U.S. Navy Marine Species Density Database Phase III

for the

Mariana Islands Training and Testing Study Area

Technical Report

July 2018

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EXECUTIVE SUMMARY

The purpose of the United States Navy's Marine Species Density Database Technical Report is to document the process used to derive density estimates for marine mammal and sea turtle species occurring in the Mariana Islands Training and Testing (MITT) Study Area, and to provide a summary of species-specific and area-specific density estimates incorporated into the Navy's Marine Species Density Database. In 2005, the Navy and the National Oceanic and Atmospheric Administration reached an agreement on a coordinated programmatic strategy for assessing certain environmental effects of military readiness activities at sea. The Navy is currently in the third phase of implementing this programmatic approach. The following discussion summarizes improvements that have been made to the density estimates used for Phase III of the Navy's environmental compliance process.

In the MITT Study Area there is a paucity of line-transect survey data, and little is known about the stock structure of the majority of marine mammal species in the region. The Navy conducted the first comprehensive marine mammal survey of waters off Guam and the Commonwealth of the Northern Mariana Islands in 2007, and data from this survey were used to derive line-transect abundance estimates for 12 cetacean species (Fulling et al., 2011). There has not been a subsequent systematic survey of the MITT Study Area at this scale, so these data still provide the best available density estimates for this region.

In the absence of study-area-specific density data, line-transect estimates derived for Hawaiian waters were used to provide conservative density estimates for the MITT Study Area. For Phase II, these estimates were based on systematic surveys conducted by Southwest Fisheries Science Center within the Exclusive Economic Zone of the Hawaiian Islands in 2002 (Barlow, 2006). New survey data collected within the Exclusive Economic Zone of the Hawaiian Islands (2010) and Palmyra Atoll/Kingman Reef (2011–2012) allowed the National Marine Fisheries Service Pacific Islands Fisheries Science Center to update the line-transect density estimates that included new sea-state-specific estimates of trackline detection probability (Bradford et al., 2017) and represent improvements to the estimates used for Phase II. In addition, an updated density estimate for minke whale was available for Phase III based on line-transect analyses of acoustic data collected from a towed hydrophone during the 2007 systematic survey (Norris et al., 2017). Finally, a habitat model was developed for sperm whale based on acoustic data collected during the 2007 survey, and provided spatially explicit density predictions at a 10 kilometer x 10 kilometer (100 square kilometer) spatial resolution (Yack et al., 2016).

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ACRONYMS AND ABBREVIATIONS

˚C	degrees Celsius
CENPAC	Central Pacific
CNMI	Commonwealth of the Northern Mariana Islands
CV	Coefficient of Variation
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
FDM	Farallon de Medinilla
HARPS	High-Frequency Acoustic Recording Packages
IWC	International Whaling Commission
km	kilometer(s)
km^2	square kilometer(s)
m	meter(s)
mi.	mile(s)
MIRC	Mariana Islands Range Complex
MITT	Mariana Islands Training and Testing
MMPA	Marine Mammal Protection Act
˚N	Degrees North
Navy	U.S. Department of the Navy
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
NMSDD	Navy Marine Species Density Database
NUWC	Naval Undersea Warfare Center
OPAREA	Operating Area
PIFSC	Pacific Islands Fisheries Science Center
RES	Relative Environmental Suitability
SAR	Stock Assessment Report
SMRU Ltd.	Sea Mammal Research Unit, Limited (at University of St. Andrews)
SOCAL	Southern California
SWFSC	Southwest Fisheries Science Center
U.S.	United States
˚W	Degrees West

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1 BACKGROUND

To ensure compliance with United States (U.S.) legal requirements, including the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the National Environmental Policy Act, and Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions), the U.S. Department of the Navy (Navy) takes responsibility for reviewing and evaluating the potential environmental impacts of conducting at-sea training and testing. All marine mammals in the United States are protected under the MMPA, and some species receive additional protection under the ESA. 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 distribution of the species where those activities may occur. The most appropriate unit of metric for this type of analysis is density, which is the number of animals present per unit area.

In 2005, the Navy and the National Oceanic and Atmospheric Administration reached an agreement on a coordinated programmatic strategy for assessing certain environmental effects of military readiness activities at sea. The Navy is currently in the third phase of implementing this programmatic approach. This report includes a description of the available density data used in the "Phase III" quantitative impact analysis for each marine mammal and sea turtle species present in the Mariana Islands Training and Testing (MITT) Study Area.

NOTE: The density data are organized by species and presented in groups of related taxa within Sections 5 through 9 of this report. Within each individual species section, density data are described for the MITT Study Area as appropriate. Information on which species are found in the Study Area is provided in Table 4-1.

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 surveys are required, often in areas that are not easily accessible (e.g., far offshore). National Marine Fisheries Service (NMFS) is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Exclusive Economic 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, population structure and abundance data for island-associated populations of cetaceans in Hawaiian waters are collected by various non-NMFS researchers (e.g., Baird et al., 2009; McSweeney et al., 2007).

For most cetacean species, abundance is estimated using line-transect surveys or mark-recapture studies (e.g., Barlow & Forney, 2007; Barlow, 2010; Calambokidis et al., 2008). 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 off California, Oregon, and Washington (referred to as a "uniform" density estimate). This is the general approach applied in estimating cetacean abundance in the NMFS stock assessment reports. The disadvantage of these methods is that they do not provide information on the variation in concentrations of species in sub-regions of very large areas, and do not estimate density for other seasons or timeframes that were not surveyed. More recently, spatial habitat modeling has been used to estimate cetacean densities that address some of these shortcomings (e.g., Barlow et al., 2009; Becker et al., 2010; 2012; 2014; Becker et al., 2016; Ferguson et al., 2006; Forney et al., 2012; 2015; Redfern et al., 2006). Spatial habitat models allow estimates of cetacean densities on finer scales than traditional line-transect or mark-recapture analyses and can thus provide information on species distribution patterns within a study area.

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 (CV) of the estimate, which is derived using standard statistical methods and calculated as the standard error divided by the estimate. When the CV exceeds 1.0, the standard error is thus greater than the estimate. The CV is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. The greater the CV, the greater the uncertainty in the estimate. However, the CV may not capture the full extent of all sources’ uncertainty if they could not be estimated. For example, changes in cetacean distribution in response to oceanic variability can increase uncertainty (Becker et al., 2012).

Ideally, density data would be available for all species throughout the study area year-round, in order to best estimate the impacts of Navy activities on marine species. However, in many places, ship availability, lack of funding, inclement 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 typical 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.

The amount of effort required to collect and analyze data to estimate the densities for all protected marine species for the Navy's study areas is beyond the scope of any single organization and beyond any feasible means for the Navy. Therefore, to characterize marine species density for large oceanic regions, 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 selection and compilation of the best available marine species density data resulted in the Navy Marine Species Density Database (NMSDD).

Uncertainty, as used in this report, 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, and uncertainty in the estimate can be directly related to the method applied. As noted above, 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 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 beginning of this report provides a summary of the protocol that the Navy developed to compare data sources to each other and an explanation of the principles the Navy used to guide the choice of the most appropriate source to use for the specific area. These data are compiled for the Fleets and Systems Commands and are incorporated into Navy environmental compliance documents.

The Navy completed the first NMSDD for the Pacific and published a final report describing the density data used in the "Phase II" quantitative impact analysis for each marine mammal and sea turtle species present in the Navy's Pacific 3rd and 7th Fleet's Areas of Responsibility (U.S. Department of the Navy, 2015). The Pacific Fleet Study Areas addressed in the 2015 report included the Hawaii-Southern California Training and Testing Study Area, the MITT Study Area, the Northwest Training and Testing Study Area, and the Gulf of Alaska Temporary Maritime Activities Area Study Area. For the present "Phase III" analyses, a separate technical report will be prepared for each of these four study areas. This technical report provides further details on Navy protocol and how it was implemented for each marine mammal and sea turtle species present in the Navy's MITT Study Area.

2 NAVY MARINE SPECIES DENSITY DATABASE PROTOCOL

2.1 DENSITY ESTIMATION METHODS AND RELATIVE UNCERTAINTY

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 (km^2). Density estimation of marine species, in particular marine mammals and sea turtles, is very difficult because of the large amount of survey effort required, often spanning multiple years, and the resulting low number of observed sightings. "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 generally provides one single average density estimate for each species for the entire survey coverage extent, and usually is constrained to a specific timeframe or season. The estimate does not provide information on the species distribution or concentrations within that area, and does not estimate density for other timeframes/seasons that were not surveyed.

To quantify how species density varies geographically requires stratifying survey effort into smaller sub-regions during the density estimation process. Several methods 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) designed-based, (2) stratified-designed based, and (3) spatial models. Another suite of models, Relative Environmental Suitability (RES) models, uses 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 result in more certainty in the extrapolated estimates. This includes an extrapolation of no occurrence based on other sources of data, such as the NMFS stock assessment reports or expert judgment. Following is a short summary of each of the density estimation methods.

2.1.1 Designed-Based Density Estimate

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. 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 & 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 stock assessment reports. 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.

2.1.2 Stratified Designed-Based Density Estimate

Stratified designed-based 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 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 value 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.

2.1.3 Spatial Models

Spatial models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow density predictions on finer spatial scales than designed-based or stratified designed-based methods. Spatial 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. The advantage of this method is that the resulting density estimates are spatially defined, typically at the resolution of the environmental data used for model development, and thus show variation in species density and distribution. For geographic-specific impact assessments, this is the most preferred method of density estimation, and has been applied for many of the species in the Navy Operating Area (OPAREA) Density Estimates model for the Atlantic Ocean and the Southwest Fisheries Science Center (SWFSC) density models for the Pacific Ocean. Since this method of density estimation yields the best value estimation with the least uncertainty, it is the preferred data source when available.

2.1.4 Density Based on Relative Environmental Suitability Models

The three methods described above estimate density directly using 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 (also known as Environmental Envelope or Habitat Suitability Index 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. 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 based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed. Two examples include the Kaschner et al. (2006) global density estimates and the Sea Mammal Research Unit, Limited, at University of St. Andrews global density estimates. Given that uncertainty is very high, and results can substantially diverge from adjacent empirically based results (or don't correspond to densities measured from surveyed areas), this method of density estimation is the least preferred type of data source.

2.2 Overarching Data Source Selection and Implementation Guidelines

Ideally, marine species sighting data would be collected for the specific area and time period of interest and density estimates derived accordingly. However, as mentioned above, density data are not available for every species and season necessary for Navy impact analyses because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, depending on the region, species, and season of interest, there may be little to no density data available or multiple estimates derived from different methods. For example, in contrast to waters off the U.S. west coast (e.g., Forney et al., 2012), systematic line-transect survey data are extremely limited in the MITT Study Area, particularly in the offshore areas. Most survey efforts in this region are localized and very close to shore, thus making it impossible to directly quantify the density of most species known to occur in the region. In these cases, density estimates from other areas with similar oceanographic properties need to be used. Such extrapolations inherently include a higher degree of uncertainty than derived for the original density estimates, since it is not known how applicable the data are to the new areas.

The methods used to develop the density estimate directly affect the level of inherent uncertainty in the estimate. As described above, 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. Further, marine mammal surveys are typically conducted during one or two seasons because in many places poor weather conditions, and high sea states, prohibit the completion of winter surveys. So for the same species in the same region, one density estimation method may provide a better value for one season and a different method for the other seasons. Understanding these methods and how they affect the quality of the resulting density estimate is important to making an informed decision about which species-specific estimates are implemented in the NMSDD for each geographic area and season.

All density estimates are subject to a level of uncertainty. Further, many of the sources of uncertainty and the data themselves are not independent, which complicates standard analytical methods for estimating variance. Density estimates and predictions from ecological models should always be considered an approximation to truth (Burnham & Anderson, 1998). 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 mammal biodiversity, any single model will not completely explain the results.

In summary, for every region and species there is a broad range of available data of varying qualities that the Navy needs to evaluate in order to select the best values for incorporation into the NMSDD. Therefore, in order to provide a systematic structure for data source selection, the Navy established a hierarchical approach for ranking density estimates as described below.

2.2.1 Hierarchical Approach for Ranking Density Estimates

Some methods of density estimation are better than others and 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. As depicted in Table 2-1 for the NMSDD, modeling methods are ranked as follows:

(A) Density estimates from spatial models will be used when available. As described in Section 2.1.3, spatial models provide the best source of density data at the finest spatial scales and yield information on variation in species density and distribution useful for environmental planning efforts.

(1) The only habitat model available for the MITT Study Area was developed for sperm whale based on acoustic data collected during a 2007 line-transect survey (Yack et al., 2016).

(B) If no density spatial model based estimates were available, the following were used in order of preference:

(1) Density estimates using designed-based methods incorporating line-transect survey data and involving spatial stratification (i.e., estimates split by depth strata or arbitrary 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 designed-based methods incorporating only line-transect survey data (i.e., regional density estimate, stock assessment report).

(3) Density estimates derived using a RES model. As described in Section 2.1.4, this is the least preferred source of density data given their very coarse spatial resolution (global estimates) and high uncertainty. Based on the Navy's hierarchical approach, these data should be used only when other sources of density data are not available. Density estimates from RES models were not used anywhere in the MITT Study Area.

(C) As mentioned in Section 2.1, in some cases extrapolation 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.

(1) In the absence of study-area-specific density data and based on recommendations from scientists at the Pacific Islands Fisheries Science Center (PIFSC), line-transect estimates derived for Hawaiian waters were used to provide conservative density estimates for the MITT Study Area.

Table 2-1: Hierarchy of Density Data Sources

Level	Sources
Level 1 (Most Preferred)	Peer reviewed and/or published studies of density spatial models that provide spatially explicit density estimates or values derived from these sources
Level 2	Peer reviewed and/or published studies of stratified designed-based density estimates or values derived from these sources
Level 3	Peer reviewed and/or published studies of designed-based density estimates or values derived from these sources
Level 4 (Least Preferred)	Density estimates derived using a RES model

2.2.2 Navy Marine Species Density Database Density Data Compilation and Integration

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 are compiled for each specific area by season using the hierarchical approach outlined in Table 2-1.

For example, consider the annual density data file for sperm whale (*Physeter macrocephalus*) in the MITT Study Area.

Density data sources are ranked in order based on the methods outlined in Section 2.2.1 and used to fill in the density data extent for the MITT Study Area portrayed in Figure 2-1. They are:

(1) Spatial model (Yack et al., 2016)
(2) Designed-based estimate (Fulling et al., 2011)

The resulting density data file in Figure 2-1 shows the designated geographic location of density estimates integrated from the sources chosen above. Since the Yack et al. (2016) density spatial model is the most desirable data source for geographic areas where such models are available, these data are used in lieu of any other sources for this species. As is evident in Figure 2-1, the habitat model provides spatially explicit density estimates within the region that was systematically surveyed in 2007. Designed-based density estimates were used for the remaining study area and are depicted as an area of uniform density. The hierarchical data selection process ensures that the highest ranking and thus best available estimate is used for each species considered and that there is only one representative density value for each geographic location. The hierarchical ranking process is applied on a species-by-species basis since available data sources often vary by species. The results are species-specific density data files that are compilations of density data from potentially multiple sources, are defined seasonally where possible, and provide density values per season for each geographic area of interest.

If species-specific or season-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 when data for that species are not available.

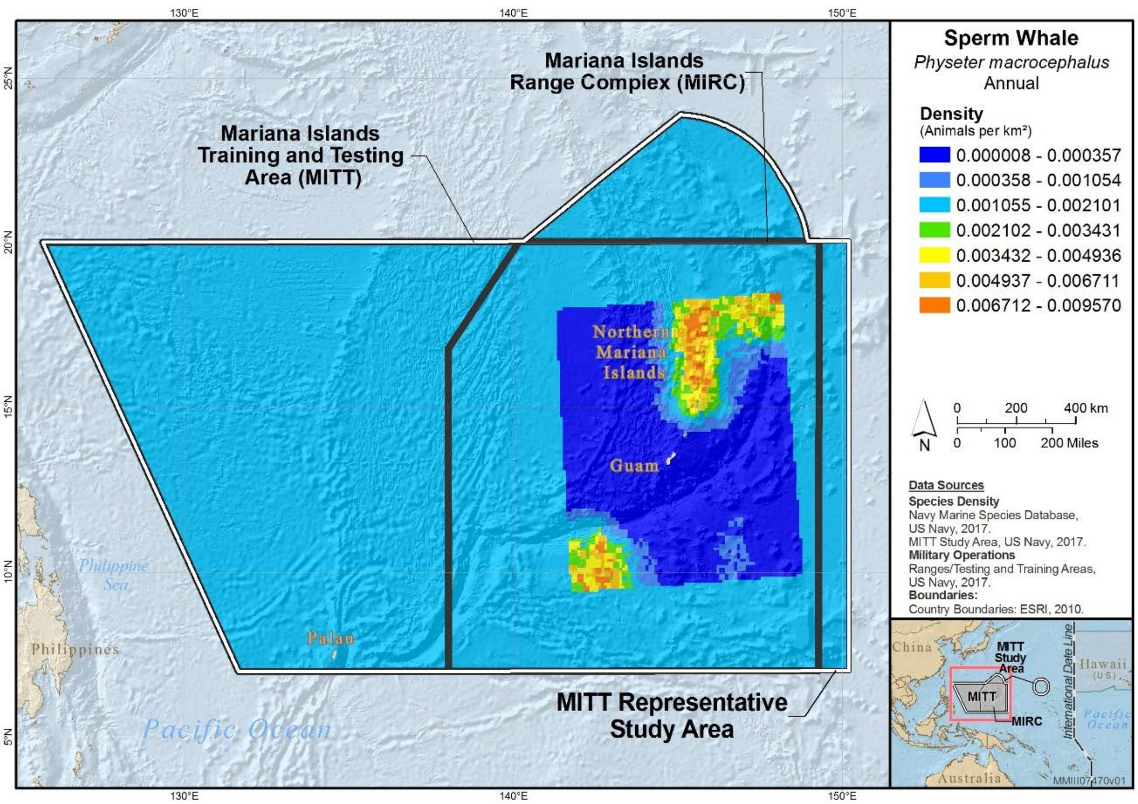


Figure 2.2-1: Example of a Combined NMSDD Density Data File for Sperm Whale

2.2.3 Methods for Seasonal Designation

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

The dataset with the most seasonal classifications determines the number of seasonal density data files that need to be developed on a species-by-species basis. A separate density data file is required for each season designation. NMSDD shapefiles for the Pacific are generally stratified by four seasons in order to capture potential temporal changes in species abundance and distribution. However, for many species, only annual density data are available. In these cases, 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. 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.

NMSDD shapefiles for the MITT Study Area are stratified by four seasons for consistency with density datasets developed for other Navy study areas in the Pacific:

Winter: December–February
Spring: March–May
Summer: June–August
Fall: September–November

However, given the absence of seasonal density data for the MITT Study Area, and the lower seasonal variability generally expected for low-productivity tropical waters typified by this region, density estimates for most species are provided on an annual basis. The exception is for blue, fin, sei (*Balaenoptera edeni*), minke (*Balaenoptera acutorostrata*), and humpback (*Megaptera novaeangliae*) whales, which are likely absent from low-productivity tropical waters in the summer (Jefferson et al., 2008; Perrin et al., 2009b), and were assigned a zero density estimate for that season.

2.2.4 File Format and Management

Density data incorporated into the NMSDD and subsequently used as input for the Navy's acoustic effects modeling are centrally stored and managed at the Naval Undersea Warfare Center. The file format and structure standards are managed by the Naval Undersea Warfare Center modeling team in collaboration with Naval Facilities Engineering Command, 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 estimates need to be in an ArcGIS compatible format for integration with the Navy acoustic effects model. All data are clipped to the National Geospatial-Intelligence Agency 1:250,000 coastline data for the coastal boundary. At a minimum, the metadata fields listed in Appendix B are included in the database file (.dbf) for all density values in the density data files.

Uncertainty is characterized in different ways by the original density data provider, and these estimates are preserved in the file format for use in the effects modeling (U.S. Department of the Navy, 2012b). Additional metadata fields other than the ones listed in Appendix B can be used to incorporate and retain these values.

3 NAVY MARINE SPECIES DENSITY DATABASE PHASE III – OVERALL METHODS AND SOURCES IMPLEMENTED

The following sections describe the MITT Study Area for which density data have been compiled and incorporated into the NMSDD Phase III. Available density data sources are also described. A summary of the improvements that have been made to the NMSDD from Phase II to Phase III is provided in the Executive Summary.

3.1 Mariana Islands Training and Testing Study Area

The MITT Study Area includes the existing Mariana Islands Range Complex (MIRC), additional areas on the high seas, and a transit corridor between the MIRC and the Hawaii Range Complex starting at the International Date Line where training and testing activities may occur (Figure 3-1). A representative region was selected to model the transit corridor, referred to as the "Transit Corridor Representative Study Area" on all the density figures. The MIRC is the only Navy range complex in the Study Area.

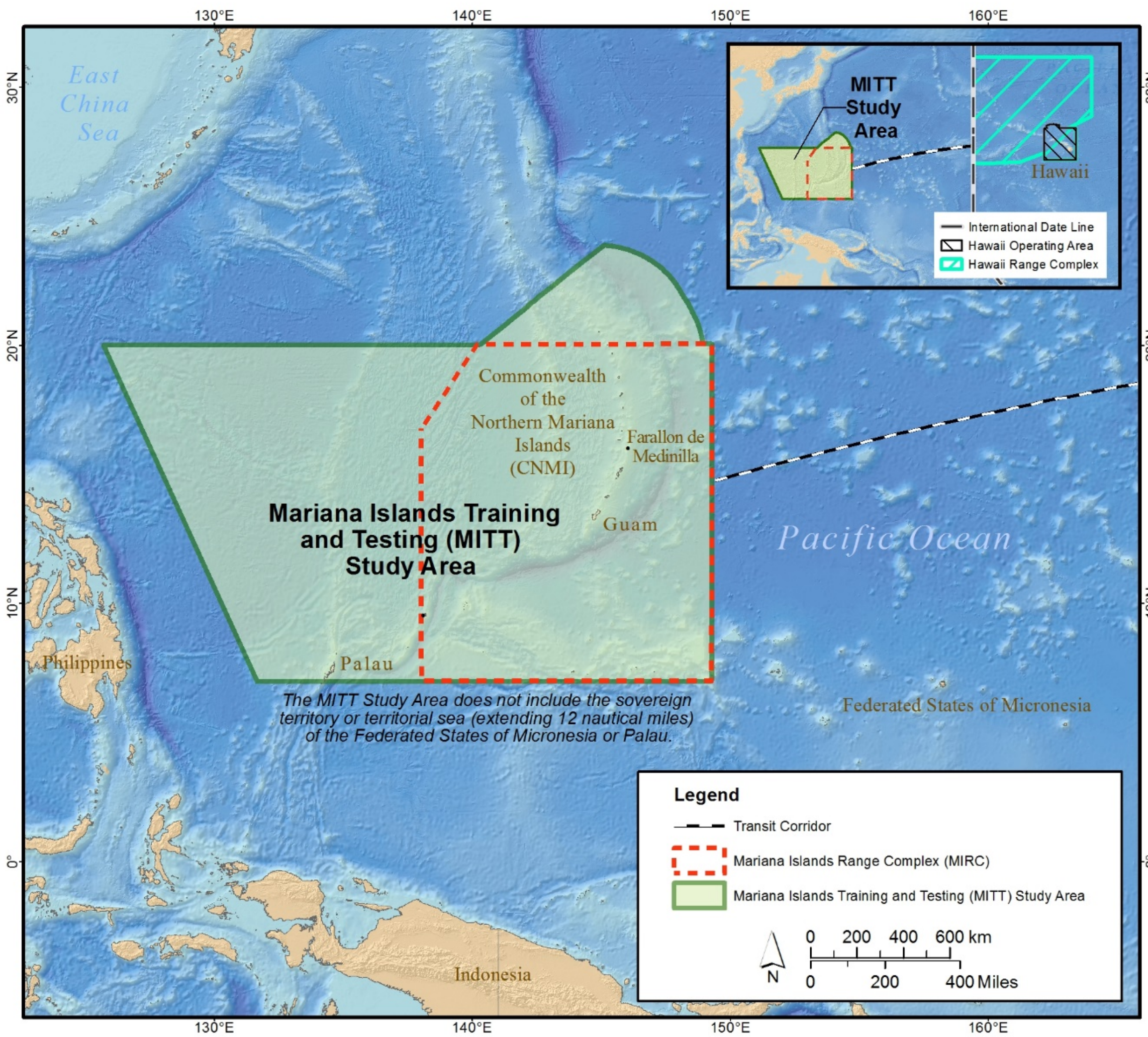


Figure 3.1-1: Mariana Islands Training and Testing Study Area

3.2 *INFORMATION ON DENSITY DATA SOURCES CONSIDERED AND INCLUDED*

The NMSDD hierarchy (see Section 2.2.1) was applied when selecting the best available marine species density data for the MITT Study Area. There was only one Level 1 data source (a habitat-based density model based on acoustic detections of sperm whale) available for the MITT Study Area, and no Level 2 sources (stratified designed-based density estimates). Level 3 data (designed-based density estimates) were available for only 12 species. These are described in more detail below.

3.2.1 LEVEL 1–LEVEL 3 DATA SOURCES

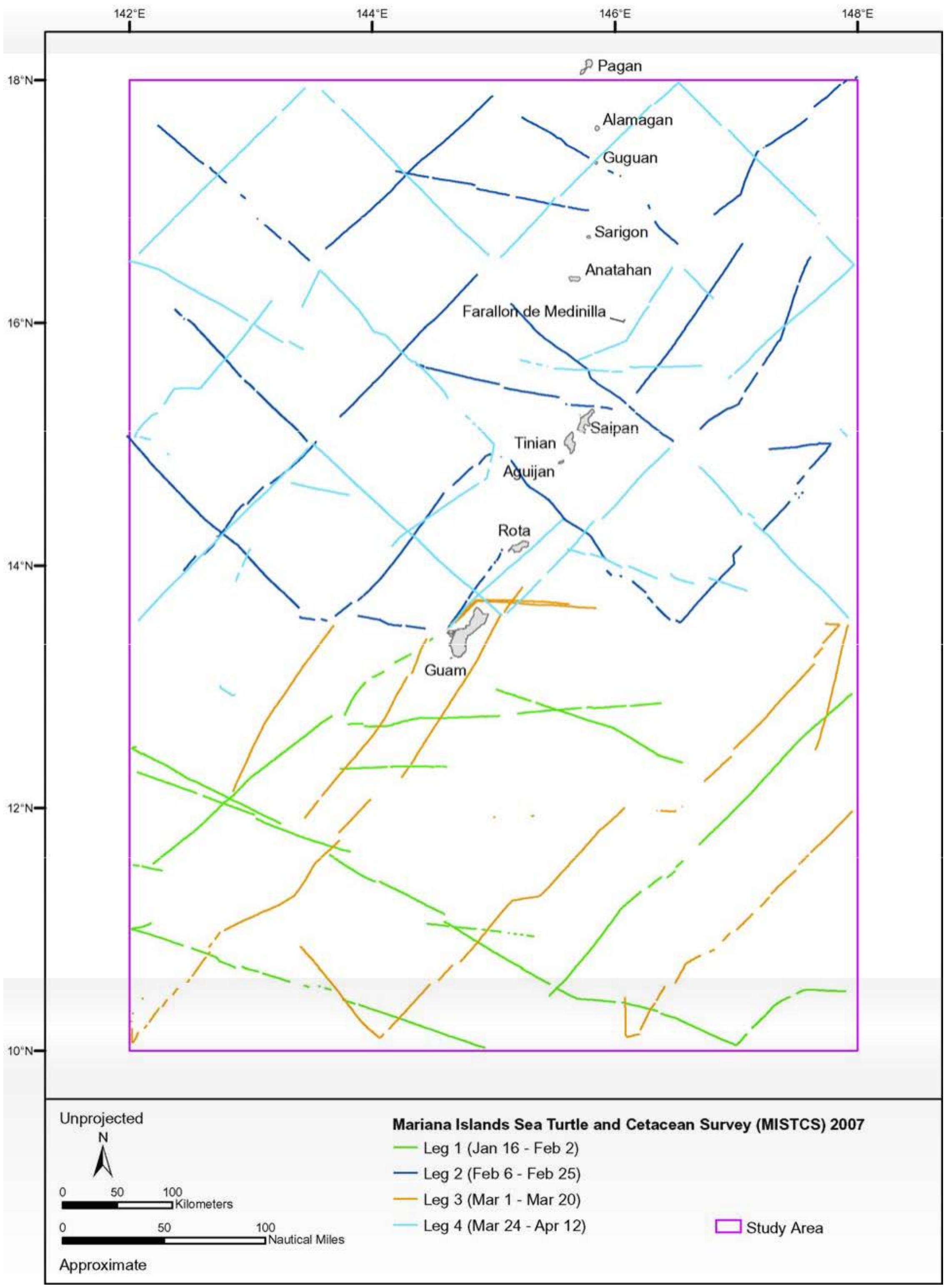
There is a paucity of line-transect survey data within the MITT Study area, and little is known about the stock structure of the majority of marine mammal species in the region. The Navy conducted the first comprehensive marine mammal survey of waters off Guam and the Commonwealth of the Northern Mariana Islands in 2007 (Fulling et al., 2011), and this Level 3 data source still provides the best available density estimates for the majority of species that occur in the MITT Study Area. Prior to the 2007 survey, there was little information available on the occurrence of marine mammals in the MITT Study Area, and much of what was known came from whaling records, stranding records, and anecdotal sighting reports. Some sighting data were available from scientific surveys conducted in the western and central Pacific, although most of these efforts focused on waters off Japan, Taiwan, the Philippines, and lower latitude regions (Darling & Mori, 1993; Dolar et al., 2006; Wang et al., 2001; Yang et al., 1999), and provide limited to no data specific to the Study Area.

PIFSC conducted a second line-transect survey in the MITT Study Area in May of 2015. The survey was conducted along a set of transect lines that extended out to 50 nautical miles (NM) from the archipelago, and additional effort was spent circumnavigating each of the northern islands except FDM (E. Oleson, PIFSC personal communication, 2018). Unfortunately, there were only about 40 total sightings during the 30-day survey, and approximately 25 of these were on-effort sightings identified to the species level, prohibiting the derivation of density estimates.

Consequently, the only available Level 1 data source is a habitat model developed for sperm whales based on acoustic data collected during the 2007 survey (Yack et al., 2016). This model provides spatially explicit sperm whale density predictions at a 10 km x 10 km (100 km^2) spatial resolution.

<u>Navy Line-Transect Density Estimates for the Mariana Islands Region</u>

As noted above, the Navy conducted the first line-transect survey within the MITT Study Area from January 13 to April 13, 2007 (Fulling et al., 2011) (Figure 3.2-1). The Mariana Islands Sea Turtle and Cetacean Survey covered an area of approximately 301,300 km^2 within the larger MITT Study Area, which encompasses approximately 1,300,000 km^2. This data source is one of the preferred (Level 3) sources of density data in the established hierarchy. The survey was conducted using a systematic line-transect survey protocol consistent with that used by NMFS SWFSC (Barlow, 2003, 2006). Both visual and acoustic detection methods were used during the survey (Fulling et al., 2011; Norris et al., 2017).



Source (U.S. Department of the Navy, 2007)

Figure 3.2-1: Transect Lines Completed During the 2007 Mariana Islands Survey

The majority of the survey was conducted in high sea states (i.e., Beaufort Sea state > 4), but 13 cetacean species were observed. Fulling et al. (2011) provided line-transect abundance estimates for 12 cetacean species using standard methods (Marques & Buckland, 2003). Norris et al. (2017) used modified line-transect methods to estimate minke whale (*Balaenoptera acutorostrata*) density based on passive acoustic detections from the 2007 survey.

Navy/PIFSC Small Boat Surveys for the Mariana Islands

In partnership with the Navy, U.S. Pacific Fleet, PIFSC has been conducting small boat surveys for marine mammals since 2010 in waters surrounding Guam and the Commonwealth of the Northern Mariana Islands (CNMI) (Hill et al., 2014; Hill et al., 2015; Hill et al., 2016; Hill et al., 2017a). The purpose of these surveys is to develop a better understanding of cetacean occurrence in the region through the collection of visual sighting data, photo identification, tissue samples (for genetic analysis of population structure), and deployment of satellite tags to assess movements of individual animals throughout the broader region. Data collected during these surveys have provided valuable information on the occurrence, distribution, and stock structure of cetaceans within the study area. However, sighting data are not collected systematically using distance sampling methodologies (Buckland et al., 2001) and have not been used for density estimation.

Navy/PIFSC Sea Turtle Surveys

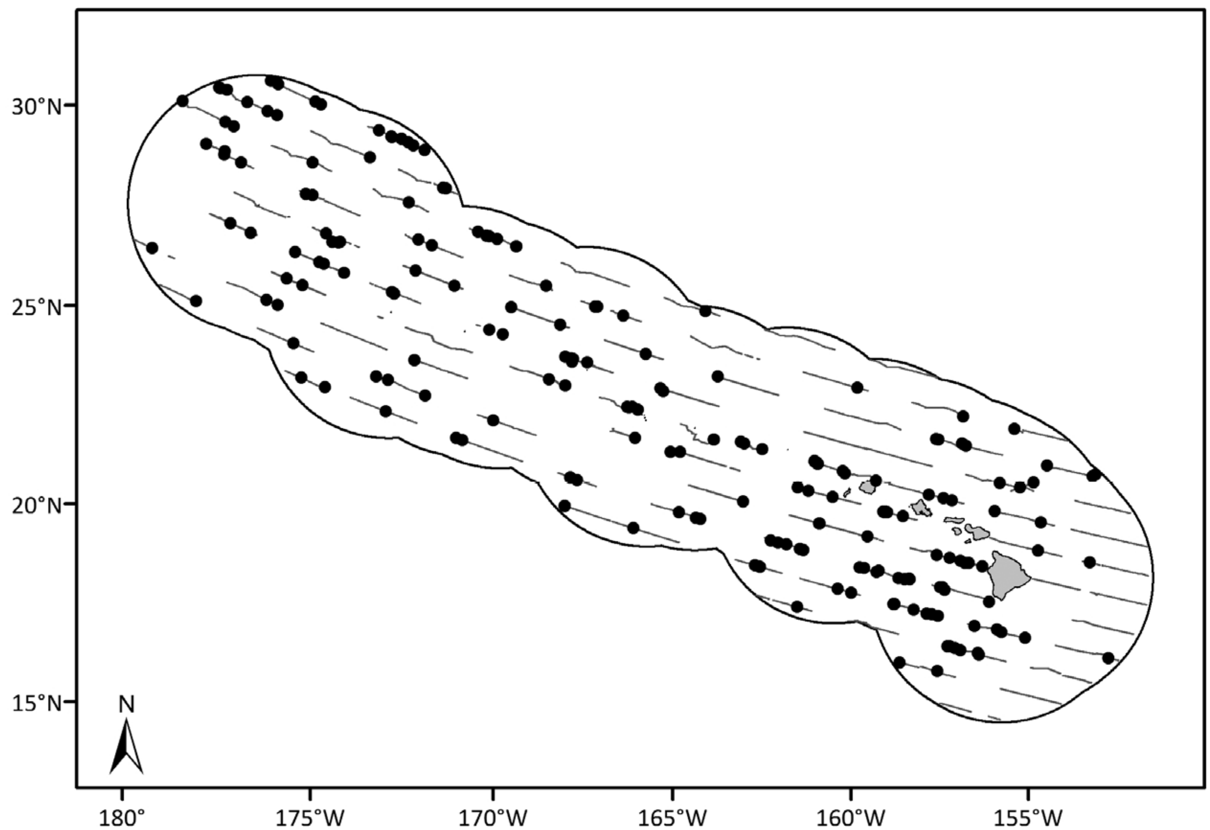
In partnership with the Navy, U.S. Pacific Fleet, PIFSC has been conducting sea turtle observations, captures, and satellite tag deployments since 2013 from boat-based snorkel surveys in nearshore waters of Guam, Saipan, and Tinian (Jones & Van Houtan, 2014; Jones et al., 2015; Jones & Martin, 2016; Martin & Jones, 2016; Martin et al., 2018). In addition, in July of 2013, the U.S. Marine Corps sponsored surveys along the coastlines of Tinian and Pagan using three different survey methods: tow-board transects, cliff-line surveys, and scuba and snorkeling surveys (U.S. Department of the Navy, 2014a). The purpose of these surveys is to develop a better understanding of sea turtle occurrence in the region through the collection of visual sighting data and deployment of satellite tags to assess movements of individual animals throughout the CNMI and Guam. Data collected during these surveys have provided valuable information on the occurrence and distribution of green and hawksbill sea turtles within the Study Area, and the data were used along with other data to support density estimates of those two species in the Study Area, as described in Section 9 (Sea Turtles).

NMFS SWFSC/PIFSC Line-Transect Density Estimates for the Hawaiian Exclusive Economic Zone

As noted in Section 2.1.1, it is often necessary to extrapolate appropriate density values from Levels 1–3 when study area-specific data are not available. Based on expert opinion from scientists at PIFSC, stratified line-transect estimates from PIFSC and SWFSC surveys off Hawaii were used to provide density estimates for some species known to occur in the MITT Study Area. These estimates are considered conservative since Hawaiian waters likely have higher densities than the MITT Study Area, but they represent the best available data for cetacean populations in the northern tropical Pacific.

NMFS SWFSC conducted a ship-based line-transect survey in summer/fall (August–November) 2002 covering U.S. EEZ waters surrounding Hawaii, including all of the Northwest Hawaiian Islands (Figure 3.2-2). Barlow (2006) provided line-transect abundance estimates for 19 cetacean species based on a multiple covariate approach (Marques & Buckland, 2003).

In the summer and fall of 2010, an additional survey was conducted collaboratively by SWFSC and PIFSC in the Hawaiian EEZ using the same survey methods and survey design as the prior 2002 survey (Figure 3-3). A multiple-covariate line-transect approach (Marques & Buckland, 2003) was used to derive uniform density estimates from these survey data (Bradford et al., 2017). The new analysis also included new estimates of trackline detection probability based on a method developed by Barlow (2015). For those species for which MITT-Study-Area-specific density data were not available, these new uniform density estimates were incorporated into the NMSDD and used by the Navy as conservative estimates for the MITT Phase III analyses.



Source: Bradford et al. (2017)

Figure 3.2-2: Study Area for the Shipboard Line-Transect Surveys Conducted by NMFS SWFSC in 2002 and 2010. Fine lines show transects completed in 2010 and black dots show sighting locations during this survey.

Density Estimates Derived in Support of ESA, MMPA, NEPA and EO 12114 Compliance Documents

In the absence of existing density data, the Navy and other entities often need to develop unique methods for deriving study-area-specific density estimates in order to assess potential impacts in compliance with the ESA, MMPA, NEPA and EO 12114. Depending on the study area, the time period(s), and the assumptions used to generate the estimates, these data can provide representative density estimates when other data do not exist, particularly since they have been reviewed by NMFS. The sources reviewed for the NMSDD are provided below. These are included within this section because they all rely primarily on Level 2 or Level 3 density data sources.

EA for a Marine Geophysical Survey in Southeast Asia (LGL Limited 2008). In order to assess potential impacts on cetaceans from a seismic survey in southeast Asia, LGL Limited (2008) estimated densities using effort and sighting data from Yang et al. (1999) and Wang et al. (2001), and derived correction factors for detection bias (both f(0) and g(0)) from a variety of sources. Since the Yang et al. (1999) and Wang et al. (2001) surveys were conducted predominantly in areas with steep slopes and complex bathymetry, LGL Limited (2008) incorporated density estimates for cetaceans in deep water areas of the Eastern Tropical Pacific derived by Ferguson and Barlow (2003). They then calculated an overall weighted density estimate representing complex bathymetry and slope habitat (~8 percent) and deep, flat, or gently sloping bottom habitat (~92 percent). For baleen whales not sighted during these surveys, they used 10 percent of the abundance estimates for Bryde’s whales calculated by Shimada et al. (2008) for areas in the northwestern Pacific. There is uncertainty regarding how representative these density data are to the MITT Study Area; however, in the absence of any other density data in this region, the density estimates provided by LGL Limited provide a reasonable approximation given their habitat assumptions (i.e., a mix of bathymetry but primarily deep water habitat) and use of actual sighting data.

EA for a Low-Energy Marine Geophysical Survey in the Western Tropical Pacific Ocean (LGL Limited 2011). In order to assess potential impacts on marine mammals from a seismic survey in the western tropical Pacific Ocean, LGL Limited (2011) estimated densities of species with known or suspected occurrence in the region. The study area included waters within the U.S. EEZ of Wake Island, as well as in surrounding International Waters, and encompassed the study area used by the Navy to represent conditions within the MITT transit corridor. LGL Limited (2011) used effort-weighted mean densities for the Mariana Islands (Fulling et al., 2011, see above) and the outer EEZ of Hawaii (Barlow, 2006) to represent the best available estimates for this region.

3.2.2 Level 4 Data Sources

The Level 4 data sources are based on environmental suitability models and are the least preferred sources of density data, as noted in Table 3-1. No Level 4 data sources were used for the MITT Study Area.

4 INTRODUCTION TO THE INDIVIDUAL SPECIES' 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 MITT 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, sperm whales, delphinids, beaked whales, and sea turtles. Within each group, species are presented in alphabetical order by their scientific name. This organization scheme keeps closely related species together. Information on which species are found in the MITT Study Area is provided in Table 4-1.

There are three elements in each species profile: (1) species-specific information related to stock structure and detection in the field, (2) information on the density data used for the MITT Study Area, and (3) maps of the estimated species density in the Study Area. Each of these elements is described in more detail below. In a few cases, one of the elements may be expanded or removed based on special circumstances for that species.

Table 4-1: Species with Mariana Islands Training and Testing Study Area Density Estimates Included in the NMSDD Phase III

Taxonomic Name	Common Name
Cetaceans (Order Cetacea)	
Baleen Whales (Suborder Mysticeti)	
Balaenoptera acutorostrata	Common or dwarf minke whale
Balaenoptera borealis	Sei whale
Balaenoptera edeni	Bryde's whale
Balaenoptera musculus	Blue whale
Balaenoptera omurai	Omura's whale
Balaenoptera physalus	Fin whale
Megaptera novaeangliae	Humpback whale
Toothed Whales (Suborder Odontoceti)	
Sperm Whales (Family Physeteridae [sperm whale] and Family Kogiidae [pygmy and dwarf sperm whale])	
Kogia breviceps	Pygmy sperm whale
Kogia sima	Dwarf sperm whale
Physeter macrocephalus	Sperm whale
Dolphins (Family Delphinidae)	
Feresa attenuata	Pygmy killer whale
Globicephala macrorhynchus	Short-finned pilot whale
Grampus griseus	Risso's dolphin
Lagenodelphis hosei	Fraser's dolphin
Orcinus orca	Killer whale

Taxonomic Name	Common Name
Peponocephala electra	Melon-headed whale
Pseudorca crassidens	False killer whale
Stenella attenuata	Pantropical spotted dolphin
Stenella coeruleoalba	Striped dolphin
Stenella longirostris	Spinner dolphin
Steno bredanensis	Rough-toothed dolphin
Tursiops truncatus	Common bottlenose dolphin
Beaked Whales (Family Ziphiidae)	
Indopacetus pacificus	Longman's beaked whale
Mesoplodon densirostris	Blainville's beaked whale
Mesoplodon ginkgodens	Ginkgo-toothed beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Sea Turtles (Order Testudines, Suborder Cryptodira)	
Chelonia mydas	Green sea turtle
Eretmochelys imbricata	Hawksbill sea turtle
Caretta caretta	Loggerhead sea turtle
Dermochelys coriacea	Leatherback sea turtle

4.1 INFORMATION INCLUDED IN THE SPECIES DESCRIPTIONS

For each species, a brief description of the general appearance and notable identifying characteristics is provided. The description is not meant to be a detailed profile of the species, but conveys the ease or challenges of detecting and identifying the species in the field. This information provides a context for the information on species presence. Species that have a low likelihood of being seen or a high likelihood of being confused with other species lead to higher levels of uncertainty in estimates of their density. Scientists are often conservative in classifying a marine mammal or sea turtle seen in the field, unless there is a high level of certainty. Challenges to identifying animals in the field can result in a lack of sufficient sighting data to enable the estimation of species-specific density or abundance; in these cases, density is sometimes estimated for broader taxa (e.g., "small beaked whales," *Mesoplodon* spp.).

Within each species description, information on stocks recognized by NMFS and the International Whaling Commission (IWC) (for large whales) is also presented if known. Stocks are the management unit used by NMFS (Carretta et al., 2017) for most species; however, NMFS has recently identified distinct population segments (DPSs) for a few species to refine management and listing under the ESA (e.g., humpback whales and green sea turtles). For those stocks and DPSs that are Threatened or Endangered, the Navy needs to be aware of stock structure and the likelihood of interacting with a particular stock or DPS. When an individual marine mammal or sea turtle is observed, it may be quite difficult to define which stock or DPS it belongs to if the geographic ranges of two or more stocks overlap. Given that little is known about the stock structure of the majority of marine mammal species occurring in the MITT Study Area, densities are reported for the species as a whole.

4.1.1 SPECIES CONSIDERED BUT NOT INCLUDED

Spatially explicit, at-sea density estimates of the type needed for quantitative analysis of impacts are not available for several taxa of concern to the Navy and trustee agencies, specifically ESA-listed sea birds and ESA-listed marine fishes. To the Navy's knowledge, the data needed to create spatially explicit, absolute at-sea density estimates for ESA-listed fish species or ESA-listed sea birds occurring in the MITT Study Area do not exist, nor could they be readily created. As such, density estimates for fishes or sea birds are not included in this technical report.

4.2 DENSITY DATA FOR THE MARIANA ISLANDS TRAINING AND TESTING STUDY AREA

4.2.1 TABLES

Information on the sources of density data are summarized in the text. The density values used in the NMSDD Phase III are reported in a table that appears in each species description. Due to the different sources of density data and their inherent limitations, the precision of the density estimates is variable. Specific uniform density values are provided for designed-based estimates. If a quantitative density range is provided, this indicates that more than one uniform density estimate was applied to the region (e.g., where there may be stratified density estimates applicable to different portions of the region). For density spatial models for which density values vary throughout the range, the letter "S" is used to indicate the model source. In all cases, given the different data sources and their associated spatial resolution, the table should be viewed concurrently with the density maps (Section 4.2.2).

4.2.2 MAPS

Maps from the Geographic Information System database used in NMSDD Phase III are provided for each species. As noted in Section 3.2, shapefiles for the NMSDD Phase III are currently stratified by four seasons; however, density data are rarely available at this temporal resolution. Given the absence of seasonal density data for the MITT Study Area, and the lower seasonal variability generally expected for low-productivity tropical waters typified by this region, density estimates for most species are provided on an annual basis. Maps are not provided for seasons for which study area densities are expected to be zero. As noted above, the density table should be viewed concurrently with the density maps, particularly if one is interested in a specific value that may be presented in the table but represented by a range of values on the map.

Up to seven colors are used on the density maps to represent bins of density values across the range of total values. For each species, the density bins are classified by the Jenks natural breaks classification method. The ranges of the bins are specific to the species being considered and are not directly comparable from species to species.

5 BALEEN WHALES

5.1 BALEEN WHALES SPECIES PROFILES

5.1.1 *BALAENOPTERA ACUTOROSTRATA*, COMMON OR DWARF MINKE WHALE

Minke whales are a species whose presence can be challenging to quantify, because they are difficult to observe on visual surveys. They can move quickly over sustained distances (Ford et al., 2005), their blow is cryptic and relatively small, and they do not raise their flukes when diving (Jefferson et al., 2015; Leatherwood et al., 1988). In some cases, they do approach ships, enabling good identification (Leatherwood et al., 1988; Perrin et al., 2009a). Common minke whales are the smallest baleen whale in the North Pacific (Leatherwood et al., 1988). Their body shape is distinctive for a rorqual whale, because they have a sleek body and a pointed head. Their dorsal fin is tall and falcate for a baleen whale. The coloration is distinctive with a dark back, white belly, swathes and streaks of intermediate color on the sides, and a white band on the pectoral fins (Jefferson et al., 2015; Leatherwood et al., 1988). At a distance, the species could be mistaken for other baleen whales, such as a fin whale, sei whale (*Balaenoptera borealis*), or Bryde's whale (Jefferson et al., 2015; Leatherwood et al., 1988). If only the back is seen, the species could also be mistaken for a beaked whale (Jefferson et al., 2015; Leatherwood et al., 1988).

The IWC recognizes three stocks of minke whales in the North Pacific: (1) the Sea of Japan/East China Sea, (2) the rest of the western Pacific west of 180 degrees North (°N), and (3) the "remainder of the Pacific" (Donovan, 1991). These broad designations basically reflect a lack of knowledge about the population structure of minke whales in the North Pacific (Carretta et al., 2017). NMFS has designated three stocks of minke whale in the North Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al., 2017). The three NMFS stocks primarily fall into the IWC's "remainder of the Pacific" stock. Little is known about the stock structure of minke whales in the MITT Study Area but, presumably, whales in this area are members of the IWC's "rest of the western Pacific west of 180°N" stock.

MITT. During the Navy's 2007 line-transect survey of the waters off Guam and the Commonwealth of the Northern Mariana Islands, sea states were typically high and there were no sightings of minke whales. However, the survey included passive acoustic monitoring using a towed array system, and resulted in 30 unique acoustic detections of minke whales (Norris et al., 2017). Recent line-transect analyses of these acoustic detections resulted in a minimum density estimate of 0.00015 animals/km^2 (coefficient of variation [CV] = 0.34) in the Study Area (Norris et al., 2017). Methods for estimating density from acoustic detections are currently being developed, and numerous assumptions are associated with the calculations. However, despite the caveats inherent in the analysis (e.g., average group size estimates, g(0) estimates), these data provide the best available density estimates for minke whale in the MITT Study Area and consequently were also applied to the MITT transit corridor. These data were used to characterize minke whale density in fall, winter, and spring.

Minke whales are likely absent from low-productivity tropical waters in the summer (Jefferson et al., 2008; Perrin et al., 2009b); therefore, a density of zero is used for that season in the MITT and associated transit corridor study areas.

Table 5-1: Summary of Density Values for Minke Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00015	0	0.00015	0.00015
MITT Transit Corridor	0.00015	0	0.00015	0.00015

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

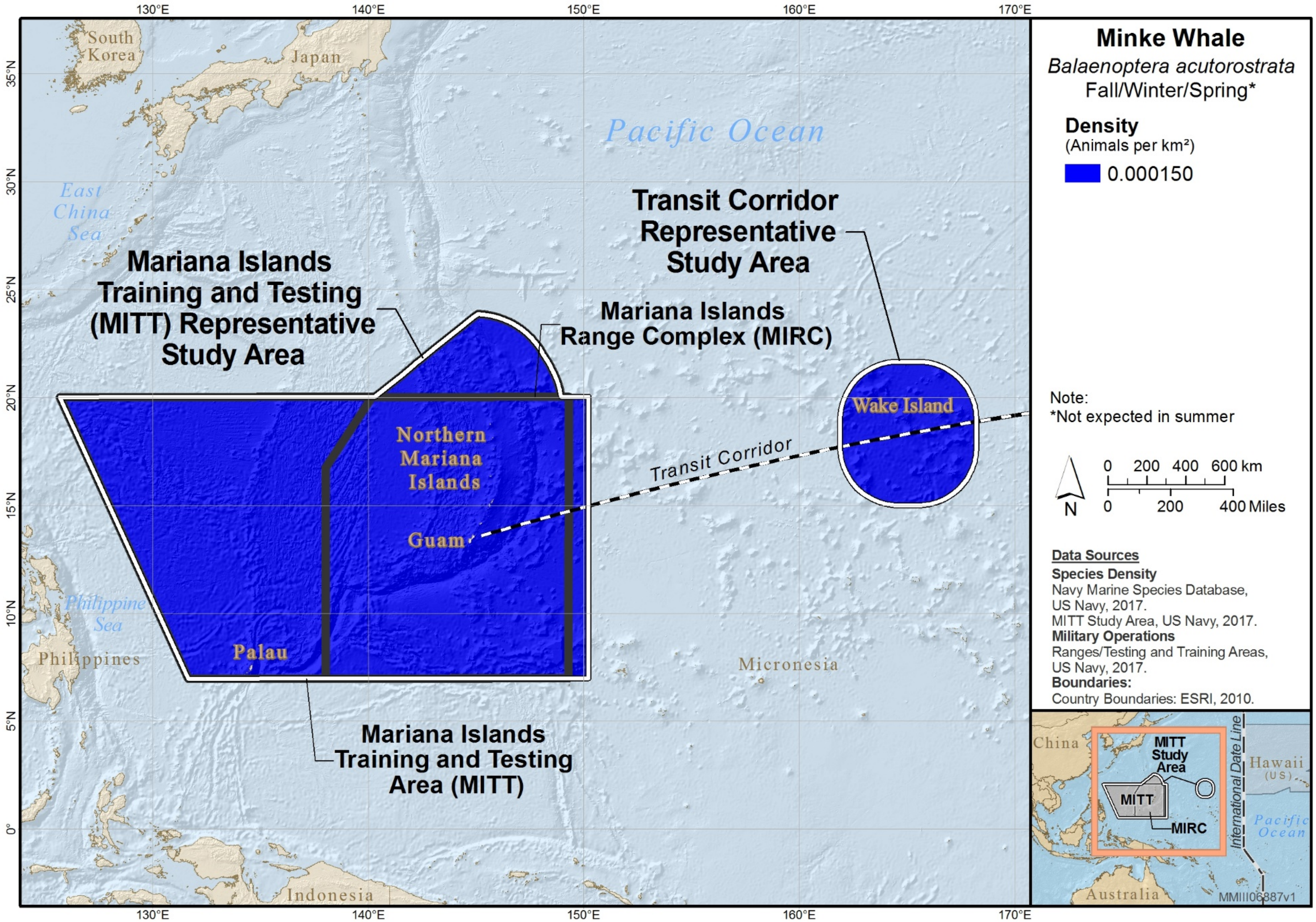


Figure 5.1-1: Fall/Winter/Spring Distribution of Minke Whale

5.1.2 *BALAENOPTERA BOREALIS*, SEI WHALE

Sei whales are relatively large, dark-colored baleen whales. Sei whales are more common in colder waters and are nearly absent from tropical zones, particularly in the summer (Jefferson et al., 2015; Perrin et al., 2009a). They are a species that can be difficult to identify positively from a distance, because of their superficial similarity to fin and Bryde's whales (Jefferson et al., 2015; Leatherwood et al., 1988). For this reason, sei whales may often be underrepresented in data from visual surveys; with their identity unresolved, they are relegated to the "unidentified rorqual" or "unidentified large whale" categories. NMFS recognizes two stocks of sei whales in the U.S. Pacific, the Eastern North Pacific stock and the Hawaii stock (Carretta et al., 2017). The IWC only recognizes one sei whale stock in the North Pacific. Little is known about the stock structure of sei whales in the MITT Study Area.

MITT. Sei whales were considered to be extralimital in the MITT Study Area until the Navy's 2007 systematic survey, when sei whales were sighted on 16 separate occasions. Eleven of these were on-effort sightings, resulting in a density estimate of 0.00029 animals/km^2 (CV = 0.49) (Fulling et al., 2011). A density estimate of 0.00013 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data were used to characterize sei whale density in fall, winter, and spring.

Sei whales are likely absent from low-productivity tropical waters in the summer (Jefferson et al., 2008; Perrin et al., 2009b); therefore, a density of zero is used for that season in the MITT and associated transit corridor study areas.

Table 5-2: Summary of Density Values for Sei Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00029	0	0.00029	0.00029
MITT Transit Corridor	0.00013	0	0.00013	0.00013

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

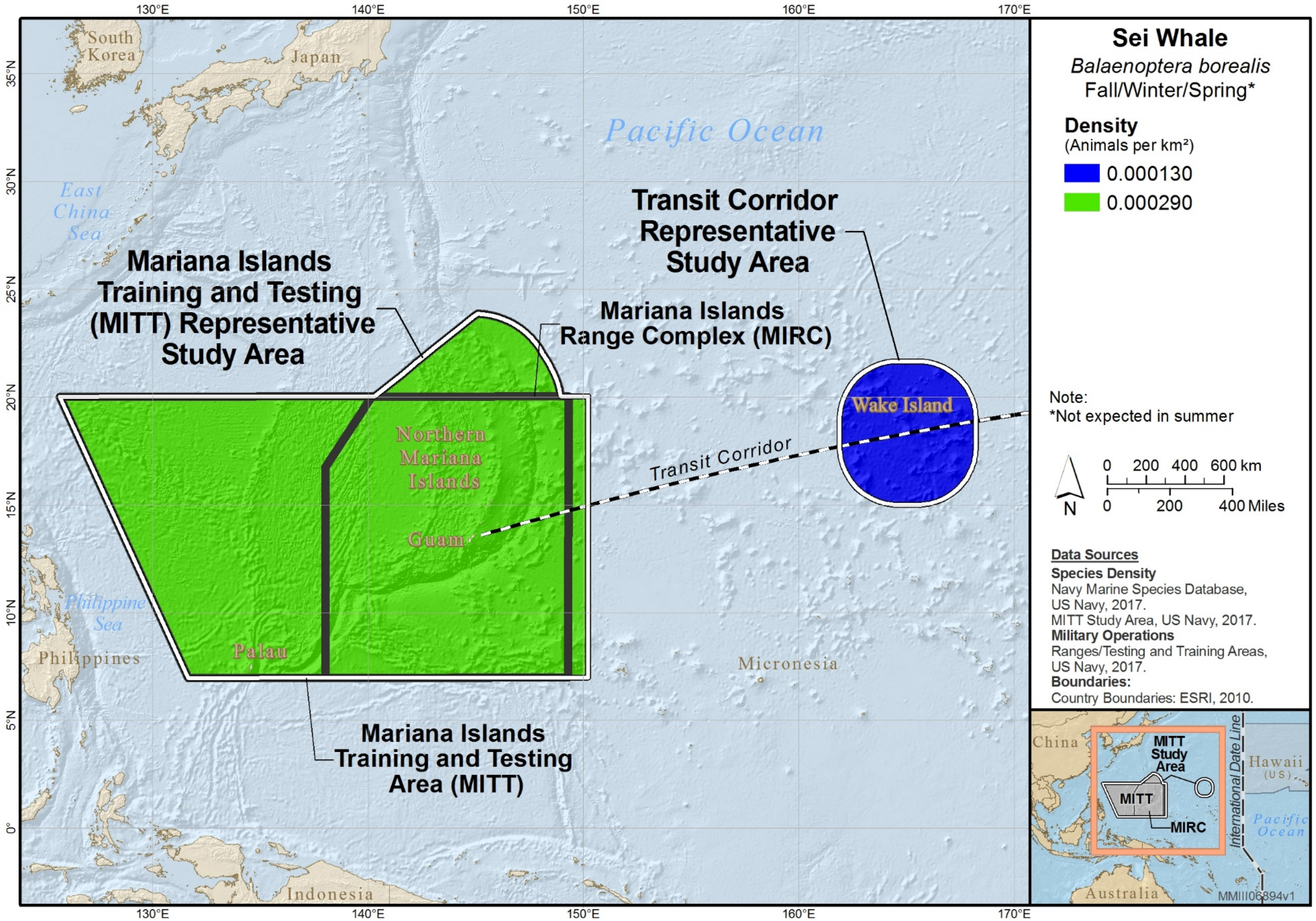


Figure 5.1-2: Fall/Winter/Spring Distribution of Sei Whale

5.1.3 *Balaenoptera edeni*, Bryde's Whale

Bryde's whale is a baleen whale typically found only in tropical and warm temperate waters (Kato & Perrin, 2008; Leatherwood et al., 1988). Bryde's whales can be difficult to identify positively from a distance, because of their superficial similarity to sei and Omura's whales (Jefferson et al., 2015). Positive identification of the species requires a clear view of three rostral ridges in front of the blowhole. The difficulty of observing this feature is confounded by the fact that Bryde's whales are rapid swimmers and are not easy to view closely from a vessel (Jefferson et al., 2015; Leatherwood et al., 1988). For these reasons, Bryde's whales may often be underrepresented in data from visual surveys; they are included primarily in the "unidentified rorqual" or "unidentified large whale" categories. NMFS recognizes two stocks of Bryde's whales in the U.S. Pacific, the Eastern Tropical Pacific stock and the Hawaii stock (Carretta et al., 2017). The IWC recognizes a complex suite of Bryde's whale stocks in the Pacific; there are three stocks the North Pacific (eastern, western, and East China Sea), three stocks in the South Pacific (eastern, western, and Solomon Islands), and one cross-equatorial stock, called the Peruvian stock (Carretta et al., 2017). Little is known about the stock structure of Bryde's whales in the MITT Study Area.

MITT. Bryde's whales were identified 18 times during the Navy's 2007 survey of the MITT Study Area (Fulling et al., 2011). They were observed in groups of one to three, with several sightings including calves. Sixteen of these were on-effort sightings, resulting in a density estimate of 0.00041 animals/km^2 (CV = 0.45) (Fulling et al., 2011). A density estimate of 0.00030 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data were used to characterize annual Bryde's whale density.

Table 5-3: Summary of Density Values for Bryde's Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00041	0.00041	0.00041	0.00041
MITT Transit Corridor	0.00030	0.00030	0.00030	0.00030

Note: The units for numerical values are animals/km^2.

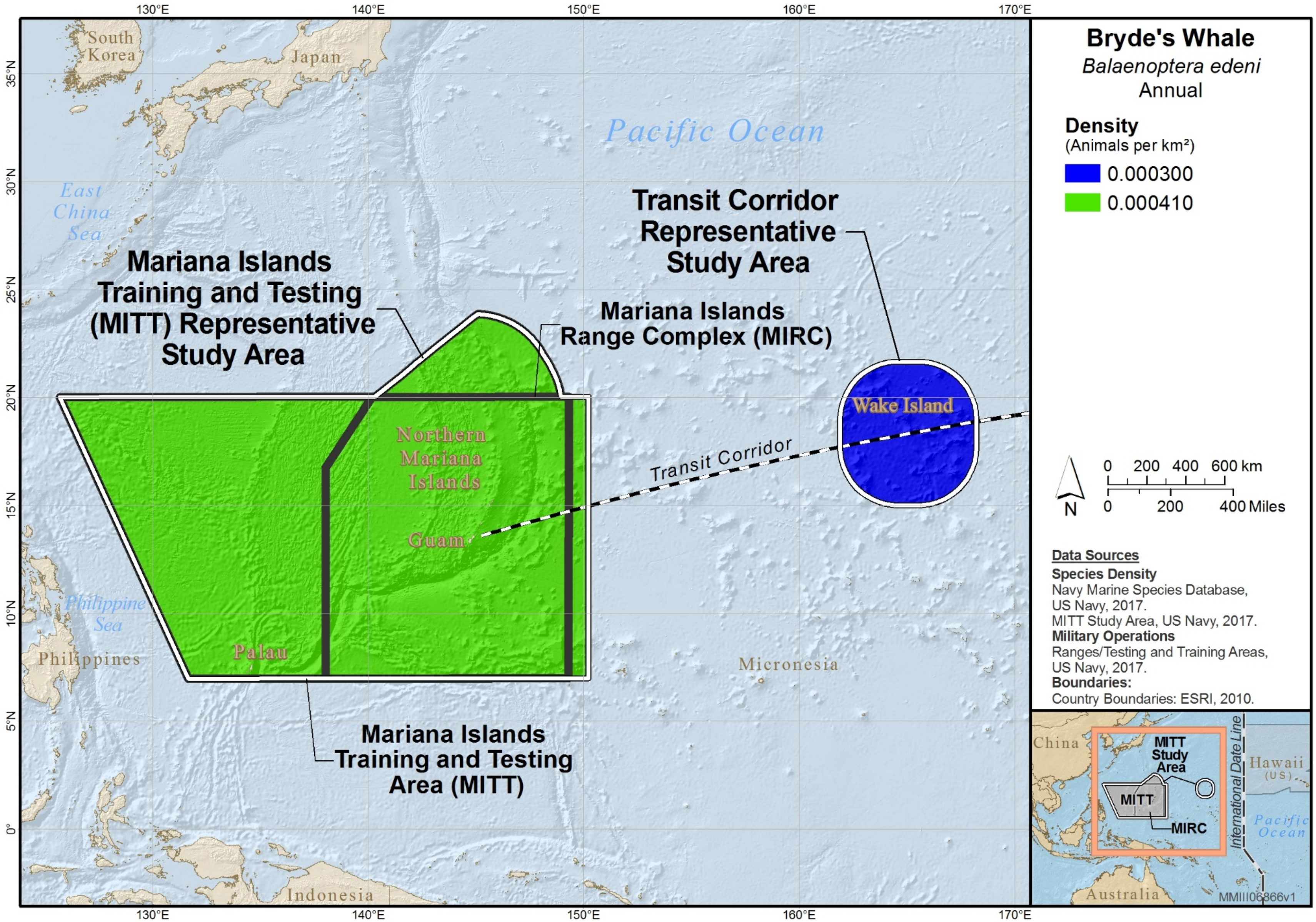


Figure 5.1-3: Annual Distribution of Bryde's Whale

5.1.4 *BALAENOPTERA MUSCULUS*, BLUE WHALE

Blue whales are relatively easy to observe and identify in the field. They are the largest baleen whale, their blow is tall and distinctive, and their color is a mottled, light gray-blue compared to the dark gray to black of the other large baleen whales (Jefferson et al., 2015). The dorsal fin is set far back on the body and is reduced in size—it may be present only as a small bump (Jefferson et al., 2015; Leatherwood et al., 1988). From a distance or in backlight, blue whales could be mistaken for fin whales, but a close view will dispel misidentification (Jefferson et al., 2015; Leatherwood et al., 1988). There are four subspecies of blue whale, but only *Balaenoptera musculus* is found in the North Pacific (Muto et al., 2017). The IWC recognizes a single stock of blue whales in the North Pacific, while NMFS recognizes two stocks: an Eastern North Pacific stock and a Central North Pacific stock (Carretta et al., 2017). The Eastern North Pacific stock includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al., 2017). Little is known about the stock structure of blue whales in the MITT Study Area, but given the two currently recognized NMFS stocks, blue whales in the MITT Study Area would likely belong to the Central North Pacific stock.

MITT. There are no recent sighting records for blue whale in the MITT Study Area, although this area is in the distribution range for this species (Reilly et al., 2008a). Blue whales are most likely to occur in the MITT Study Area during the winter, although none were observed during the Navy's systematic survey conducted from January to April 2007 (Fulling et al., 2011). Blue whales were positively identified acoustically by high-frequency acoustic recording packages (HARPs) deployed at both Saipan and Tinian for 2010–2013 (Oleson et al., 2015).

In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate derived for Hawaiian waters (Bradford et al., 2017) was used to represent the best available estimate for the MITT Study Area. The resulting density estimate of 0.00005 animals/km^2 was used for the MITT Study Area and associated transit corridor for fall, winter, and spring.

Blue whales are likely absent from low-productivity tropical waters in the summer (Jefferson et al., 2008; Perrin et al., 2009b); therefore, a density of zero is used for that season in the MITT and associated transit corridor study areas.

Table 5-4: Summary of Density Values for Blue Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00005	0	0.00005	0.00005
MITT Transit Corridor	0.00005	0	0.00005	0.00005

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

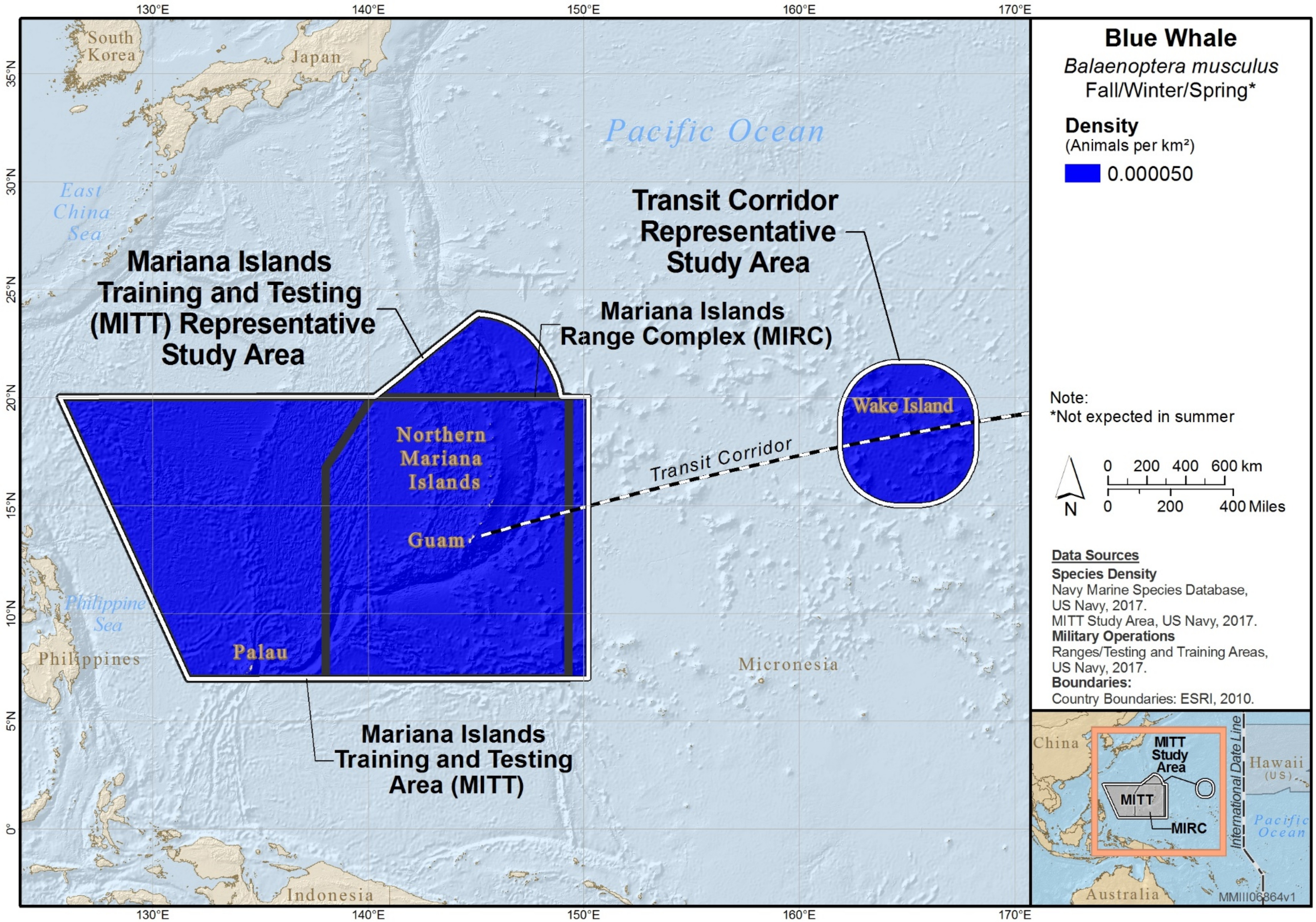


Figure 5.1-4: Fall/Winter/Spring Distribution of Blue Whale

5.1.5 *BALAENOPTERA OMURAI*, OMURA'S WHALE

Before its formal description in 2003, all medium-sized baleen whales were considered members of one of two species, Bryde's whale or sei whale. However, at least three genetically distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato & Perrin, 2008; Rice, 1998). In 2003, a new species, Omura's whale (*Balaenoptera omurai*), was first described from records from the Philippines, eastern Indian Ocean, Indonesia, Sea of Japan, and the Solomon Islands (Wada et al., 2003). Whales in the Solomon Islands were found to be distinct from Bryde's whales found in the offshore waters of the western North Pacific and the East China Sea (Wada & Numachi, 1991; Yoshida & Kato, 1999). Later it became evident that the term "pygmy Bryde's whale" had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al., 2004). Given the general paucity of data on this species, nothing is known of the stock structure of Omura's whale.

Little is known of the geographic range of Omura's whale, since few sightings of this species have been confirmed. Omura's whale is known to occur in the tropical and subtropical waters of the western Pacific and eastern Indian Oceans (Jefferson et al., 2008). It generally occurs alone or in pairs, and has been sighted primarily over the continental shelf in nearshore waters (Jefferson et al., 2008).

MITT. Given the relatively recent identification of this species and the lack of confirmed sighting data, the range of Omura's whale is poorly known. However, the International Union for Conservation of Nature shows that the distribution of this species extends into the MITT Study Area (Reilly et al., 2008b). There are no reliable estimates of the global population size of Omura's whale, nor are there abundance estimates specific to the MITT Study Area. In the absence of density data, the Navy followed an approach consistent with LGL Limited (2008) and used a density estimate of 10 percent of the study-area-specific density estimate for Bryde's whale for both the MITT and associated transit corridor study areas (0.00004 animals/km^2). These values are used to characterize year-round density of Omura's whale.

Table 5-5: Summary of Density Values for Omura's Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00004	0.00004	0.00004	0.00004
MITT Transit Corridor	0.00004	0.00004	0.00004	0.00004

Note: The units for numerical values are animals/km^2.

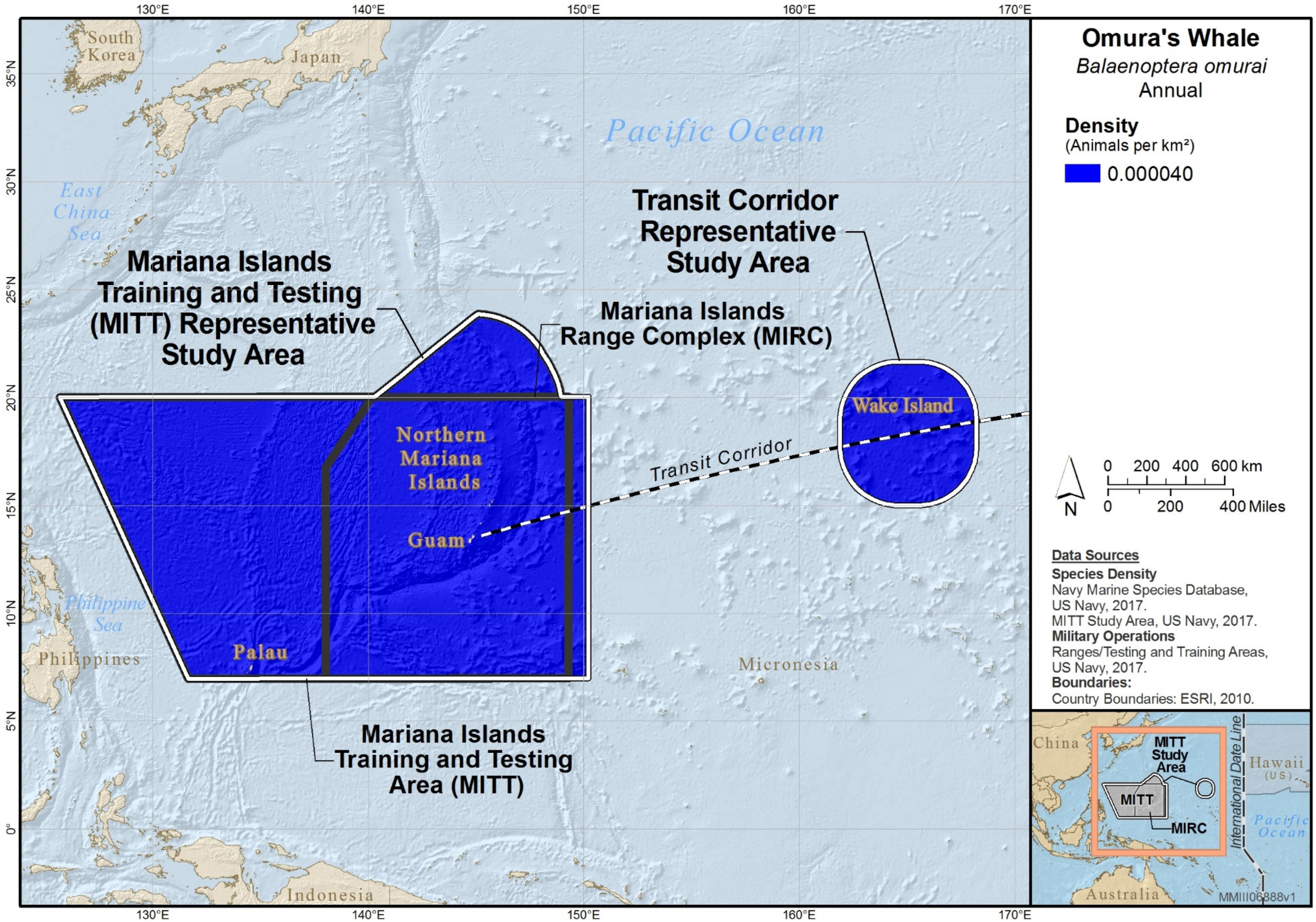


Figure 5.1-5: Annual Distribution of Omura's Whale

5.1.6 *BALAENOPTERA PHYSALUS*, FIN WHALE

Fin whales are the second largest baleen whale species, and they are almost black in color, except for a bright white right lip, whitish belly, and light chevron and streaks on the back (Jefferson et al., 2015). They are sometimes observed with blue whales (Aguilar, 2009), but the difference in color makes the species relatively distinguishable. Fin whales can be difficult to identify positively from a distance, because of their superficial similarity to sei and Bryde's whales (Jefferson et al., 2015; Leatherwood et al., 1988). For these reasons, fin whales may often be underrepresented in data from visual surveys, because they may fall into the "unidentified rorqual" or "unidentified large whale" categories. NMFS recognizes three stocks of fin whales in U.S. Pacific waters: (1) the Northeast Pacific stock, (2) the California/Oregon/Washington stock, and (3) the Hawaii stock (Carretta et al., 2017). The IWC only recognizes two stocks of fin whales in the North Pacific: the East China Sea stock and the rest of the North Pacific. Little is known about the stock structure of fin whales in the MITT Study Area.

MITT. Fin whales are typically not expected south of 20°N during summer and are not likely to occur near Guam (Edwards et al., 2015; Miyashita et al., 1996). Miyashita et al. (1996) presented a compilation of at-sea sighting results from commercial fisheries vessels in the Pacific Ocean from 1964 to 1990. For fin whales in August, Miyashita et al. (1996) reported no sightings south of 20°N, and significantly more sightings north of 40°N. However, they also showed limited search effort south of 20°N. There were no fin whale sightings during the winter 2007 survey of the Study Area (Fulling et al., 2011). During systematic surveys in the eastern tropical Pacific from 1986 to 2005, there were far fewer sightings of fin whales than blue whales south of 30°N (Hamilton et al., 2009). However, fin whales were positively identified acoustically in April and May by HARPs deployed at both Saipan and Tinian for 2010–2013 (Oleson et al., 2014).

In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate derived for Hawaiian waters (Bradford et al., 2017) was used to represent the best available estimate for the MITT Study Area. The resulting density estimate of 0.00006 animals/km^2 was used for the MITT Study Area and associated transit corridor for fall, winter, and spring.

Fin whales are likely absent from low-productivity tropical waters in the summer (Jefferson et al., 2008; Perrin et al., 2009b); therefore, a density of zero is used for that season in the MITT and associated transit corridor study areas.

Table 5-6: Summary of Density Values for Fin Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00006	0	0.00006	0.00006
MITT Transit Corridor	0.00006	0	0.00006	0.00006

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

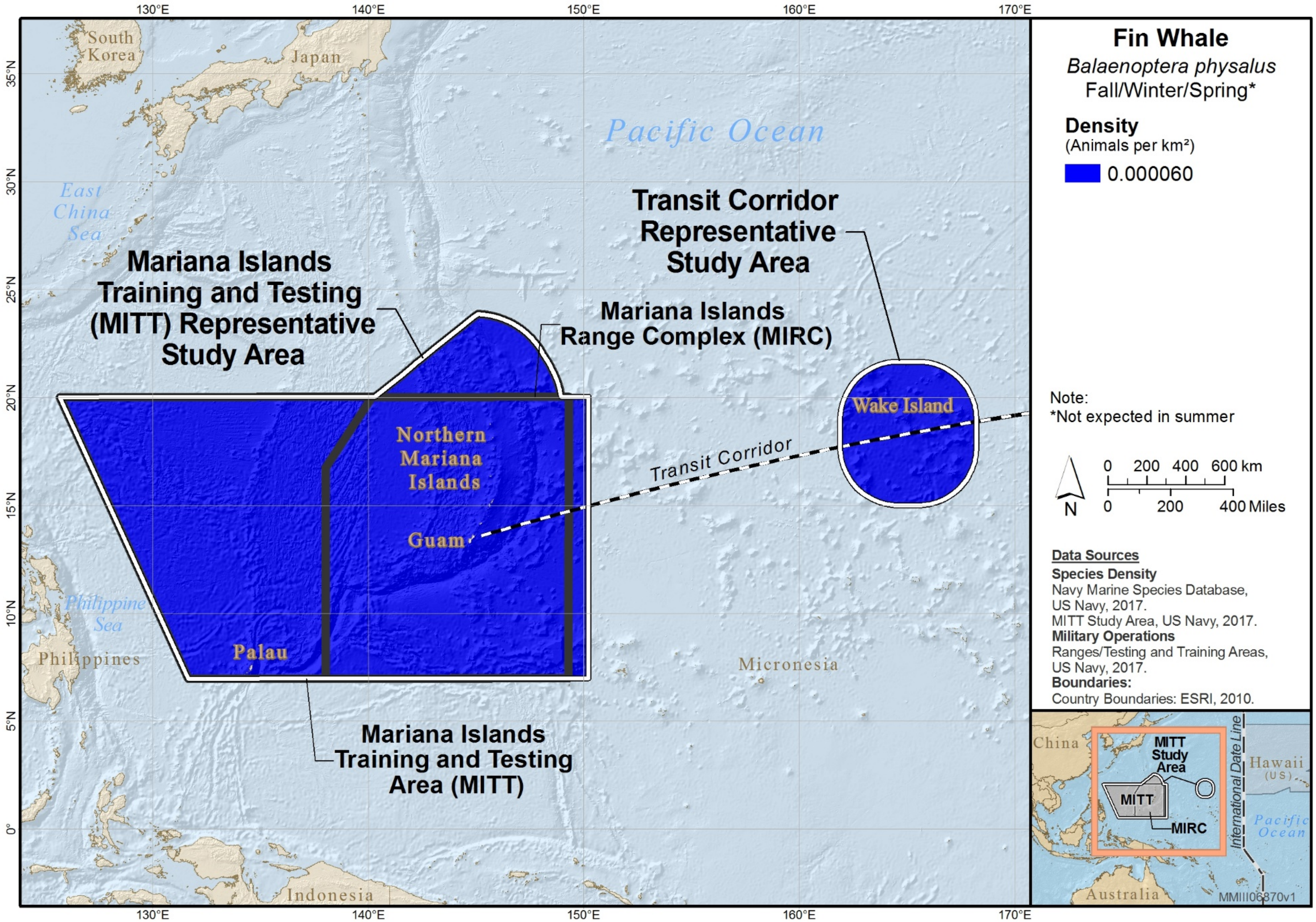


Figure 5.1-6: Fall/Winter/Spring Distribution of Fin Whale

5.1.7 *Megaptera novaeangliae*, Humpback Whale

Humpback whales are a relatively easily identified species of baleen whale, because of notable morphological features and behaviors they exhibit. They have long pectoral flippers that are white underneath, have a fairly distinctive dorsal fin that they arch high out of the water when they dive, often raise their flukes in the air when they dive, and exhibit surface-active behaviors such as breaching or slapping their tail or fins on the water (Clapham, 2000). In the Pacific, NMFS previously divided humpback whales into four stocks (Carretta et al., 2017): (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; (3) the California, Oregon, Washington, and Mexico stock, consisting of winter and spring populations in coastal Central America and coastal Mexico that migrate to coastal California and to British Columbia in summer and fall; and (4) the American Samoa stock, with largely undocumented feeding areas as far south as the Antarctic Peninsula (Carretta et al., 2017; Muto et al., 2017). On October 11, 2016, NMFS's Final Rule was published (81 Federal Register 62259) to discard the current stock designations and divide the species into 14 DPSs worldwide, four of which occur in the North Pacific: (1) Western North Pacific, (2) Hawaii, (3) Mexico, and (4) Central America. Given the DPSs currently recognized by NMFS, humpback whales in the MITT Study Area would likely belong to the Western North Pacific DPS.

MITT. Humpback whales have been sighted during the Navy's routine aerial surveys of Farallon de Medinilla (FDM) on several occasions, including two sightings in 2006 (January and March), both close to the island, and another sighting in February 2007, 18 miles (29 kilometers [km]) north of Saipan (Vogt, 2008). During a ship survey in the Study Area (January–April 2007), there was only one humpback whale sighting, but there were numerous acoustic detections (Fulling et al., 2011). These observations suggest that there could be a small wintering population of humpback whales in the MITT Study Area, although additional research is needed for confirmation (Fulling et al., 2011; Ligon et al., 2011). Humpback whales were also positively identified acoustically by HARPs deployed at both Saipan and Tinian for 2010–2013 (Oleson et al., 2014). In 2015, four humpback whale mother/calf pairs and four other humpback whales were sighted west of Saipan (Hill et al., 2016). Five humpback whale mother/calf pairs were observed during small boat surveys conducted in March of 2016, providing additional evidence that the Marianas may be a calving area (Hill et al., 2017b). During a subsequent small boat survey of Saipan in February 2017, there were 13 humpback whale sightings, including two mother/calf pairs. There is now a total of 35 non-calf individual humpback whales in the current photo identification catalog for the study area.

Unfortunately, the limited systematic sighting data do not allow for density estimation. In the absence of study-area-specific data, a density estimate of 0.00089 animals/km^2 from LGL Limited (2008) was used to characterize humpback whale density in both the MITT and associated transit corridor study areas for fall, winter, and spring. Humpback whales are likely absent from low-productivity tropical waters in the summer (Jefferson et al., 2008; Perrin et al., 2009b); therefore, a density of zero is used for that season.

Table 5-7: Summary of Density Values for Humpback Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00089	0	0.00089	0.00089
MITT Transit Corridor	0.00089	0	0.00089	0.00089

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

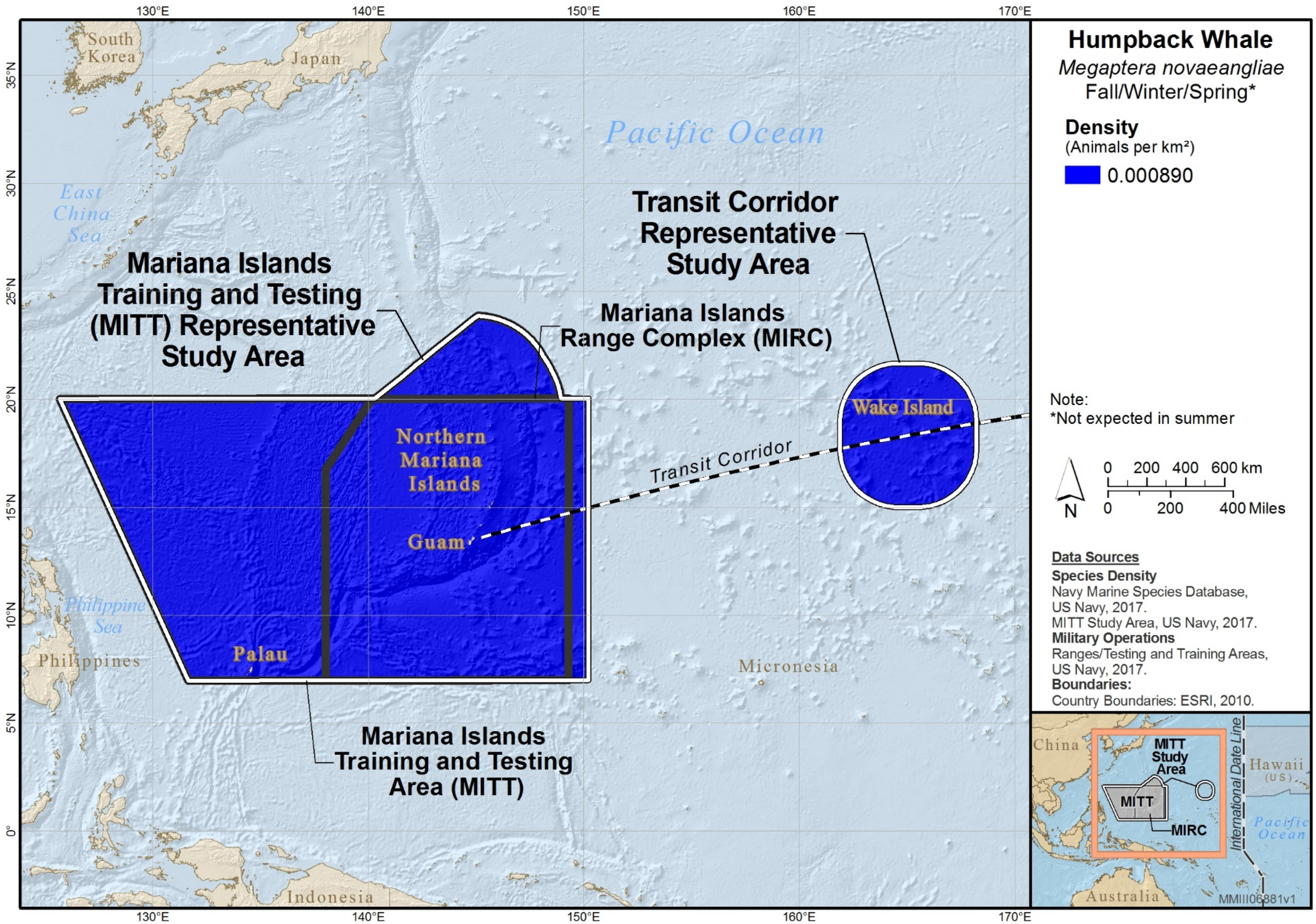


Figure 5.1-7: Fall/Winter/Spring Distribution of Humpback Whale

6 SPERM WHALES

6.1 SPERM WHALES SPECIES PROFILES

6.1.1 *KOGIA BREVICEPS*, PYGMY SPERM WHALE

Pygmy sperm whales are small, dark, toothed whales that are difficult to distinguish in the field from the closely related dwarf sperm whale (Leatherwood et al., 1988). Their small size and inconspicuous surfacing behavior make them difficult to sight in all but the lowest Beaufort sea states (Barlow, 2006; Leatherwood et al., 1988). Pygmy sperm whales in U.S. Pacific waters have been divided into two stocks by NMFS: the California/Oregon/Washington stock, and the Hawaii stock (Carretta et al., 2017). The two stocks are considered to be discrete from each other. The IWC does not recognize stock structure for *Kogia* species. Little is known about the stock structure of pygmy sperm whales in the MITT Study Area.

MITT. There were no *Kogia* species sighted during the 2007 survey of the Marianas Study Area (Fulling et al., 2011). However, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort Sea states greater than 4). There is only one stranding record available for *Kogia* in the Study Area and vicinity (Eldredge, 1991, 2003; Kami & Lujan, 1976; Reeves et al., 1999). During 2007 marine mammal monitoring for Valiant Shield, a group of three *Kogia* (dwarf or pygmy sperm whales) was observed about 8 NM east of Guam (Mobley, 2007). In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate of 0.00291 animals/km^2 derived for Hawaiian waters (Barlow, 2006) was used to represent the best available estimates for the MITT Study Area (there were no on-effort sightings of pygmy sperm whale during the more recent 2010 survey of Hawaiian waters). The density estimate of 0.00176 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual pygmy sperm whale density.

Table 6-1: Summary of Density Values for Pygmy Sperm Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00291	0.00291	0.00291	0.00291
MITT Transit Corridor	0.00176	0.00176	0.00176	0.00176

Note: The units for numerical values are animals/km^2.

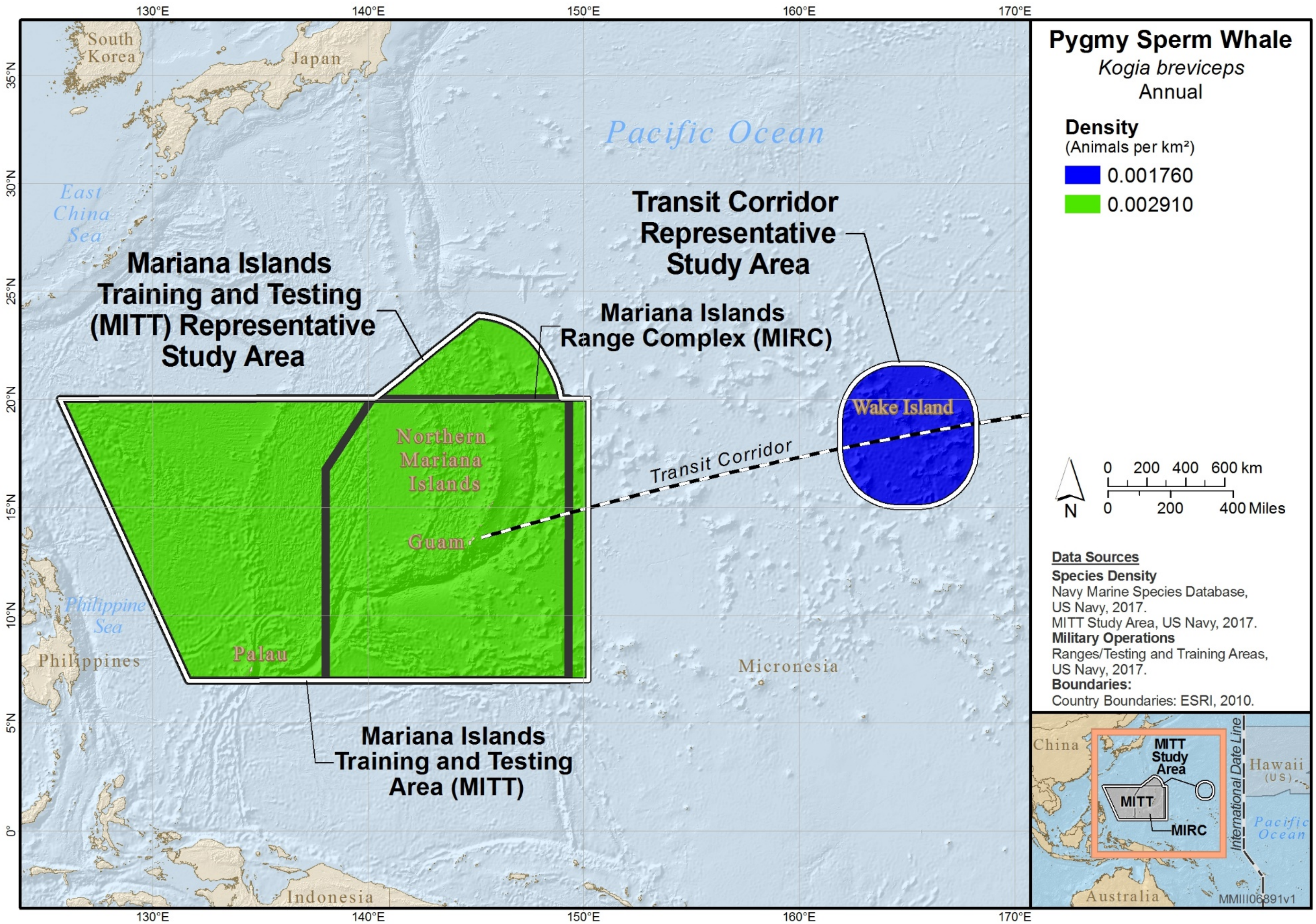


Figure 6.1-1: Annual Distribution of Pygmy Sperm Whale

6.1.2 *Kogia sima*, Dwarf Sperm Whale

Dwarf sperm whales are small, dark, toothed whales that look very similar to, but are smaller than, the closely related pygmy sperm whale (Leatherwood et al., 1988; McAlpine, 2009). Until viewed closely, the species are difficult to tell apart. Their small size and slow, inconspicuous surfacing behavior makes them difficult to sight unless conditions are calm, although they sometimes rest for long periods of time at the water surface, making them more available for observation (Barlow, 2006; McAlpine, 2009). Dwarf sperm whales in U.S. Pacific waters have been divided into two stocks by NMFS: the California/Oregon/Washington stock, and the Hawaii stock (Carretta et al., 2017). The two stocks are considered to be discrete and non-contiguous. The IWC does not provide stock structure of *Kogia* species. Little is known about the stock structure of dwarf sperm whales in the MITT Study Area.

MITT. There were no sightings of *Kogia* made during the 2007 survey of the Marianas Study Area (Fulling et al., 2011). However, similar to the pygmy sperm whale, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort Sea states greater than 4). There is only one stranding record available for *Kogia* in the Study Area and vicinity (Eldredge, 1991, 2003; Kami & Lujan, 1976; Reeves et al., 1999). During marine mammal monitoring for Valiant Shield 07, a group of three *Kogia* (dwarf or pygmy sperm whales) was observed about 8 NM east of Guam (Mobley, 2007). There was one sighting of a single dwarf sperm whale in the Marpi Reef area, northeast of Saipan, during small boat surveys conducted in August and early September 2011 (Hill et al., 2011). During small boat surveys conducted in May and June 2016 there were four dwarf sperm whale sightings off the west side of Guam, including two separate sightings of the same two mother-calf pairs (Hill et al., 2017a).

In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate of 0.00714 animals/km^2 derived for Hawaiian waters (Barlow, 2006) was used to represent the best available estimates for the MITT Study Area (there were no on-effort sightings of dwarf sperm whale during the more recent 2010 survey of Hawaiian waters). The density estimate of 0.00430 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual dwarf sperm whale density.

Table 6-2: Summary of Density Values for Dwarf Sperm Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00714	0.00714	0.00714	0.00714
MITT Transit Corridor	0.00430	0.00430	0.00430	0.00430

Note: The units for numerical values are animals/km^2.

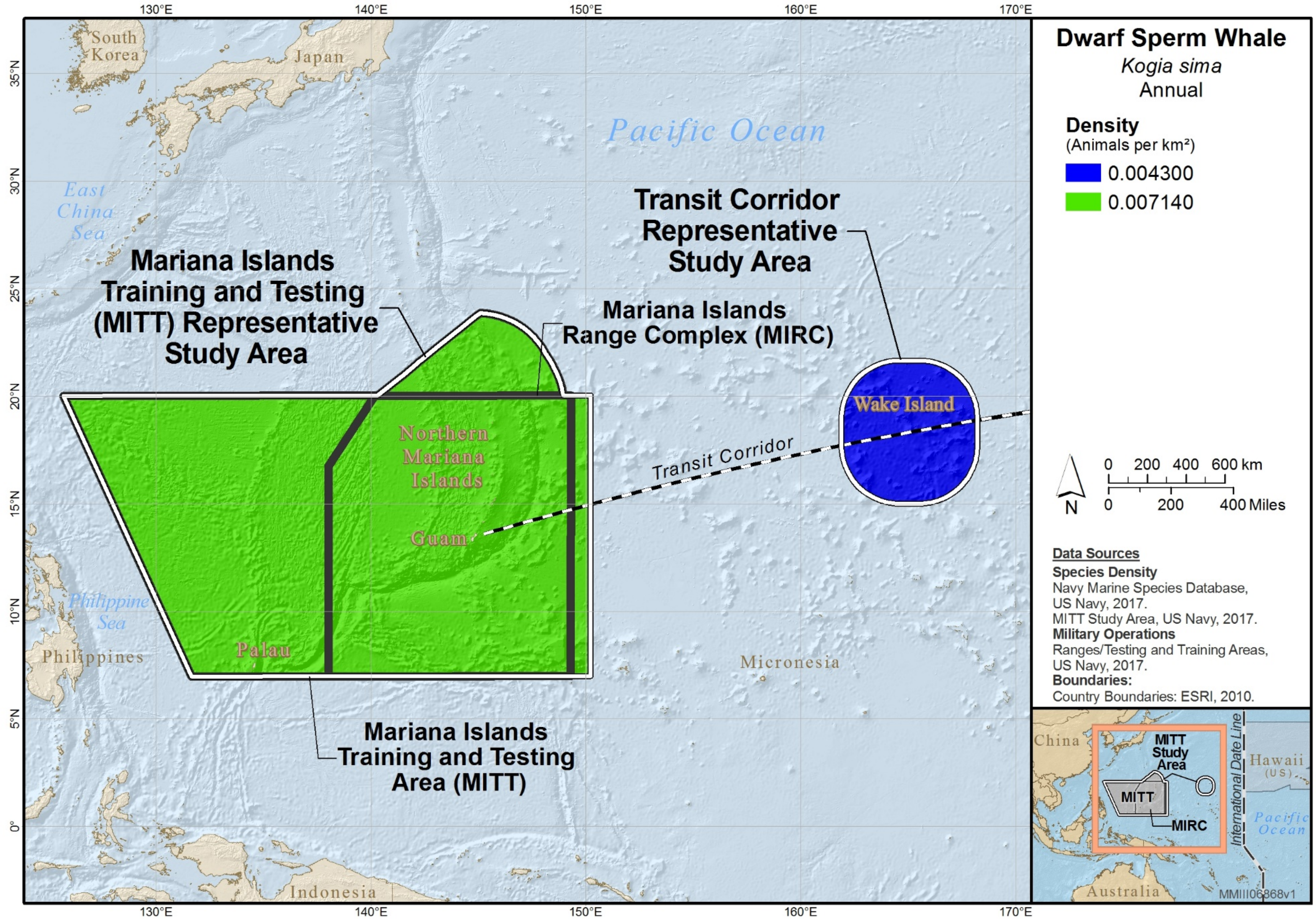


Figure 6.1-2: Annual Distribution of Dwarf Sperm Whale

6.1.3 *PHYSETER MACROCEPHALUS*, SPERM WHALE

Sperm whales are the largest of the extant toothed whales and are one of the best studied species of whale in the world (Whitehead, 2003). Their size, distinctive form, and angled "bushy" blow makes them one of the easiest species of whale to identify in the field (Leatherwood et al., 1988; Whitehead & Weilgart, 2000). Sperm whales are one of the most-widely distributed species of marine mammal (Whitehead, 2008; Whitehead et al., 2008). NMFS has divided sperm whales in the North Pacific into three stocks: the California/Oregon/Washington stock, the Hawaii stock, and the North Pacific (Alaska) stock (Carretta et al., 2017). The North Pacific stock primarily uses the Gulf of Alaska and the Bering Sea. NMFS acknowledges the stocks are not entirely discrete, but they are thought to reflect population centers (Carretta et al., 2017) and are based on a phylogeographic approach to defining stock structure (Dizon et al., 1992). The IWC recognizes eastern North Pacific and western North Pacific management units of sperm whales (Carretta et al., 2017). Although little is known about the stock structure of sperm whales in the MITT Study Area, the species would presumably be included in the IWC western North Pacific management unit.

MITT. Whaling records demonstrate sightings of sperm whales year-round in the MITT Study Area (Townsend, 1935). Sperm whales positively identified acoustically by HARPs deployed at both Saipan and Tinian for 2010–2013 also revealed year-round occurrence (Oleson et al., 2014). Sperm whales were also acoustically detected from sonobuoy deployments at Pagan in August 2013 (U.S. Department of the Navy, 2014b). No clear seasonal pattern was evident from the recordings, although they may be more common from January to March. The sperm whale was the most-frequently sighted cetacean (21 sightings) during the Navy's 2007 survey with acoustic detections three times higher than visual detections (Fulling et al., 2011). Line-transect abundance estimates derived from these survey data yielded a density estimate of 0.00123 animals/km^2 (CV = 0.60) in the MITT Study Area (Fulling et al., 2011). Recently, a habitat model was developed for sperm whale based on the acoustic data collected during the 2007 survey, and provided spatially explicit density predictions at a 10 km x 10 km (100 km^2) spatial resolution (Yack et al., 2016). Predictions from the model were made for the survey area, which is smaller than the MITT Study Area (refer to Figure 3-4), and incorporated into the NMSDD; the Fulling et al. (2011) line-transect estimate was applied elsewhere within the MITT Study Area. The density estimate of 0.00222 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual sperm whale density.

Table 6-3: Summary of Density Values for Sperm Whale

Location	Spring	Summer	Fall	Winter
MITT	S	S	S	S
MITT Transit Corridor	0.00222	0.00222	0.00222	0.00222

Notes: The units for numerical values are animals/km^2. S = spatial model with various density values throughout the range.

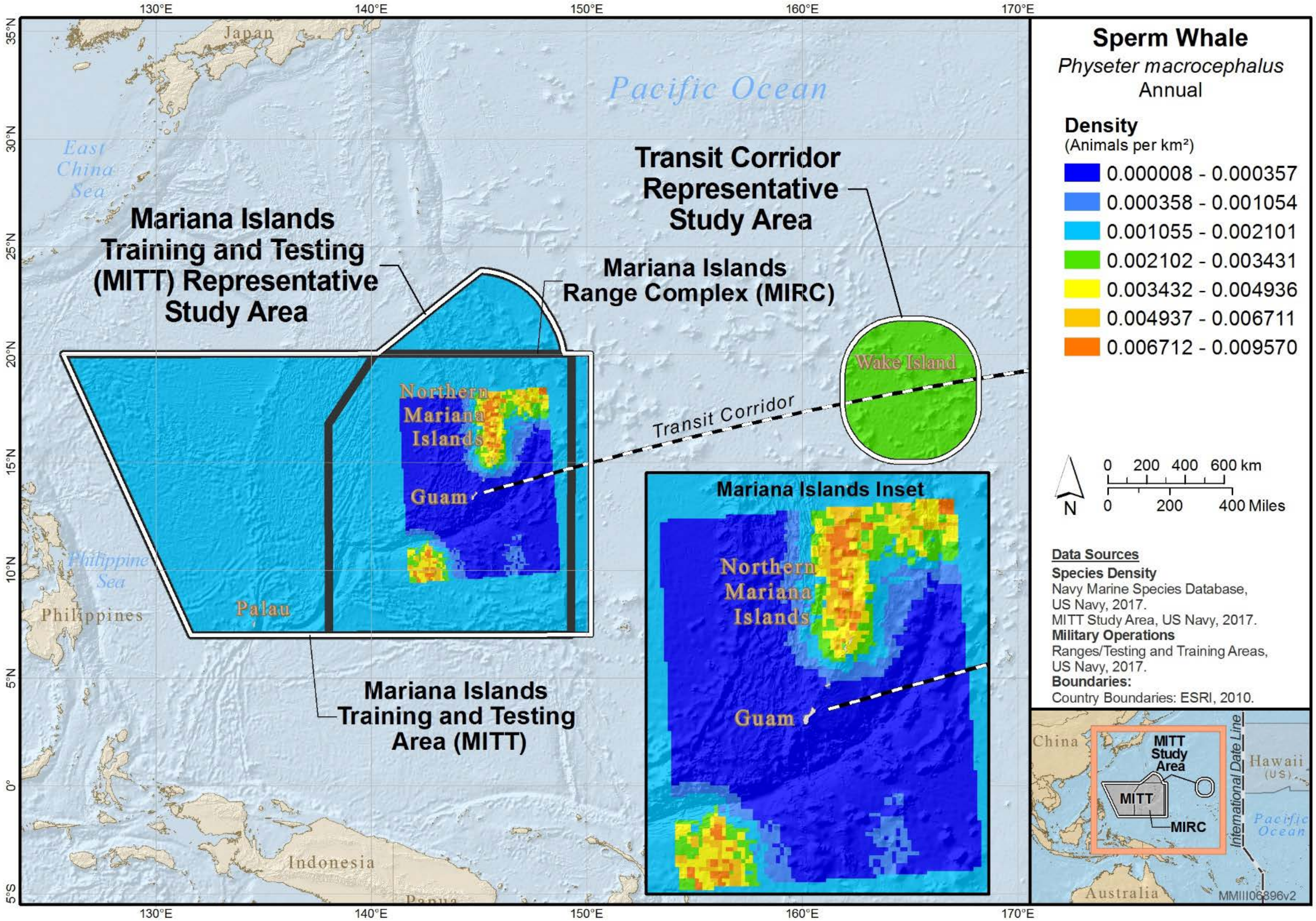


Figure 6.1-3: Annual Distribution of Sperm Whale

7 DELPHINIDS (DOLPHINS)

7.1 DELPHINID SPECIES PROFILES

This family includes a wide variety of species found in the Study Area, including various dolphins, killer whales, pilot whales, false killer whales, pygmy killer whales, and melon-headed whales.

7.1.1 *FERESA ATTENUATA*, PYGMY KILLER WHALE

Pygmy killer whales are part of a group of species generally referred to by fishers as “blackfish,” which are small, dark, blunt-headed whales (Allen et al., 2011; Leatherwood et al., 1988). They are one of the smaller species recognized as blackfish, reaching only around 2.5 m when mature (Jefferson et al., 2015). The similarity among the blackfish species in the group can make identification at sea difficult. Pryor et al. (1965) described a pygmy killer whale as looking like a small false killer whale. This misidentification between the species is easy to make; one of the helpful distinguishing characteristics is the dark cape present on the pygmy killer whale (Baird, 2010). When viewed from the side, the head of pygmy killer whales is rounded, similar to that of melon-headed whales or pilot whales. However, it is less triangular than that of melon-headed whales when viewed from above, and the lips are often white, making them distinguishable from pilot whales if viewed relatively closely (Jefferson et al., 2015; Leatherwood et al., 1988). The pygmy killer whale has a rounded head, like other blackfish, but it has flippers with bluntly rounded tips and a prominent cape that does not dip low on the side, making it distinguishable (Jefferson et al., 2015; Leatherwood et al., 1988). When swimming in groups, pygmy killer whales may swim in long coordinated lines of simultaneously breathing animals. Pygmy killer whales are seen rarely, but some studies have been able to establish that they occur near shore around tropical islands, such as Hawaii (Baird, 2011; McSweeney et al., 2009). Records also show that the species has been observed in pelagic zones of the eastern Tropical Pacific (Hamilton et al., 2009). NMFS recognizes a single Hawaiian stock of pygmy killer whales (Carretta et al., 2017). Little is known about the stock structure of pygmy killer whales in the MITT Study Area.

MITT. There was only one pygmy killer whale sighting of a group of six animals during the Navy’s 2007 survey of the MITT Study Area (Fulling et al., 2011). However, estimates of f(0) (a correction factor to account for the decreased probability of detecting an animal as its distance from the transect line increases) were made based on pooling the sightings of all blackfish (Fulling et al., 2011). Line-transect abundance estimates derived from these survey data yielded a density estimate of 0.00014 animals/km^2 (CV = 0.88) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.00006 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These estimates were used to characterize annual pygmy killer whale density.

Table 7-1: Summary of Density Values for Pygmy Killer Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00014	0.00014	0.00014	0.00014
MITT Transit Corridor	0.00006	0.00006	0.00006	0.00006

Note: The units for numerical values are animals/km^2.

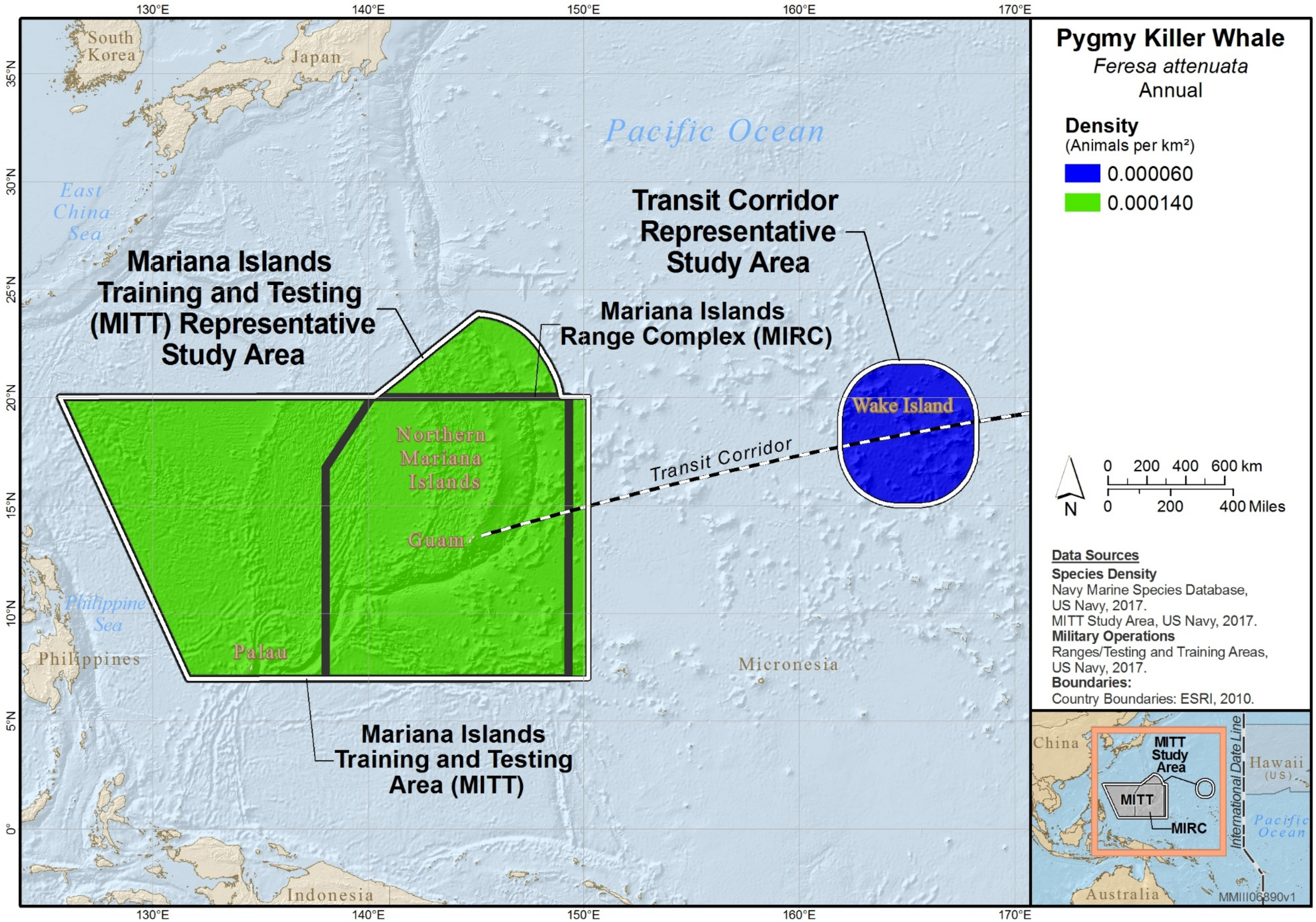


Figure 7.1-1: Annual Distribution of Pygmy Killer Whale

7.1.2 *GLOBICEPHALA MACRORHYNCHUS*, SHORT-FINNED PILOT WHALE

Short-finned pilot whales are another species of small, dark, blunt-headed whales that are categorized into the grouping of "blackfish" (Allen et al., 2011; Leatherwood et al., 1988). Of the blackfish, this species is more easily identified than other species if certain features are observed. Their bulbous forehead lives up to the scientific name of genus; this feature is especially emphasized in adult males (Jefferson et al., 2015). They also have a dorsal fin that is located forward on the back, quite falcate, and very broad at the base (Allen et al., 2011; Jefferson et al., 2015). Younger individuals that do not have the well-developed head and dorsal fin can be confused with false killer whales, melon-headed whales, or pygmy killer whales (Leatherwood et al., 1988). Pilot whales are sometimes seen associating with other species such as bottlenose dolphin, rough-toothed dolphin, pygmy killer whale, and even humpback whales (Bernard & Reilly, 1999; McSweeney et al., 2009). Short-finned pilot whales are seen relatively frequently in the pelagic waters of the eastern Tropical Pacific (Hamilton et al., 2009). NMFS defines two stocks of short-finned pilot whales in the Pacific, a Hawaiian stock, and a California/Oregon/Washington stock (Carretta et al., 2017). In Japanese waters, two stocks (northern and southern) have been identified based on pigmentation patterns and head shape differences of adult males (Kasuya et al., 1988). The southern stock of short-finned pilot whales is probably the stock associated with the Mariana Islands area (Kasuya et al., 1988).

MITT. During the Navy's 2007 survey of the Study Area, there were a total of five sightings of short-finned pilot whales with group size ranging from 5 to 43 individuals (Fulling et al., 2011). Line-transect abundance estimates derived from these survey data yielded a density estimate of 0.00159 animals/km^2 (CV = 0.68) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.00211 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual density for short-finned pilot whale.

Table 7-2: Summary of Density Values for Short-Finned Pilot Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00159	0.00159	0.00159	0.00159
MITT Transit Corridor	0.00211	0.00211	0.00211	0.00211

Note: The units for numerical values are animals/km^2.

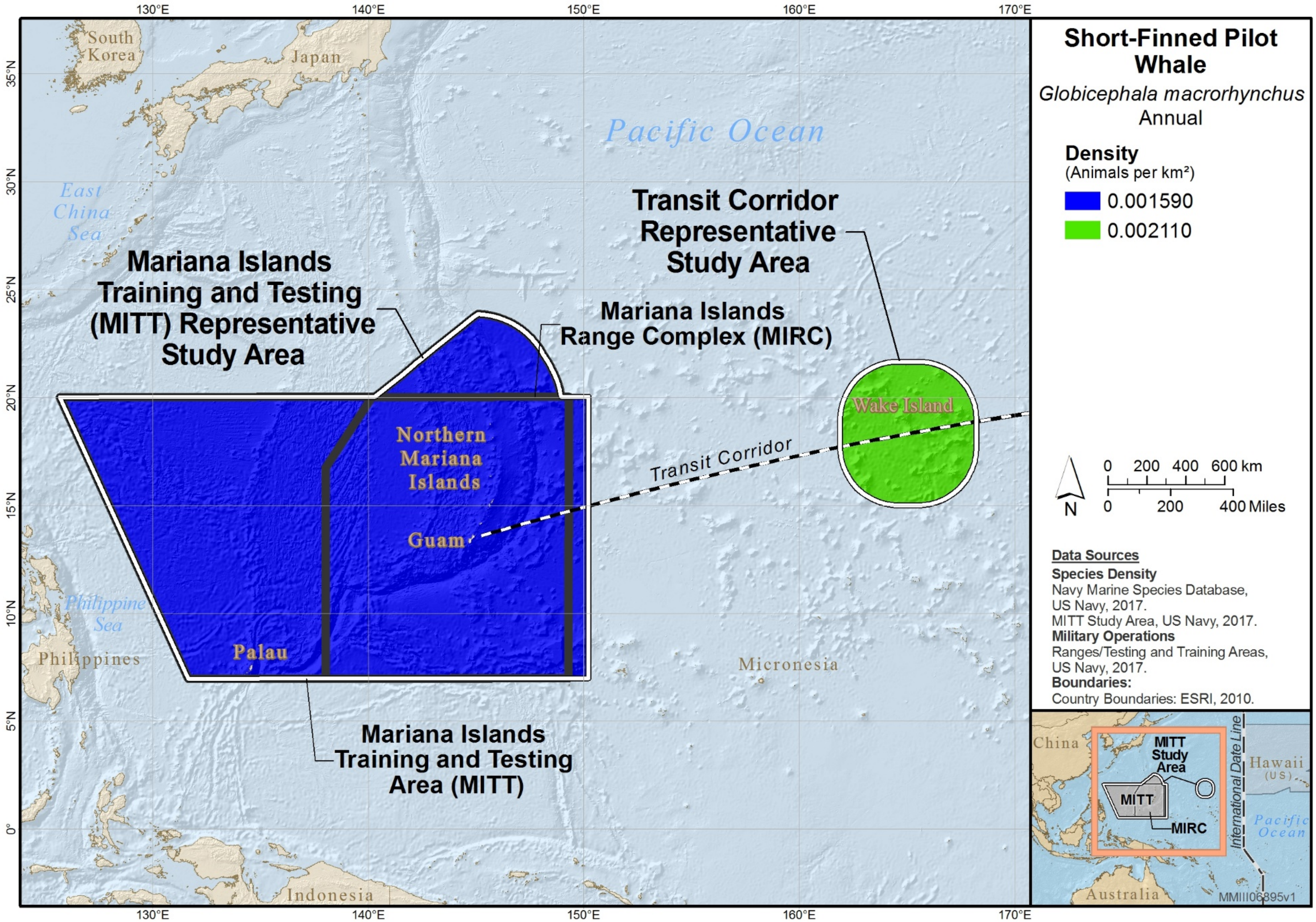


Figure 7.1-2: Annual Distribution of Short-Finned Pilot Whale

7.1.3 *GRAMPUS GRISEUS*, RISSO'S DOLPHIN

This distinctive dolphin is one of the easiest dolphin species to identify, even from a long distance. They typically appear to be lighter gray than other dolphins or even white in color because the body of a mature individual is covered with scratches and scars that are light gray to white in color (Jefferson et al., 2015; Kruse et al., 1999). The scars are hypothesized to be caused by conspecifics (MacLeod, 1998) and the squid that are common prey of Risso's dolphins (Clarke & Young, 1998). They also have one of the tallest dorsal fins with respect to body size of any cetacean (Baird, 2008). One of the few species that could be confused with Risso's dolphins from a distance could be killer whales because of the height of the dorsal fin (Leatherwood et al., 1988). It is not unusual for Risso's dolphins to be seen in mixed species groups, particularly with Pacific white-sided dolphins and/or northern right whale dolphins (Jefferson et al., 2015; Leatherwood et al., 1988). NMFS defines two stocks of Risso's dolphins in the Pacific, a Hawaiian stock, and a California/Oregon/Washington stock (Carretta et al., 2017). Little is known about the stock structure of Risso's dolphins in the MITT Study Area.

MITT. Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Au & Perryman, 1985; Carretta et al., 2010; Leatherwood et al., 1980; Miyashita, 1993; Miyashita et al., 1996; Wang et al., 2001). On March 30, 2010, during an oceanographic survey of waters in Micronesia and the Commonwealth of the Northern Mariana Islands, there was a single Risso's dolphin sighting of three individuals, at approximately 17°N, more than 60 NM north of FDM (Oleson & Hill, 2010). There were no Risso's dolphin sightings during the Navy's 2007 systematic survey of the Study Area (Fulling et al., 2011). In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, line-transect estimates derived for Hawaiian waters (Bradford et al., 2017) were used to represent the best available estimates for the MITT Study Area. The density estimate of 0.00046 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual density for Risso's dolphin.

Table 7-3: Summary of Density Values for Risso's Dolphin

Location	Spring	Summer	Fall	Winter
MITT	0.00474	0.00474	0.00474	0.00474
MITT Transit Corridor	0.00046	0.00046	0.00046	0.00046

Note: The units for numerical values are animals/km^2.

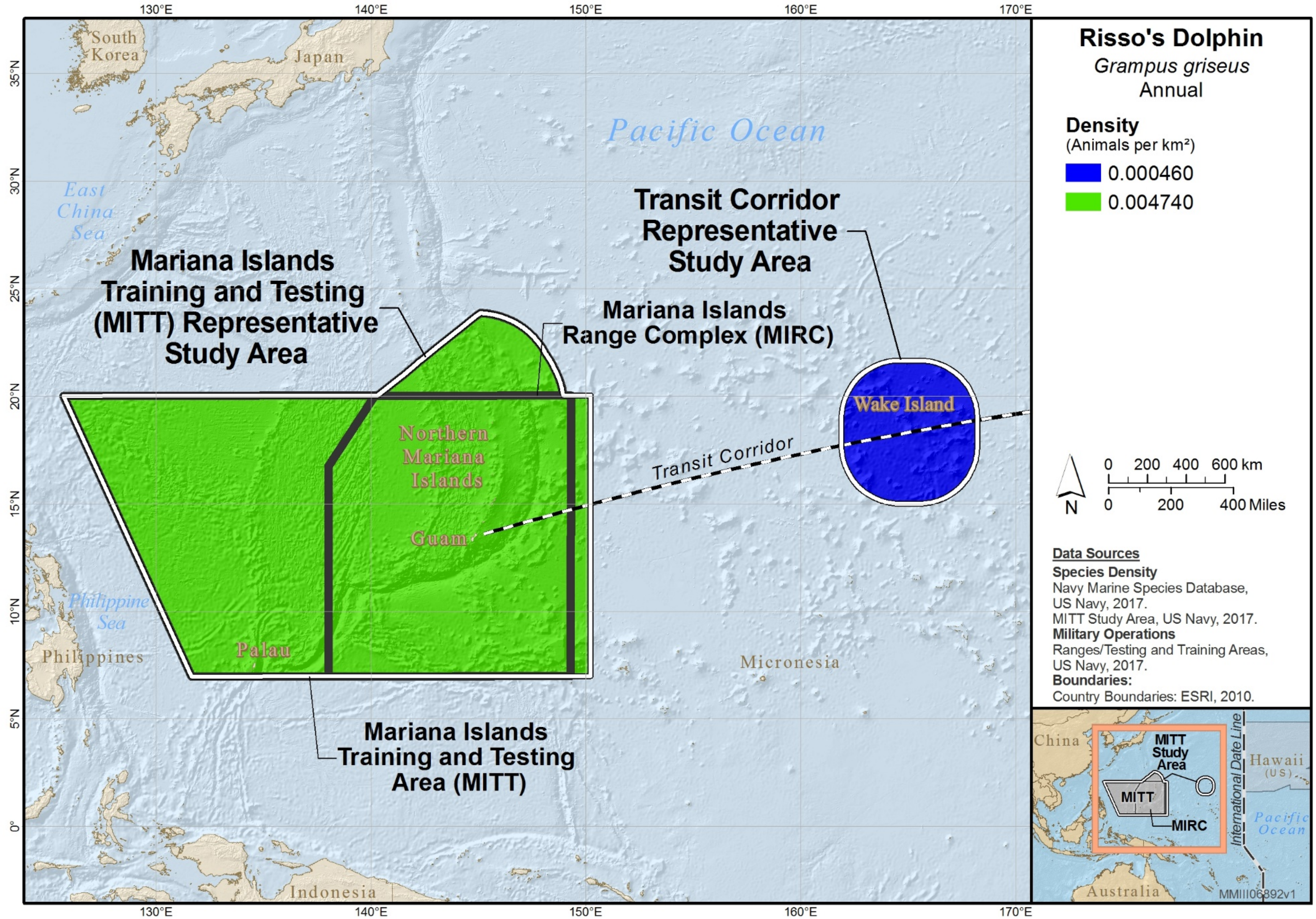


Figure 7.1-3: Annual Distribution of Risso's Dolphin

7.1.4 *LAGENODELPHIS HOSEI*, FRASER'S DOLPHIN

Fraser's dolphin (*Lagenodelphis hosei*) is a tropical species of dolphin about which little is known. The species was described based on a skeleton in 1956. An actual intact specimen was not identified until 1971 (Dolar, 2008). When viewed clearly, the species should be readily identifiable. They have a body that is stocky, often described as particularly "robust" (Jefferson et al., 2015; Leatherwood et al., 1988) with a short beak and very small appendages. They have a dark band running from the eyes and beak to the anus (Dolar, 2008; Jefferson et al., 2015). At a distance the striping could cause confusion with striped dolphins, but the dark stripe on the Fraser's dolphin is broad, especially in adult males, and the body is much more stocky (Leatherwood et al., 1988). Fraser's dolphin have been observed in very large groups, greater than 1,000 individuals, and may be seen in mixed species groups with various species including Risso's, pantropical spotted, striped, and spinner dolphins, melon-headed whales, pilot whales, false killer whales, and sperm whales (Jefferson et al., 2015; Kiszka et al., 2011; Leatherwood et al., 1988). NMFS recognizes a single Hawaiian stock of Fraser's dolphins in U.S. waters (Carretta et al., 2017). Little is known about the stock structure of Fraser's dolphins in the MITT Study Area.

MITT. There were no Fraser's dolphin sightings during the Navy's 2007 systematic survey of the Study Area (Fulling et al., 2011), and there are no abundance estimates for Fraser's dolphin in the region. In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, line-transect estimates derived for Hawaiian waters (Bradford et al., 2017) were used to represent the best available estimates for the MITT Study Area (0.02104 animals/km^2). The density estimate of 0.00252 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual density for Fraser's dolphin.

Table 7-4: Summary of Density Values for Fraser's Dolphin

Location	Spring	Summer	Fall	Winter
MITT	0.02104	0.02104	0.02104	0.02104
MITT Transit Corridor	0.00252	0.00252	0.00252	0.00252

Note: The units for numerical values are animals/km^2.

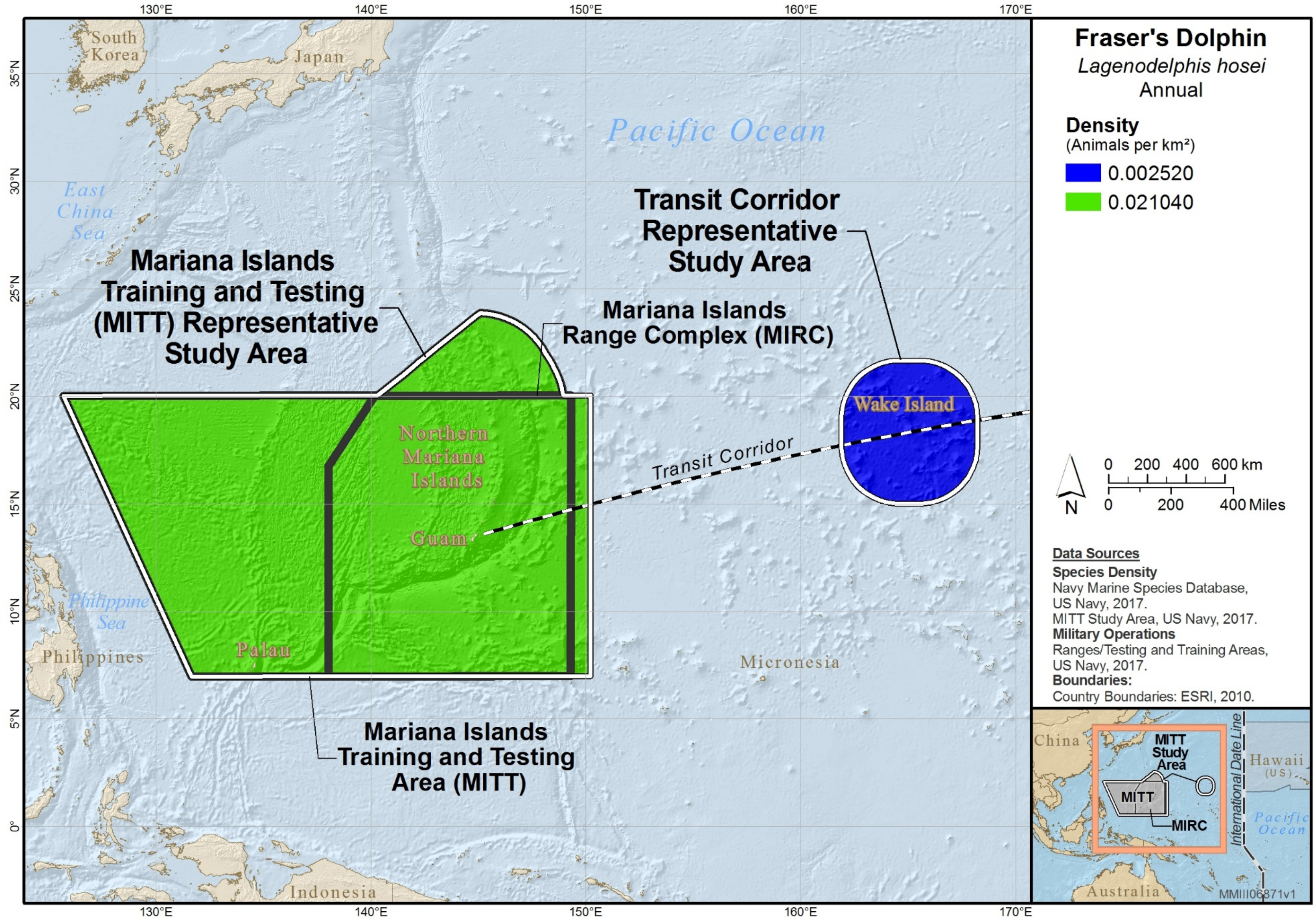


Figure 7.1-4: Annual Distribution of Fraser's Dolphin

7.1.5 *Orcinus orca*, Killer Whale

Killer whales are top predators that are found throughout the world's oceans (Dahlheim & Heyning, 1999; Jefferson et al., 2015). The structure of the division of groups within the species is complex and has a strong bearing on the range, behavior, foraging strategy, and physiology of each type of killer whale (Baird, 2000; Foote et al., 2009; Foote et al., 2011; Kasamatsu et al., 2000; Pitman & Durban, 2012). A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are currently called "ecotypes" (Ford, 2008; Morin et al., 2010). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits. In the North Pacific, these recognizable geographic forms are variously known as "residents," "transients," and "offshores" (Baird, 2000; Barrett Lennard et al., 1996). Killer whales' physical profile is unmistakable. They have a tall dark dorsal fin, a robust black body with a striking patch of white behind the eye, a white lower jaw, and lighter-colored "saddle patch" behind the dorsal fin (Jefferson et al., 2015). They are unlikely to be mistaken for any other species, except possibly Risso's dolphins if only the dorsal fins are seen from a distance or false killer whales if only females (which are smaller than males) and juveniles are encountered (Leatherwood et al., 1988).

Eight killer whale stocks are recognized within the Pacific U.S. EEZ, including (1) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock (Prince William Sound through the Aleutian Islands and Bering Sea); (2) the AT1 Transient stock (Alaska from Prince William Sound through the Kenai Fjords); (3) the Alaska resident stock (Southeast Alaska to the Aleutian Islands and Bering Sea); (4) the Northern Resident stock (British Columbia through part of Southeast Alaska); (5) the West Coast Transient stock (Alaska through California); (6) the Offshore stock (Southeast Alaska through California); (7) the Southern Resident stock (mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California); and (8) the Hawaii stock (Carretta et al., 2017; Muto et al., 2017). Little is known about the stock structure of killer whales in the MITT Study Area.

MITT. Although killer whales are found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim & Heyning, 1999). Killer whales have been sighted in the MITT Study Area (Eldredge, 1991; Rock, 1993; Wenninger, 2010); however, there were no killer whale sightings during the Navy's 2007 systematic survey of the Study Area (Fulling et al., 2011). In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, line-transect estimates derived for Hawaiian waters (Bradford et al., 2017) were used to represent the best available estimates for the MITT Study Area (0.00006 animals/km^2). The density estimate of 0.00009 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual killer whale density.

Table 7-5: Summary of Density Values for Killer Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00006	0.00006	0.00006	0.00006
MITT Transit Corridor	0.00009	0.00009	0.00009	0.00009

Note: The units for numerical values are animals/km^2.

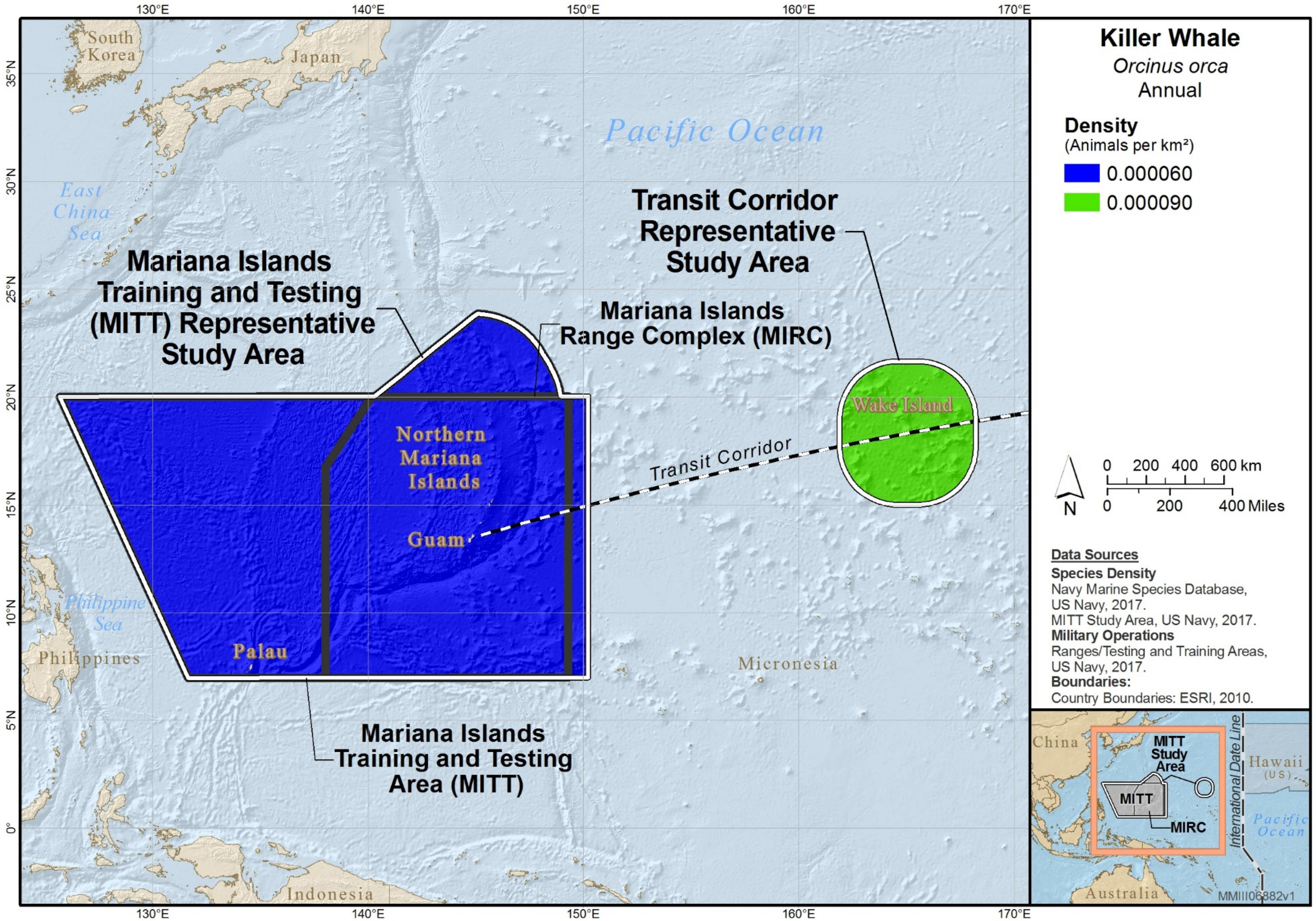


Figure 7.1-5: Annual Distribution of Killer Whale

7.1.6 *PEPONOCEPHALA ELECTRA*, MELON-HEADED WHALE

Melon-headed whales are one of the species that fall into the group known as "blackfish." They fit the definition for the group ideally because they are small, dark, and have a rounded head (Allen et al., 2011; Leatherwood et al., 1988). Adults do not have a beak (though newborns have a slight one), nor do they have a strongly bulbous melon like pilot whales or false killer whales (Allen et al., 2011). Their coloration is actually more charcoal gray than black, and they have subtle variation in color across their body including a dark cape and face and a lighter patch on the belly (Jefferson et al., 2015). Good lighting is required to see the color subtleties. Melon-headed whales have lighter colored lips, somewhat like the pygmy killer whale, but the white area is usually more extensive on the lower jaw on pygmy killer whales (Leatherwood et al., 1988). Despite having these identifying characteristics, they require relatively close examination for positive identification. For that reason, melon-headed whales are easily confused with false killer whales and especially pygmy killer whales (Jefferson et al., 2015; Leatherwood et al., 1988). What may add to the confusion is the fact that the melon-headed whale is typically smaller than a false killer whale, but similar in size to a pygmy killer whale. Melon-headed whales are a species that can be found in association with other dolphins, such as Fraser's dolphin, spinner dolphin, rough-toothed dolphin, and common bottlenose dolphin (Allen et al., 2011; Kiszka et al., 2011). NMFS recognizes two Pacific management stocks within the Hawaiian Islands EEZ: (1) the Kohala Resident stock, and (2) the Hawaiian Islands stock (Carretta et al., 2017). Little is known about the stock structure of melon-headed whales in the MITT Study Area.

MITT. Based on sighting data from the Navy's 2007 survey, there were an estimated 2,455 (CV = 0.70) melon-headed whales in the surveyed area (Fulling et al., 2011). The density estimate of 0.00428 animals/km^2 (CV= 0.70) derived by Fulling et al. (2011) was used for the larger MITT Study Area. The density estimate of 0.00267 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual melon-headed whale density.

Table 7-6: Summary of Density Values for Melon-Headed Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00428	0.00428	0.00428	0.00428
MITT Transit Corridor	0.00267	0.00267	0.00267	0.00267

Note: The units for numerical values are animals/km^2.

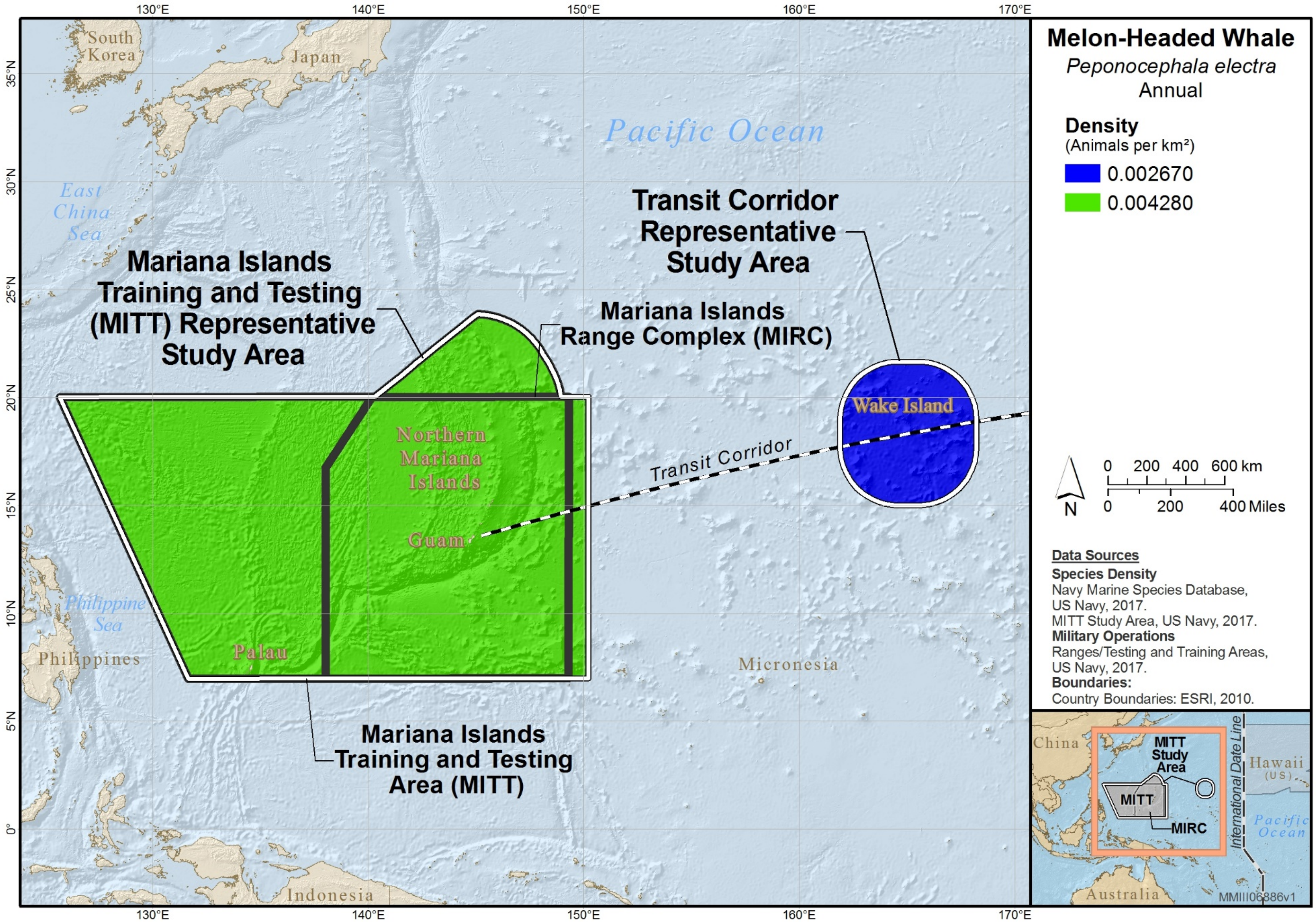


Figure 7.1-6: Annual Distribution of Melon-Headed Whale

7.1.7 *PSEUDORCA CRASSIDENS*, FALSE KILLER WHALE

False killer whales are the quintessential “blackfish,” as they are a relatively small cetacean that is almost entirely black and have a rounded melon (Jefferson et al., 2015; Leatherwood et al., 1988). Like the melon-headed whale, they do not have a beak. Due to the similarity among blackfish, false killer whales can be confused with pilot whales (*Globicephala* sp.), melon-headed whales, and pygmy killer whales (Baird, 2010; Jefferson et al., 2015; Leatherwood et al., 1988). Close attention to the shape of the body, which is relatively slender, as well as to the shape of the head and the shape and position of the dorsal fin is necessary to tell the blackfish apart (Jefferson et al., 2015). The best feature is actually the shape of the flippers, which have an S-shape in false killer whales. Observers at sea may have an opportunity to view the entirety of a false killer whale because they are known to be acrobatic (Baird, 2009; Leatherwood et al., 1988; Odell & McClune, 1999).

False killer whales are one of the largest of the dolphins (Allen et al., 2011), and are a top-order predator that feeds on large pelagic fish like mahi-mahi, as well as on deep water prey such as squid (Odell & McClune, 1999). They are found throughout the world in tropical and temperate oceans (Baird, 2009). NMFS currently recognizes three stocks of false killer whale in Hawaiian waters: the Main Hawaiian Islands insular stock, the Hawaii pelagic stock, and the Northwestern Hawaiian Islands stock (Carretta et al., 2017). There are two additional stocks recognized outside of Hawaiian waters including the Palmyra Atoll stock, which includes animals found within the U.S. EEZ of Palmyra Atoll, and the American Samoa stock, which includes animals found within the U.S. EEZ of American Samoa. Little is known about the stock structure of false killer whales in the MITT Study Area, despite multiple non-systematic small boat surveys conducted since February 2010 (Hill et al., 2011; Hill et al., 2013; Hill et al., 2014; Hill et al., 2015; Hill et al., 2016; Hill et al., 2017a).

MITT. During the Navy’s 2007 survey of the Study Area, false killer whales were sighted 10 times in groups ranging from 2 to 26 individuals with several including calves (Fulling et al., 2011). Based on sighting data from the 2007 survey, there were an estimated 0.00111 animals/km^2 (CV = 0.74) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.00057 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual false killer whale density.

Table 7-7: Summary of Density Values for False Killer Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00111	0.00111	0.00111	0.00111
MITT Transit Corridor	0.00057	0.00057	0.00057	0.00057

Note: The units for numerical values are animals/km^2.

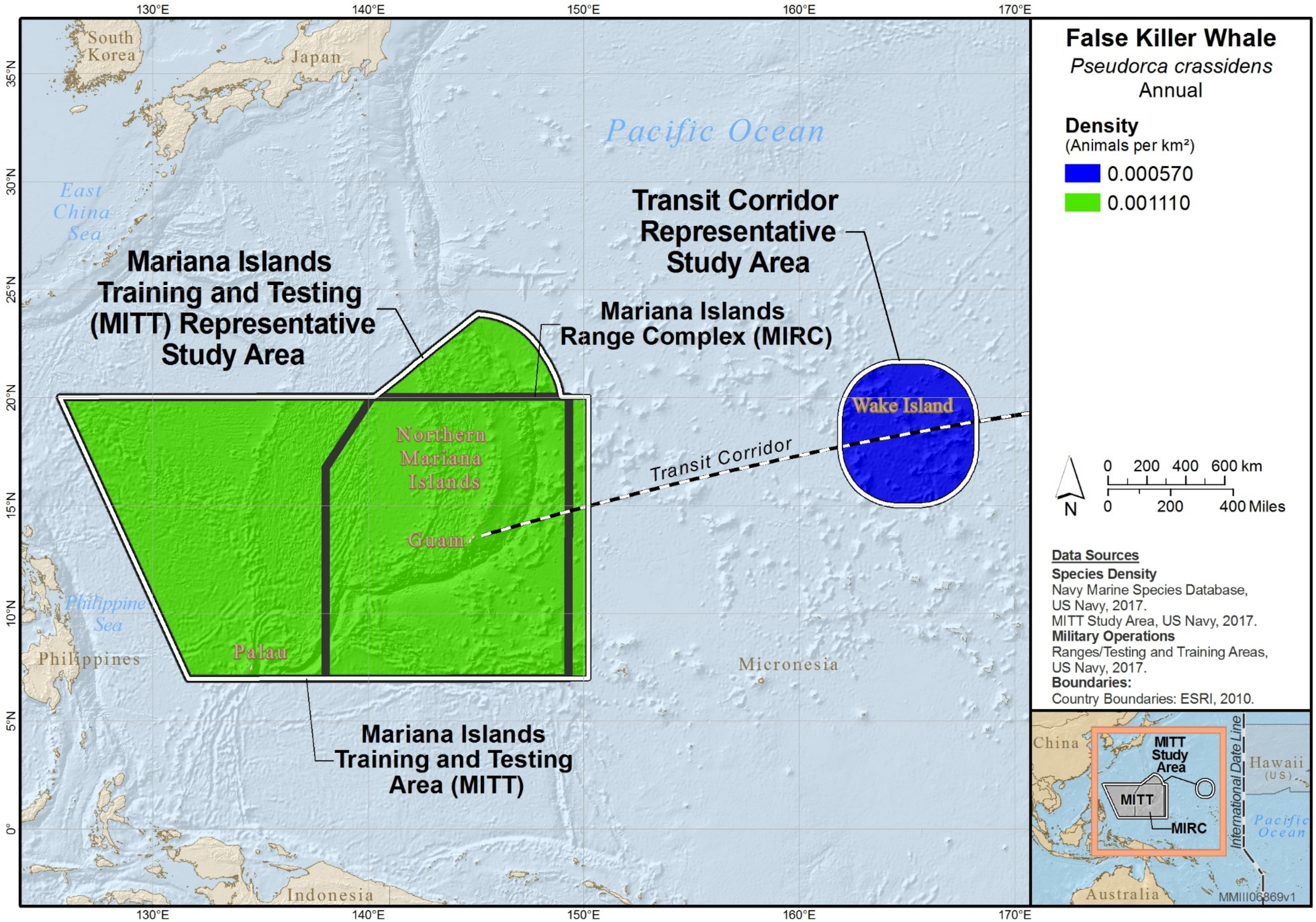


Figure 7.1-7: Annual Distribution of False Killer Whale

7.1.8 *STENELLA ATTENUATA*, PANTROPICAL SPOTTED DOLPHIN

As the name suggests, pantropical spotted dolphins are found in the tropics and subtropics across the world's oceans (Jefferson et al., 2015; Perrin et al., 2009a). This is a long-beaked dolphin that is found both near shore and in oceanic zones; there are coloration and body shape differences associated with the different zones (Jefferson et al., 2015; Leatherwood et al., 1988). Spotting on the dolphins is highly variable, develops and increases with age, and may not be a particularly good indicator of the species identification in the field (Allen et al., 2011; Jefferson et al., 2015). The dark cape on the back and white on the lips and the tip of rostrum (which also develops with age) are better indicators of species identification (Allen et al., 2011; Jefferson et al., 2015). Spotted dolphins could be mistaken for a number of dolphin species including spinner dolphins and bottlenose dolphins; they move and jump like striped dolphins and common dolphins (*Delphinus* spp.) when seen from a distance (Allen et al., 2011; Jefferson et al., 2015; Leatherwood et al., 1988). To make things slightly more challenging for field identification, pantropical spotted dolphins associate often with spinner dolphins (Gross et al., 2009; Psarakos et al., 2003) and sometimes with bottlenose dolphins (Baird, 2015). NMFS recognizes four management stocks within the U.S. EEZ of the Hawaiian Islands: (1) the Oahu stock, (2) the 4-Islands stock, (3) the Hawaii Island stock, and (4) the Hawaii Pelagic stock (Carretta et al., 2017). Little is known about the stock structure of pantropical spotted dolphins in the MITT Study Area.

MITT. Pantropical spotted dolphins were sighted throughout the Study Area during the Navy's 2007 ship survey in waters with a variable bottom depth, ranging from 113 to 5,639 m (Fulling et al., 2011). Group size ranged from 1 to 115 individuals. There were multiple sightings that included young calves, and one mixed species aggregation with melon-headed whales and another with an unidentified *Balaenoptera* species. These pantropical spotted dolphins were identified as the offshore morphotype. Small boat surveys have been conducted around the Mariana Islands since 2010 and pantropical spotted dolphins are one of the most frequently encountered species (Hill et al., 2014). Based on the 2007 survey data, there were an estimated 0.0226 animals/km^2 (CV = 0.70) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.01132 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual pantropical spotted dolphin density.

Table 7-8: Summary of Density Values for Pantropical Spotted Dolphin

Location	Spring	Summer	Fall	Winter
MITT	0.0226	0.0226	0.0226	0.0226
MITT Transit Corridor	0.01132	0.01132	0.01132	0.01132

Note: The units for numerical values are animals/km^2.

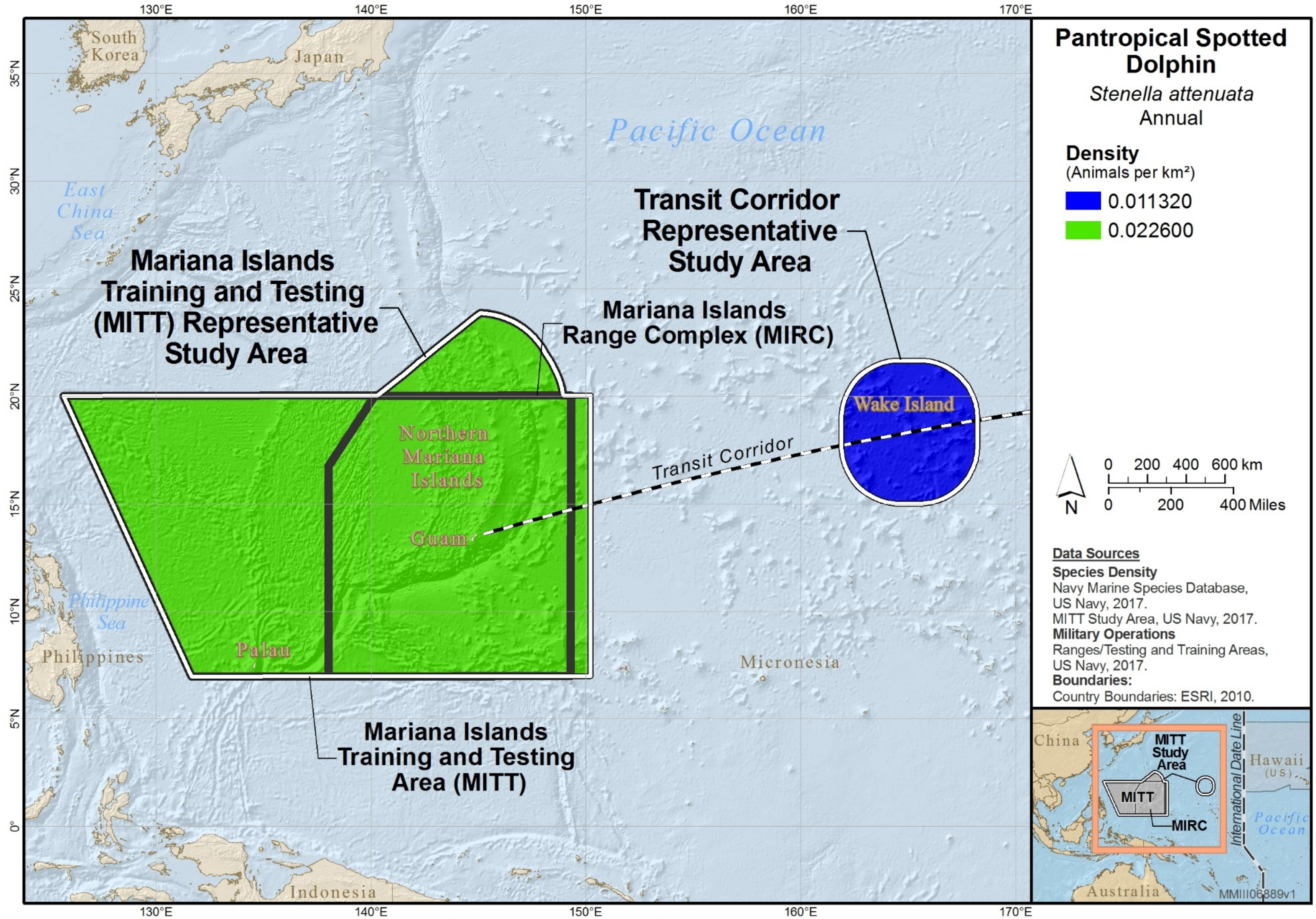


Figure 7.1-8: Annual Distribution of Pantropical Spotted Dolphin

7.1.9 *STENELLA COERULEOALBA*, STRIPED DOLPHIN

Striped dolphins are primarily pelagic and are typically found past the continental shelf (Archer, 2009). They have a similar appearance to spinner, spotted, and common dolphins (Jefferson et al., 2015). Their beak is moderate in length and is therefore distinguishable from the longer beak of the spinner dolphin and long-beaked common dolphin (Jefferson et al., 2015). They have a color pattern on their face and sides that allows them to be distinguished from other dolphins. A blaze of light color on the side of the body extends up into the dark cape, and dark stripes from the rostrum extend back to the anus and down to the front of the pectoral fin (Jefferson et al., 2015). There is some literature reporting striped dolphins mixing with other species (Querouil et al., 2008), but it may not be a common occurrence in many places. Striped dolphins may be difficult to observe, because they are notorious for avoiding vessels (Jefferson et al., 2015; Leatherwood et al., 1988), or at least not bow riding, if a group is approached (Archer, 2009). These behavioral features may cause this species to be under-represented in some data sets, but there are some behaviors that allow the species to be more easily identified at sea. The species will perform leaps from the water and move at high speeds away from vessels; they will also perform a unique behavior called "roto-tailing," which is a rotation of the tail while jumping (Archer & Perrin, 1999). NMFS recognizes a Hawaiian stock of striped dolphins and a California/Oregon/Washington stock (Carretta et al., 2017). Little is known about the stock structure of striped dolphins in the MITT Study Area.

MITT. Prior to the Navy's 2007 survey of the Study Area (Fulling et al., 2011), striped dolphins were only known from one stranding that occurred in July 1985 (Eldredge, 1991, 2003). However, striped dolphins were sighted throughout the Study Area during the 2007 survey in waters with variable bottom depth, ranging from 2,348 to 7,526 m (Fulling et al., 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group size ranged from 7 to 44 individuals, and several sightings included calves. Based on the 2007 survey data, there were an estimated 0.00616 striped dolphins/km^2 (CV = 0.54) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.00584 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual striped dolphin density.

Table 7-9: Summary of Density Values for Striped Dolphin

Location	Spring	Summer	Fall	Winter
MITT	0.00616	0.00616	0.00616	0.00616
MITT Transit Corridor	0.00584	0.00584	0.00584	0.00584

Note: The units for numerical values are animals/km^2.

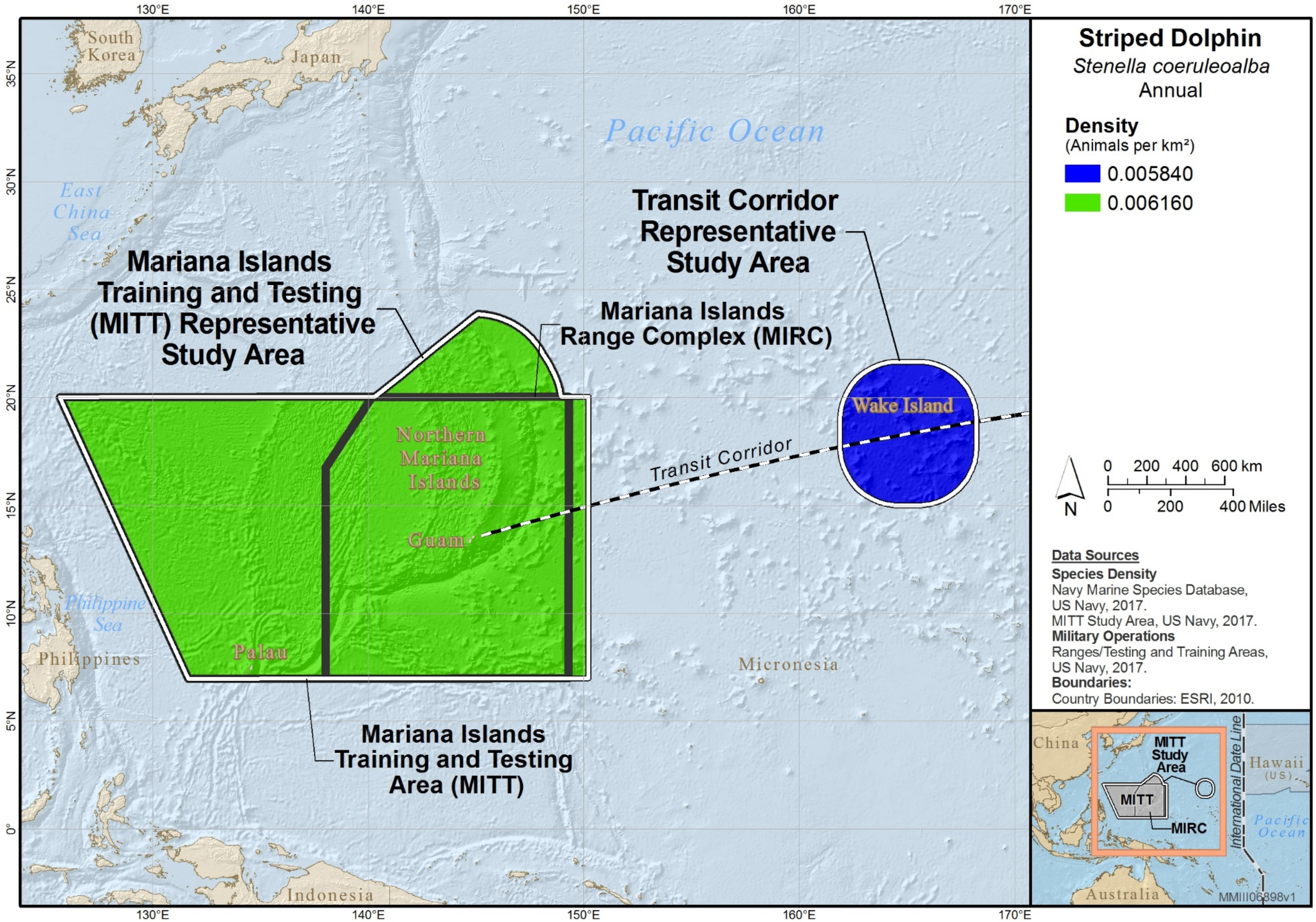


Figure 7.1-9: Annual Distribution of Striped Dolphin

7.1.10 *STENELLA LONGIROSTRIS*, SPINNER DOLPHIN

This well-known tropical dolphin is small-bodied and has a very long beak (Jefferson et al., 2015). Adult males develop a post-anal "hump" in what is otherwise a thin tail stock (Allen et al., 2011; Jefferson et al., 2015). The spinner dolphins have an erect, triangular dorsal fin, which is relatively unique in shape when compared to other dolphin species (Leatherwood et al., 1988). These morphological features serve to make the spinner dolphin distinguishable from other dolphins in their range that they could be mistaken for, including bottlenose dolphin, spotted dolphin, striped dolphin, common dolphin (*Delphinus* spp.), and Fraser's dolphin. The general basic color of spinner dolphins is gray above and white below, with an intermediate side, but a great deal of regional variation in color is observed in this species and four subspecies are recognized: *Stenella longirostris* in oceanic waters throughout the world, *Stenella longirostris orientalis* in the offshore eastern tropical Pacific, *Stenella longirostris centroamericana* in the coastal eastern tropic Pacific, and *Stenella longirostris roseiventris* off Southeast Asia and northern Australia (Jefferson et al., 2015; Norris et al., 1994). One of the things that distinguishes this species most clearly from other species is the behavior that is their namesake. Their various twisting, spinning leaps, as well as many other conspicuous surface behaviors, have been described in detail (Fish et al., 2006; Norris & Dohl, 1980; Norris et al., 1994). Spinner dolphins associate with other species, and a common association is with pantropical spotted dolphins (Jefferson et al., 2015; Kiszka et al., 2011; Psarakos et al., 2003).

In Hawaii, spinner dolphin populations can be partitioned into subpopulations that are associated with a particular island or group of islands (Andrews et al., 2010; Karczmarski et al., 2005; Perrin et al., 2009a). NMFS recognizes a stock complex of spinner dolphins for the Hawaiian Islands (Carretta et al., 2017). The complex includes a Hawaii Island stock, Oahu/4-islands stock, a Kauai/Niihau stock, a Pearl and Hermes Reef stock, a Midway Atoll/Kure stock, and a Hawaii Pelagic stock.

Little is known about the stock structure of spinner dolphins in the MITT Study Area. However, based on recent sighting data (Hill et al., 2011; Hill et al., 2017a; Ligon et al., 2011; Oleson & Hill, 2010; U.S. Department of the Navy, 2011) and what is known of the Hawaiian Islands stocks, it is likely that there are both island-associated and pelagic populations of spinner dolphins in the MITT Study Area. In 2012 and 2013, sightings of spinner dolphins off Guam and Saipan support the existence of island-associated populations (Hill et al., 2013; U.S. Department of the Navy, 2011). In 2013, during surveys around Pagan in the Commonwealth of the Northern Mariana Islands, there were a large number of spinner dolphin sightings in association with these islands, also suggestive of island-associated populations there (U.S. Department of the Navy, 2014b). Small boat surveys have been conducted around the Mariana Islands since 2010, and spinner dolphins were one of the most frequently encountered species (Hill et al., 2014). Individual spinner dolphins have been identified on these small boat surveys using photo identification techniques; however, these encounter rates and photo identifications still do not permit quantitative abundance estimates (Hill et al., 2017a).

MITT. Although there are multiple sighting records of spinner dolphins around the Mariana Islands (Hill et al., 2011; Hill et al., 2013; Hill et al., 2017a; Ligon et al., 2011; Oleson & Hill, 2010; U.S. Department of the Navy, 2011, 2012a), no abundance estimate is available for the region. The only large-scale systematic line-transect survey of the Study Area was the Navy's 2007 survey for which there was only one sighting of this species (Fulling et al., 2011), and a robust abundance estimate was not possible. Consistent with recommendations from scientists at PIFSC, the Navy assumed that both an island(s)-associated spinner dolphin population, within 10 NM of all the islands, and a pelagic spinner dolphin population exist. For the island-associated spinner dolphins, the Navy used the estimate of spinner dolphin abundance of 0.066 for the Big Island of Hawaii (Tyne et al., 2014), since it is perhaps the most analogous and complete survey for an island-associated population in the tropical Pacific. For the pelagic population, the Navy used line-transect estimates derived by Barlow (2006) for waters in an offshore Hawaiian EEZ stratum (0.00083 animals/km^2). The density estimate of 0.00187 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual spinner dolphin density.

Table 7-10: Summary of Density Values for Spinner Dolphin

Location	Spring	Summer	Fall	Winter
MITT (within 10 NM of islands)	0.066	0.066	0.066	0.066
MITT (> 10 NM of islands)	0.00083	0.00083	0.00083	0.00083
MITT Transit Corridor	0.00187	0.00187	0.00187	0.00187

Notes: The units for numerical values are animals/km^2. NM = nautical miles.

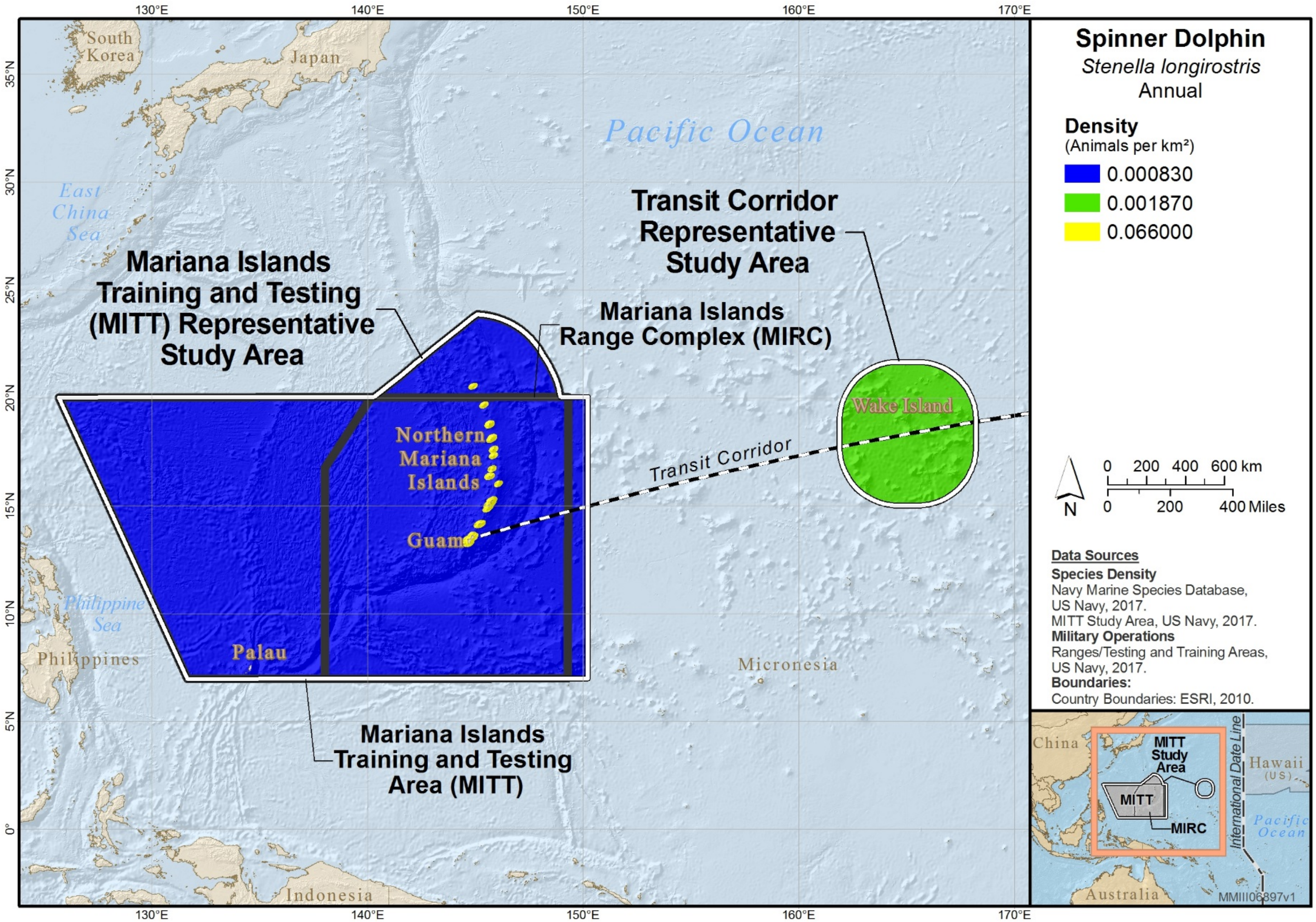


Figure 7.1-10: Annual Distribution of Spinner Dolphin

7.1.11 *STENO BREDANENSIS*, ROUGH-TOOTHED DOLPHIN

This dolphin is found in offshore waters of the tropics around the world (Baird et al., 2008; Jefferson et al., 2015; Leatherwood et al., 1988). Rough-toothed dolphins are somewhat unusual looking for a dolphin as they have a gently sloping melon instead of a rounded area in front of the eyes. There is no crease between the melon and beak, as there is in most dolphins, and this shape gives the head a conical appearance (Jefferson et al., 2015; Leatherwood et al., 1988). Rough-toothed dolphins are dark gray in color with a darker cape. Often they have a white (often with a pinkish tinge) coloration on the belly that can make irregular patches of white/pink color around the mouth, head, and lower sides of the body (Leatherwood et al., 1988). They are acrobatic and jump out of the water with regularity, but landings are less graceful than other dolphins and look more like flops or breaches that humpback whales perform (Hanser, 2009–2014). Because of their gray color they can be confused with bottlenose dolphins and pantropical spotted dolphins, and their aerial behavior can appear to be like spinner dolphins from a distance (Leatherwood et al., 1988). Closer observation of the coloration and the head shape will resolve identification issues. NMFS recognizes two Pacific management stocks: the Hawaiian stock and the American Samoa stock (Carretta et al., 2017). Little is known about the stock structure of rough-toothed dolphins in the MITT Study Area.

MITT. During the Navy's 2007 survey of the Study Area, there were two sightings of rough-toothed dolphins, both in groups of nine individuals, with calves present in one sighting (Fulling et al., 2011). During small boat surveys conducted around the Mariana Islands since 2010, there have been multiple encounters with rough-toothed dolphins (Hill et al., 2014; Hill et al., 2017a).
Based on the 2007 survey data, there were an estimated 0.00029 animals/km^2 (CV = 0.89) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.00185 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual rough-toothed dolphin density.

Table 7-11: Summary of Density Values for Rough-Toothed Dolphin

Location	Spring	Summer	Fall	Winter
MITT	0.00029	0.00029	0.00029	0.00029
MITT Transit Corridor	0.00185	0.00185	0.00185	0.00185

Note: The units for numerical values are animals/km^2.

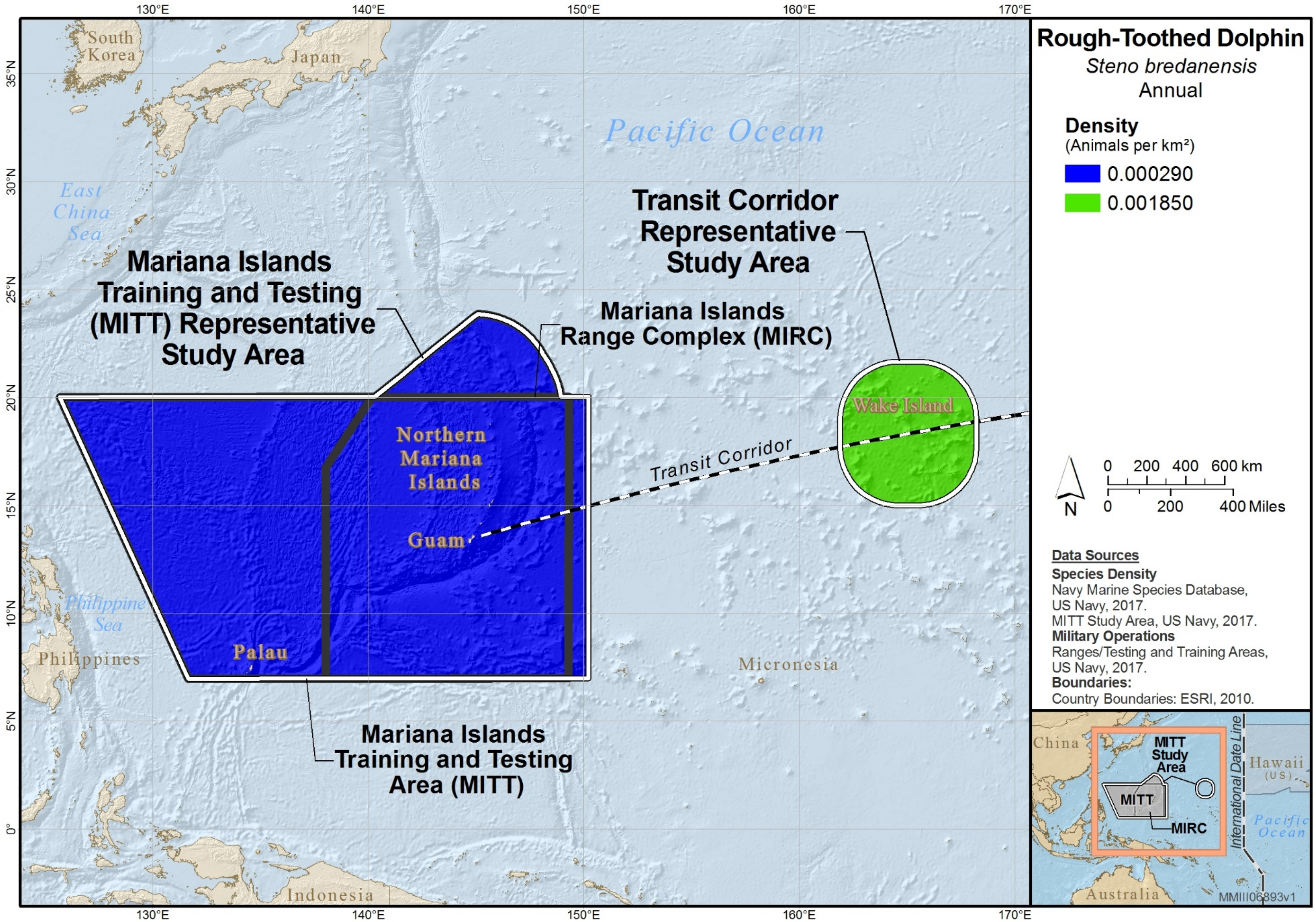


Figure 7.1-11: Annual Distribution of Rough-Toothed Dolphin

7.1.12 *TURSIOPS TRUNCATUS*, COMMON BOTTLENOSE DOLPHIN

The common bottlenose dolphin is the “standard” dolphin envisioned by the general public from the media and public exhibits. They have the most generalized color scheme of any dolphin; they are primarily gray counter shaded with white (occasionally with a pinkish tinge) sometimes on the ventral side (Allen et al., 2011; Jefferson et al., 2015). Their body is robust and powerfully built, the beak is a moderate length, and their dorsal fin is prominent, falcate, and pointed (Allen et al., 2011; Jefferson et al., 2015; Leatherwood et al., 1988). The general similarity of bottlenose dolphins to many other dolphins means that they can be confused with a variety of species, most often rough-toothed dolphins and pantropical spotted dolphins (Leatherwood et al., 1988). Bottlenose dolphins are so widespread in tropical and temperate waters, that the degree to which the species can be mistaken with other dolphins often depends on where one is in the world (Jefferson et al., 2015). It is unclear if misidentifications systematically tend to overestimate sightings in favor of bottlenose dolphins or in favor of species other than bottlenose dolphins. The best field protocols clearly are ones that quantify the uncertainty of sightings or categorize species as unidentified, unless the species can be established with high certainty.

Bottlenose dolphins are strongly social and often associate with other marine mammal species (Connor et al., 2000; Scott & Chivers, 1990)**.** Species can include spotted dolphins, spinner dolphins, common dolphins, rough-toothed dolphins, Risso’s dolphins, pilot whales, humpback whales, and California sea lions (Deakos et al., 2010; Fulling et al., 2011; Hanser et al., 2010; Hill et al., 2014; Kiszka et al., 2011; Leatherwood et al., 1988; Querouil et al., 2008; Wells & Scott, 1999). Bottlenose dolphin populations have a complex structure. The basic division in populations is often between offshore and coastal forms (Baird et al., 1993; Wells et al., 1999). There may be more or less population structure in differing areas. NMFS recognizes two stocks and one stock complex of bottlenose dolphins in U.S. waters: a Hawaiian Island Stock Complex, a California/Oregon/Washington Offshore stock, and a California Coastal stock (Carretta et al., 2017). Little is known about the stock structure of bottlenose dolphins in the MITT Study Area.

MITT. During the Navy’s 2007 survey of the Study Area, there were a total of four sightings (three on-effort) of bottlenose dolphins, including two mixed-species aggregations: one included sperm whales (with calves) logging at the surface and another involved short-finned pilot whales and rough-toothed dolphins (Fulling et al., 2011). Bottlenose dolphins have also been encountered during small boat surveys conducted around the Mariana Islands since 2010 (Hill et al., 2014). Based on the 2007 survey data, there were an estimated 0.00021 bottlenose dolphins/km^2 (CV = 0.99) in the MITT Study Area (Fulling et al., 2011). The density estimate of 0.00077 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual common bottlenose dolphin density.

Table 7-12: Summary of Density Values for Common Bottlenose Dolphin

Location	Spring	Summer	Fall	Winter
MITT	0.00021	0.00021	0.00021	0.00021
MITT Transit Corridor	0.00077	0.00077	0.00077	0.00077

Note: The units for numerical values are animals/km^2.

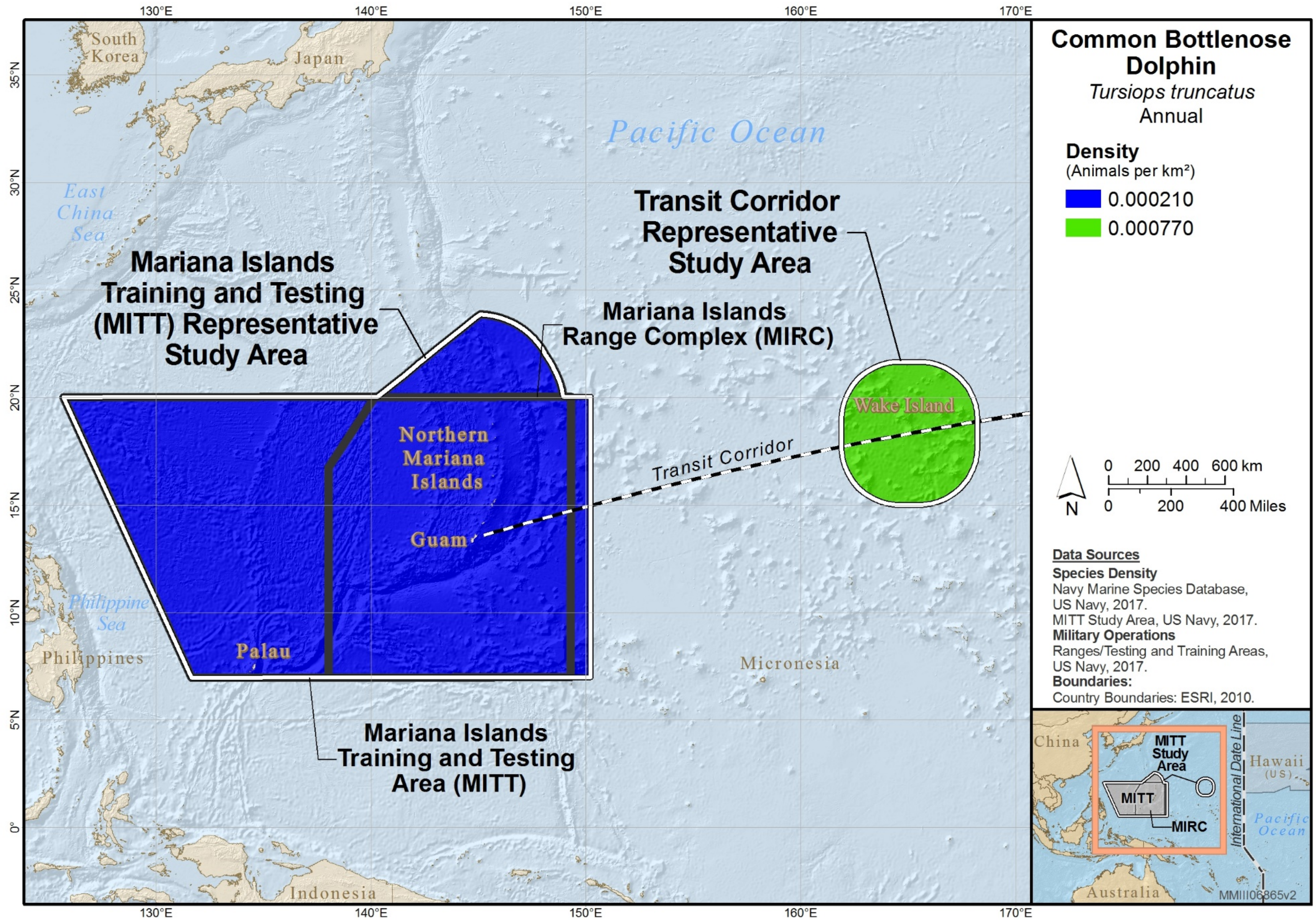


Figure 7.1-12: Annual Distribution of Common Bottlenose Dolphin

8 BEAKED WHALES

8.1 BEAKED WHALE SPECIES PROFILES

This group of species is problematic in terms of establishing values for the marine mammal density database. Beaked whales are notoriously difficult to detect and identify at sea because of their short surfacing series relative to long dive times (Baird et al., 2006; Barlow, 1999), low profile (Barlow et al., 2006), and likely avoidance of vessels (Heyning, 1989; Pitman, 2008). These difficulties result in having few sightings for a number of species and questionable identification in many cases for the whales that are seen. Researchers have addressed these problems primarily by pooling the data into groups either by family or at least size. Although this dilutes the actual knowledge for a particular species, it allows for a more robust sense of the presence of beaked whales in general. This is a better solution than not estimating the degree of presence until sufficient data exist, because the Navy needs to be able to quantify to some degree its interactions with all species of concern in its OPAREAs.

Acoustic data indicate that there are at least 10 species of beaked whales in the North Pacific, but information on their distribution is limited (Baumann-Pickering et al., 2014). In general, scientists believe they have recordings of more species of beaked whale than have been observed (Baumann-Pickering et al., 2010; McDonald et al., 2009). Beaked whales were identified acoustically by HARPs deployed at both Saipan and Tinian for 2010–2013 (Oleson et al., 2014). Beaked whales were detected year-round, with no clear seasonal pattern, and were classified as Cuvier's (*Ziphius cavirostris*), Blainville's (*Mesoplodon densirostris*), and possible ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*) (Oleson et al., 2014). Currently, density data for four species of beaked whale are incorporated into the NMSDD for the MITT Study Area: Longman's beaked whale (*Indopacetus pacificus*), Blainville's beaked whale, ginkgo-toothed beaked whale, and Cuvier's beaked whale.

Although the extent of Longman's beaked whale distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al., 2009; Dalebout et al., 2002; Dalebout et al., 2003; Moore, 1972). There were two *Mesoplodon* whale sightings during the Navy's 2007 survey of the Study Area, but they were not identified to the species level (Fulling et al., 2011). Since Blainville's beaked whale is probably the most common and abundant tropical species of *Mesoplodon* (U.S. Department of the Navy, 2005), it is likely to occur in the MITT Study Area. The ginkgo-toothed beaked whale is known only from strandings in tropical waters of the Pacific and Indian Oceans (Mead, 1989a; Palacios, 1996), and there are no occurrence records for this species in the Study Area. However, this area is within the known distribution range for this species (Taylor et al., 2008). Cuvier's beaked whales have been sighted in the MITT Study Area (Mobley, 2007). Density values were thus included in the Navy's database for the four species known or strongly suspected to be present (i.e., Longman's, Blainville's, ginkgo-toothed, and Cuvier's beaked whales).

8.1.1 INDOPACETUS PACIFICUS, LONGMAN'S BEAKED WHALE

Longman's beaked whale is a prime example of a whale species that is often misidentified. Until recently this species was only described from skulls (Dalebout et al., 2003). Scientists became aware in the 1990s that sightings in the tropics which were previously identified as *Hyperoodon* sp. were actually

Indopacetus (Pitman et al., 1999). Little is known about Longman's beaked whale. It is a large beaked whale, but not as big as Baird's beaked whale. The species' color ranges from brown to blue-gray, and it has a somewhat bulging forehead and a moderately long, tubular beak. The area from the rostrum to the blowhole is lighter colored than the rest of the body (Dalebout et al., 2003; Jefferson et al., 2015). This species is unlikely to be confused with most other species in its range if seen closely. Like Baird's beaked whale, Longman's beaked whale may occur more often in groups larger than 11 individuals (MacLeod et al., 2006). Only one stock of Longman's beaked whale is recognized by NMFS, and it is around Hawaii (Carretta et al., 2011). However, this simple stock structure may be the result of a lack of knowledge about the species. Nothing is known about the stock structure of Longman's beaked whale in the MITT Study Area.

MITT. There were no sightings of Longman's beaked whale during the Navy's 2007 survey of the Study Area (Fulling et al., 2011). In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate of 0.00311 animals/km^2 derived for Hawaiian waters (Bradford et al., 2017) was used to represent the best available estimate for the MITT Study Area. The density estimate of 0.00025 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual Longman's beaked whale density.

Table 8-1: Summary of Density Values for Longman's Beaked Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00311	0.00311	0.00311	0.00311
MITT Transit Corridor	0.00025	0.00025	0.00025	0.00025

Note: The units for numerical values are animals/km^2.

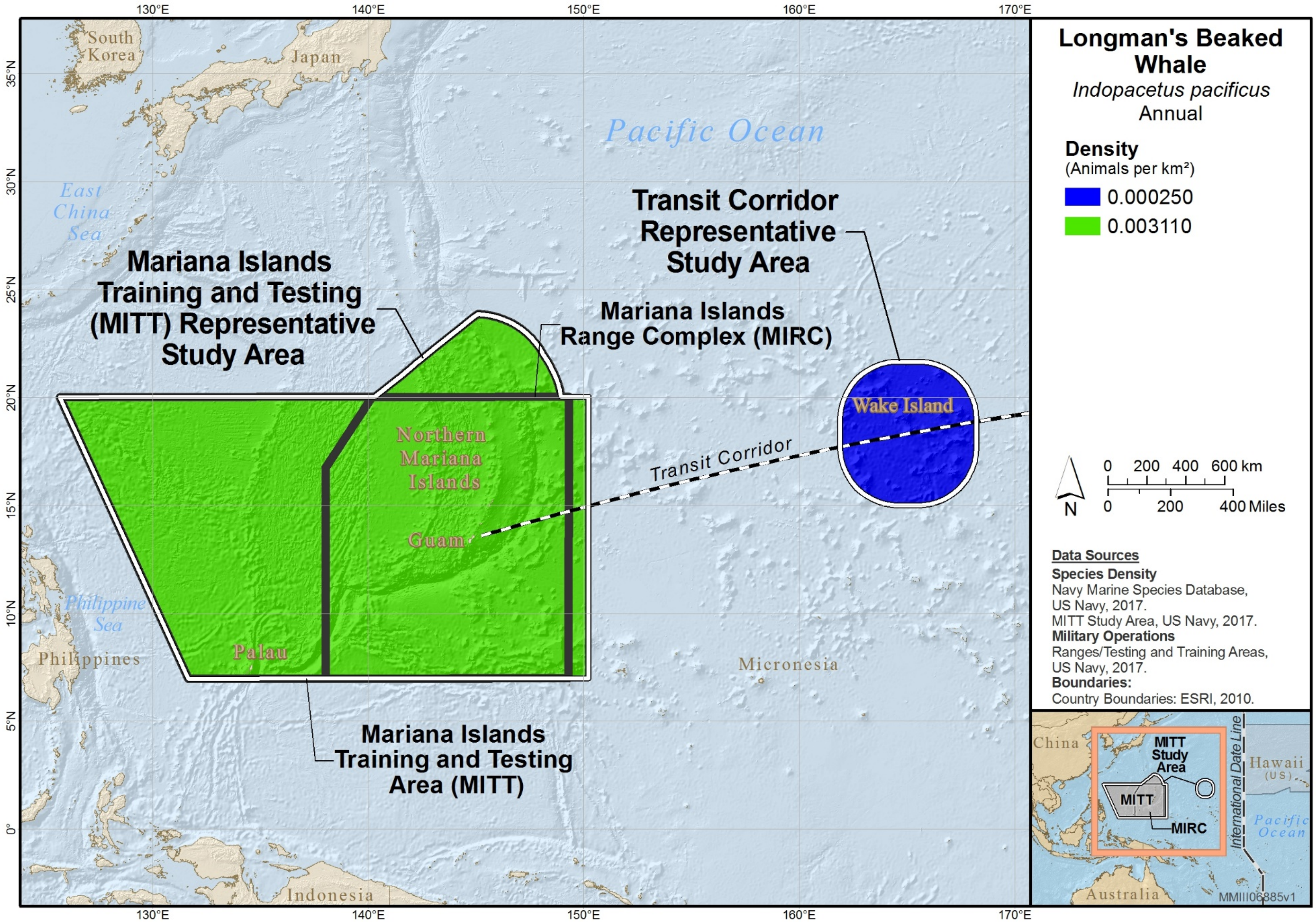


Figure 8.1-1: Annual Distribution of Longman's Beaked Whale

8.1.2 *MESOPLODON DENSIROSTRIS*, BLAINVILLE'S BEAKED WHALE

Blainville's beaked whale is found in warm temperate and tropical waters around the world (Pitman, 2008). The shape of the body is typical for mesoplodonts with a spindle-shaped torso, small dorsal fin two-thirds of the way along the body, a relatively small head, and small pectoral fins (Jefferson et al., 2015; Pitman, 2008). The general coloration is counter shaded brown or gray with many scars from cookie cutter sharks (*Isistius brasiliensis*). The lower jaw is the most distinctive identifying feature of Blainville's beaked whale. The posterior half of the lower jaw is arched in all sexes and age groups. In adult males, the arches of the jaw extend above the melon and large teeth, or tusks, erupt from the jaw, and protrude above the head at a 45° angle (Jefferson et al., 2015; Leatherwood et al., 1988; Pitman, 2008). The unusual shape of the jaw makes adult males reasonably distinguishable at sea, but young individuals and females may be difficult to identify positively. The species is most likely to be misidentified with other mesoplodonts and Cuvier's beaked whale, whose range overlaps significantly with Blainville's beaked whale (Jefferson et al., 2015; Leatherwood et al., 1988). When viewed at close range, it is clear that Cuvier's beaked whale has a more straight jaw line and a more bulbous head than Blainville's beaked whale (Leatherwood et al., 1988), but other mesoplodonts can cause significant identification problems, especially for younger individuals and females.

NMFS recognizes a stock for Blainville's beaked whale around Hawaii, as well as recognizing the species as a member of the California/Oregon/Washington Mesoplodont Beaked Whale stock of six species (Carretta et al., 2017). Little is known about the stock structure of Blainville's beaked whale in the MITT Study Area.

MITT. There were two *Mesoplodon* whale sightings during the Navy's 2007 survey of the Study Area, but they were not identified to the species level (Fulling et al., 2011). In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate of 0.00086 animals/km^2 derived for Hawaiian waters (Bradford et al., 2017) was used to represent the best available estimate for Blainville's beaked whale in the MITT Study Area. The density estimate of 0.00070 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual Blainville's beaked whale density.

Table 8-2: Summary of Density Values for Blainville's Beaked Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00086	0.00086	0.00086	0.00086
MITT Transit Corridor	0.00070	0.00070	0.00070	0.00070

Note: The units for numerical values are animals/km^2.

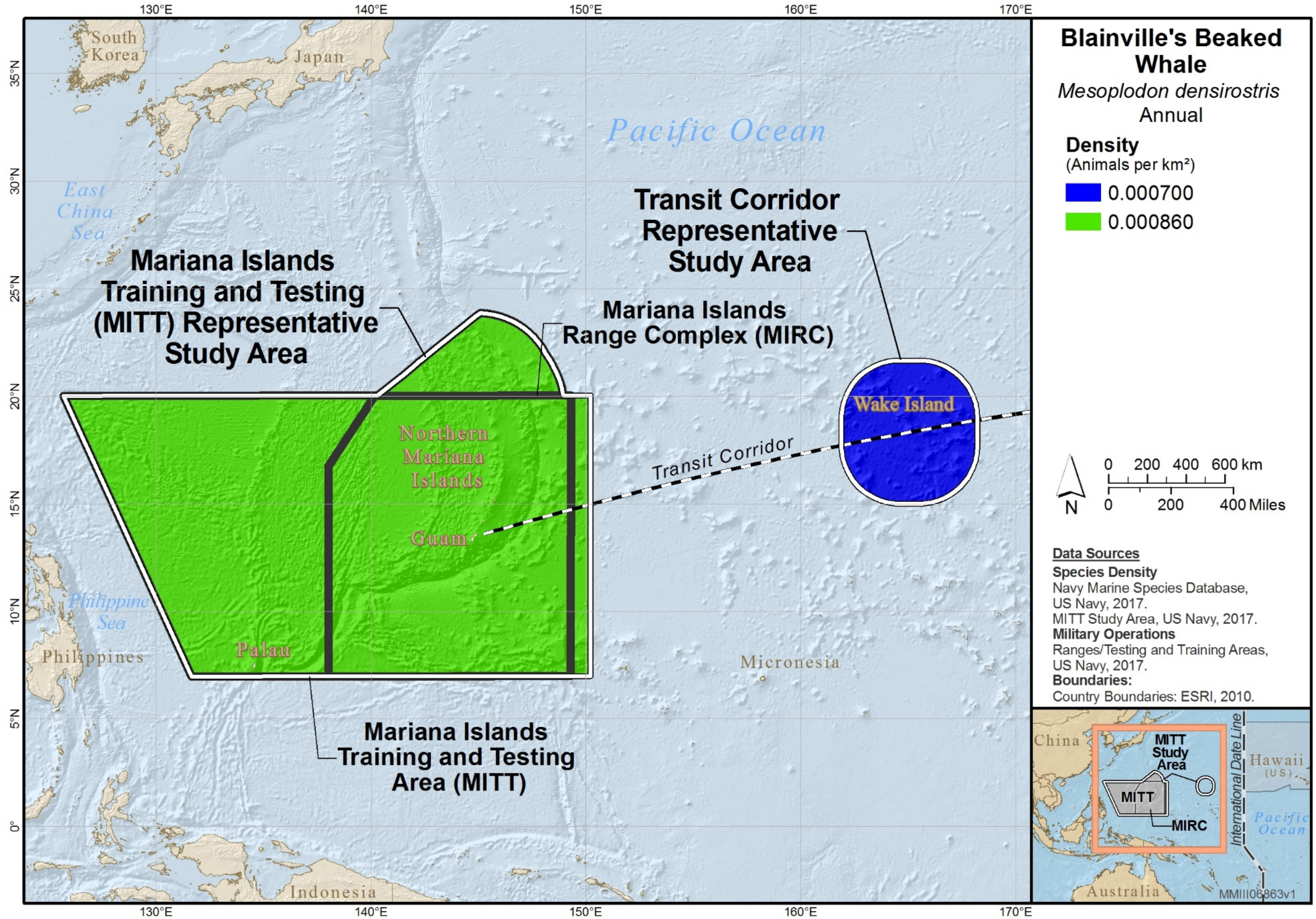


Figure 8.1-2: Annual Distribution of Blainville's Beaked Whale

8.1.3 *MESOPLODON GINKGODENS*, GINKGO-TOOTHED BEAKED WHALE

The ginkgo-toothed beaked whale is known only from strandings and a few unconfirmed sightings in tropical waters of the Pacific and Indian Oceans (Mead, 1989b; Palacios, 1996). Due to the similarities between the species, the ginkgo-toothed beaked whale may be virtually indistinguishable at sea from some other *Mesoplodon* species. The newly recognized Deraniyagla's beaked whale (*M. hotaula*) is very similar in external appearance and skull morphology to *M. ginkgodens*, and the two species would likely require detailed examination of the cleaned skull, or molecular analyses, to distinguish them (see Dalebout et al., 2014). *Mesoplodon hotaula* appears to be a more tropical species than *M. ginkgodens*, but the actual ranges of both species are not well known, and may in fact overlap. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another, the ginkgo-toothed beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al., 2010). Little is known of the stock structure of ginkgo-toothed beaked whales in the MITT Study Area.

MITT. There were two *Mesoplodon* whale sightings during the Navy's 2007 survey of the Study Area, but they were not identified to the species level (Fulling et al., 2011). Because ginkgo-toothed beaked whale densities are poorly characterized throughout the oceans, estimated values from *Mesoplodon* sp. for other areas were used as a basis for calculating densities in MITT. In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate of 0.00189 animals/km^2 derived for Hawaiian waters for unidentified *Mesoplodon* (Bradford et al., 2017) was used to represent the best available estimate for ginkgo-toothed beaked whale in the MITT Study Area and associated transit corridor. Since sighting data are not available to prorate by species, the density estimate for unidentified sightings of all *Mesoplodon* species was used to represent ginkgo-toothed whale density.

Table 8-3: Summary of Density Values for Ginkgo-Toothed Beaked Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00189	0.00189	0.00189	0.00189
MITT Transit Corridor	0.00189	0.00189	0.00189	0.00189

Note: The units for numerical values are animals/km^2.

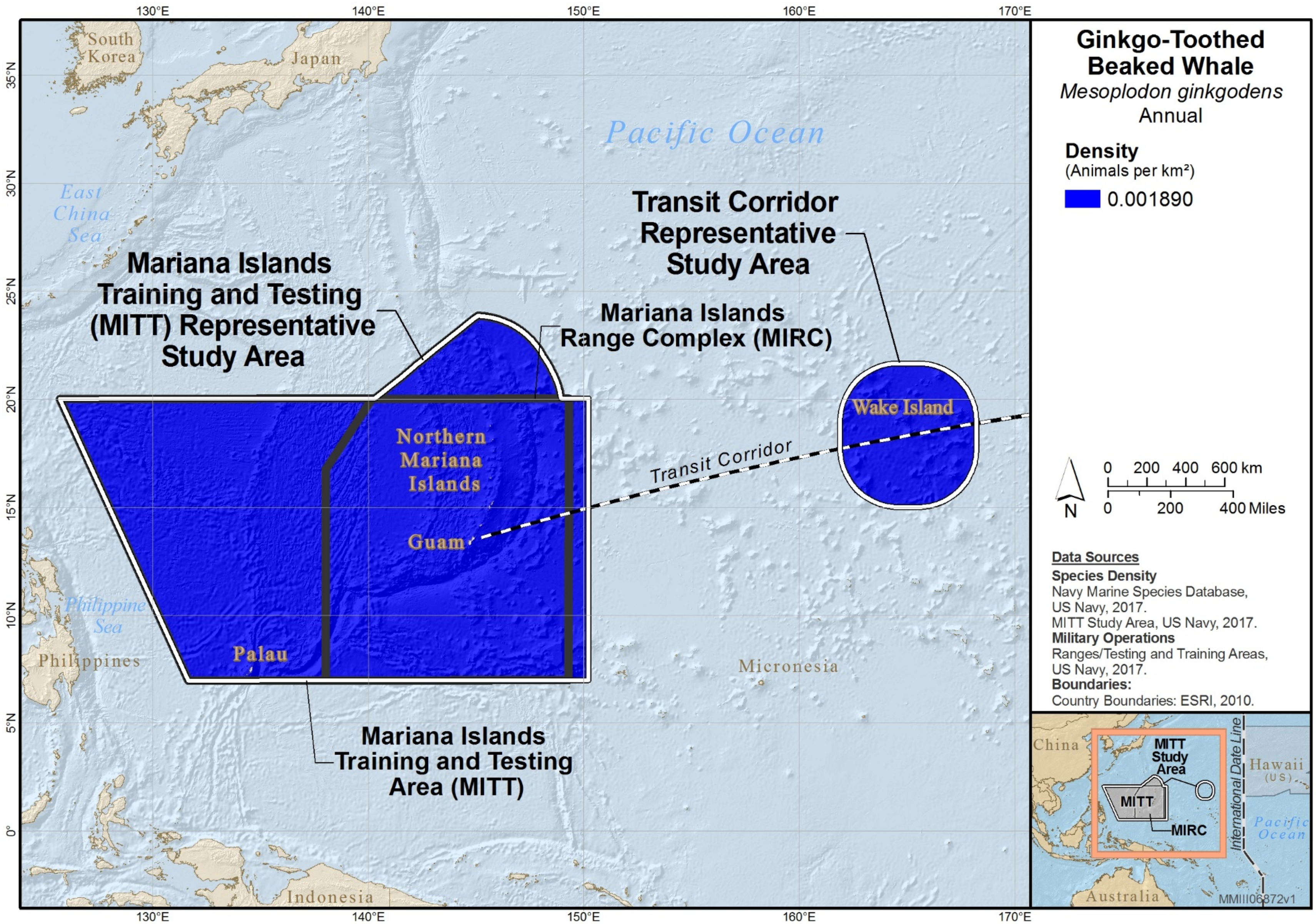


Figure 8.1-3: Annual Distribution of Gingko-Toothed Beaked Whale

8.1.4 *ZIPHIUS CAVIROSTRIS*, CUVIER'S BEAKED WHALE

This beaked whale is the most cosmopolitan of the beaked whales with a presence in all oceans except the polar seas (Heyning, 1989). Cuvier's beaked whale is a "robust" version of the typical beaked whale form (Jefferson et al., 2015; Leatherwood et al., 1988). Like other beaked whales, their dorsal fin is small, falcate, and sits two-thirds of the way back on the length of the body. They have a stubby beak and a gently sloped to bulbous head which is pronounced in adult males (Jefferson et al., 2015; Leatherwood et al., 1988). Their jaw line only curves gently and is upturned at the gape (Jefferson et al., 2015). The color can be slate gray to brown and is lighter or white around the head and on the back anterior to the blowhole, especially so in adult males, which may appear completely white around the head and anterior body. Their blow is diffuse and angled forward and they actively avoid boats, so they can be quite difficult to observe at sea, except in calm sea states (Heyning & Mead, 2008; Jefferson et al., 2015). When observed they can be mistaken for other beaked whales, but the robustness of the body and fact that they have one of the shortest beaks of any beaked whale makes them reasonably distinguishable (Jefferson et al., 2015; Leatherwood et al., 1988). Their body color, particularly their head, is lighter than most other cetaceans, making them easier to identify than other beaked whales (Leatherwood et al., 1988). Cuvier's beaked whale is also one of the most active of the beaked whales when at the surface (Leatherwood et al., 1988).

There are three stocks of Cuvier's beaked whale recognized by NMFS: an Alaska stock, a California/Oregon/Washington stock, and a Hawaii stock (Carretta et al., 2017). Little is known about the stock structure of Cuvier's beaked whale in the MITT Study Area.

MITT. During marine mammal monitoring for Valiant Shield 07, a single Cuvier's beaked whale was observed about 65 NM south of Guam at the edge of the Mariana Trench (Mobley, 2007). This species was also heard and positively sighted near Pagan, in the Commonwealth of the Northern Mariana Islands, during a 2013 marine mammal survey of the coastal waters of that island (U.S. Department of the Navy, 2014b). One ziphiid whale was observed in deep water during the Navy's 2007 survey of the Study Area, but was not identified to the species level (Fulling et al., 2011). In the absence of study-area-specific density data, and consistent with recommendations from scientists at PIFSC, the line-transect estimate of 0.00030 animals/km^2 derived for Hawaiian waters (Bradford et al., 2017) was used to represent the best available estimate for the MITT Study Area. The density estimate of 0.00374 animals/km^2 from LGL Limited (2011, see Section 3.2) was used for the MITT transit corridor. These data sources were used to characterize annual Cuvier's beaked whale density.

Table 8-4: Summary of Density Values for Cuvier's Beaked Whale

Location	Spring	Summer	Fall	Winter
MITT	0.00030	0.00030	0.00030	0.00030
MITT Transit Corridor	0.00374	0.00374	0.00374	0.00374

Note: The units for numerical values are animals/km^2.

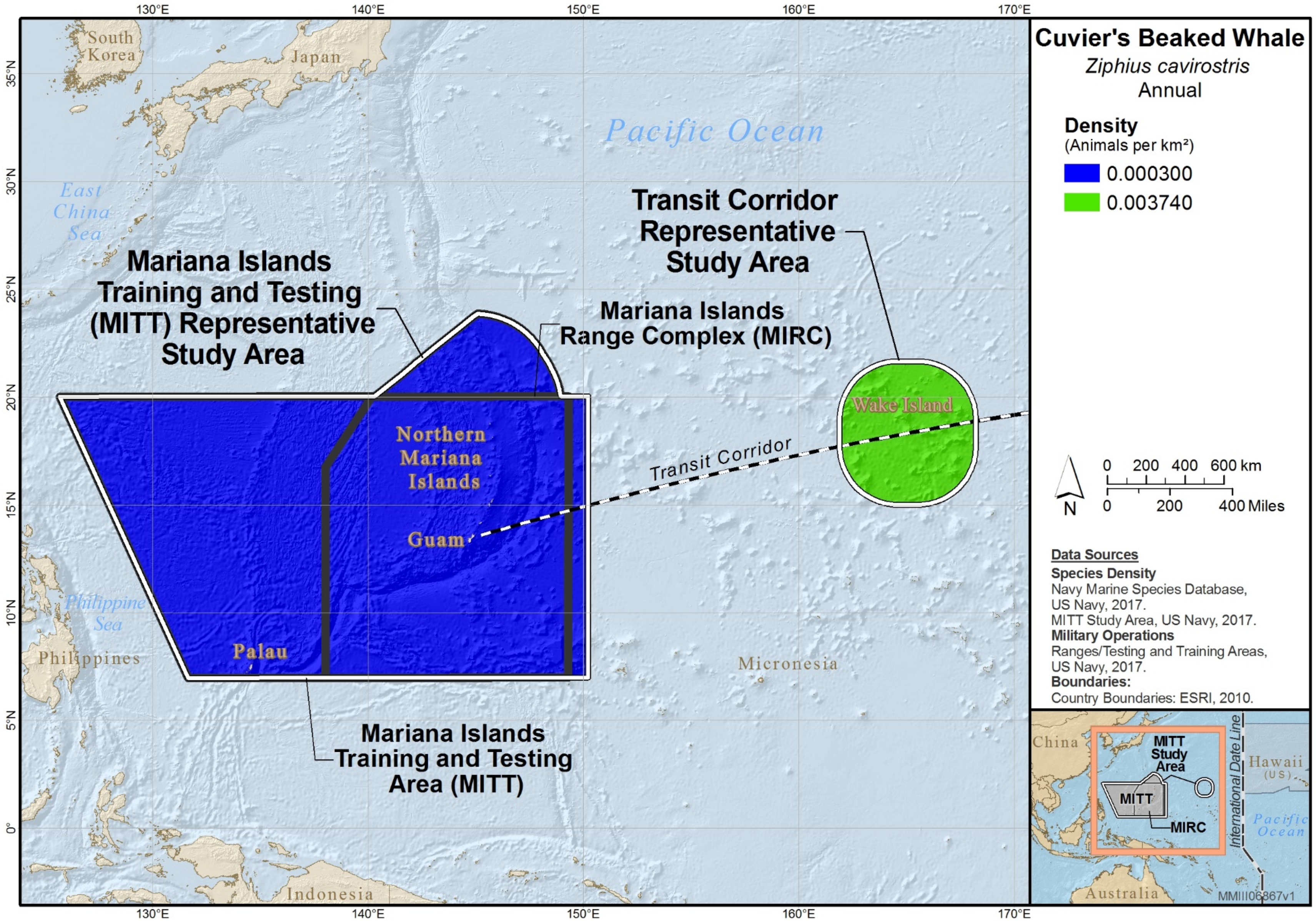


Figure 8.1-4: Annual Distribution of Cuvier's Beaked Whale

9 SEA TURTLES

9.1 SEA TURTLE SPECIES PROFILES

Sea turtles are a group of marine reptiles whose species are either threatened or endangered (Lutz & Musick, 1997; National Marine Fisheries Service, 2018; Spotila, 2004). There is limited data on the in-water occurrence of sea turtles. Although tagging studies of individual turtles have been performed (Blumenthal et al., 2009; Eguchi et al., 2010; Gaos & Yañez, 2008; Gaos et al., 2011; Jones & Van Houtan, 2014; Jones et al., 2015; Jones & Martin, 2016; Martin et al., 2018; Shillinger et al., 2008; Whiting & Miller, 1998; Witt et al., 2010) the majority of the information on species' abundance and distribution is based on data gathered from nesting beaches. Many of those studies estimate sea turtle abundance by counting nesting individuals or the number of eggs in nests (Cheng et al., 2008; Hitipeuw et al., 2007; Honarvar et al., 2008; Lopez-Castro et al., 2004; Patino-Martinez et al., 2008). In partnership with the Navy, the PIFSC has been conducting visual surveys and passive acoustic monitoring for cetaceans in the waters surrounding Guam and the CNMI as part of an ongoing effort to develop a record of cetacean occurrence in the region. In addition to cetacean sightings, observers have been recording the occurrences and locations of sea turtles sighted during the surveys (Hill et al., 2011; Hill et al., 2013; Hill et al., 2014; Hill et al., 2015; Hill et al., 2016; Hill et al., 2017a).

In 2013, in-water surveys for sea turtles were conducted in nearshore waters around the islands of Tinian and Pagan in the Mariana Islands (U.S. Department of the Navy, 2014a), and a summary of 32 years of in-water aerial surveys around Guam were compiled by Martin et al. (2016). Summers et al. (2017) assessed population demographics and habitat use of green and hawksbill turtles off Tinian, Saipan, and Rota using a mark-recapture study. They captured 493 green and 36 hawksbill turtles between August 2006 and February 2014 and noted long-term residency and high site fidelity among both species. Estimates from data on bycatch also contribute to a better understanding of species' at-sea occurrence (Bartol & Ketten, 2006; Donoso & Dutton, 2010). Sea turtle densities in the MITT Study Area are derived from scientific literature and the Navy monitoring and surveying efforts.

The two sea turtle species most commonly found in the MITT Study Area are green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles. Records indicate that loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles also pass through the MITT Study Area during migration, and the Navy has included density estimates in the NMSDD to account for their occasional presence. The occurrence of the olive ridley turtle (*Lepidochelys olivacea*) is rare throughout the year in all waters surrounding Guam and the Commonwealth of the Northern Mariana Islands, so the degree of their presence cannot be estimated at this time.

9.1.1 *CHELONIA MYDAS*, GREEN SEA TURTLE

Green turtles are found in all of the world's oceans, but primarily in the tropics (Ernst et al., 1994). In April 2016, NMFS and the U.S. Fish and Wildlife Service identified 11 DPSs for green sea turtles worldwide (81 Federal Register 20057). Three DPSs are listed as endangered under the ESA and the remaining eight are listed as threatened. Green sea turtles occurring in the Study Area would most likely be from either the threatened East Indian – West Pacific DPS or the endangered Central West Pacific DPS. Green turtles are by far the most abundant sea turtle found throughout the Marianas archipelago.

Green turtles are expected to occur year-round in all shelf waters of the MITT Study Area from FDM to Guam and likely occur off other islands in the CNMI as well. Juvenile and adult green turtles spend a great deal of their time resting and foraging in relatively shallow (< 100 m) nearshore waters (e.g., near fringing reefs and reef flats) (Blumenthal et al., 2010; Brill et al., 1995; Hazel et al., 2009), but they also migrate through deeper waters between island groups (Craig et al., 2004; Rice & Balazs, 2008).

Guam. Aerial surveys conducted by the Guam Division of Aquatic and Wildlife Resources indicated the year-round presence of a resident population in Guam's nearshore waters (Kolinski et al., 2001; National Marine Fisheries Service & U. S. Fish and Wildlife Service, 1998; Pultz et al., 1999). Martin et al. (2016) summarized the results of five decades of marine surveys around Guam, which included over 10,000 sea turtle sightings, and further documented the longtime presences of sea turtles, particularly green and hawksbill sea turtles, around Guam. The researchers divided the Guam coastline into 12 geographic survey zones extending from shore to the outer reef and calculated densities within each zone. Sightings have increased steadily since 2000, and based on data from 2008 through 2012 (the most recent five years for which data are available), the highest average sea turtles densities were found off the southern and northeastern coasts (Zones 8, 9, and 12 in Martin et al. (2016)). These areas are characterized by low human density, reefs with coral cover, and either seagrass beds or a Marine Protected Area (or both).

Two data sources were used to estimate sea turtle densities in Apra Harbor and the coastal waters surrounding Guam. Densities in Apra Harbor were based on Navy in-water surveys conducted from 1999 through 2010. Densities for nearshore waters (< 100 m depth) surrounding Guam (excluding Apra Harbor) were based on Martin et al. (2016). Densities reported by Martin et al. (2016) for nearshore waters ranged from 0.03 animals/km^2 on the west side of the island to 2.08 animals/km^2 off the south coast. The average over all 12 geographic zones was 0.54 animals/km^2.

The Apra Harbor survey data and the densities reported in Martin et al. (2016) did not distinguish between turtle species (i.e., green and hawksbill). Martin et al. (2016) suggested a ratio of 85 percent green sea turtles to 15 percent hawksbill sea turtles as a reasonable approximation for estimating species specific densities. This ratio was applied to all data in Apra Harbor and in nearshore waters surrounding Guam.

Commonwealth of the Northern Mariana Islands. In July of 2013, the U.S. Marine Corps sponsored surveys along the coastlines of Tinian and Pagan using three different survey methods: tow-board transects, cliff-line surveys, and scuba and snorkeling surveys (U.S. Department of the Navy, 2014a). However, in most cases only one or two methods were used at each location around the islands, and each method had its limitations. The two in-water survey methods almost certainly missed turtles due primarily to the limited, downward-focused field of view, and cliff-line observations likely double-counted some turtles, particularly when many turtles were observed at the same time. The report provided separate density estimates for each island and for each method. For the NMSDD, density values from all three survey methods were averaged, and two separate densities, one for Tinian and one for Pagan, were calculated for nearshore waters around the islands. On Tinian, 94 percent of observed sea turtles were identified as green sea turtles, and the remaining 6 percent were identified as hawksbills (U.S. Department of the Navy, 2014a). On Pagan, the ratio of green to hawksbill sea turtles was estimated to be 64 percent greens to 34 percent hawksbills. The authors noted that this relatively high percentage of hawksbill sea turtles in the waters around Pagan is unique for the CNMI. Hawksbill sea turtles are rarely recorded in the Southern Arc Islands. No similar surveys off Rota, Saipan, or other islands in the CNMI have been conducted. However, the Navy conducts regular surveys off these islands and sea turtles, primarily green and a few hawksbill, are often observed (Hill et al., 2011; Hill et al., 2013; Hill et al., 2014; Hill et al., 2015; Hill et al., 2016; Hill et al., 2017a). In addition, in-depth surveys of nesting beaches on Saipan, as well as rapid surveys of beaches on Tinian and Rota, provided the first comprehensive assessment of the nesting population of green sea turtles in the CNMI (Summers et al., 2018). Over the 11 year survey period, researchers observed 117 nesting turtles on the three islands combined and, on Saipan, the population growth rate is estimated to be between 11.4 and 7.4 percent, with the variability dependent on the extent of illegal poaching.

To represent the occurrence of sea turtles in other nearshore habitats in the CNMI, the densities from U.S. Department of the Navy (2014a) and Martin et al. (2016) were extrapolated to the remaining islands. The density calculated for Tinian was used as a surrogate density for nearshore waters surrounding Rota, because the two islands have similar levels of development and anthropogenic influences, factors which correlated with sea turtle occurrence (Martin et al., 2016). The median of the densities from the 12 geographic zones used by Martin et al. (2016) was used as a surrogate density for nearshore waters surrounding Saipan, because Guam and Saipan have similar levels of development and anthropogenic influences. The median of the 12 densities was used instead of the average, because the very high density in Zone 8 around Guam, relative to densities in other zones, would have skewed the average. For all other nearshore (< 100 m) waters in the CNMI, a single density value was calculated by averaging the Pagan and Tinian nearshore densities.

Offshore. Beyond the outer reef and in water depths greater than 100 m, green sea turtle occurrence is expected to be lower. Nesting females and early juveniles are known to move through deeper marine waters between islands in the Marianas archipelago during their reproductive and developmental migrations (Kolinski et al., 2006), but likely not in large numbers.

Table 9-1: Summary of Density Values for Green Sea Turtle in the Study Area

Location	Density (Animals/km^2)			
	Spring	Summer	Fall	Winter
Apra North	0	0	0	0
Apra South	8.7483	12.5341	12.5341	8.7483
Apra Gab Gab	25.9168	24.5057	24.5057	25.9168
Apra Glass Breakwater	0	8.4255	8.4255	0
Apra Inner	0	0	0	0
Apra Kilo	9.7966	31.8549	31.8549	9.7966
Apra Orote	4.3389	5.2032	5.2032	4.3389
Apra Sumay East	2.5962	0	0	2.5962
Guam Nearshore Zone 1	0.17	0.17	0.17	0.17
Guam Nearshore Zone 2	0.153	0.153	0.153	0.153

Location	Density (Animals/km^2)			
	Spring	Summer	Fall	Winter
Guam Nearshore Zone 3	0.0255	0.0255	0.0255	0.0255
Guam Nearshore Zone 4	0.0595	0.0595	0.0595	0.0595
Guam Nearshore Zone 5	0.068	0.068	0.068	0.068
Guam Nearshore Zone 6	0.1445	0.1445	0.1445	0.1445
Guam Nearshore Zone 7	0.1955	0.1955	0.1955	0.1955
Guam Nearshore Zone 8	1.768	1.768	1.768	1.768
Guam Nearshore Zone 9	0.2805	0.2805	0.2805	0.2805
Guam Nearshore Zone 10	0.204	0.204	0.204	0.204
Guam Nearshore Zone 11	0.102	0.102	0.102	0.102
Guam Nearshore Zone 12	0.3145	0.3145	0.3145	0.3145
Tinian Nearshore	92.4921	92.4921	92.4921	92.4921
Pagan Nearshore	39.3113	39.3113	39.3113	39.3113
Rota Nearshore	92.4921	92.4921	92.4921	92.4921
Saipan Nearshore	0.1615	0.1615	0.1615	0.1615
All Other Nearshore Areas	65.9017	65.9017	65.9017	65.9017
MITT (Offshore and Transit Corridor)	0.00039	0.00039	0.00039	0.00039

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

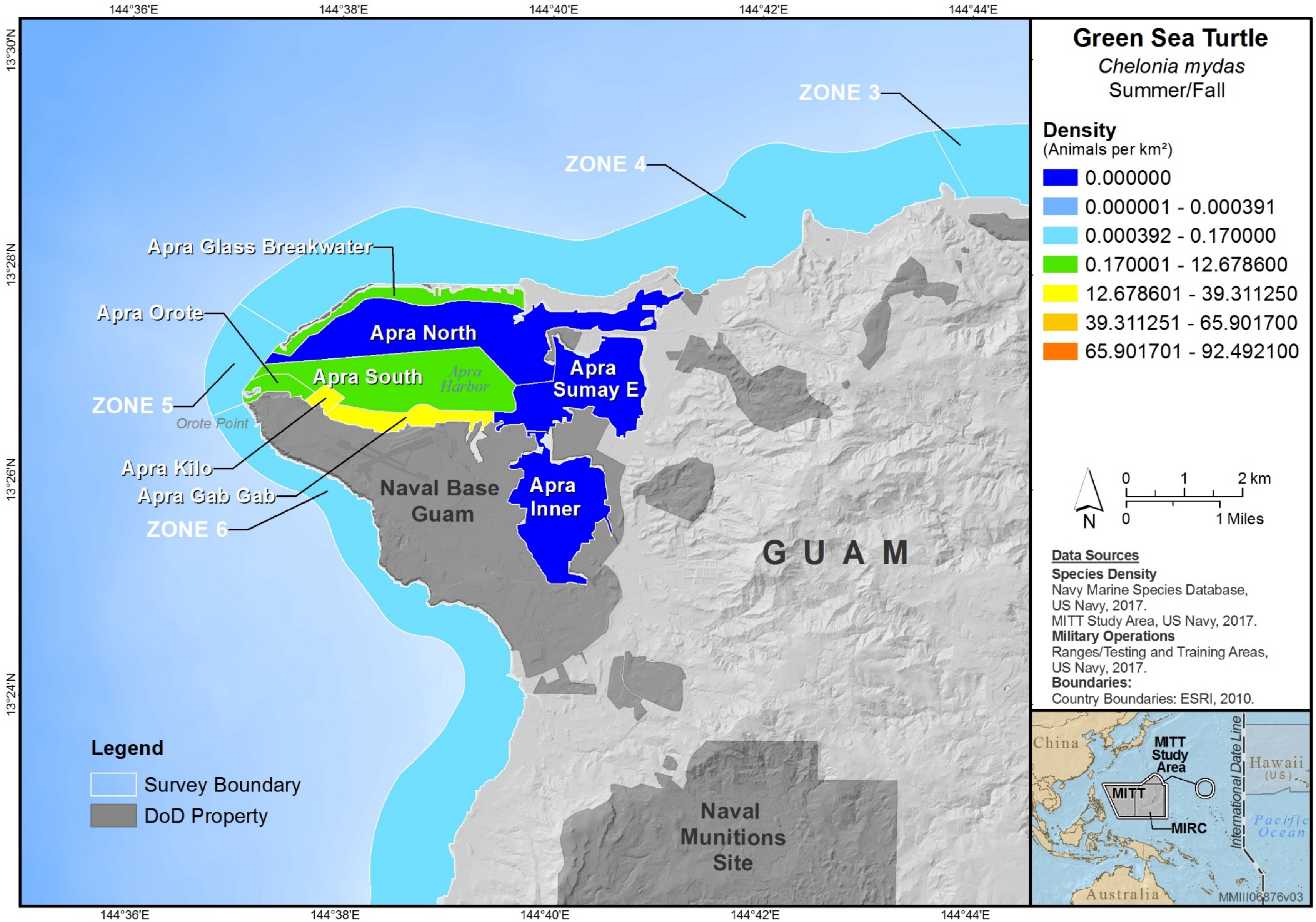


Figure 9.1-1: Apra Harbor Summer/Fall Distribution of Green Sea Turtles

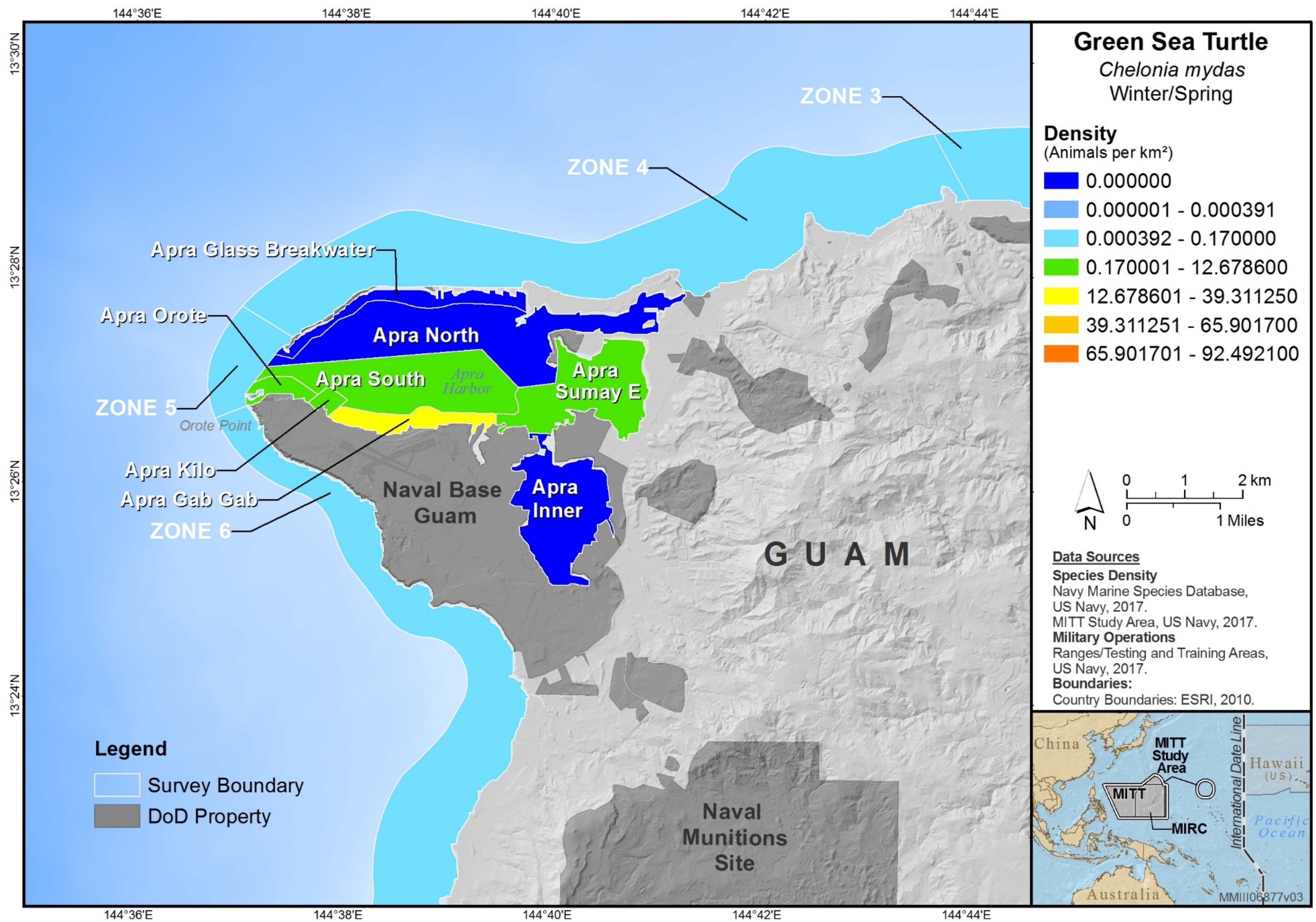


Figure 9.1-2: Apra Harbor Winter/Spring Distribution of Green Sea Turtles

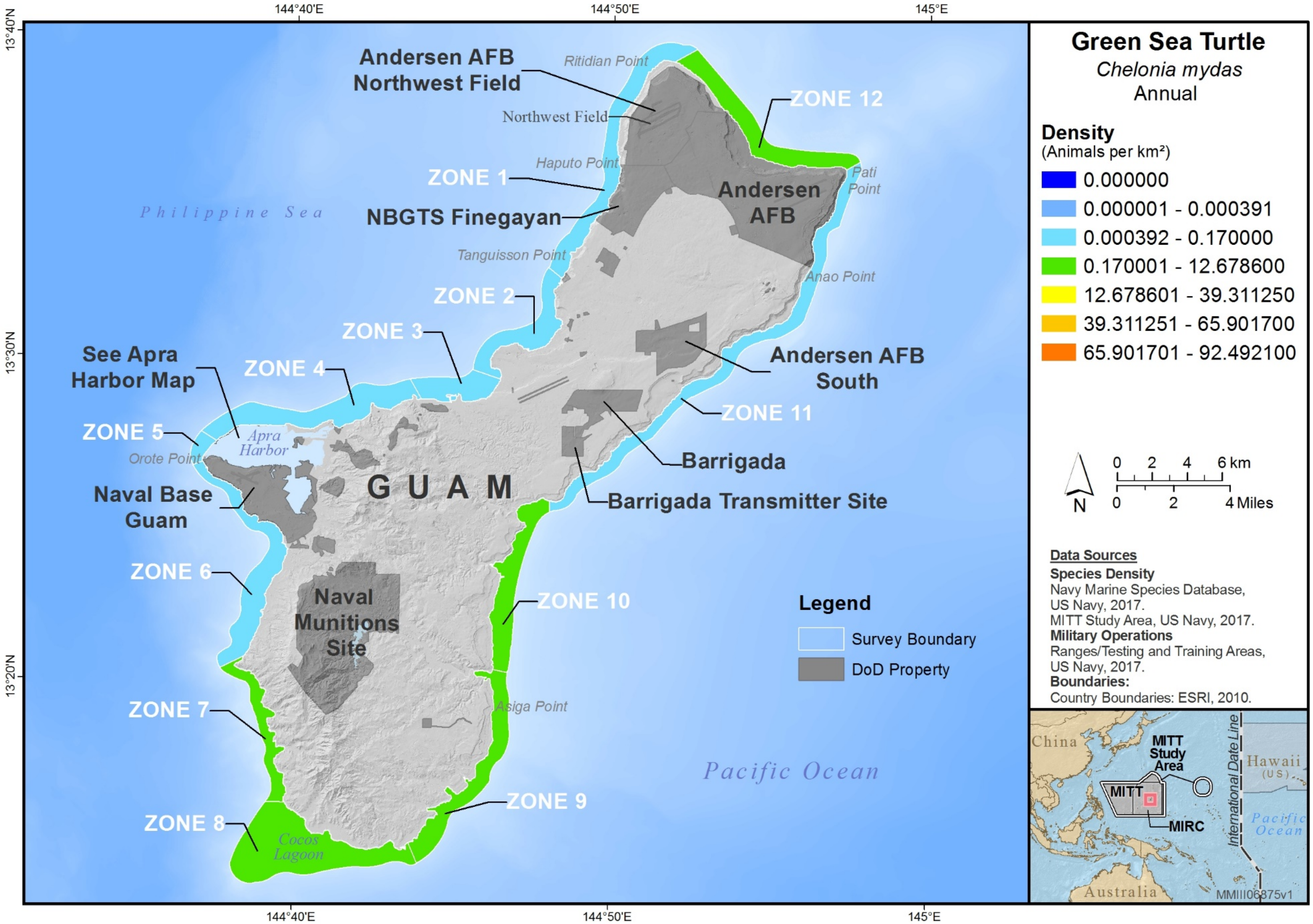


Figure 9.1-3: Annual Distribution of Green Sea Turtles in Nearshore Waters around Guam

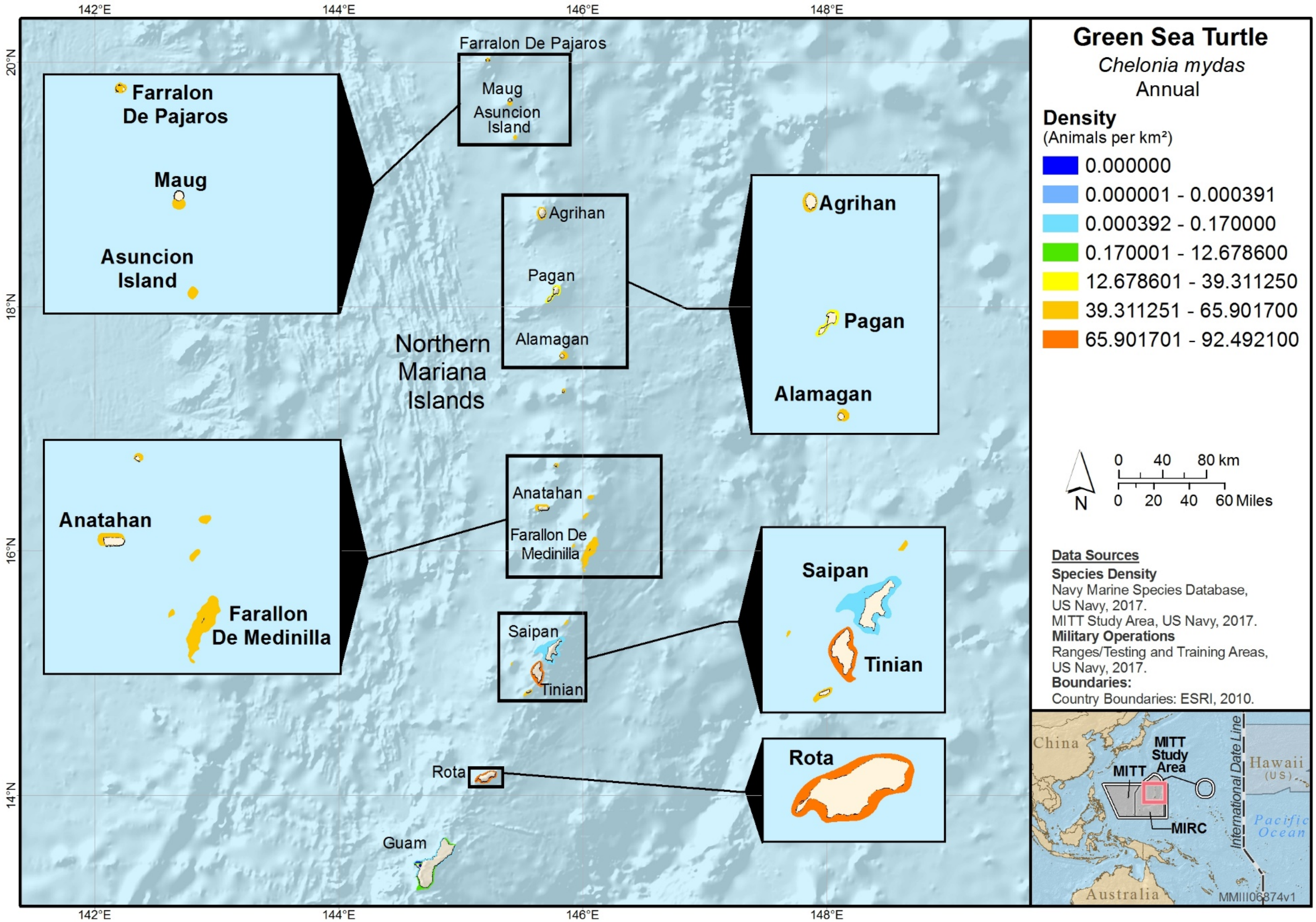


Figure 9.1-4: Annual Distribution of Green Sea Turtles in Nearshore Waters in the CNMI

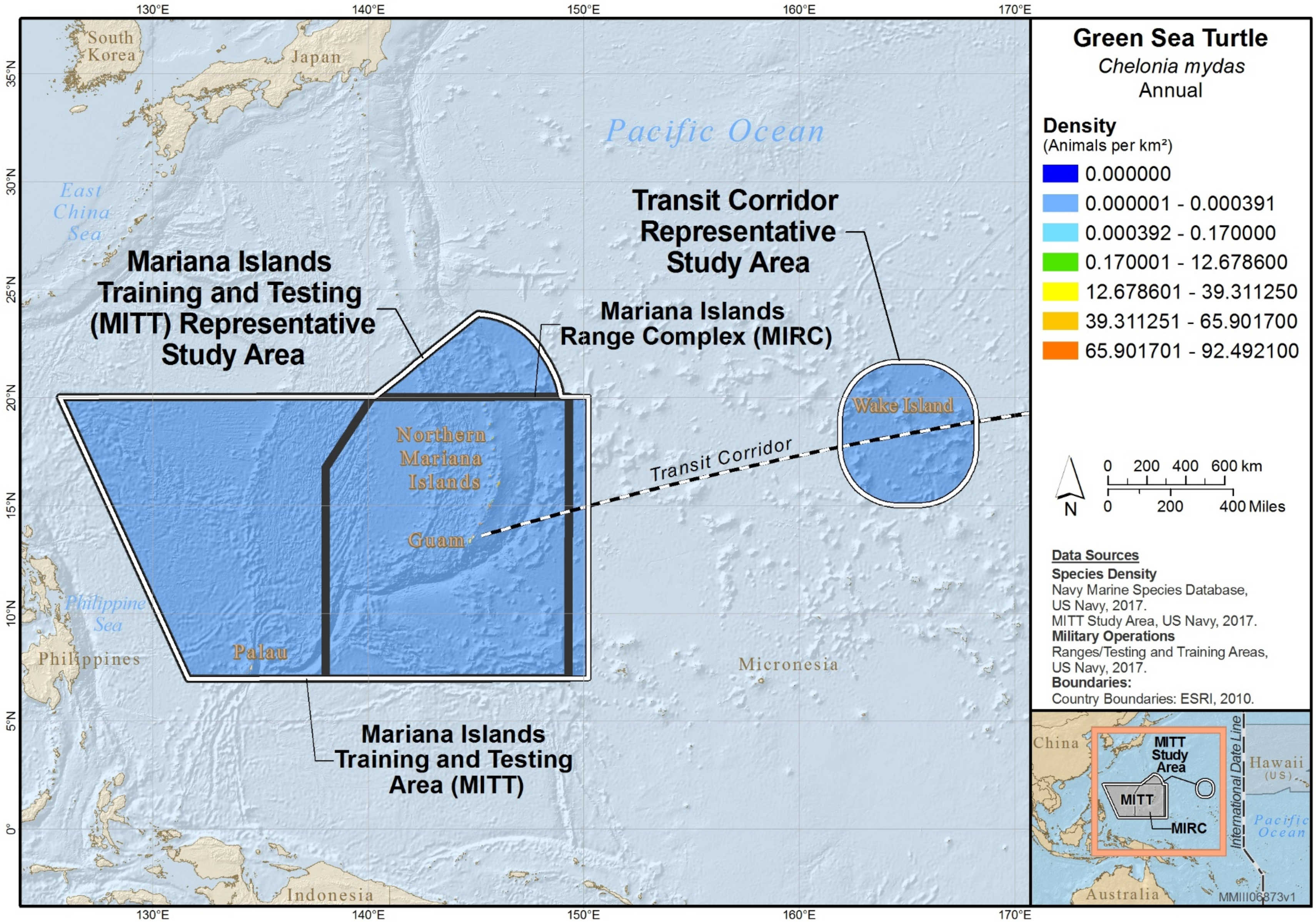


Figure 9.1-5: Annual Distribution of Green Sea Turtles in Offshore Waters of the Study Area

9.1.2 *ERETMOCHELYS IMBRICATA*, HAWKSBILL SEA TURTLE

Hawksbill turtles were one of the first turtles protected under the ESA (Ernst et al., 1994). The hawksbill remains endangered throughout the world and has not shown the same upward population trend seen with green sea turtles. Historical records indicate that hawksbill sea turtles have been present in the coastal waters surrounding islands in the southern Marianas (i.e., from FDM south to Guam), and recent surveys conducted by the Navy and other government organizations confirm that hawksbills occur in nearshore waters off Guam, Tinian, and Pagan and likely occur off other islands in the CNMI as well (Jones & Martin, 2016; Kolinski et al., 2001; Martin et al., 2016; U.S. Department of the Navy, 2014a). As a result, hawksbill turtles are expected to occur in all waters located inside the outer reefs within the Study Area, including within Apra Harbor. Since hawksbill turtles are critically endangered and do not occur in large numbers anywhere within the region, there are no known areas of concentrated occurrence around Guam and the Commonwealth of the Northern Mariana Islands. In deeper waters beyond fringing reefs, the occurrence of hawksbill sea turtles is unknown and expected to be low.

Guam. Prior to the sea turtle sightings reported in Martin et al. (2016); U.S. Department of the Navy (2014a), Navy surveys in Apra Harbor and at four locations off Tinian (Babui, Chulu, Babui-Chulu, and Dankulo), reported 88 sea turtles sighting. Of the 88 sightings, one was reported as possibly being a hawksbill, which represented approximately 1.14 percent of all sightings. Based on this ratio of hawksbill to green sea turtles, the density of hawksbill sea turtles in Apra Harbor was estimated to be 1.14 percent of the densities of green sea turtles in Apra Harbor (i.e., the densities for green sea turtles in Apra Harbor shown in Table 9-1 were multiplied by 0.0114 to estimate the Apra Harbor densities for hawksbill sea turtles shown in Table 9-2).

Martin et al. (2016) estimated that 15 percent of the sea turtles occurring in nearshore waters around Guam are hawksbills (and 85 percent are green sea turtles). Applying this ratio to the data reported in Martin et al. (2016) results in the densities for hawksbill sea turtles in the 12 zones around Guam shown in Table 9-2 (i.e., the densities for green sea turtles in nearshore waters around Guam shown in Table 9-1 were multiplied by 0.15 to estimate the densities for hawksbill sea turtles in nearshore waters around Guam shown in Table 9-2).

CNMI. As discussed above for green sea turtles, on Tinian, 6 percent of observed sea turtles were identified as hawksbill sea turtles, and the remaining 94 percent were identified as greens (U.S. Department of the Navy, 2014a). On Pagan, the ratio of hawksbill to green sea turtles was estimated to be 34 percent hawksbills to 66 percent green sea turtles. The authors noted that this relatively high percentage of hawksbill sea turtles in the waters around Pagan is unique for the CNMI. Hawksbill sea turtles are rarely recorded in the Southern Arc Islands. No similar surveys off Rota, Saipan, or other islands in the CNMI (with the exception of FDM) have been conducted. Densities for nearshore areas around the other islands in the CNMI, including Rota and Saipan, were estimated based on Martin et al. (2016) and U.S. Department of the Navy (2014a) as described above for green sea turtles. Additional Navy surveys in waters surrounding FDM reported low but persistent sightings of hawksbills (Smith & Marx, 2009; Smith et al., 2013), and these data were used to estimate a nearshore density at FDM of 1.0734 turtles per km^2.

Offshore. There are no known nesting beaches for hawksbills in the Study Area, and regional nesters may only number in the hundreds (Gaos et al., 2011; Limpus, 2009). However, telemetry data collected by Miller et al. (1998) indicated that hawksbill sea turtles migrate between Australia and other countries in the region, including Vanuatu, Solomon Islands, Papua New Guinea, and Indonesia. Surveys conducted by Naughton (1991) at Oroluk Atoll recorded hawksbill and green sea turtles with only 6 percent of sightings identified as hawksbills. The density for pelagic green sea turtles was used as a base and multiplied by 0.06 to calculate a density estimate for hawksbill sea turtles.

Table 9-2: Summary of Density Values for Hawksbill Sea Turtle in the Study Area

Location	Density (Animals/km^2)			
	Spring	Summer	Fall	Winter
Apra North	0	0	0	0
Apra South	0.1009	0.1445	0.1445	0.1009
Apra Gab Gab	0.2989	0.2826	0.2826	0.2989
Apra Glass Breakwater	0	0.09716	0.09716	0
Apra Inner	0	0	0	0
Apra Kilo	0.1130	0.3673	0.3673	0.1130
Apra Orote	0.0500	0.0600	0.0600	0.0500
Apra Sumay East	0.0299	0	0	0.0299
Guam Nearshore Zone 1	0.03	0.03	0.03	0.03
Guam Nearshore Zone 2	0.027	0.027	0.027	0.027
Guam Nearshore Zone 3	0.0045	0.0045	0.0045	0.0045
Guam Nearshore Zone 4	0.0105	0.0105	0.0105	0.0105
Guam Nearshore Zone 5	0.012	0.012	0.012	0.012
Guam Nearshore Zone 6	0.0255	0.0255	0.0255	0.0255
Guam Nearshore Zone 7	0.0345	0.0345	0.0345	0.0345
Guam Nearshore Zone 8	0.312	0.312	0.312	0.312
Guam Nearshore Zone 9	0.0495	0.0495	0.0495	0.0495
Guam Nearshore Zone 10	0.036	0.036	0.036	0.036
Guam Nearshore Zone 11	0.018	0.018	0.018	0.018
Guam Nearshore Zone 12	0.0555	0.0555	0.0555	0.0555
Tinian Nearshore	5.9038	5.9038	5.9038	5.9038
Pagan Nearshore	20.25125	20.2513	20.2513	20.25125
Rota Nearshore	5.9038	5.9038	5.9038	5.9038
Saipan Nearshore	0.0285	0.0285	0.0285	0.0285
Farallon de Medinilla	1.0734	1.0734	1.0734	1.0734
All Other Nearshore Areas	13.0775	13.0775	13.0775	13.0775
MITT (Offshore and Transit Corridor)	0.000024	0.000024	0.000024	0.000024

Notes: The units for numerical values are animals/km^2. 0 = species is not expected to be present.

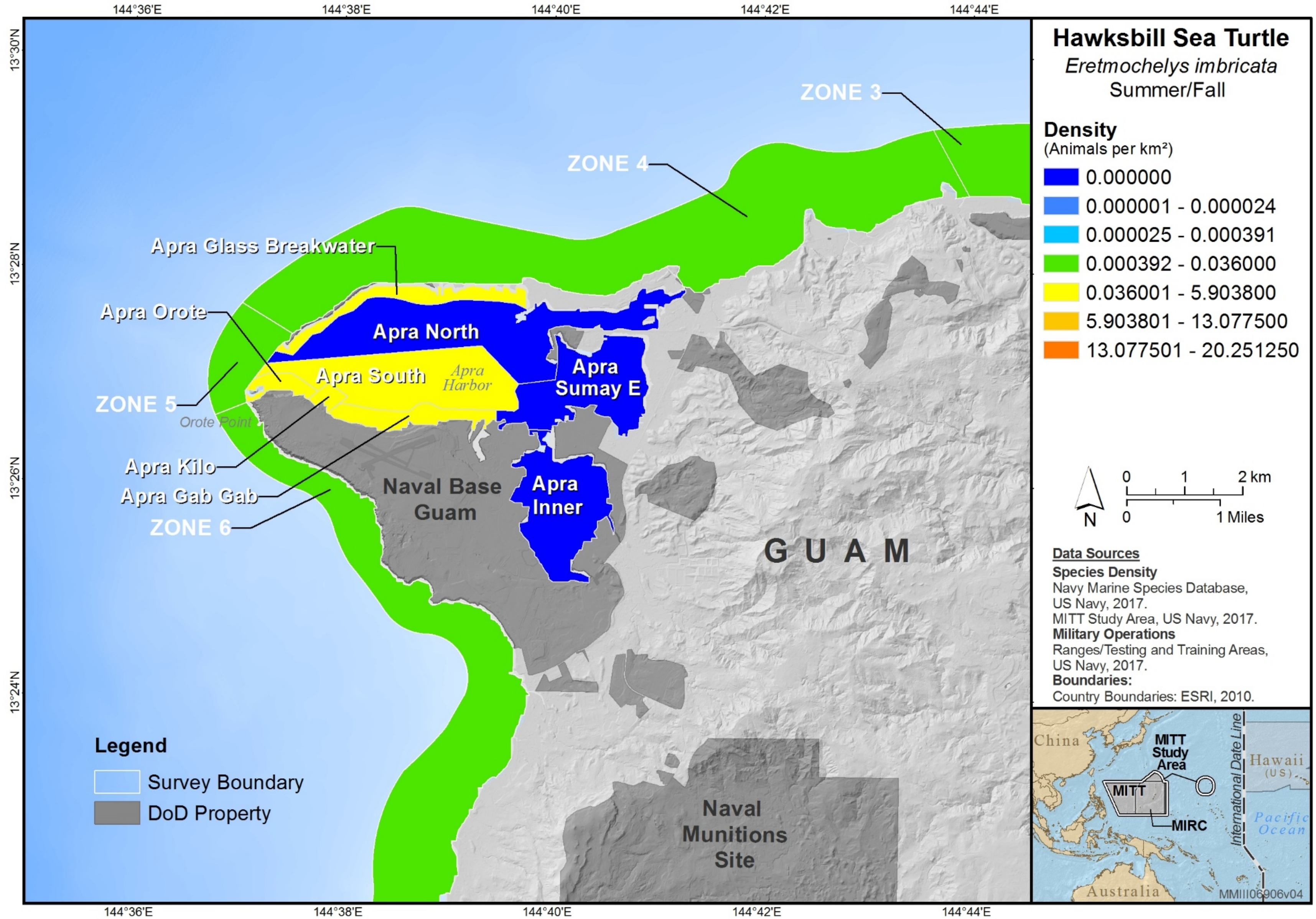


Figure 9.1-6: Apra Harbor Summer/Fall Distribution of Hawksbill Sea Turtles

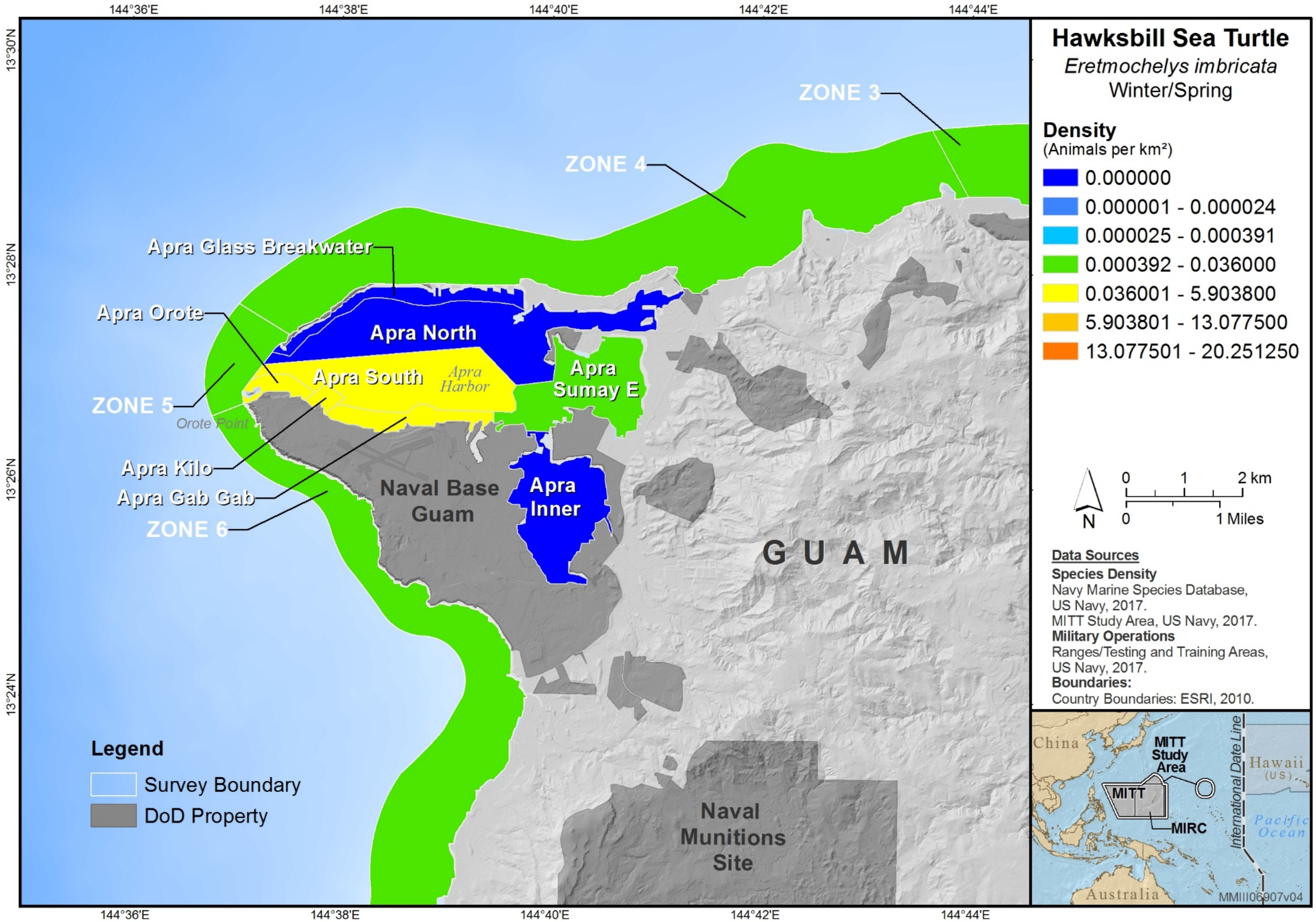


Figure 9.1-7: Apra Harbor Winter/Spring Distribution of Hawksbill Sea Turtles

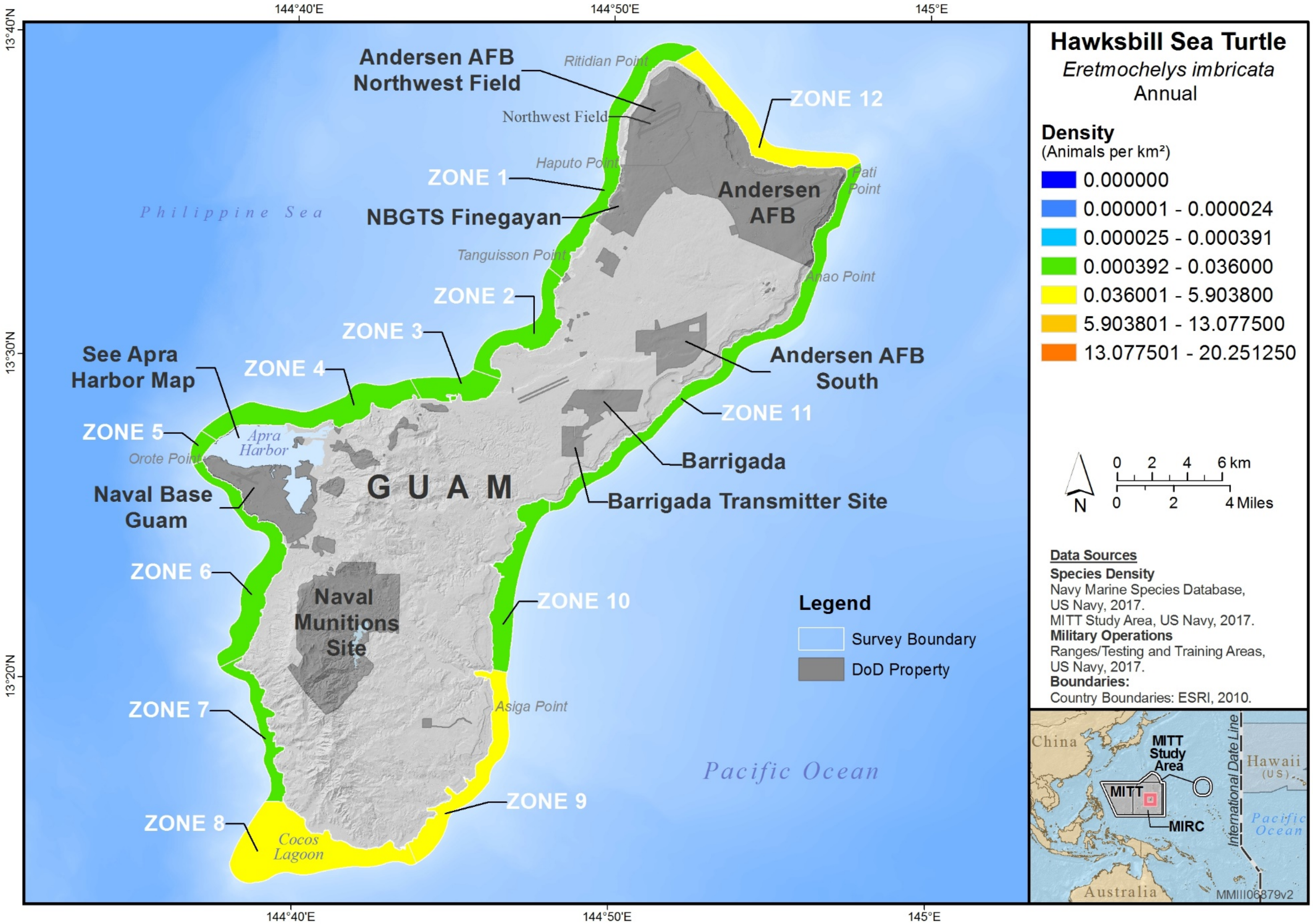


Figure 9.1-8: Annual Distribution of Hawksbill Sea Turtles in Nearshore Waters around Guam

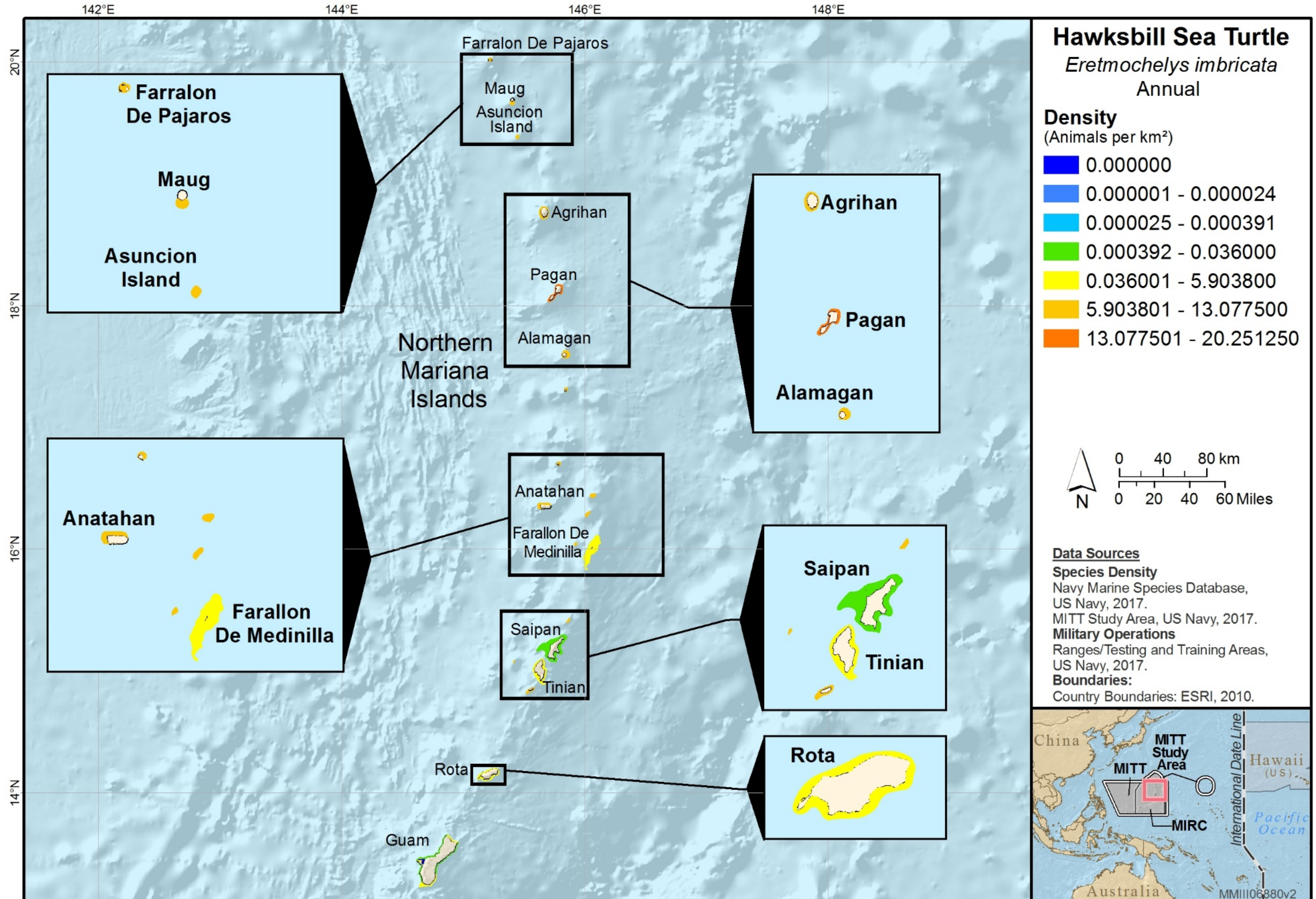


Figure 9.1-9: Annual Distribution of Hawksbill Sea Turtles in Nearshore Waters in the CNMI

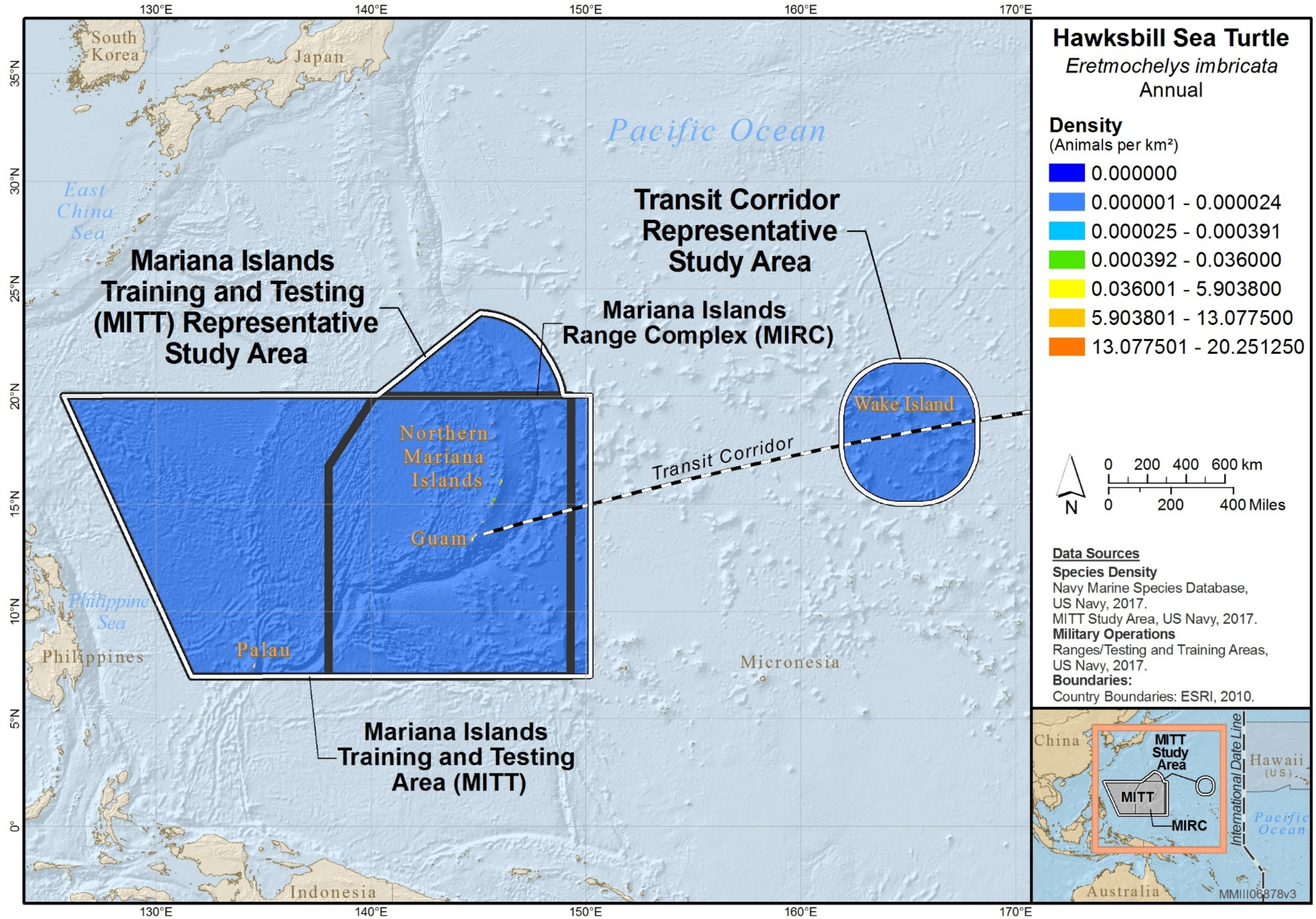


Figure 9.1-10: Annual Distribution of Hawksbill Sea Turtle in Offshore Waters of the Study Area

9.1.3 *CARETTA CARETTA*, LOGGERHEAD SEA TURTLE

The loggerhead sea turtle is found in temperate to tropical regions, generally between 40°N and 40°S in the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2007). Loggerhead sea turtles have adapted to a wide variety of habitats and can be found hundreds of miles offshore, as well as inshore in areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers (Dodd, 1988).

Juvenile loggerhead sea turtles originating from nesting beaches in Japan migrate through the North Pacific Transition Zone on their way to important foraging habitats in Baja California, Mexico (Bowen et al., 1995; Kobayashi et al., 2008). The highest densities of loggerheads can be found in the North Pacific Transition Zone just north of Hawaii (Polovina et al., 2000).

MITT Study Area. There are no sighting, stranding, or nesting records for loggerhead sea turtles around Guam or the CNMI. As a result, loggerhead turtles are considered rare within the Study Area. This species is more apt to be found in temperate waters of the North Pacific Ocean (i.e., north of 25°N) off of Japan, China, Taiwan, Hawaii, northwestern Mexico, and the southwestern U.S. coast (Kobayashi et al., 2008; National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2007; Polovina et al., 2004). However, Guam and the Commonwealth of the Northern Mariana Islands are identified as being within the species' overall range (Kobayashi et al., 2008; National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2007). Also, the westward flowing North Pacific Equatorial Current, which late juvenile stage loggerheads use when returning to the western Pacific, passes through the Marianas region.

For modeling purposes and given a lack of any records of loggerheads in the Study Area, the Navy used the density derived for leatherback sea turtles of 0.000022 animals per km^2 as a proxy for loggerheads in the Study Area (Section 9.1.4). Similar to leatherbacks, telemetry studies show that loggerheads may transit the Study Area; however, the available data indicate that their preferred habitat is in north of the Study Area. While nesting counts outside of the Study do exist, they are not sufficient to estimate an at-sea density for loggerhead sea turtles transiting through the Study Area. The density is applied year round and is intended to represent the occasional occurrence of loggerheads transiting through the Study Area.

Table 9-3: Summary of Density Values for Loggerhead Sea Turtle in the Study Area

Location	Density (Animals/km^2)			
	Spring	Summer	Fall	Winter
Study Area	0.000022	0.000022	0.000022	0.000022

Note: The units for numerical values are animals/km^2.

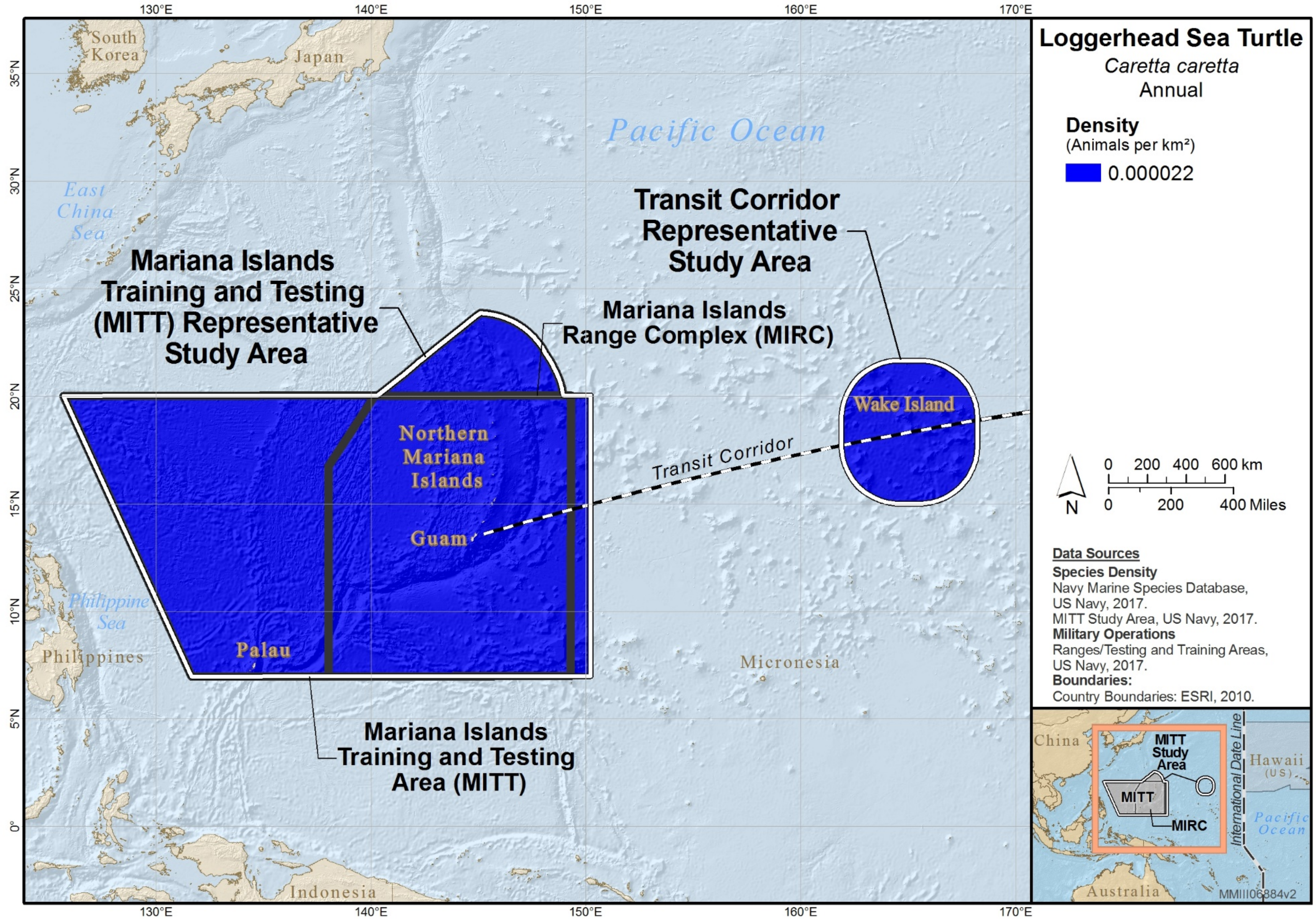


Figure 9.1-11: Annual Distribution of Loggerhead Sea Turtles in the Study Area

9.1.4 *DERMOCHELYS CORIACEA*, LEATHERBACK SEA TURTLE

The leatherback sea turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans (71°N to 47°S) and have the most extensive adult range of any sea turtle. Leatherbacks are known to nest on tropical and occasionally subtropical beaches (Benson et al., 2011; Eckert, 1995; Myers & Hays, 2006; National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1992). Telemetry studies indicate that leatherback sea turtles occur most often between 28 and 44°N and in waters with sea surface temperatures of approximately 15–24°C.

Leatherbacks are the most migratory sea turtle and are able to tolerate colder water temperatures than other sea turtle species. Thermoregulatory adaptations such as a counter-current heat exchange system, high oil content, and large body size allow leatherbacks to maintain a core body temperature higher than that of the surrounding water. (Hughes et al., 1998; James & Mrosovsky, 2004). In a study analyzing the movements of 135 leatherbacks fitted with satellite tracking tags, the turtles were found to inhabit waters with sea surface temperatures ranging from 11.3 to 31.7 degrees Celsius (°C) (mean of 24.7°C) (Bailey et al., 2012). The study also found that oceanographic features such as mesoscale eddies, convergence zones, and areas of upwelling attracted foraging leatherbacks, likely because these features are often associated with aggregations of prey. Benson et al. (2011) analyzed telemetry data from 126 leatherbacks identifying migratory patterns and associations with similar oceanographic features such as current boundaries and stationary fronts. The data recorded year-long, transoceanic migrations from nesting beaches in the western North Pacific to the California Current Ecosystem (waters off the U.S. west coast between the shore and approximately 300 NM offshore) in the eastern North Pacific. Adult leatherback turtles forage in temperate and subpolar regions in all oceans, and migrate to tropical nesting beaches located between 30°N and 20°S. Nesting beaches are widely distributed, but primarily occur on isolated mainland beaches in tropical regions of the Atlantic and Pacific oceans, with fewer in the tropical Indian Ocean.

MITT Study Area. Of the three sea turtle species that have been sighted in waters around Guam and the CNMI during marine surveys, the leatherback turtle is the least common (U.S. Department of the Navy, 2003). This species is occasionally encountered in the deep, pelagic waters of the Marianas archipelago, although only a few occurrences have been recorded (Eckert et al., 1999). Satellite tracking of leatherback sea turtles departing from regional nesting habitats in Malaysia, Indonesia, the Solomon Islands, and the Philippines occasionally show that leatherbacks transit through the Study Area (Benson et al., 2007; Benson et al., 2011). As for nearshore waters, Eldredge (2003) noted a rescue in 1978 of a 250 lb. leatherback from waters southeast of Cocos Island, Guam. From 1987 to 1989, divers reported seeing leatherbacks in the waters off Harnom Point, Rota, and, during aerial surveys from October 1989–April 1991, 2.6% of the sea turtles recorded were leatherbacks (Eldredge, 2003). However, no recent sightings have been reported. Leatherbacks do not nest at any of the islands in Micronesia. As a result, the occurrence of leatherback turtles would be considered rare throughout the year in nearshore waters of the Study Area.

For modeling purposes, the Navy estimated that 6.5 percent of leatherback sea turtles would transit through the Study Area from regional nesting locations. The estimate is based on the tracks of satellite-tagged leatherbacks leaving nesting sites in the western Pacific (Benson et al., 2011). An abundance estimate of 900 females was derived from counts at nesting sites reported by Hitipeuw et al. (2007) and supplemented with an additional 30 percent to account for males transiting through the Study Area (Benson et al., 2011; Curtis et al., 2015). The abundance and density were calculated as:

Abundance = 900 (nesting females) + (900 x 0.30 males) = 1,170 sea turtles

Density = (1,170 sea turtles x 0.065) / 3,456,818 km^2 = 0.000022 sea turtles/km^2

Given a lack of seasonal occurrence data, the density is used as a year-round estimate.

Table 9-4: Summary of Density Values for Leatherback Sea Turtle in the Study Area

Location	Density (Animals/km^2)			
	Spring	Summer	Fall	Winter
Study Area	0.000022	0.000022	0.000022	0.000022

Note: The units for numerical values are animals/km^2.

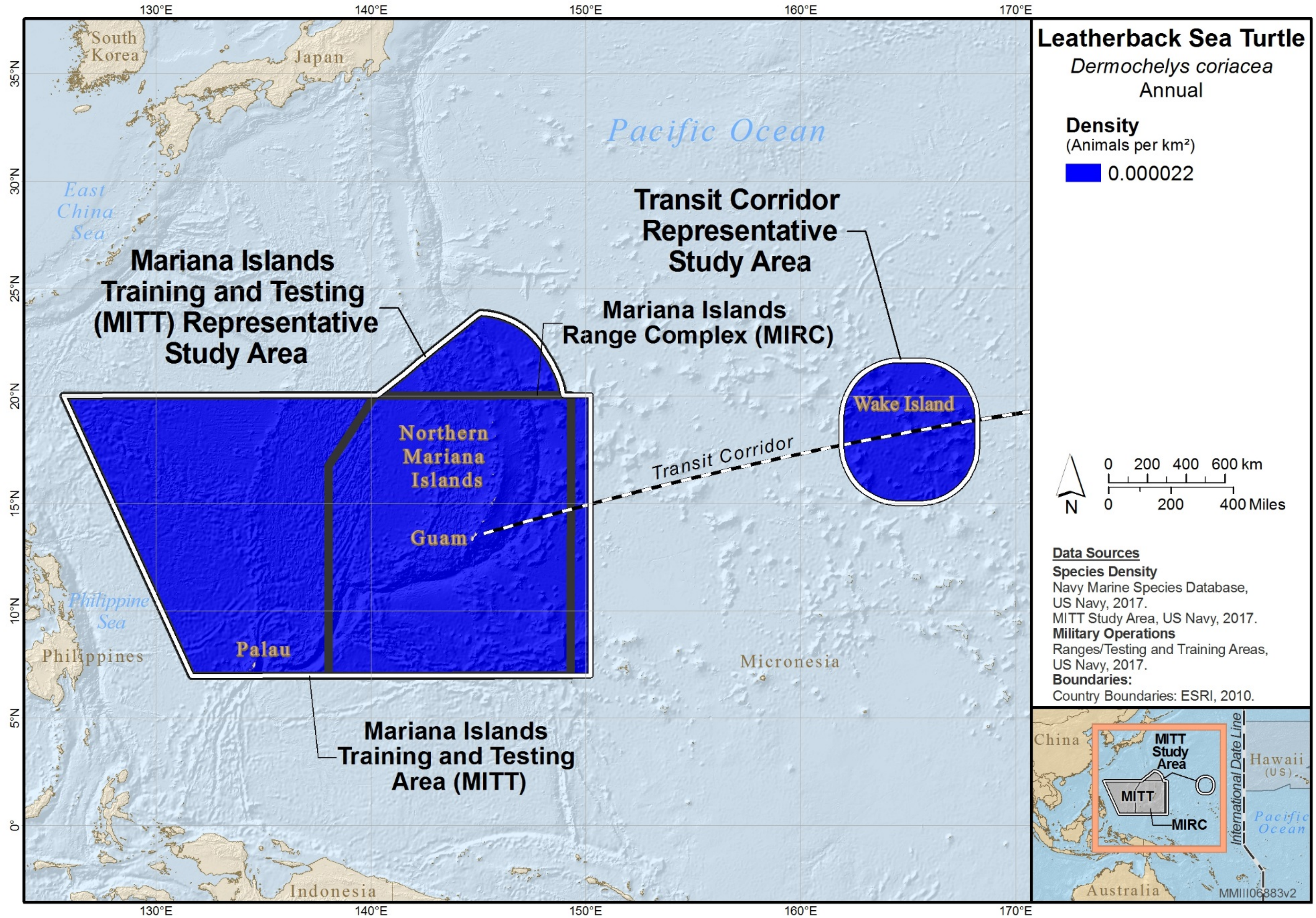


Figure 9.1-12: Annual Distribution of Leatherback Sea Turtle in the Study Area

10 CONCLUSION

The density estimates provided in this report represent an agreed-upon set of values that were used in modeling the effects from Navy Phase III sound sources to marine species. These data have been updated since the Navy's Phase II analyses (U.S. Department of the Navy, 2015), and represent the most current and best available science. However, if better estimates become available, the NMSDD will be updated for use in future Navy modeling efforts. It is an ambitious endeavor to maintain accurate information on all of the marine species in the Navy's OPAREAs, but the partnership and pooling of resources and expertise amongst NMFS, scientific experts, and the Navy is more likely to achieve this goal than any other partnership that has come before.

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APPENDIX A GLOSSARY OF TERMS

Abundance: Total number of individuals in a given area.

Central Pacific (CENPAC) Models: CENPAC habitat-based density models developed by Southwest Fisheries Science Center. The CENPAC models are defined by the Navy as top tier (Level 1) data sources because they estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark-recapture analyses.

Cetacean: A marine mammal included in the taxonomic order Cetacea that includes whales, dolphins, and porpoises.

Coefficient of variation (CV): The CV is a measure used to express uncertainty in published density estimates, and is calculated by dividing the standard error of the estimate by the best available density point estimate (i.e., the ratio of the standard error to the mean). A CV can be expressed as a fraction or a percentage and ranges upward from zero, indicating no uncertainty, to high values. For example, a coefficient of variation of 0.85 would indicate high uncertainty in the population estimate.

Density: The number of animals present per unit area, typically expressed as number of animals per square kilometer.

Designed-based density estimates: A type of estimation that uses line-transect survey data and usually involves distance sampling theory to estimate density for the entire survey extent.

Distance sampling: A widely used technique for estimating the size of a population. Observers travel the length of line transects (or use points) to collect sighting data, with the objective of estimating the average density of objects within a region. In addition to counting occurrences, observers estimate the distance of the object from the path. This results in an estimate of the way in which detectability increases from probability 0 (far from the path) and approaches 1 (near the path). Using the raw count and this probability function, one can arrive at an estimate of the population size (distance sampling theory is described in detail in (Buckland et al., 2001)).

Exclusive Economic Zone (EEZ): The EEZ is a sea zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights regarding the exploration and use of marine resources. The United States EEZ extends no more than 200 nautical miles from the territorial sea baseline and is adjacent to the 12 nautical mile territorial sea of the United States, including the Commonwealth of Puerto Rico, Guam, American Samoa, the U.S. Virgin Islands, the Commonwealth of the Northern Mariana Islands, and any other territory or possession over which the United States exercises sovereignty.

Habitat suitability models: Models that use information on species occurrence and known or inferred habitat associations to predict densities. These models are used typically when survey data are unavailable. (Also known as relative environmental suitability models or habitat suitability index models).

Haulout site: Areas on land or ice used regularly by seals, sea lions, or turtles between periods of foraging activity. Haulout sites are used for mating, giving birth (termed "rookeries"), and rest. Other benefits of hauling-out may include predator avoidance, thermal regulation, social activity, and parasite reduction.

Hierarchy of Density Data Sources for the Hawaii-Southern California Training and Testing Study Area:

The Navy ranked density data sources from most to least preferable, as follows:

- Level 1 (Most Preferred): Peer-reviewed published studies of density spatial models that provide spatially explicit density estimates (i.e., habitat-based density models)
- Level 2: Peer-reviewed published studies of stratified designed-based density estimates (i.e., stratified line-transect density estimates)
- Level 3: Peer-reviewed published studies of designed-based density estimates
- Level 4: St. Andrew's Relative Environmental Stability (RES) Model (Sea Mammal Research Unit, Limited [SMRU Ltd.] 2012), used for species for which density data are completely lacking
- Level 5 (Least Preferred): Kaschner et al. RES Model (Kaschner et al., 2006)

Level 4 and 5 data sources are based on environmental suitability models.

Kaschner et al. (2006) Marine Mammal Density Models: Kaschner et al. (2006) developed relative environmental suitability models to predict the average annual range of a marine mammal species on a global level. Habitat preferences based on sea surface temperature, bathymetry, and distance to nearest land or ice edge were used to characterize species distribution and relative concentration on a global oceanic scale at 0.5° grid cell resolution. Published estimates of global population were then used to transform the relative concentrations to density estimates. One of the disadvantages of these models is that validating the results is difficult because much of the area covered by the models has never been surveyed. This is the least preferred (Level 5) source of density data.

Line-transect: A path along which one counts and records occurrences of a target species. In a line-transect survey, the observers count occurrences as well as estimate the distance of the object from the path (see distance sampling).

Marine mammal stock: The Marine Mammal Protection Act (MMPA) defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." For management purposes under the MMPA, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area.

Mark-recapture: A method commonly used to estimate the size of a population. Typically, a portion of the population is captured, marked, and released. Later, another portion is captured and the number of marked individuals within the sample is counted. Since the number of marked individuals within the second sample should be proportional to the number of marked individuals in the whole population, an estimate of the total population size can be obtained. Mark-recapture techniques for cetaceans use photographs to "capture" a proportion of the population, and distinctive physical features (e.g., humpback flukes) are used as the "marks" for comparison to subsequent photographs.

Mysticete: A whale of the suborder Mysticeti ("baleen whales"), characterized by a symmetrical skull, paired blowholes, and rows of baleen plates for feeding on zooplankton.

NMFS SWFSC Habitat-Based Density Models: Spatially explicit models that estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark-recapture analyses (see CENPAC Models).

Odontocete: A whale or dolphin in the suborder Odontoceti ("toothed whales"), characterized by an asymmetrical skull, a single blowhole, and rows of teeth, feeding primarily on fish, squid, and crustaceans.

Pinniped: A marine mammal included in the taxonomic order Carnivora that includes the extant families Odobenidae (whose only living member is the walrus), Otariidae (the eared seals: sea lions and fur seals), and Phocidae (the earless, or true seals).

Potential Biological Removal: Potential Biological Removal is defined by the MMPA as the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

Relative Environmental Suitability models: Also known as Environmental Envelope or Habitat Suitability Index models, RES models can be used to understand the possible extent and relative expected concentration of a marine species distribution. (see Kaschner et al. (2006) Marine Mammal Density Models.)

Seasons: While most people are familiar with the traditional four calendar seasons, the Navy Marine Species Density Database shapefiles for the Study Area were separated into four seasonal periods as follows:

Northern Hemisphere:
Winter: December–February
Spring: March–May
Summer: June–August
Fall: September–November

Southern Hemisphere:
Summer: December–February
Fall: March–May
Winter: June–August
Spring: September–November

Shapefiles: This is a simple, nontopological ESRI (Environmental Systems Research Institute) format used to store geometric location and attribute information of geographic features.

Sea Mammal Research Unit, Limited (SMRU Ltd.), global habitat-based models: This is one of the least preferred (Level 4) source of density data. Data for 45 species of marine mammals were determined by developing a relationship between the Kaschner RES values (see Kaschner et al. (2006) Marine Mammal

Density Models) and empirical density data. That relationship is then used to generate density predictions for locations where no surveys have been conducted.

Southwest Fisheries Science Center: One of the six science centers under the purview of National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS).

Spatial Models: Spatial models are those for which density predictions are spatially defined (i.e., density varies based on a species geographic distribution and concentration), and are typically based on a species relationship with habitat features (see NMFS Southwest Fisheries Science Center Habitat-Based Density Models).

St. Andrews University RES global model: See SMRU Ltd., global habitat-based models.

Stratified designed-based density estimates: Stratified designed-based 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 are estimated specific to each sub-region.

Stock Assessment Reports (SARs): NMFS prepares annual stock assessment reports for marine mammals that occur in waters under U.S. jurisdiction. The U.S. Fish and Wildlife Service prepares SARs for marine mammals under their jurisdiction (manatees, polar bears, sea otters, and walruses). Each SAR includes a description of the stock's geographic range, a minimum population estimate, current population trends, current and maximum productivity rates, "Potential Biological Removal" levels, status of the stock, estimates of annual human-caused mortality and serious injury by source, and descriptions of other factors that may be causing a decline or impeding the recovery of strategic stocks.

Surrogate species: Species with similar morphology, behavior, and habitat preferences to the species whose density is being determined. The density values of a surrogate species are used when species-specific density data are unavailable.

Systematic line-transect surveys: Line-transect surveys in which the lines are systematically spaced (versus randomly placed). Systematic survey designs are often preferred over random placement because they provide better spatial coverage and can be designed to ensure that the lines do not coincide with a regular spatial feature (e.g., sampling along an isobath where bias can be introduced into the sampling).

APPENDIX B METADATA DICTIONARY

Field name	Type	Description
UID	Long	Unique ID Field for species per study area. This field is created prior to coming to NUWC but populated by NUWC as it is specific to modeling.
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 (e.g., 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)
MODEL_VERS	Text50	Not needed for NAEMO modeling but may be used for density creators/publishers for their 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 used as a metric in the QAQC process and to aid 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.

Seasonal feature/layer creation and additional attribute table information:

- Species with seasonal distributions: Create 4 layers, 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: Create 4 layers, one for each season, Spring, Summer, Fall, or Winter

  - o Duplicate the annual layer for each of the four seasons so there are four separate seasonal layers for each species that hold identical annual density information across all four seasons, i.e., Blue_whale_spring, Blue_whale_summer, Blue_whale_fall, Blue_whale_winter

- Species with monthly distribution: Create 12 layers, one for each month, i.e., Blue_whale_01, Blue_whale_02, Blue_whale_03, etc.

Other Notes
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 (e.g., for Phase III SOCAL the NGA 75k coastline was used with manual removal of bays and inlets by NUWC).

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