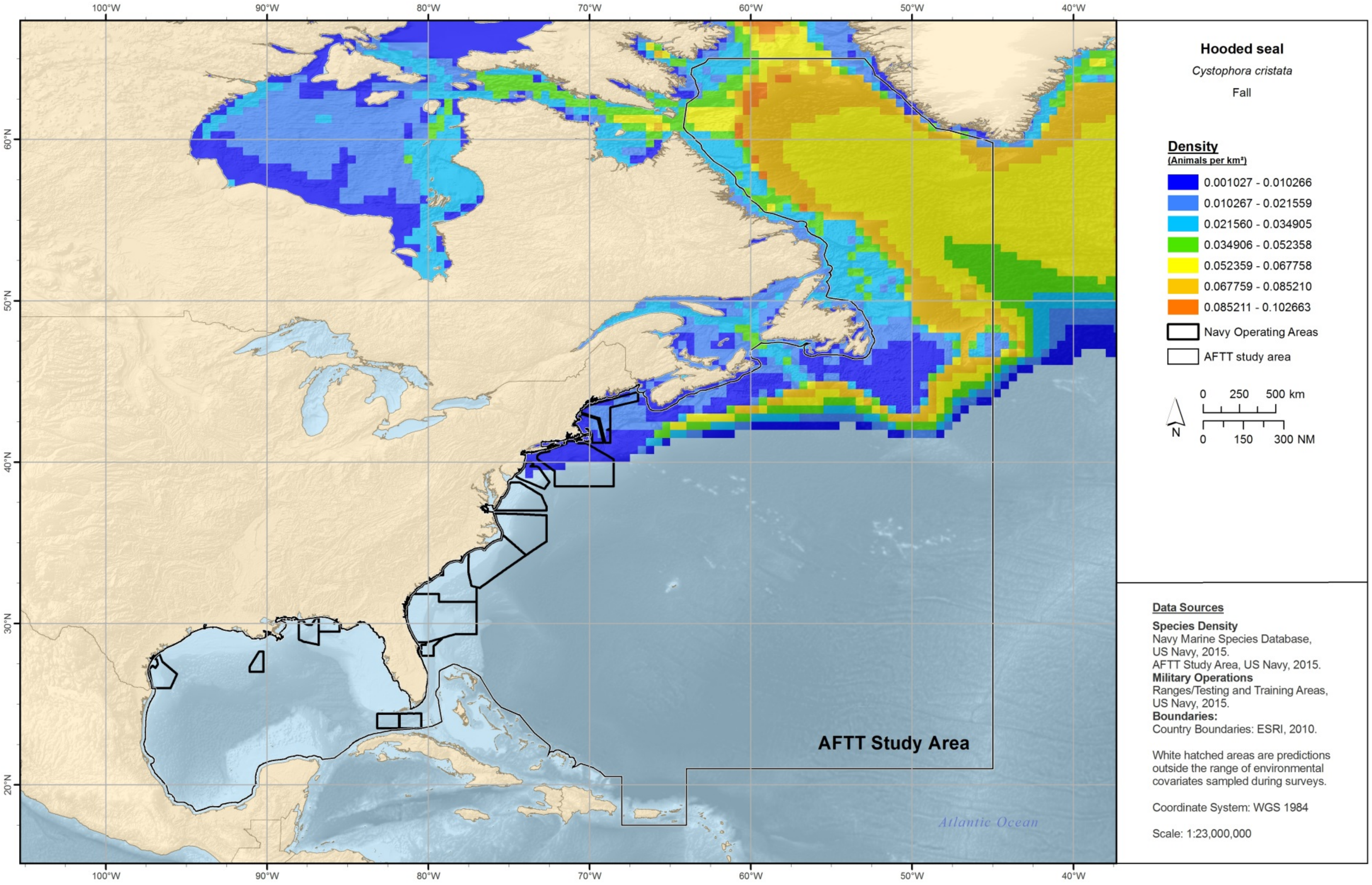


Figure 4-151. Fall RES density prediction for hooded seals.

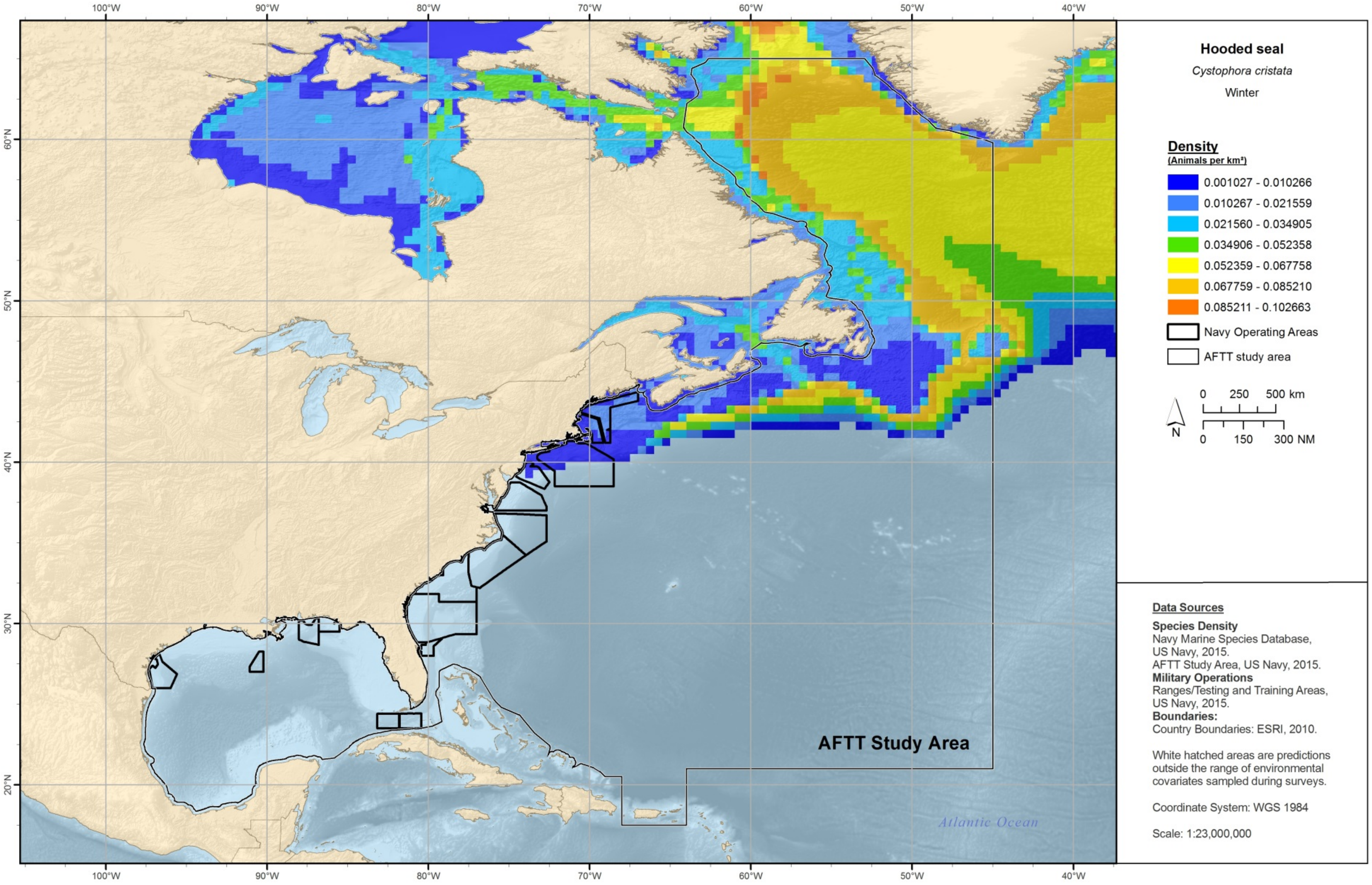


Figure 4-152. Winter RES density prediction for hooded seals.

Ringed seal (*Pusa hispida*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species come from the Kaschner RES models. One model was used for the entire study area, covering portions of the AFTT and East Coast strata. This species is assumed absent in the Gulf of Mexico given a historical lack of sightings data in that region and its expected distribution is limited to the northern reaches of the AFTT Study Area. Four seasons were defined for this species, based on human seasons for convenience, similar to other RES data. The temporal resolution of the density predictions was seasonal.

Survey Data and Selected Models:

Globally available line-transect survey data through 2005 were used in the creation of the Kaschner RES data. This is the only broad scale density estimate currently available for this species. See **Section 3.3** for a description of how the Kaschner RES models were made. The ringed seal model does not deviate from that general methodology.

Other Density Estimates:

No other broad scale in-water density estimates for this species exist in the AFTT Study Area. There is no SAR for this species in the Atlantic. The primary distribution of this species in the AFTT Study Area is around Canada and Greenland.

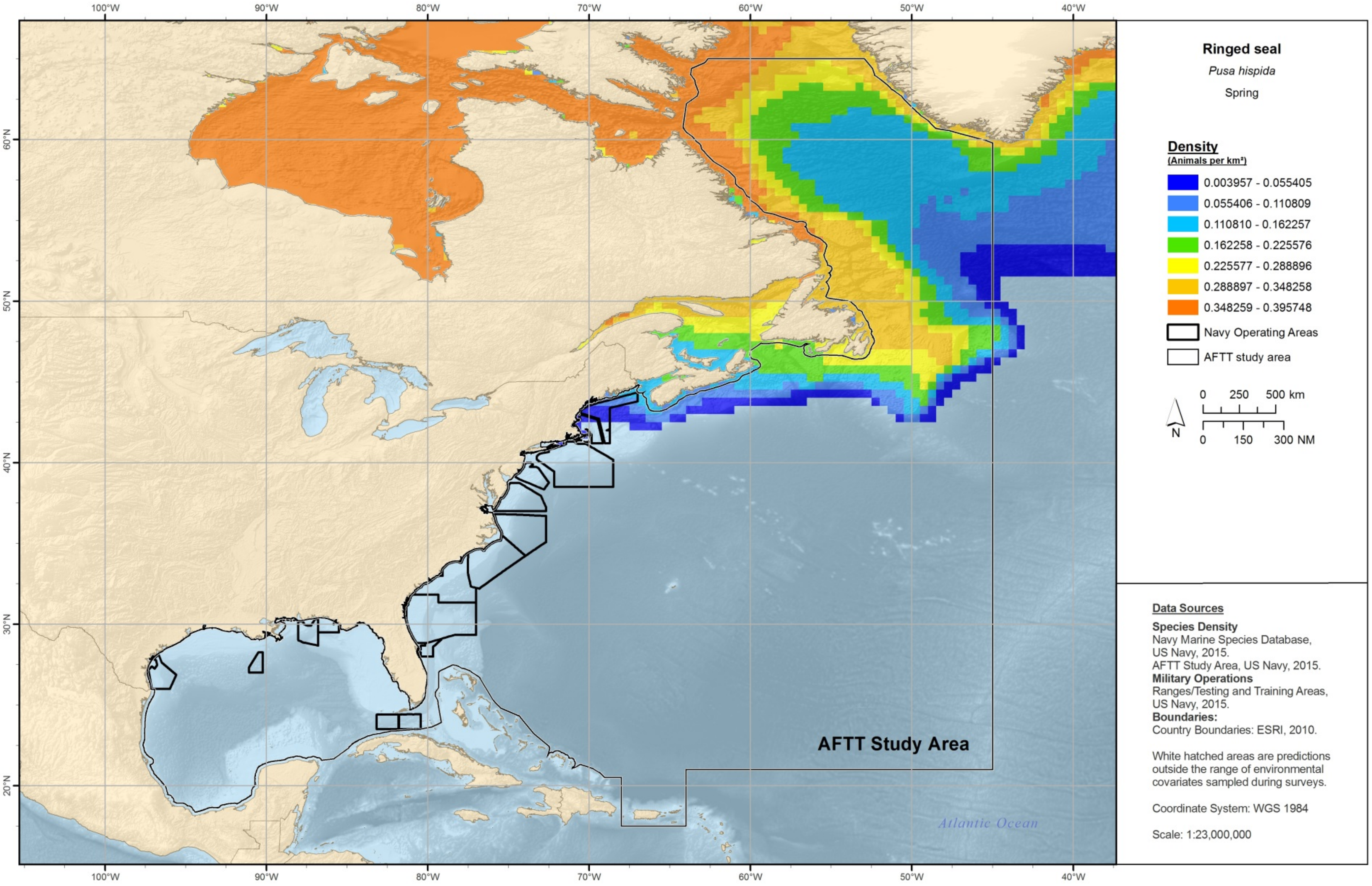


Figure 4-153. Spring RES density prediction for the ringed seal.

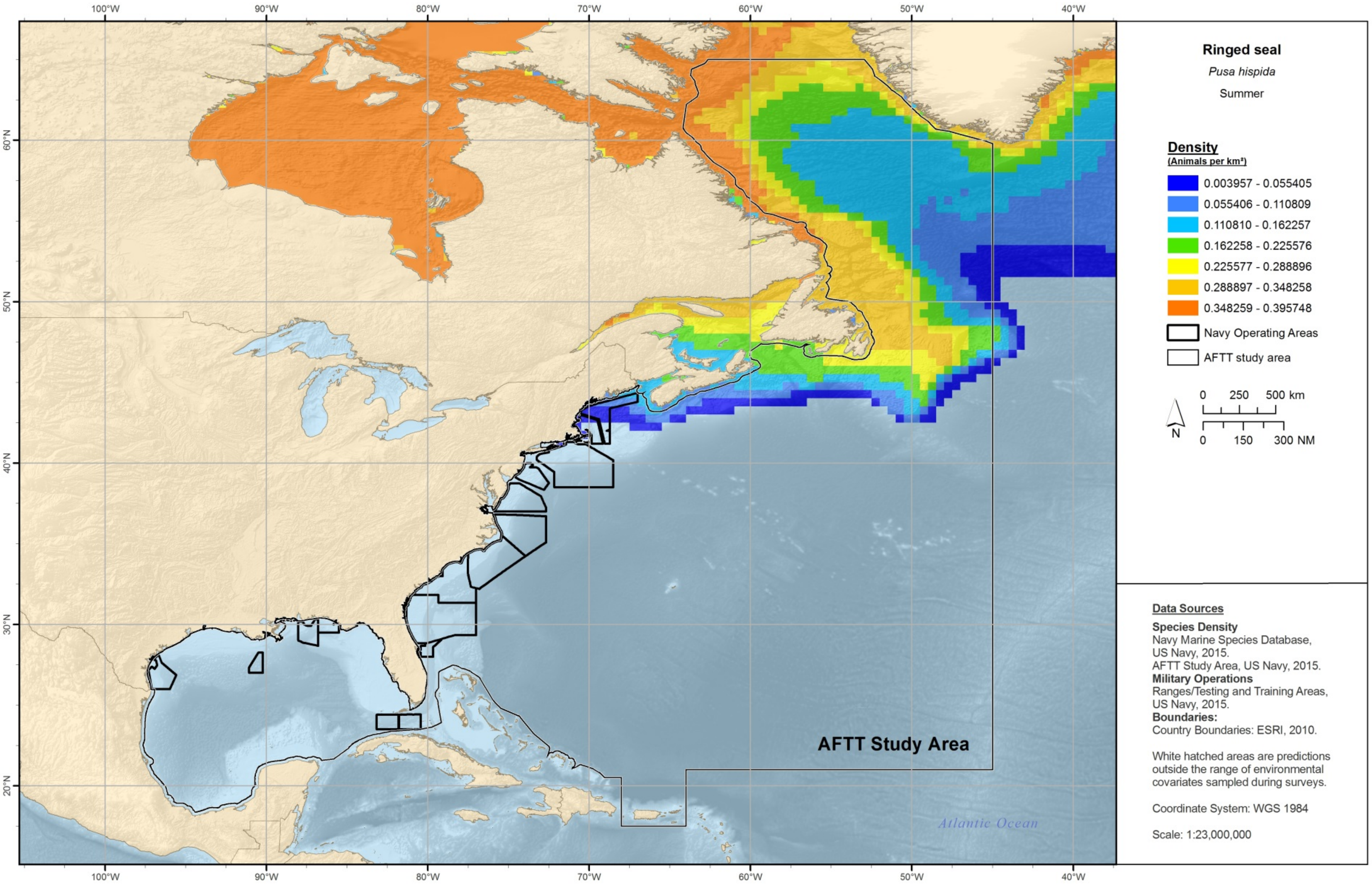


Figure 4-154. Summer RES density prediction for the ringed seal.

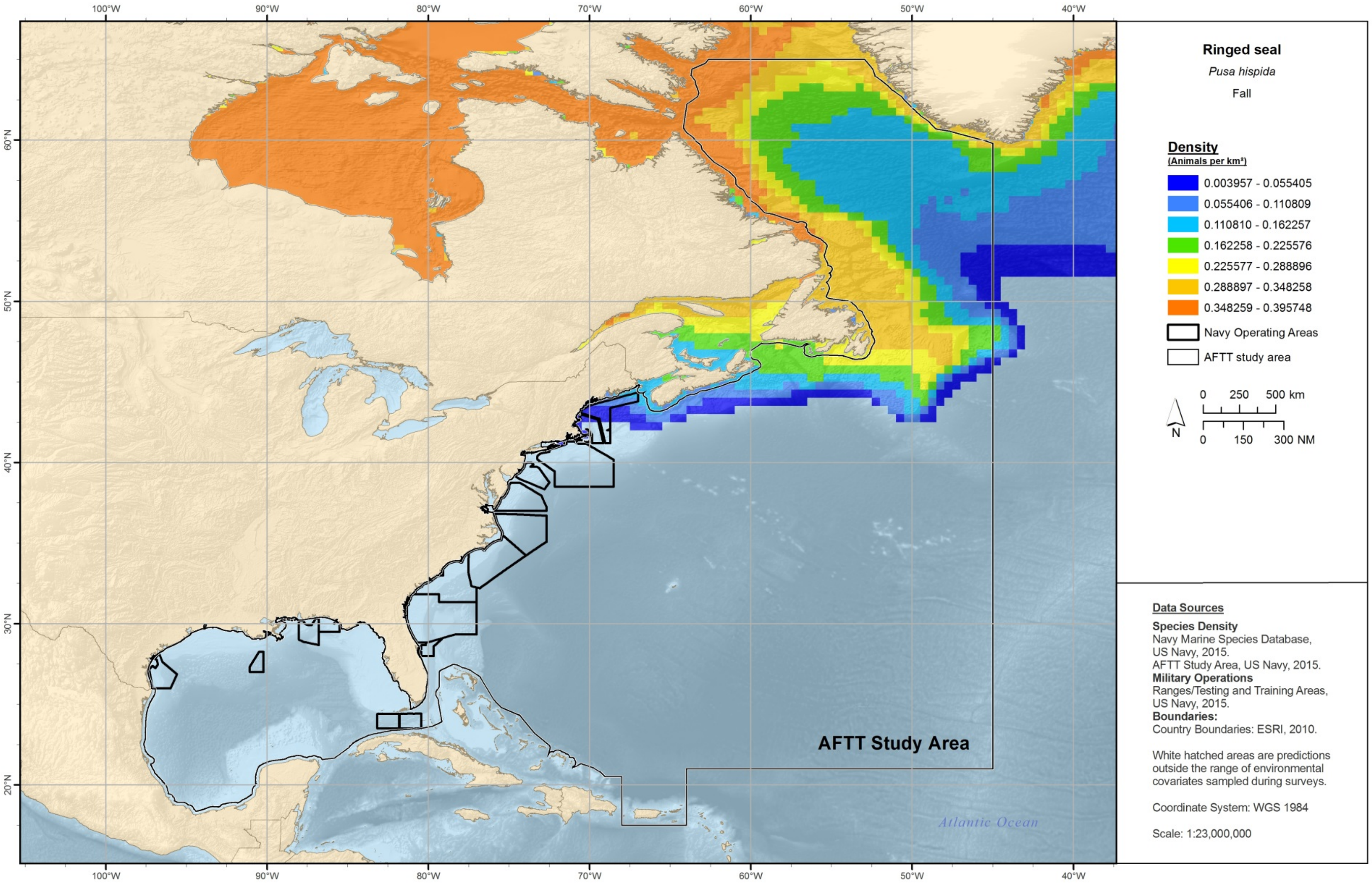


Figure 4-155. Fall RES density prediction for the ringed seal.

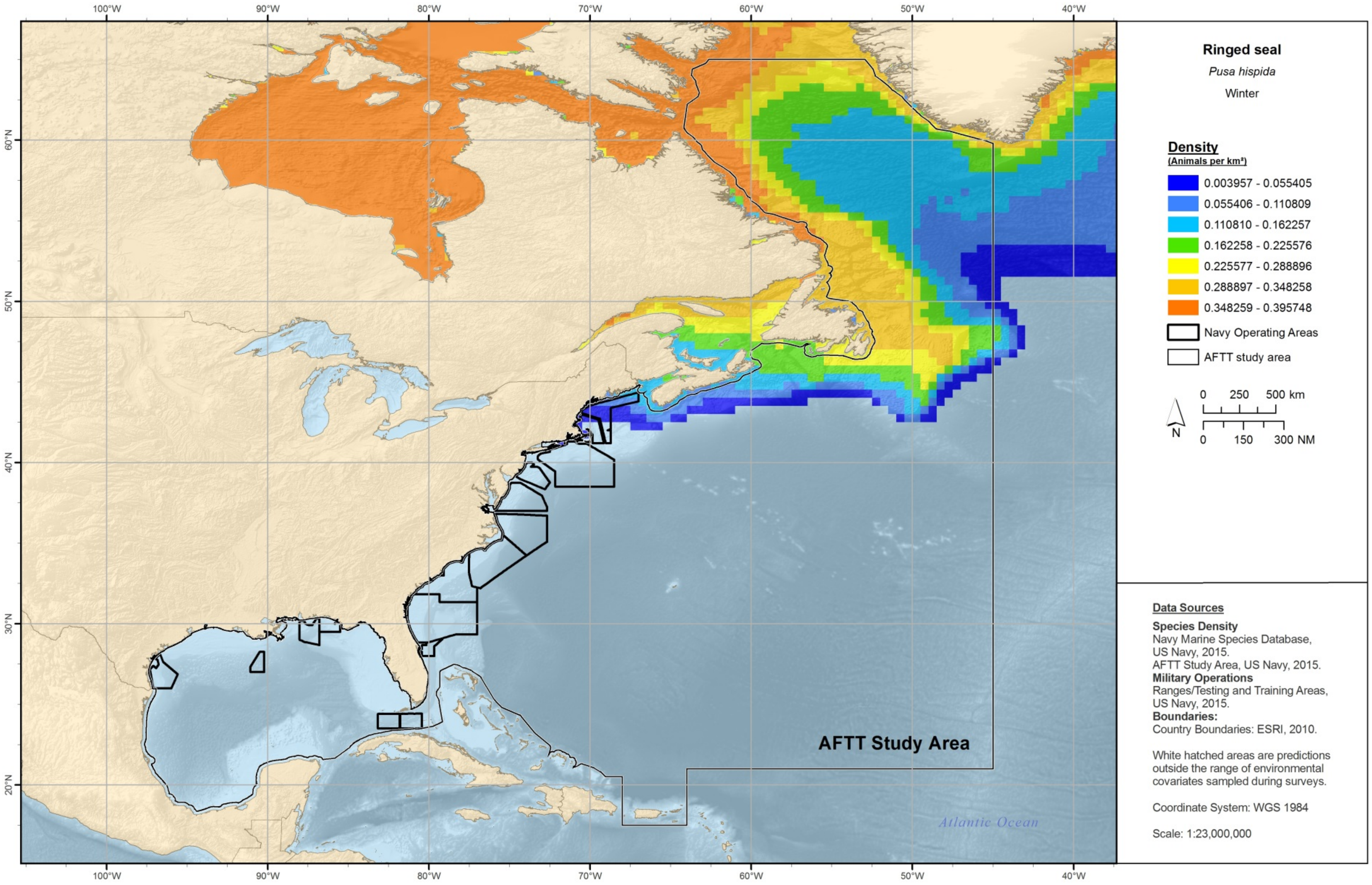


Figure 4-156. Winter RES density prediction for the ringed seal.

Seals: gray seal (*Halichoerus grypus*) and harbor seal (*Phoca vitulina*)

These two species are the most common in U.S. waters and are difficult to distinguish at sea leading to many ambiguous sightings. A classification of ambiguous sightings was not possible and as such the two species were modeled as a guild.

In inland waters it may be more appropriate to use haul-out counts spread over an area defined by telemetry tracking data as a substitute for line-transect density estimates. Here, line-transect methods are used as the areas being assessed are predominantly oceanic habitat and at-sea sightings represent the best available data for density estimation over this broad region.

Data Sources and Seasonality:

All density data incorporated into the NMSDD for these species comes from density spatial models developed by Roberts et al. (2016) and stratified density models developed by Mannocci et al. (2016). A density spatial model was fit for the East Coast stratum. A stratified spatial model was fit for the AFTT stratum. These species were assumed absent in the Gulf of Mexico and south of the northern border of the Gulf Stream. In the East Coast, summer and winter seasons were defined based on the SAR for harbor seals. The temporal resolution of the density predictions was seasonal for the East Coast stratum and annual for the AFTT.

Survey Data and Selected Models:

In the East Coast stratum, a total of 842 sightings from the combined survey data were used for model development. This species is limited to the northern regions of the East Coast and so the model was limited to south of the northern limit of the Gulf Stream. The climatological models consistently explained more deviance than models fitted with contemporaneous covariates.

The model for the AFTT stratum used the East Coast stratum sightings, as well as 56 from Europe. The stratified model was limited to continental shelf areas given the ecology of these species.

Other Density Estimates:

The Roberts et al. (2016) AFTT model predicts 98,747 (CV=0.55) individuals in the summer in the East Coast stratum. A 2012 Maine coastal survey counted 75,834 seals (harbor seals only, did not include gray seals [Waring et al. 2015]). Kaschner RES data were used in TAP Phase II for individual species so no comparable estimate is available. Meaningful comparison is difficult given the absence of a CV for the coastal survey and other factors such as different spatial and temporal extents, different environmental covariates considered, different modeling frameworks, and different survey data used. However, the model used is in the same order of magnitude of the coastal survey. The Roberts et al. (2016) estimate was chosen over the Kaschner models as it is higher in the NMSDD hierarchy.

An abundance estimate of 50,007individuals (CV=0.01) was derived from the AFTT stratum model (Mannocci et al. 2016). Because this stratum encompasses largely unsurveyed regions, all density estimates in the far offshore areas of the AFTT stratum are speculative. However, the Mannocci et al. (2016) model is more closely tied to data in the region than global density estimates used in the past (such as the SMRU and Kaschner RES data) and as such is expected to provide more realistic density estimates than those datasets. This model should not be used for nearshore or inland water estimates where haul-out counts combined with telemetry data are expected to provide a much more realistic density estimate.

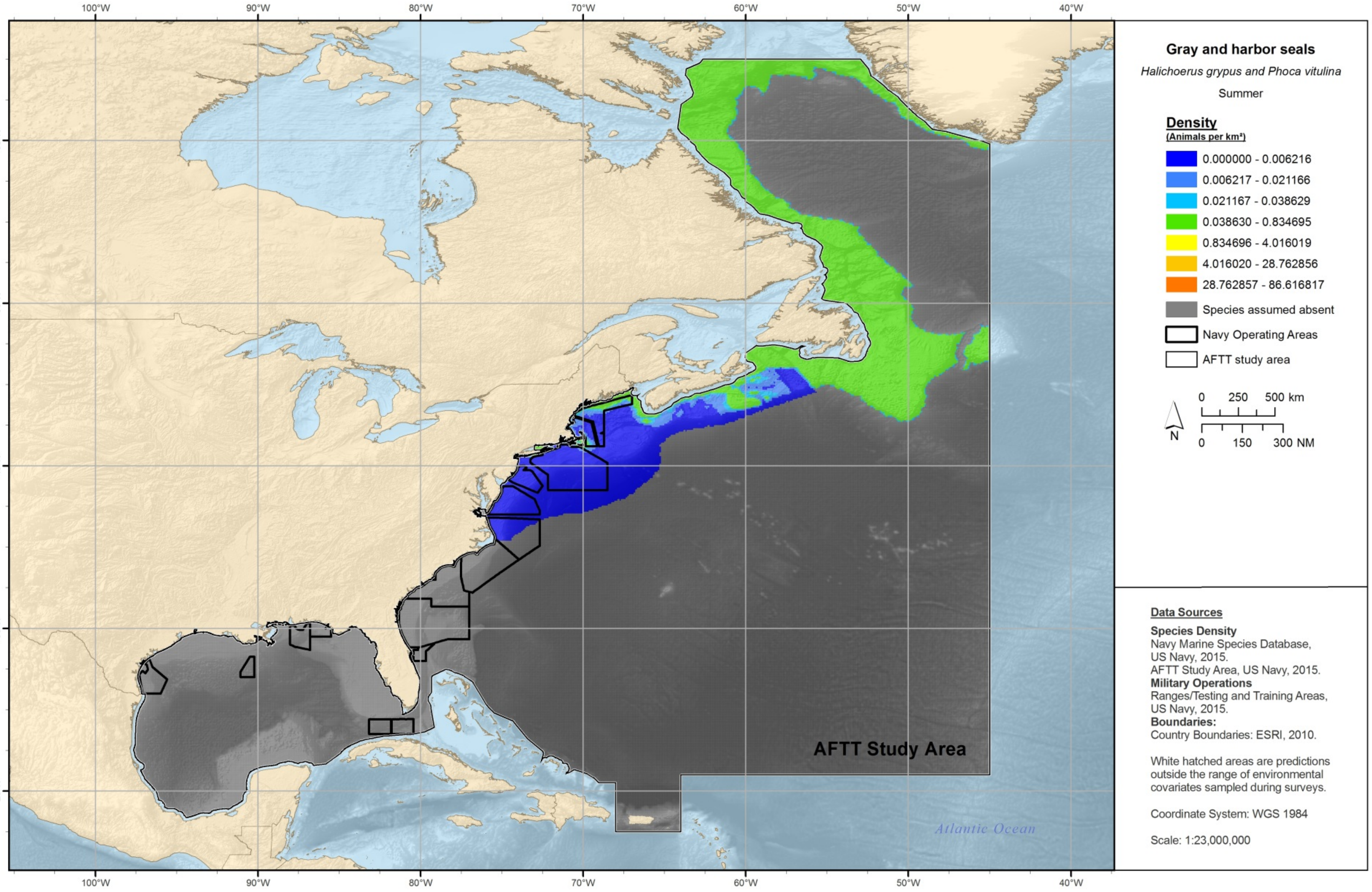
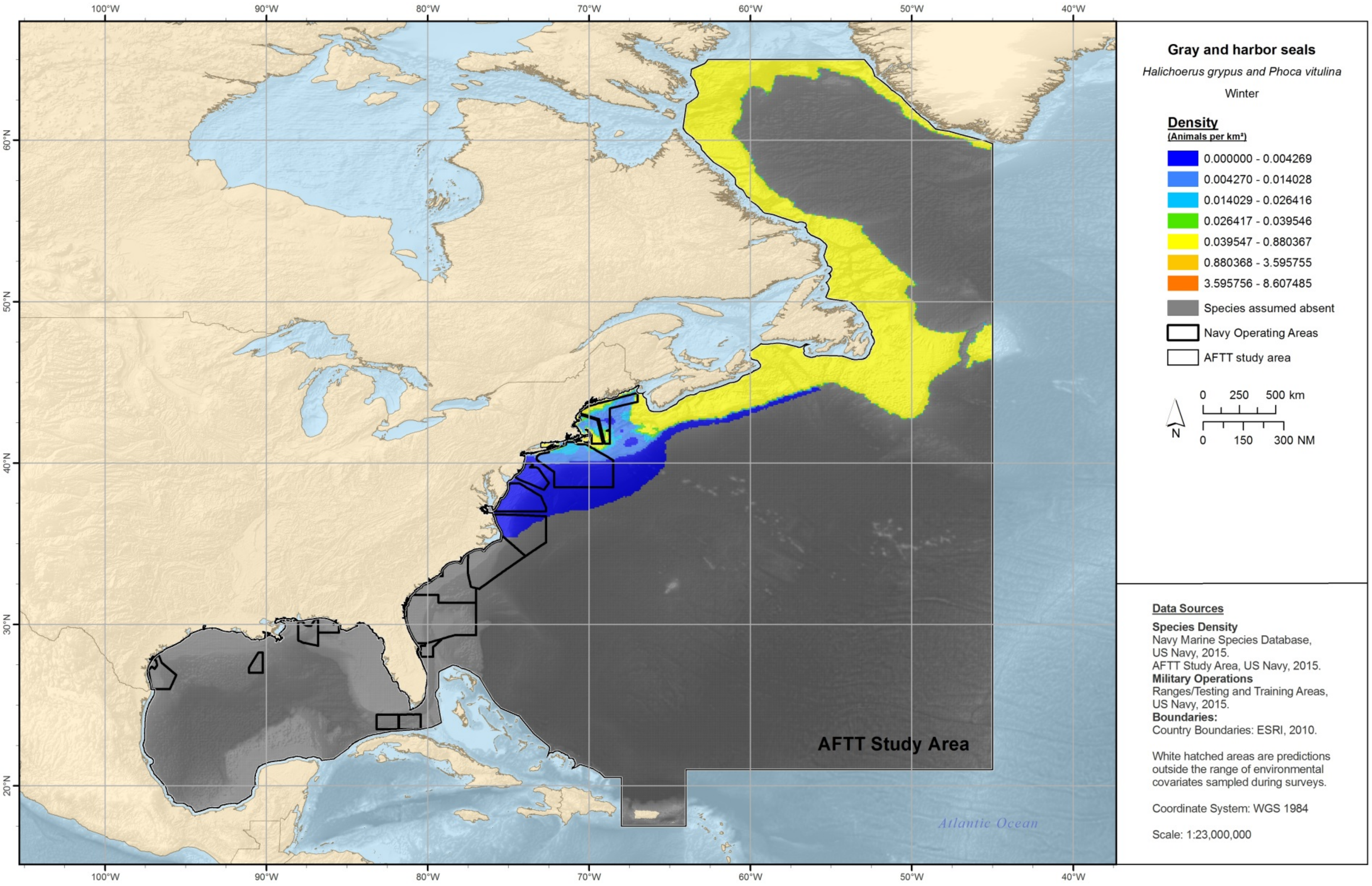


Figure 4-157. Summer density prediction for gray and harbor seals for the East Coast and AFTT strata.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-158. Winter density prediction for gray and harbor seals for the East Coast and AFTT strata.

Walrus (*Odobenus rosmarus*)

Because of their extremely limited distribution within the AFTT Study Area, impacts to the walrus are assessed qualitatively in the document. As such, no density data for the walrus was analyzed.

4.9 POLAR BEAR

Polar bear (*Ursus maritimus*)

Because of their extremely limited distribution within the AFTT Study Area, impacts to the polar bear are assessed qualitatively in the document. As such, no density data for the polar bear was analyzed.

4.10 SEA TURTLES

Hardshell turtles

Data Sources and Seasonality:

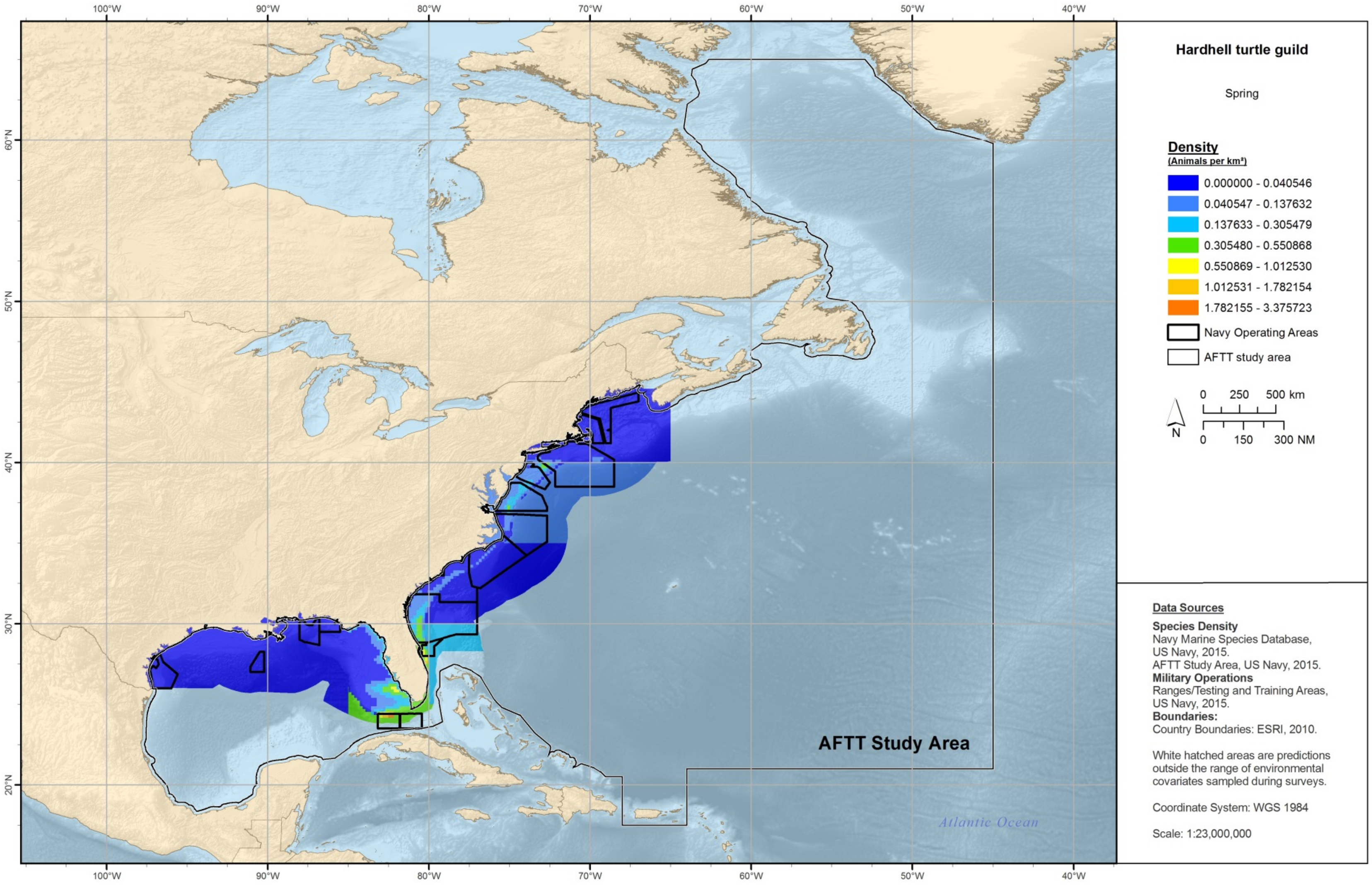
All density data incorporated into the NMSDD for this guild comes from the NODES and extrapolations from NODES density spatial models and are not updated from TAP Phase II. This model was produced from all unidentified turtle sightings available for the NODE effort and excludes leatherback turtles that have a distinctive shell and are readily identified on surveys. Individuals in this guild may include loggerhead turtles, Kemp’s ridley turtles, green turtles, hawksbill turtles, and possibly olive ridley turtles though their presence is very unlikely given their current distribution. These sightings account for a large enough percentage of all turtle sightings that not accounting for them would substantially underestimate turtle density. Species with enough confirmed sightings are also modeled separately. The density spatial model was limited to the shelf break where most sea turtle sightings occur. An extrapolation out to the U.S. EEZ was made in order to cover the portions of Navy OPARAEAs that occur off the shelf break. Values from the edge of the density spatial model were used and the extrapolated areas are broken into several strata arranged north to south. Four seasons were defined for this species, based on human seasons for convenience, similar to the RES data. The temporal resolution of the density predictions is seasonal. This guild is used to complement the models for loggerhead, Kemp’s ridley, and green turtles that were generated with confirmed sightings so as to not underestimate density for these species. It is also the only density estimate that includes green and hawksbill turtles in the study area.

Survey Data and Selected Models:

NMFS line-transect survey data in the East Coast and Gulf of Mexico strata from 1999 to 2004 were used in the creation of the NODE models. A spatial density model using both static and dynamic covariates was fit to areas on the shelf break with stratified extrapolations of the model used in areas off the shelf break and extending to the U.S. EEZ. No broad scale models or estimates exist in the far offshore areas of the study area or in the vicinity of Puerto Rico.

Other Density Estimated

Only one other relatively broad scale estimate of sea turtle density exists in the study area – the Virginia Aquarium estimate for loggerhead turtles, which is discussed in that species’ section. No SARs exist for sea turtle species. Isolated, fine scale density estimates exist in some locations for some species but are either unavailable or inappropriate for inclusion into the NMSDD.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-159. Spring NODES density spatial model for hardshell turtles.

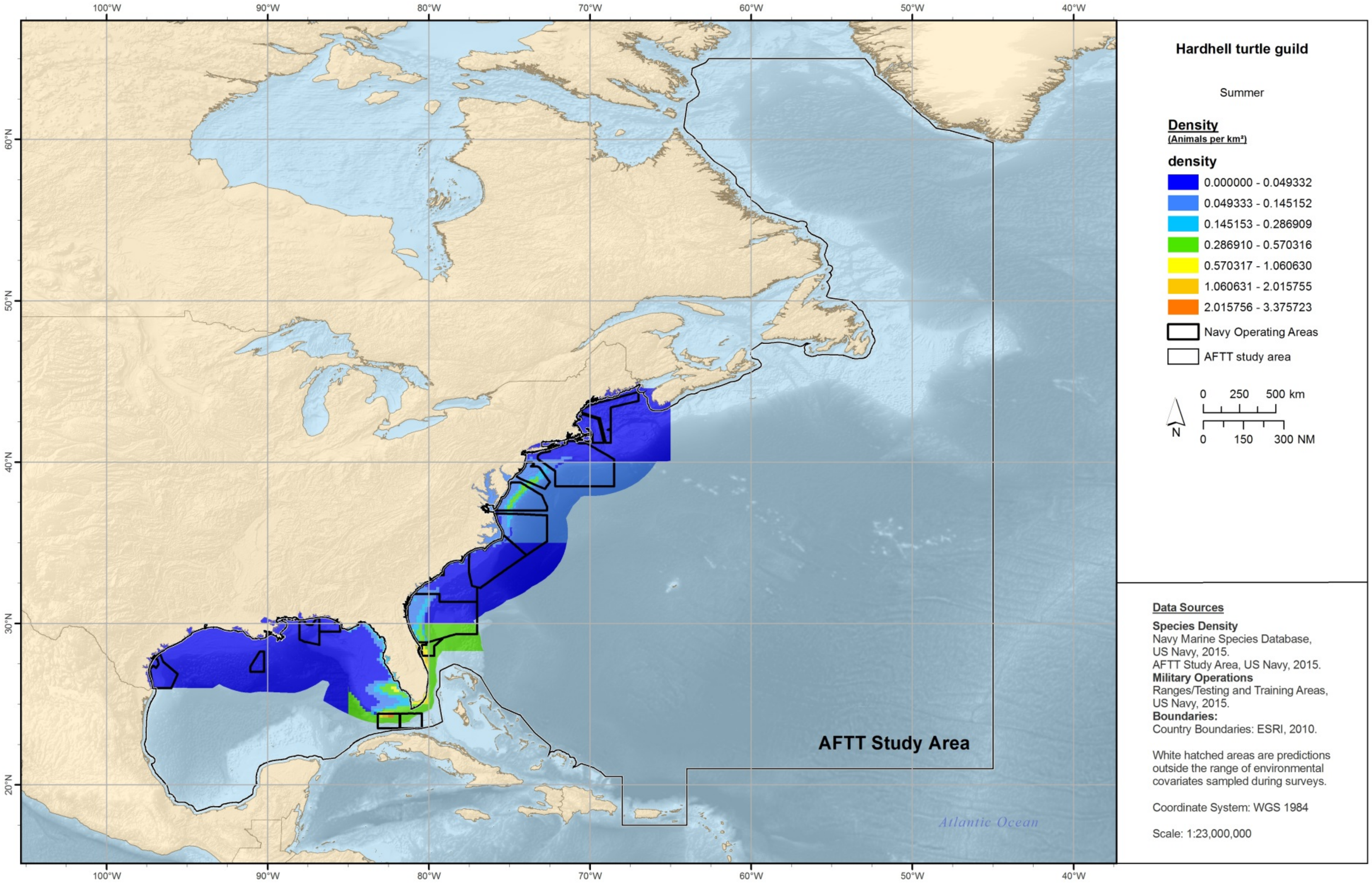
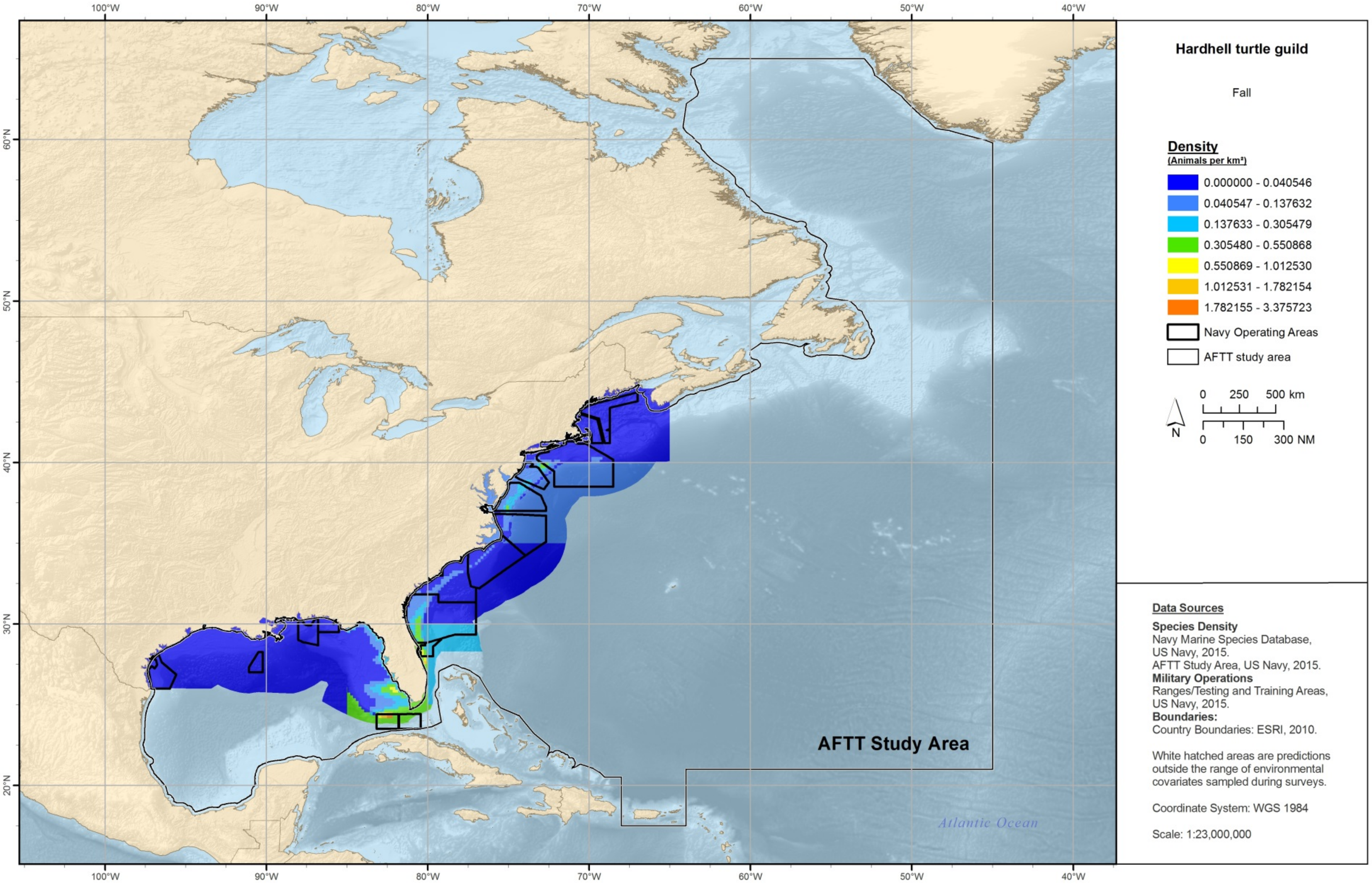


Figure 4-160. Summer NODES density spatial model for hardshell turtles.



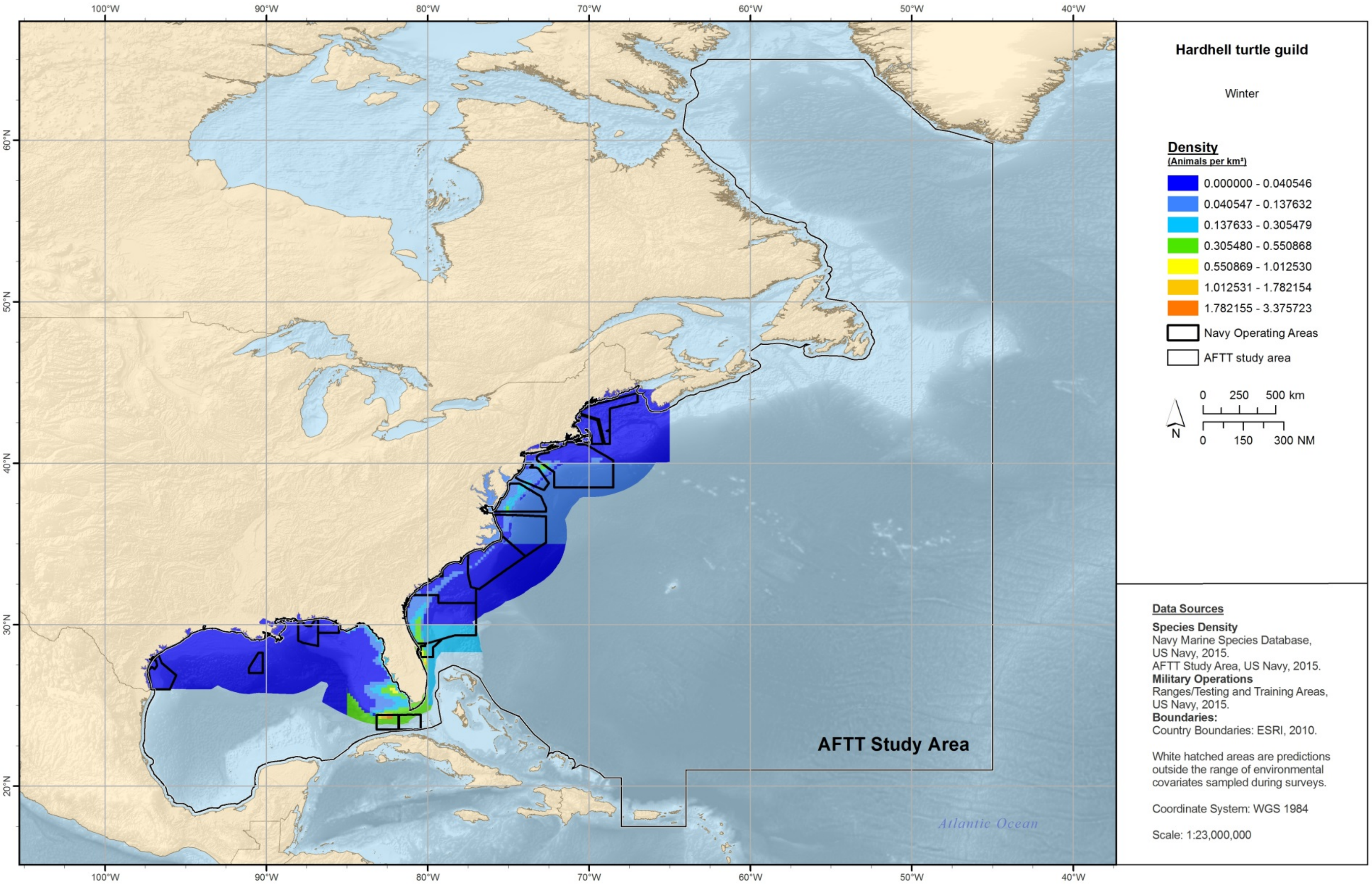
Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-161. Fall NODES density spatial model for hardshell turtles.



Data Sources
Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-162. Winter NODES density spatial model for hardshell turtles.

Kemp's ridley turtle (*Lepidochelys kempii*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from the NODES and extrapolations from NODES density spatial models and are not updated from TAP Phase II. The density spatial model was limited to the shelf break where most sea turtle sightings occur and includes only confirmed sightings of Kemp's ridley turtles. Unidentified turtles are accounted for in the 'hardshell turtle guild' model. An extrapolation out to the U.S. EEZ was made in order to cover the portions of Navy OPARAEAs that occur off the shelf break. Values from the edge of the density spatial model were used and the extrapolated areas are broken into several strata arranged north to south. Four seasons were defined for this species, based on human seasons for convenience, similar to the RES data. The temporal resolution of the density predictions is seasonal.

Survey Data and Selected Models

NMFS line-transect survey data in the East Coast and Gulf of Mexico strata from 1999 to 2004 were used in the creation of the NODE models. A spatial density model using both static and dynamic covariates was fit to areas on the shelf break with stratified extrapolations of the model used in areas off the shelf break and extending to the U.S. EEZ. No models or estimates exist in the far offshore areas of the study area or in the vicinity of Puerto Rico.

Other Density Estimates:

No SARs exist for sea turtle species. No other broad scale Kemp's ridley density models exist in the study area. Isolated, fine scale density estimates exist in some locations for some species but are either unavailable or inappropriate for inclusion into the NMSDD. There is no SAR for this species as turtle are not managed in the same way as marine mammals under the MMPA.

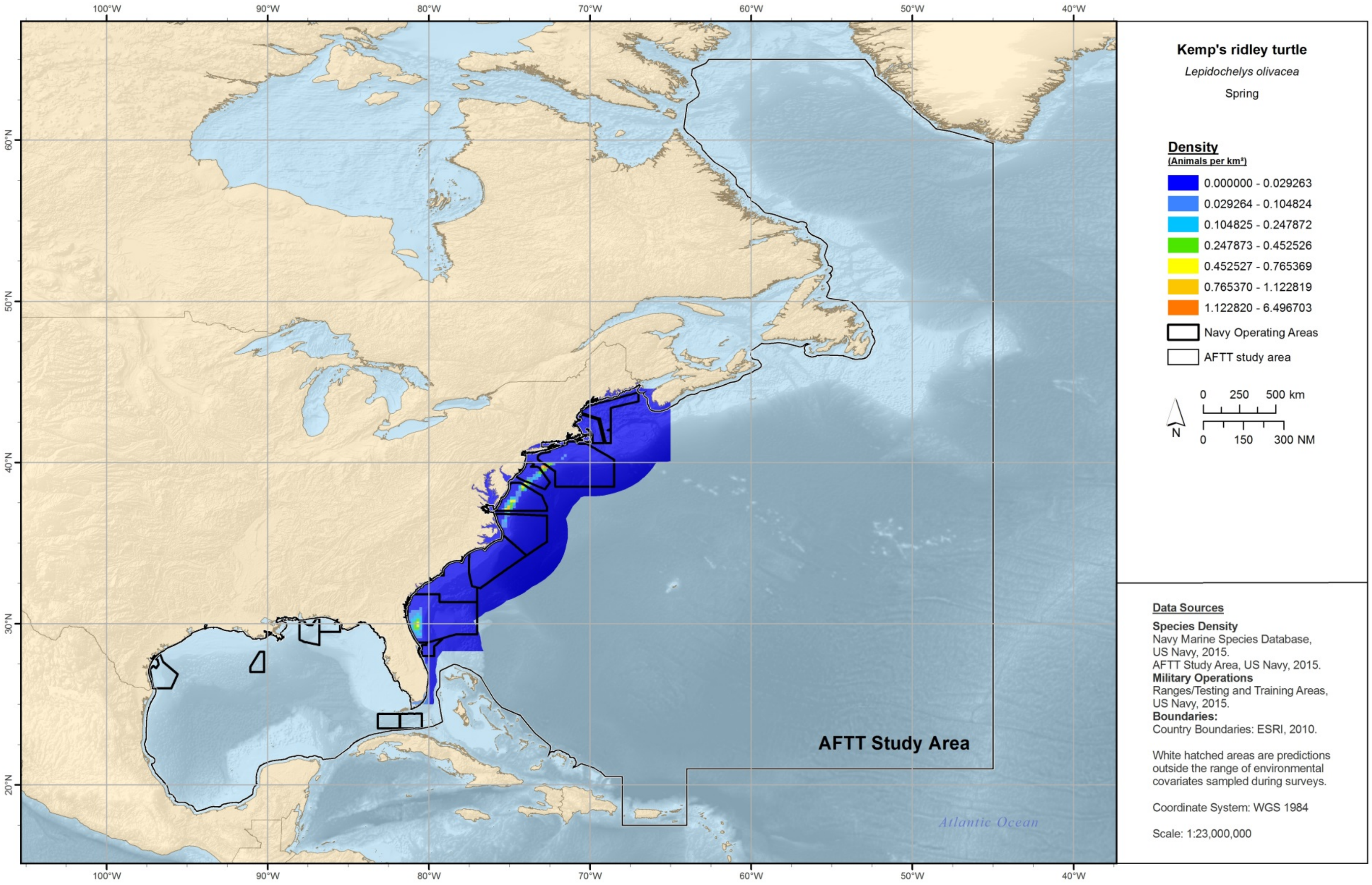
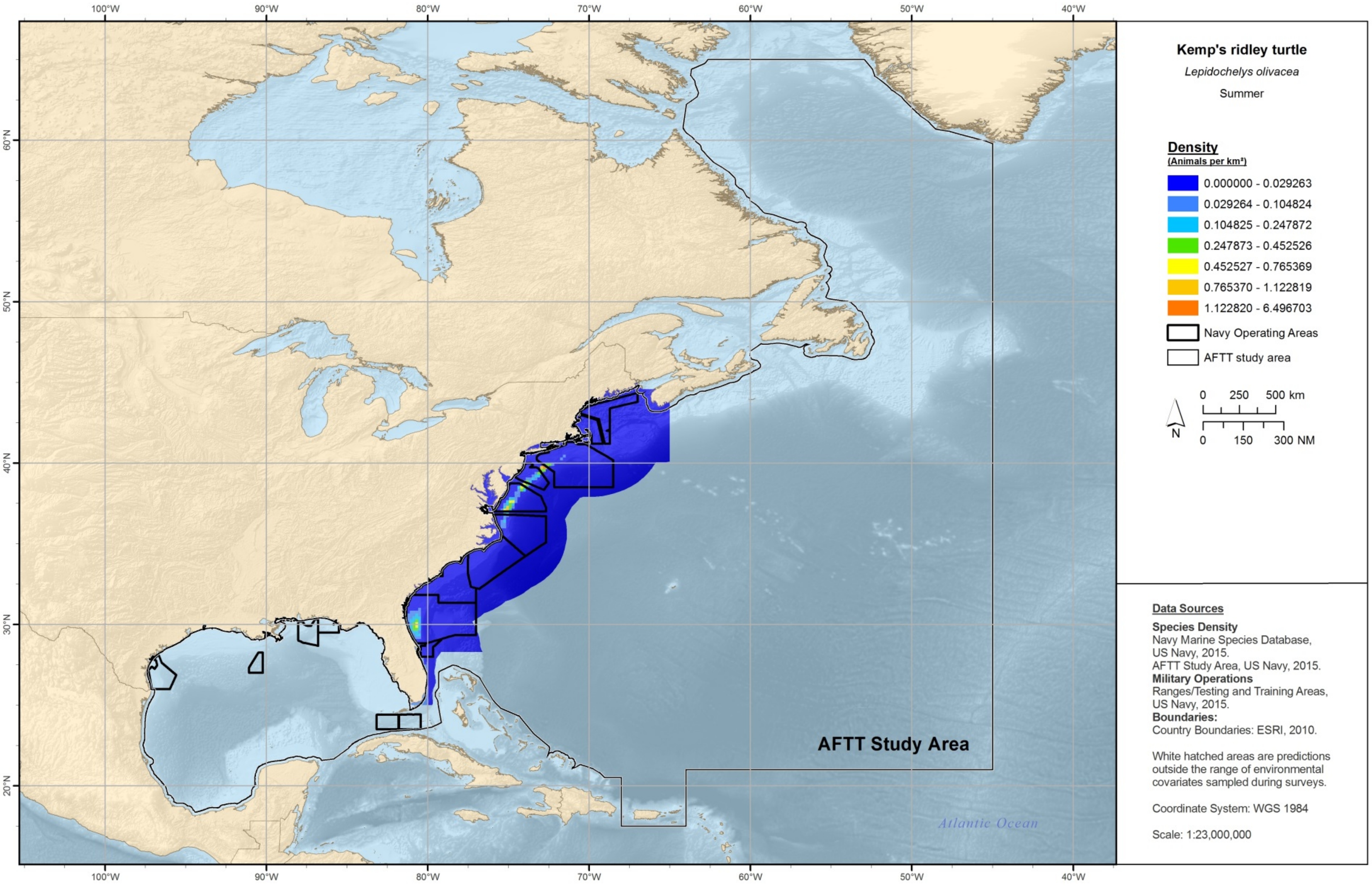


Figure 4-163. Spring NODES density spatial model for the Kemp's ridley turtle.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-164. Summer NODES density spatial model for the Kemp's ridley turtle.

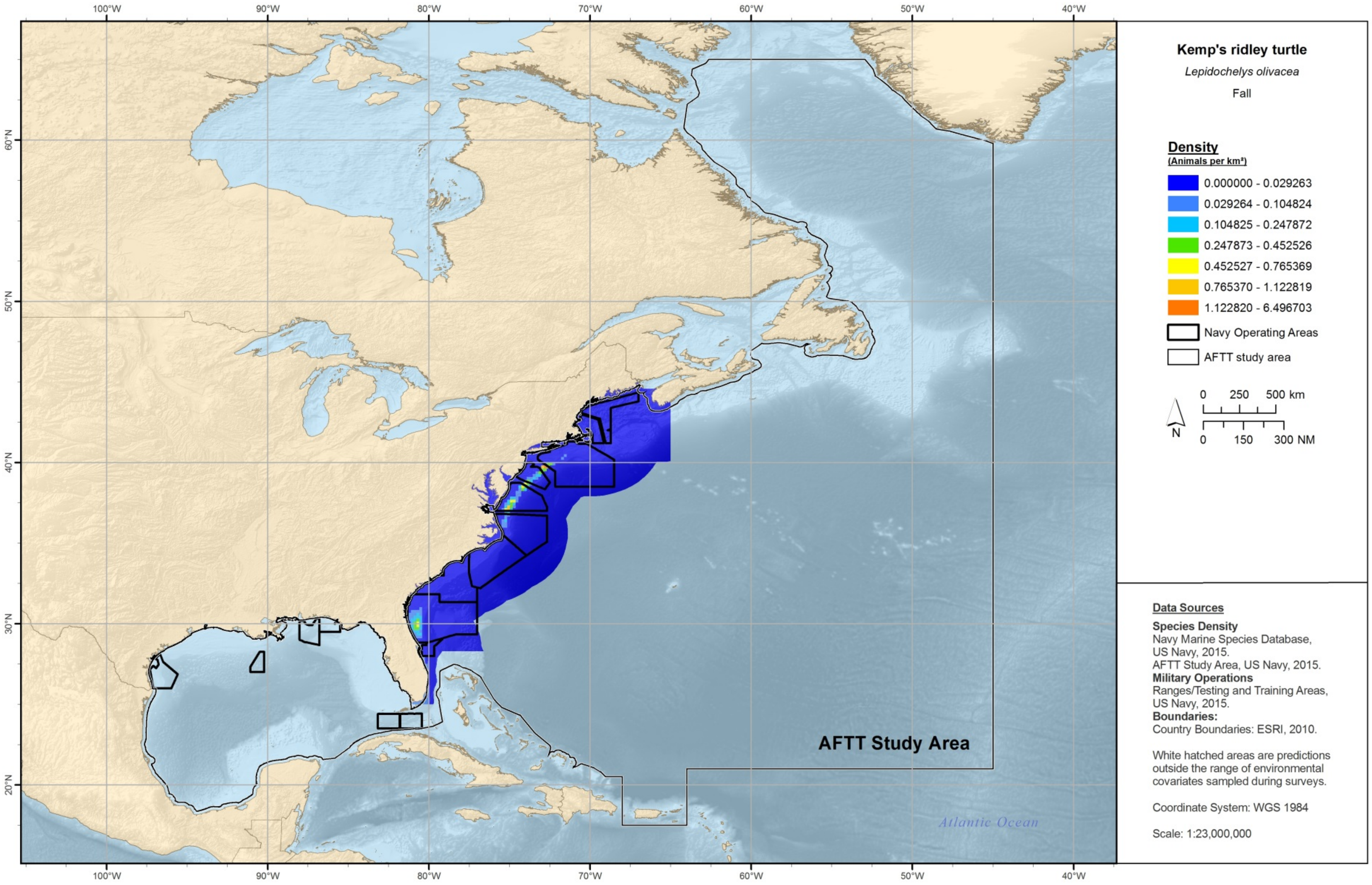


Figure 4-165. Fall NODES density spatial model for the Kemp's ridley turtle.

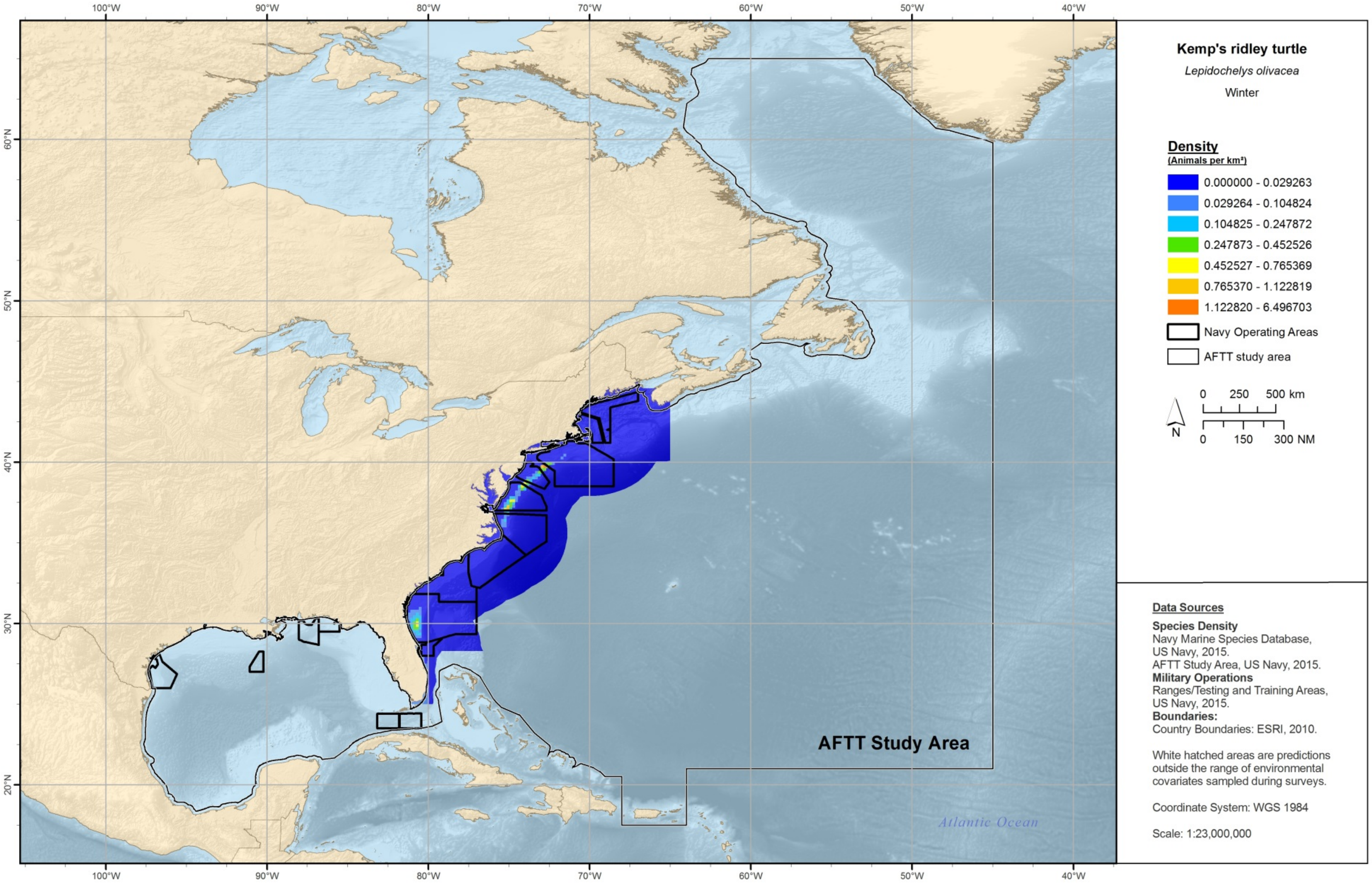


Figure 4-166. Winter NODES density spatial model for the Kemp's ridley turtle.

Leatherback turtle (*Dermochelys coriacea*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from the NODES and extrapolations from NODES density spatial models and are not updated from TAP Phase II. The density spatial model was limited to the shelf break where most sea turtle sightings occur. Given their distinctive shell, it is not anticipated that unidentified turtles in any of the surveys would be leatherbacks. An extrapolation out to the U.S. EEZ was made in order to cover the portions of Navy OPARAEAs that occur off the shelf break. Values from the edge of the density spatial model were used and the extrapolated areas are broken into several strata arranged north to south. Four seasons were defined for this species, based on human seasons for convenience, similar to the RES data. The temporal resolution of the density predictions is seasonal.

Survey Data and Selected Models:

NMFS line-transect survey data in the East Coast and Gulf of Mexico strata from 1999 to 2004 were used in the creation of the NODE models. A density spatial model using both static and dynamic covariates was fit to areas on the shelf break with stratified extrapolations of the model used in areas off the shelf break and extending to the U.S. EEZ. No models or estimates exist in the far offshore areas of the study area or in the vicinity of Puerto Rico.

Other Density Estimates:

No SARs exist for sea turtle species. No other broad scale leatherback density models exist in the study area. Isolated, fine scale density estimates exist in some locations for some species but are either unavailable or inappropriate for inclusion into the NMSDD. There is no SAR for this species as turtle are not managed in the same way as marine mammals under the MMPA.

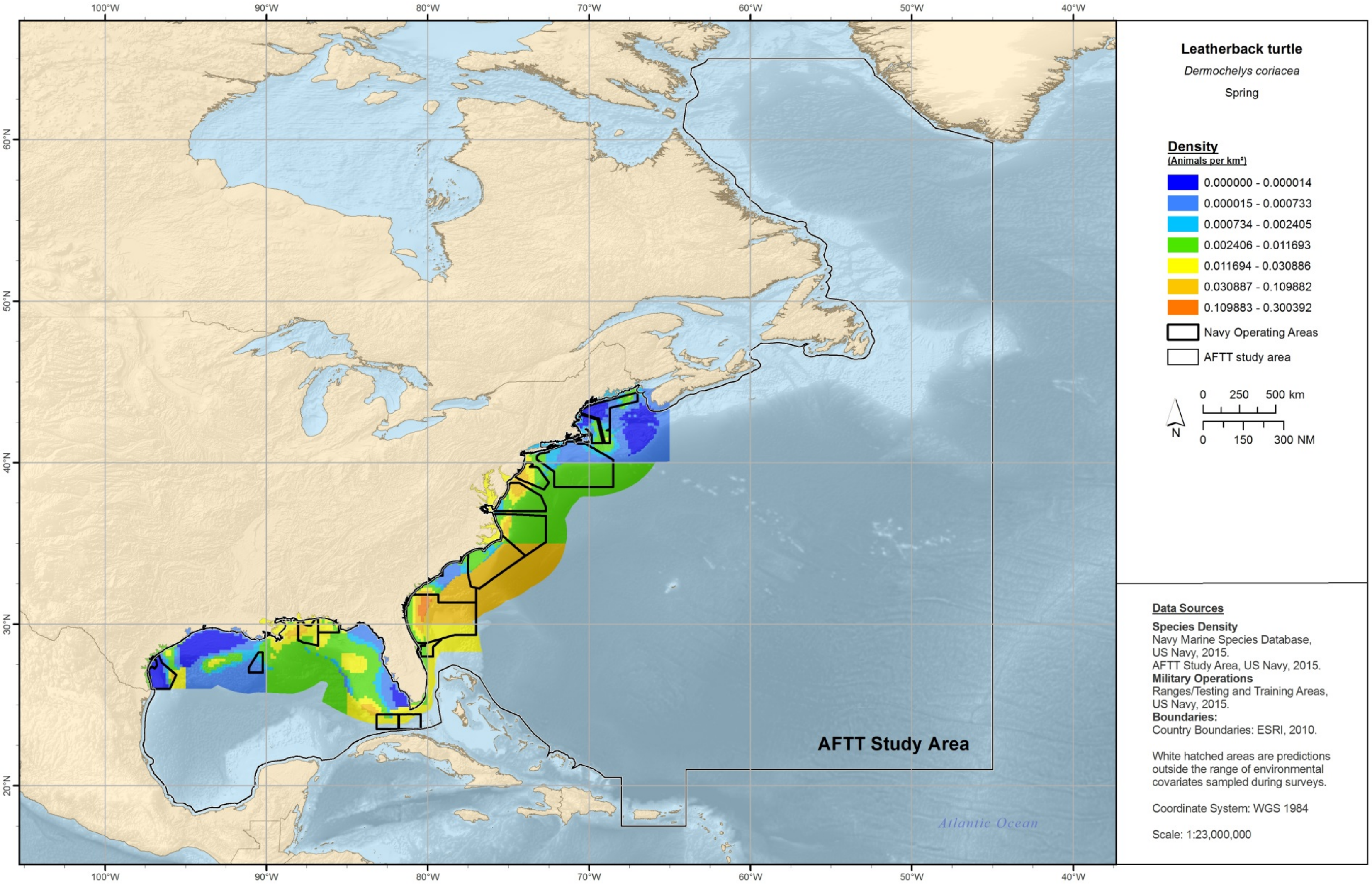
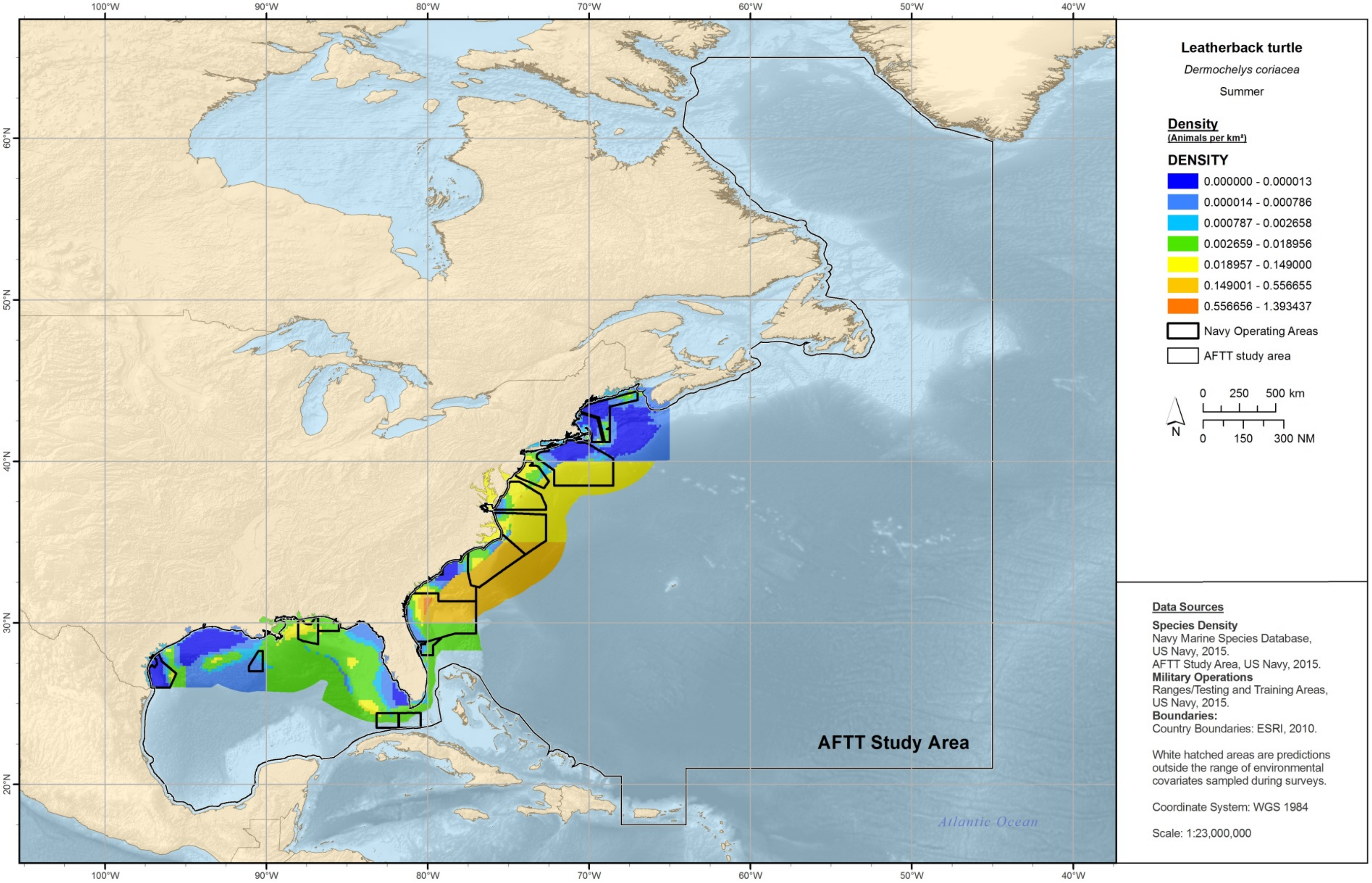


Figure 4-167. Spring NODES density spatial model for the leatherback turtle.



Data Sources

Species Density
Navy Marine Species Database, US Navy, 2015.
AFTT Study Area, US Navy, 2015.
Military Operations
Ranges/Testing and Training Areas, US Navy, 2015.
Boundaries:
Country Boundaries: ESRI, 2010.

White hatched areas are predictions outside the range of environmental covariates sampled during surveys.

Coordinate System: WGS 1984

Scale: 1:23,000,000

Figure 4-168. Spring NODES density spatial model for the leatherback turtle.

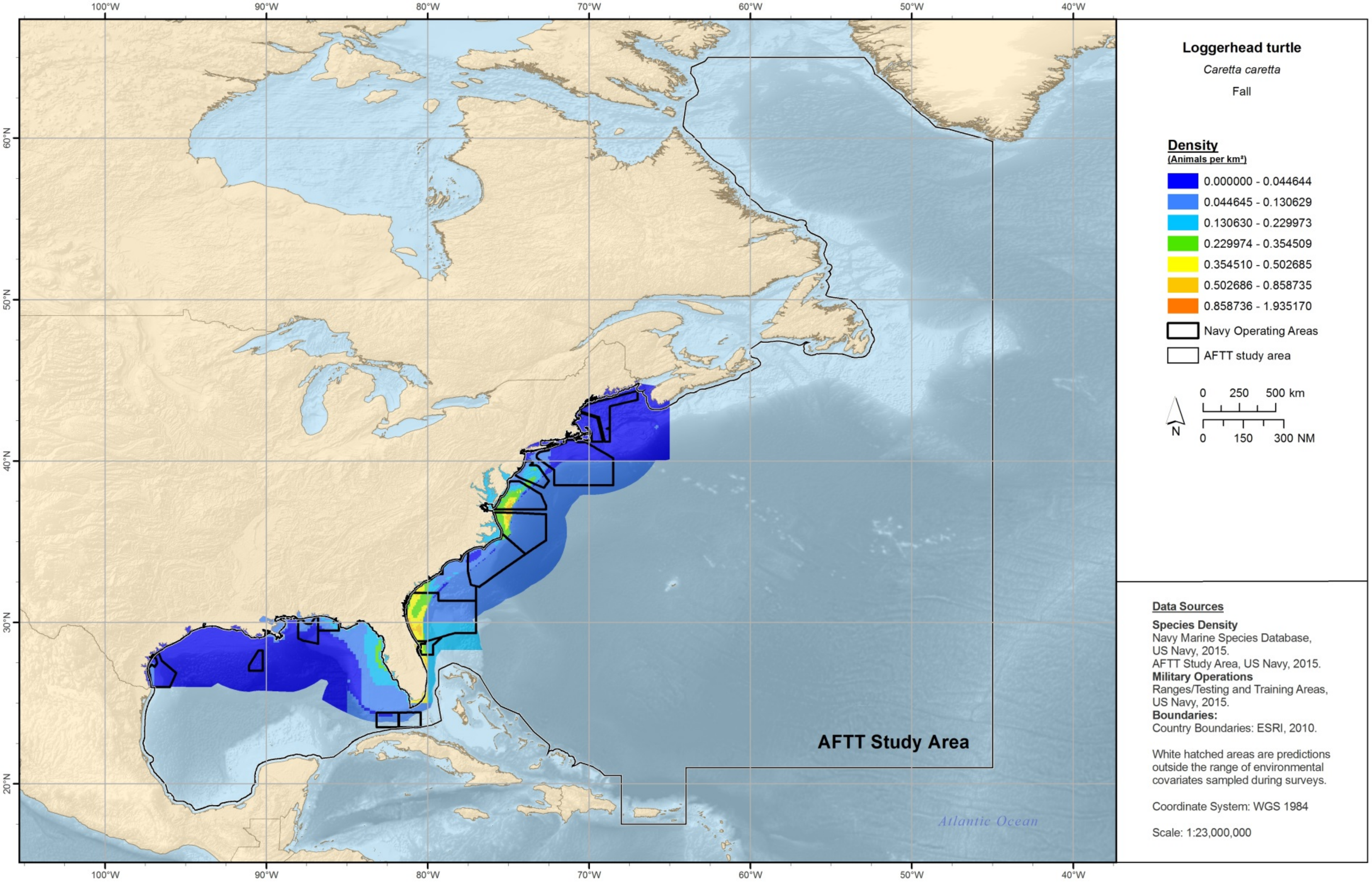


Figure 4-169. Fall NODES density spatial model for the leatherback turtle.

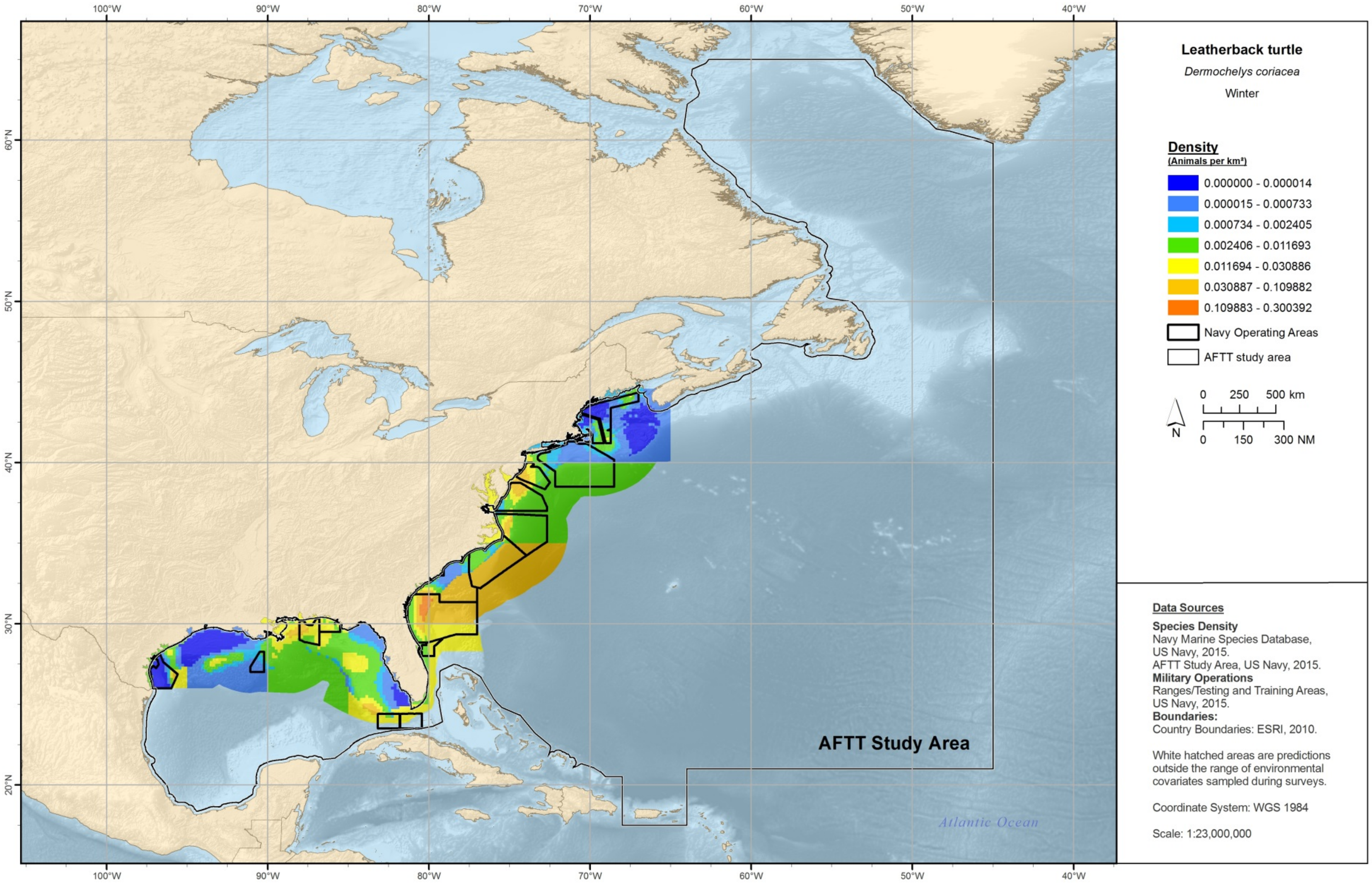


Figure 4-170. Winter NODES density spatial model for the leatherback turtle.

Loggerhead turtle (*Caretta caretta*)

Data Sources and Seasonality:

All density data incorporated into the NMSDD for this species comes from the NODES, and extrapolations from NODES density spatial models, as well as density spatial models derived from Virginia Aquarium surveys of the Chesapeake Bay and mid-Atlantic. Only the Chesapeake Bay and mid-Atlantic are updated from TAP Phase II. The density spatial models are limited to the shelf break where most sea turtle sightings occur and include only confirmed sightings of loggerhead turtles. Unidentified turtles from surveys used in the NODE models are accounted for in the ‘hardshell turtle guild’ model. They are not accounted for in the models derived from the Virginia Aquarium surveys. An extrapolation out to the U.S. EEZ was made from the NODE spatial density model in order to cover the portions of Navy OPARAEAs that occur off the shelf break. Values from the edge of the NODE density spatial model were used and the extrapolated areas are broken into several strata arranged north to south. Four seasons were defined for this for both spatial density models species, based on human seasons for convenience, similar to the RES data. The temporal resolution of the density predictions is seasonal.

Survey Data and Selected Models:

NMFS line-transect survey data in the East Coast and Gulf of Mexico strata from 1999 to 2004 were used in the creation of the NODE models. Aerial surveys from 2011-2013 were used in the development of the Chesapeake Bay and mid-Atlantic spatial density models. No models or estimates exist in the far offshore areas of the study area or in the vicinity of Puerto Rico.

Other Density Estimate

No SARs exist for sea turtle species. No other broad scale loggerhead density models exist in the study area. Isolated, fine scale density estimates exist in some locations for some species but are either unavailable or inappropriate for inclusion into the NMSDD. A stratified density estimate for loggerheads exists on the Atlantic coast of Florida (Bovery and Wyneken 2015) but the NODE data, while older, still occupies a higher place on the NMSDD hierarchy and so is used in that area.

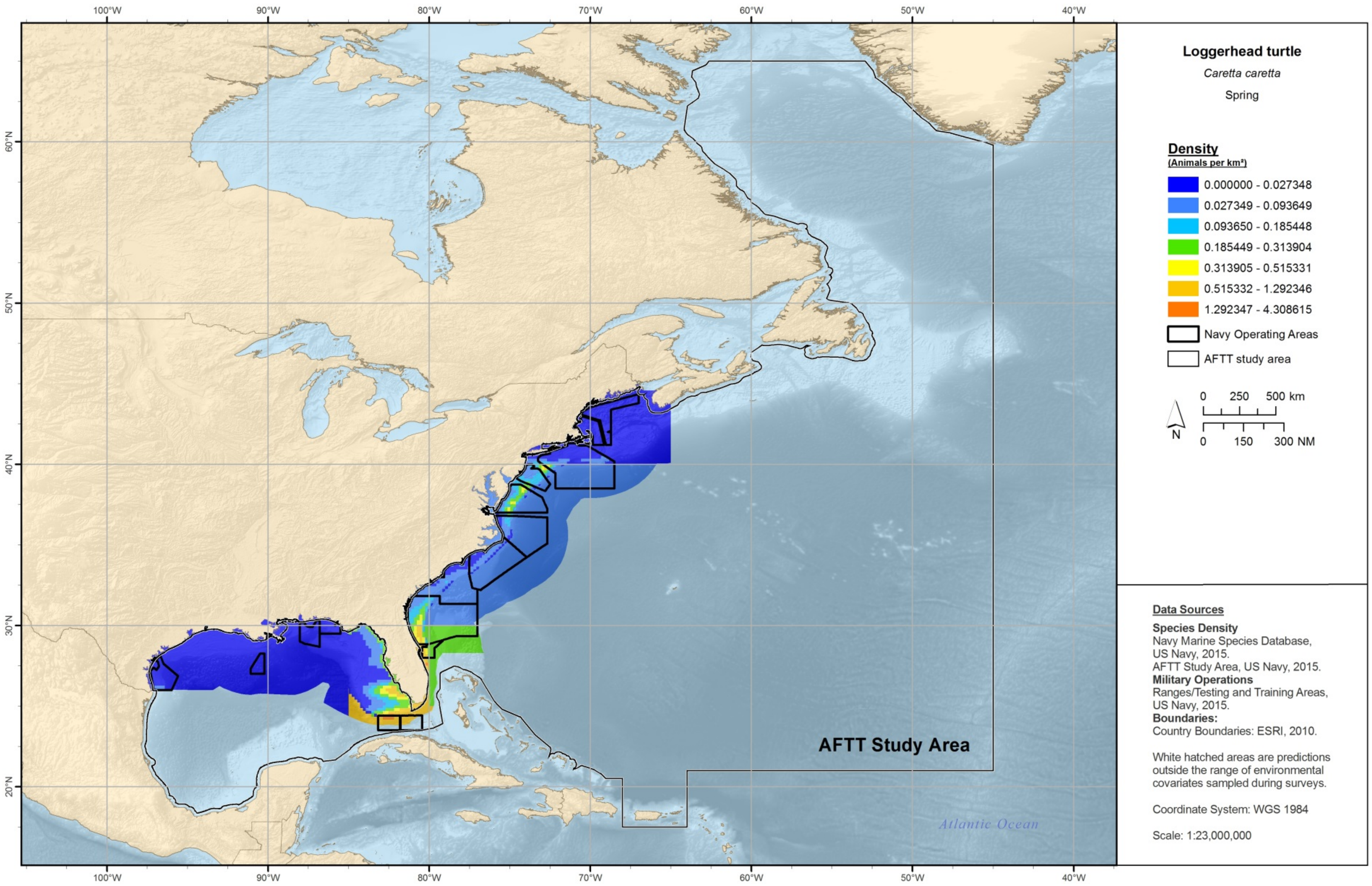


Figure 4-171. Spring NODES density spatial model for the loggerhead turtle.

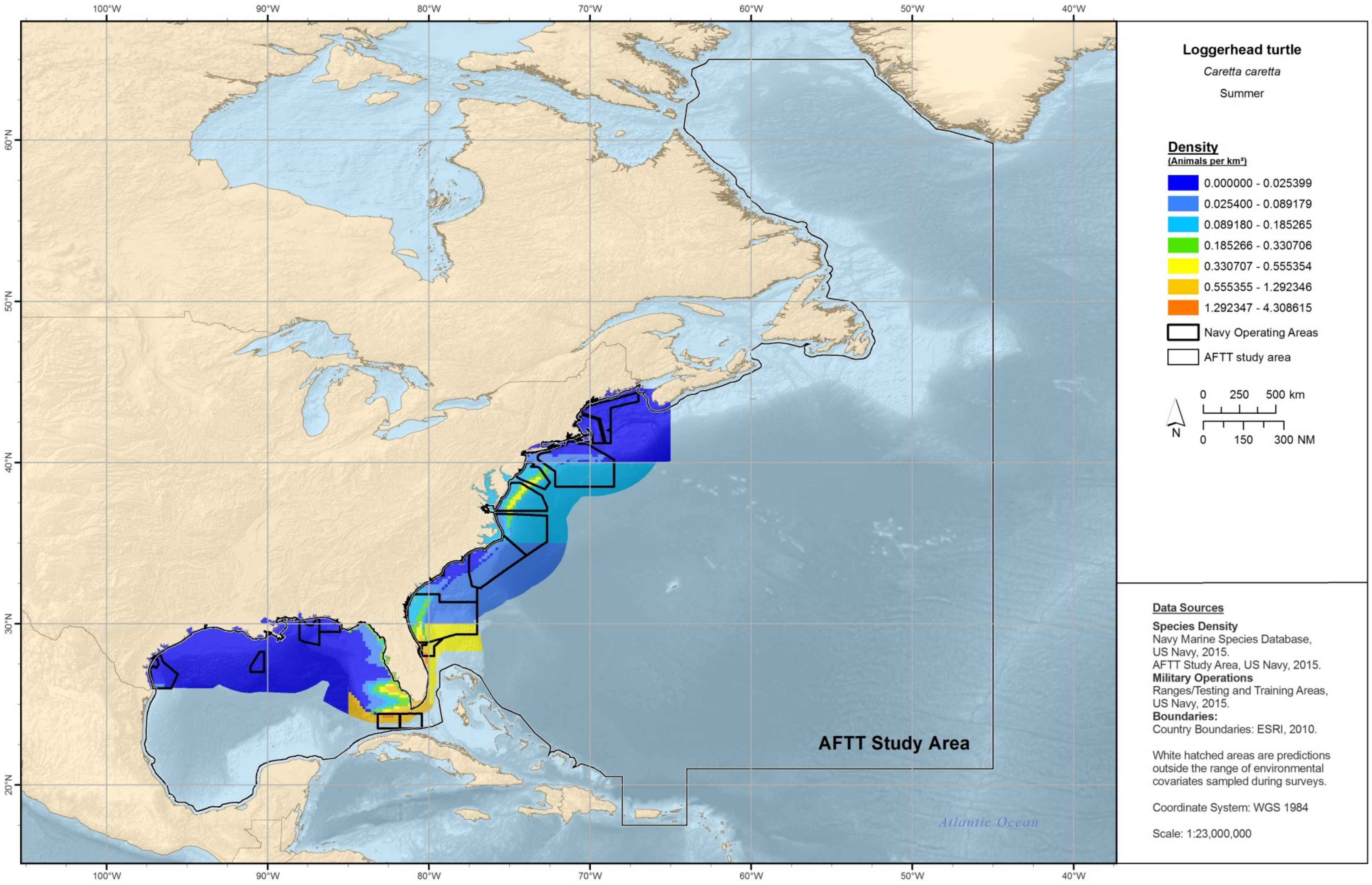


Figure 4-172. Summer NODES density spatial model for the loggerhead turtle.

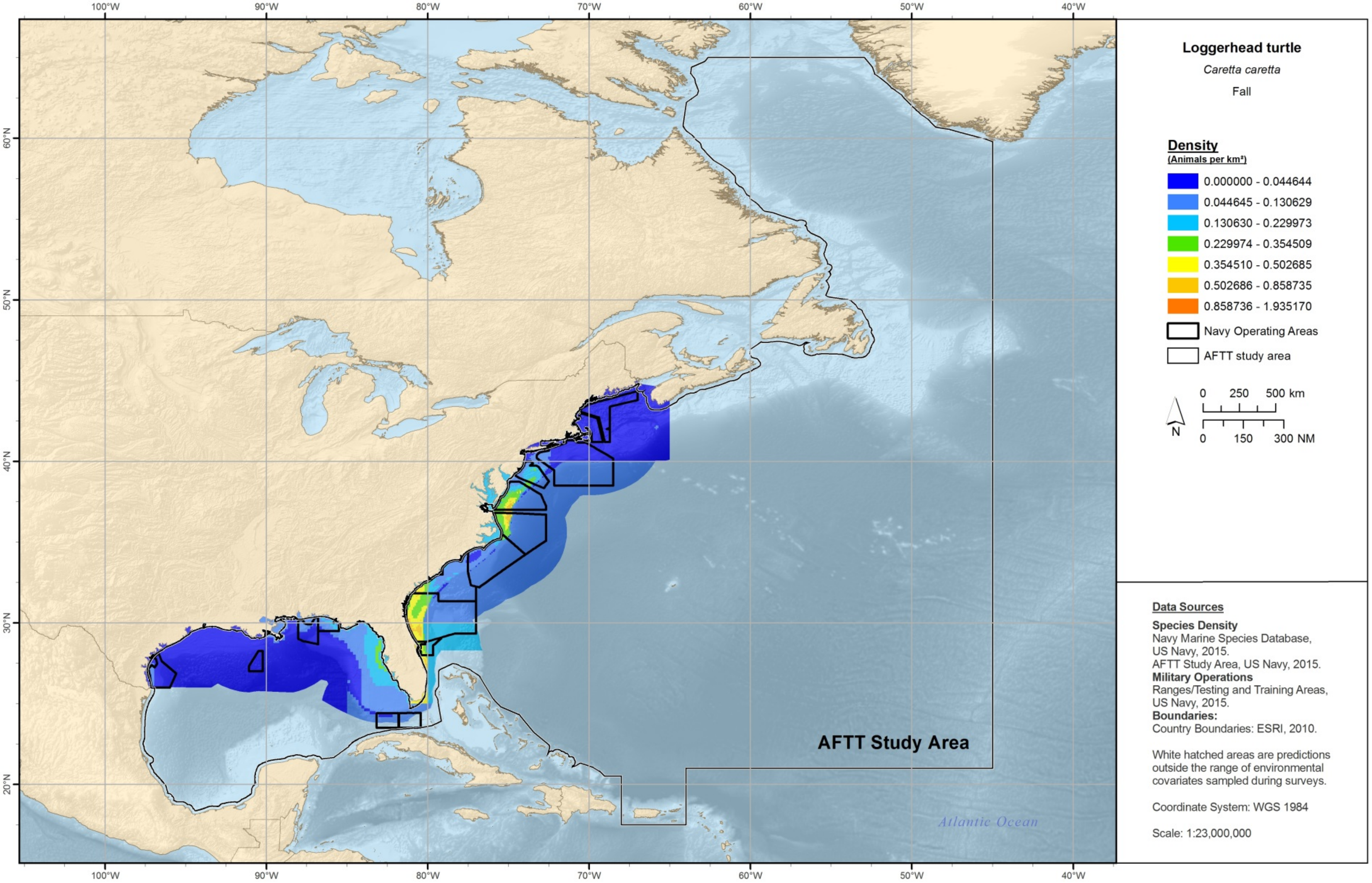


Figure 4-173. Fall NODES density spatial model for the loggerhead turtle.

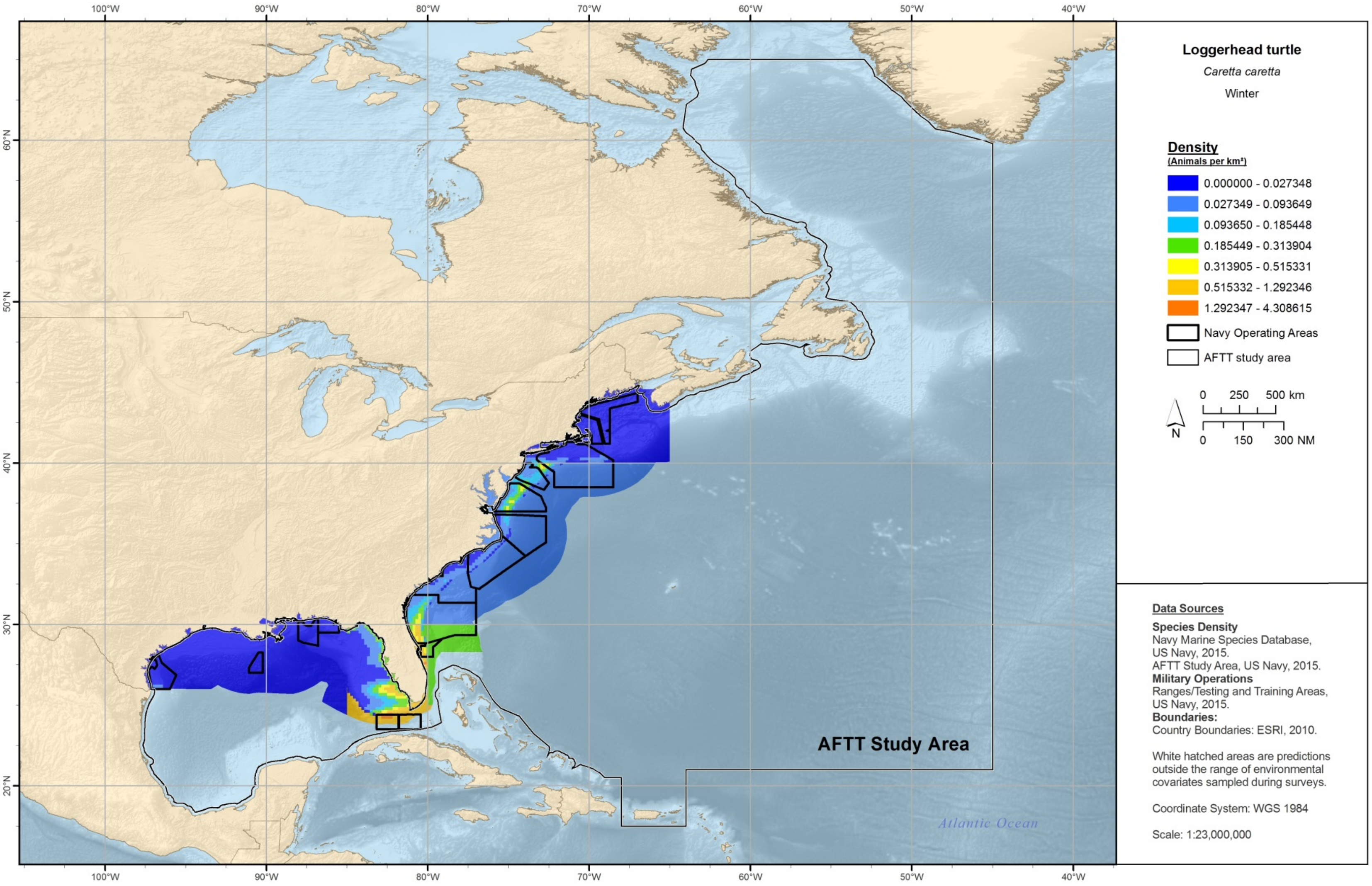


Figure 4-174. Winter NODES density spatial model for the loggerhead turtle.

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6 APPENDIX A: NMSDD AFTT PHASE III DATA DICTIONARY

Field name	Type	Description
UID	Long	Unique ID Field for species per study area.
SPECIES	Text254	Species common name (no apostrophes or special characters)
SPECIES_2	Text254	Species scientific name (no apostrophes or special characters)
MONTH_NUMB	Long	Month number 01-12 if you are going to use, if not make 'null'
MONTH_NAME	Text50	Month name January-December if you are going to use, if not make 'null'
STUDY	Text254	Source/study information
STRATUM	Text50	Stratum name
MODEL_TYPE	Text50	Identifies what type of model was used to calculate density (For AFTT these were 'Spatial Extrapolation, Habitat based density model, etc.
DENSITY	Double	Density value
UNCERTAINTY	Double	Numerical uncertainty value (CV)
UNCER_QUAL	Text254	Qualitative uncertainty value (description of uncertainty when numerical value is not present or to describe additional qualitative information. Duke used this column to further define the type of model that was used which called back to other documentation that described how the model was run and how it performed) Elizabeth Becker should be providing this info
MODEL_VERS	Text50	Not needed for NAEMO modeling but may be used for density creators/publishers own internal model tracking. If not used calculate as 'null'
NAEMO_VERS	Long	Identifies version of data - NAEMO specific. Populate as '01' or 'null'
SEASON	Text50	To be populated to capture season information i.e. Spring, Summer, Fall, Winter. if you are not going to use make 'null'
AREA_SQKM	Float	Area in square kilometers. Area must be calculated in features prior to delivery and projection must be documented in metadata
ABUNDANCE	Double	Calculated as 'AREA_SQKM'*'DENSITY' per cell and is used as a metric in the QAQC process and to aide in understanding the density values.

*ArcGIS built in attributes table fields not included in data dictionary but will be auto generated (Shape_Leng, Shape_Area, ObjectID, and Shape)

Feature/layer naming convention

- Feature/layer names must include the species common name and season or month when determined necessary by Navy. If multiple stocks of the same species are to be modeled then an additional method of identification will need to be developed. See example geodatabase for Bottlenose dolphin example.

Seasonal feature/layer creation and additional attribute table information:

- Species with seasonal distributions: <u>Create 4 layers</u>, one for each season, Spring, Summer, Fall, or Winter
    - Populate the SEASON field as, Spring, Summer, Fall, or Winter
    - Duplicate seasonal density data were necessary to accommodate the Cold and Warm classification

    - Duplicate seasonal density data were necessary to accommodate multiple seasons, I.E. Spring, Summer, Fall, and not Winter

- Species with annual distribution: <u>Create 4 layers</u>, one for each season, Spring, Summer, Fall, or Winter
    - Duplicate the annual layer for each of the four seasons so there are 4 separate seasonal layers for each species that hold identical annual density information across all 4 seasons, I.E. Blue_whale_spring, Blue_whale_summer, Blue_whale_fall, Blue_whale_winter

- Species with monthly distribution: <u>Create 12 layers</u>, one for each month
    - I.E. Blue_whale_01, Blue_whale_02, Blue_whale_03, etc.

<u>Other Notes</u>
Restrict All Special Characters from text fields:
Commas ,
Apostrophes ‘
Dashes -
Periods .

MONTH_NAME and MONTH_NUMB Fields
Should be NULL unless needed to do temporal resolution

Projection:
Features should be delivered in WGS84.

Coastline:
Minimum coastline resolution of 250k should be used.

Grid:
Grid size should reflect resolution of the model however efforts should be made to align grid cells with existing NMSDD data if possible.