U.S. Navy Marine Species Density Database Phase III

for the

Northwest Training and Testing Study Area

Final Technical Report

Amended August 12, 2020

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

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Technical Report

September 20, 2019

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Naval Undersea Warfare Center, Code 1151

The recommended citation for this report is as follows:

U.S. Department of the Navy. (2019). U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI. 262 pp.

ACKNOWLEDGMENTS

The density data included in the Navy Marine Species Density Database (NMSDD) Phase III for the NWTT Study Area and described in this technical report came from multiple scientists working in study areas throughout the Pacific. Density estimates would not exist without the dedication of the marine mammal and sea turtle observers, principal investigators, and survey crews who worked hard collecting the data used for the density estimates included here. We thank them and the many study area experts and Navy biologists who provided input on the data incorporated into the NMSDD Phase III, including (in alphabetical order):

- Andrea Balla-Holden (U.S. Pacific Fleet, U.S. Navy)
- Jay Barlow (NOAA, NMFS, Southwest Fisheries Science Center)
- Jason Benda (NUWC, Division Newport)
- Scott Benson (NOAA, NMFS, Southwest Fisheries Science Center)
- John Calambokidis (Cascadia Research Collective)
- Jim Carretta (NOAA, NMFS, Southwest Fisheries Science Center)
- Marilyn Dahlheim (NOAA, NMFS, Alaska Fisheries Science Center)
- Bob DeLong (NOAA, NMFS, Marine Mammal Laboratory, Alaska Fisheries Science Center)
- Andrew DiMatteo (NAVFAC Atlantic, U.S. Navy)
- Tomo Eguchi (NOAA, NMFS, Southwest Fisheries Science Center)
- Candice Emmons (NOAA, NMFS, Northwest Fisheries Science Center)
- Karin Forney (NOAA, NMFS, Southwest Fisheries Science Center)
- Brad Hanson (NOAA, NMFS, Northwest Fisheries Science Center)
- Steve Jeffries (Washington Department of Fish & Wildlife)
- Chip Johnson (U.S. Pacific Fleet, U.S. Navy)
- Deanna Lynch (U.S. Fish and Wildlife Service)
- Tenaya Norris (The Marine Mammal Center)
- Stephanie Sleeman (NAVFAC Northwest, U.S. Navy)
- Laura Sparks (NUWC, Division Newport)
- Phil Thorson (NUWC, Division Newport)
- Alex Zerbini (Cascadia Research Collective)

Finally, many thanks to Marisha Apodaca, Karyn Palma, and Kerin Van Hoosear (ManTech) for their help formatting, editing, and producing this report.

EXECUTIVE SUMMARY

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

Offshore. Additional survey data collected in 2014 off the U.S. West Coast allowed the Southwest Fisheries Science Center to update their California Current Ecosystem habitat-based density models using improved methods that incorporated species-specific and segment-specific estimates of both effective strip width and trackline detection probability (Becker et al., In Prep.). Density predictions from the updated models are grid-based and provide finer spatial resolution than the models used for Phase II. The Southwest Fisheries Science Center also used the 2014 survey data to update geographically stratified density estimates using a multiple-covariate line-transect approach that included new estimates of trackline detection probability (Barlow, 2016). A new telemetry-based habitat model was developed for blue whale (Hazen et al., 2016) that provides spatially explicit density estimates for this species for winter and spring. In addition, a new seasonal gray whale migration model was developed (DeAngelis et al., 2011), and monthly density estimates from this model were used to more accurately reflect the distribution patterns of this largely nearshore population. New geographically stratified line transect analyses were also completed for harbor porpoise and provide stock-specific density estimates for this species in the offshore waters (Forney et al., 2014). Finally, Hanson et al. (2018) developed a state space movement model that enabled the derivation of spatially-explicit density estimates for the Southern Resident stock of killer whales in the offshore area. In summary, density estimates were updated for all the cetacean species for the offshore portion of the NWTT study area for Phase III.

All pinniped density estimates were updated for the Phase III analysis based primarily on the latest published abundance and distribution data. For some species, unpublished data were used or information from different sources was combined to derive the best estimate possible. For example, the most recent abundance data available from National Marine Fisheries Service stock assessment reports were based on surveys dating back several years (e.g., harbor seal) (Carretta et al., 2017a; Muto et al., 2017). To overcome this limitation and use a more representative abundance to calculate densities, a species' published growth rate was applied for each year between the most recent survey year and 2017. The projected 2017 abundance estimates were then used to calculate densities.

In the Offshore Area, abundance estimates were stratified by season and spatially, either by distance from shore or depth, for most species. Seasonal in-water abundance for California sea lion was estimated from strip transect survey data in the Offshore area along the California coastline (Lowry & Forney, 2005). A third stratum for California sea lions in the Offshore area was added to account for a wider distribution farther from shore (~450 kilometers) during El Niño years (Weise et al., 2006). Historic sealing data were used to augment more recent estimates of the offshore distribution of northern fur seals (Kajimura, 1984; Kenyon & Wilke, 1953). An abundance estimate for Steller sea lion off the Washington coast was used to account for documented pup births that were not included in the stock assessment abundance (Carretta et al., 2017a; Wiles, 2015). Unpublished satellite tracking data reported by Norris (2017a) were used to update the distribution of Guadalupe fur seals in the Offshore area north of Guadalupe Island, Mexico. Surveys conducted during the breeding season on Guadalupe Island resulted in a higher abundance estimate than reported in Carretta et al. (2017a). Abundance and distribution data for leatherback sea turtle reported by Curtis (2015) and Benson (2011) were extrapolated from survey data collected in the California Current Ecosystem to estimate a density in the Offshore area.

Inland Waters. Navy-funded systematic aerial surveys were conducted in the inland waters portion of the NWTT Study Area and data from these surveys were used to develop stratified line-transect density estimates for harbor porpoise (Jefferson et al., 2016; Smultea et al., 2017). These survey data were also used to derive Dall's porpoise density estimates for the Strait of Juan de Fuca and San Juan Islands region based on prorated sighting numbers. Systematic ship survey data in these regions provided line-transect density estimates for both minke whale and Pacific white-sided dolphin (Williams & Thomas, 2007). Seasonal residency data from Hanson and Emmons (*in prep*) were used in conjunction with sighting data collected from January 2003 through December 2016 to estimate seasonal density of Southern Resident killer whales, and data from Houghton et al. (2015) were used to estimate seasonal density of transient killer whales. Density estimates for humpback and gray whales were derived based on 2012–2017 opportunistic sighting data in conjunction with input from local scientists. In summary, density estimates were updated for all the cetacean species for the inland waters portion of the NWTT study area for Phase III.

The same factors used to estimate pinniped densities in the Offshore area were used for the Inland Waters area. In addition to accounting for spatial and temporal distributions, species' abundances in the Inland Waters area were adjusted using a species-specific haulout factor to account for the portion of time pinniped species are hauled out on land. This additional factor is necessary to achieve an accurate in-water density and to align with the purpose of the Navy's acoustic effects model, which is to estimate effects from sonar and explosives used underwater.

Density estimates for California sea lion in the Strait of Juan de Fuca and San Juan Islands region were based on recent abundance data from DeLong et al. (2017) and transit times for migrating sea lions reported in Gearin et al. (2017). DeLong et al. (2017) conducted weekly counts of California sea lions at four Navy facilities in Puget Sound and used satellite dive recorders to determine haulout times and local distribution. The Navy funded line-transect aerial surveys of Puget Sound from 2013 through 2016 (Smultea et al., 2017). The results were used by Jefferson et al. (2017) to estimate the in-water density and abundance of harbor seals in Hood Canal and by Smultea et al. (2017) to estimate in-water abundance for harbor seals in the Northern Washington Inland Waters stock and the Southern Puget Sound stock. Sighting data provided by Jeffries (2017) were used to estimate density and abundance of harbor seal in the Strait of Juan de Fuca and the San Juan Islands. Estimates of northern elephant seal in the Strait of Juan de Fuca were based on Jeffries et al. (2014). The abundance of Steller sea lions in the Strait of Juan de Fuca and the San Juan Islands was based on data from Wiles (2015), and sightings reported by Smultea et al. (2017) were used to estimate an abundance for Hood Canal. Sightings of hauled-out Steller sea lions reported by Jeffries (2014) and DeLong et al. (2017) were used to estimate an abundance in Puget Sound. Northern fur seals, Guadalupe fur seals, and leatherback sea turtles are not expected in the Inland Waters area.

Western Behm Canal. Systematic ship surveys conducted in Southeast Alaskan waters from 1991 to 2012 provided data to develop stratified line-transect density estimates for harbor porpoise in regions overlapping a portion of the Behm Canal Study Area (Dahlheim et al., 2015). These data were also used to derive density estimates for Dall's porpoise (Dahlheim et al, *in prep*). Given that more recent density data for other species are not yet available, Phase II density estimates were used for the remainder of the cetacean species.

Pinniped density estimates for the Behm Canal region were derived from publications, the Alaska stock assessment report (Muto et al., 2018a) and consultation with subject matter experts (DeLong & Jeffries, 2017). The distribution of harbor seals in the Clarence Strait stock overlaps with the Behm Canal area. Seasonal haulout factors were derived from Huber et al. (2001), National Marine Fisheries Service (2015), and Simpkins et al. (2003). Based on input from Jeffries and DeLong (2017), 10 percent of male northern elephant seals could occur seasonally in the Behm Canal area and would not be expected to haulout. The herring fishery is closed in Behm Canal, but northern fur seals have been known to forage for herring in the canal in spring (DeLong & Jeffries, 2017). A seasonal occurrence based on Kenyon and Wilke (1953) reporting that "several thousand" female northern fur seals enter deep inland waters to feed was used to estimate density. For Steller sea lion, abundance and growth rate were taken from the stock assessment report (Muto et al., 2018a), and seasonally variable haulout factors were applied (Call et al., 2007; DeLong & Jeffries, 2017; Merrick & Loughlin, 1997; Trites & Porter, 2002). Some individuals from the endangered Western stock of Steller sea lions may occur in southeast Alaska, but not in sufficient numbers to estimate a density. California sea lion, Guadalupe fur seal, and leatherback sea turtle are not expected to occur in Behm Canal or surrounding inland waters.

Elimination of Data Sources Low in the Data Quality Hierarchy. Given the representative acoustic modeling study areas established for the NWTT Study Area for Phase III, the Navy was able to eliminate the use of all Level 4–5 data sources (i.e., the least preferred sources of density data). Given the uncertainty associated with predictions from relative environmental suitability models, and the sometimes orders-of-magnitude difference in relative environmental suitability estimates as compared to validated estimates derived from years of survey data (U.S. Department of the Navy, 2015), this represents a substantial improvement to the Phase III NMSDD.

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ACRONYMS AND ABBREVIATIONS

AOR	Area of Responsibility
BIA	Biologically Important Area
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCE	California Current Ecosystem
CENPAC	Central Pacific
CV	Coefficient of Variation
DPS	distinct population segment
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
GIS	Geographical Information System
IWC	International Whaling Commission
km	kilometer(s)
km^2	square kilometer(s)
m	meter(s)
MMPA	Marine Mammal Protection Act
N	North
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMSDD	Navy Marine Species Density Database
NUWC	Naval Undersea Warfare Center
NWTT	Northwest Training and Testing
OPAREA	Operating Area
PCFG	Pacific Coast Feeding Group
RES	Relative Environmental Suitability
SAR	Stock Assessment Report
SEAFAC	Southeast Alaska Acoustic Measurement Facility
SMRU Ltd.	Sea Mammal Research Unit, Limited (at University of St. Andrews)
SWFSC	Southwest Fisheries Science Center
SYSCOMS	System Commands
TAP	Tactical Training Theater Assessment and Planning Program
U.S.	United States
USFWS	United States Fish and Wildlife Service
W	West

1 BACKGROUND

To ensure compliance with United States (U.S.) regulations, including the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the National Environmental Policy Act (NEPA), and Executive Order 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. As stipulated by the MMPA and ESA, information on the species and numbers of protected marine species is required in order to estimate the number of animals that might be affected by a specific activity. The Navy performs quantitative analyses to estimate the number of marine mammals and sea turtles that could be affected by at-sea training and testing activities. A key element of this quantitative impact analysis is knowledge of the abundance and concentration (density) of the species in specific areas where those activities 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. This report includes a description of the currently available density data used in the "Phase III" quantitative impact analysis for each marine mammal and sea turtle species present in the Navy's Northwest Training and Testing (NWTT) Study Area. Phase III is the third implementation of the Navy's Tactical Training Theater Assessment and Planning Program (TAP). TAP is a comprehensive, integrated process to preserve access to and use of Navy training ranges, testing ranges, and operating areas (OPAREAs) by addressing encroachment and environmental compliance issues. In addition to preserving access and use of ranges, TAP's purpose is to comply thoroughly with environmental laws.

NOTE: The density data are organized by species and presented in groups of related taxa within Sections 5 through 12 of this report. Within each individual species section, density data are described for the NWTT Study Areas as appropriate. Information on which species are found in the Study Area is provided in Table 3.3-1.

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 observations 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, 2010; Barlow & Forney, 2007; 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 varied 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, a newer method called 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., In Prep.; 2012a; Becker et al., 2010; 2014; Ferguson et al., 2006; 2015; Forney et al., 2012; Redfern et al., 2006). (Note that spatial habitat models are also referred to as “species distribution models” or “habitat-based density models.”) These models estimate density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth) and thus, within the study area that was modeled, densities can be predicted at all locations where these habitat variables can be measured or estimated. Spatial habitat models therefore allow estimates of cetacean densities on finer scales than traditional line-transect or mark-recapture analyses.

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

The methods used to estimate pinniped at-sea densities are typically different than those used for cetaceans, because pinnipeds are not limited to the water and spend a significant amount of time on land (e.g., at rookeries). Pinniped abundance is generally estimated via shore counts of animals on land at known haulout sites or by counting number of pups weaned at rookeries and applying a correction factor to estimate the abundance of the population (for example Harvey et al., 1990; Jeffries et al., 2003; Lowry, 2002; Sepulveda et al., 2009). Estimating in-water densities from land-based counts is difficult given the variability in foraging ranges, migration, and haulout behavior between species and within each species, and is driven by factors such as age class, sex class, breeding cycles, and seasonal variation. Data such as age class, sex class, and seasonal variation are often used in conjunction with abundance estimates from known haulout sites to assign an in-water abundance estimate for a given area. The total abundance divided by the area of the region provides a representative in-water density estimate for each species in a different location, which enables analyses of in-water stressors resulting from at-sea Navy testing or training activities. In addition to using shore counts to estimate pinniped density, traditional line-transect derived estimates are also used, particularly in open ocean areas.

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, 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 or 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 resulting compilation and structure of the selected 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, of which 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 describe how the data sources compare to each other and to provide guidance on the most appropriate source to use for the specific area. These data are compiled by the Fleets and Systems Commands and are incorporated into Navy environmental compliance documents. The Navy completed the first NMSDD 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 Area of Responsibility (AOR) (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 Mariana Islands Training and Testing Study Area, the NWTT Study Area, and the Gulf of Alaska Temporary Maritime Activities Area Study Area. For the “Phase III” analyses, each of these four study areas is addressed in a separate technical report. 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 NWTT 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 are not detected during surveys (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 (also known as Environmental Envelope or Habitat Suitability Index 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 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 from survey sighting data in conjunction with distance sampling theory. However, the majority of the world's oceans have not been surveyed in a manner that supports quantifiable density estimation of marine mammals and sea turtles. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and (the likelihood of) the presence of specific species has 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 that results in defining the suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed. Two recognized methods and sources of density estimation for marine mammals are considered here: the Kaschner et al. (2006) global density estimates and the Sea Mammal Research Unit, Limited at University of St. Andrews (SMRU Ltd.) global density estimates (SMRU Ltd., 2012), hereafter referred to as the Kaschner et al. RES model or Kaschner et al. marine mammal density models, and the SMRU Ltd. model. Predictions from the SMRU Ltd. model are preferred over the Kaschner et al. model because the SMRU Ltd. version used separately derived population abundance estimates to constrain the global density estimates from the RES model. Given that uncertainty is very high, 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 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, relative to many other areas of the world's oceans, waters off the U.S. West Coast have been surveyed extensively for the purpose of estimating cetacean abundance; both stratified designed-based (e.g., Barlow & Forney, 2007) and density spatial models (e.g. Forney et al., 2012) are available for many of these species. Some of these surveyed areas overlap with Navy OPAREAs; however, very little survey data are available for other regions that encompass the Navy's AOR. For example, systematic line-transect survey data are not available for Behm Canal, thus making it impossible to directly quantify the density of most species known to occur in this region of the NWTT Study Area. In this case, density estimates from adjoining areas need to be used, thus inherently including a high degree of uncertainty.

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, inclement 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 hierarchal 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 Figure 2.2-1 for the NMSDD, modeling methods are ranked as follows:

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

– For the U.S. EEZ on the west coast, SWFSC models for the California Current Ecosystem (CCE) were used.

(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 from SMRU Ltd. (2012) or Kaschner et al. (2006). These are the least preferred sources 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 had to be used for the Navy's Phase II analyses; however, given the representative acoustic modeling study areas established for NWTT Phase

III, the Navy was able to eliminate the use of RES data, thereby improving the density data used for Phase III acoustic modeling.

(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.

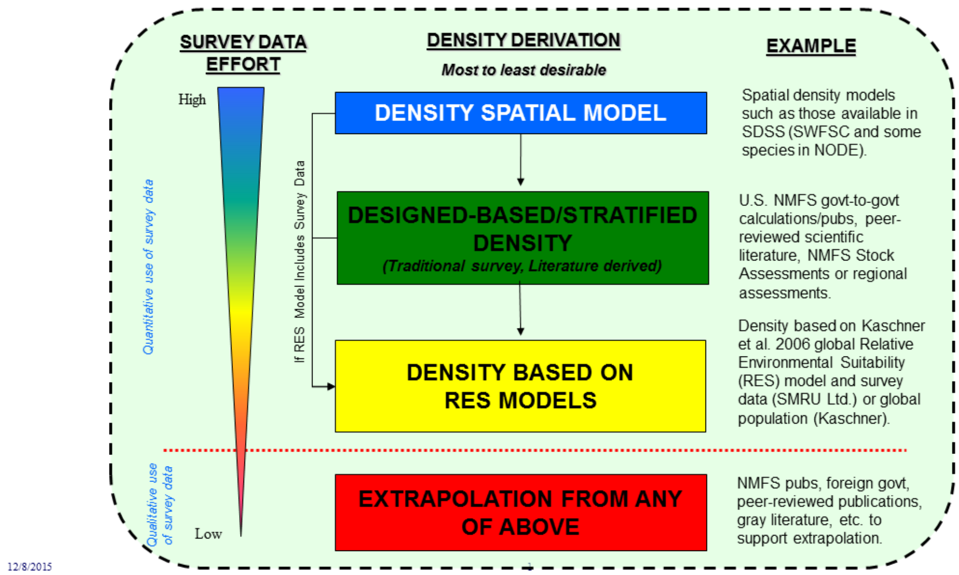


Figure 2.2-1: Graphical Depiction of Methods of Density Data Derivation and How They Rank in Guiding the Determination of What Density Data to Include in the NMSDD

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 Figure 2.2-1 as a guideline for selection.

For example, consider the fin whale (*Balaenoptera physalus*) density data file for the eastern North Pacific during summer and fall:

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

1. SWFSC spatial models (U.S. EEZ)
2. SWFSC stratified designed-based estimates off Baja, California, Mexico
3. SMRU Ltd., RES model estimates (everywhere else)

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 SWFSC 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 and season (Figure 2.2-2). As is evident in Figure 2-2, the SWFSC model provides spatially explicit density estimates within the U.S. EEZ. Stratified designed-based density estimates were available for waters off Baja California, Mexico, and are depicted as an area of uniform density directly south of the U.S. EEZ. Data from the SMRU Ltd. RES model were selected for the remaining areas shown on the map because no other density data were available. 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.

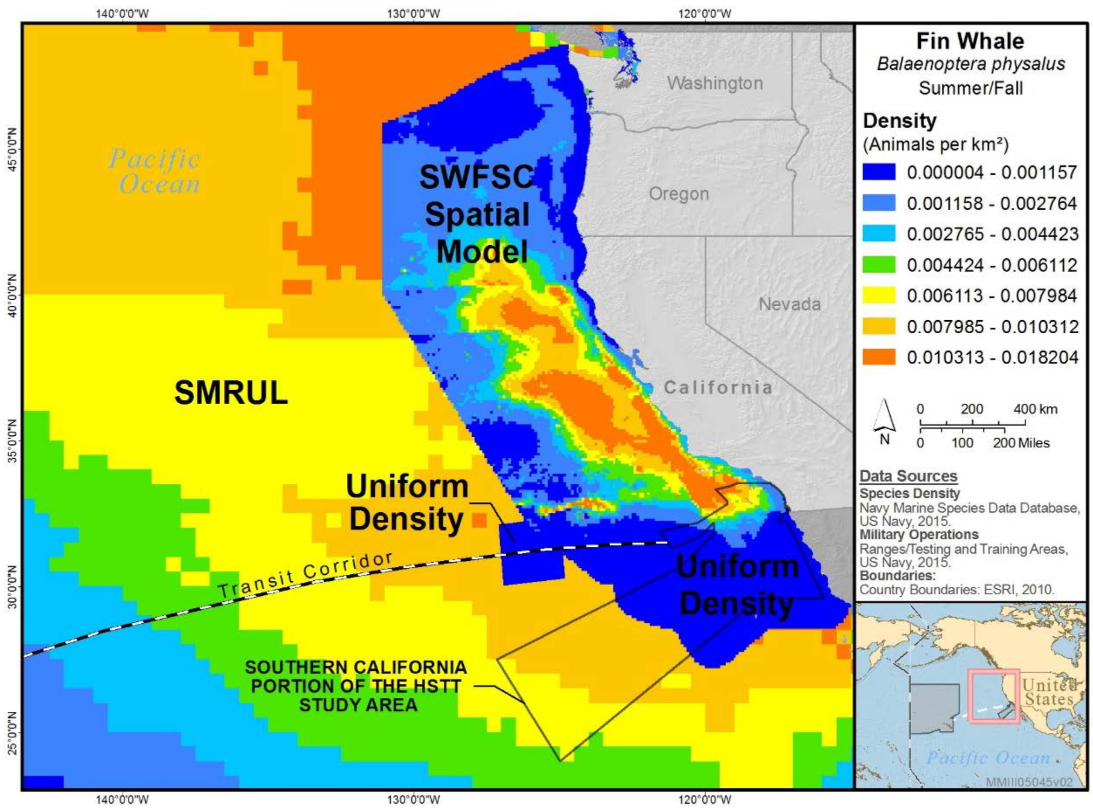


Figure 2.2-2: Example of a Combined NMSDD Density Data File

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

Pacific Fleet, Atlantic Fleet, and System Commands (SYSCOMS) are each responsible for reviewing and including the best available density data for their AOR in an ArcGIS compatible format with associated metadata for inclusion into the master Atlantic and Pacific datasets. There is continual coordination between Pacific Fleet, Atlantic Fleet, and SYSCOMS to ensure consistency between regional environmental analyses (e.g., Pacific and Atlantic Environmental Impact Statements) and commands across the Navy. Pacific Fleet, Atlantic Fleet, and SYSCOMS are also each responsible for developing the supporting documentation on the methods of implementation for data included in the NMSDD.

2.2.3 METHODS FOR SEASONAL DESIGNATION

Seasons are defined by the available data and the minimum number of timeframes that characterize the species distribution over one year. The number of timeframe designations could vary based on the detail of the available data. This could be designated by the traditional four seasons, warm and cold seasons, breeding and feeding seasons, 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. A separate density data file is required for each season designation. In instances of combining a species for which there is an annual density estimate and a seasonally parsed density estimate, multiple density data files may be developed based on the seasonal category. For example, a species density dataset with four seasonal classifications is merged with a density dataset with an annual classification. The annual data need to be repeated for all four seasons and each repeated value must have the same season start and end dates as the season classification. There should be no overlapping time frames or geographic areas represented by the density data within the combination of the multiple datasets.

The ultimate result is a series of density data files that spatially and temporally have density values that span the species' expected distribution for the entire year. The number of density data files for a given species is defined by the data region of greatest detail (i.e., the greatest number of seasonal timeframe designations) and may result in geographic partitioning and multiple density data files for a single species if seasonal definitions differ for oceanic areas.

2.2.4 FILE FORMAT AND MANAGEMENT

All density estimates need to be in an ArcGIS compatible format for integration with the Navy effects analysis model. All data are clipped to the National Geospatial-Intelligence Agency 1:250,000 coastline data for the coastal boundary. At a minimum, the metadata fields listed in Appendix B are to be included in the database file (.dbf) for all density values in the density data files.

The file format and structure standards are managed by the Naval Undersea Warfare Center (Newport, Rhode Island) 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.

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, *In Progress*). 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 NWTT 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 NORTHWEST TRAINING AND TESTING STUDY AREA

The NWTT Study Area is composed of established maritime operating and warning areas in the eastern North Pacific Ocean region, including the Strait of Juan de Fuca, Puget Sound, and Western Behm Canal in Southeast Alaska. The area includes air and water space within and outside Washington state waters, and within and outside state waters of Oregon and Northern California, as well as state waters of Alaska. The Study Area includes four existing range complexes and facilities: the Northwest Training Range Complex, the Keyport Range Complex, Carr Inlet Operations Area, and the Southeast Alaska Acoustic Measurement Facility (SEAFAC). In addition to these range complexes, the Study Area also includes Navy pierside locations where sonar maintenance and testing occurs as part of overhaul, modernization, maintenance, and repair activities at Navy piers at Naval Base Kitsap Bremerton, Naval Base Kitsap Bangor, and Naval Station Everett (Figure 3.1-1). Given the complexity of the NWTT Study Area, it was divided into three distinct geographic and functional subdivisions to aid in the identification of density data and for subsequent Navy effects modeling: (1) NWTT Offshore, (2) NWTT Inland Waters, and (3) NWTT Western Behm Canal, Alaska.

Based on the sound sources modeled in the Navy's effects analysis for Phase III, acoustic modeling study areas were established to best characterize Navy training and testing and capture the range of environmental conditions within the NWTT Study Area (Figure 3.1-2). In some cases (e.g., Behm Canal), these modeling areas extend outside the boundaries of the NWTT Study Area in order to cover the full extent of potential acoustic propagation. Density data incorporated into the NMSDD provide coverage for the full extent of the acoustic modeling areas.

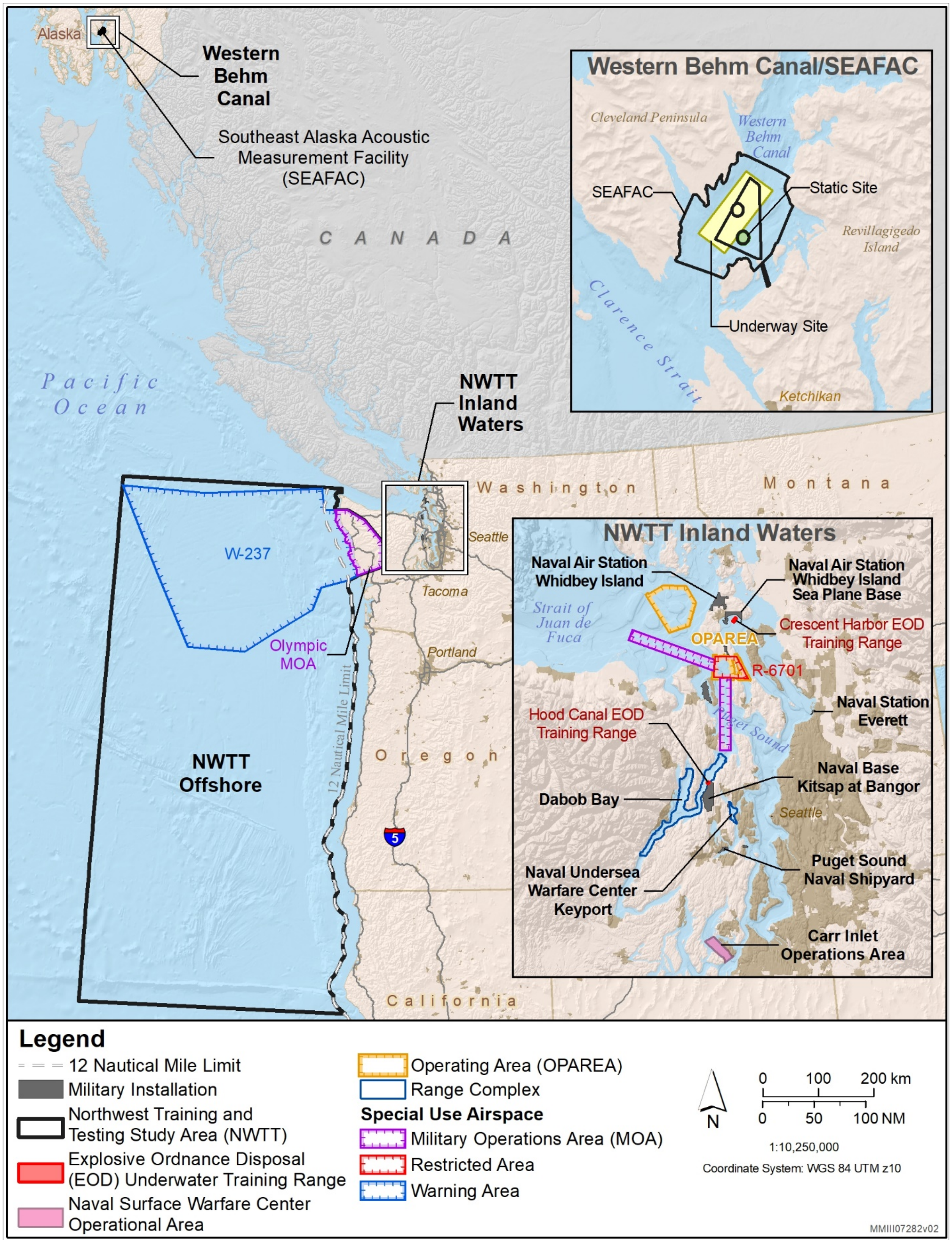


Figure 3.1-1: Northwest Training and Testing Study Area

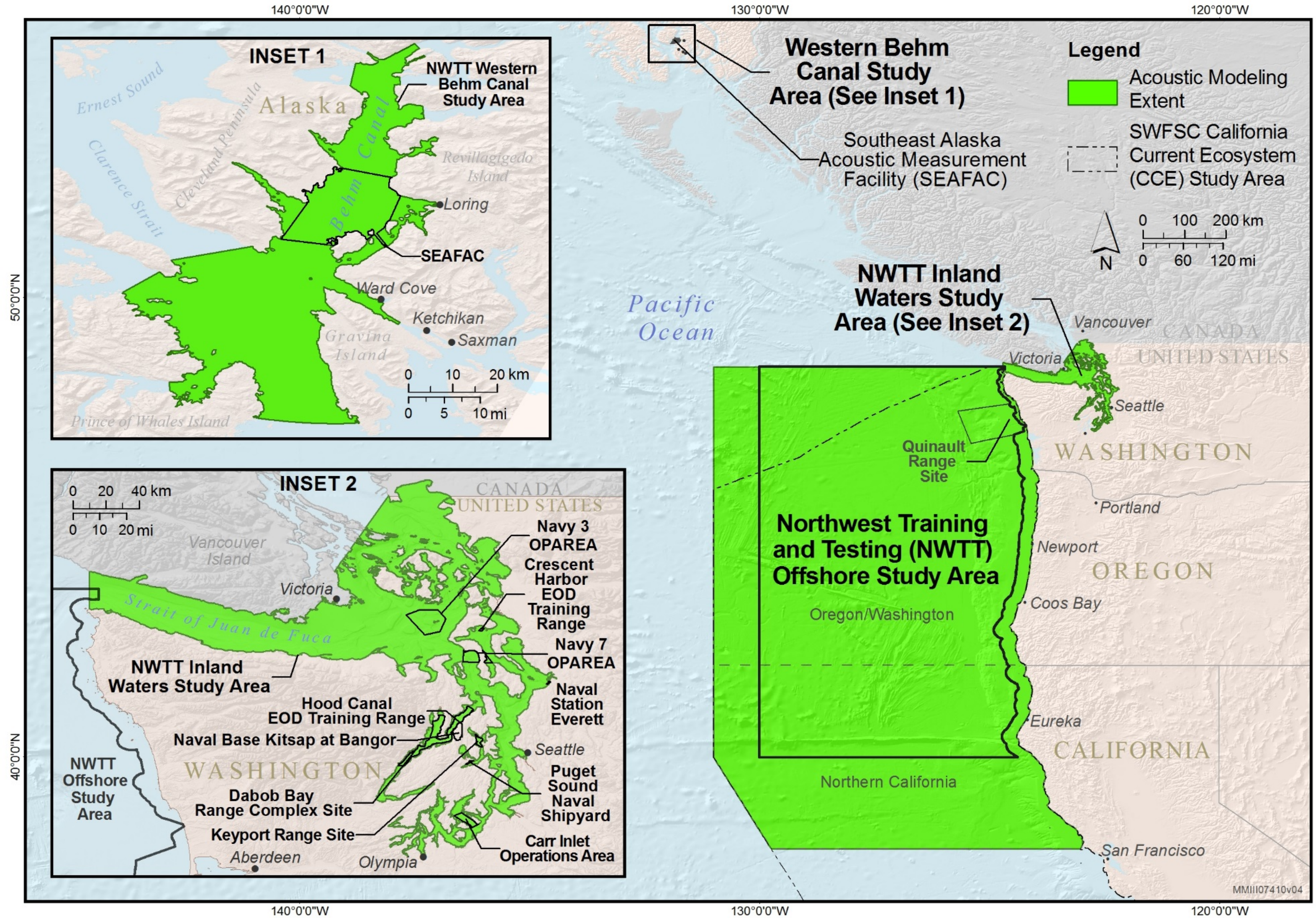


Figure 3.1-2: Acoustic Modeling Study Areas

3.2 APPLICATION OF THE NAVY MARINE SPECIES DENSITY DATABASE PROTOCOL

NMSDD shapefiles for the NWTT Study Area are currently stratified by four seasons:

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

However, density data were rarely available at this temporal resolution. Marine mammal surveys are typically conducted during only one or two seasons because rough weather conditions in winter/spring make it difficult to collect shipboard line-transect data. Off the U.S. West Coast, for example, much of NMFS' data that exist for winter/spring have been collected during aerial surveys. In this case, ship survey data provide the best estimates for summer/fall, while aerial survey data provide the best estimates for winter/spring. Further, the current NMSDD seasonal stratification approach is not appropriate for every project region. Ideally, seasonal strata would be based on the greatest differences in oceanographic conditions for a given study area. For example, off the U.S. West Coast, the "warm-water period" is generally considered June–November and the "cool-water period" January–April, while December and May are considered periods of transition. In this case, given the seasonal periods used for the NMSDD, the warm-water period fits nicely into the summer/fall strata, while the cool-water and transitional periods are both included in the winter/spring strata. In this example, given limitations in the available survey data, the "summer/fall" estimate will populate both the "summer" and "fall" shapefiles and the "winter/spring" estimate will populate both the "winter" and "spring" shapefiles. In the case of an annual density estimate, it will be repeated for all four seasons.

For each area and season, the Navy's goal is to identify the best available density estimate, and thus different data sources may be relied upon. To select marine species density estimates, the Navy established a data hierarchy based on available data (Table 3-1). These levels were established consistent with the hierarchical approach for ranking density estimates as described in Section 2.2.1. When appropriate, the most preferred density values may be those extrapolated from Levels 1 through 3 below. As described in Section 2.2.1, extrapolation from neighboring regional density estimates or population/stock assessments is appropriate based on expert opinion and is preferred over using RES models because of discrepancies identified by local expert knowledge.

The different data sources are described in more detail in the following sections.

Table 3.2-1: 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	St. Andrew's RES Model (SMRU Ltd., 2012)
Level 5 (Least Preferred)	Kaschner et al. RES Model (Kaschner et al., 2006)

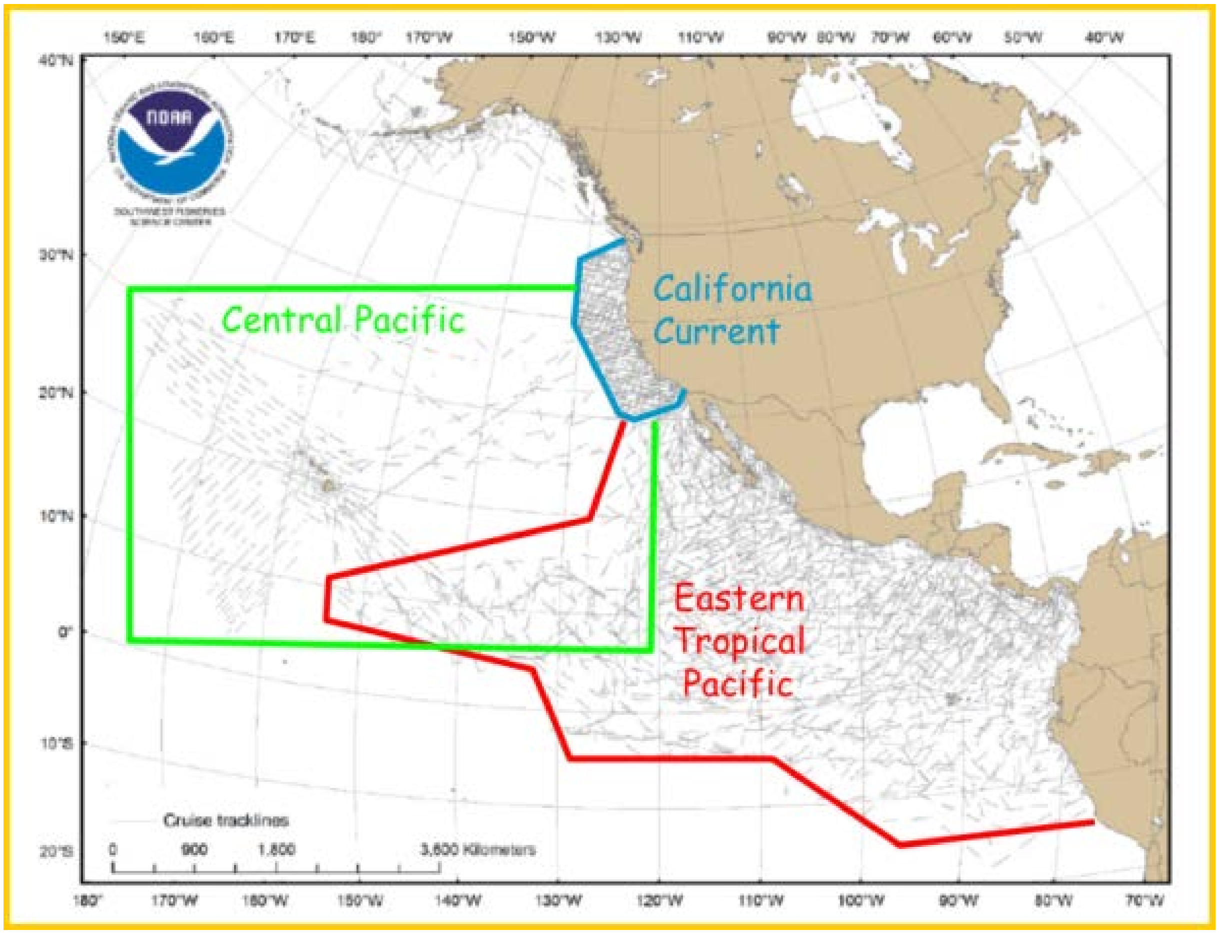
The NMSDD protocol was applied when selecting the best available marine species density for each study area. For the NWTT Study Area, Level 1 data (habitat-based density models) were available for multiple species/species groups within the NMFS SWFSC survey areas off the U.S. West Coast for the summer/fall seasons. For other species, seasons, and areas, stratified line-transect density estimates (i.e., Level 2 data) were available. For a small portion of the NWTT Study Area that extended northwest of the SWFSC survey area, density estimates were extrapolated from adjoining density estimates. Based on expert opinion from scientists at the SWFSC, for these NWTT cases for which Level 1–3 density estimates were not available, extrapolated density estimates were considered more representative of expected densities than those generated from the lower level sources (i.e., Level 4 and 5 data).

Information on the data density sources available for the NWTT Study Area is included in the next section.

3.3 Information on Density Data Sources Considered and Included

3.3.1 Level 1–Level 3 Data Sources

Consistent with the hierarchical approach for ranking density estimates as described in Section 2.2.1 and the established levels summarized in Table 3-1, the majority of Level 1 through Level 3 data used to describe cetacean densities within the NWTT Study Area were estimated from systematic line-transect shipboard surveys conducted by NMFS SWFSC (Figure 3.3-1). As noted in Section 2.2.1, these sources of density data are the most preferred. The SWFSC surveys are typically conducted in summer/fall (roughly July–November) and cover three major study areas: (1) CCE (waters off the U.S. West Coast between the shore and approximately 300 nautical miles offshore), (2) Central Pacific (waters north of the equator between the International Date Line and approximately 130° west [W] longitude), and (3) Eastern Tropical Pacific (waters extending from the U.S.-Mexico Border south to Peru and west to approximately 130°W longitude). Data from these surveys have been used to develop spatial density models and to estimate densities using line-transect analyses as described below. The study area used to develop spatial density models for the CCE overlaps a large portion of the NWTT Study Area.



Source for transect lines: Hamilton et al. 2009

Figure 3.3-1: Transect Coverage for Surveys Conducted by the Southwest Fisheries Science Center between 1986 and 2006 in Three Broad Study Areas in the Eastern North Pacific

<u>NMFS SWFSC Habitat-Based Density Models for the California Current Ecosystem (CCE Models)</u>

This data source is the top tier (Level 1) in the hierarchy of density data.

SWFSC has been developing predictive habitat-based density models for cetaceans in the CCE for more than 15 years. Habitat variables used in the density models have included temporally dynamic environmental measures (e.g., sea surface temperature, mixed layer depth) derived from remotely sensed sources or collected *in situ* during the line-transect surveys, as well as more static geographical measures (e.g., water depth, bathymetric slope). The CCE habitat models have received extensive validation using a variety of methods including cross validation (Barlow et al., 2009; Becker et al., 2010; Forney, 2000; Forney et al., 2012), predictions on novel data sets (Barlow et al., 2009; Becker et al., 2012a; Becker et al., 2014; Forney et al., 2012), and expert opinion (Barlow et al., 2009; Forney et al., 2012).

For the Navy's Phase II analyses, model predictions from the then-current CCE model predictions (Becker et al., 2012b) were provided to the Navy in ArcGIS format and incorporated into the NMSDD

(U.S. Department of the Navy, 2015). These models were developed using six years of systematic line-transect data collected in the CCE between 1991 and 2008 (Becker et al., 2012b). Model results were provided for striped dolphin (*Stenella coeruleoalba*), short-beaked common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), Dall's porpoise (*Phocoenoides dalli*), sperm whale (*Physeter macrocephalus*), fin whale, blue whale (*Balaenoptera musculus*), humpback whale, Baird's beaked whale (*Berardius bairdii*), and a small beaked whale guild (including Cuvier's beaked whale [*Ziphius cavirostris*] and *Mesoplodon* spp.).

More recently, in support of the Navy's Phase III NMSDD needs described in this report, improved methods were used to develop a new set of CCE habitat-based density models that included an additional set of survey data collected in waters off Southern California in 2009 and off the entire U.S. West Coast in 2014 (Becker et al., In Prep.). Sighting data from the combined 1991–2014 survey data enabled the development of models for two additional species, long-beaked common dolphin (*Delphinus capensis*) and common bottlenose dolphin (*Tursiops truncatus*). Within the CCE study area, density predictions for distinct daily composites covering the entire survey periods (1991–2014) were averaged to produce spatial grids of average species density at 10 kilometer (km) x 10 km resolution, as well as spatially explicit measures of uncertainty (Becker et al., In Prep.). Final model predictions were provided to the Navy in ArcGIS format and incorporated into the NMSDD for their current NWTT Phase III analyses.

NMFS SWFSC Line-Transect Density Estimates for the California Current Ecosystem

This data source is one of the preferred (Level 2) sources of density data in the established hierarchy.

Summer/Fall Shipboard Surveys. Ship-based line-transect surveys were conducted by NMFS SWFSC in their CCE study area from July through November 1991, 1993, 1996, 2001, 2005, and 2008. In 2009, an additional line-transect survey was conducted from September to December that focused on waters off Southern California. Information on the search effort and number of species sighted during these surveys is reported in numerous NMFS SWFSC administrative reports, technical memoranda, and peer-reviewed publications.

Cetacean density estimates for the CCE study area (1,141,800 km^2) are typically stratified into four geographic regions: waters off (1) Oregon and Washington (322,200 km^2 north of 42° north [N]); (2) northern California (258,100 km^2 south of 42°N and north of Point Reyes at 38°N); (3) central California (243,000 km^2 between Point Conception at 34.5°N and Point Reyes); and (4) Southern California (318,500 km^2 south of Point Conception). Barlow and Forney (2007) used a multiple-covariate line-transect approach (Marques & Buckland, 2003) to derive uniform density estimates for each of these four regions for 19 species, as well as *Kogia* spp. and *Mesoplodon* spp. For those species for which habitat-density models could not be developed (due to insufficient sample sizes), these stratified uniform density estimates were used by the Navy for their Phase II analyses (U.S. Department of the Navy, 2015).

In the summer and fall of 2014, an additional survey was conducted by SWFSC in the CCE study area. The same survey methods and survey design were used as the prior 1991–2008 surveys, and similar analytical methods were used to estimate density for the four geographic regions described above (Barlow, 2016). However, the new analysis included new estimates of trackline detection probability based on a method developed by Barlow (2015) and incorporated new methods for selecting detection function covariates based on results presented by Barlow et al. (2011). In addition, data from the 1991 to 2008 surveys were re-analyzed using the new methods to provide more accurate estimates (Barlow, 2016). For those species for which habitat-density models could not be developed (due to insufficient sample sizes), these new stratified uniform density estimates were incorporated into the NMSDD and used by the Navy for their current Phase III analyses.

Additional Line-Transect Density Estimates for Regions within the NWTT Study Area

In addition to the National Oceanic and Atmospheric Administration line-transect density estimates described above, additional peer-reviewed published studies of designed-based estimates (Level 2; see Table 3-1) were used.

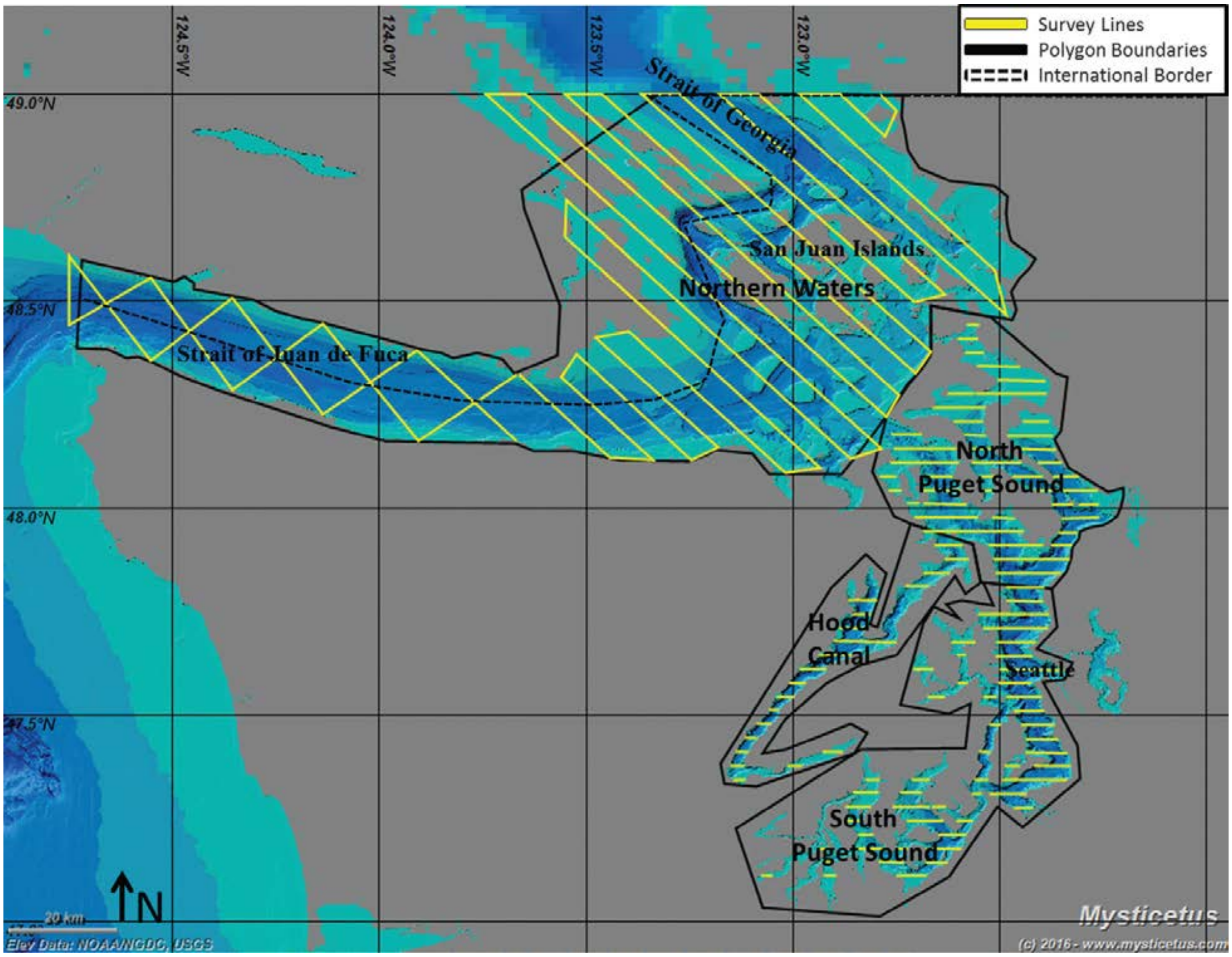
Puget Sound Aerial Surveys. Navy-funded aerial line-transect surveys were conducted in Puget Sound waters of Washington from 2013 to 2016 (Figure 3.3-2). Smultea et al. (2017) produced spatially explicit density estimates for harbor porpoise and harbor seal within sub regions of Puget Sound. Jefferson et al. (Jefferson et al., 2016) used aerial survey data collected in 2015 in the Strait of Juan de Fuca and San Juan Islands to estimate density for harbor porpoise.

Southeast Alaska Ship Surveys. The National Marine Mammal Laboratory, Alaska Fisheries Science Center, has conducted ship-based surveys in Southeast Alaska since 1991. Although systematic surveys were not conducted within Behm Canal, survey coverage did extend throughout Clarence Strait, adjacent to the southern entrance of Behm Canal. Recently, data from the 1991 to 2012 surveys were analyzed to produce density estimates for harbor porpoise (Dahlheim et al., 2015) and Dall's porpoise (Dahlheim et al, *in prep*), and density estimates based on the most recent data (2010–2012) were incorporated into the NMSDD.

NMFS Stock Assessment Reports for the Pacific

This data source is one of the preferred (Level 3) sources of density data in the established hierarchy.

In addition to the above, density estimates are available from NMFS Stock Assessment Reports for the Pacific (Carretta et al., 2017b) and Alaska (Muto et al., 2017). These Stock Assessment Reports provide uniform abundance estimates for recognized stocks of marine mammals within broad geographic strata.



Source: Jefferson et al. (2016)

Figure 3.3-2: Aerial Survey Transect Lines Used for NWTT Inland Waters Density Estimation

3.3.2 Level 4–Level 5 Data Sources

The Level 4–5 data sources are the least preferred sources of density data, as noted in Table 3-1. These data sources are based on environmental suitability models. (Note that a Level 5 density source, Kaschner et al. (2006) is described first below, because the Level 4 source, SMRU Ltd. (2012) is based on improvements to the Kaschner et al. (2006) models.

Kaschner et al. Marine Mammal Density Models

This data source is one of the least preferred (Level 5) sources of density data in the established hierarchy.

Based on a synthesis of existing observations about the relationships between basic environmental conditions and species presence, Kaschner et al. (2006) used environmental suitability models to predict the average annual range of a marine mammal species on a global level. Habitat preferences were based on sea surface temperature, bathymetry, and distance to nearest land or ice edge. These data were then used to characterize species distribution and relative concentration on a global oceanic scale at 0.5° grid cell resolution. To transform the RES values to density estimates, published global population estimates were used to compute a mean annual global population estimate. Kaschner et al. (2006) then prorated the global abundance estimates using the RES values as an index of relative concentration (i.e., so that if one was to sum up all of the cells, the result would be the mean global population). One of the disadvantages of this method is that it is difficult to validate the results because much of the area covered has never been surveyed and uncertainty was qualitatively assessed. In the Pacific, Kaschner et al.'s (2006) predicted distributions for many species do not correspond well with known distributions (Ferguson et al., 2011). Some of the discrepancies between the Kaschner et al. (2006) model predictions and known species distributions could be due to the difference between the "fundamental niche" and the "realized niche" (Hutchinson, 1957); the fundamental niche describes all environments that permit a species to survive, while the realized niche is the species-observed distribution which results from interspecific and intraspecific dynamics, interactions with the physical environment, and historical events.

Sea Mammal Research Unit Limited (SMRU Ltd.) Marine Mammal Density Model

This data source is one of the least preferred (Level 4) sources of density data in the established hierarchy.

SMRU Ltd. developed a global density model using a different approach for 45 species of marine mammals (SMRU Ltd., 2012). The SMRU Ltd. model used the seasonally defined RES values (Kaschner et al., 2006) described above and developed a relationship between the RES values and empirical density data in order to generate predictions of density for locations where no surveys have been conducted. A thorough literature search for survey data was undertaken to identify ship-based and/or aerial surveys of marine mammals. Survey data were collated on a global level and included surveys since 1980, although most surveys included in the analysis were post-1990. Models relating density (from surveys) to RES values were constructed using Generalized Linear Models. Initial model fitting used only the summer season data for the Northern and Southern hemispheres. The summer RES values were passed through the fitted equations to give predicted densities for all 0.5° grid-cells. This, coupled with database values for the area of water within each cell, gave a "global abundance" estimate. Seasonal predictions were made by allocating this global abundance in accordance with the seasonal RES values and the model coefficients. This approach ensured that the total global abundance of a species did not change between seasons. The advantage of this approach over the Kaschner et al. (2006) models is that SMRU Ltd. used actual density data from a number of sources and developed a model fit to the RES value to make the predictions. This method allowed for the uncertainly in each cell to be quantitatively assessed, which was not possible with the Kaschner et al. (2006) model. For the purpose of environmental impact assessment, when available, this method of density estimation is preferred over Kaschner et al.'s (2006) density model.

4 INDIVIDUAL SPECIES' DENSITY PROFILES

The remainder of this document provides the density profiles that are being used by the Navy for modeling the potential exposure of each species to Navy sound sources in the NWTT 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, porpoises, beaked whales, pinnipeds, and sea turtles. Within each group, species are presented in alphabetical order by their scientific name; hence, the scientific names are presented before the common names. This organization scheme keeps closely related species together. Information on which species are found in the NWTT Study Area is provided in Table 4-1.

All species included in Table 3.3-1had density estimates revised and updated for Phase III, either for the entire species and all seasons, for specific stocks or geographic areas (Offshore, Inland Waters, Behm Canal), or for select seasons. Given the representative acoustic modeling study areas established for NWTT Phase III, the Navy was able to eliminate the use of all Level 4–5 data sources (i.e., the least preferred sources of density data, as noted in Table 3-1), thereby improving the quality and reducing the uncertainty of data used for Phase III acoustic modeling.

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 different regions within the NWTT 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 3.3-1: Species with Northwest Training and Testing Study Area Density Estimates Included in the NMSDD Phase III[1]

Taxonomic Name	Common Name	NWTT Offshore	NWTT Inland Waters	NWTT Behm Canal
Cetaceans (Order Cetacea)				
Baleen Whales (Suborder Mysticeti)				
Balaenoptera acutorostrata	Common or dwarf minke whale	X	X	X
Balaenoptera borealis	Sei whale	X		
Balaenoptera musculus	Blue whale	X		
Balaenoptera physalus	Fin whale	X		X
Eschrichtius robustus	Gray whale	X	X	
Megaptera novaeangliae	Humpback whale	X	X	X
Toothed Whales (Suborder Odontoceti)				
Sperm Whales (Family Kogiidae [pygmy and dwarf sperm whale] and Family Physeteridae [sperm whale])				
Kogia breviceps	Pygmy sperm whale	X[2]		
Kogia sima	Dwarf sperm whale	X[2]		
Physeter macrocephalus	Sperm whale	X		
Dolphins (Family Delphinidae)				
Delphinus delphis	Short-beaked common dolphin	X		
Globicephala macrorhynchus	Short-finned pilot whale	X		
Grampus griseus	Risso's dolphin	X		
Lagenorhynchus obliquidens	Pacific white-sided dolphin	X	X	X
Lissodelphis borealis	Northern right whale dolphin	X		
Orcinus orca	Killer whale	X	X	X
Stenella coeruleoalba	Striped dolphin	X		
Tursiops truncatus	Common bottlenose dolphin	X		
Porpoises (Family Phocoenida)				
Phocoena phocoena	Harbor porpoise	X	X	X
Phocoenoides dalli	Dall's porpoise	X	X	X
Beaked Whales (Family Ziphiidae)				
Berardius bairdii	Baird's beaked whale	X		
Mesoplodon carlhubbsi	Hubbs' beaked whale	X[3]		
Mesoplodon densirostris	Blainville's beaked whale	X[3]		
Mesoplodon ginkgodens	Ginkgo-toothed beaked whale	X[3]		
Mesoplodon perrini	Perrin's beaked whale	X[3]		
Mesoplodon peruvianus	Pygmy beaked whale	X[3]		
Mesoplodon stejnegeri	Stejneger's beaked whale	X[3]		
Ziphius cavirostris	Cuvier's beaked whale	X[3]		

Taxonomic Name	Common Name	NWTT Offshore	NWTT Inland Waters	NWTT Behm Canal
Pinnipeds (Order Carnivora[4], Suborder Pinnipedia)				
Arctocephalus townsendi	Guadalupe fur seal	X	X	
Callorhinus ursinus	Northern fur seal	X		X
Mirounga angustirostris	Northern elephant seal	X	X	X
Phoca vitulina	Pacific Harbor seal	X	X	X
Zalophus californianus	California sea lion	X	X	X
Eumetopias jubatus	Steller sea lion	X	X	X
Sea Turtles (Order Testudines, Suborder Cryptodira)				
Dermochelys coriacea	Leatherback sea turtle	X		

[1] Species for which existing data do not support the derivation of study-area specific density estimates do not have values included in the NMSDD Phase III. They are indicated in the table as an acknowledgement of possible occurrence without a density assigned. Blank cells indicate lack of expected regular occurrence within a given area.
[2] Study Area density estimates are represented by a genus (*Kogia* spp.).
[3] Study Area density estimates are represented by a small beaked whale guild (includes Cuvier's beaked whale and beaked whales of the genus *Mesoplodon*).

4.1 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. This conservative approach leads to observations that cannot be positively classified to species and thus fall into general groups such as "unidentified large cetacean" or guilds such as "*Kogia* species" (for the pygmy sperm whale [*Kogia breviceps*] and dwarf sperm whale [*Kogia sima*]). Those species that are more difficult to sight or identify are more likely than others to have large number of observations fall into the general groups. Challenges to identifying animals in the field can thus be an impediment to obtaining enough 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. Stocks are the management unit used by NMFS (Carretta et al., 2017b) 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). 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 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, as it does for species such as killer whales.

When possible, densities are provided for specific stocks, but for the majority of cases, densities are reported for the species as a whole.

4.1.1 Species Considered but Not Included

Spatially explicit, absolute 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 marine fishes and ESA-listed sea birds.

To the Navy's knowledge, the data needed to create spatially explicit, absolute at-sea density estimates for the ESA-listed fish species occurring within the NWTT Study Area do not exist, nor could they be readily created. As such, density estimates for fishes are not included in this technical report.

Little or no telemetry data are available for the ESA-listed sea birds expected to be in offshore areas of the NWTT Study Area. Although population estimates do exist for some seabird species, without robust information on distribution patterns, too many assumptions would need to be made to produce reasonable in-water density estimates for these species and, as such, they are excluded from this report. U.S. Fish and Wildlife Service has produced relative density models for guilds of sea birds, but these relative abundance models cannot be used for quantitative take estimation.

4.2 Density Data for the Northwest 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 or RES models for which density values vary throughout the range, a letter 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).

The majority of density estimates used in the NMSDD Phase III come from the sources and methods described in Sections 2 and 3 of this document. In some cases, density for a particular species could not be characterized by the data available from these sources. In those cases, information from scientific literature was used to derive a density estimate. This method relied mainly on information provided in peer-reviewed publications. In all cases the data sources were prioritized based on the descriptions in Sections 2.2.1 and 3.2 to ensure consistency with the hierarchical approach established to select density values.

4.2.2 MAPS

Maps from the Geographic Information System database used in NMSDD Phase III are provided for each species. Maps are only supplied for areas where a species is expected to occur. If a species does not occur in an area, a map will not be provided. For example, blue whales (*Balaenoptera musculus*) occur in the Offshore portion of the NWTT study area, but are not expected in the Inland Waters or Behm Canal. Therefore, there are blue whale density maps for the Offshore region, but not maps for the other two areas. 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. Therefore, for some species there may be a map for every season but, for many species, seasons will be combined or there will only be one annual map. If there is a difference in density values between seasons in the study areas, then a map will be provided for the seasons that differ. Seasons whose predicted densities are the same will be combined into one map that is labelled appropriately. Maps are not provided for seasons for which study area densities are expected to be zero.

The maps of species density should be interpreted with caution. Since the global models predict habitat suitability, they may not be consistent with values based on field data. Even designed-based and spatial models may differ by orders of magnitude at the borders of their predictive areas, because of differences in assumptions, ecological variables used in the models, and other factors. These differences between data sources can cause incongruities in density values displayed on maps. Ultimately, the Navy is most concerned with having the highest quality data in the areas where Navy exercises take place and where animals may be exposed to sound generated from Navy activities. For many of these areas, marine mammal and sea turtle densities are currently characterized in a satisfactory manner by the models available; however, there are ongoing efforts to improve density datasets, and the Navy will incorporate improved estimates into the NMSDD as they become available.

To ensure consistent representation throughout the report, a density classification scheme was developed that includes seven density classes with colors representing low (light blue) to higher (dark orange) values relative to each species. For species with seven or fewer unique density estimates per layer, exact values were assigned to each color in the density key. For species with greater than seven unique values, but with discrete values for large portions of the Study Area, a density range was assigned to each color in the density key and exact values were included on the map. Finally, for species with spatially explicit density estimates for relatively small areas (e.g., 100 km^2), a density range was assigned to each color in the density key and on the map.

5 BALEEN WHALES

5.1 BALEEN WHALES SPECIES PROFILES

5.1.1 *BALAENOPTERA ACUTOROSTRATA*, COMMON AND 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, affording good identification (Leatherwood et al., 1988; Perrin et al., 2009). 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°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., 2017b). 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., 2017b). The three NMFS stocks primarily fall into the IWC's "remainder of the Pacific" stock. Minke whales in the Offshore and Inland Waters regions of the NWTT Study Area are part of the California/Oregon/Washington stock, while animals in the Western Behm Canal portion belong to the Alaska stock.

Offshore. Density values for minke whales are available for the SWFSC Oregon/Washington (0.00130 animals/km^2; CV = 1.05) and Northern California (0.00034 animals/km^2; CV = 0.52) offshore strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates. Since they currently provide the best available density data for this species, these estimates were also used for winter/spring.

Inland Waters. Minke whales appear to establish home ranges in the inland waters of Washington (Dorsey, 1983; Dorsey et al., 1990). Minke whales are reported in the inland waters year-round, although the majority of the records are from March through November (Calambokidis & Baird, 1994). Minke whales are sighted primarily in the Strait of Juan de Fuca and San Juan Islands area, and are relatively rare in Puget Sound south of Admiralty Inlet (Washington Department of Fish and Wildlife, 2008). There are few sightings of minke whales in Hood Canal.

Published density estimates for minke whales in the Inland Waters of the United States are not available. However, Williams and Thomas (2007) provide line-transect density estimates for seven cetacean species based on ship surveys conducted in the Inside Passage of British Columbia, Canada, including the Strait of Juan de Fuca and areas just north of the San Juan Islands. The Williams and Thomas (2007) minke whale density estimate of 0.01 animals/km^2 (CV = 1.08) in the Strait of Juan de Fuca/Strait of Georgia is based on systematic ship surveys conducted in the summer of 2004 and 2005 and was used to characterize minke whale density in the Strait of Juan de Fuca/San Juan Islands region.

Based on 2006–2017 sighting data from Orca Network, an online forum available to the public to report and compile marine mammal sightings (www.orcanetwork.org), it was conservatively estimated that minke whale density in Puget Sound could be as high as 0.00045 animals/km^2. Given the lack of sighting data within Hood Canal, it was assumed that density would be reduced by two orders of magnitude (i.e., 0.0000045 animals/km^2) in this region. Minke whales are observed year-round and these density values are thus considered year-round estimates.

Western Behm Canal. For the Western Behm Canal, density estimates for all seasons were taken from the Marine Mammal Occurrence/Density Report prepared in support of a NEPA document for Navy activities at SEAFAC (U.S. Department of the Navy, 2010).

Table 5.1-1: Summary of Density Values for Minke Whale

Location	Spring	Summer	Fall	Winter
Offshore	0.00130–0.00034	0.00130–0.00034	0.00130–0.00034	0.00130–0.00034
Inland Waters	0.0000045–0.01	0.0000045–0.01	0.0000045–0.01	0.0000045–0.01
Western Behm Canal	0.0003	0.0008	0.0005	0.0003

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

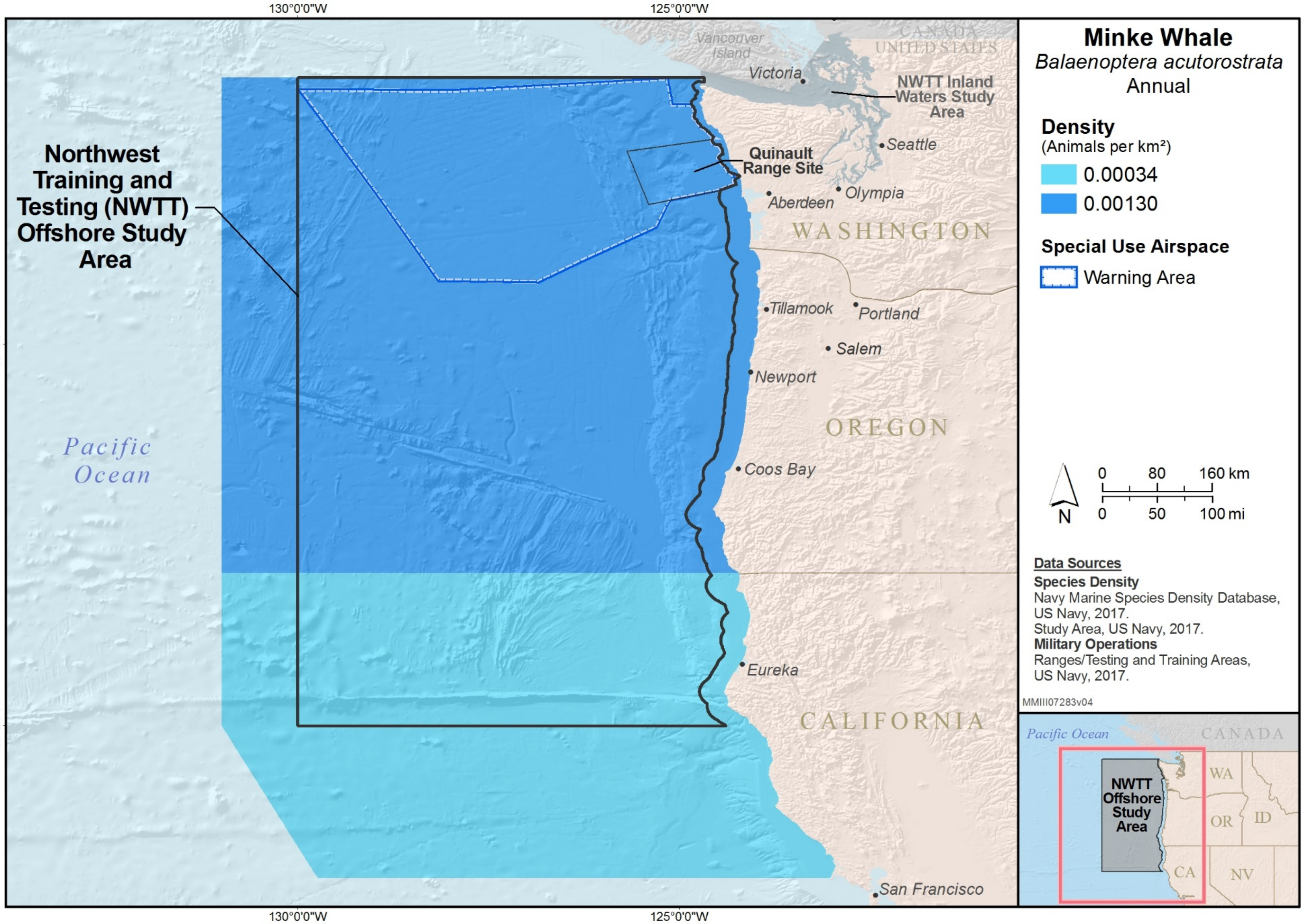


Figure 5.1-1: Offshore Annual Distribution of Minke Whale

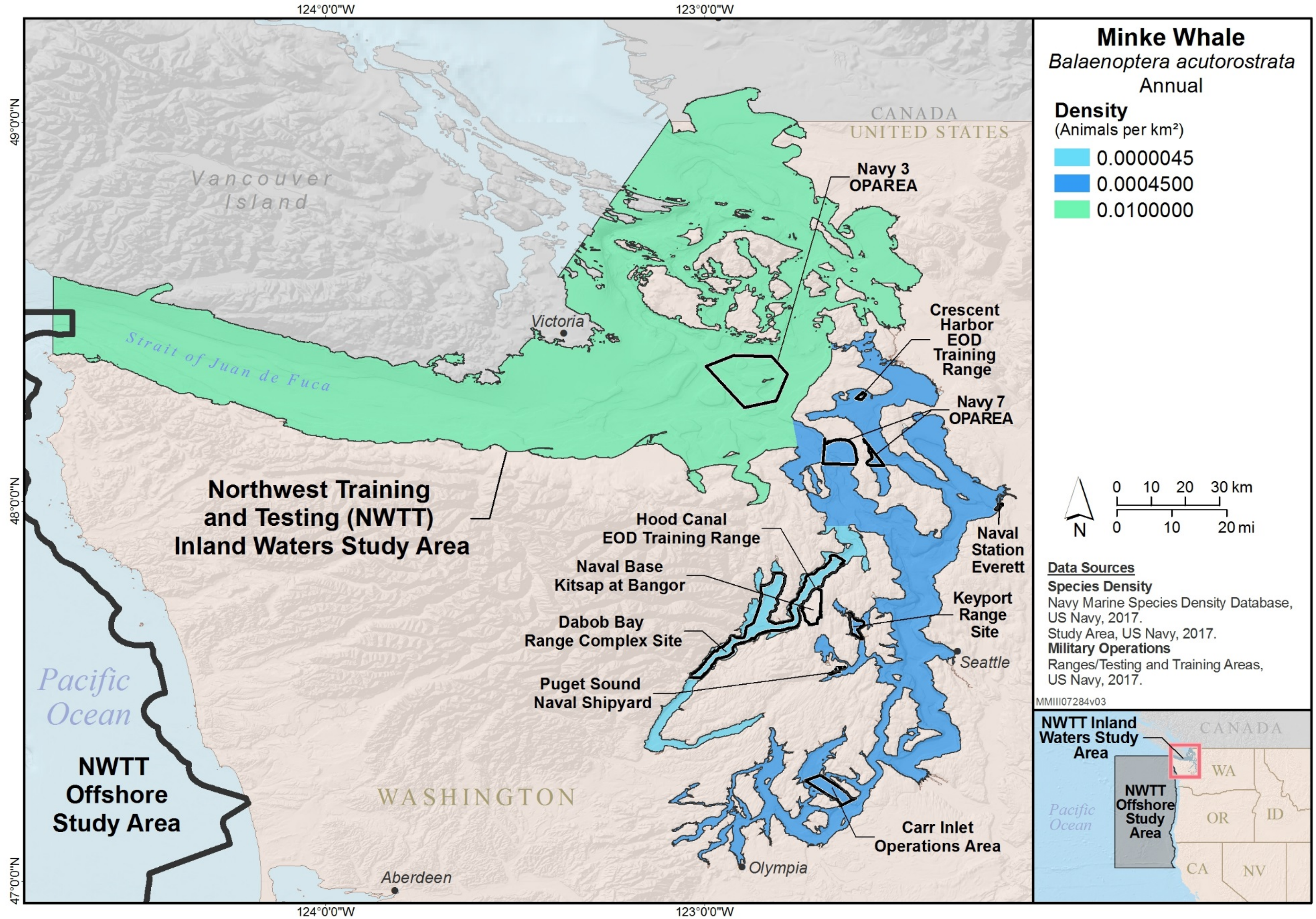


Figure 5.1-2: Inland Waters Annual Distribution of Minke Whale

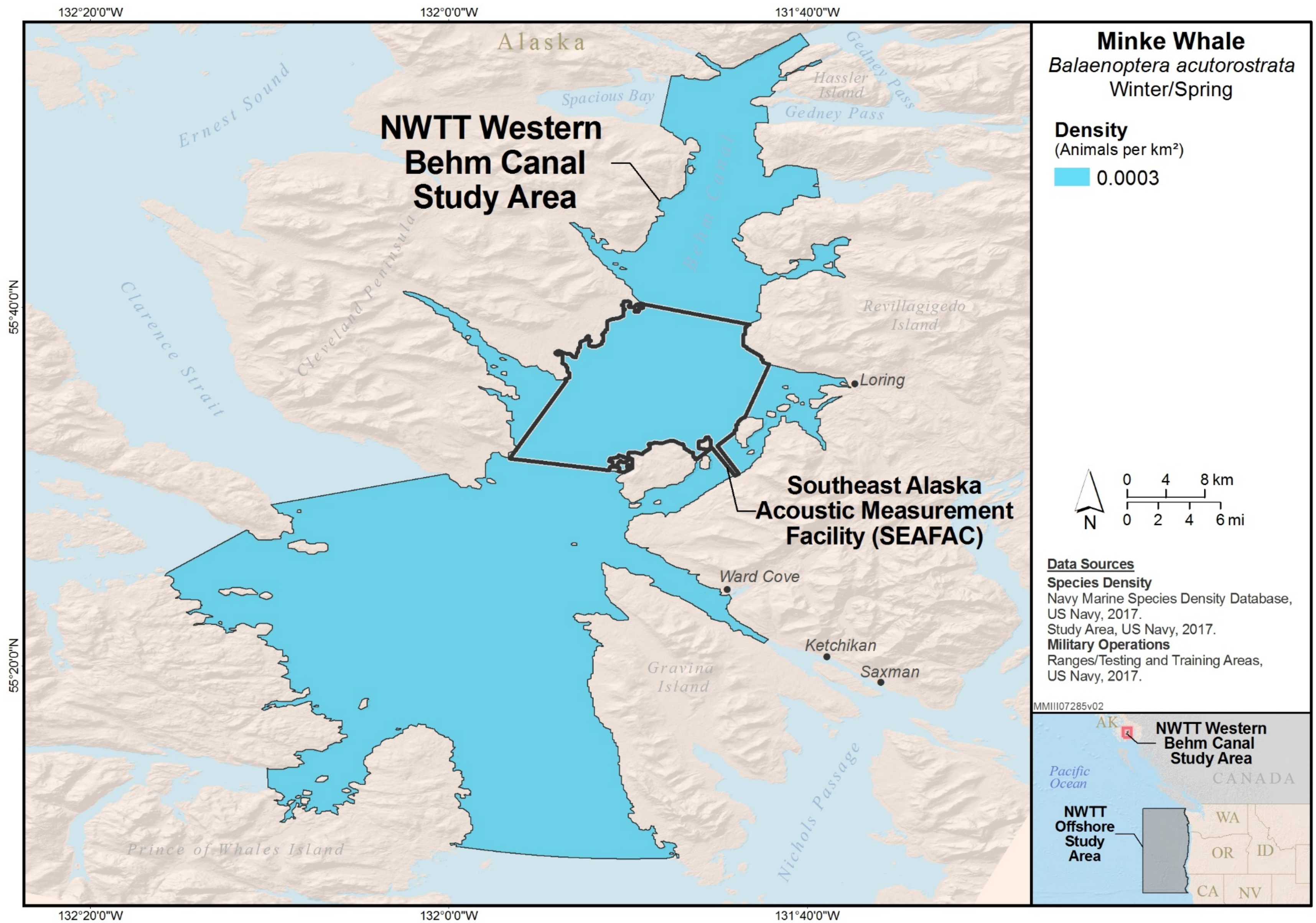


Figure 5.1-3: Western Behm Canal Winter/Spring Distribution of Minke Whale

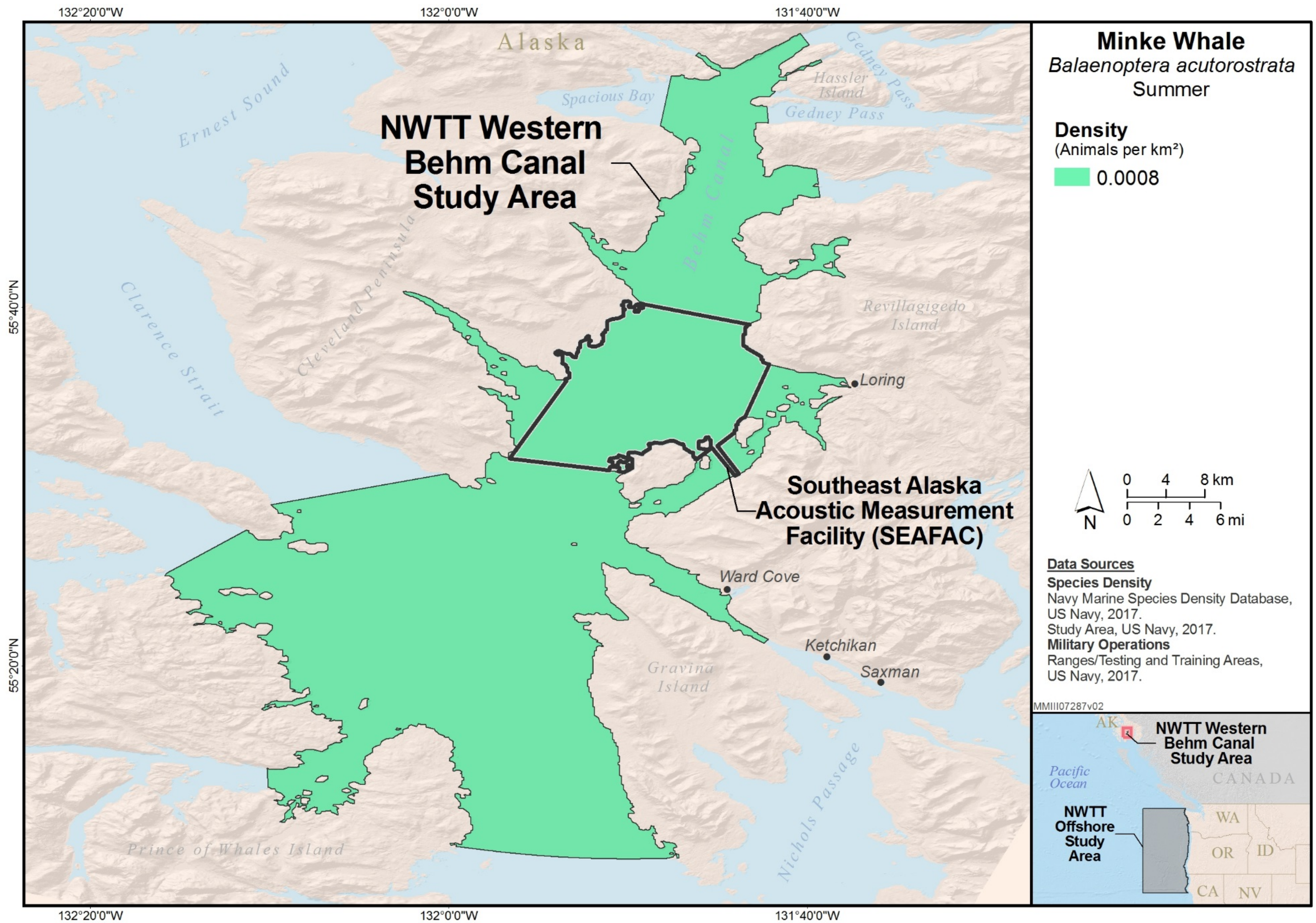


Figure 5.1-4: Western Behm Canal Summer Distribution of Minke Whale

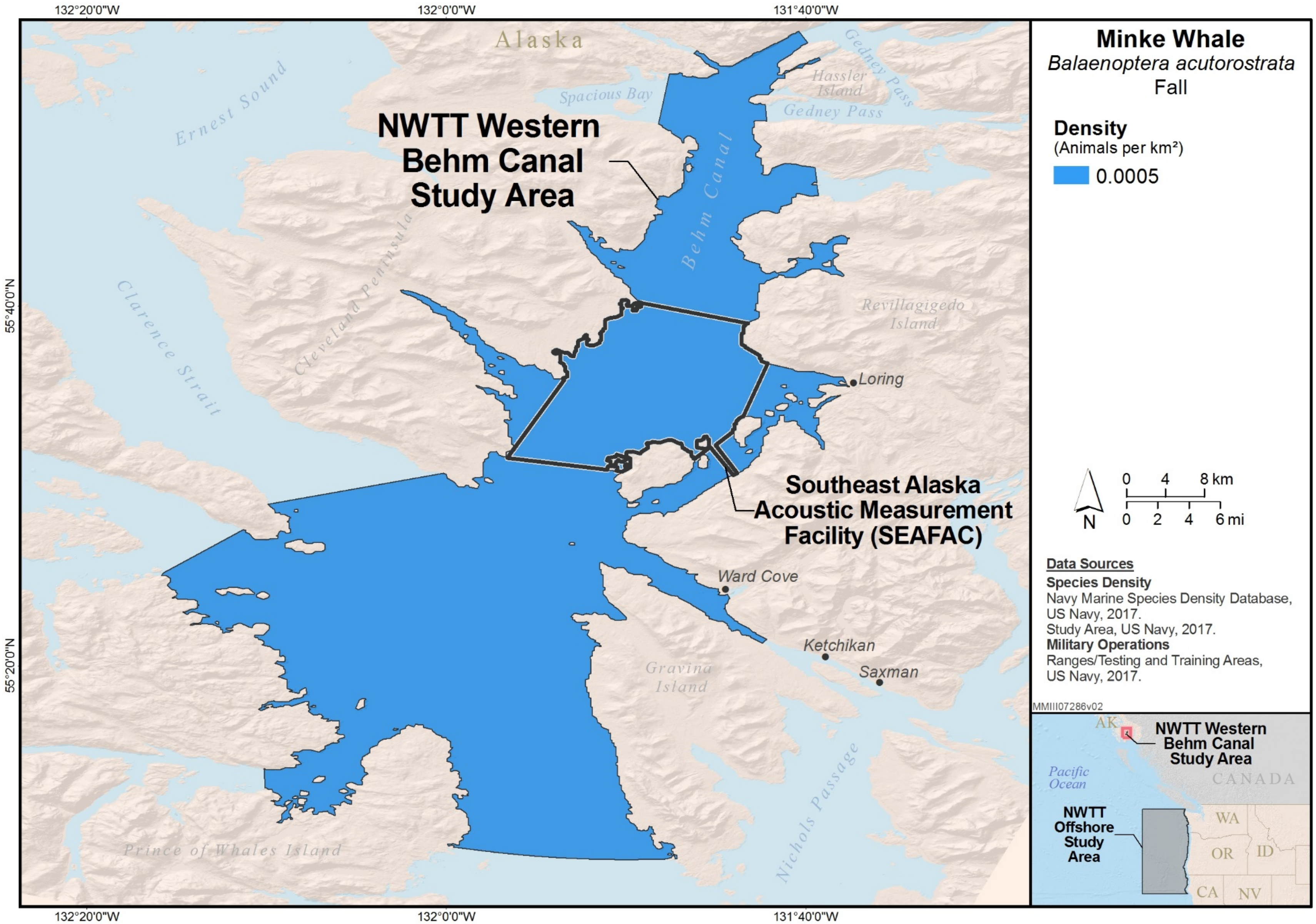


Figure 5.1-5: Western Behm Canal Fall Distribution of Minke Whale

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., 2009). 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., 2017b). Sei whales present in the Offshore region of the NWTT Study Area belong to the Eastern North Pacific stock.

Offshore. Density values for sei whales are available for the SWFSC Oregon/Washington (0.00040 animals/km^2; CV = 0.48) and Northern California (0.00032 animals/km^2; CV = 0.52) offshore strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates. Since they currently provide the best available density data for this species, these estimates were also used for winter/spring.

Inland Waters. Sei whales are considered rare/extralimital in the Inland Waters including Puget Sound. A sei whale washed ashore west of Port Angeles in the Strait of Juan de Fuca during September 2003 (Preston, 2003), but this is considered an unusual event.

Western Behm Canal. Sei whales are not expected to occur within the SEAFAC region of the Study Area since it is well inland of the areas normally inhabited by sei whales.

Table 5.1-2: Summary of Density Values for Sei Whale

Location	Spring	Summer	Fall	Winter
Offshore	0.00032–0.00040	0.00032–0.00040	0.00032–0.00040	0.00032–0.00040
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

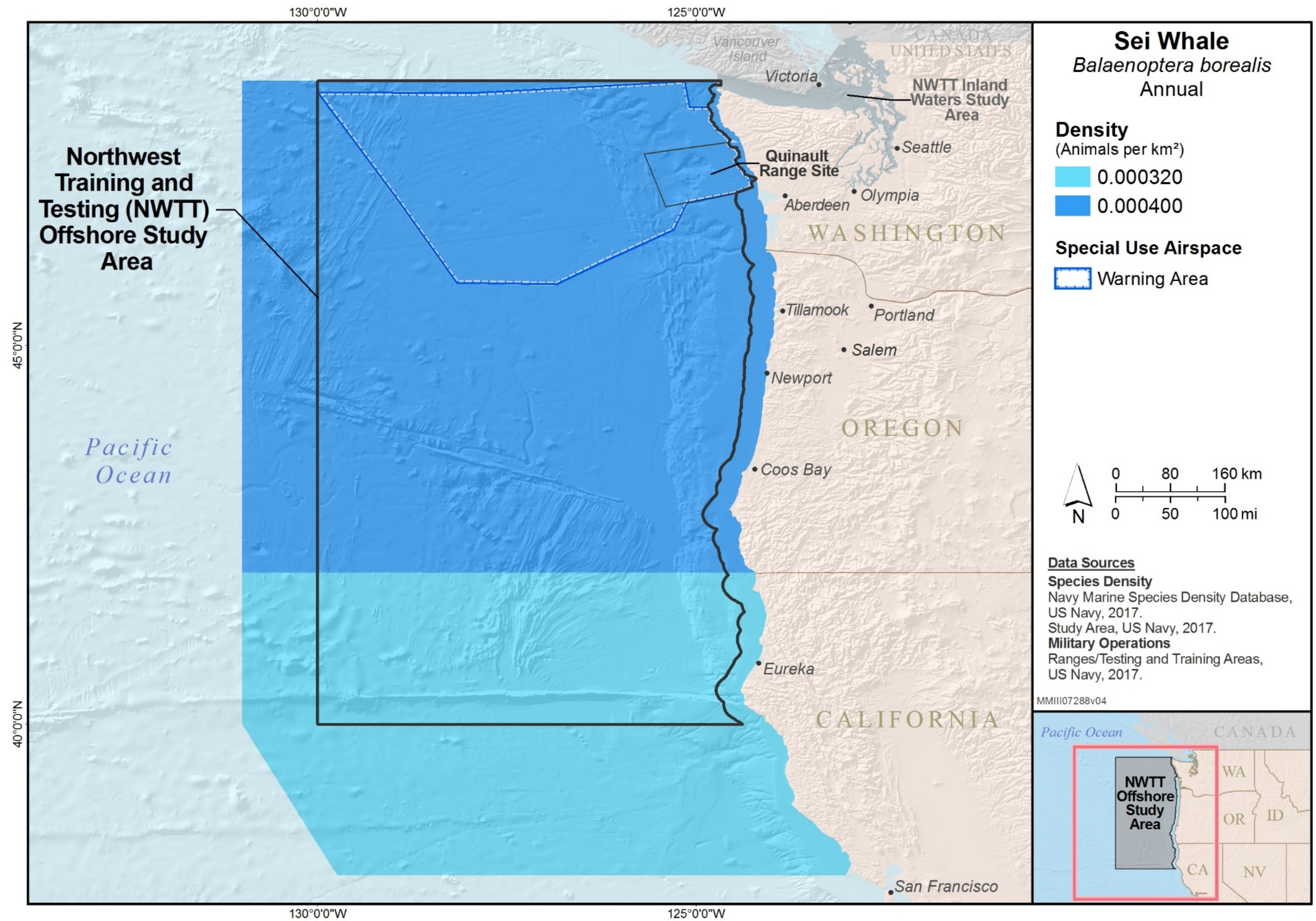


Figure 5.1-6: Offshore Annual Distribution of Sei Whale

5.1.3 *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). Because they are readily identifiable, density values for blue whales are available in the literature and NMFS reports for areas that have been surveyed.

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., 2017b). 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., 2017b). Blue whales in the NWTT Study Area belong to the Eastern North Pacific stock.

Offshore. The U.S. West Coast is a known feeding area for blue whales during summer and fall (Calambokidis et al., 2009), although primary occurrence for this species is south of 44°N (Forney et al., 2012; Hamilton et al., 2009). NMFS SWFSC developed a CCE habitat-based density model for blue whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Hazen et al. (2016) developed telemetry-based habitat models for blue whales that provide year-round spatially explicit density estimates for waters off the U.S. West Coast. Monthly predictions were available for December to May of 2009, 2016, and 2017, and were averaged to provide representative density estimates for the winter/spring season.

Inland Waters. Blue whales are not expected to occur within the Inland Waters region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

Western Behm Canal. Blue whales are not expected to occur within the Western Behm Canal region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

Table 5.1-3: Summary of Density Values for Blue Whale

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

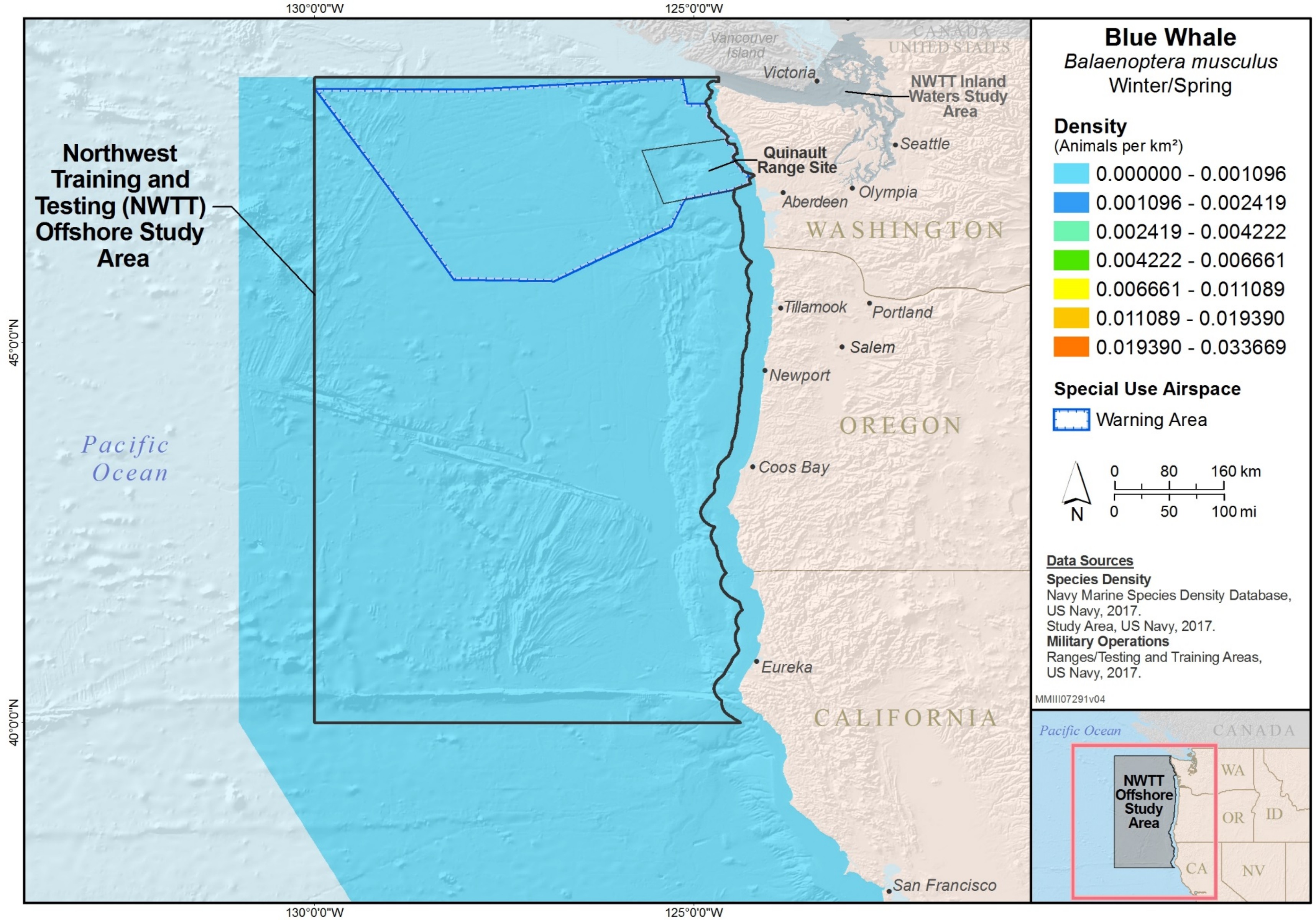


Figure 5.1-7: Offshore Winter/Spring Distribution of Blue Whale

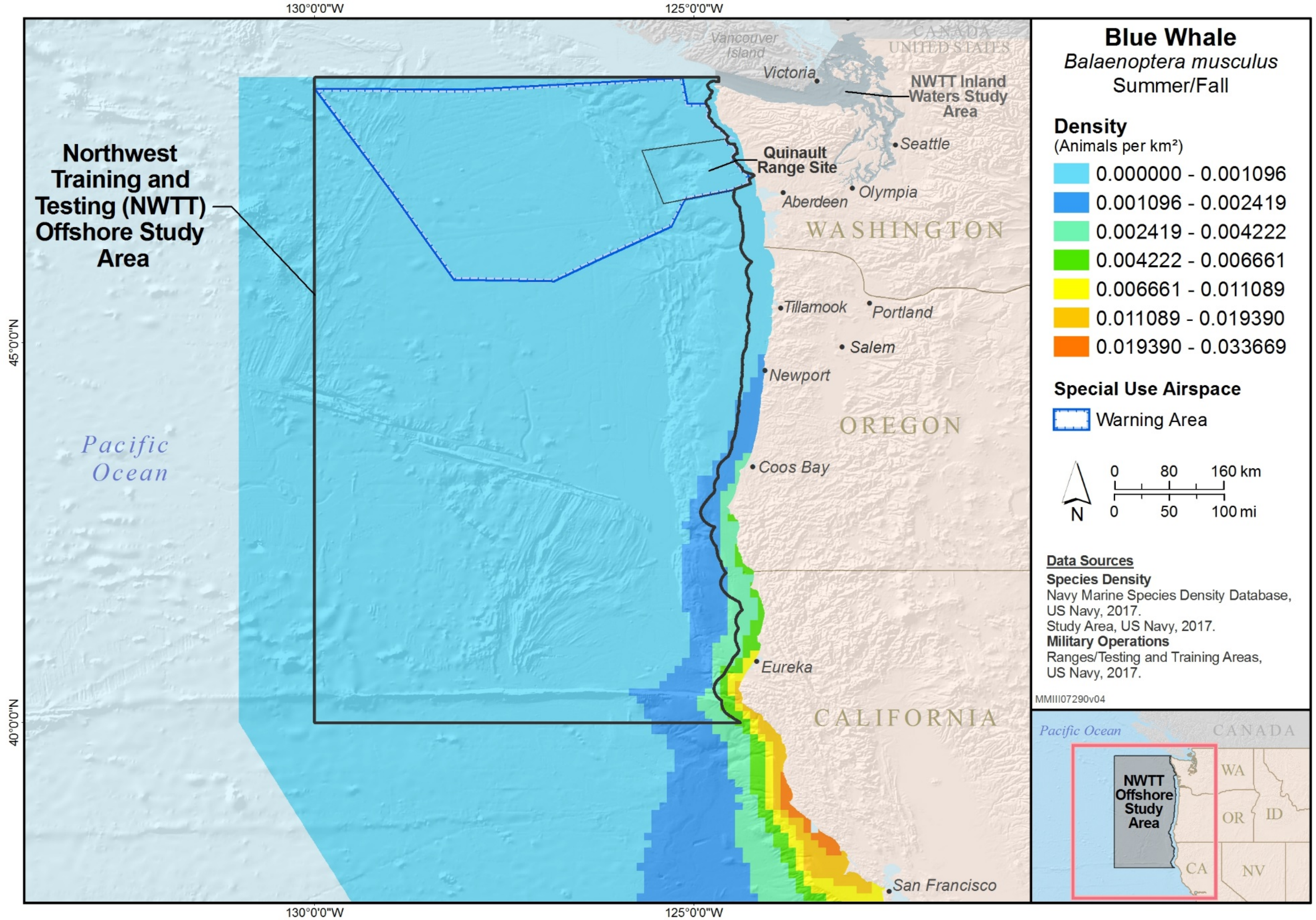


Figure 5.1-8: Offshore Summer/Fall Distribution of Blue Whale

5.1.4 *BALAENOPTERA PHYSALUS*, FIN WHALE

Fin whales are, overall, 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: the Northeast Pacific stock, the California/Oregon/Washington stock, and the Hawaii stock (Carretta et al., 2017b). In the NWTT Study Area, fin whales in the Offshore or Western Behm Canal regions are likely from the California/Oregon/Washington and Alaska stocks, respectively.

Offshore. Fin whales occur year-round off the U.S. West Coast (Barlow & Forney, 2007; Moore et al., 1998; Oleson et al., 2009; Širović et al., 2012a; Širović et al., 2012b). NMFS SWFSC developed a CCE habitat-based density model for fin whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Winter/spring density data for fin whales are not available. Although the Navy has two High-frequency Acoustic Recording Packages off the coast of Washington that have provided year-round acoustic data, call rates for fin whales are seasonal so these acoustic data are not informative for making inferences about seasonal abundance. Campbell et al. (2015) published seasonal density estimates of fin whale based on quarterly California Cooperative Oceanic Fisheries Investigations (CalCOFI) survey data collected off southern California; however, this study excluded the CalCOFI sampling stations located off central California. In order to provide a more representative sample and to reduce the potential bias associated with resident fin whales present off Southern California year-round, relative density estimates for winter/spring and summer/fall were derived from the 2005–2015 CalCOFI survey data collected from the full study area (i.e., up to approximately 38°N latitude). Relative density/abundance was calculated from 20 CalCOFI surveys conducted during summer/fall and 20 CalCOFI surveys conducted during winter/spring to provide a ratio of seasonal abundance. Since the estimates include the Southern California resident fin whales, the derived ratio (0.22) is conservative; however, it provides a measure of what might be expected off Northern California, Oregon, and Washington in terms of overall seasonal abundance ratios. Therefore, based on input from NMFS SWFSC, the summer/fall distributions from the habitat-based density model were prorated by this derived ratio to account for seasonal differences in abundance.

Inland Waters. Fin whales are currently extremely rare within the Inland Waters. Strandings reported within Puget Sound have all been individuals struck by ships, and they presumably were carried on the bow into the sound (Norman et al., 2004).

Western Behm Canal. For the Western Behm Canal, density estimates for all seasons were taken from the Marine Mammal Occurrence/Density Report prepared in support of a NEPA document for Navy activities at SEAFAC (U.S. Department of the Navy, 2010).

Table 5.1-4: Summary of Density Values for Fin Whale

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0.0001	0.0001	0.0001	0.0001

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

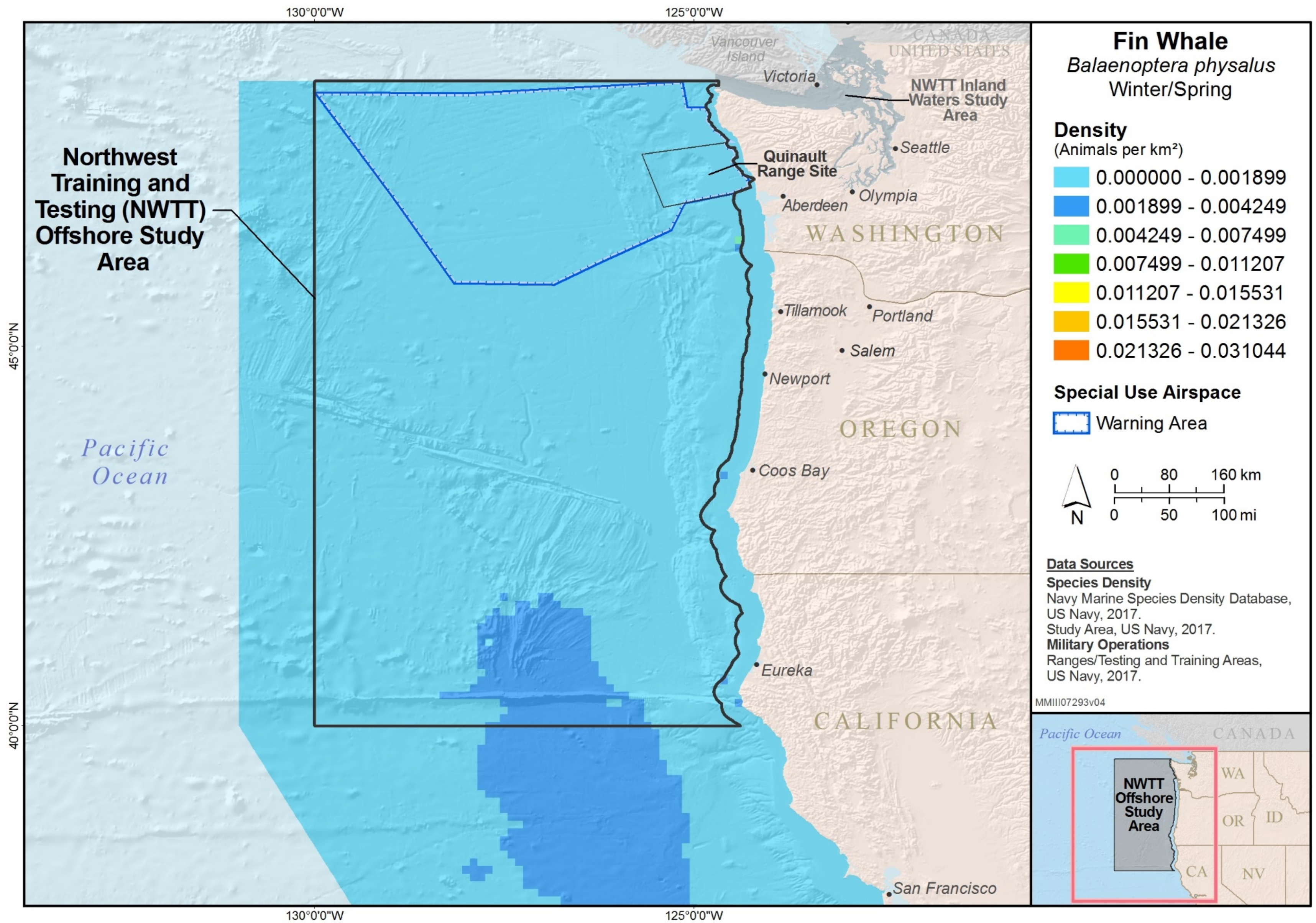


Figure 5.1-9: Offshore Winter/Spring Distribution of Fin Whale

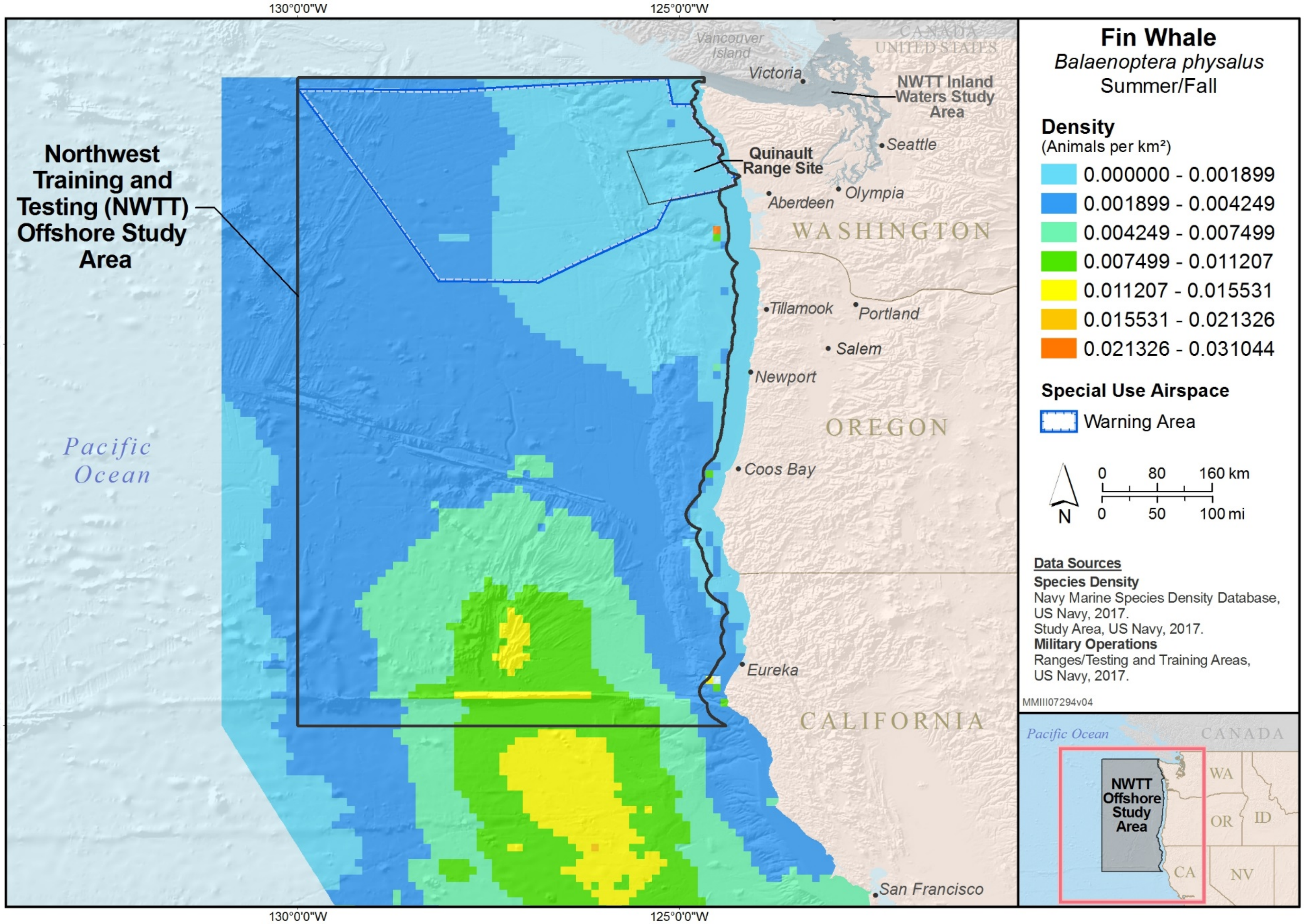


Figure 5.1-10: Offshore Summer/Fall Distribution of Fin Whale

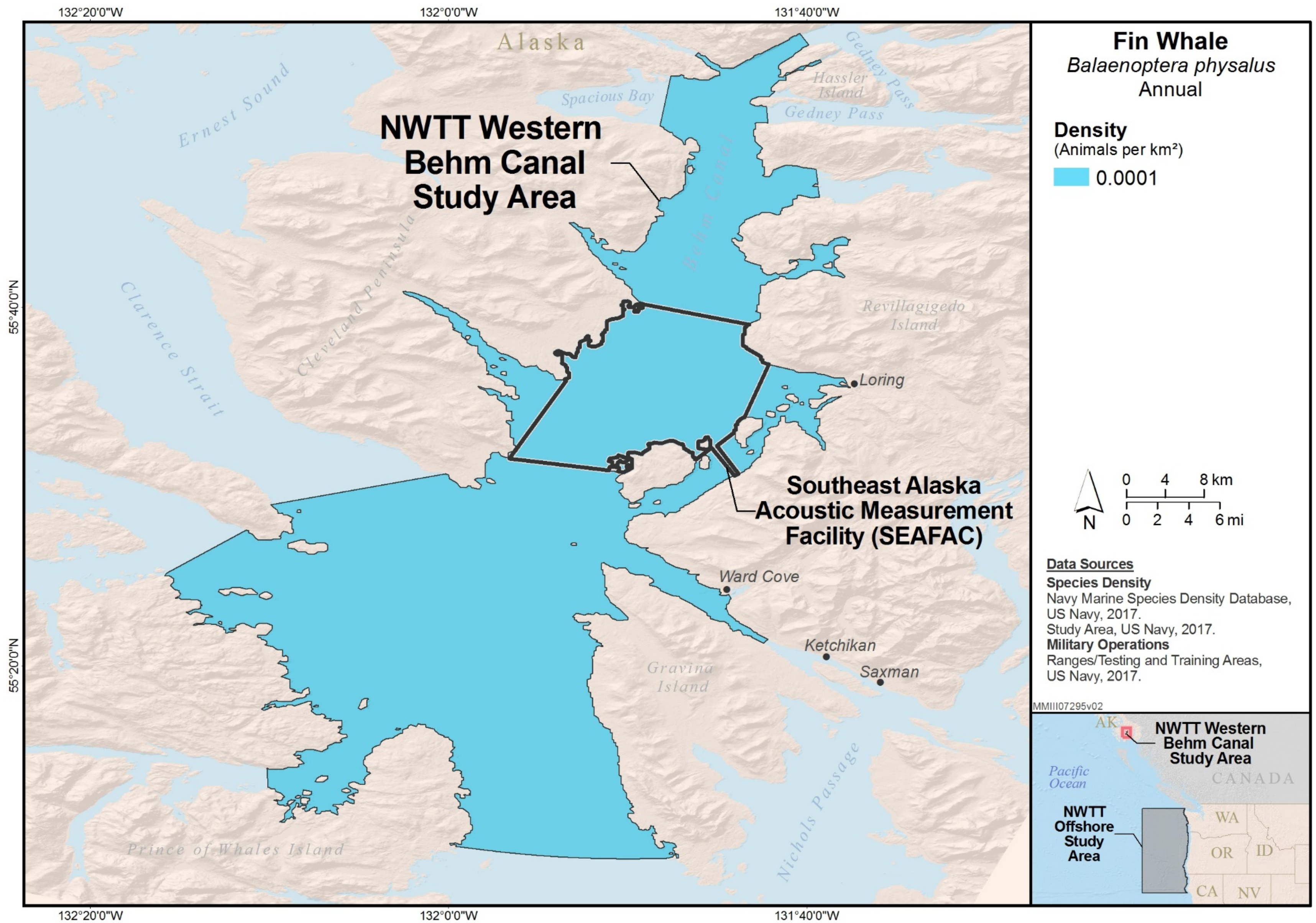


Figure 5.1-11: Western Behm Canal Annual Distribution of Fin Whale

5.1.5 *ESCHRICHTIUS ROBUSTUS*, GRAY WHALE

The gray whale is distinctive in appearance, with a small dorsal hump and many barnacles and irregularities on their skin, which is a uniform light gray (Jones et al., 1984). NMFS recognizes two stocks of gray whales in the North Pacific: the larger Eastern North Pacific stock and the highly endangered Western North Pacific stock (Carretta et al., 2017b); the IWC also recognizes the same two stocks. Until recently, these two stocks were considered exclusive from each other, but recent satellite tagging and photo mark-recapture data have suggested that there is some exchange of individuals (Mate et al., 2013; Mate et al., 2015). Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were sighted off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al., 2013). While it is possible that sightings of western population animals might be included in the data used to estimate gray whale density in the Eastern North Pacific, given the current paucity of data regarding the western population, as well as the very low population numbers, separate density estimates for the western population were not included in the NMSDD Phase III. Density values in the NMSDD Phase III are thus presumed to apply to the Eastern North Pacific stock of gray whales.

Eastern North Pacific gray whales are a nearshore species that migrate from feeding areas in the Bering and Chukchi Seas and the coast of the Alaskan Bight, British Columbia, and the Pacific Northwest to breeding areas in Baja California, Mexico (Jones et al., 1984; Rice & Wolman, 1971). They pass through the offshore region of the NWTT Study Area during their migration, and occasionally enter the Inland Waters.

A group of a few hundred gray whales known as the Pacific Coast Feeding Group (PCFG) feeds along the Pacific coast between Southeast Alaska and Southern California throughout the summer and fall (Calambokidis et al., 2002). This group of whales has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al., 2017b). Photo-identification, telemetry, and genetic studies suggest that the PCFG is demographically distinct (Calambokidis et al., 2010; Frasier et al., 2011; Mate et al., 2010). Currently, the PCFG is not treated as a distinct stock in the NMFS Stock Assessment Reports, but this may change in the future based on new information (Carretta et al., 2017b).

Offshore. DeAngelis et al. (2011) developed a migration model that provides monthly, spatially explicit predictions of gray whale abundance along the U.S. West Coast from December through June. These monthly density estimates apply to a “main migration corridor” that extends from the coast to 10 km offshore. A zone from the main migration corridor out to 47 km offshore is designated as an area of “potential presence”. To derive a density estimate for this area the Navy assumed that 1 percent of the population could be within the 47-km “potential presence” area during migration. Given the stock assessment population estimate of 20,990 animals (Carretta et al., 2017b), approximately 210 gray whales may use this corridor. Assuming the migration wave lasts 30 days, then 7 whales on average on any one day could occur in the "potential presence" area. The area from the main migration route offshore to 47 km within the NWTT study area = 45,722.06 km^2, so density within this zone = 0.00015 whales/km^2.

From July–November, gray whale occurrence off the coast is expected to consist primarily of whales belonging to the PCFG. Calambokidis et al. (2012) provided an updated analysis of the abundance of the PCFG whales in the Pacific Northwest and recognized that this group forms a distinct feeding aggregation. Calambokidis et al. (2015) identified five Biologically Important Areas (BIAs) along the U.S. West Coast that support the PCFG feeding aggregations. All the BIAs are in coastal nearshore waters where 77 percent of the PCFG whales were documented. The 2016 Final Pacific Stock Assessment Report (Carretta et al., 2017b) provides an abundance estimate of 209 whales (CV = 0.07) for the PCFG. For the purposes of establishing density, the Navy assumed that from July 1 to November 30 all the 209 PCFG whales could be present off the coast in the Northern California/Oregon/Washington region (this accounts for the potential that some PCFG whales may be outside of the area but that there also may be some non-PCFG whales in the region as noted by Calambokidis et al.(2012)). Given that the PCFG whales are found largely nearshore, it was assumed that all the whales could be within 10 km of the coast. To capture the potential presence of whales further offshore (e.g., Oleson et al., 2009), it was assumed that a percentage of the whales could be present from 10 km out to 47 km off the coast; the 47 km outer limit is consistent with the DeAngelis et al. (2011) migration model. Since 77 percent of the PCFG sightings were within the nearshore BIAs (Calambokidis et al., 2015), it was assumed that 23 percent (48 whales) could potentially be found further offshore. Two strata were thus developed for the July–November gray whale density layers: (1) from the coast to 10 km offshore, and (2) from 10 km to 47 km offshore. Based on the area calculations for these strata, density estimates were as follows:

- Density = 0.0155 animals/km^2 for the stratum from the coast to 10 km offshore
- Density = 0.0010 animals/km^2 for the stratum from 10 km to 47 km offshore
- Density = 0 for areas offshore of 47 km

Inland Waters. Based on sightings from Orca Network, an online forum available to the public to report and compile marine mammal sightings (www.orcanetwork.org), it was conservatively assumed that 10 percent of gray whales migrating offshore in the winter/spring may occur in the Strait of Juan de Fuca and the San Juan Islands. Since the offshore estimates for December through June were based on a migration model (DeAngelis et al., 2011) and are thus spatially explicit, the average value of the pixels at the entrance to the Strait of Juan de Fuca from the migration model were used to provide an average estimate for the Strait of Juan de Fuca and the San Juan Islands (0.0084 animals/km^2). During the summer/fall, when the PCFG is present, it was conservatively assumed that 30 percent of gray whales offshore may occur in the Strait of Juan de Fuca and the San Juan Islands (0.0047 animals/km^2).

As verified by sightings recorded by the Orca Network, the majority of gray whales within Puget Sound are found in north Puget Sound in the spring; a conservative density estimate of 0.0048 animals/km^2 was thus applied to this area based on sighting records. Given the fewer number of sightings in north Puget Sound for the remaining seasons, a density estimate of 0.00086 animals/km^2 was applied. Based on the few sightings of gray whales in the remainder of Puget Sound, it was assumed that 10 percent of the whales that occur in north Puget Sound would occur within south Puget Sound and Hood Canal seasonally (i.e., 0.00048 animals/km^2 in spring and 0.000086 animals/km^2 in summer/fall/winter).

Western Behm Canal. Gray whales were not observed during 1991–2007 surveys of the inland waters of Southeast Alaska (Dahlheim et al., 2009), and they are considered extralimital in this region of the NWTT Study Area.

Table 5.1-5: Summary of Density Values for Gray Whale

Location	Spring	Summer	Fall	Winter
Offshore: 0–10 km from shore	S	0.0155	0.0155	S
Offshore: 10-47 km from shore	0.00015	0.0010	0.0010	0.00015
Inland Waters	0.00048 –0.0084	0.000086–0.0047	0.000086–0.0047	0.000086–0.0084
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

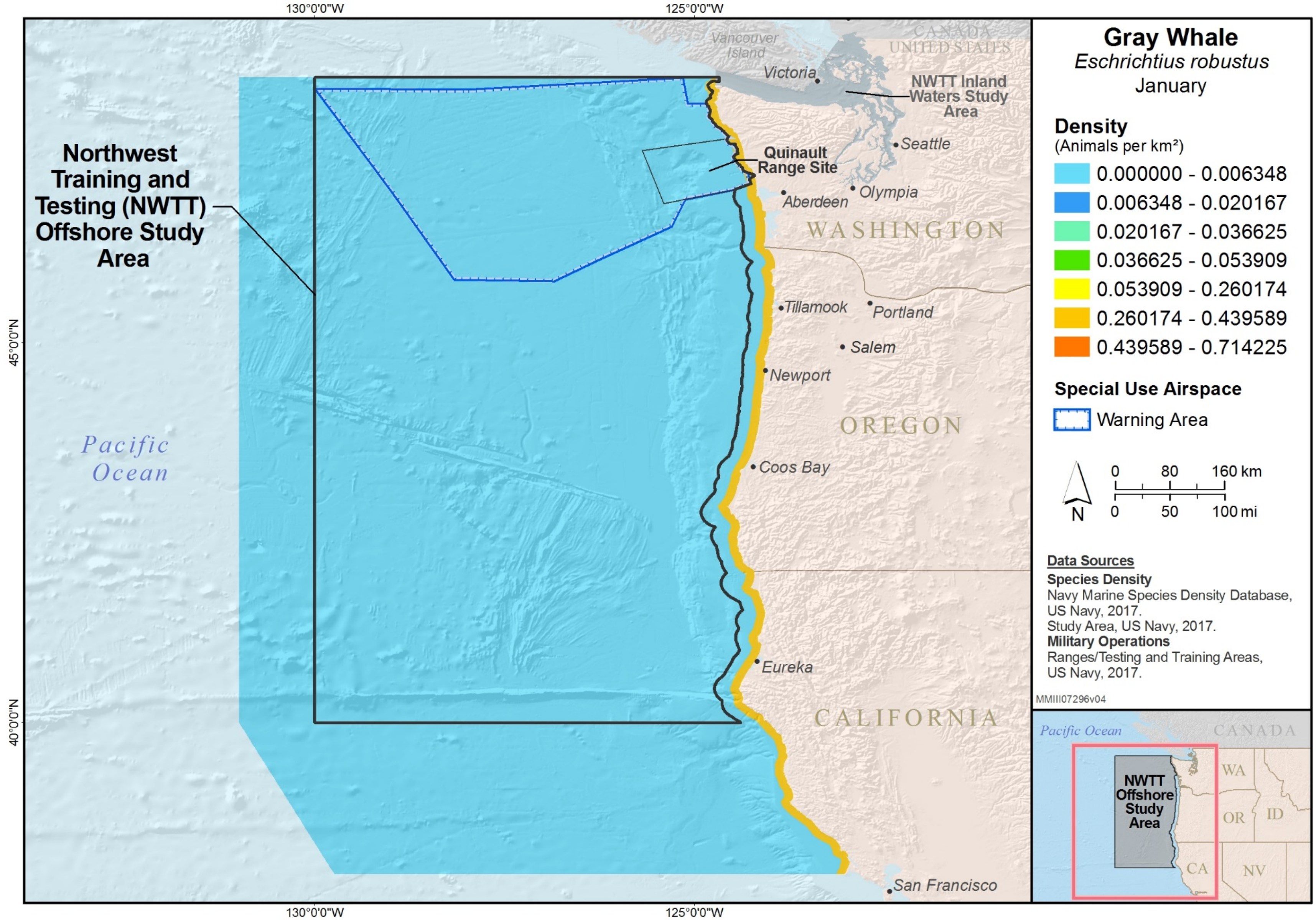


Figure 5.1-12: Offshore January Distribution of Gray Whale

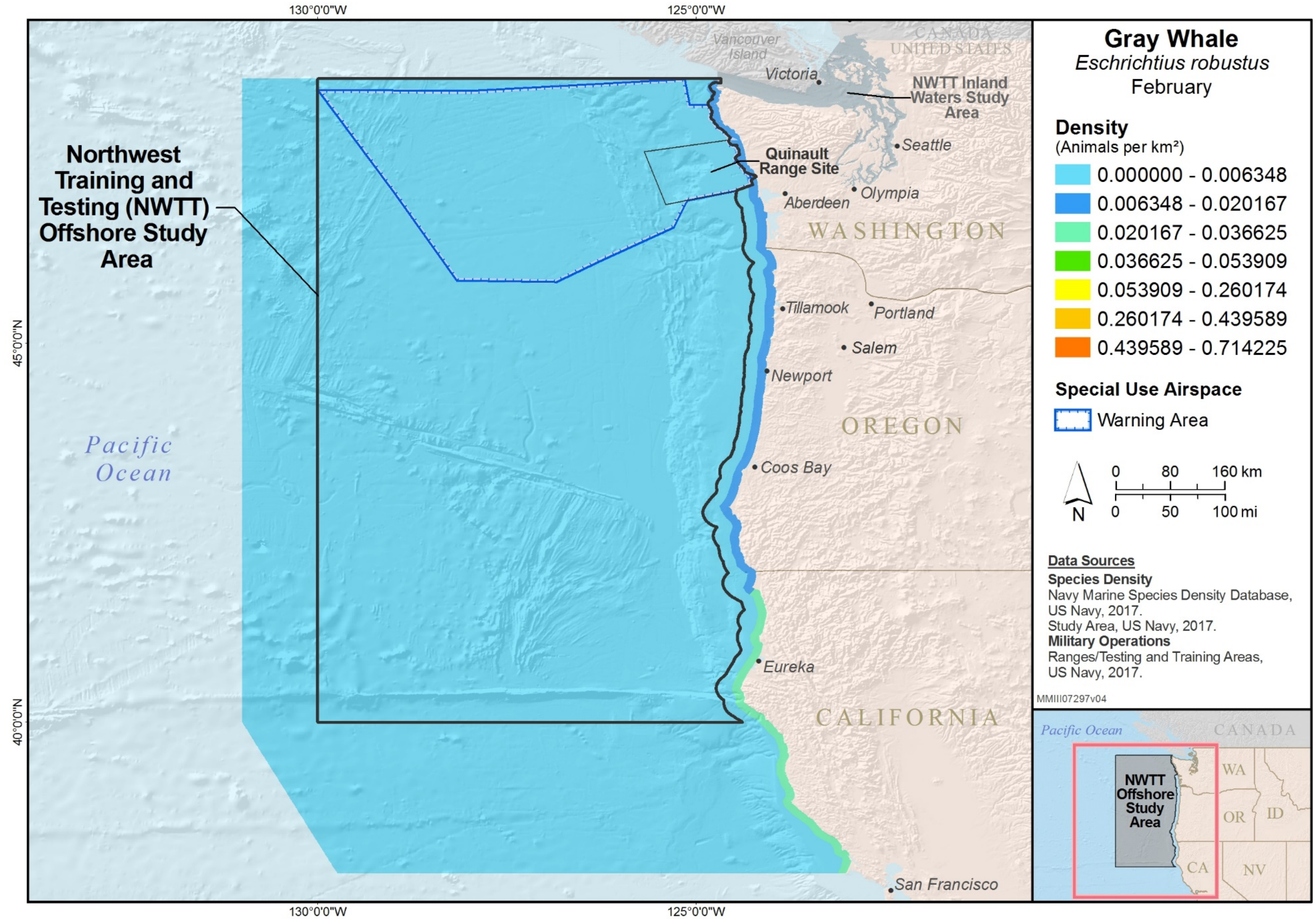


Figure 5.1-13: Offshore February Distribution of Gray Whale

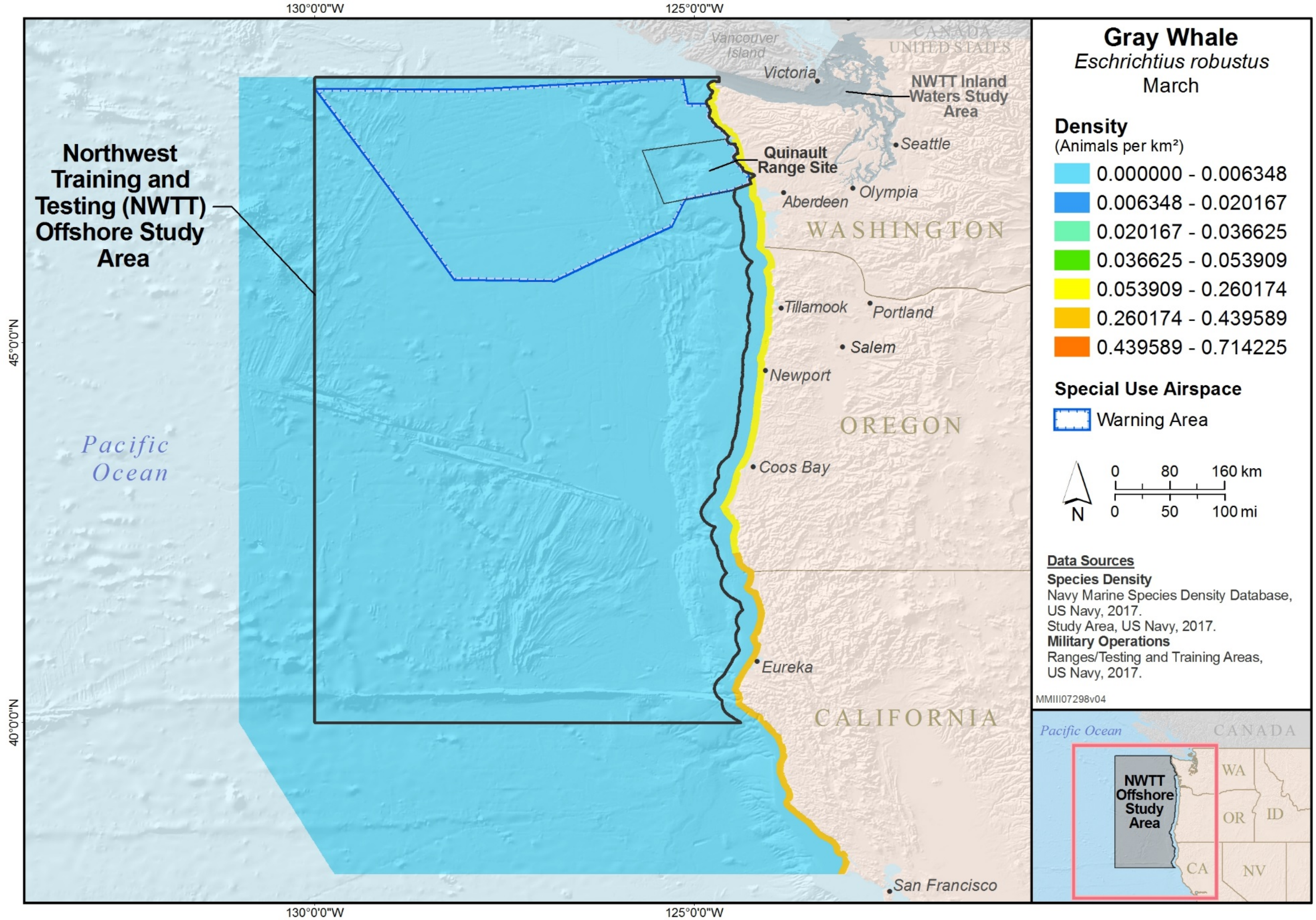


Figure 5.1-14: Offshore March Distribution of Gray Whale

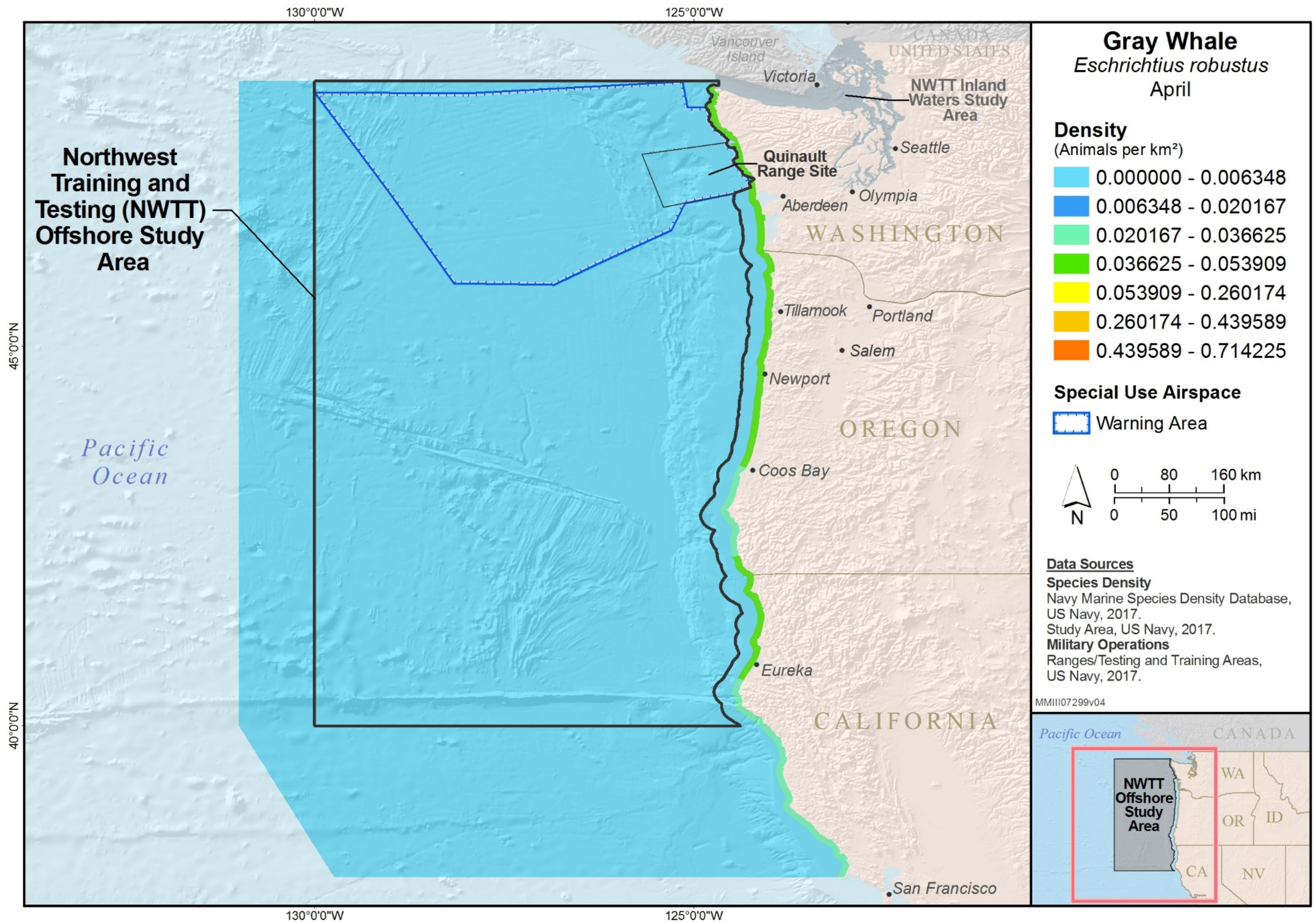


Figure 5.1-15: Offshore April Distribution of Gray Whale

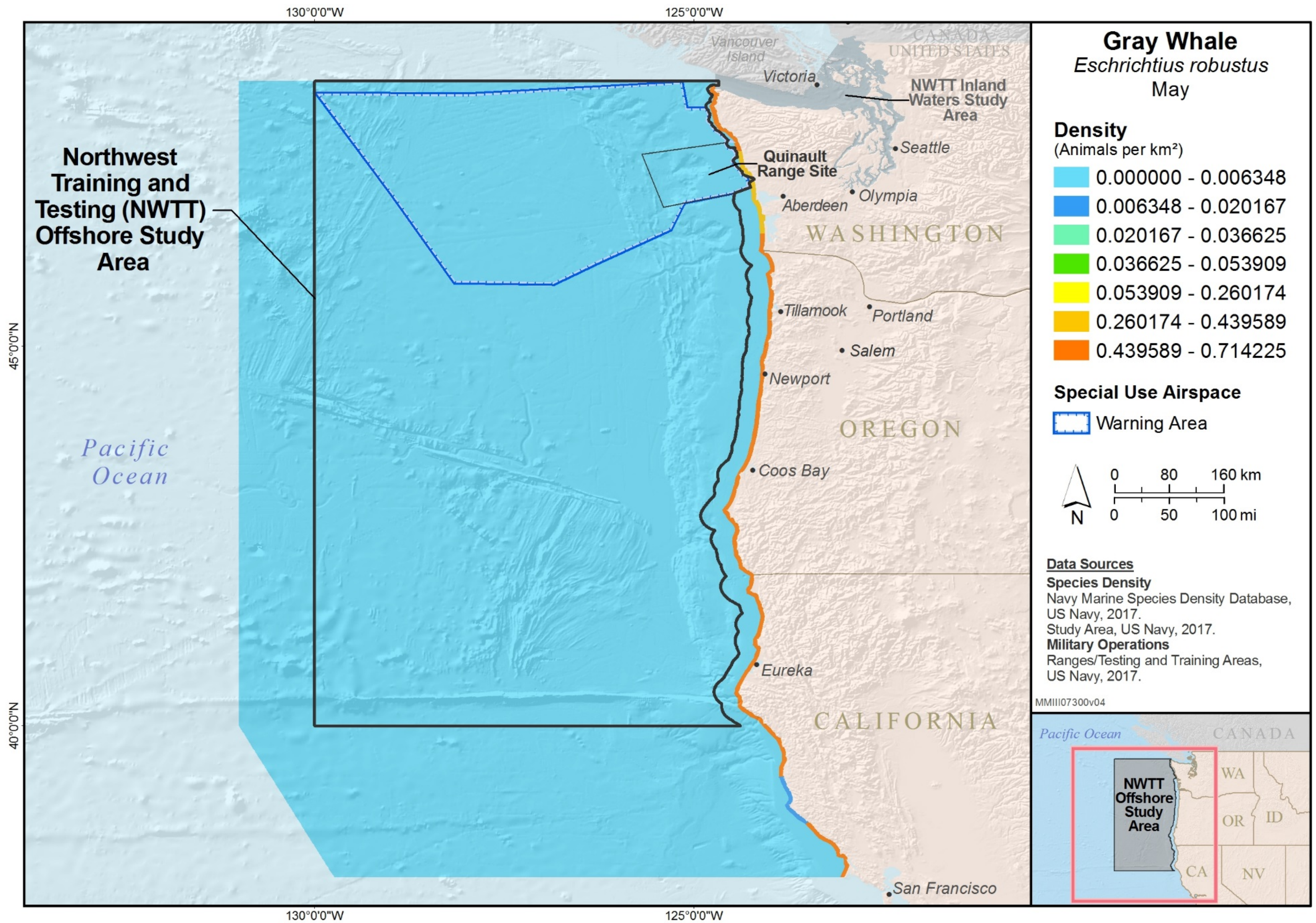


Figure 5.1-16: Offshore May Distribution of Gray Whale

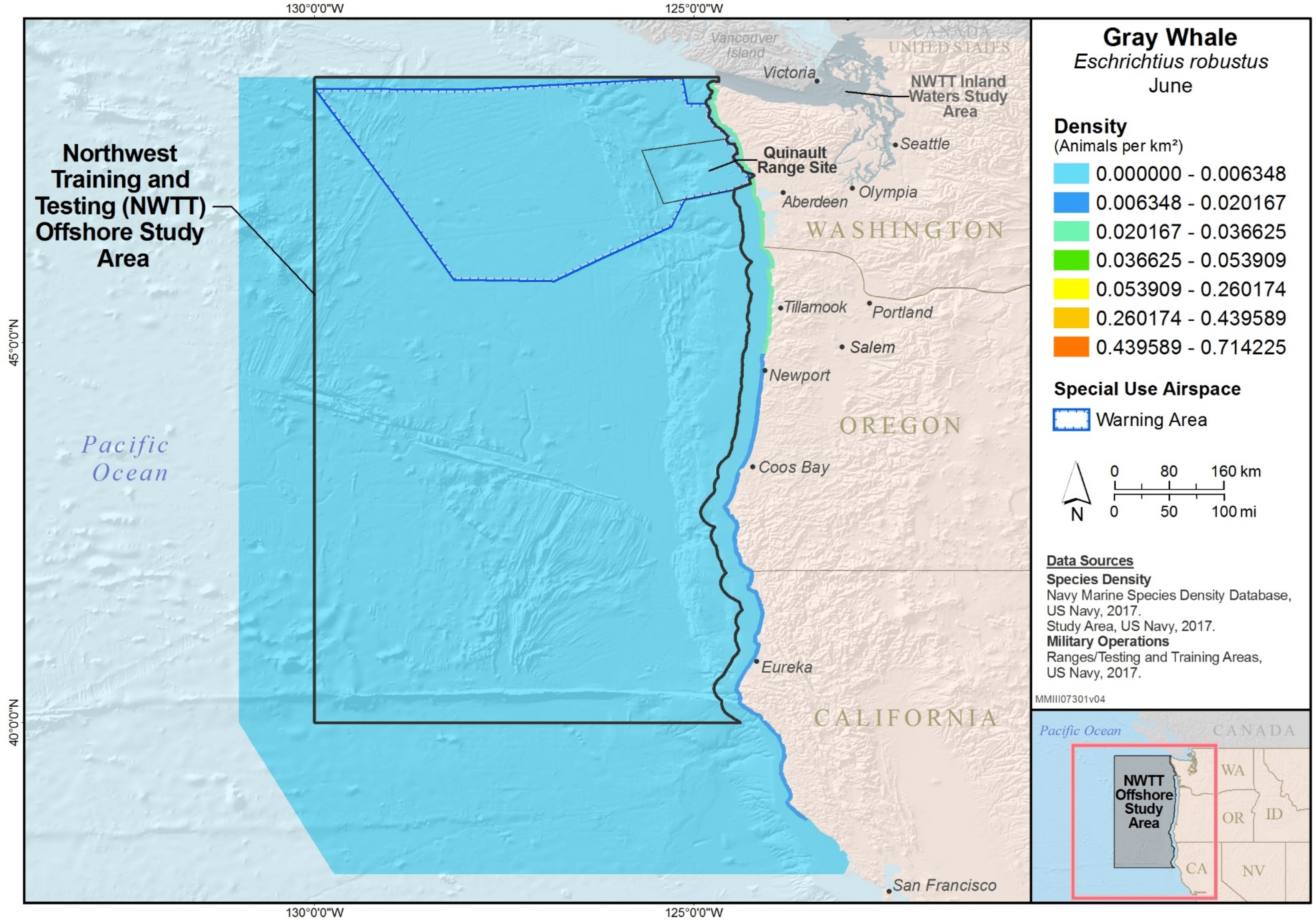


Figure 5.1-17: Offshore June Distribution of Gray Whale

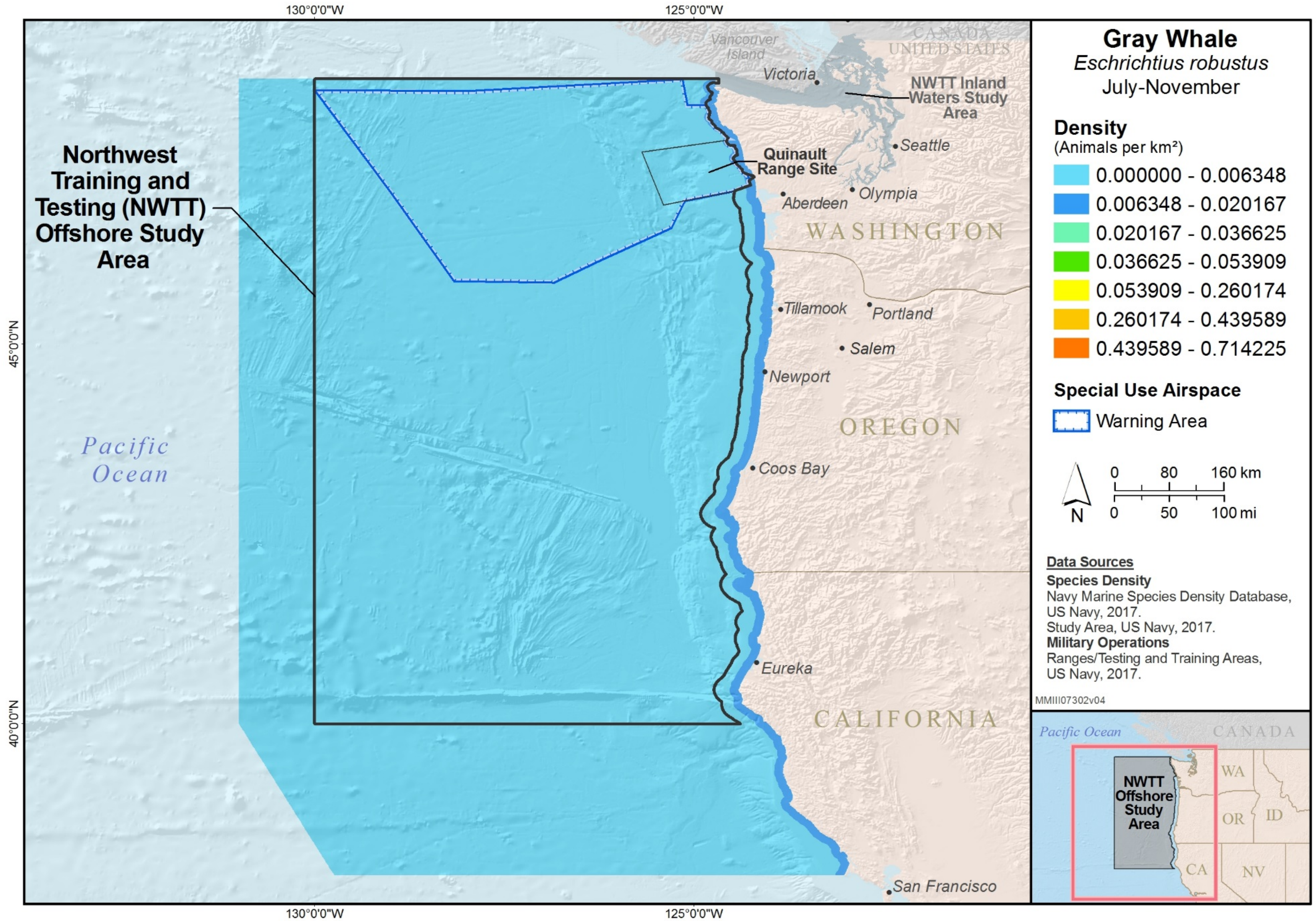


Figure 5.1-18: Offshore July–November Distribution of Gray Whale

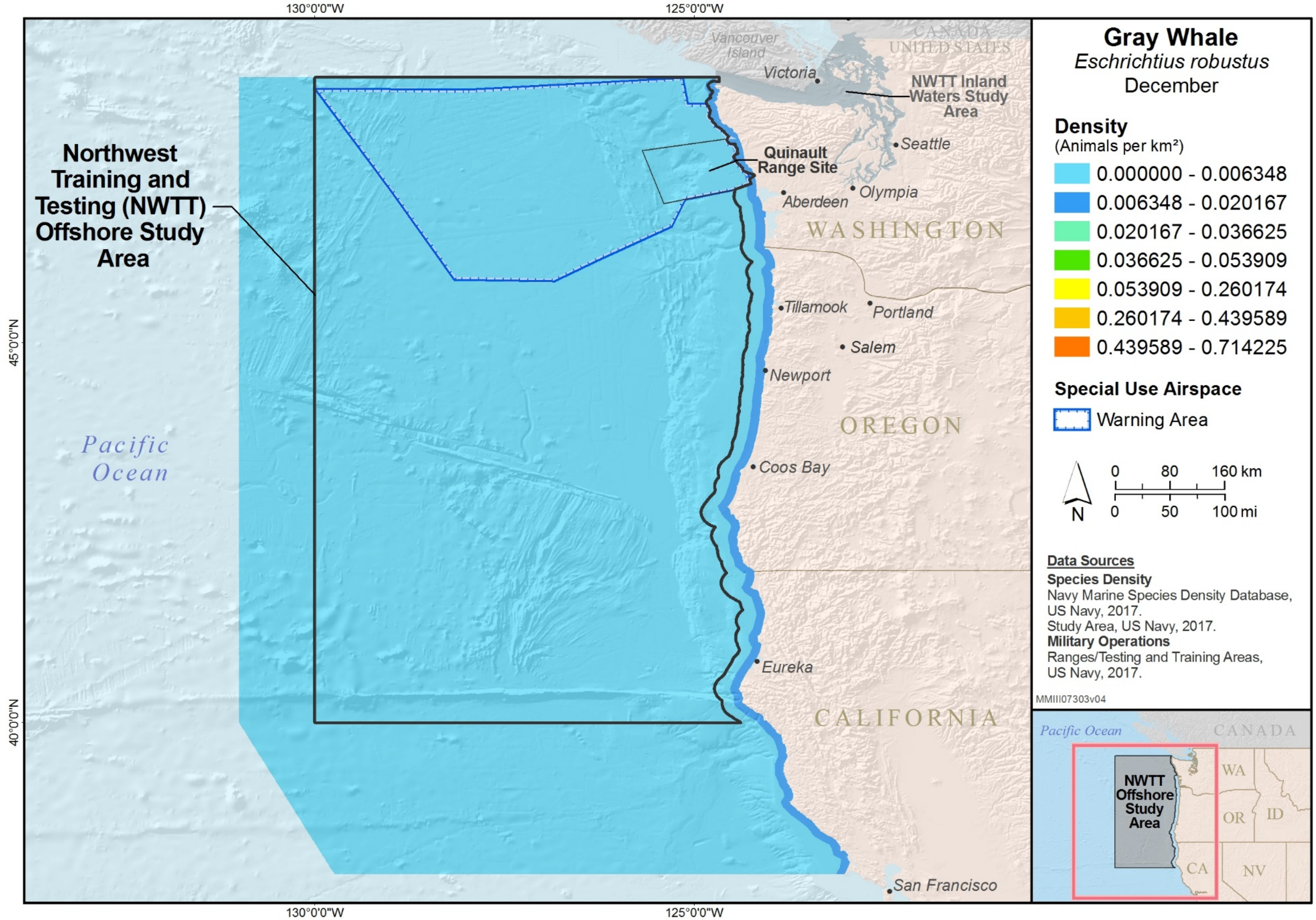


Figure 5.1-19: Offshore December Distribution of Gray Whale

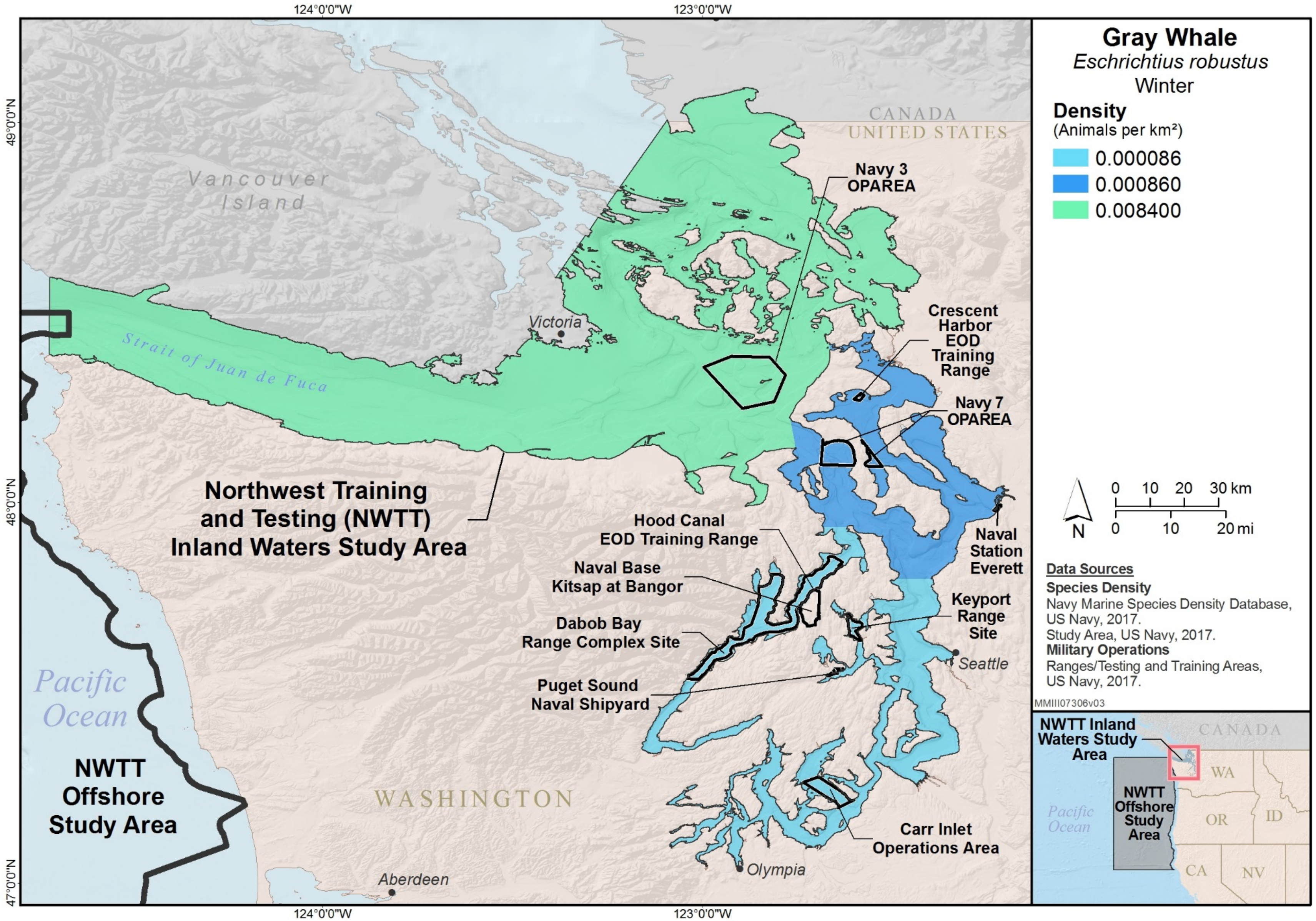


Figure 5.1-20: Inland Waters Winter Distribution of Gray Whale

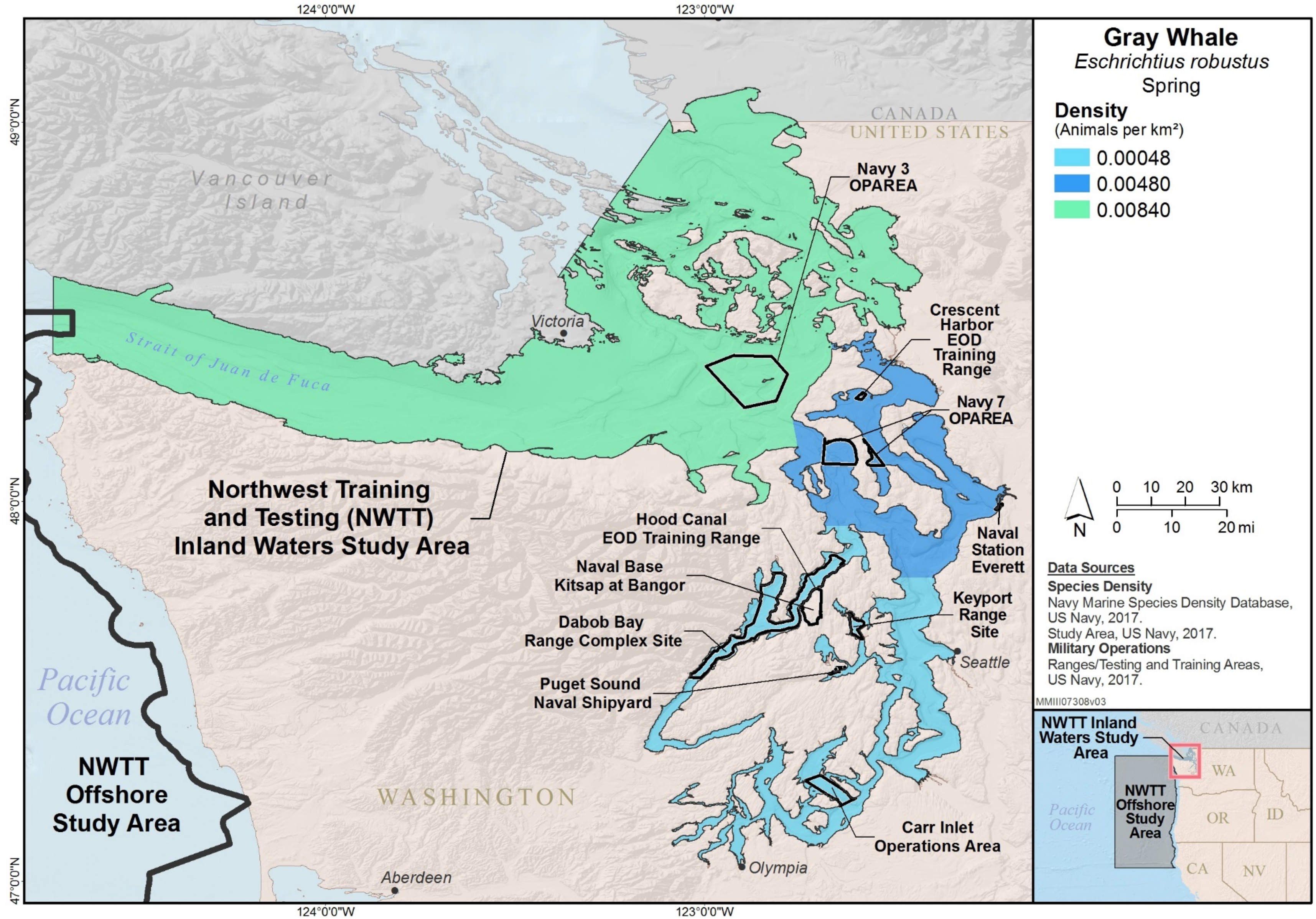


Figure 5.1-21: Inland Waters Spring Distribution of Gray Whale

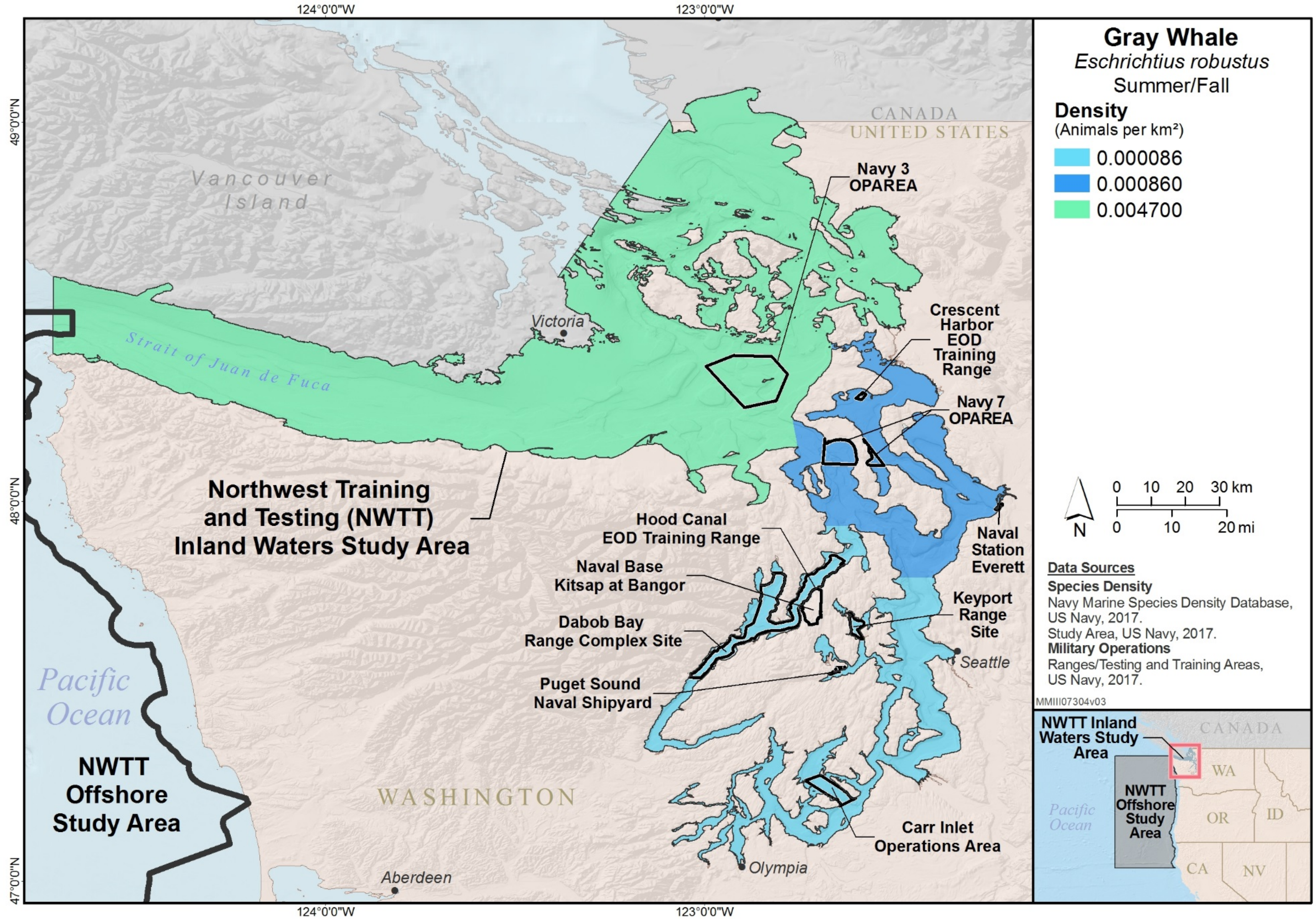


Figure 5.1-22: Inland Waters Summer/Fall Distribution of Gray Whale

5.1.6 *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 divides humpback whales into four stocks (Carretta et al., 2017b): (1) 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) Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; (3) 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) American Samoa stock, with largely undocumented feeding areas as far south as the Antarctic Peninsula (Carretta et al., 2017b; Muto et al., 2017). On October 11, 2016, NMFS's Final Rule was published (81 Federal Register 62259) to designate 14 DPSs worldwide, four of which occur in the North Pacific: (1) Western North Pacific, (2) Hawaii, (3) Mexico, and (4) Central America.

Humpback whales of the Mexico DPS are listed as threatened and those from the Central America DPS are listed as endangered under the ESA (National Marine Fisheries Service, 2016a). Together these two DPSs are considered the California, Oregon, and Washington stock of humpback whales and are listed as depleted under the MMPA (Carretta et al., 2017b; National Marine Fisheries Service, 2016a). Within the NWTT Study Area, both the Central North Pacific stock (Western Behm Canal) and the California, Oregon, and Washington stock (Offshore and Inland Waters) occur.[1]

Offshore. The California, Oregon, and Washington stock of humpback whales uses the waters off the U.S. West Coast as a summer feeding ground. They are present off the northern California coast mainly between April and December and off the Oregon and Washington coasts mainly from May through November (Calambokidis et al., 2010; Calambokidis et al., 2004; Dohl et al., 1983; Forney & Barlow,

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[1] Between 1990 and 1993 in the Okinawa/Osagawara breeding area of the Western North Pacific DPS, a photographically identified female humpback whale was observed on four occasions (once with a calf) and, in 1991, this same individual was observed off La Perouse Bank, in Canadian waters (Darling et al., 1996). La Perouse Bank is centered approximately 20 NM north of the NWTT Study Area. In 1991, only 24 individual humpback whales had been photo-identified during small boat surveys in waters off Northern Washington/British Colombia (Calambokidis et al., 2004) and a total of 177 had been identified in Japan waters (Darling et al., 1996). Given the small sample sizes of the photo-identification data in 1991 for the Western North Pacific DPS in the two areas involved, this one detection may represent a much more prevalent occurrence of Western North Pacific DPS whales in the vicinity of the NWTT Study Area. In addition, data provided by Titova et al. (2017) found photo-identification matches between humpbacks in Russian waters with 35 animals in Hawaiian breeding grounds and 11 animals in Mexican breeding grounds. These Russian waters/Western North Pacific stock whales are designated in the Alaska stock assessment report as representing the Okinawa/Osagawara/Philippines or Western North Pacific DPS (Muto et al., 2018a). Thus, these new data, along with photo-identification data having matches between what are supposed to be separate breeding areas and feeding areas, result in further inconsistencies with the stock structure of Central North Pacific stock whales being the Hawaii DPS, and the California, Oregon, Washington stock being mostly comprised by the Mexico DPS. The Navy's analysis presumes that, due to the Western North Pacific stock/DPS being few in number and the NWTT Study Area being outside their main feeding area in the western North Pacific, Western North Pacific DPS/stock humpback whales are not likely to be present in the NWTT Study Area.

1998; Green et al., 1992). Visual surveys and acoustic monitoring studies have detected humpbacks along the Washington coast year-round, with peak occurrence during the summer and fall (Oleson et al., 2009). Recordings from two Navy-funded offshore passive acoustic monitoring devices also indicate that humpback whales are most common between September and December (Širović et al., 2012a; Širović et al., 2012b). Photo-identification studies suggest that whales feeding in this region are part of a small sub-population that primarily feeds from central Washington to southern Vancouver Island (Calambokidis et al., 2008; Calambokidis et al., 2004). In winter and spring (roughly January–March), most whales are further south on their breeding grounds and are likely not as abundant in the Offshore regions of the Study Area during these times.

NMFS SWFSC developed a CCE habitat-based density model for humpback whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Winter/spring density data for humpback whales are not available for the offshore study area so based on input from NMFS SWFSC, the summer/fall distributions from the habitat-based density models were prorated to account for seasonal differences in abundance. Although the Navy has two High-frequency Acoustic Recording Packages off the coast of Washington that have provided year-round acoustic data, call rates for humpback whales are seasonal so these acoustic data are not informative for making inferences about seasonal abundance. Menza et al. (2016) developed predictive habitat-based models using available shipboard and aerial survey data collected off the Washington coast from multiple sources between 1995 and 2014. These models provide monthly estimates of relative humpback whale density for December through October. Appendix D of Menza et al. (2016) provides average observed density (animals/km^2) per transect segment, basically a simple mean of the distribution of observed densities along transect segments. One relatively high value inflates the average observed density for December relative to other months. We thus used "overall density" per season provided by Menza et al. (2016), which weights the observed counts along each transect segment by the survey effort. This metric is more representative of observed densities across months because it weights the observed counts along each transect segment by the survey effort. The ratio of the average summer/fall (June–October) to winter/spring (December–May) weighted density estimates from Menza et al. (2016) of 0.20 were thus used to prorate the summer/fall estimates.

Inland Waters. Humpback whales were common in inland Washington waters prior to the whaling period, but few sightings had been reported in this area until recently, when the number of humpback whale sightings increased. Since 2001, opportunistic sightings of cetaceans in inland waters have been reported to the Orca Network, an online forum available to the public to report and compile marine mammal sightings (www.orcanetwork.org). Based on a review of this database, most humpback whale sightings occur in the Strait of Juan de Fuca and in the San Juan Island area, with only occasional sightings in Puget Sound. A review of these Puget Sound opportunistic sightings indicates that humpback whales usually occur as individuals or in pairs. Although sightings have been reported during every month of the year, opportunistic sightings in the inland waters occur primarily from April through July.

Published density estimates for humpback whales in the inland waters are not available. Based on consideration of opportunistic sightings recorded by the Orca Network, it was conservatively assumed that the abundance of humpback whales occurring within the Strait of Juan de Fuca and the San Juan Islands area would be 20 percent of the offshore estimates, while fewer whales would be found within Puget Sound. Since the offshore estimates are based on habitat models and are thus spatially explicit, the average value of the pixels at the entrance to the Strait of Juan de Fuca from the habitat-based density model estimates were used to provide an average estimate for the Strait of Juan de Fuca and the San Juan Islands area (0.0027 whales/km^2 for summer/fall and 0.0005 whales/km^2 for winter/spring).

As verified by sightings recorded by the Orca Network, the majority of humpback whales within Puget Sound occur in summer/fall; a conservative density estimate of 0.00074 animals/km^2 was thus applied to this area based on sighting records. Given the fewer number of sightings for winter/spring, a density estimate of 0.00058 animals/km^2 was applied.

Western Behm Canal. For the Western Behm Canal, density estimates for all seasons were taken from the Marine Mammal Occurrence/Density Report prepared in support of a NEPA document for Navy activities at SEAFAC (U.S. Department of the Navy, 2010).

Table 5.1-6: Summary of Density Values for Humpback Whale

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0.0005 –0.00058	0.00074 –0.0027	0.00074 –0.0027	0.0005 –0.00058
Western Behm Canal	0.0081	0.0117	0.0180	0.0081

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

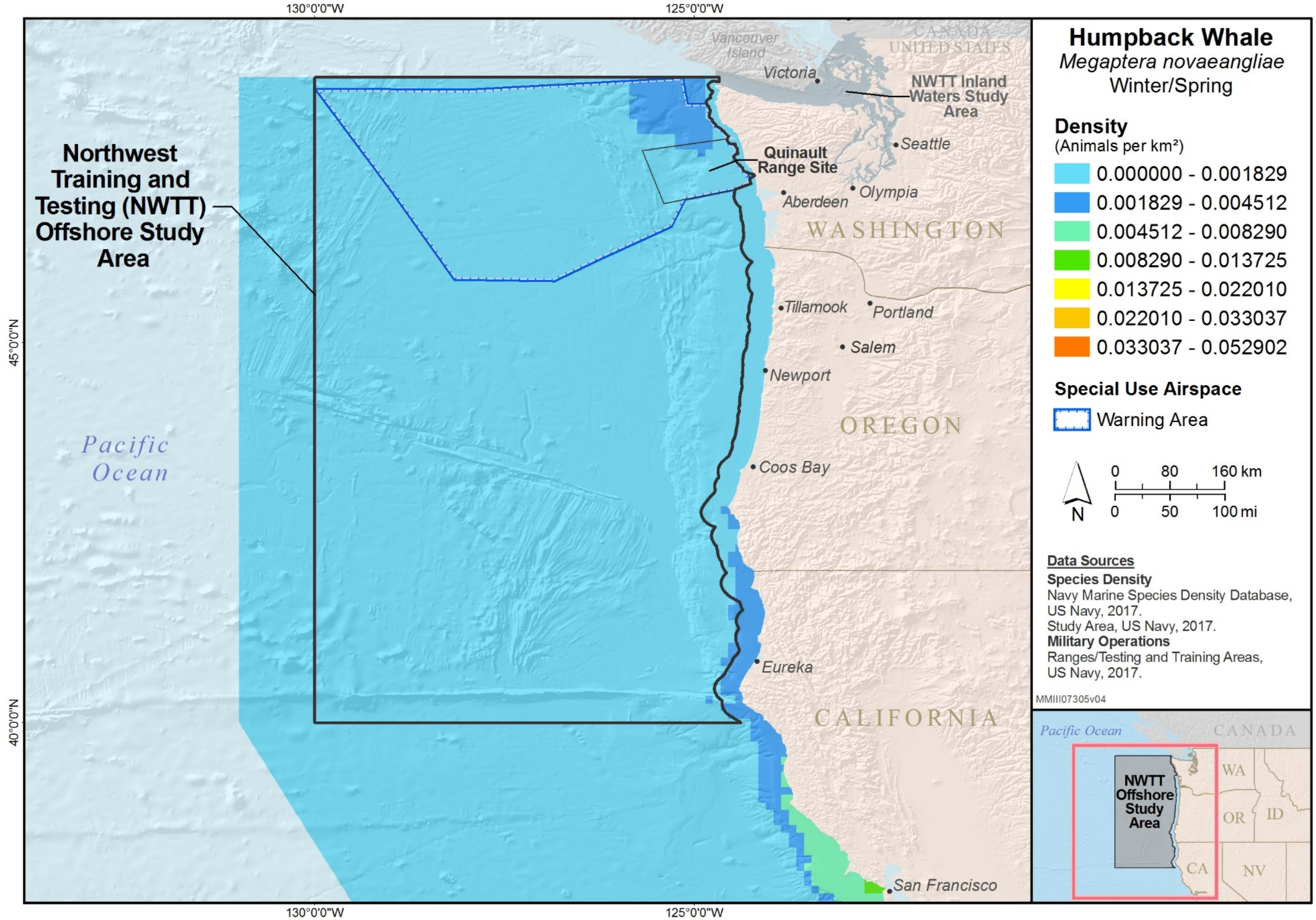

Figure 5.1-23: Offshore Winter/Spring Distribution of Humpback Whale

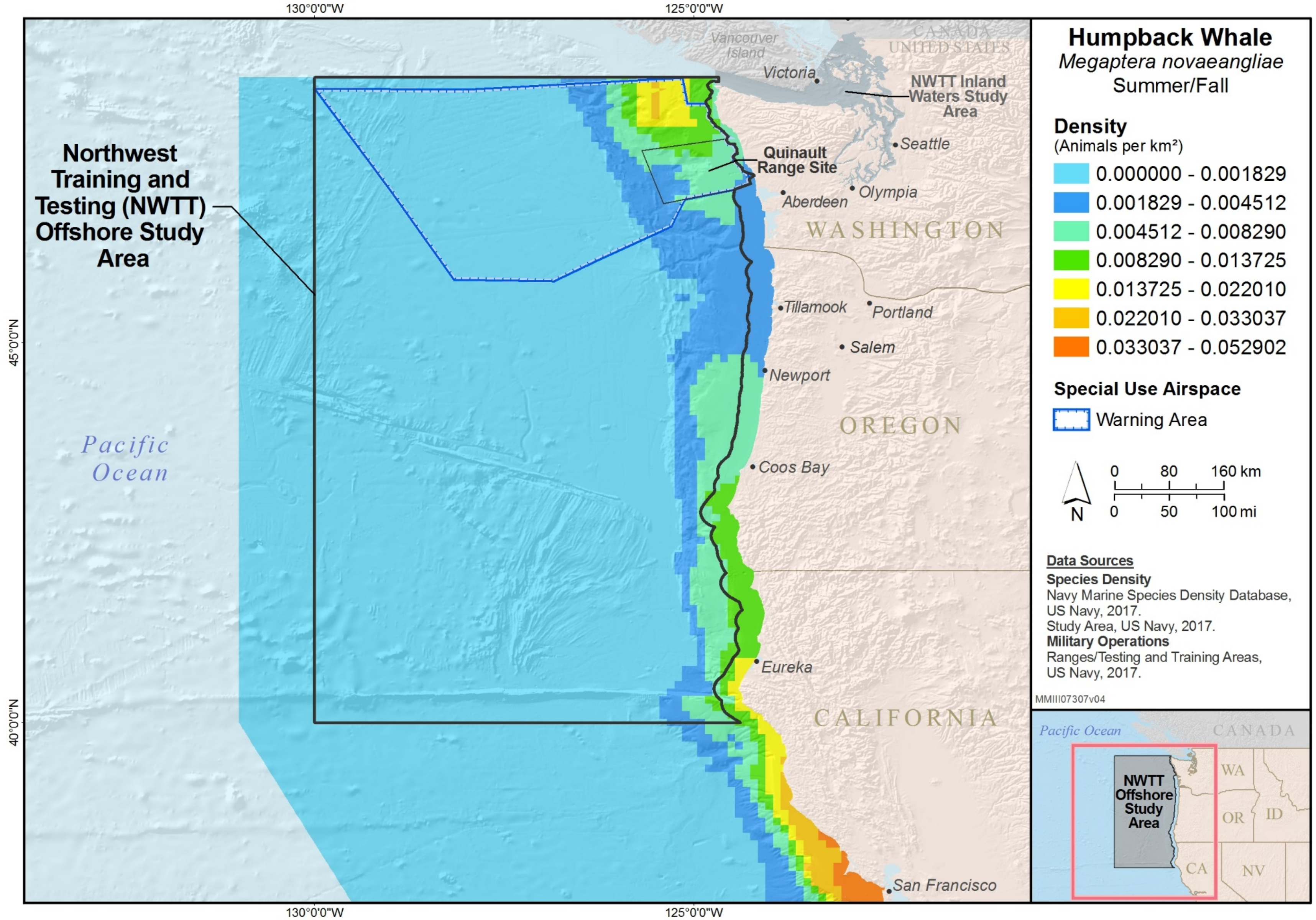

Figure 5.1-24: Offshore Summer/Fall Distribution of Humpback Whale

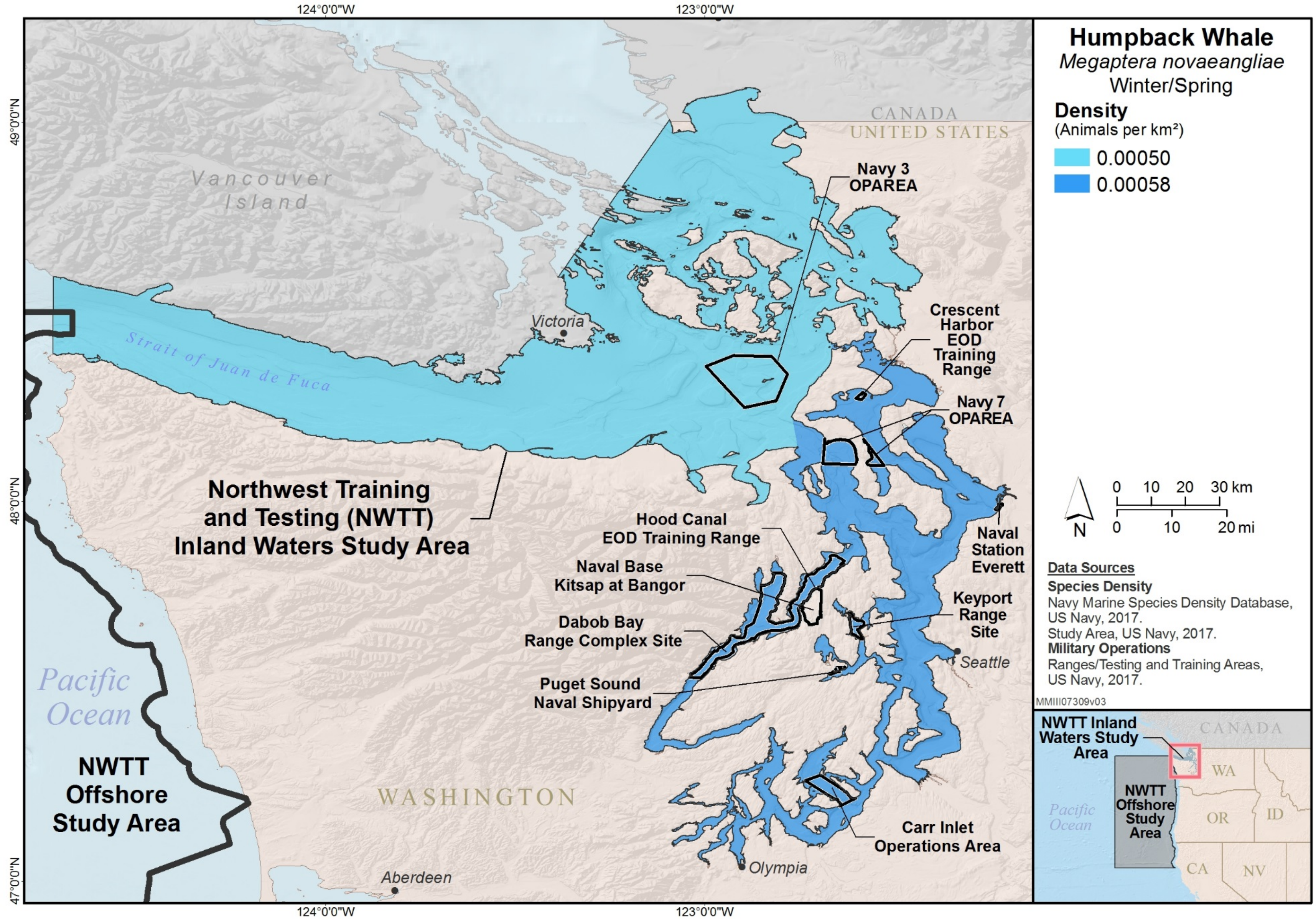

Figure 5.1-25: Inland Waters Winter/Spring Distribution of Humpback Whale

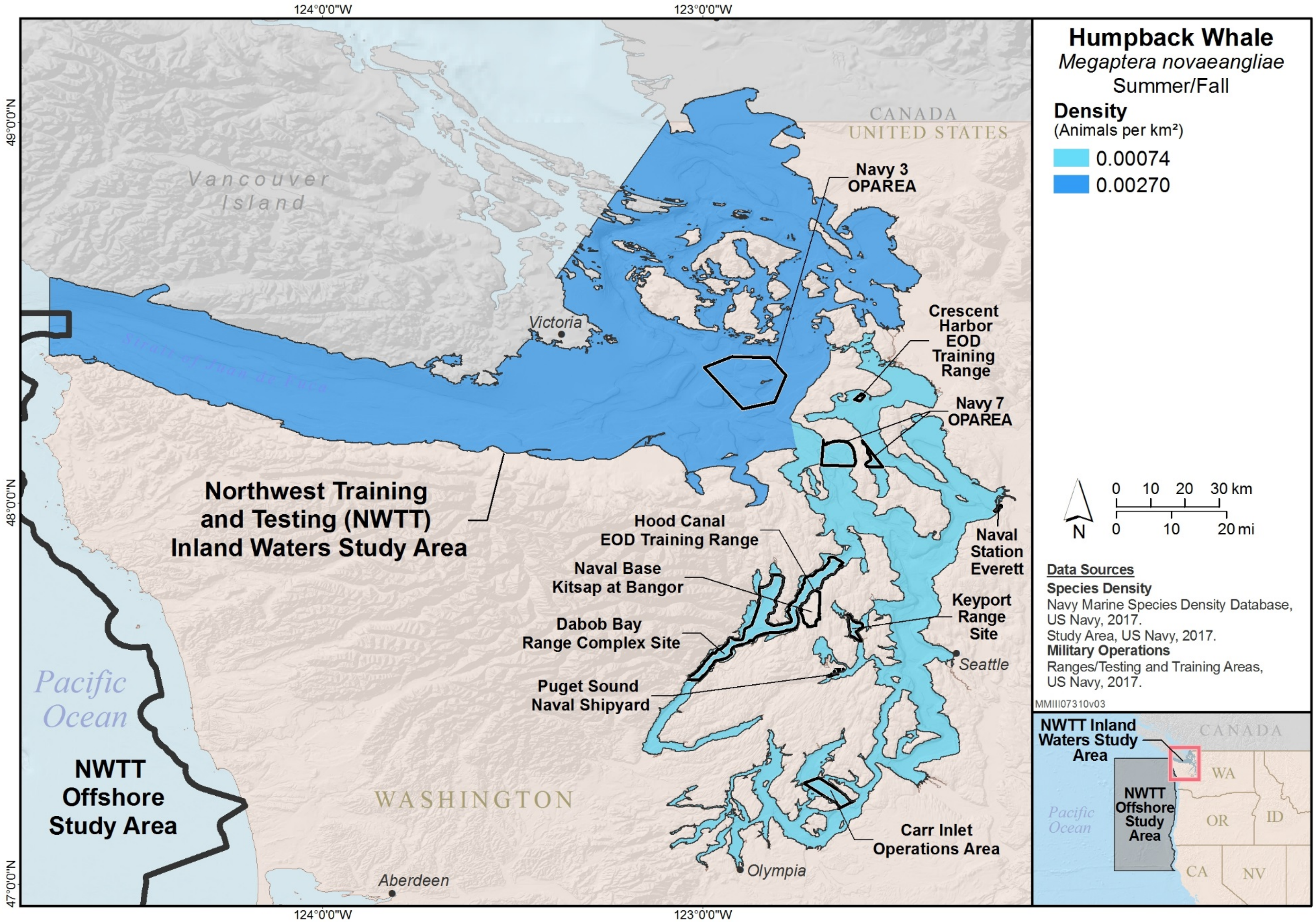

Figure 5.1-26: Inland Waters Summer/Fall Distribution of Humpback Whale

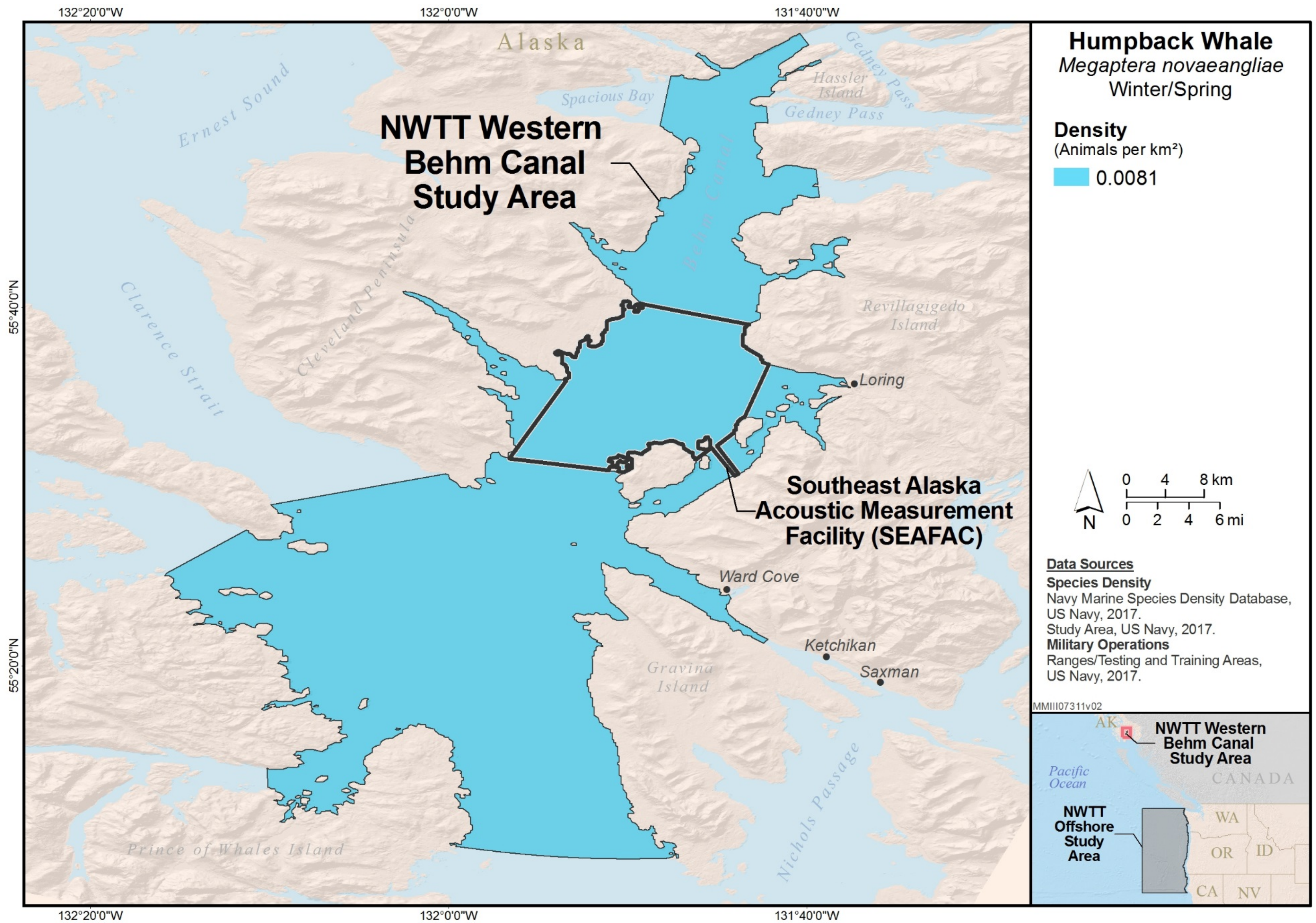

Figure 5.1-27: Western Behm Canal Winter/Spring Distribution of Humpback Whale

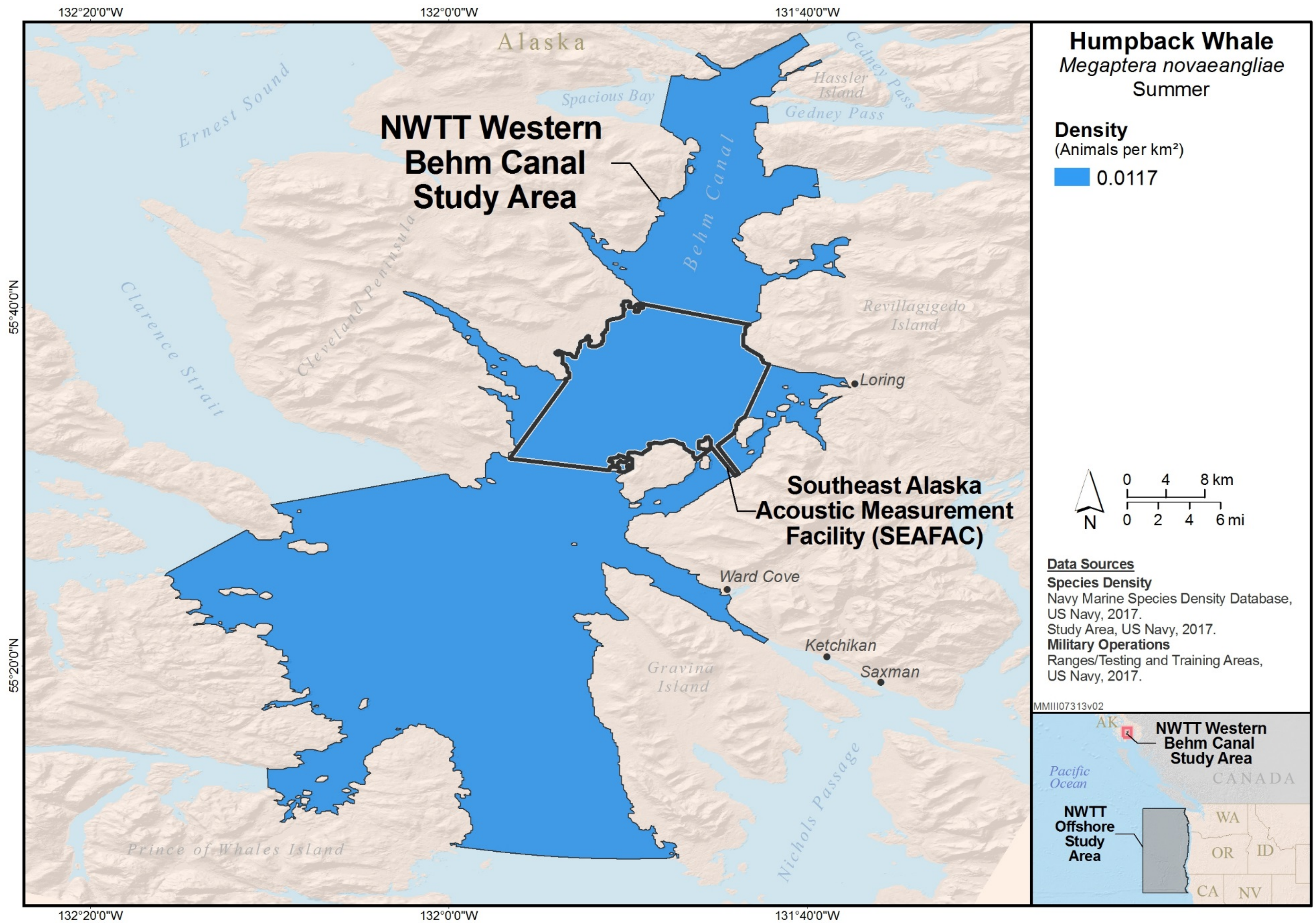

Figure 5.1-28: Western Behm Canal Summer Distribution of Humpback Whale

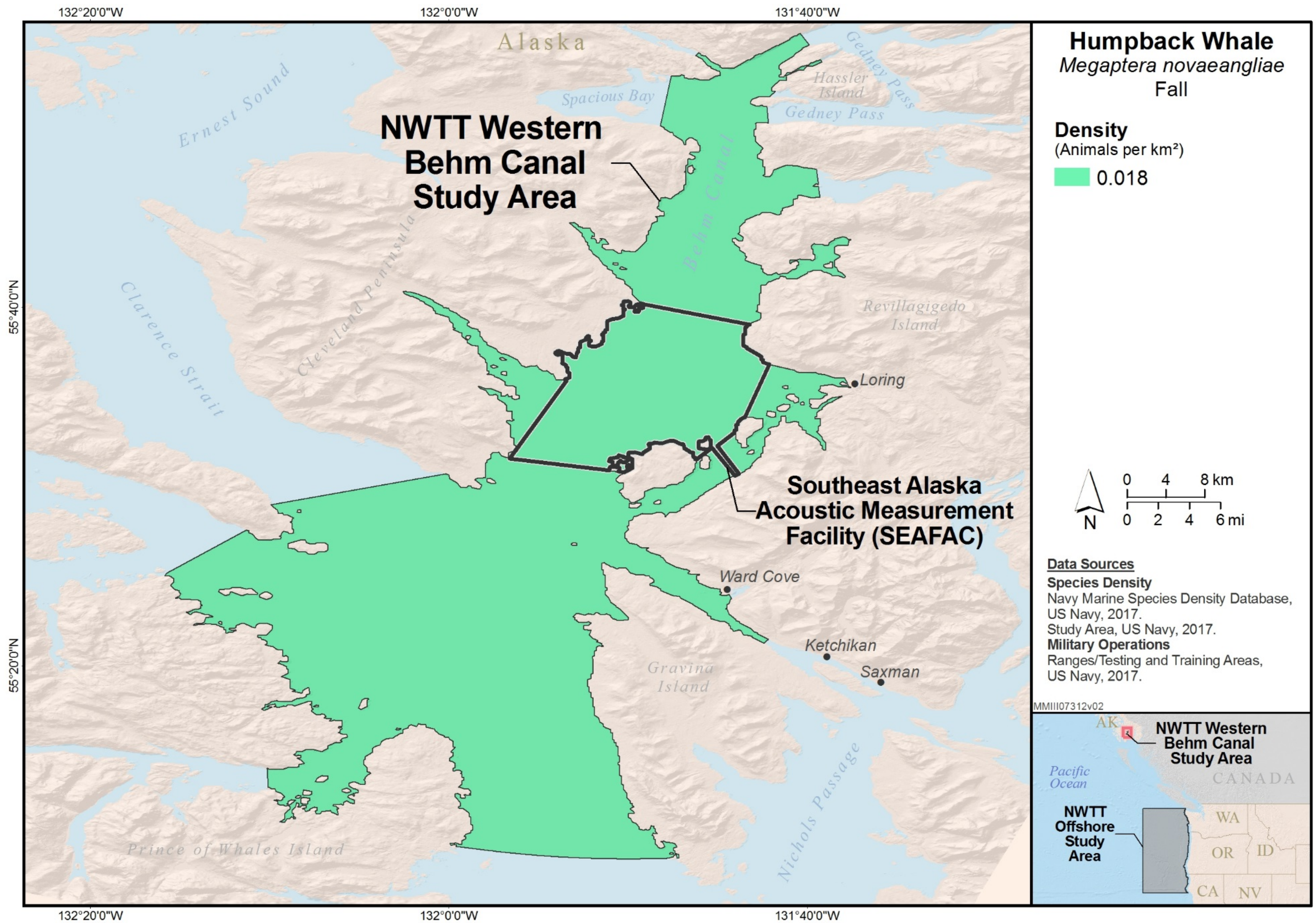

Figure 5.1-29: Western Behm Canal Fall Distribution of Humpback Whale

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., 2017b). The two stocks are considered to be discrete from each other. Pygmy sperm whales in the NWTT Study Area belong to the California/Oregon/Washington stock. The IWC does not recognize stock structure for *Kogia* species. Due to the limited number of sightings of *Kogia* off the U.S. West Coast, NMFS is only able to provide density values for *Kogia* as a genus (Barlow, 2016), and thus density values for NWTT are also provided for *Kogia* as a genus (the density figure follows the dwarf sperm whale description below).

Offshore. *Kogia* species are treated as a guild off the U.S. West Coast (Barlow & Forney, 2007). The majority of sightings of *Kogia* in the Offshore region of the NWTT Study Area are likely to have been pygmy sperm whales (Carretta et al., 2017b). Barlow (2016) provided stratified density estimates for *Kogia* spp. for waters off California, Oregon, and Washington; these were used for all seasons for both the Northern California (0.00094 animals/km^2; CV = 1.43) and Oregon/Washington (0.00163 animals/km^2; CV = 1.40) strata. In the absence of other data, the Barlow (2016) Oregon/Washington estimate was also used for the area northwest of the SWFSC strata for all seasons.

Inland Waters. Pygmy sperm whales are not expected to occur within the Inland Waters region of the NWTT Study Area and would be considered extralimital in this area.

Western Behm Canal. Pygmy sperm whales are not expected to occur within Western Behm Canal and would be considered extralimital in this area.

Table 6.1-1: Summary of Density Values for Pygmy Sperm Whale

Location	Spring	Summer	Fall	Winter
Offshore	0.00094–0.00163	0.00094–0.00163	0.00094–0.00163	0.00094–0.00163
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

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., 2017b). The two stocks are considered to be discrete and non-contiguous. Dwarf sperm whales in the NWTT Study Area belong to the California/Oregon/Washington stock. The IWC does not recognize stock structure for *Kogia* species. Due to the limited number of sightings of *Kogia* off the U.S. West Coast, NMFS is only able to provide density values for *Kogia* as a genus (Barlow, 2016). Density values for NWTT are thus provided for *Kogia* as a genus, and the associated density figure is presented following the density summary table below.

Offshore. As previously indicated, *Kogia* species are treated as a genus off the U.S. West Coast (Barlow & Forney, 2007). The majority of sightings of *Kogia* in the Offshore region of the NWTT Study Area are likely to have been pygmy sperm whales (Carretta et al., 2017b). Barlow (2016) provided stratified density estimates for *Kogia* spp. for waters off California, Oregon, and Washington; these were used for all seasons for both the Northern California (0.00094 animals/km^2; CV = 1.43) and Oregon/Washington (0.00163 animals/km^2; CV = 1.40) strata. In the absence of other data, the Barlow (2016) Oregon/Washington estimate was also used for the area northwest of the SWFSC strata for all seasons.

Inland Waters. Dwarf sperm whales are not expected to occur within the Inland Waters region of the NWTT Study Area and would be considered extralimital in this area.

Western Behm Canal. Dwarf sperm whales are not expected to occur within Western Behm Canal and would be considered extralimital in this area.

Table 6.1-2: Summary of Density Values for Dwarf Sperm Whale

Location	Spring	Summer	Fall	Winter
Offshore	0.00094–0.00163	0.00094–0.00163	0.00094–0.00163	0.00094–0.00163
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

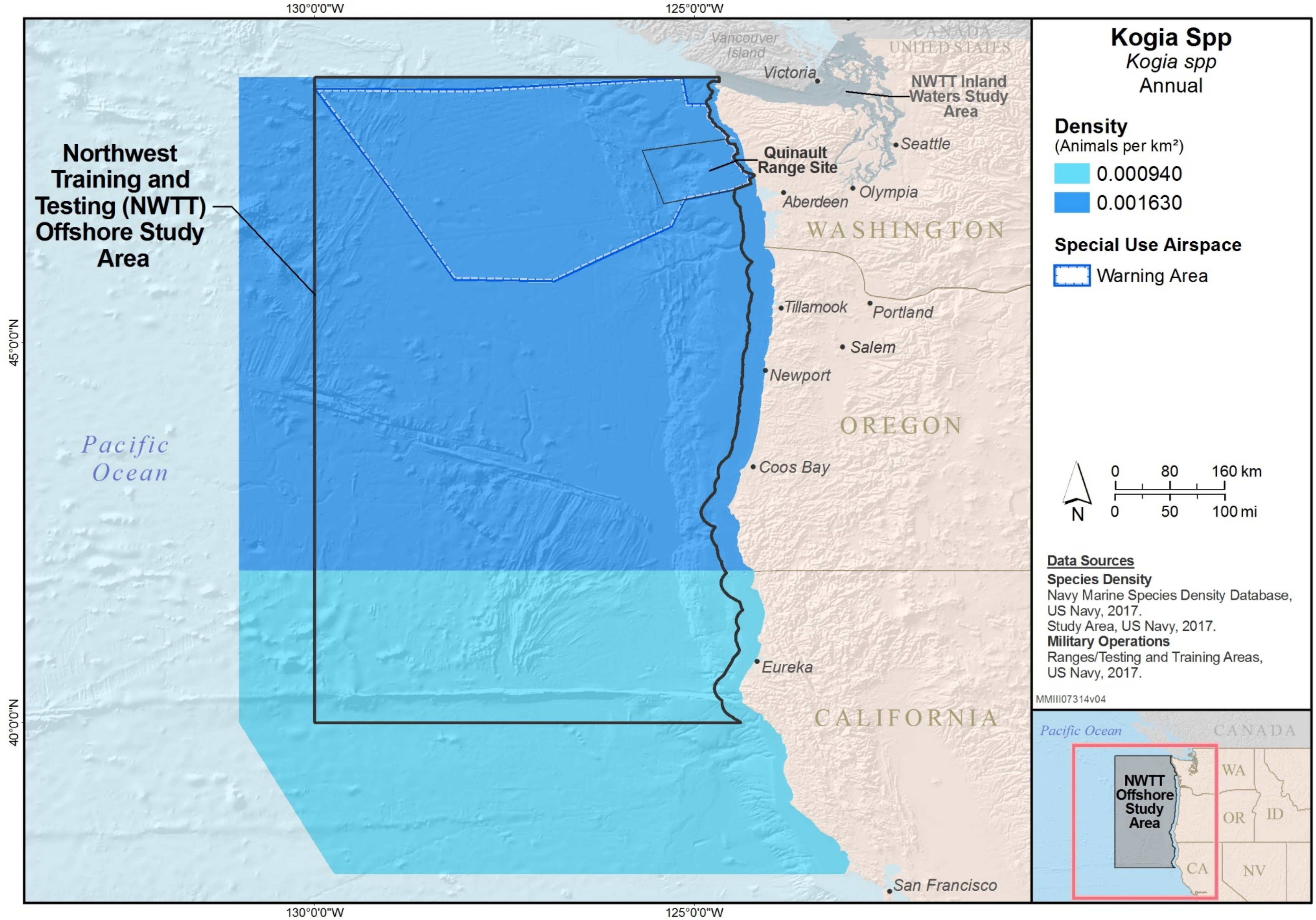

Figure 6.1-1: Offshore Annual Distribution of *Kogia* (Pygmy Sperm Whale and Dwarf Sperm Whale)

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, 2009). NMFS has divided sperm whales in the North Pacific into three stocks: the California/Oregon/Washington stock, the Hawaii stock, and the North Pacific stock (Carretta et al., 2017b). 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., 2017b) 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., 2017b). Sperm whales occurring in the NWTT Offshore region of the Study Area belong to the California/Oregon/Washington stock.

Offshore. Sperm whales have been detected acoustically year-round at offshore sites monitored from 2004 to 2008 off the Washington coast, with peak occurrence from April to August (Oleson et al., 2009). NMFS SWFSC developed a CCE habitat-based density model for sperm whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Winter/spring density data are not available for the NWTT Offshore Study Area; however, Navy-funded acoustic monitoring studies have detected sperm whales in Washington offshore waters year-round (Širović et al., 2012a; Širović et al., 2012b). Since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. Sperm whales are not expected to occur within the Inland Waters region of the NWTT Study Area and would be considered extralimital in this area.

Western Behm Canal. Sperm whales are not expected to occur within Western Behm Canal and would be considered extralimital in this area.

Table 6.1-3: Summary of Density Values for Sperm Whale

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

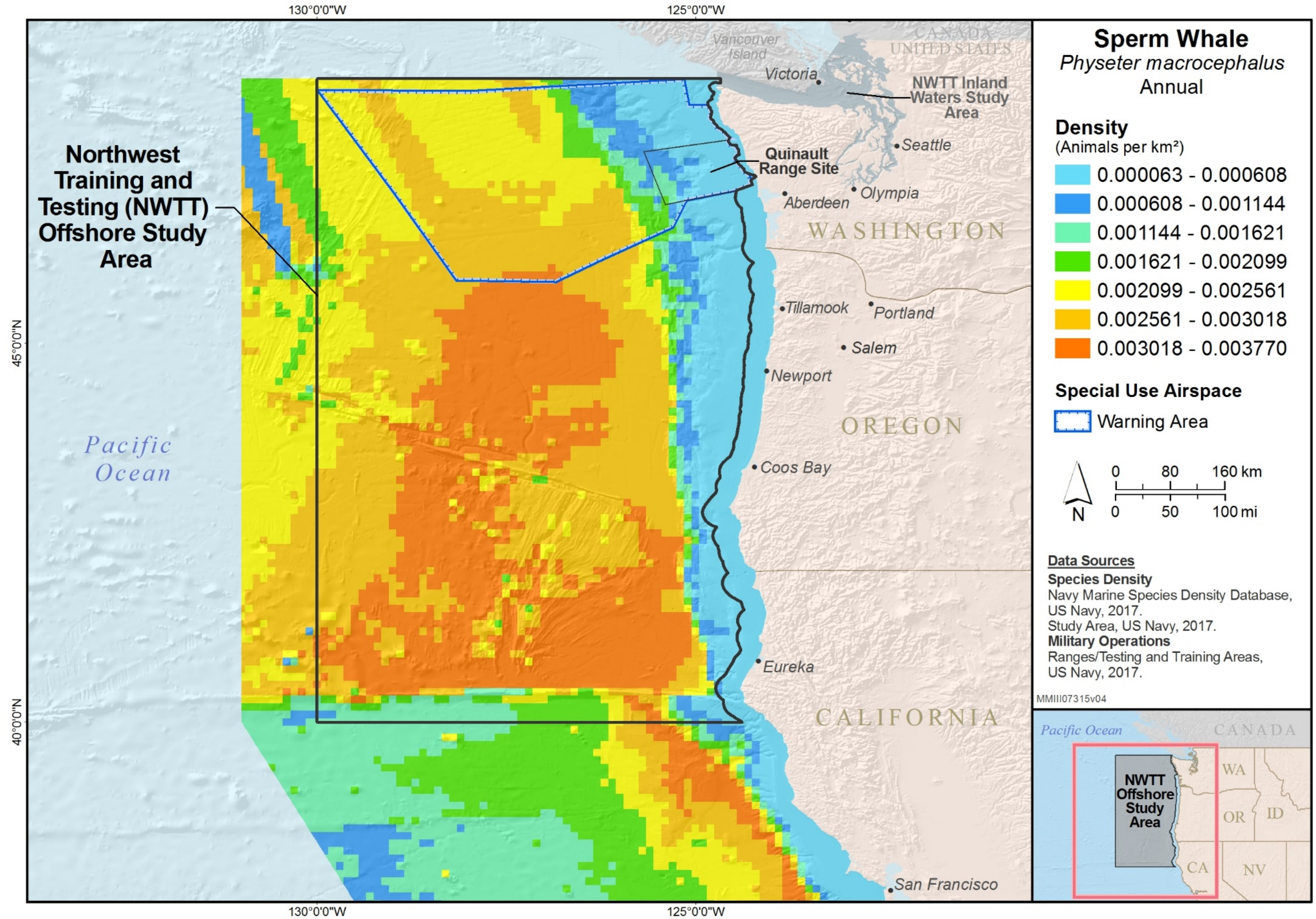

Figure 6.1-2: Offshore Annual Distribution of Sperm Whale

7 DELPHINIDS (DOLPHINS)

7.1 DELPHINID SPECIES PROFILES

7.1.1 *DELPHINUS DELPHIS*, SHORT-BEAKED COMMON DOLPHIN[2]

This species is encountered in a much broader portion of the Pacific than the closely related long-beaked common dolphin (Hamilton et al., 2009). At great distance, the short-beaked common dolphin can be confused with several of the other dolphin species, especially the long-beaked common dolphin (Allen et al., 2011). When viewed up close, distinctive hourglass coloration on the flanks, the steep forehead, and a relatively short rostrum allow this species to be positively identified (Jefferson et al., 2015). Short-beaked common dolphins can occur in large groups, sometimes numbering more than 1,000 individuals (Forney & Barlow, 1998; Leatherwood et al., 1988; Soldevilla et al., 2006). They are also known to occur in mixed-species groups with other toothed whales such as Pacific white-sided dolphins and pilot whales (*Globicephala* sp.), although the two species of common dolphin are not observed to co-occur in groups (Allen et al., 2011; Jefferson et al., 2015). NMFS recognizes a California/Oregon/Washington stock of short-beaked common dolphins in the U.S. EEZ (Carretta et al., 2017b). This species is managed as part of the "northern common dolphin" stock for the tropical Pacific tuna fishery in the eastern tropical Pacific (Carretta et al., 2017b). Historically, common dolphins, short-beaked in particular, have been one of the species most impacted by fisheries bycatch (Julian & Beeson, 1998; Moore et al., 2009; Read et al., 1988). In the NWTT Study Area, this stock is observed in U.S. offshore waters.

Offshore. Short-beaked common dolphins are found off the U.S. West Coast throughout the year, distributed between the coast and at least 345 miles (556 km) from shore (Barlow, 2010; Becker et al., 2017; Carretta et al., 2017b). The short-beaked common dolphin is the most abundant cetacean species off California (Barlow, 2016; Carretta et al., 2017b; Forney et al., 1995); however, their abudance decreases dramatically north of about 40° North (N) (Barlow et al., 2009; Becker et al., In Prep.; Becker et al., 2012c; Forney et al., 2012). Short-beaked common dolphins are occasionally sighted in waters off Oregon and Washington, and one group of approximately 40 short-beaked common dolphins was sighted off northern Washington in 2005 at about 48°N (Forney, 2007), and multiple groups were sighted as far north as 44°N during anomalously warm conditions in 2014 (Barlow, 2016).

NMFS SWFSC developed a CCE habitat-based density model for short-beaked common dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Winter/spring density data are not available for

[2] Recently, the Society for Marine Mammalogy's Committee on Taxonomy has lumped all common dolphins back into the single species, *D. delphis*. Long-and short-beaked common dolphins are still recognized as separate subspecies, *D. delphis bairdii* and *D. delphis delphis*, respectively.

the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. This species is not expected to occur within the Inland Waters region of the NWTT Study Area.

Western Behm Canal. This species is not expected to occur within the Western Behm Canal region of the NWTT Study Area.

Table 7.1-1: Summary of Density Values for Short-Beaked Common Dolphin

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

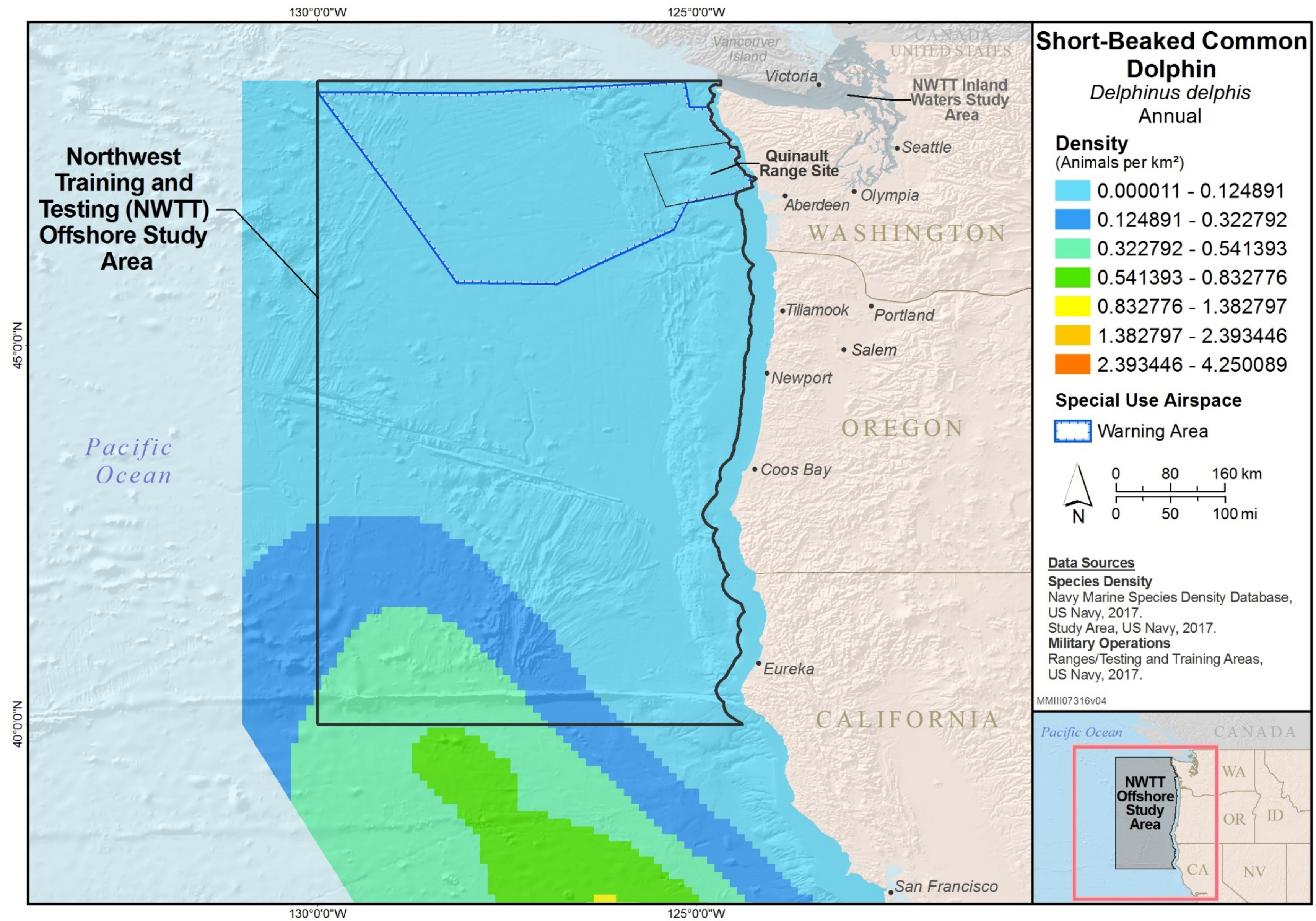

Figure 7.1-1: Offshore Annual Distribution of Short-Beaked Common Dolphin

7.1.2 *GLOBICEPHALA MACRORHYNCHUS*, SHORT-FINNED PILOT WHALE

Short-finned pilot whales are a 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, is 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 and gray whales (Bernard & Reilly, 1999; McSweeney 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., 2017b). Animals that may occur in the Northern California portion of the NWTT Study Area belong to the California/Oregon/Washington stock.

Offshore. Along the U.S. West Coast, short-finned pilot whales were once common south of Point Conception, California (Carretta et al., 2017b; Reilly & Shane, 1986), but now sightings off the U.S. West Coast are infrequent and typically occur during warm water years (Carretta et al., 2017b). Stranding records for this species from Oregon and Washington waters are considered to be beyond the normal range of this species rather than an extension of its range (Norman et al., 2004). Density values for short-finned pilot whales are available for the SWFSC Oregon/Washington (0.00025 animals/km^2; CV = 1.12) and Northern California (0.00056 animals/km^2; CV = 0.84) strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates. These values were used to represent density year-round.

Inland Waters. This species is not expected to occur within the Inland Waters region of the NWTT Study Area.

Western Behm Canal. This species is not expected to occur within the Western Behm Canal region of the NWTT Study Area.

Table 7.1-2: Summary of Density Values for Short-Finned Pilot Whale

Location	Spring	Summer	Fall	Winter
Offshore	0.00025–0.00056	0.00025–0.00056	0.00025–0.00056	0.00025–0.00056
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

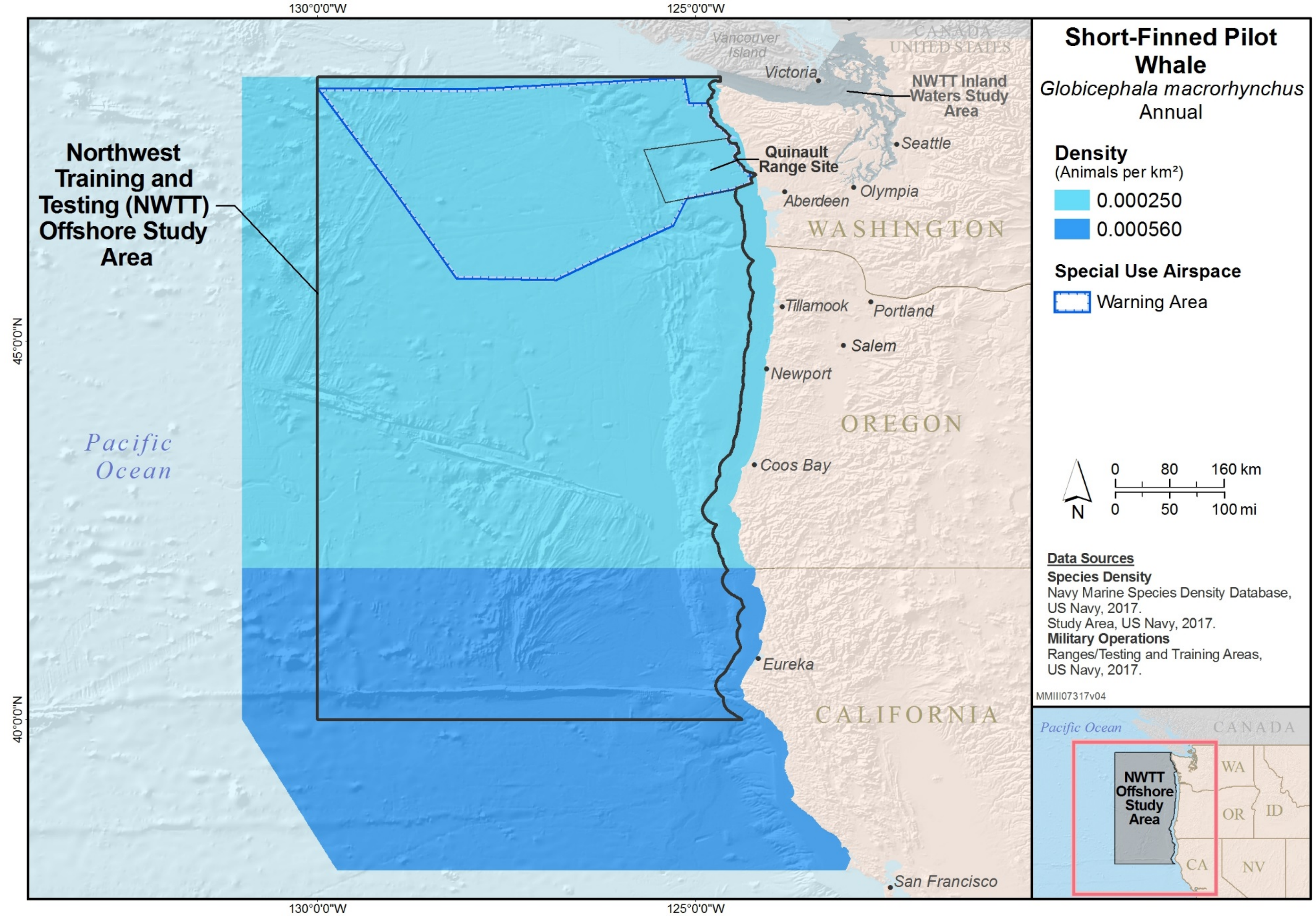

Figure 7.1-2: Offshore Annual Distribution of Short-Finned Pilot Whale

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., 2017b). Animals that occur in the Offshore region of the NWTT Study Area belong to the California/Oregon/Washington stock.

Offshore. Risso's dolphin was the most commonly sighted odontocete during aerial surveys in Oregon and Washington offshore waters in the late 1980s (Green et al., 1992), and were sighted frequently off the Washington coast in summer and fall during ship surveys in 1996, 2001, and 2005 (Barlow & Forney, 2007). However, they have been sighted infrequently off Oregon and Washington during recent surveys (Barlow, 2016; Oleson et al., 2009). Based on systematic survey data and acoustic studies conducted in offshore waters of the Study Area during the last 10 years, there appears to be high interannual variability in the occurrence of this species (Barlow, 2010; Oleson et al., 2009), although acoustic detections of Risso's dolphins have been made year-round in waters off Washington (Oleson et al., 2009).

NMFS SWFSC developed a CCE habitat-based density model for Risso's dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. This species is not expected to occur within the Inland Waters region of the NWTT Study Area. Inland water stranding records for this species include a March 1975 report for Discovery Bay in the eastern Strait of Juan de Fuca (Everitt et al., 1980) and another near Port Angeles in October 1987 (Osborne et al., 1988). Two reported sightings of juvenile Risso's dolphins took place in late 2011 (Cascadia Research Collective, 2011), and a pair of Risso's dolphins was sighted in Puget Sound during aerial surveys in 2013 (Smultea & Bacon, 2013); however, these sightings are considered very unusual, as the species is considered extralimital to the Study Area and occurrence is unlikely.

Western Behm Canal. This species is not expected to occur within the Western Behm Canal region of the NWTT Study Area.

Table 7.1-3: Summary of Density Values for Risso's Dolphin

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

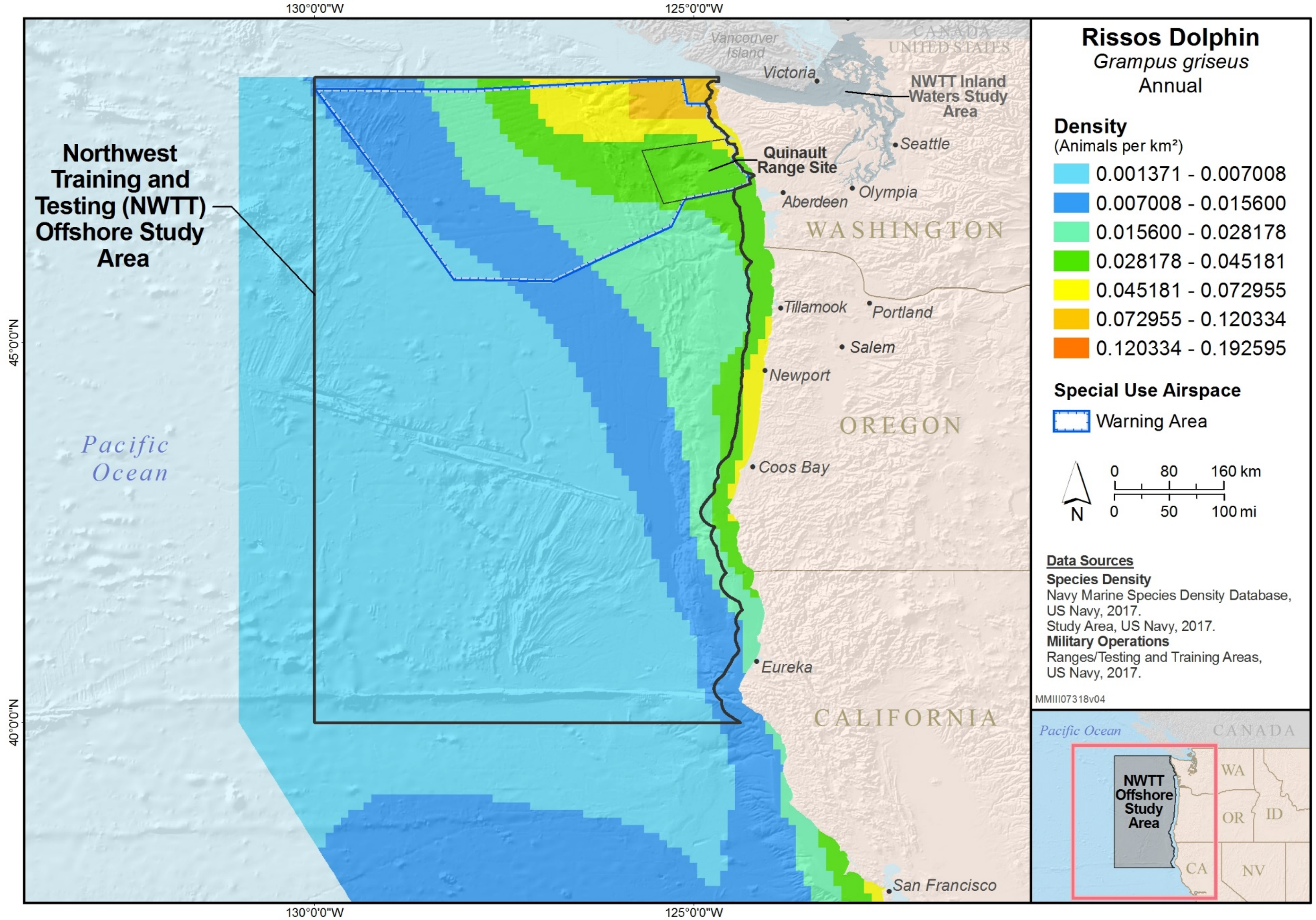

Figure 7.1-3: Offshore Annual Distribution of Risso's Dolphin

7.1.4 *Lagenorhynchus obliquidens*, Pacific White-Sided Dolphin

This small-bodied dolphin with a small, but distinctive beak is found in the temperate waters of the North Pacific (Jefferson et al., 2015). It is primarily seen off the slope and shelf along the west coast of North America (Hamilton et al., 2009). The coloration of Pacific white-sided dolphins is distinctive, bold, and complex. The white belly is separated from the gray patch on the side by a thin black line and the dorsal side has a “suspenders” pattern that flows from the rostrum over the shoulder to the flank (Black, 2009; Brownell et al., 1999). The dorsal fin is distinctive because it is strongly curved or hooked, particularly in older individuals, in which the fin takes on a lobate shape (Allen et al., 2011; Jefferson et al., 2015). Although the diagnostic coloration and the shape of the fin should make this species relatively easy to identify, they could be mistaken for common dolphins (*Delphinus* sp.) and Dall’s porpoise (Leatherwood et al., 1988). At a distance, a rapidly moving group of Pacific white-sided dolphins could be mistaken for a large group of either long- or short-beaked common dolphin. The “rooster-tail” splashes made by the dorsal fins of Pacific white-sided dolphins are similar to the splashes typically made by Dall’s porpoises (Leatherwood et al., 1988). What often gives away the identity of Pacific white-sided dolphins is their acrobatic behavior (Black, 2009; Brownell et al., 1999). They are often seen in groups with a wide variety of marine mammals, including California sea lions (*Zalophus californianus*) (Baird & Stacey, 1991; Black, 2009; Brownell et al., 1999; Leatherwood et al., 1988). Two stocks of Pacific white-sided dolphin are recognized by NMFS (Carretta et al., 2017b). One is a complex of units (the California/Oregon/Washington, Northern and Southern stocks) that contains two forms of the species, which should ostensibly be separate stocks. The second stock recognized by NMFS is the North Pacific stock that covers the west coast of Canada, the Gulf of Alaska, and the area around the Aleutian Islands (Carretta et al., 2017b). Pacific white-sided dolphins that occur in the Offshore and Inland Waters regions of the NWTT Study Area belong to the California/Oregon/Washington stock and those animals that occur in Behm Canal belong to the North Pacific stock.

Offshore. Pacific white-sided dolphins occur year-round in the Offshore region of the NWTT Study Area, with increased abundance in the summer/fall (Barlow, 2010; Forney & Barlow, 1998; Oleson et al., 2009). NMFS SWFSC developed a CCE habitat-based density model for Pacific white-sided dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. Pacific white-sided dolphins are known to enter the inshore passes of British Columbia and Washington, and have been encountered in the Strait of Juan de Fuca and the Strait of Georgia (Norman et al., 2004; Osborne et al., 1988; Stacey & Baird, 1991; Williams & Thomas, 2007). Small groups have also been seen in Haro Strait off San Juan Island. Pacific white-sided dolphins are generally rare in Puget Sound, with one stranding in southern Puget Sound recorded in the 1980s (Osborne et al.,

1988) and a few incidental sightings reported to the Orca Network, an online forum available to the public to report and compile marine mammal sightings (www.orcanetwork.org).

Published density estimates for Pacific white-sided dolphins in the Inland Waters of the United States are not available. However, Williams and Thomas (2007) provide line-transect density estimates for seven cetacean species based on ship surveys conducted in the Inside Passage of British Columbia, Canada, including the Strait of Juan de Fuca and areas just north of the San Juan Islands. The Williams and Thomas (2007) Pacific white-sided dolphin density estimate of 0.11 animals/km^2 (CV = 0.94) in the Strait of Juan de Fuca/Strait of Georgia is based on systematic ship surveys conducted in the summer of 2004 and 2005 and was used to characterize Pacific white-sided dolphin density in the Strait of Juan de Fuca/San Juan Islands region. Based on 2006–2017 sighting data from Orca Network, which confirms that Pacific white-sided dolphins are rarely sighted within Puget Sound, zero density was assigned to this region.

Western Behm Canal. For the Western Behm Canal, density estimates for all seasons were taken from the Marine Mammal Occurrence/Density Report prepared in support of a NEPA document for Navy activities at SEAFAC (U.S. Department of the Navy, 2010).

Table 7.1-4: Summary of Density Values for Pacific White-Sided Dolphin

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0–0.11	0–0.11	0–0.11	0–0.11
Western Behm Canal	0.0849	0.0075	0.0075	0.0849

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

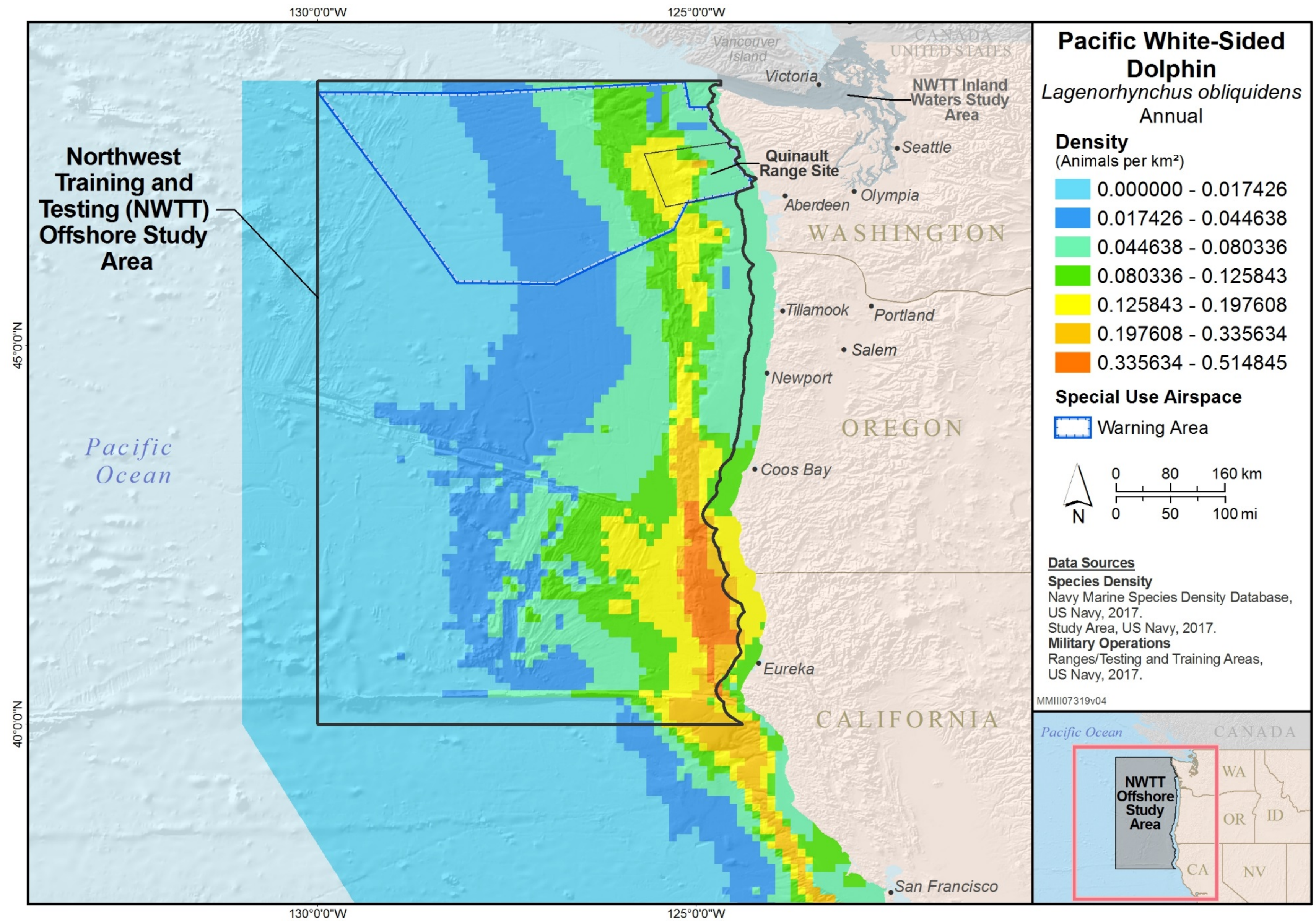

Figure 7.1-4: Offshore Annual Distribution of Pacific White-Sided Dolphin

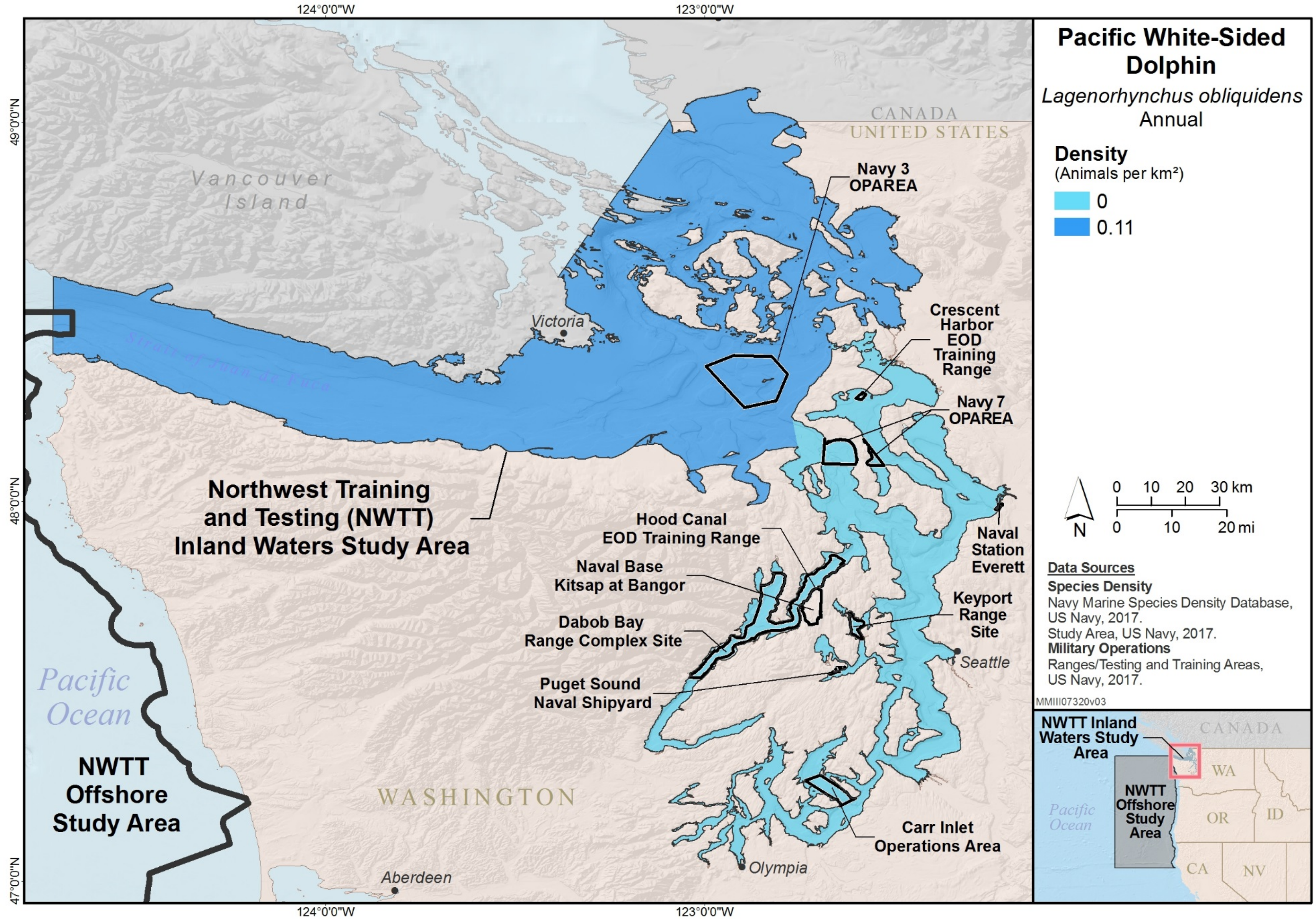

Figure 7.1-5: Inland Waters Annual Distribution of Pacific White-Sided Dolphin

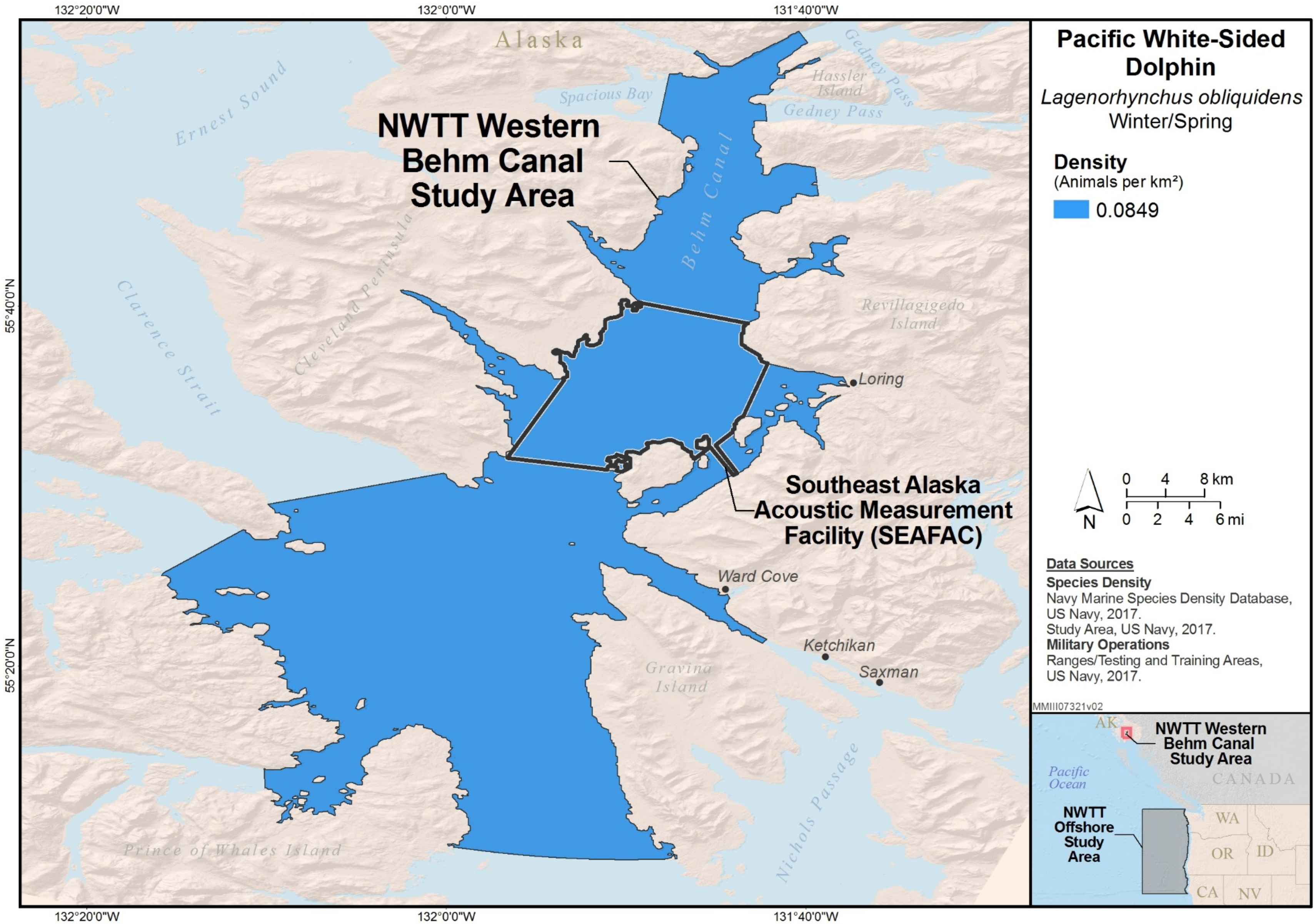

Figure 7.1-6: Western Behm Canal Winter/Spring Distribution of Pacific White-Sided Dolphin

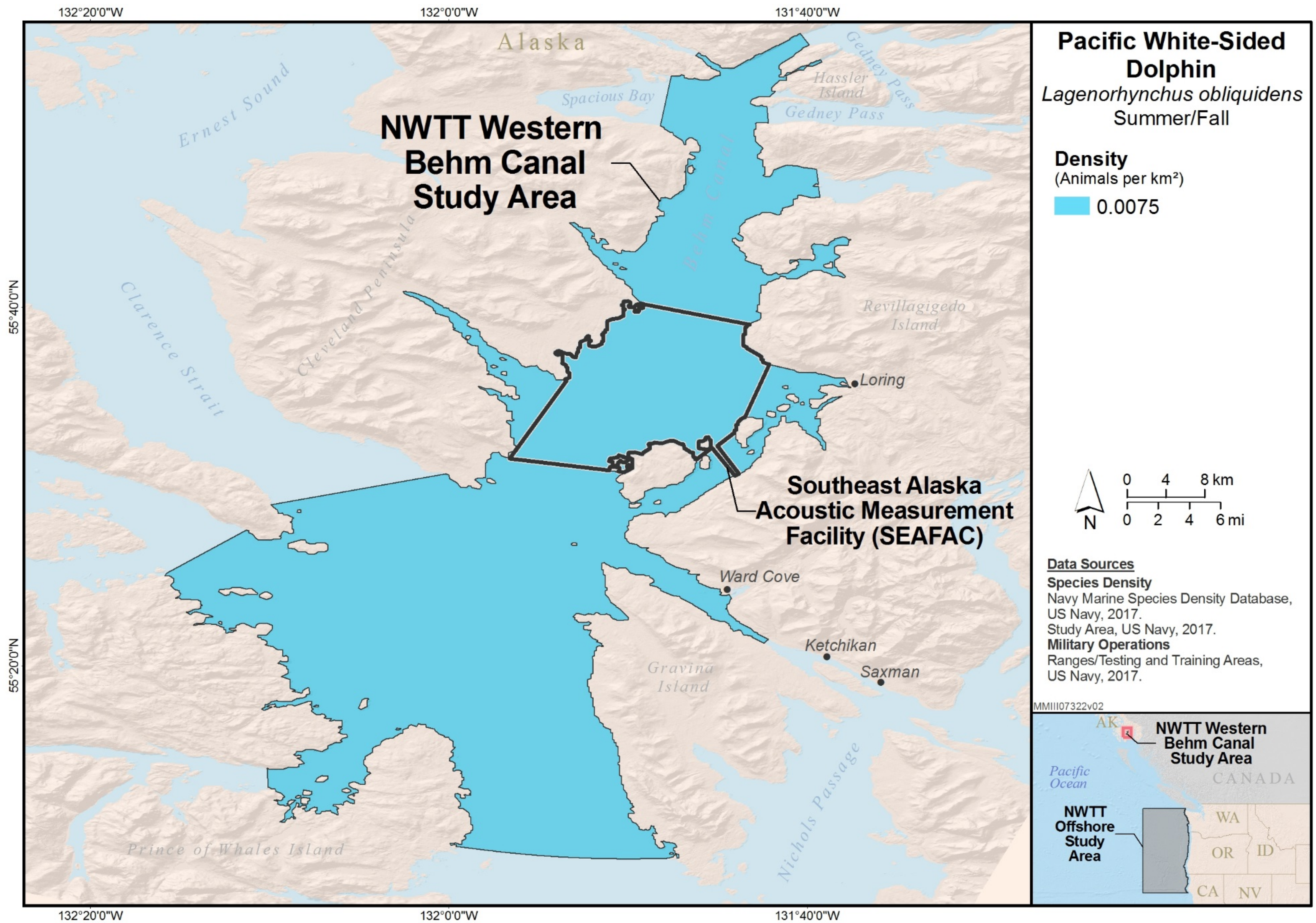

Figure 7.1-7: Western Behm Canal Summer/Fall Distribution of Pacific White-Sided Dolphin

7.1.5 *LISSODELPHIS BOREALIS*, NORTHERN RIGHT WHALE DOLPHIN

The northern right whale dolphin is an unusual-looking cetacean because it has a long, svelte body, no dorsal fin, and small flukes and pectoral fins (Jefferson et al., 2015; Leatherwood et al., 1988). They are all black with a small amount of white on the belly and tail. The uniqueness of this species' appearance makes them unlikely to be mistaken for any other species in their range, if seen clearly. The northern right whale dolphin is a temperate species found across the Pacific (Lipsky, 2009). It appears more in Southern California in the cool months (Soldevilla et al., 2006) and is not seen frequently in Canadian waters (Baird & Stacey, 1991). The lack of a dorsal fin means they cause minimal disturbance at the surface of the water; therefore, they may be difficult to observe in elevated Beaufort sea states (Jefferson et al., 2015). At a distance, when they are porpoising, they could be mistaken for a group of traveling sea lions (Jefferson et al., 2015; Leatherwood et al., 1988). They are seen in groups with a wide variety of marine mammals, including California sea lions, but their most frequent associates are Pacific white-sided dolphins, Risso's dolphins, and common dolphins (*Delphinus* sp.) (Allen et al., 2011; Leatherwood et al., 1988). A single stock of northern right whale dolphins, the California/Oregon/Washington stock, is recognized by NMFS (Carretta et al., 2017b), and northern right whale dolphins that occur in the Offshore region of the NWTT Study Area belong to this stock.

Offshore. Survey data suggest that, at least in the eastern North Pacific, seasonal inshore-offshore and north-south movements are related to prey availability, with peak abundance in the Southern California Bight during winter and distribution shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Barlow, 1995; Becker et al., 2014; Forney & Barlow, 1998; Forney et al., 1995; Leatherwood & Walker, 1979). NMFS SWFSC developed a CCE habitat-based density model for northern right whale dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. Northern right whale dolphins are relatively common off the Washington coast, but based on a lack of sighting records, this species is not expected to occur within the Inland Waters region of the NWTT Study Area.

Western Behm Canal. Northern right whale dolphins are not expected to occur within the Western Behm Canal region of the NWTT Study Area.

Table 7.1-5: Summary of Density Values for Northern Right Whale Dolphin

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

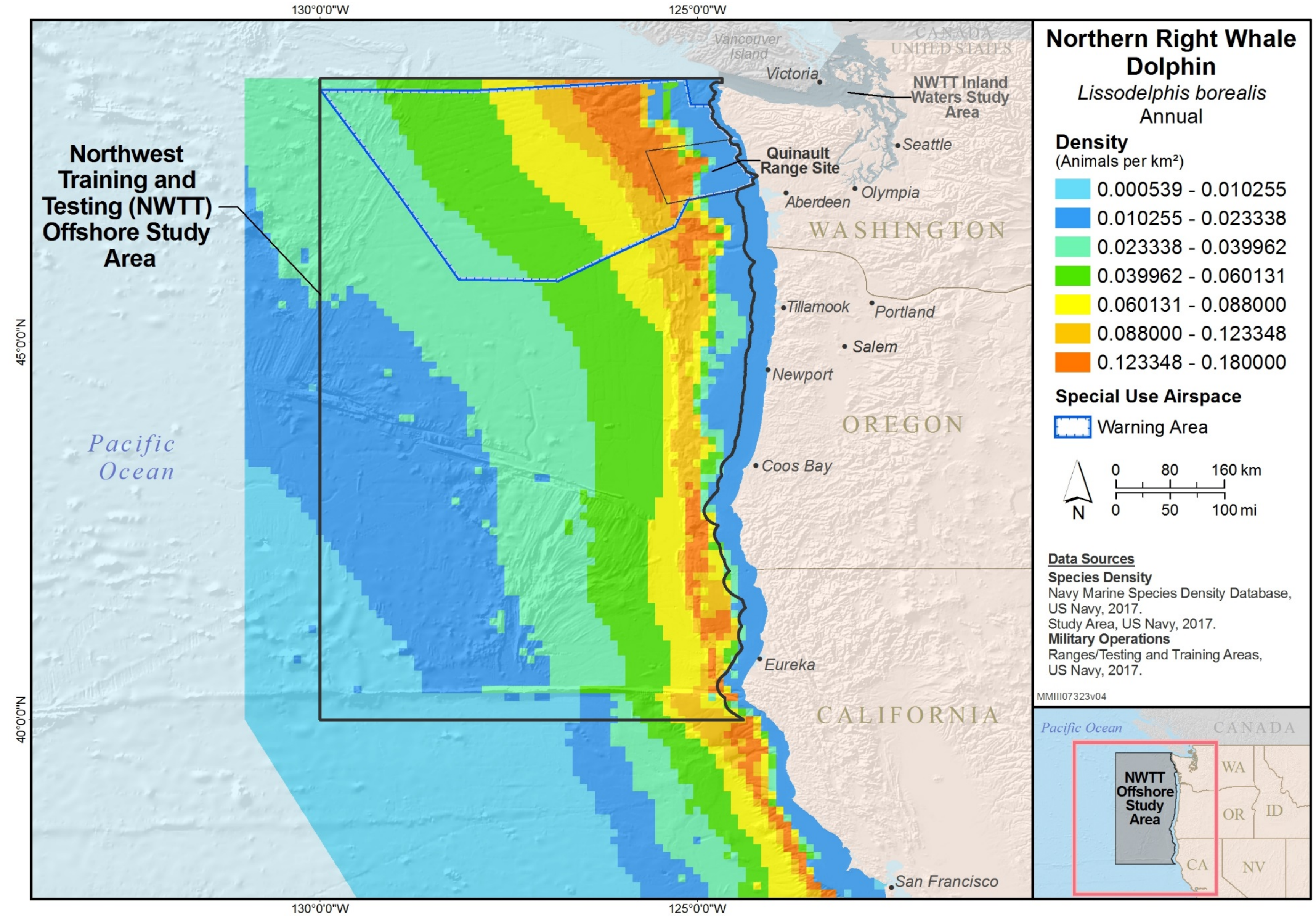

Figure 7.1-8: Offshore Annual Distribution of Northern Right Whale Dolphin

7.1.6 *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., 2011; Foote et al., 2009; 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 the (1) Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock (Prince William Sound through the Aleutian Islands and Bering Sea); (2) AT1 Transient stock (Alaska from Prince William Sound through the Kenai Fjords); (3) Alaska resident stock (Southeast Alaska to the Aleutian Islands and Bering Sea); (4) Northern Resident stock (British Columbia through part of Southeast Alaska); (5) West Coast Transient stock (Alaska through California); (6) Offshore stock (Southeast Alaska through California); (7) Southern Resident stock (within the inland waters of Washington State and southern British Columbia, and also in coastal waters from British Columbia through California); and (8) Hawaii stock (Carretta et al., 2017b; Muto et al., 2017). Three separate pods comprise the Southern Resident stock, identified as the J, K, and L pods (Ford et al., 2000). The Offshore and West Coast Transient stocks are those most likely to occur in the Offshore region of the NWTT Study Area, although both the Southern and Northern Resident stocks may also occur offshore, although their distribution patterns are seasonally variable (Hanson et al., 2018). The Southern Resident and West Coast Transient stocks are the stocks most likely to occur in the Inland Waters region of the NWTT Study Area. The Alaska Resident and West Coast Transient stocks are the stocks most likely to occur in the Western Behm Canal region of the NWTT Study Area, although individuals of the Offshore stock may also occur in the region.

Offshore. A combination of movement data (from both visual observations and satellite-linked tags) and detections from stationary acoustic recorders have provided information on the offshore distribution of the Southern Resident stock (Hanson et al., 2018). These data have been used to develop state space movement models that provide estimates of the probability of occurrence (or relative density) of Southern Residents in the offshore study area in winter and spring (Hanson et al., 2018). Since the total number of animals that comprise each pod is known, the relative density estimates were used in association with the total abundance estimates to derive absolute density estimates (i.e., number of animals/km^2) within the offshore study area. Given that the K and L pods were together during all but one of the satellite tag deployments, Hanson et al. (2018) developed two separate state space models, one for the combined K and L pods and one for the J pod. The absolute density estimates were thus derived based on a total of 53 animals for the K and L pods (K pod = 18 animals, L pod = 35 animals) and 22 animals for the J pod (Center for Whale Research, 2019). Of the three pods, the K and L pods appear to have a more extensive and seasonally variable offshore coastal distribution, with rare sightings as far south as Monterey Bay, California (Carretta et al., 2019; Ford et al., 2000; Hanson et al., 2018). Two seasonal density maps were thus developed for the K and L pods, one representing their distribution from January to May (the duration of the tag deployments), and another representing their distribution from June to December. Based on stationary acoustic recording data, their excursions offshore from June to December are more limited and typically do not extend south of the Columbia River (Emmons). To provide more conservative density estimates, the June to December distribution was extended just south of the Columbia River and the total K and L populations (53 animals) were redistributed within the more limited range boundaries. A conservative approach was also adopted for the J pod since the January to May density estimates were assumed to represent annual occurrence patterns, despite information that this pod typically spends more time in the inland waters during the summer and fall (Carretta et al., 2019; Ford et al., 2000; Hanson et al., 2018). Further, for all seasons the Navy assumed that all members of the three pods of Southern Residents could occur either offshore or in the inland waters, so the total number of animals in the stock was used to derive density estimates for both study areas.

Due to the difficulties associated with reliably distinguishing the different stocks of killer whales from at-sea sightings, density estimates for the rest of the stocks are presented as a whole (i.e., includes the Offshore, West Coast Transient, and Northern Resident stocks). Density values for these combined stocks of killer whale are available for the SWFSC Oregon/Washington (0.00092 animals/km^2; CV = 1.27) and Northern California (0.00051 animals/km^2; CV = 1.12) offshore strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates. These values were used to represent density year-round.

Inland Waters. As noted above, the Southern Resident and West Coast Transient stocks are the two that are most likely to occur in the Inland Waters region of the NWTT Study Area. The Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. Photo-identification of individual whales through the years has resulted in a substantial understanding of this stock's structure, behaviors, and movements in inland waters. However, residency patterns vary by year, month, area, and pod (Hanson & Emmons, *in prep*). Average seasonal residency patterns in concert with sighting data maintained by the Whale Museum from January 2003 through December 2016 were used to provide estimates of Southern Resident Killer Whale density by season and area. Hanson and Emmons (*in prep*) presented the percentage of time the Southern Resident pods spent within the inland waters on a monthly basis. Their monthly sighting data were used to establish residency patterns for four seasonal periods. The mean percentage of each three-month period was used to estimate the average number of animals present in the inland waters assuming a total population of 81 animals (the estimate of all three Southern Resident pods at the time this analysis was conducted (Carretta et al., 2017b)). Sighting data from the Whale Museum's Southern Resident Killer Whale sighting database were then used to determine distribution patters within each of the four seasons.

Consistent with the approach taken by Hanson and Emmons, data from January 2003 onward were used, and included only those database sightings positively identified as Southern Residents. Monthly sightings from all years combined were plotted using ArcGIS and overlaid on the Study Area strata. Geographic strata used for density estimation were developed consistent to the degree possible with designated critical habitat strata (National Marine Fisheries Service, 2008). Sightings by stratum were then calculated in ArcGIS and exported to Excel in order to estimate the percentage of sightings occurring monthly in each of the Study Area strata. The total number of animals estimated per season within each stratum, divided by the area of each stratum, provided an estimate of seasonal density for each of the strata.

Data from Houghton et al. (2015) were used to estimate seasonal occurrence patterns of transient killer whales in the Inland Waters. Based on sighting data collected over a seven-year period (2004–2010), Houghton et al. (2015) presented the number of unique occurrences within inland waters on a monthly basis for five geographic strata. Their monthly occurrence data, in concert with their average group size estimate for the 2004–2010 period (5.16 animals), were used to estimate the average number of individuals occurring within the inland waters on a seasonal basis. Seasonal density was estimated based on the area of each of the strata used by Houghton et al. (2015).

Western Behm Canal. For the Western Behm Canal, density estimates for Alaska Residents and West Coast Transients for all seasons were taken from the Marine Mammal Occurrence/Density Report prepared in support of a NEPA document for Navy activities at SEAFAC (U.S. Department of the Navy, 2010). Density estimates were provided for both the Alaska Resident and West Coast Transient stocks. Density values for the offshore stock of killer whales were calculated based on prorating seasonal sighting data collected in Southeast Alaskan waters between 1991 and 2007 (Dahlheim et al., 2009). Based on the ratio of offshore killer whale and Alaska resident killer whale sightings (0.04878), density estimates for the residents were prorated to provide representative density estimates for the offshore stock.

Table 7.1-6: Summary of Density Values for Killer Whale

Location	Spring	Summer	Fall	Winter
Offshore: Southern Resident	S	S	S	S
Offshore: All other stocks	0.00051–0.00092	0.00051–0.00092	0.00051–0.00092	0.00051–0.00092
Inland Waters: Southern Resident	S	S	S	S
Inland Waters: Transient	S	S	S	S
Western Behm Canal: Alaska Resident	0.0153	0.0050	0.0349	0.0050
Western Behm Canal: Transient	0.0020	0.0057	0.0041	0.0020
Western Behm Canal: Offshore stock	0.00075	0.00024	0.00170	0.00024

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

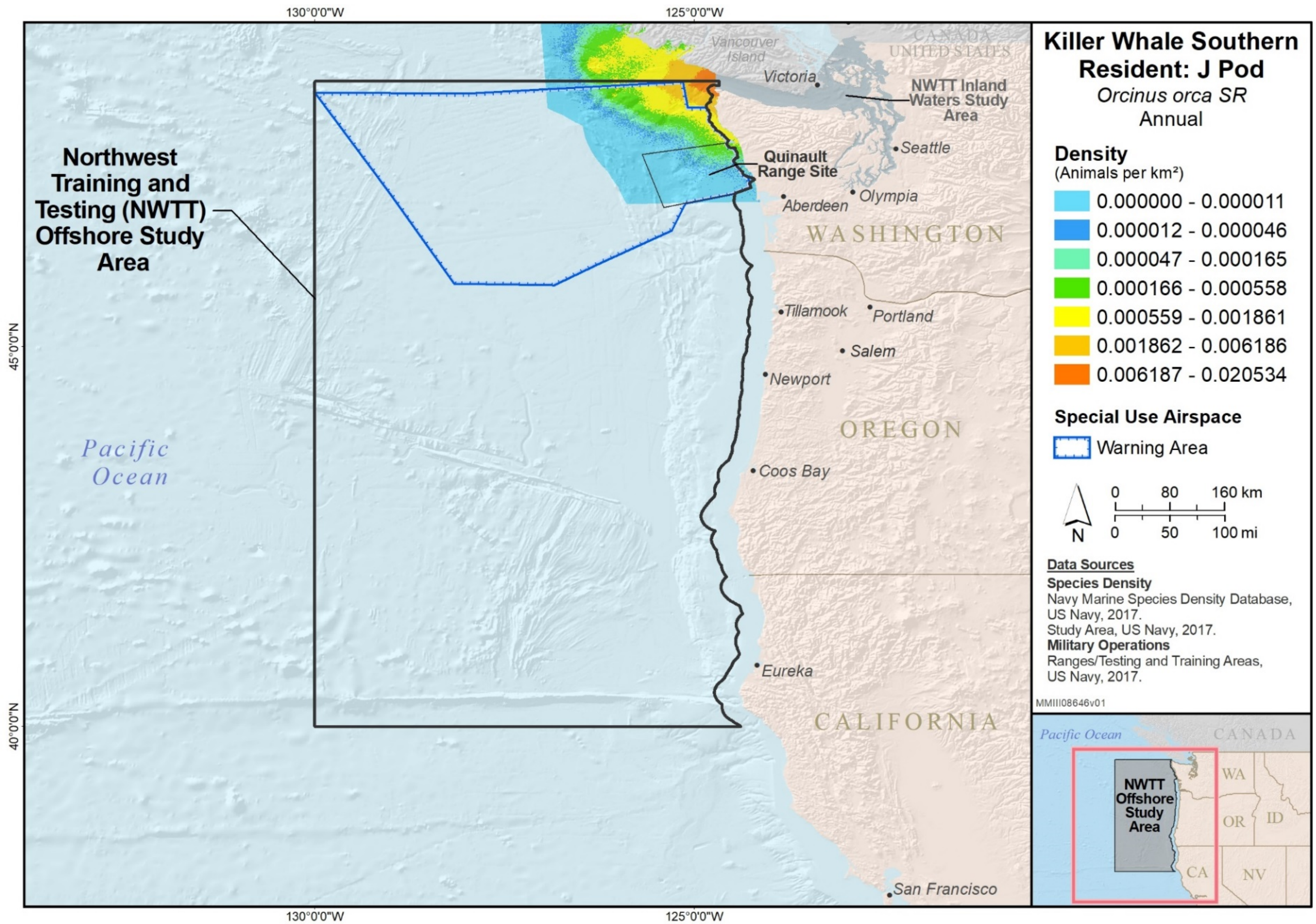

Figure 7.1-9: Offshore Annual Distribution of Southern Resident Killer Whale (J Pod)

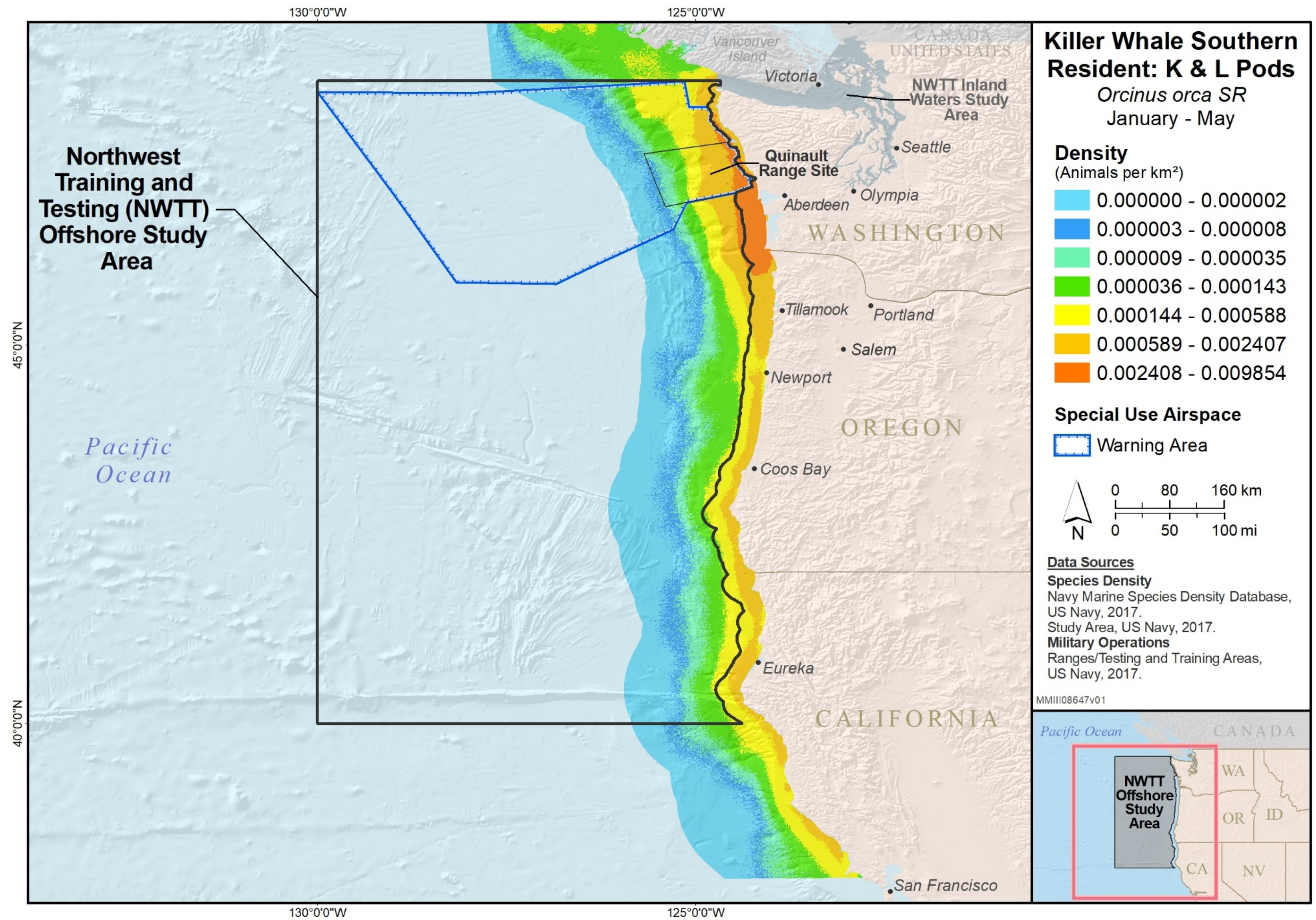

Figure 7.1-10: Offshore January–May Distribution of Southern Resident Killer Whale (K & L Pods)

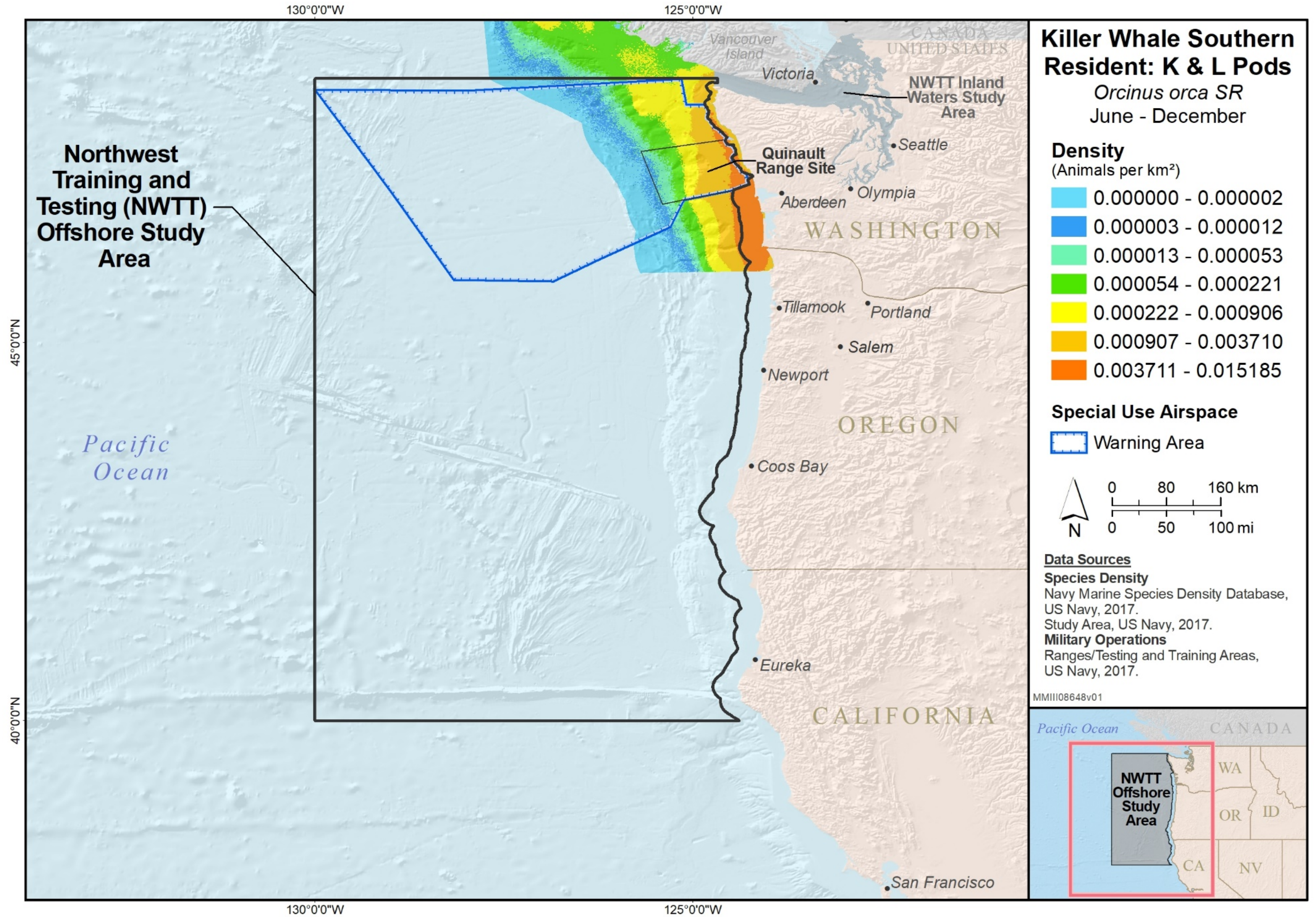

Figure 7.1-11: Offshore June–December Distribution of Southern Resident Killer Whale (K & L Pods)

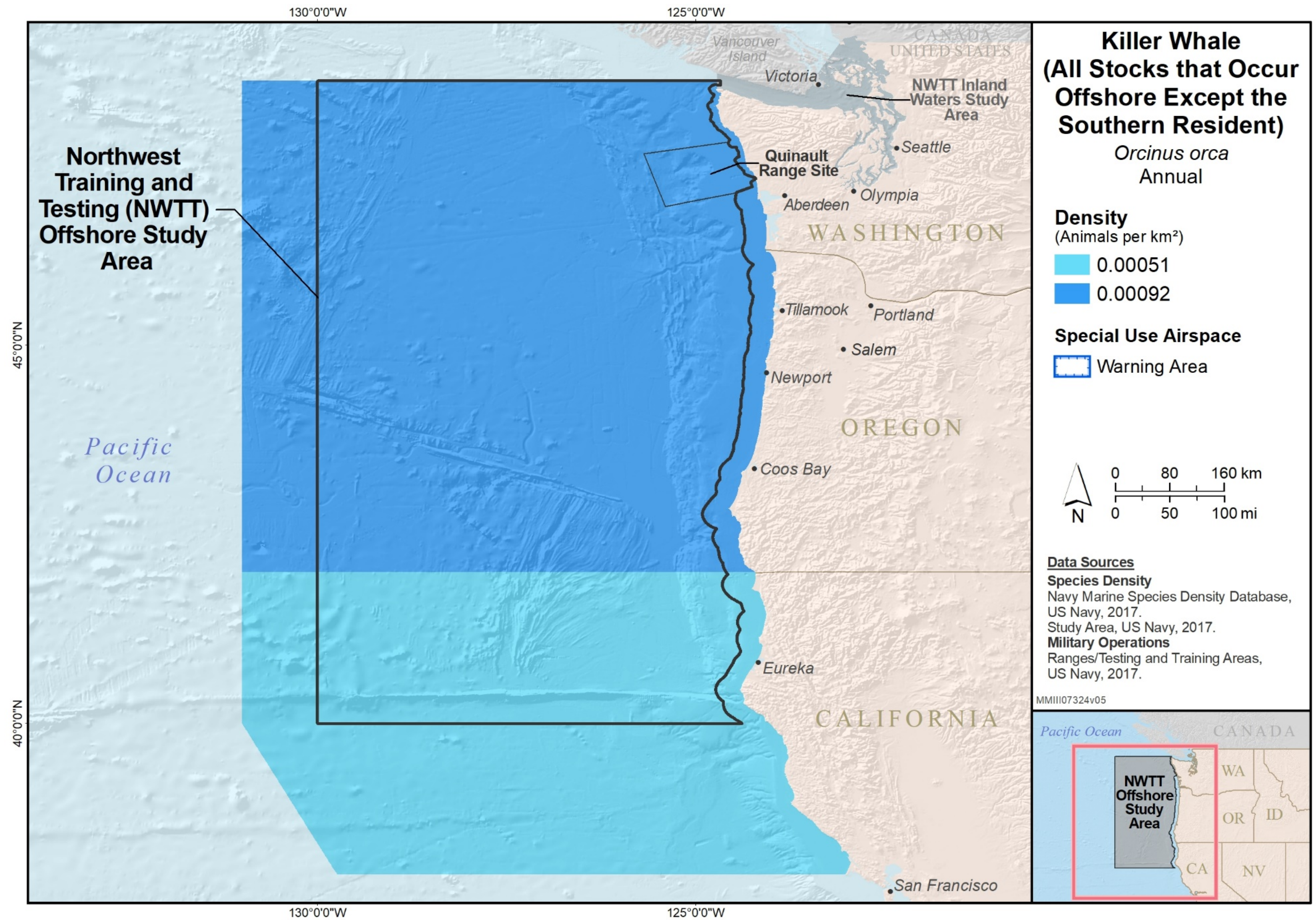

Figure 7.1-12: Offshore Annual Distribution of Killer Whale (All Stocks Except Southern Resident)

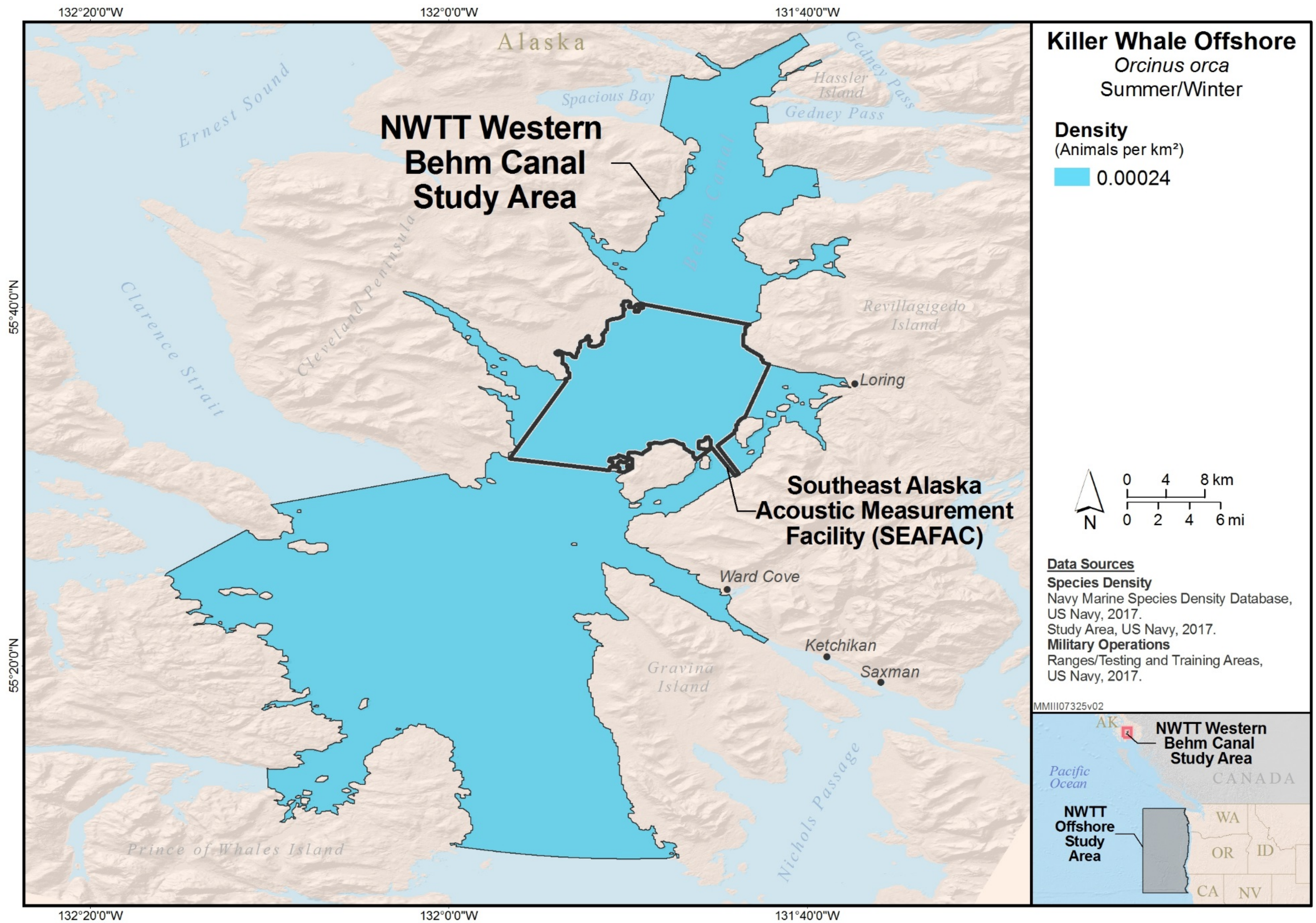

Figure 7.1-13: Western Behm Canal Summer/Winter Distribution of Offshore Killer Whale

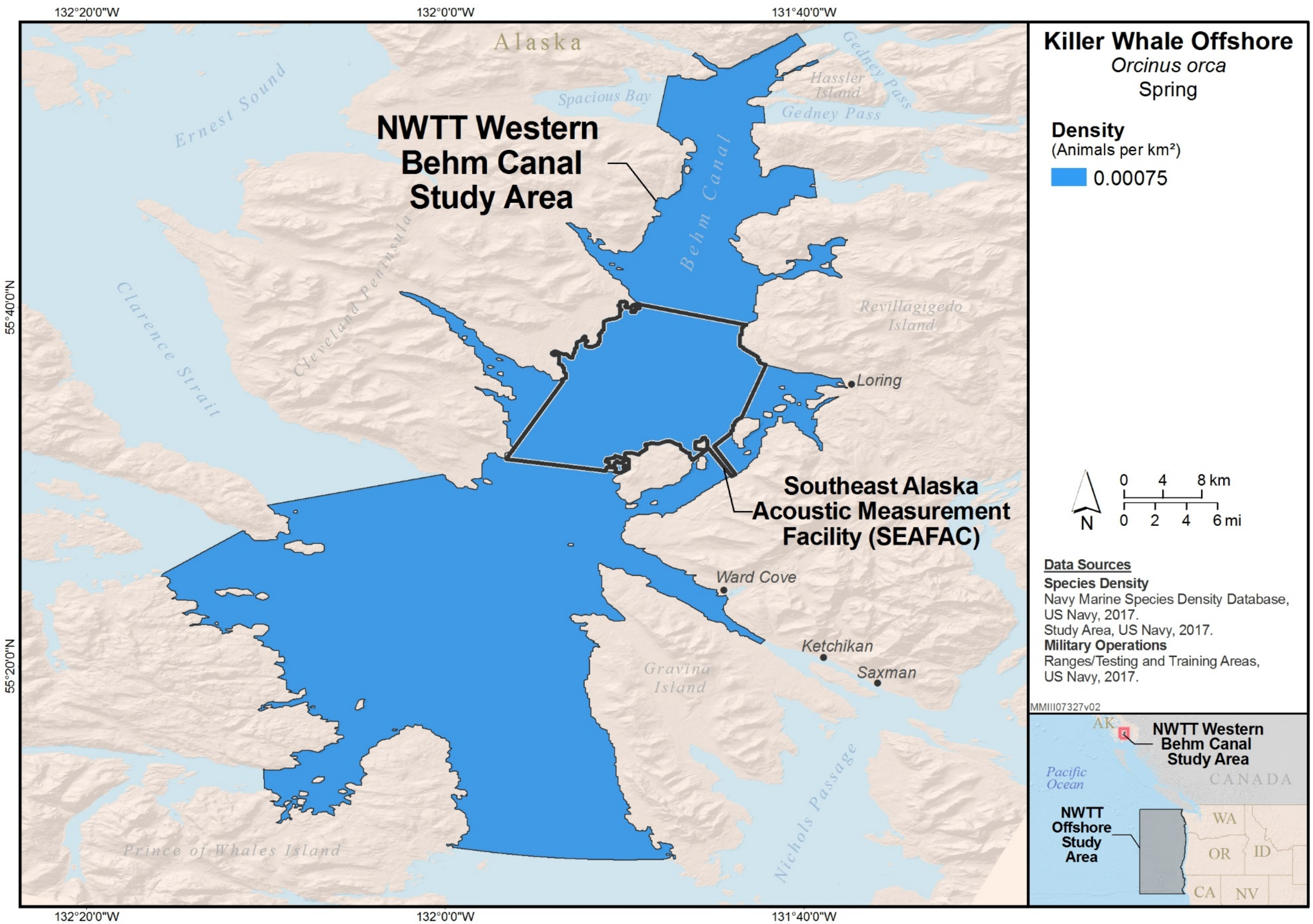

Figure 7.1-14: Western Behm Canal Spring Distribution of Offshore Killer Whale

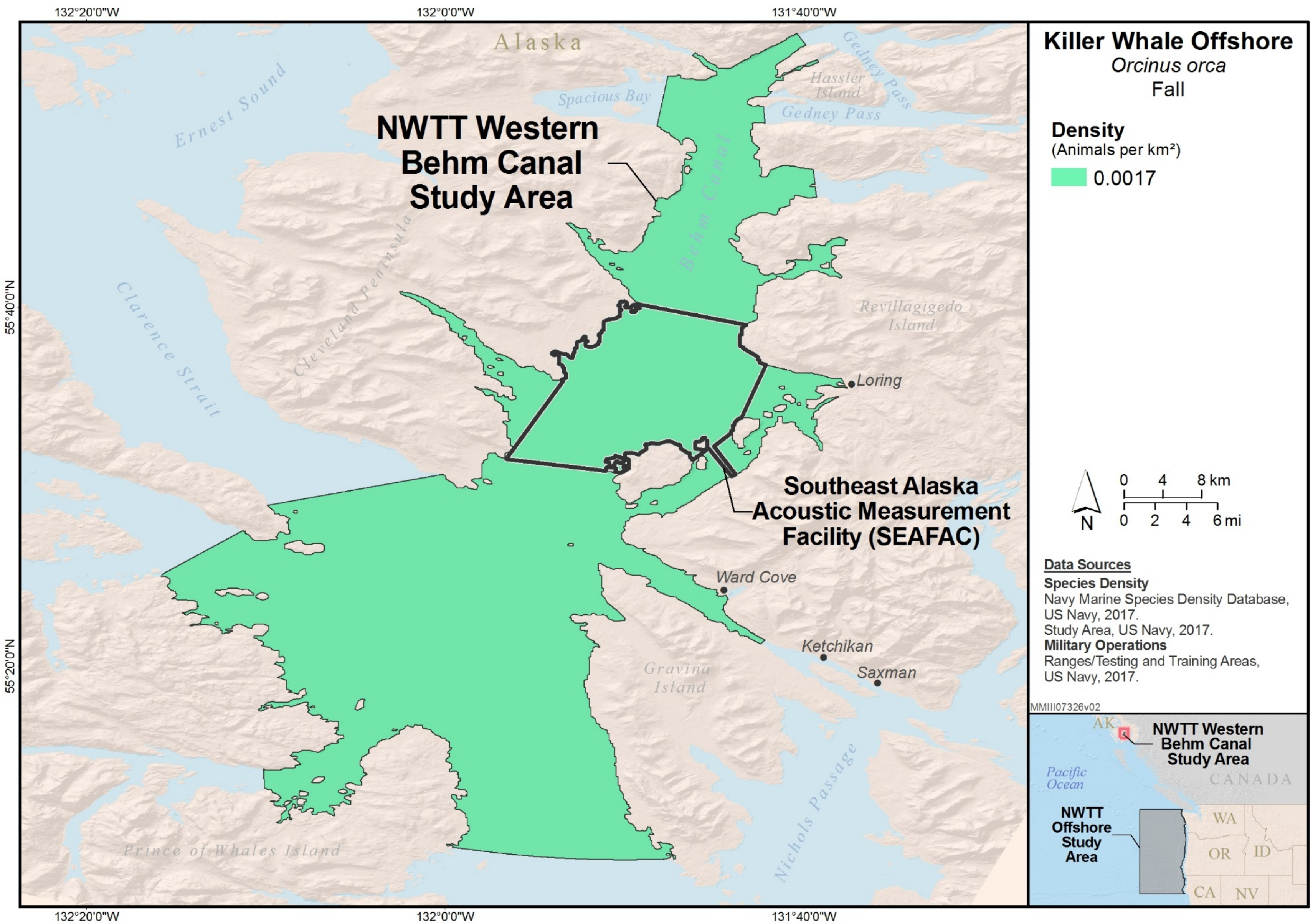

Figure 7.1-15: Western Behm Canal Fall Distribution of Offshore Killer Whale

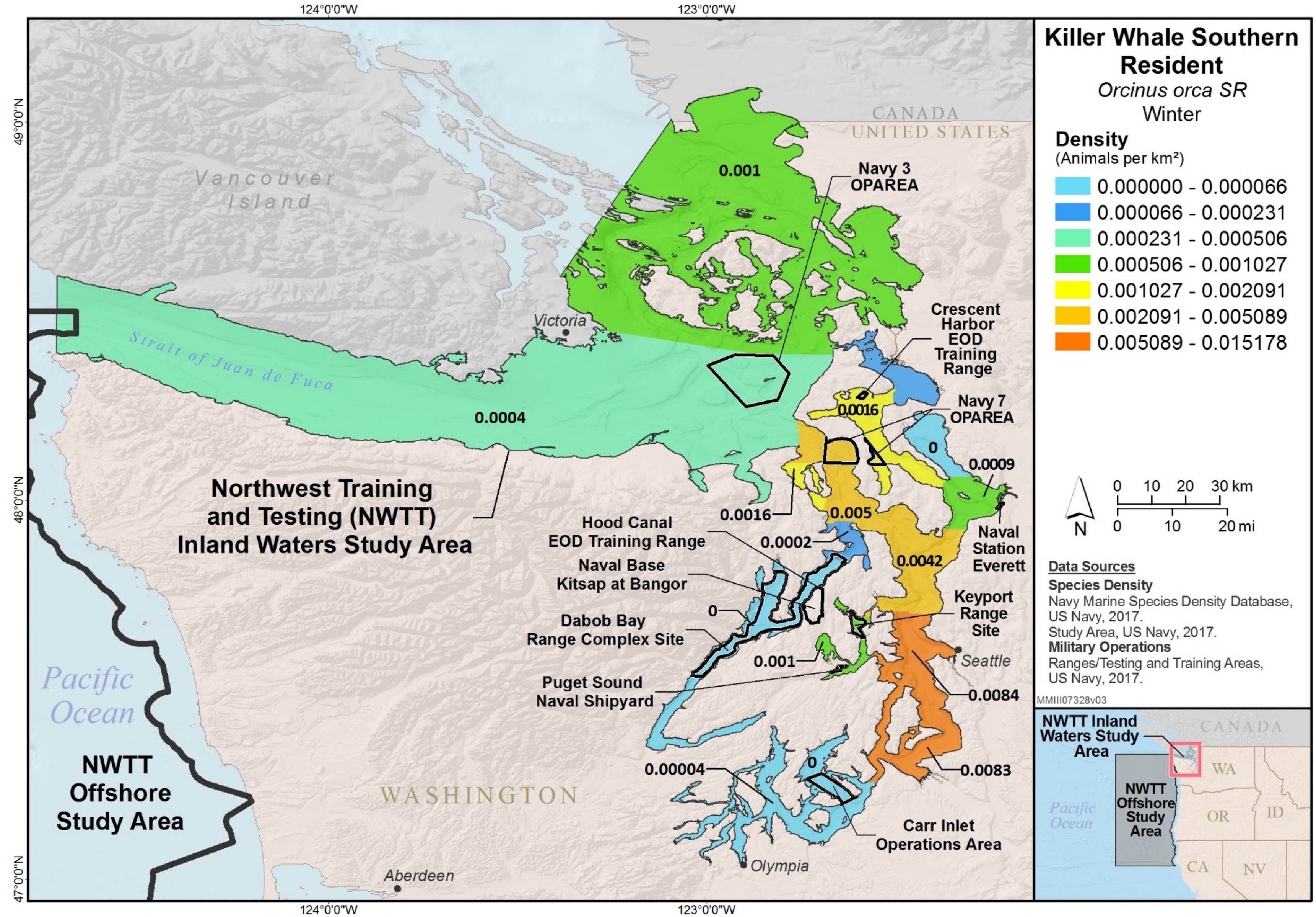

Figure 7.1-16: Inland Waters Winter Distribution of Southern Resident Killer Whale

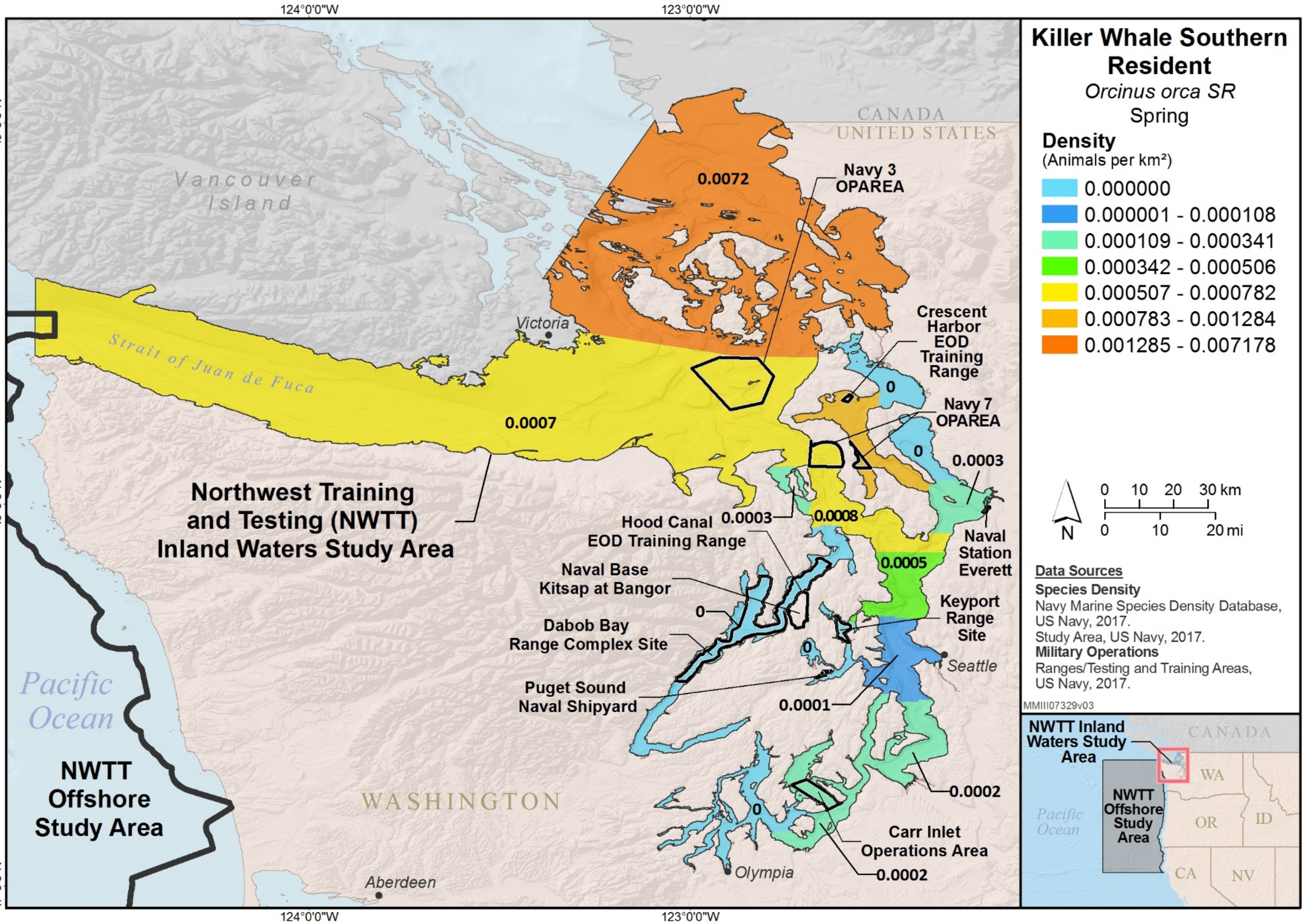

Figure 7.1-17: Inland Waters Spring Distribution of Southern Resident Killer Whale

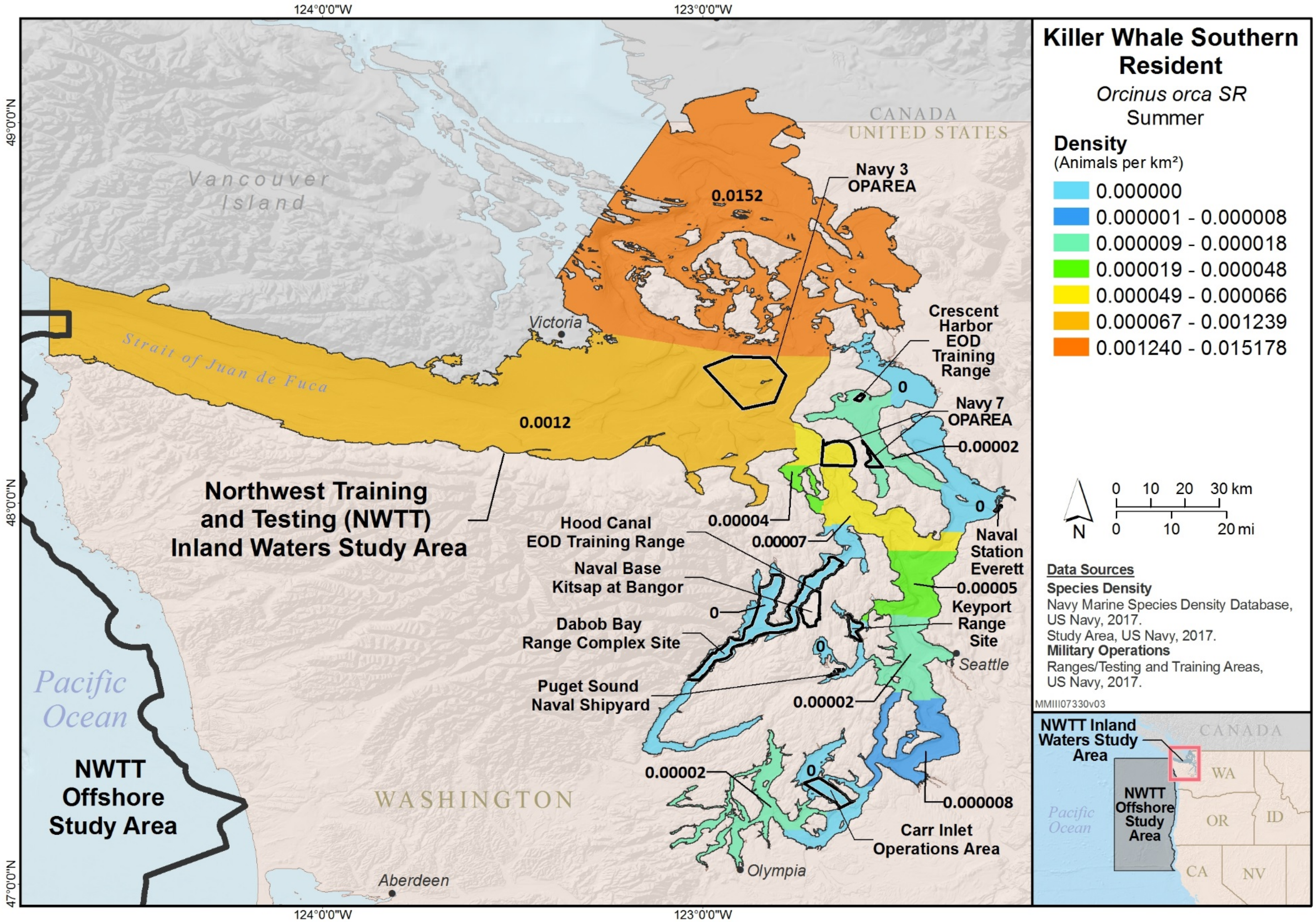

Figure 7.1-18: Inland Waters Summer Distribution of Southern Resident Killer Whale

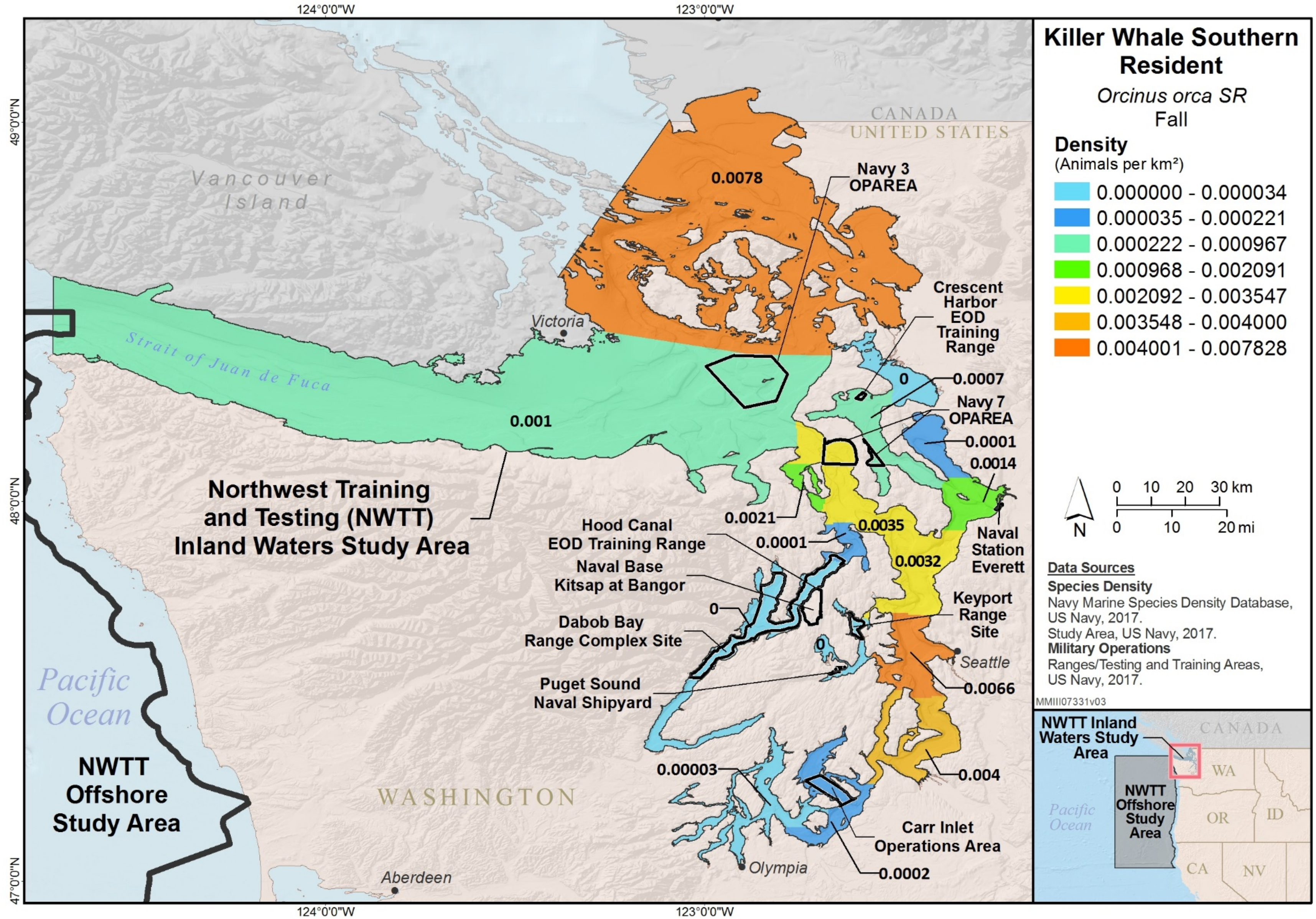

Figure 7.1-19: Inland Waters Fall Distribution of Southern Resident Killer Whale

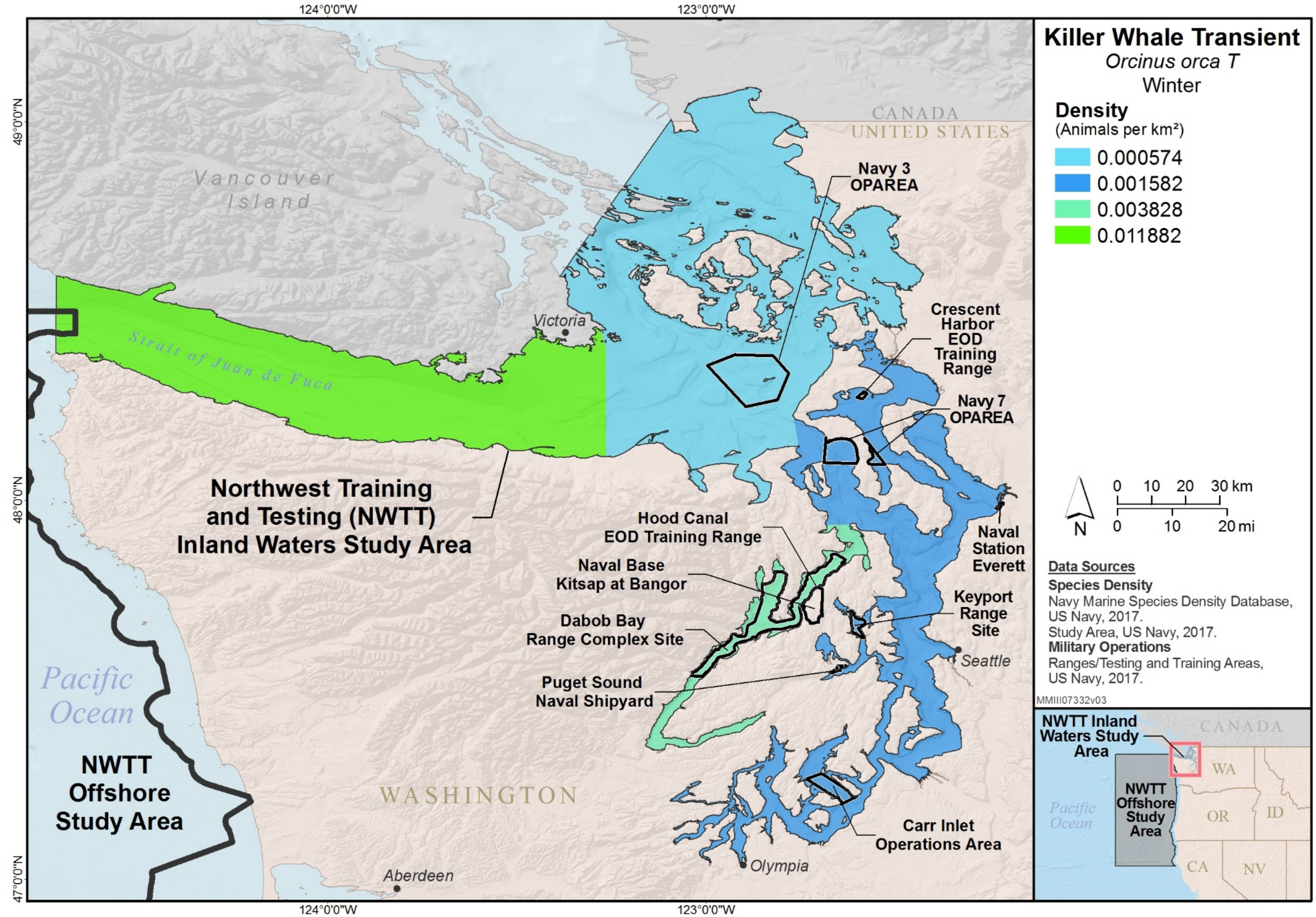

Figure 7.1-20: Inland Waters Winter Distribution of Transient Killer Whale

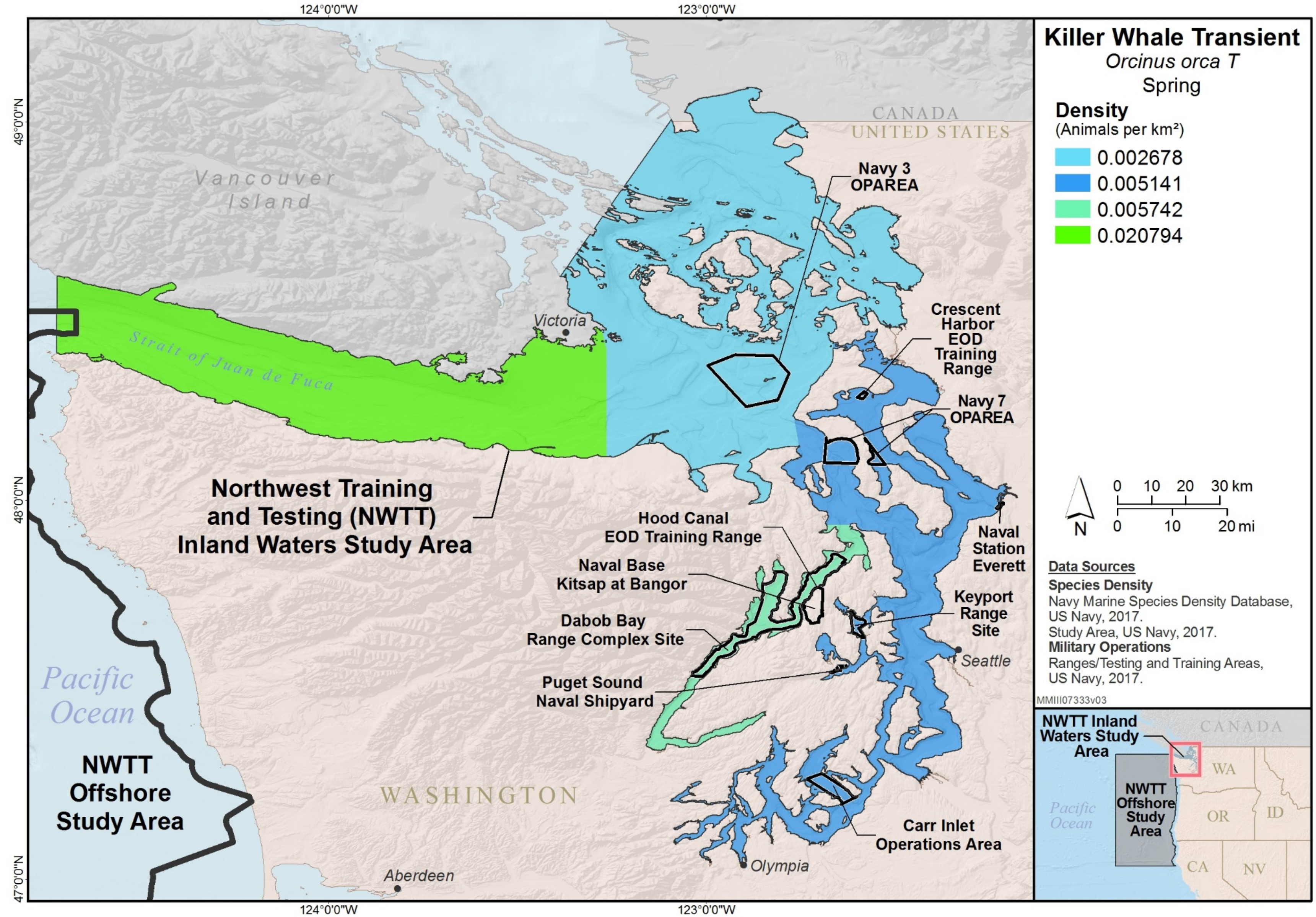

Figure 7.1-21: Inland Waters Spring Distribution of Transient Killer Whale

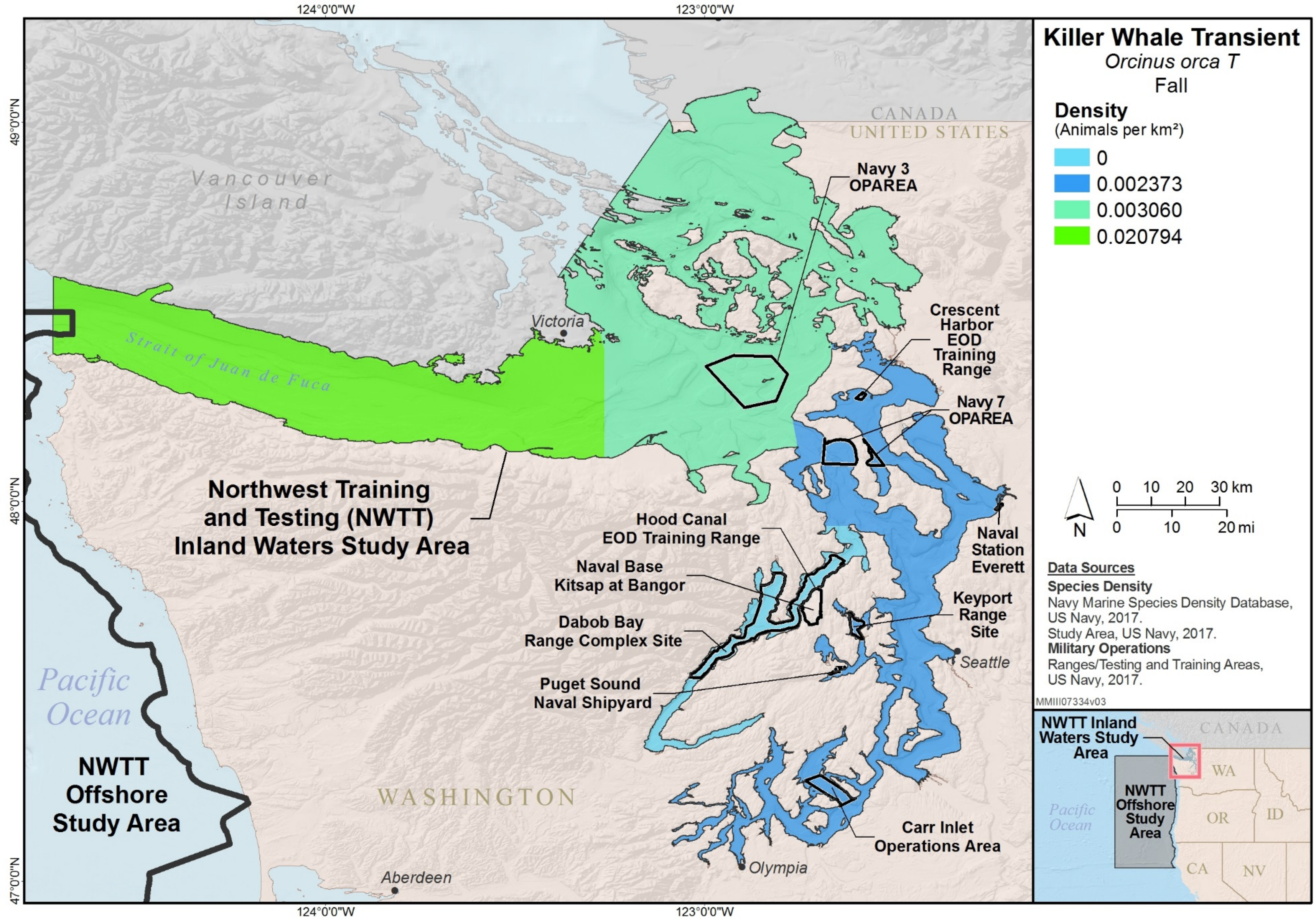

Figure 7.1-22: Inland Waters Fall Distribution of Transient Killer Whale

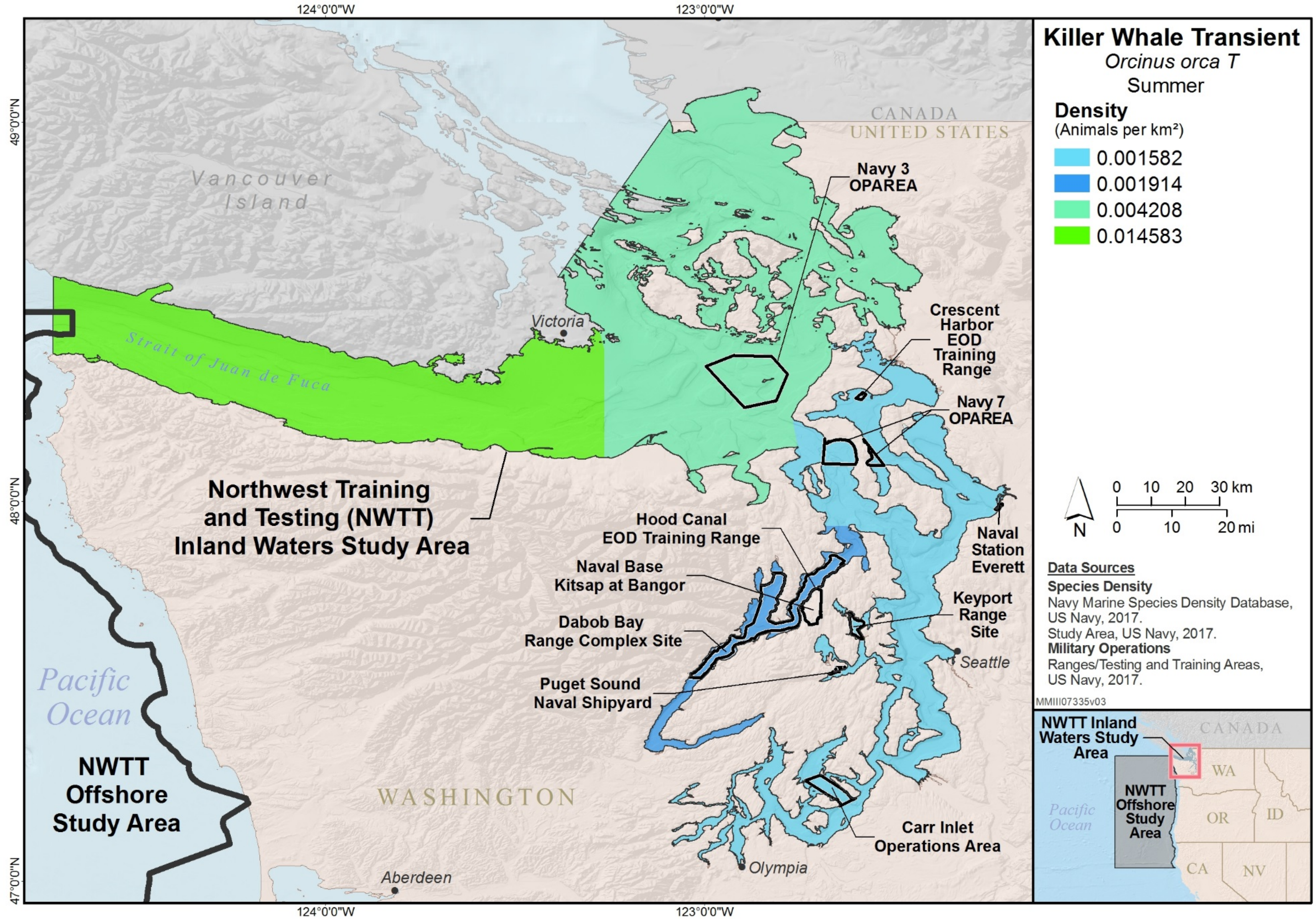

Figure 7.1-23: Inland Waters Summer Distribution of Transient Killer Whale

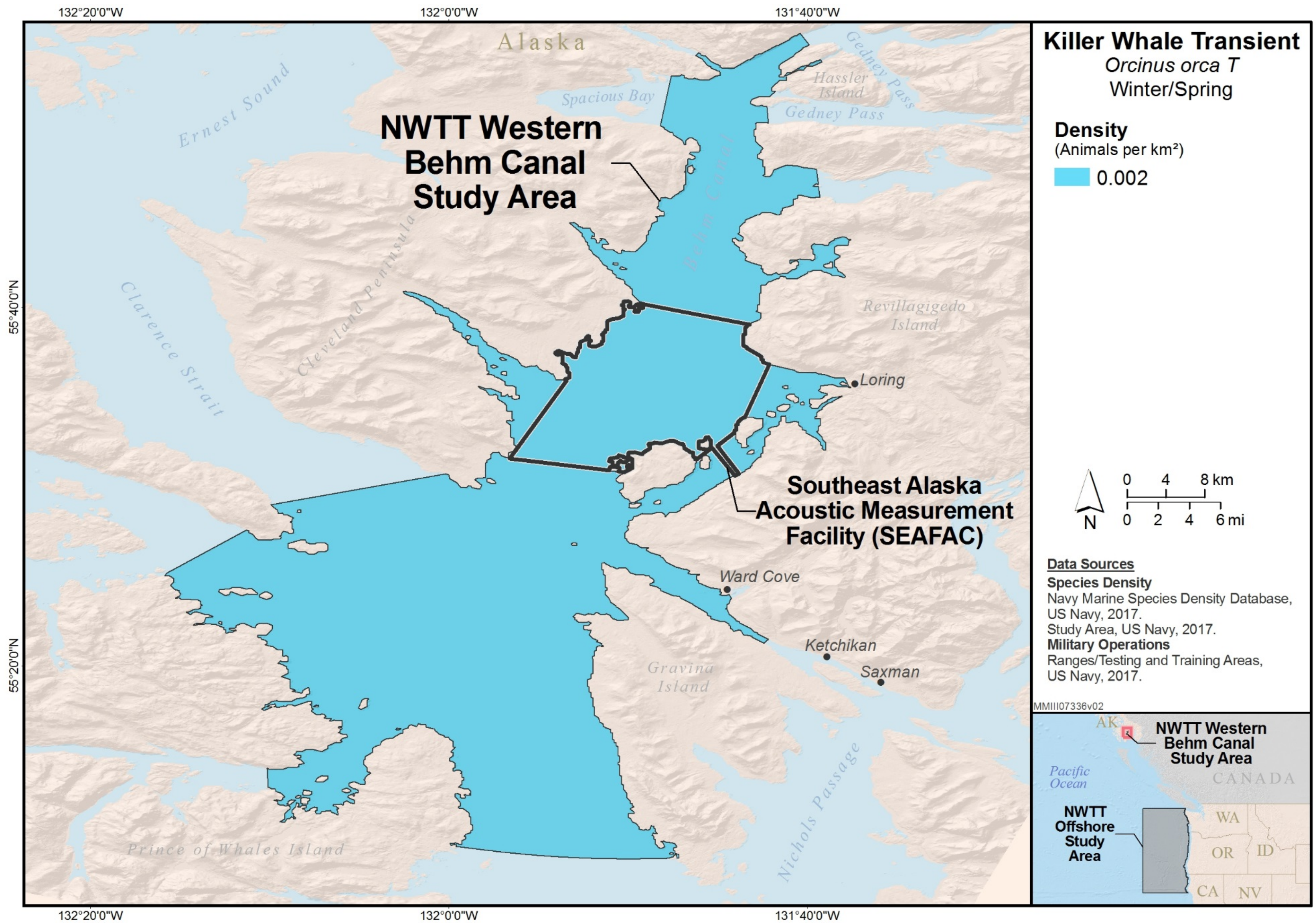

Figure 7.1-24: Western Behm Canal Winter/Spring Distribution of Transient Killer Whale

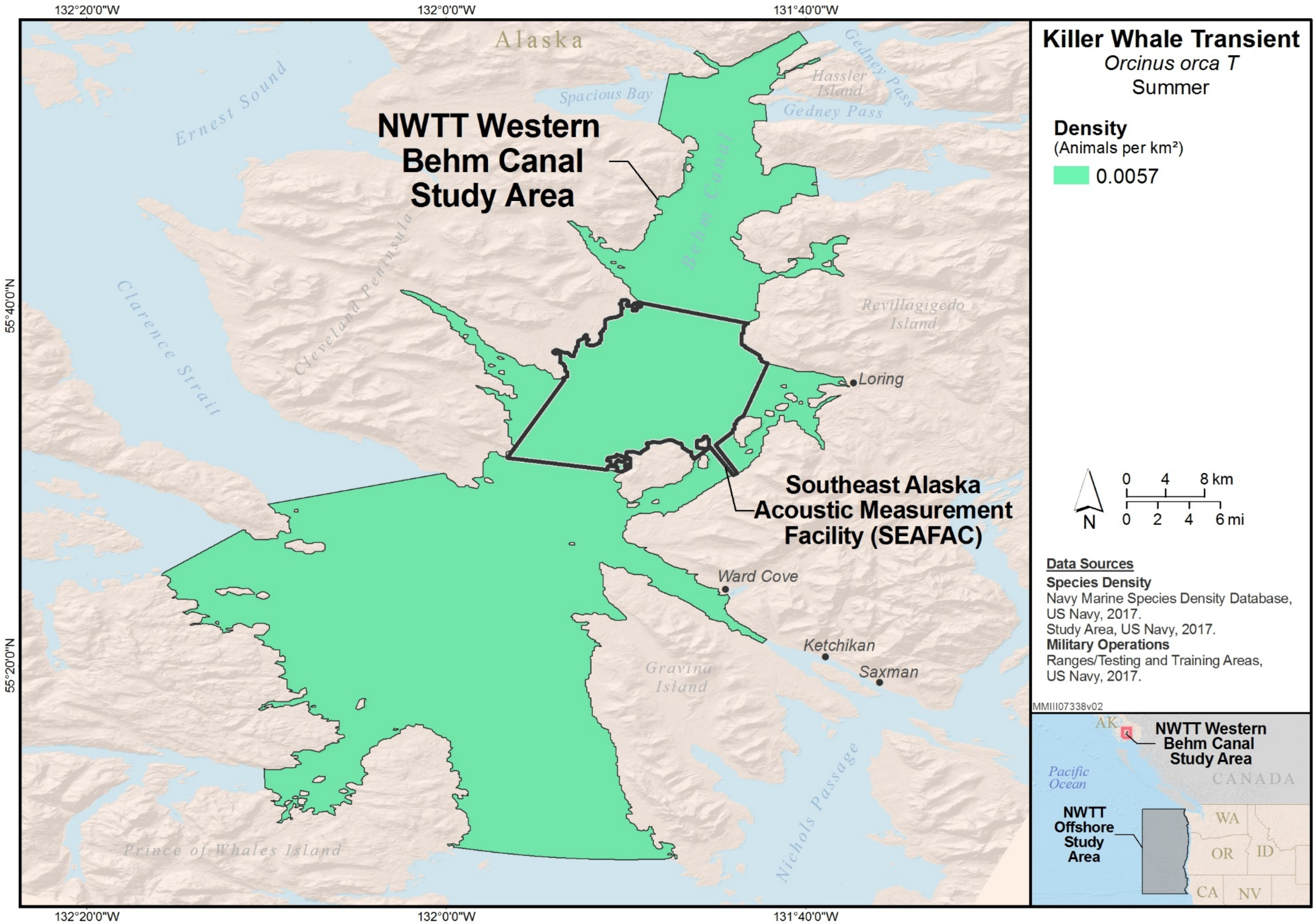

Figure 7.1-25: Western Behm Canal Summer Distribution of Transient Killer Whale

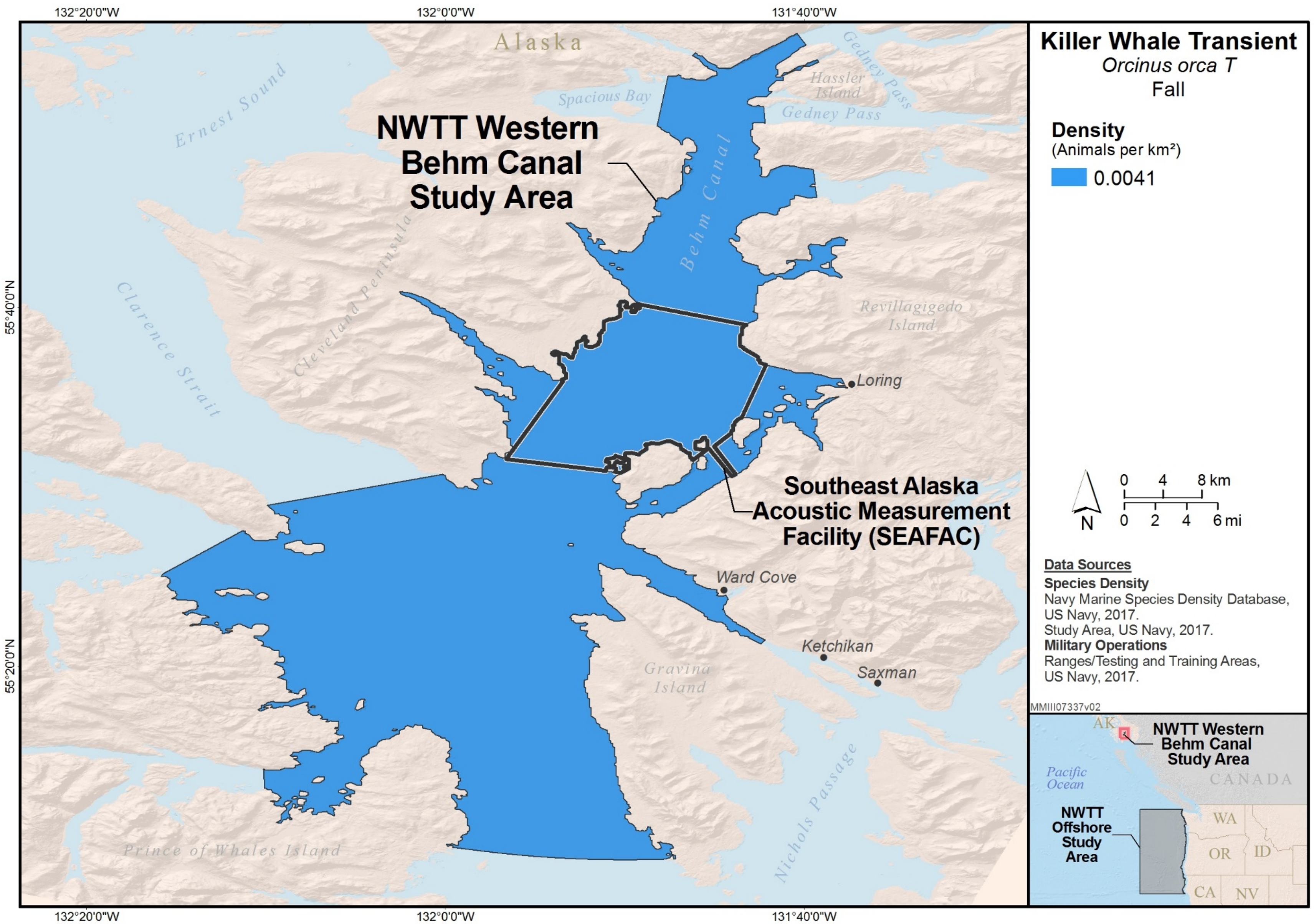

Figure 7.1-26: Western Behm Canal Fall Distribution of Transient Killer Whale

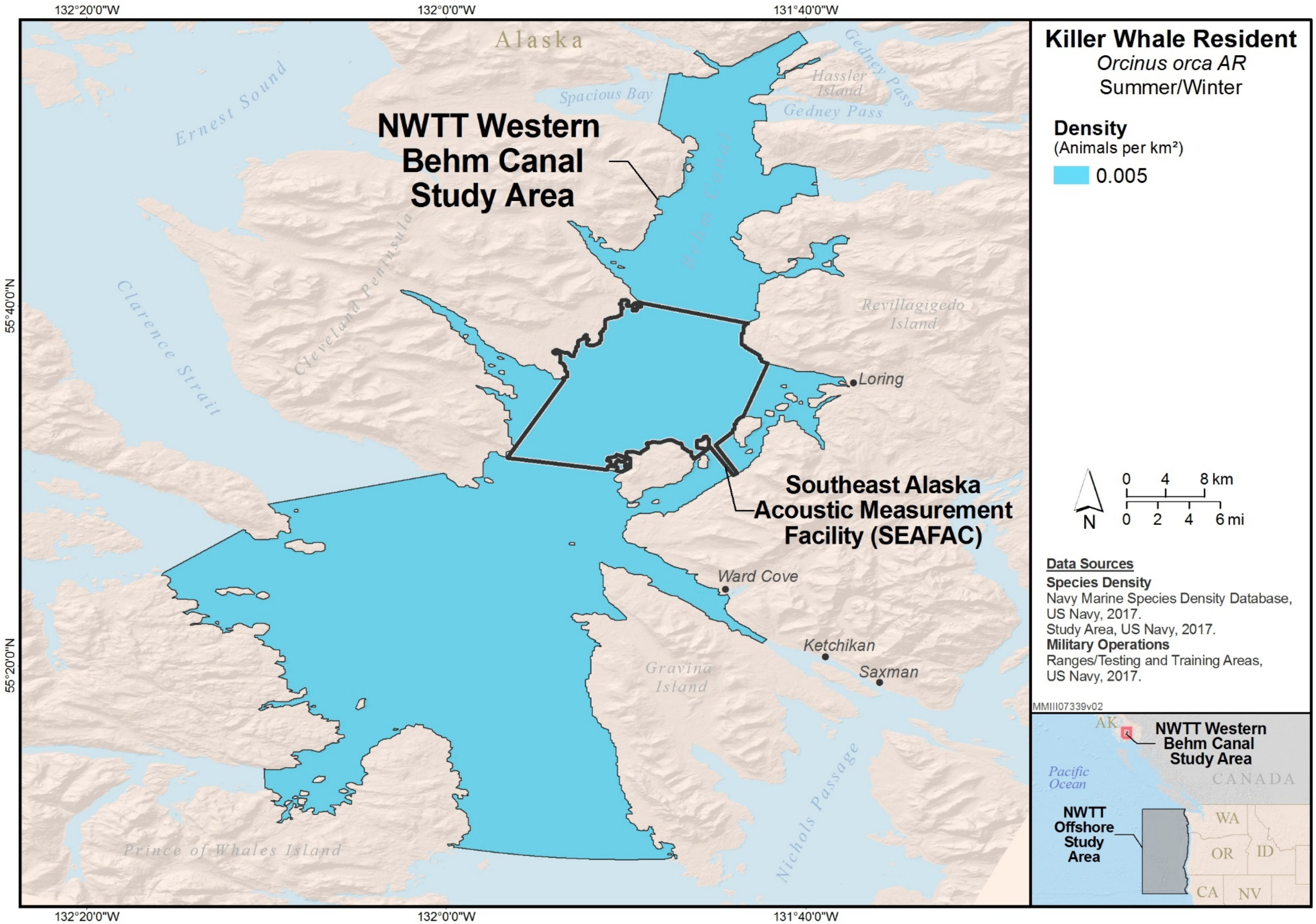

Figure 7.1-27: Western Behm Canal Summer/Winter Distribution of Resident Killer Whale

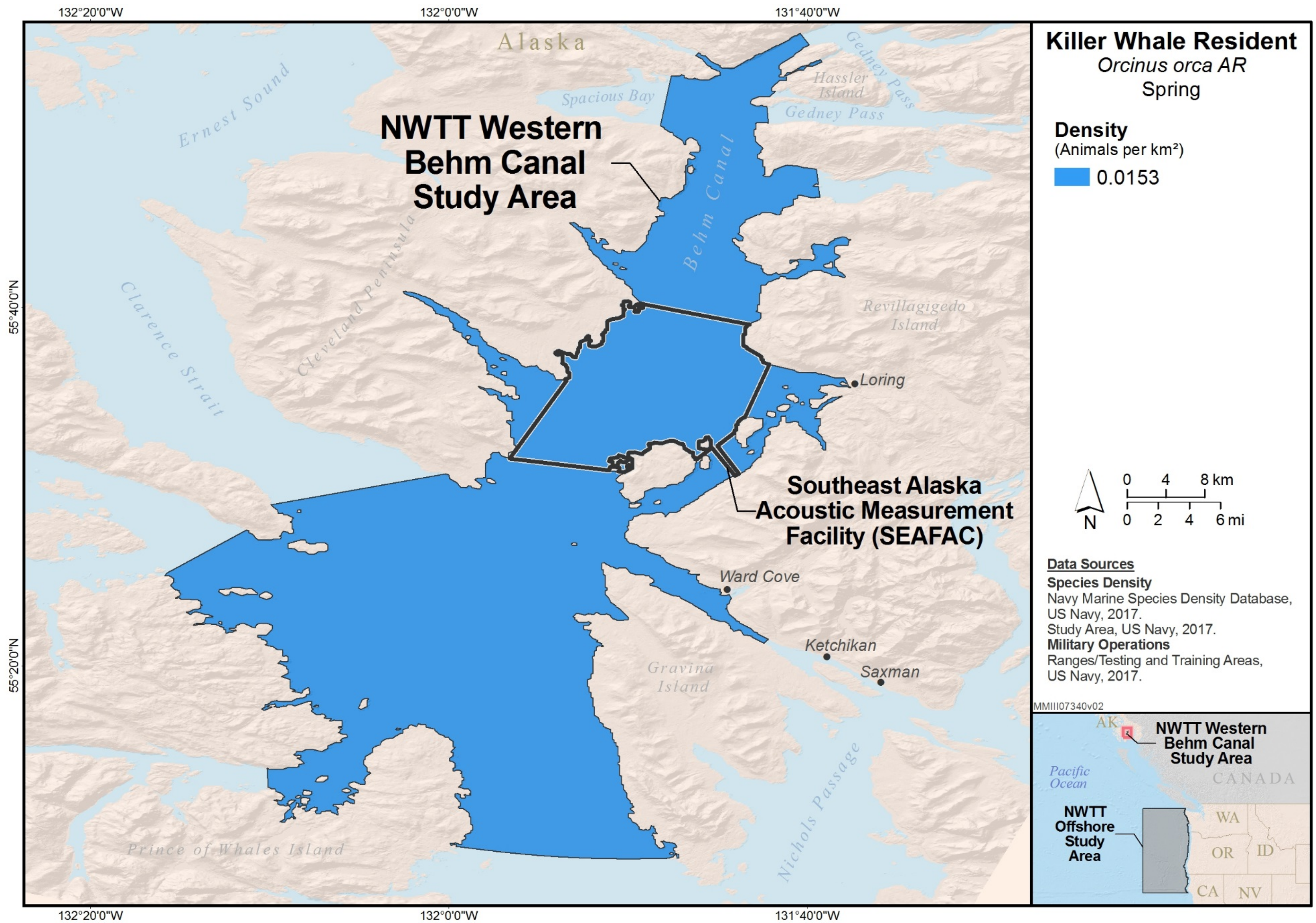

Figure 7.1-28: Western Behm Canal Spring Distribution of Resident Killer Whale

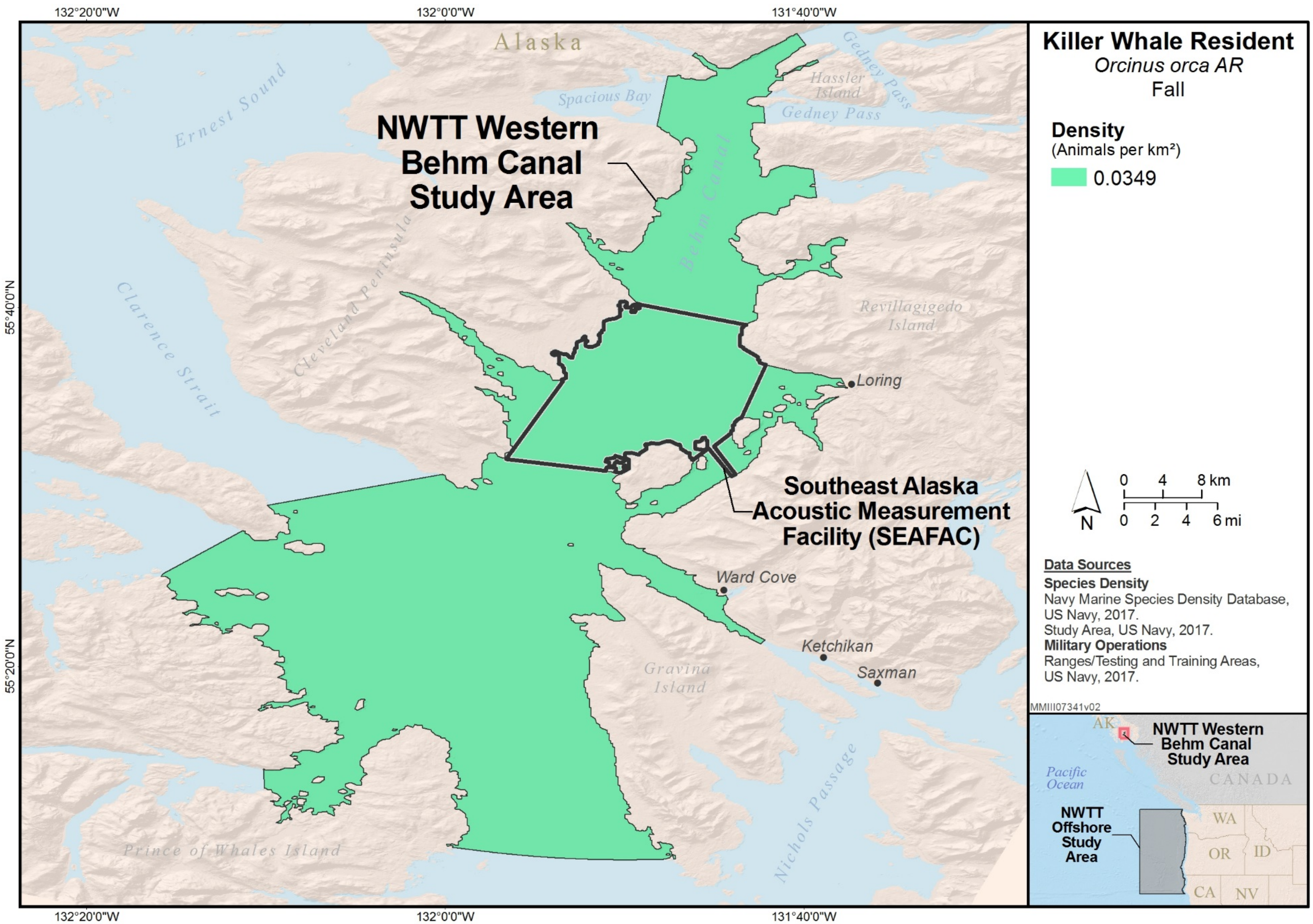

Figure 7.1-29: Western Behm Canal Fall Distribution of Resident Killer Whale

7.1.7 *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 California/Oregon/Washington stock of striped dolphins and a Hawaiian stock (Carretta et al., 2017b). Animals occurring in the Offshore region of the NWTT Study Area belong to the California/Oregon/Washington stock.

Offshore. Striped dolphin encounters increase in deep, relatively warmer waters off the U.S. West Coast, and their abundance decreases north of about 42°N (Barlow et al., 2009; Becker et al., In Prep.; Becker et al., 2012b; Forney et al., 2012). Although striped dolphins typically do not occur north of California, there are a few sighting records off Oregon and Washington (Barlow, 2003, 2010; Von Saunder & Barlow, 1999), and multiple sightings in 2014 when water temperatures were anomalously warm (Barlow, 2016). NMFS SWFSC developed a CCE habitat-based density model for striped dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. Striped dolphins are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal. Striped dolphins are not expected to occur within the Western Behm Canal region of the Study Area.

Table 7.1-7: Summary of Density Values for Striped Dolphin

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

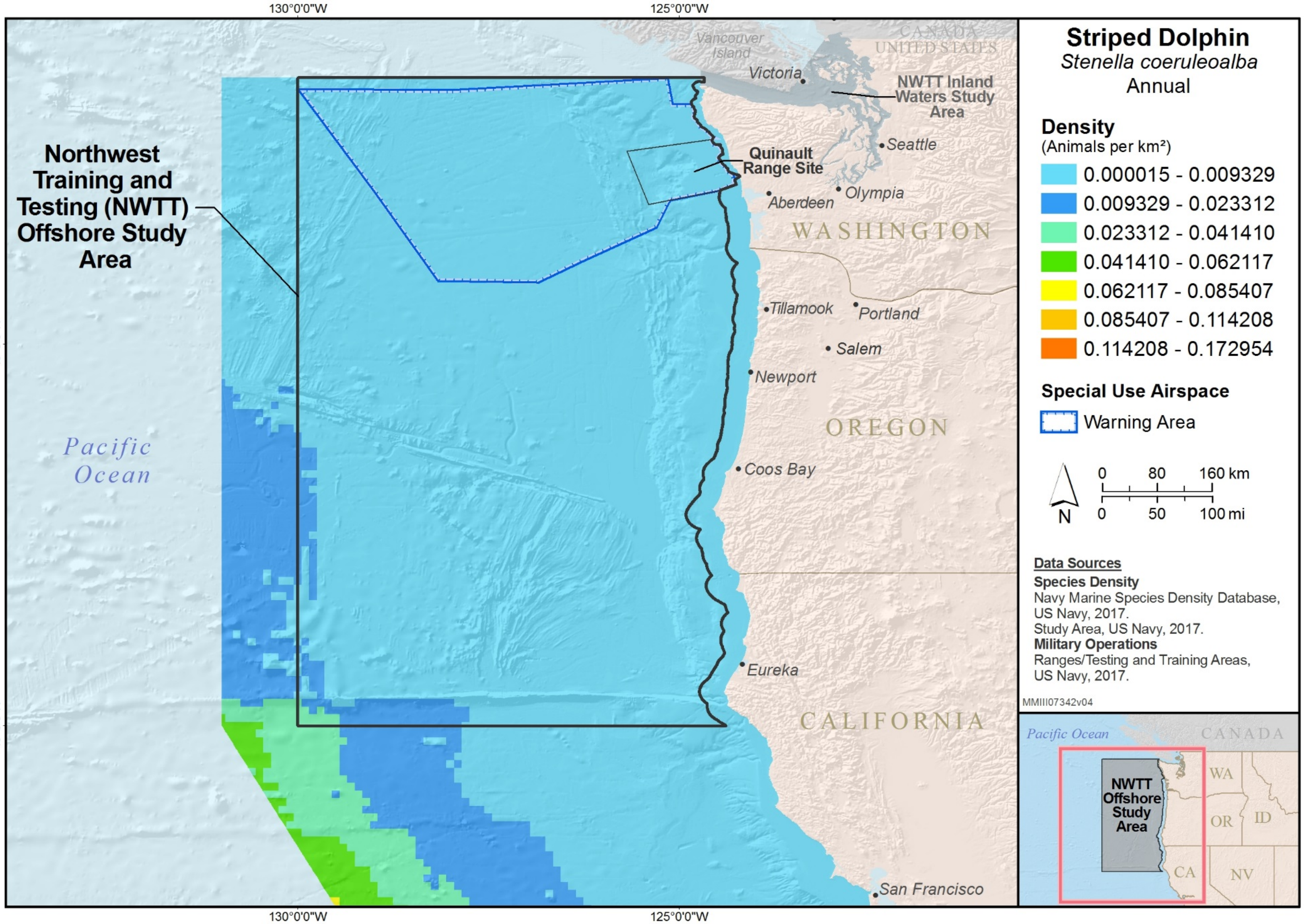

Figure 7.1-30: Offshore Annual Distribution of Striped Dolphin

7.1.8 *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, Risso's dolphins, pilot whales, humpback whales, and California sea lions (Deakos et al., 2010; Hanser et al., 2010; 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 Islands Stock Complex, a California/Oregon/Washington Offshore stock, and a California Coastal stock (Carretta et al., 2017b). Bottlenose dolphins that occur in the Offshore region of the NWTT Study Area belong to the California/Oregon/Washington Offshore stock.

Offshore. During surveys off the U.S. West Coast, offshore bottlenose dolphins were generally found at distances greater than 1.86 miles (3 km) from the coast and were most abundant off southern California (Barlow, 2010, 2016). Based on sighting data collected by SWFSC during systematic surveys in the Northeast Pacific between 1986 and 2005, there were few sightings of offshore bottlenose dolphins north of about 40°N (Hamilton et al., 2009). NMFS SWFSC developed a CCE habitat-based density model for bottlenose dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. Common bottlenose dolphins are considered extralimital in Washington inland waters; only three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound.

Western Behm Canal. This species is not expected to occur within the Western Behm Canal region of the NWTT Study Area.

Table 7.1-8: Summary of Density Values for Common Bottlenose Dolphin

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

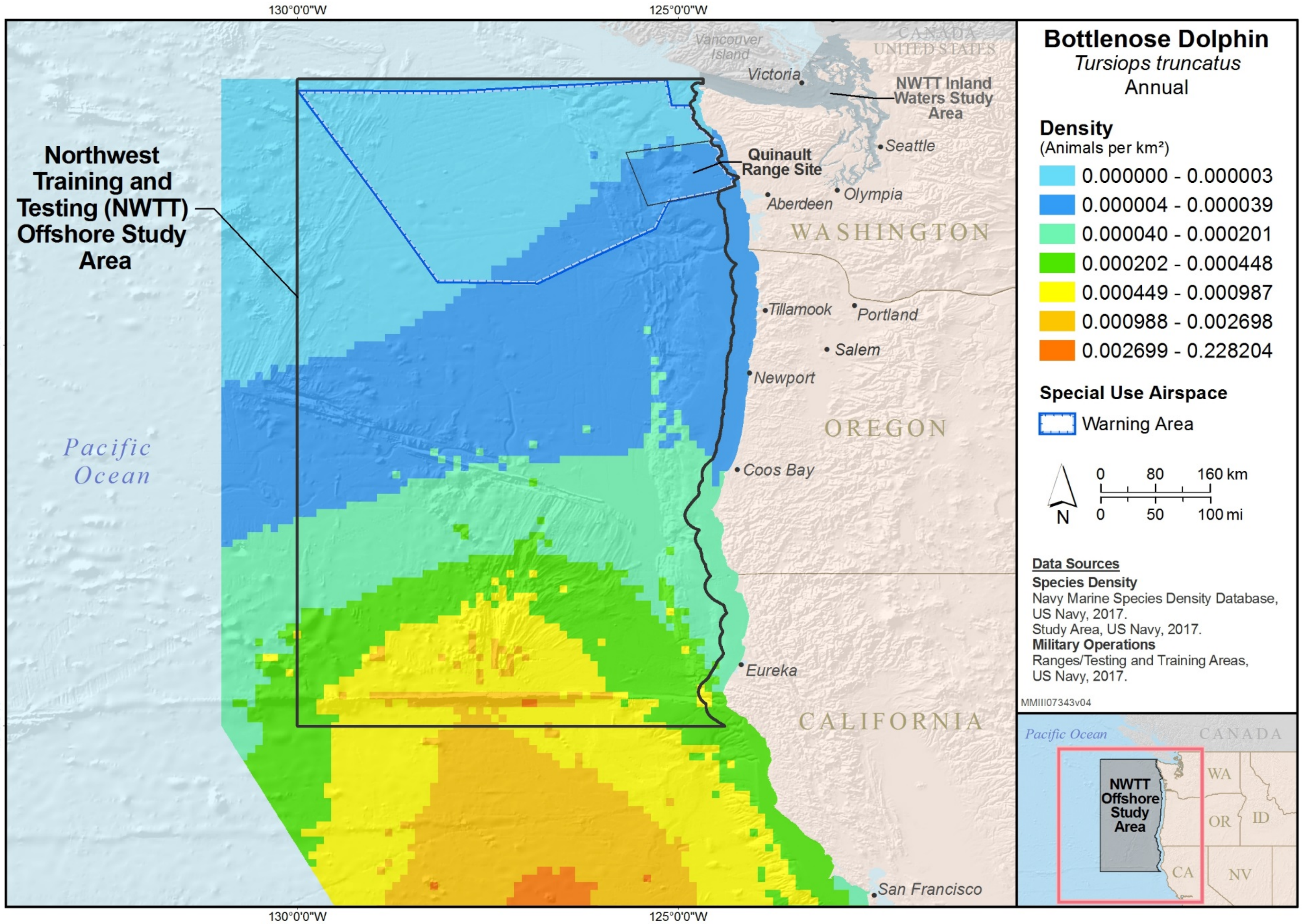

Figure 7.1-31: Offshore Annual Distribution of Common Bottlenose Dolphin

8 PORPOISES

8.1 PORPOISE SPECIES PROFILES

This group is represented by two species, the harbor porpoise (*Phocoena phocoena*) and Dall's porpoise (*Phocoenoides dalli),* and both are found off the west coast of North America and within all three regions of the NWTT Study Area.

8.1.1 *PHOCOENA PHOCOENA*, HARBOR PORPOISE

The harbor porpoise is a diminutive cetacean that is found in temperate continental shelf waters of the North Pacific (Read, 1999). It is a dark and stocky porpoise that can be quite rotund because of high blubber mass (Allen et al., 2011; Jefferson et al., 2008). They are the smallest cetacean in waters off the west coast of North America; adults are never longer than 1.8–2 meters (m) (Allen et al., 2011; Jefferson et al., 2008). The dorsal fin is short and triangular with a wide base and is set mid-way down the back, and the body is generally counter-shaded (Jefferson et al., 2008). This is in contrast to the only species that is likely to be confused with harbor porpoise: Dall's porpoise. Dall's porpoise is dramatically black and white in color, and the dorsal fin is farther forward on the back and it forms more of an upright to forward-inclined triangle (Jefferson et al., 2008; Leatherwood et al., 1988). The behavior of Dall's porpoise and harbor porpoise are usually strongly contrasting. Harbor porpoises are inconspicuous and retiring (Leatherwood et al., 1988). Often they avoid vessels (Read, 1999) and emerge quietly at the surface of the water when they are moving slowly (Jefferson et al., 2008). Dall's porpoises on the other hand often approach vessels and kick up a "rooster tail" when they surface at high speeds (Leatherwood et al., 1988). The inconspicuous behavior of harbor porpoises can make then difficult to observe in the field when sea states increase above Beaufort 2 or 3 (Palka, 1996).

Stocks of harbor porpoises are finely divided on the Pacific coast of the United States. Nine separate stocks are defined by NMFS: the Bering Sea stock, the Gulf of Alaska stock, the Southeast Alaska stock, the Washington Inland Waters stock, the Northern Oregon/Washington Coastal stock, the Northern California/Southern Oregon stock, the San Francisco-Russian River stock, the Monterey Bay stock, and the Morro Bay stock (Carretta et al., 2011). Harbor porpoise from five of the nine stocks may occur in the NWTT Study Area, including the Southeast Alaska stock in Western Behm Canal, the Washington Inland Waters stock in the Inland Waters region, and the Northern Oregon/Washington Coast, Northern California/Southern Oregon, and San Francisco-Russian River stocks in the Offshore region.

Offshore. The harbor porpoise is a common species in the nearshore coastal waters of the NWTT Offshore Study Area year-round (Carretta et al., 2009; Forney et al., 2014; Green et al., 1992; Oleson et al., 2009). Harbor porpoise are distributed from the shore out to roughly the 200 m isobath (Carretta et al., 2009). Aerial line-transect surveys were conducted by NMFS between 2007 and 2012 and geographically stratified line-transect density estimates for harbor porpoise were derived from the sighting data (Forney et al., 2014). Geographic strata extended from the coast to the 92 m isobath (inshore stratum) and from the inshore stratum to the 200 m isobath or a minimum distance from shore (18.5 km south of 37°N, 27.8 km north of this latitude; Carretta et al., 2009). Horizontal boundaries were consistent with the Northern Oregon/Washington Coast, Northern California/Southern Oregon, and San

Francisco-Russian River stock boundaries. Density estimates for each stratum were incorporated into the NMSDD to represent annual harbor porpoise density.

Inland Waters. Harbor porpoises were historically one of the most commonly observed marine mammal in Puget Sound; however, there was a decline in sightings within Puget Sound since the 1940s, and harbor porpoise were rarely seen in these waters by the 1970s. No harbor porpoise sightings were recorded during multiple surveys conducted as part of the Puget Sound Ambient Monitoring Program from 1992 to 1998 (Nysewander et al., 2005; Washington Department of Fish and Wildlife, 2008). Since 1999, the Puget Sound Ambient Monitoring Program data and stranding data have documented increasing numbers of harbor porpoise in Puget Sound, indicating that the species was returning to the area (Washington Department of Fish and Wildlife, 2008). Navy-funded systematic aerial surveys were conducted in the Inland Waters region of the NWTT Study Area and data from these surveys were used to develop geographically stratified line-transect density estimates for harbor porpoise (Jefferson et al., 2016; Smultea et al., 2017). Data from aerial surveys conducted in the Strait of Juan de Fuca and San Juan Islands region in 2015 were used to derive line-transect density estimates for these areas (Jefferson et al., 2016), and sighting data collected from 2013 to 2016 were used to develop line-transect density estimates for eight geographically stratified areas of Puget Sound (Smultea et al., 2017). These studies confirm that harbor porpoises are present in Puget Sound year-round and have reoccupied these waters. Density estimates from Jefferson et al. (2016) and Smultea et al. (2017) were used to characterize annual harbor porpoise density in the Inland Waters region.

Western Behm Canal. Shipboard line-transect sighting data collected in Southeast Alaskan waters by the National Marine Mammal Laboratory between 1991 and 2012 were used to derive harbor porpoise density estimates for geographically stratified areas during distinct time periods (Dahlheim et al., 2015). Density estimates based on 2010 to 2012 sighting data for the Clarence Strait stratum ("Region 6" adjacent to Behm Canal) were used to characterize annual harbor porpoise density for this region.

Table 8.1-1: Summary of Density Values for Harbor Porpoise

Location	Spring	Summer	Fall	Winter
Offshore	0.149–4.848	0.149–4.848	0.149–4.848	0.149–4.848
Inland Waters	0.25–2.16	0.25–2.16	0.25–2.16	0.25–2.16
Western Behm Canal	0.010	0.010	0.010	0.010

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

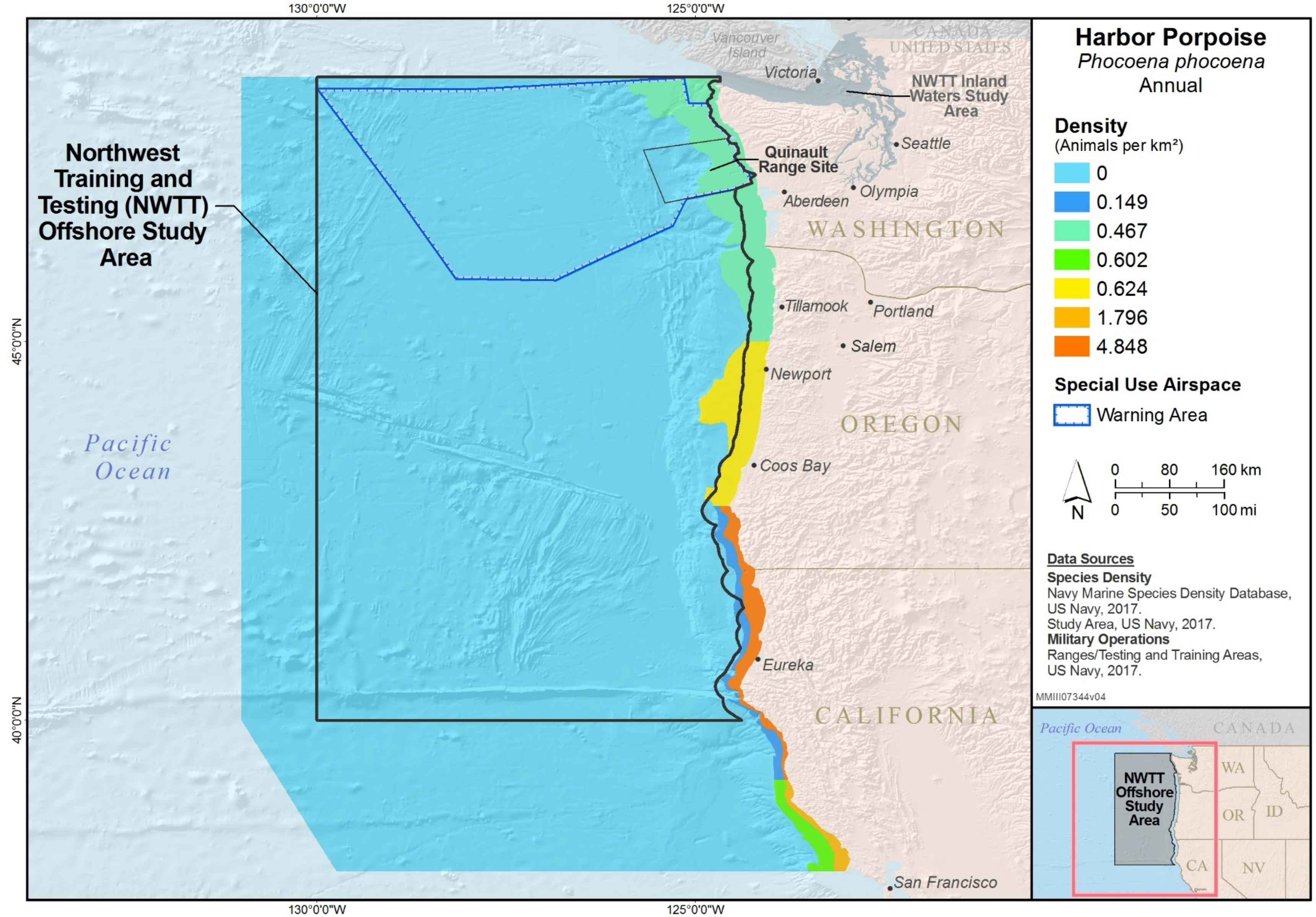

Figure 8.1-1: Offshore Annual Distribution of Harbor Porpoise

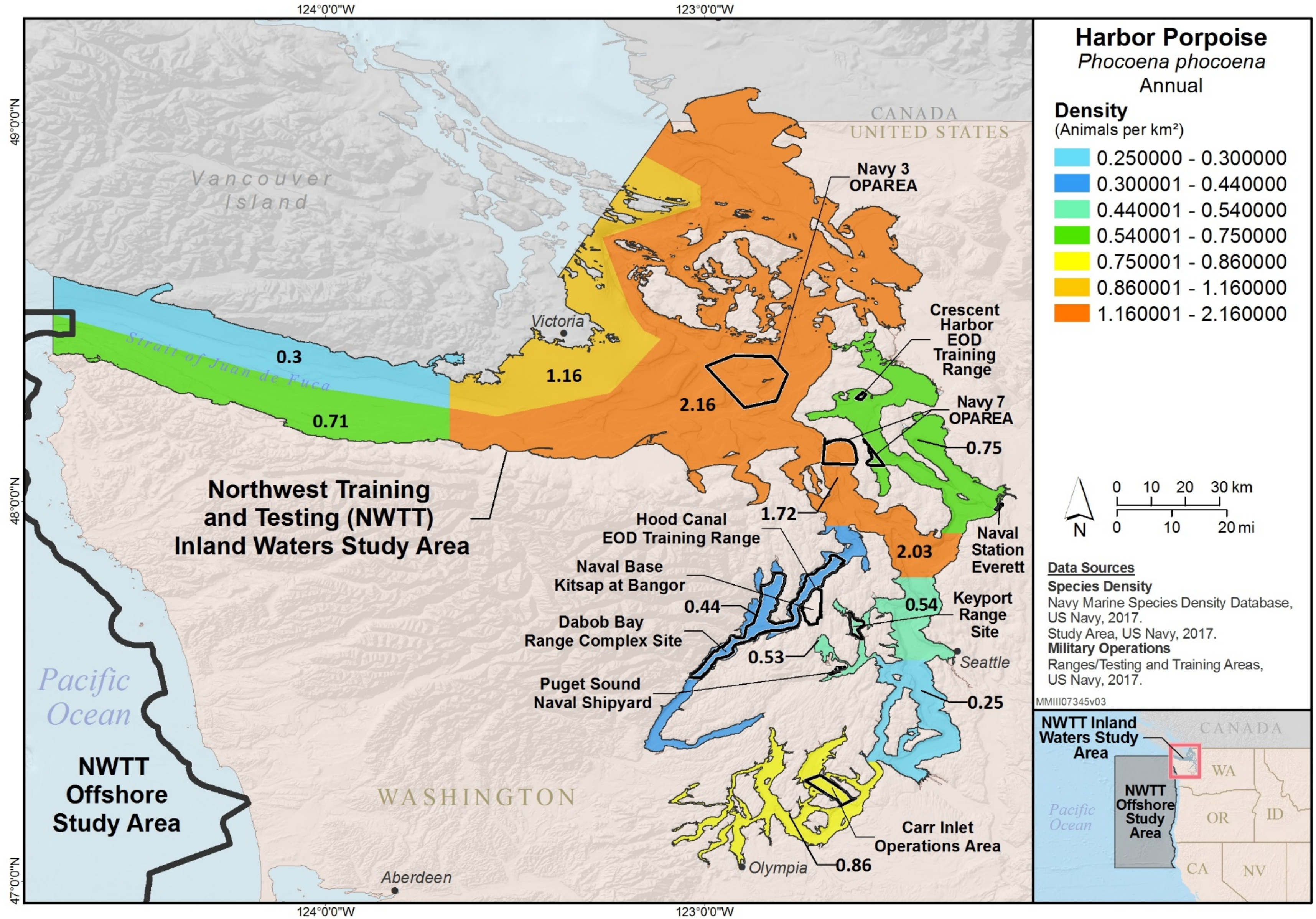

Figure 8.1-2: Inland Waters Annual Distribution of Harbor Porpoise

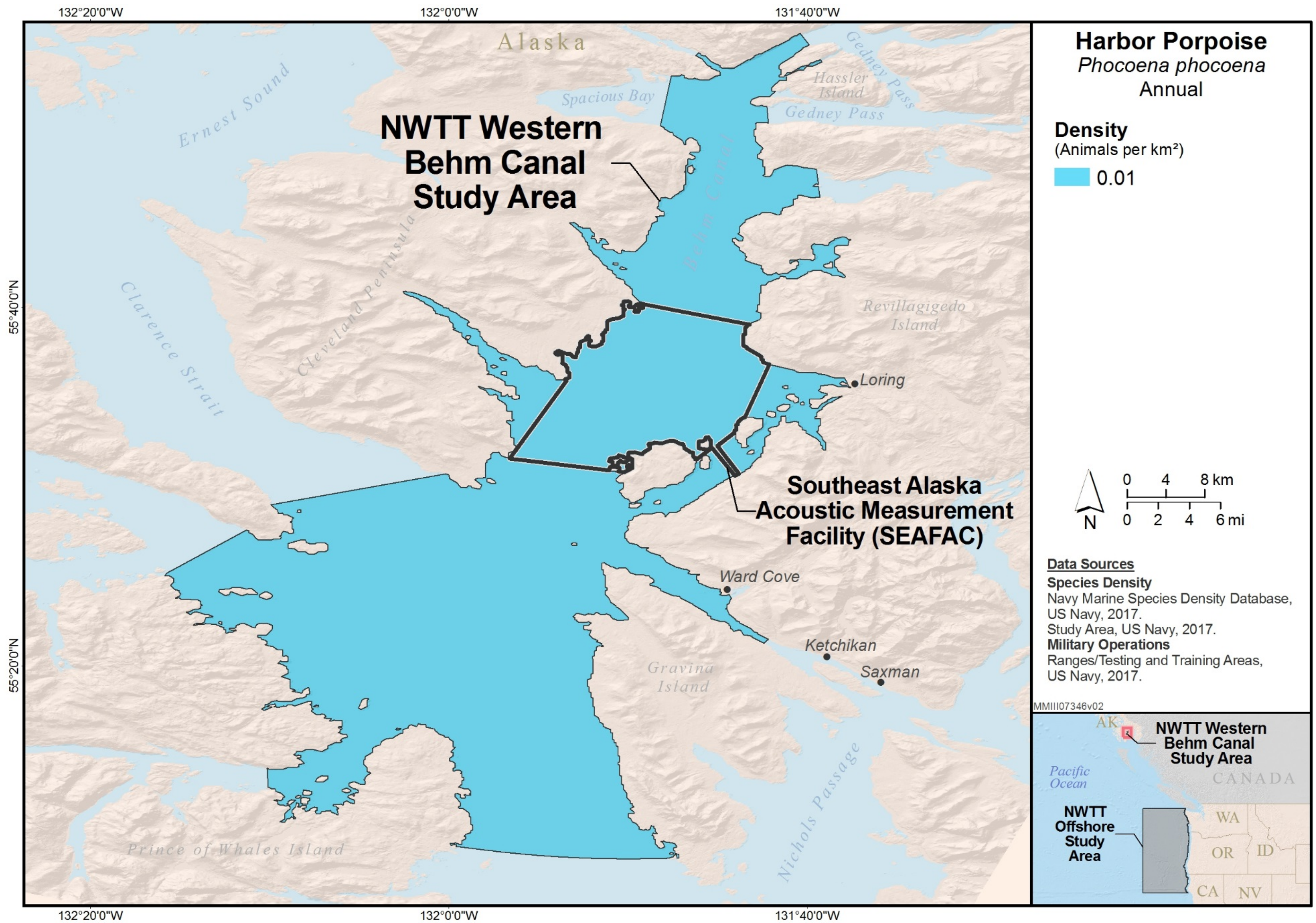

Figure 8.1-3: Western Behm Canal Annual Distribution of Harbor Porpoise

8.1.2 *PHOCOENOIDES DALLI*, DALL'S PORPOISE

Dall's porpoise is a robust cetacean that is somewhat larger than the harbor porpoise (Jefferson et al., 2015). They have an extremely stocky build, with the body particularly humped in the middle of the back and tapering quickly toward the head and at the peduncle (Allen et al., 2011; Leatherwood et al., 1988). Dall's porpoises are black with large lateral white patches, as well as white on the upper portion of the dorsal fin and the trailing edge of the flukes (Jefferson et al., 2015). The tail fluke is unusual in that it will either have a flat trailing edge or even a forward canted trailing edge (Jefferson et al., 2015). The dorsal fin is farther forward than on the harbor porpoise, and it forms an upright triangle with the front side curving or leaning forward, more so in adult males (Jefferson et al., 2015; Leatherwood et al., 1988). Dall's porpoise could be mistaken for harbor porpoise or Pacific white-sided dolphin in the field, until observed at closer range (Allen et al., 2011; Leatherwood et al., 1988). The coloration and body shape will dispel any misidentification. Dall's porpoise often move quickly and cause a spray when they break the surface of the water (Houck & Jefferson, 1999); this splash is similar to the spray at times caused by Pacific white-sided dolphins. When moving more slowly, the roll of the back of Dall's porpoise can look like a harbor porpoise if the white of the dorsal fin is not visible due to inadequate lighting.

The behavior of the Dall's porpoise and the harbor porpoise are very different in most circumstances. Dall's porpoise approach boats readily (Houck & Jefferson, 1999) and are not shy. They are one of the fastest cetaceans and they like to keep pace with vessels and weave back and forth in front of the bow (Allen et al., 2011; Houck & Jefferson, 1999). Moving in front of a pressure wave from humpback, gray, blue, and fin whales has also been reported for Dall's porpoise (Allen et al., 2011; Houck & Jefferson, 1999).

NMFS defines two stocks for Dall's porpoise, an Alaska stock and a California/Oregon/Washington stock (Carretta et al., 2017b). The California/Oregon/Washington stock is the group expected in the Offshore and Inland Water regions of the NWTT Study Area, while the Alaska stock is expected in Western Behm Canal.

Offshore. NMFS SWFSC developed a CCE habitat-based density model for Dall's porpoise which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. Dall's porpoise occur off the Washington coast year-round, and historically occurred year-round in the Inland Waters, with evidence of seasonally variability in abundance and distribution (Green et al., 1992; Nysewander et al., 2005; Washington Department of Fish and Wildlife, 2008). Based on sighting data collected during aerial surveys conducted as part of the Puget Sound Ambient Monitoring Program (Nysewander et al., 2005; Washington Department of Fish and Wildlife, 2008), the distribution of Dall's porpoise in the Inland Waters is generally concentrated in the Strait of Juan de Fuca and San Juan Island region. In the late 1990's there were an estimated 1,545 Dall's porpoise in the Inland Waters of Washington (Calambokidis et al., 1997). Williams and Thomas (2007) estimated 0.19 Dall's porpoise/km^2 (CV = 0.46) for the Canadian Strait of Juan de Fuca/Strait of Georgia waters based on line-transect data collected in 2004 and 2005. However, the abundance of Dall's porpoise has dramatically decreased in the Inland Waters in recent years, to the point that this species is now considered rare in Puget Sound (Evenson et al., 2016).

In light of this recent decline, the Navy used prorated harbor porpoise data from Jefferson et al. (2016) to estimate Dall's porpoise density in the Strait of Juan de Fuca and San Juan Islands region. Data from aerial surveys conducted in the Strait of Juan de Fuca and San Juan Islands region in 2015 were used to derive line-transect density estimates of harbor porpoise for these areas (Jefferson et al., 2016). Based on the ratio of Dall's porpoise and harbor porpoise sightings made during these systematic surveys (0.03670), density estimates for harbor porpoise were prorated to provide representative year-round, geographically stratified density estimates for Dall's porpoise that ranged between 0.011 to 0.079 animals/km^2.

Recent sighting data from Orca Network, an online forum available to the public to report and compile marine mammal sightings (www.orcanetwork.org), was used to estimate Dall's porpoise density within Puget Sound. In consideration of opportunistic Dall's porpoise sightings recorded by the Orca Network from 2015 through 2017, which confirms that Dall's porpoise are now only rarely sighted within Puget Sound, a conservative year-round density estimate of 0.00045 animals/km^2 was assigned to Puget Sound.

Western Behm Canal. Shipboard line-transect sighting data collected in Southeast Alaskan waters by the National Marine Mammal Laboratory between 1991 and 2012 were used to derive Dall's porpoise density estimates for geographically stratified areas during distinct time periods (Dahlheim et al., *in prep*). Density estimates based on 2010 to 2012 sighting data for the Clarence Strait stratum ("Region 6" adjacent to Behm Canal, see (Dahlheim et al., 2015) were used to characterize annual Dall's porpoise density for this region (0.121 animals/km^2; CV = 0.44).

Table 8.1-2: Summary of Density Values for Dall's Porpoise

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0.00045–0.079	0.00045–0.079	0.00045–0.079	0.00045–0.079
Western Behm Canal	0.121	0.121	0.121	0.121

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

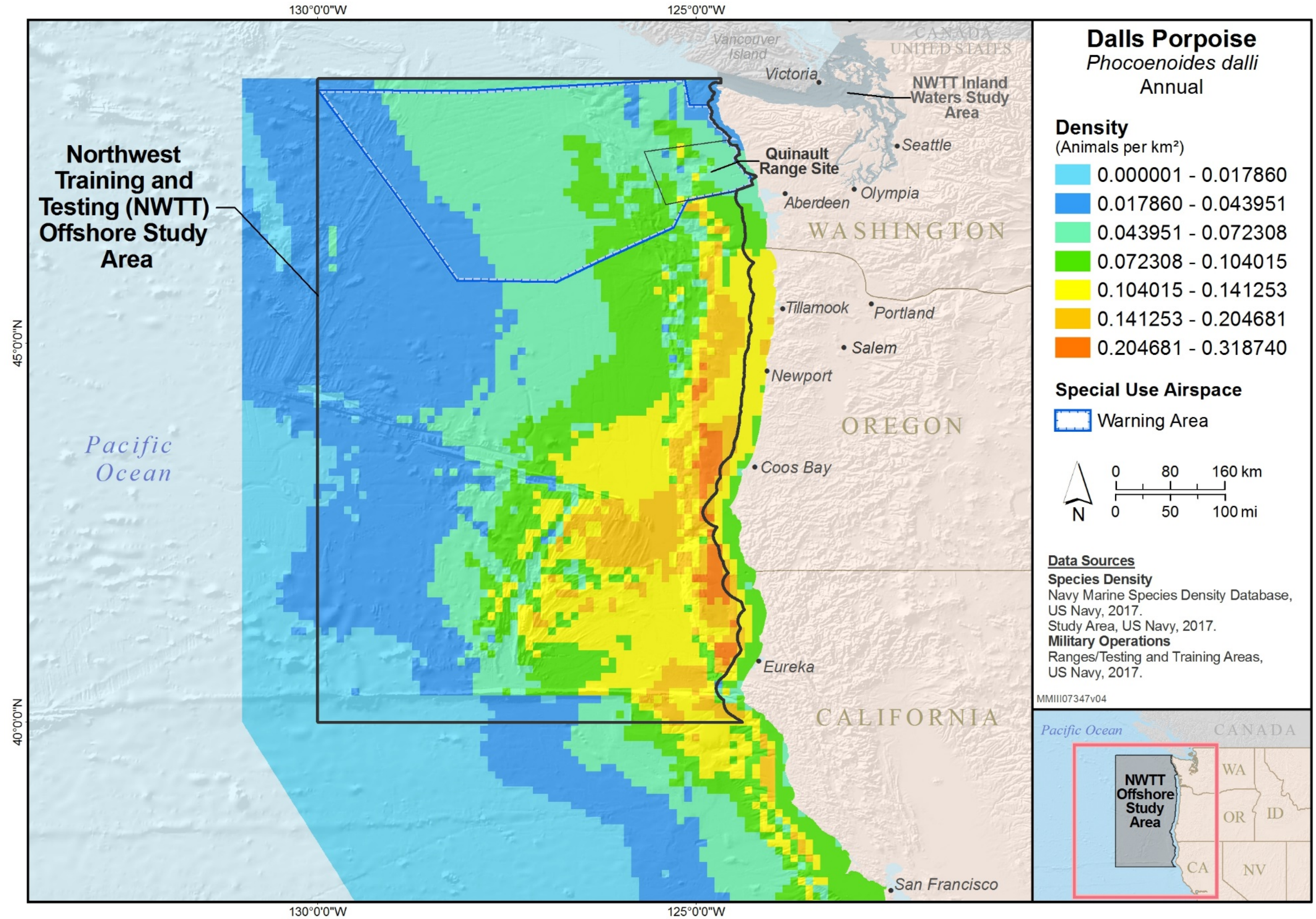

Figure 8.1-4: Offshore Annual Distribution of Dall's Porpoise

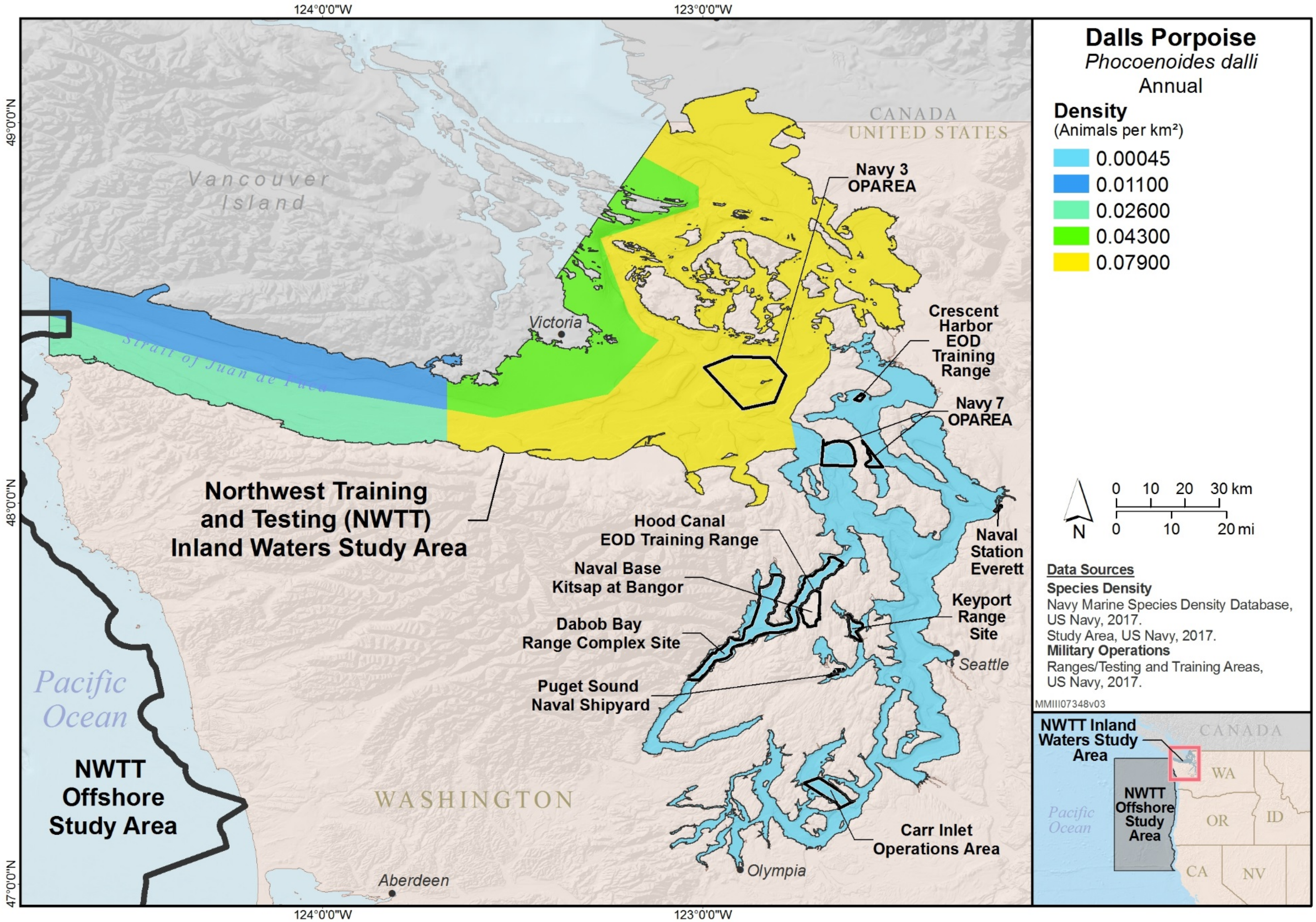

Figure 8.1-5: Inland Waters Annual Distribution of Dall's Porpoise

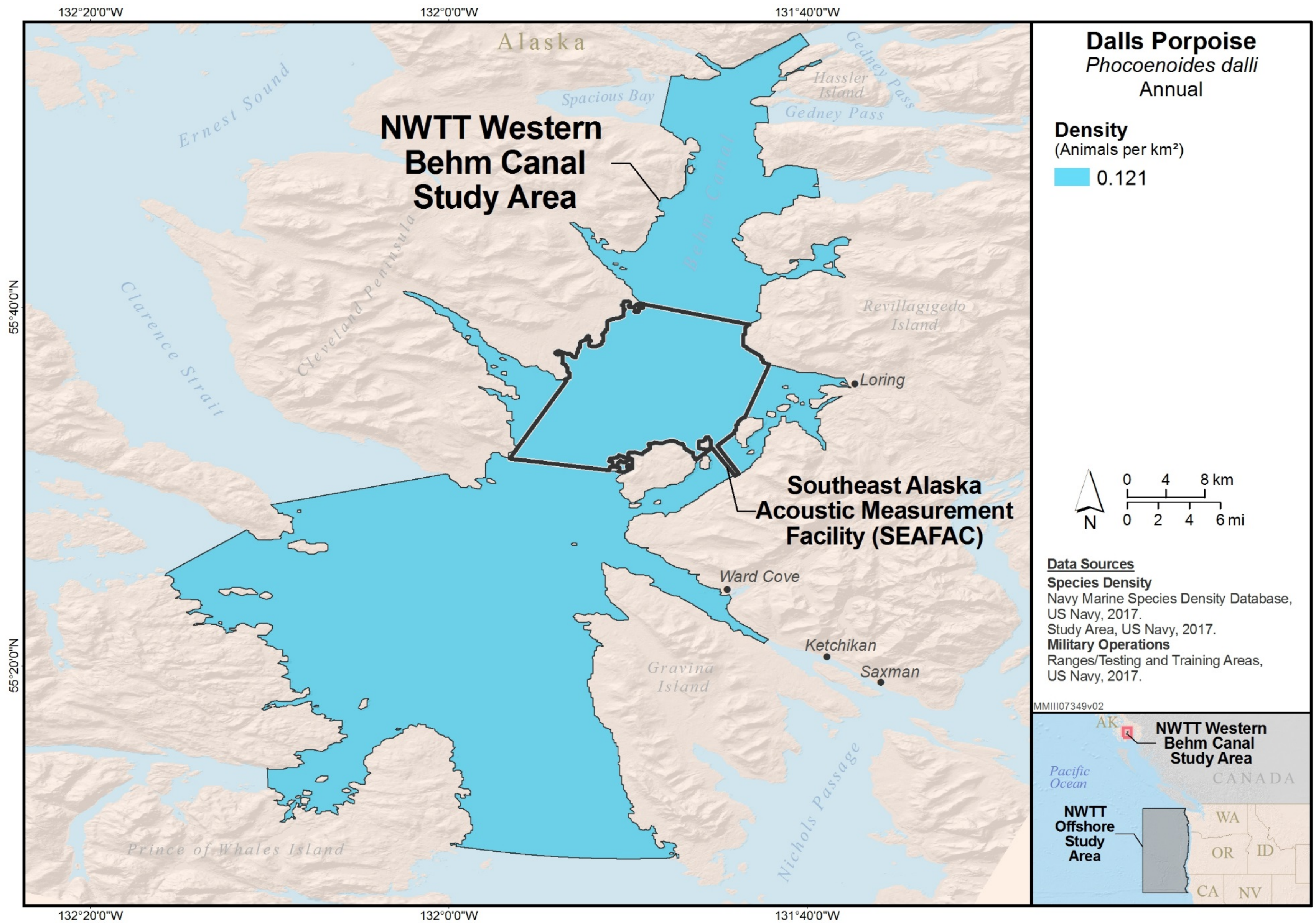

Figure 8.1-6: Western Behm Canal Annual Distribution of Dall's Porpoise

9 BEAKED WHALES

9.1 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, 2009). 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.

The range of a number of beaked whales is still very much a mystery for some areas. A myriad of beaked whales are known or suspected to be present off the U.S. West Coast. Data are sufficient for estimating densities only for Baird's beaked whale. A guild of small beaked whales has been created by NMFS to represent seven species of beaked whale that are seen or successfully identified very rarely in the CCE. This guild is used to represent density for the Offshore region of the NWTT Study Area.

9.1.1 *BERARDIUS BAIRDII*, BAIRD'S BEAKED WHALE

This large, dark colored beaked whale is the largest whale in the family *Ziphiidae* (Jefferson et al., 2015). They are found only in North Pacific temperate waters up to the vicinity of drift ice in the Bering Sea (Jefferson et al., 2015; Leatherwood et al., 1988). Baird's beaked whale may prefer continental shelf and sea mount habitat (Jefferson et al., 2015). The species can be elusive and difficult to approach (Minamikawa et al., 2007). They have a long rostrum and a slender body, giving them a relatively unique profile for a large beaked whale. Their small but obvious dorsal fin is two-thirds of the way along the body and is typically rounded at the tip (Jefferson et al., 2015; Leatherwood et al., 1988). They often have scars all over their body, like Risso's dolphin, which are thought to come from the pair of protruding teeth at the front of the lower jaw of conspecifics; both sexes have the tusks (Balcomb, 1989).

In the field, Baird's beaked whale is less likely to be confused with other beaked whales that occur in their range than they are of being confused with minke whales from a distance (Jefferson et al., 2015; Leatherwood et al., 1988). Fortunately, the surfacing behavior of Baird's beaked whale allows the unique shape of their head to be seen, as they often lift it out of the water as they surface (Jefferson et al., 2015). In contrast to minke whales and many other beaked whale species, Baird's beaked whales often occur in large groups (Baird et al., 2008; Leatherwood et al., 1988). The groups are often tight knit with the animals aligned like a "log jam" (Jefferson et al., 2015). This group behavior may sometimes make a group of Baird's beaked whales mistaken for a group of sperm whales logging at the surface (Leatherwood et al., 1988).

Two stocks of Baird's beaked whale are recognized by NMFS, an Alaska stock, which covers a large part of the North Pacific, and a California/Oregon/Washington stock that is found primarily in the CCE (Carretta et al., 2017b). The latter stock is expected to be the population that occurs within the Offshore region of the NWTT Study Area.

Offshore. NMFS SWFSC developed a CCE habitat-based density model for Baird's beaked whale which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for this species, these estimates were also used for winter/spring.

Inland Waters. This species is not expected to occur within the Inland Waters region of the NWTT Study Area.

Western Behm Canal. Extensive surveys of nearly all of the inshore waters of Southeast Alaska from 1991 to 2012 did not produce any sightings of Baird's beaked whales, indicating that this species does not occur in Western Behm Canal.

Table 9.1-1: Summary of Density Values for Baird's Beaked Whale

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

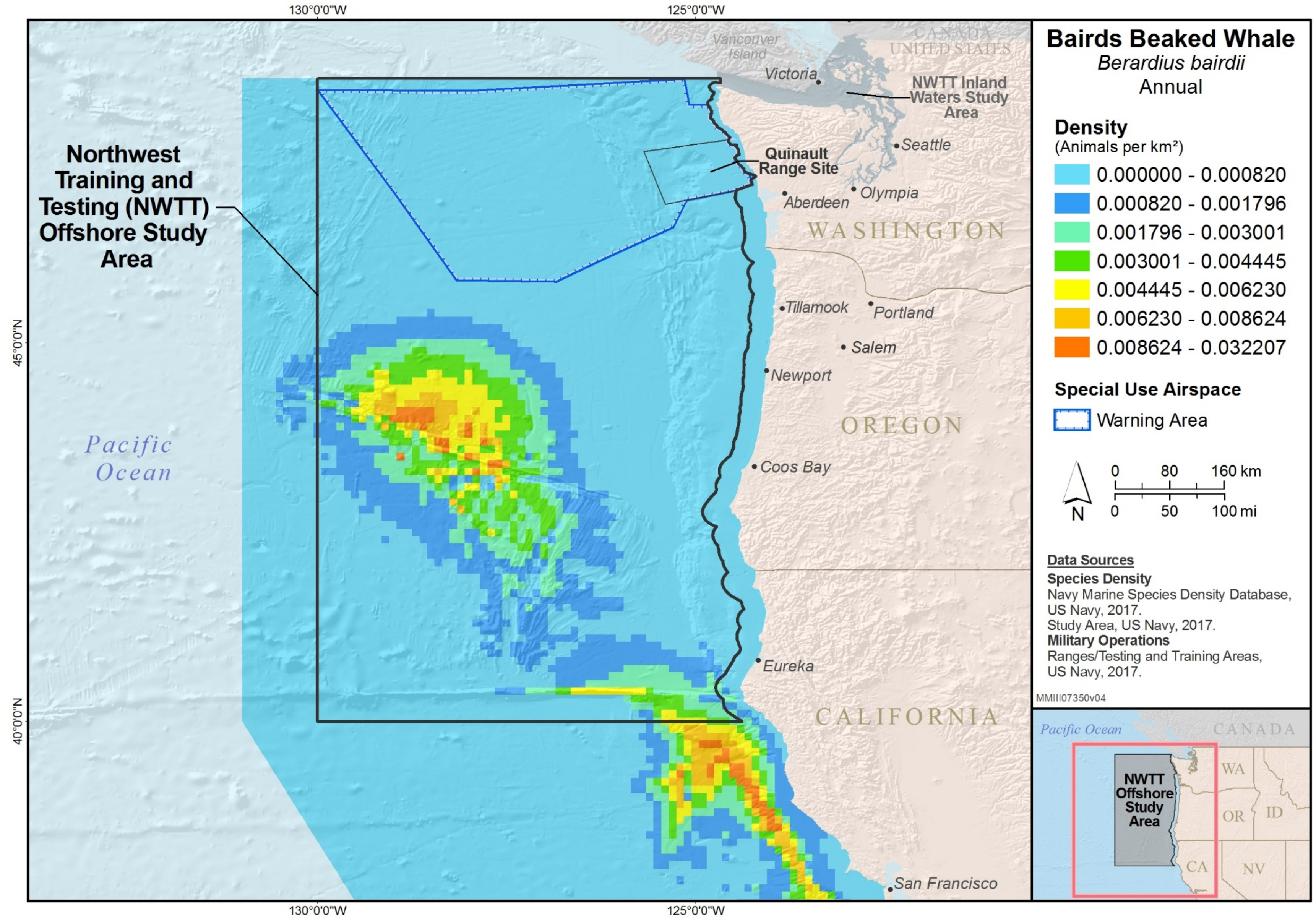

Figure 9.1-1: Offshore Annual Distribution of Baird's Beaked Whale

9.1.2 Small Beaked Whale Guild

To increase sample sizes for modeling, NMFS has developed habitat-based density models for a small beaked whale guild in the CCE (Becker et al., 2012b; Forney et al., 2012). The small beaked whale guild includes Cuvier's beaked whale (*Ziphius cavirostris)* and beaked whales of the genus *Mesoplodon,* as well as unidentified small beaked whales. It is assumed that this model is representative of the group of seven beaked whales known to occur in the CCE: Hubbs' beaked whale (*Mesoplodon carlhubbsi*), Blainville's beaked whale (*Mesoplodon densirostris)*, ginkgo-toothed beaked whale (*Mesoplodon ginkgodens)*, Perrin's beaked whale (*Mesoplodon perrini*), pygmy beaked whale (aka Peruvian, *Mesoplodon peruvianus*), Stejneger's beaked whale (*Mesoplodon stejnegeri*), and Cuvier's beaked whale. Most of these species are rarely seen and difficult to identify.

Offshore. NMFS SWFSC developed a CCE habitat-based density model for the small beaked whale guild which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker et al., In Prep.). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area. Recent winter/spring density data are not available for the NWTT Offshore Study Area; since the habitat-modeled density estimates currently provide the best available data for these beaked whale species, these estimates were also used for winter/spring.

Inland Waters. Species included in the small beaked whale guild are not expected to occur in the Inland Waters portion of the NWTT Study Area.

Western Behm Canal, Alaska. No beaked whale species are expected in the inshore waters of Southeast Alaska, of which Western Behm Canal is a part.

Table 9.1-2: Summary of Density Values for Small Beaked Whale Guild

Location	Spring	Summer	Fall	Winter
Offshore	S	S	S	S
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

The units for numerical values are animals/km^2. 0 = species is not expected to be present. S = spatial model with various density values throughout the range.

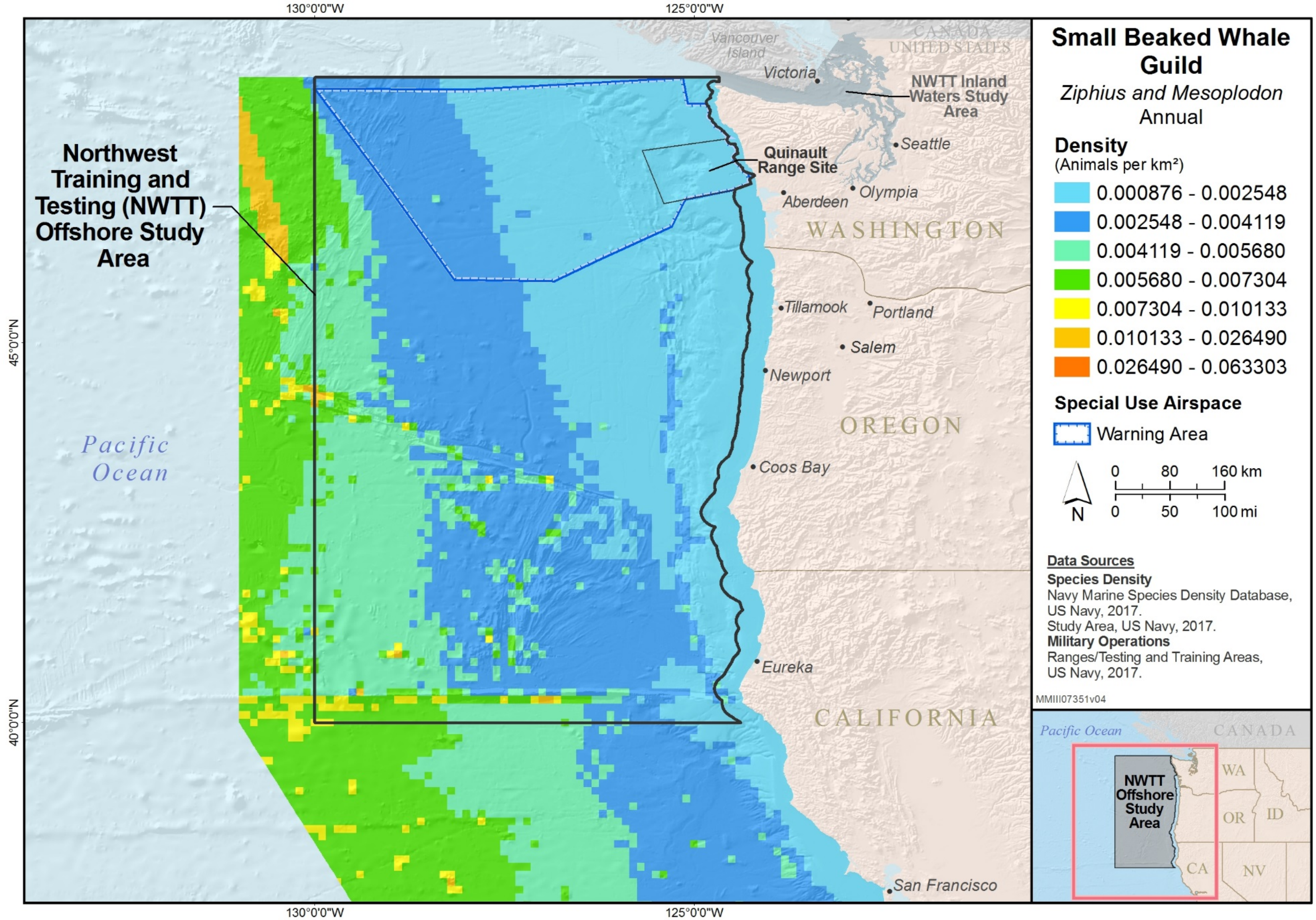

Figure 9.1-2: Offshore Annual Distribution of Small Beaked Whale Guild

10 PINNIPEDS (SEALS AND SEA LIONS)

10.1 PINNIPED SPECIES PROFILES

As many as six pinniped species occur within the NWTT Study Area: Guadalupe fur seal (*Arctocephalus townsendi*), northern fur seal (*Callorhinus ursinus*), northern elephant seal (*Mirounga angustirostris*), Pacific harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), and Steller sea lion (*Eumetopias jubatus*). Many studies assess pinniped numbers by counting individuals at haulouts or the number of pups weaned at rookeries (for example Harvey et al., 1990; Jeffries, 2014; Jeffries et al., 2003; Lowry, 2002; Lowry et al., 2014; Sepulveda et al., 2009). Translating these numbers to in-water densities presents challenges unique to pinnipeds. In areas where in-water survey data were not available, abundance estimates were adjusted using a species specific haulout factor to account for the portion of time pinniped species are hauled-out on land. Species abundance estimates were also adjusted by using a published growth rate for the species to project a 2017 abundance. The growth rate was applied to the intervening years between the year of the most recent survey supporting the published abundance estimate and the year 2017. For those species whose baseline abundance was from either the Pacific or Alaska stock assessment reports, this adjustment resulted in an abundance estimate greater than the one reported in the stock assessment report. The adjusted abundance values were distributed over a species range, which in most cases extended beyond the boundaries of the Study Area, and those values that fell within the Study Area were used in the Navy's acoustic effects model and reported in the sections below.

The strata used to estimate a species' distribution or range for the purpose of calculating a density varied with the species. Some strata are defined by a species' habitat preference which may be estimated by water depth (e.g., over the continental shelf or beyond the 1,000 m isobath). The distribution of other species is better represented by strata that are based on a distance from shore (e.g., from 30 to 70 km from shore). The strata used for pinnipeds in the Inland Waters portion of the Study Area were particularly complex due to multiple sources being used to define relatively small spatial areas for multiple species (DeLong et al., 2017; Jefferson et al., 2017; Smultea et al., 2017). While small variations in the delineation of the Inland Waters strata are slightly different for different species, any resulting variations in a density estimate would be negligible and within the error associated with estimating spatial areas in a Geographical Information System (GIS) database such as the NMSDD.

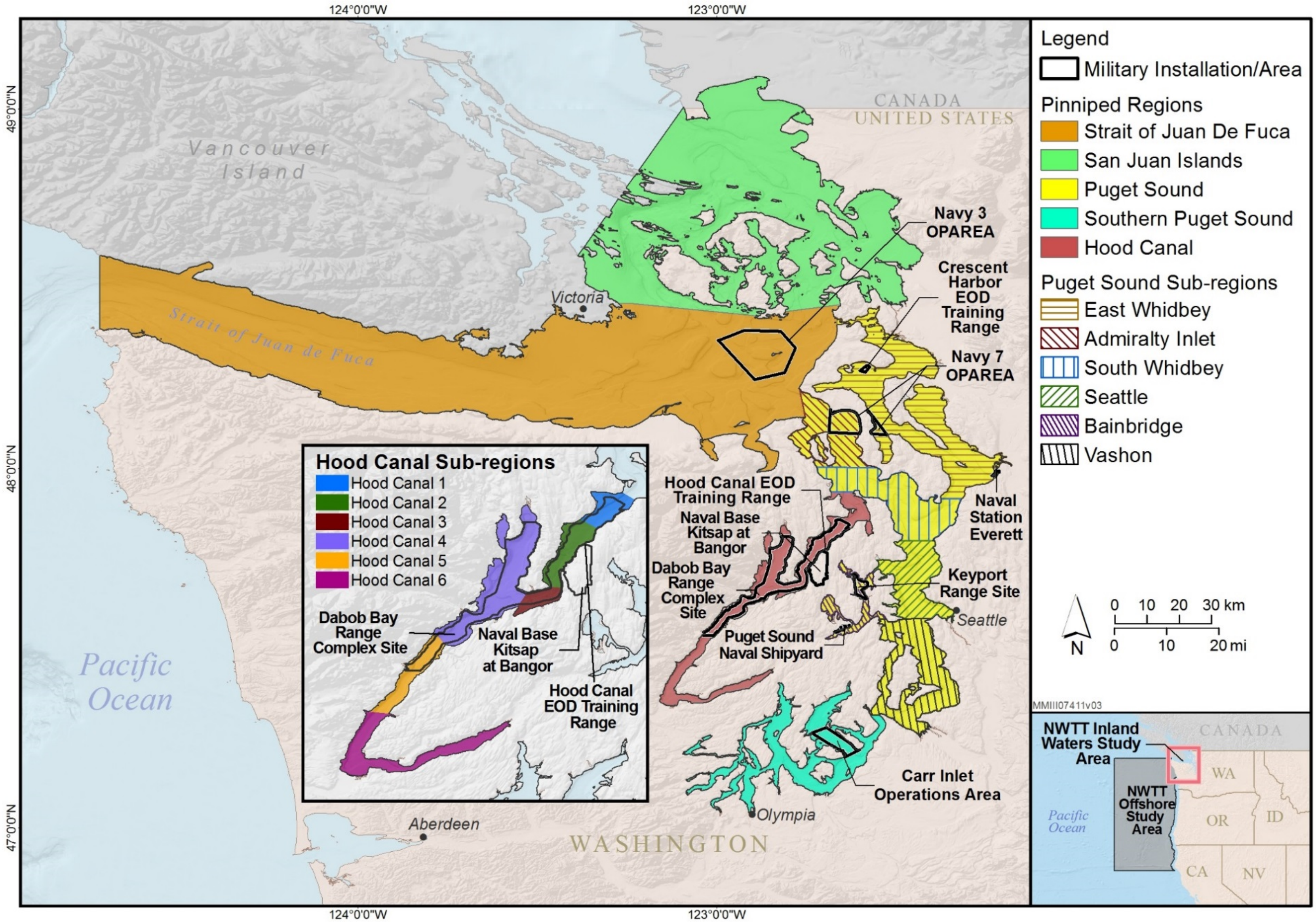

Figure 10.1-1: Inland Waters Strata Used for Pinniped Species

10.1.1 *ARCTOCEPHALUS TOWNSENDI*, GUADALUPE FUR SEAL

Guadalupe fur seals were once plentiful on the California coast, ranging from the Gulf of the Farallones near San Francisco, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa et al., 1999), but they were over-harvested in the 19th century to near extinction. After being protected, the population grew slowly; mature individuals of the species were observed occasionally in the Southern California Bight starting in the 1960s (Stewart et al., 1993), and, in 1997, a female and pup were observed on San Miguel Island (Melin & DeLong, 1999). Since then, a small group has persisted in that area (Aurioles-Gamboa et al., 2010). Although the population has been growing, the species is still listed as threatened under the ESA.

NMFS recognizes a single stock of Guadalupe fur seals, all derived from the remnant population that remained on Guadalupe Island off the coast of central Baja, Mexico (Carretta et al., 2017b). The stock assessment for this species was last updated in 2016, but is based on surveys last conducted in 2010 (Carretta et al., 2017b). Unpublished abundance and distribution data were provided by Norris (2017a, 2017b) and were incorporated into the density estimate.

The population reported in the 2016 stock assessment report (Carretta et al., 2017b) of 20,000 Guadalupe fur seals was adjusted by applying an average annual growth rate of 7.64 percent over the 7 years between 2010 and 2017. The average growth rate was derived by averaging the 10.3 percent growth rate reported in the stock assessment report for the years 2010 through 2014 (4 years) and a 4.1 percent growth rate for 2015 through 2017 (Norris, 2017b). The reduced growth rate after 2014 is consistent with an observed population decrease of approximately 60 percent at breeding sites in the San Benito Archipelago between 2014 and 2015 (Elorriaga-Verplancken et al., 2016). The resulting abundance estimate projected for 2017 is 33,485 fur seals.

The distribution of Guadalupe fur seals and occurrence in the Study Area is dependent on life stage and season. During the breeding season, June through August, adult males are expected to be on shore on Guadalupe Island and at smaller rookeries in the San Benito archipelago (Carretta et al., 2017b; Norris, 2017a). No satellite telemetry data are available for adult males; however, following the breeding season most adult males are expected to move north of breeding grounds to forage.

Based on satellite telemetry data from five tagged adult females, it appears that adult female Guadalupe fur seals spend little time north of Point Cabrillo, California (i.e., south of the Study Area). The peak time for females giving birth is late June through early July, and females nurse their pups for approximately 9 months (weaned March to April) making short foraging trips from rookeries (Gallo-Reynoso et al., 2008; Norris, 2017a; Yochem et al., 1987). Therefore, breeding females are not likely to occur in the Study Area at any time during the year, but researchers do not know the portion of adult females that breed every year, suggesting that some adult females may migrate farther north during years when they are not breeding.

In April and June 2017, none of the 10 satellite-tagged, juvenile females migrated north of Point Cabrillo. Juvenile and sub-adult males appear to have more variable movement patterns than juvenile and adult females, but only 1 of 10 satellite tagged juvenile males traveled north of Point Cabrillo in June 2017. No telemetry data from juvenile Guadalupe fur seals are available for other seasons (Norris, 2017a).

In March 2016 and April 2017, 15 weaned pups or yearlings were captured and fitted with satellite tags on Guadalupe Island. All 15 had directed northward travel before their tags stopped transmitting at or before reaching the latitude of Point Cabrillo. The directed movements of these animals indicated that most of them likely continued to travel northward into the Study Area (Norris, 2017a).

From 2015 through 2017, 26 stranded and rehabilitated fur seals between the ages of 11 and 15 months were released with satellite tags in central California. These animals frequently migrated north of Point Cabrillo and several moved into waters as far north as British Columbia, Canada. However, it is unclear if the migratory patterns of rehabilitated and released fur seals are representative of the free-ranging population migrating north from Guadalupe Island. For example, the rehabilitated fur seals remained closer to shore than the free-ranging fur seals as they migrated north (Norris, 2017a).

The satellite telemetry data indicate that Guadalupe fur seals more than two years old are likely uncommon in the Study Area, but a majority of fur seals under two years old may migrate into the Study Area and may be present throughout the year (Norris, 2017a). Lambourn et al. (2012) described an unusual mortality event during which 29 Guadalupe fur seals were reported stranded throughout the Pacific Northwest from 2007 to 2009. The strandings involved one live adult female and 28 dead yearlings of both sexes. The stranding data support the more recent telemetry data indicating that fur seals less than 2 years of age are more likely to occur in the Study Area than older fur seals.

Gallo-Reynoso (1994) reported that from 1991 to 1993, the breeding population was composed of approximately 26.4 percent adult males, 35.7 percent adult females, 22.1 percent pups, 9.7 percent juveniles, 4.7 percent sub-adult males, and 1.3 percent undetermined individuals. These demographics and the inferred movement patterns described above for each life stage were used to estimate the percentage of the population of Guadalupe fur seals potentially migrating into the Study Area. Just 2 percent of adults (males and females) are expected to be in the Study Area in winter and spring and no adults are expected in summer and fall. Ten percent of juveniles and sub-adults (> 2 years old) are assumed to be in the Study Area year-round. Seventy-five percent of weaned pups and yearlings (< 2 years old) are estimated to be in the Study Area in summer and fall, and 25 percent are estimated to occur in the winter and spring. The 1.3 percent of undetermined individuals were not incorporated into the estimates (Norris, 2017a).

Offshore. To determine the density of Guadalupe fur seals in the Offshore area, the entire population (33,485 fur seals) was adjusted based on the seasonal migration patterns for each life stage as discussed above. A sample calculation for estimating the abundance of weaned pups and yearlings in the Study Area in winter and spring is provided below:

Abundance = 33,485 x 0.22 x 0.2475 = 1,823 pups/yearlings in Study Area in winter and spring.

Similar calculations were made for each life stage. The winter/spring abundance for all life stages in the Study Area is estimated to be 2,733 fur seals, and the summer/fall abundance is estimated to be 6,007 fur seals.

Outside of the breeding season, Guadalupe fur seals are a pelagic species and would not be expected to haul out (Norris, 2017a). Sick or stranded fur seals may be sighted along the coast or on offshore islands during the non-breeding season, however, these cases are not representative of the population. Therefore, no adjustment to account for hauled-out fur seals was applied.

The distribution of Guadalupe fur seals in the Offshore area was stratified by distance from shore (or water depth) to reflect their preferred pelagic habitat (Norris, 2017b). Ten percent of fur seals in the Study Area are expected to use waters over the continental shelf (approximated as waters with depths between 10 and 200 m). A depth of 10 m is used as the shoreward extent of the shelf (rather than extending to shore), because Guadalupe fur seals in the Study Area are not expected to haul out and would not be likely to come close to shore. All fur seals (i.e., 100 percent) would use waters off the shelf (beyond the 200 m isobath) out to 300 km from shore, and 25 of percent of fur seals would be expected to use waters between 300 and 700 km from shore. The second stratum (200 m to 300 km from shore) is the preferred habitat where fur seals are most likely to occur most of the time. Individuals may spend a portion of their time over the continental shelf or farther than 300 km from shore, necessitating a density estimate for those areas, but all Guadalupe fur seals would be expected to be in the central stratum most of the time, which is the reason 100 percent is used in the density estimate for the central stratum (Norris, 2017b). Spatial areas for the three strata were estimated in a GIS and used to calculate the densities.

Two equations are provided below to illustrate how the densities were calculated. The winter/spring density for waters over the continental shelf (10 to 200 m depth) were calculated as:

$$\text{Density} = (2{,}733 \times 0.10)/39{,}185 \text{ km}^2 = 0.0070 \text{ fur seals/km}^2$$

The summer/fall density for the 200 m (depth) to 300 km (distance from shore) stratum was calculated as:

$$\text{Density} = (6{,}007 \times 1.00)/350{,}332 \text{ km}^2 = 0.0171 \text{ fur seals/km}^2$$

All density estimates for Guadalupe fur seal were calculated using the same equations but with the relevant abundance estimates and spatial area values inserted (the area of the 300 to 700 km stratum is 509,662 km^2).

Inland Waters. This species is not expected to occur in the Inland Waters portion of the NWTT Study Area.

Western Behm Canal. This species is not expected to occur in the Western Behm Canal portion of the NWTT Study Area.

Table 10.1-1: Summary of Density Values for Guadalupe Fur Seal

Location	Spring	Summer	Fall	Winter
Offshore (10 to 200 m stratum)	0.0070	0.0153	0.0153	0.0070
Offshore (200 m to 300 km stratum)	0.0078	0.0171	0.0171	0.0078
Offshore (300 km to 700 km stratum)	0.0013	0.0029	0.0029	0.0013
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

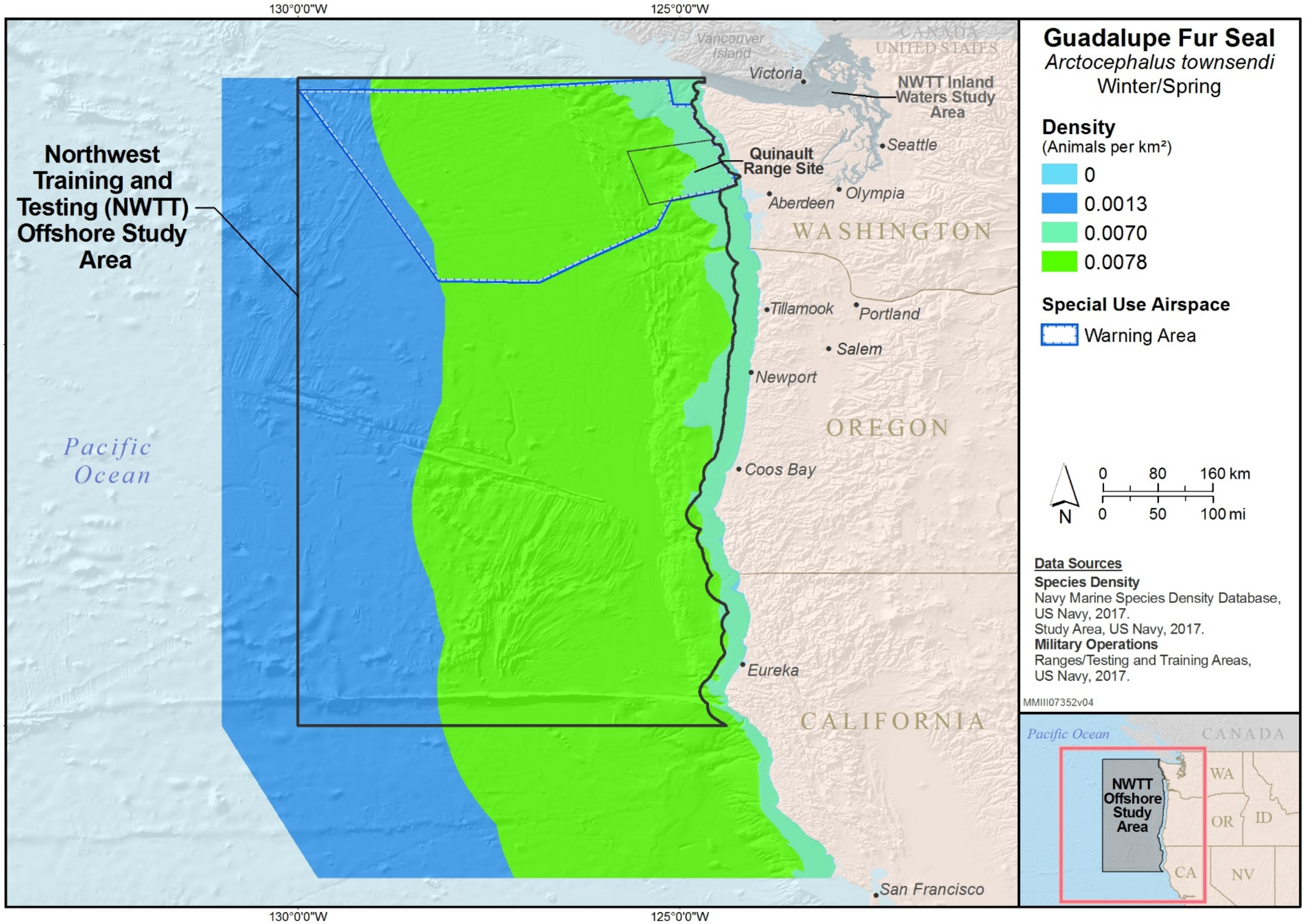

Figure 10.1-2: Offshore Winter/Spring Distribution of Guadalupe Fur Seal

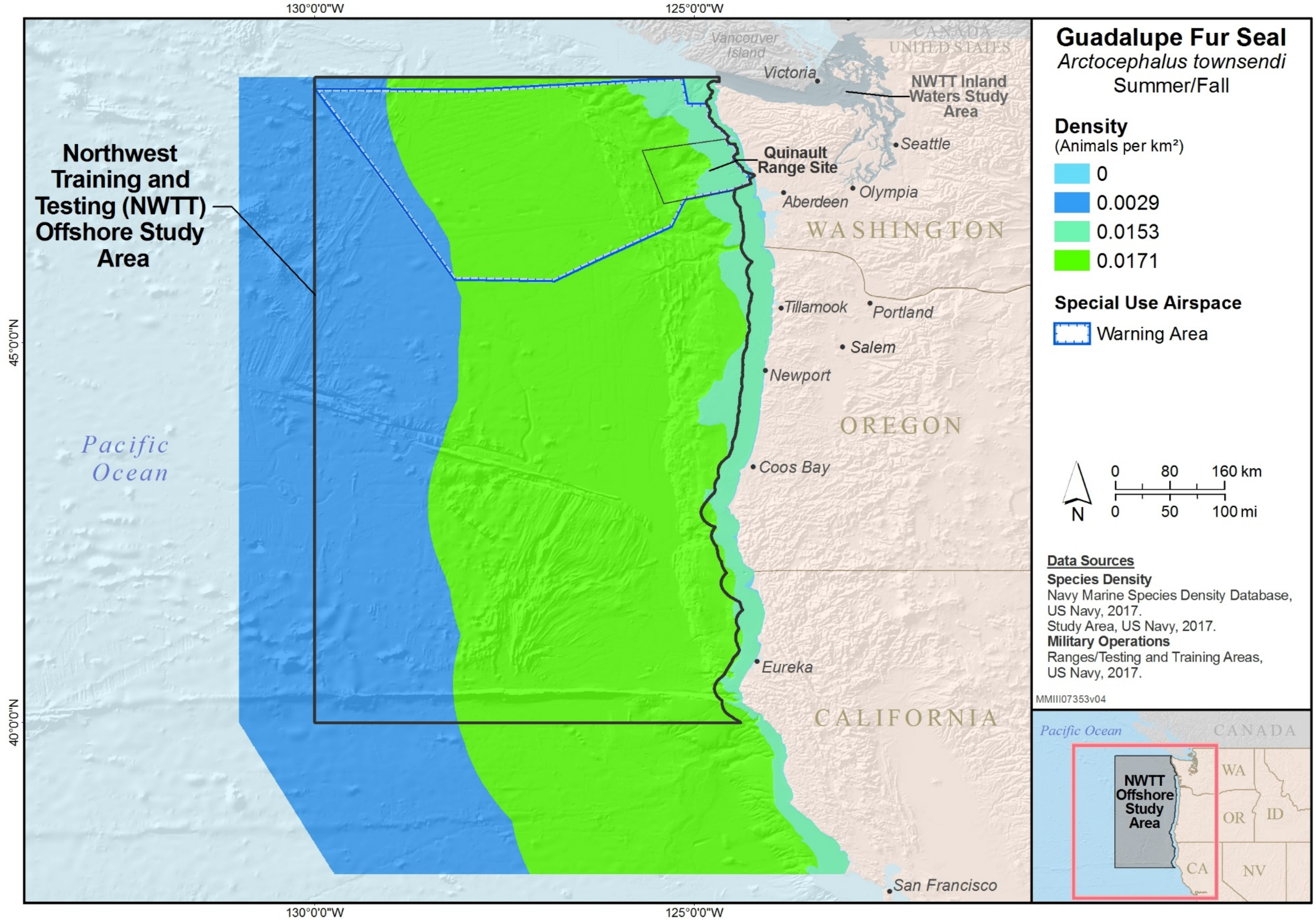

Figure 10.1-3: Offshore Summer/Fall Distribution of Guadalupe Fur Seal

10.1.2 *CALLORHINUS URSINUS*, NORTHERN FUR SEAL

The population of northern fur seals occurring in U.S. waters is comprised of two main stocks recognized by NMFS: the Eastern Pacific Stock and the California Stock (Carretta et al., 2017b; Muto et al., 2018a). There are approximately 765,000 northern fur seals in the Eastern Pacific Stock most of which breed in the Pribilof Islands located in the southern Bering Sea. In addition there are approximately 14,050 northern fur seals in the California Stock that breed on San Miguel Island and the Farallon Islands off of California (Carretta et al., 2017b; Muto et al., 2018a).

During the breeding season, approximately 74 percent of the world's population of northern fur seals is found on the Pribilof Islands (Call et al., 2008; Towell et al., 2006; Zeppelin & Ream, 2006). Adult males in the Eastern Pacific Stock arrive on shore in the Pribilof Islands between May and August, with some remaining on land through October or November (Carretta et al., 2017b; Melin et al., 2012). Following the breeding season, adult males are at sea from approximately mid-November through mid-May but migrate only as far south as the Gulf of Alaska, remaining north of the Study Area (Melin et al., 2012; National Marine Fisheries Service, 2007; Sterling et al., 2014). Adult males from the California Stock are on land at breeding sites from December through March (Carretta et al., 2017b).

Adult female northern fur seals from both stocks migrate from rookery islands in fall, and some proportion of those animals from both stocks would be expected in the NWTT Study Area, primarily in winter. Both male and female juveniles from both stocks can be expected to be present year round. Some age classes, particularly of males, are not expected to use marine habitat in the NWTT Study Area.

From 1958 through 1974 the United States and Canada collected in excess of 18,000 northern fur seals in national waters and on the high seas and of those over 6,000 were collected in Washington, Oregon and California waters. From these collections, location, age, sex, reproductive condition and food habits data were recorded from each animal collected (Lander, 1980; Olesiuk, 2012). Over the past two decades satellite tags have been attached to northern fur seals both in the Pribilof Islands and on San Miguel Island to study fur seal migration (Melin et al., 2012; Sterling et al., 2014). Some of the more recent data have yet to be published, but the data indicate that not all females, sub-adult males, and pups migrate eastward, as had been the conventional wisdom. A portion of that population moves west into the western North Pacific and towards the coast of Japan (DeLong, 2018b).

The interpretations of fur seal migrations from these two study methods are quite different. From the older pelagic collections, it was generally concluded that most adult female fur seals migrated from the Bering Sea in fall, through the Gulf of Alaska and arrived in the California Current (and the NWTT Study Area) in January and remained there until April or early May. On their return migration, the females migrated north along the British Columbia, Canada coast into and through the Gulf of Alaska and entered the Bering Sea in June or early July on the way to breeding rookeries. The pups were believed to leave the Bering Sea in fall and remain in Gulf of Alaska waters for the remainder of their first year and then enter the California Current, where they remained for most of three years as juveniles. They would finally return to rookery islands in the Bering Sea when they were four years of age, when females were recruited into the breeding population. Adult male fur seals were thought to remain in the Bering Sea or in the Gulf of Alaska during winter and were not represented in the pelagic collections off Washington, Oregon, and California. So the general pattern of the migration was believed to be that females, pups, and juveniles moved from the Bering Sea eastward through the Gulf of Alaska and into the California Current and that adult males were not present.

The pattern that has emerged from the recorded movements of satellite-tagged animals is quite different (Sterling et al., 2014). These records have shown that pups, juveniles, and adult females have two very different migratory behavioral modalities. Some leave the Bering Sea and move east through the Gulf of Alaska and into continental shelf waters and continue south into the California Current (as has been the conventional wisdom based upon the pelagic collections). Pups appear to move as far south as southern British Columbia but do not enter the California Current during the first five months (through April) of their initial migration, which occupies three fourths of their first year of life. Other females and pups move out of the Bering Sea and then spread over deep waters of the North Pacific from the Aleutian Islands south to the Transition Zone at approximately 45 degrees north latitude where they remain for the duration of winter (Sterling et al., 2014). Females return to the Bering Sea in June, and juveniles remain in the open ocean with a pelagic existence until they mature and return to the Bering Sea rookeries at approximately four years of age when females are recruited into the breeding population. Assessing the proportion of the Eastern Pacific Stock of northern fur seals that enter the NWTT Study Area will necessitate using information from both pelagic collection records and recent satellite tagging data.

The migratory behavior of the California Stock of northern fur seals is known only from some stranding data and movement of satellite tagged females and pups from San Miguel Island. Essentially, females and pups move north of the Channel Islands in fall and some females enter the Study Area while others remain south of the Study Area. Pups forage in the Study Area and some move north of the Study Area and into Canadian waters during their first year of life. Nothing is known about the movements of juvenile fur seals from the California Stock. Adult males appear to move north from the rookery islands and are occasionally seen hauled out at known pinniped haulout sites along the coast of Washington.

10.1.2.1 Eastern Pacific Stock

The abundance of northern fur seals from the Eastern Pacific Stock occurring in the Study Area, was estimated by determining the percentage of time tagged animals spent within the Study Area and applying that percentage to the population to calculate an abundance for females, juveniles, and pups independently on a monthly basis. The number of adult females was estimated by using the number of pups born in 2014 (138,829) and multiplying by 1.2 (to account for a natality rate of 80 percent) for a total of 166,595 adult females in the Eastern Pacific Stock. Based on satellite tag data, 60 percent, or 99,957 females (four years of age and older), entered the Study Area. These females spent approximately 29 percent of the time from January through May in the Study Area. Therefore 28,987 (i.e., 0.29 x 99,957) adult females could be expected at any time in the Study Area from January through May of each year.

The number of juvenile females in the Eastern Pacific Stock was estimated by applying mortality rates of 0.51 for the first year, 0.26 for the second year, and 0.14 for the third year (Lander, 1981; Loughlin et al., 1994; Wickens & York, 1997). Based on 138,829 pups born in 2014, there would be 68,026 pups after the first year, 50,339 after the second year, and 43,292 after the third year. Assuming the same number of pups were born in 2015 and 2016, and ignoring the first year total (pups are addressed separately below), the number of female juvenile fur seals potentially entering the Study Area is estimated to be 46,816 (assuming half the pups are female).

Abundance = (50,339 [year 2] + 43,292 [year 3]) x 0.50 = 46,816 female juveniles

Based on satellite tag data, approximately 60 percent of juvenile female fur seals entered the Study Area and spent 35 percent of their time within the boundaries of the Study Area. Therefore, at any time during the year (i.e., year round) there could be an estimated 9,831 juvenile females in the in the Study Area.

Number of Juvenile Females in the Study Area = (46,816 x 0.60) x 0.35 = 9,831

The satellite tag data indicate that no juvenile males would enter the Study Area. However, from the pelagic collections reported by Lander (1980) from 1958 through 1972 (see Table 2.2 in Lander (1980)) approximately 5 percent of individuals collected in Washington, Oregon, and California waters were males between one and four years of age. Assuming that the total number of females (adults and juveniles) represents 95 percent of northern fur seals in the Study Area, then the number of juvenile males in the Study Area would be 2,043. As with juvenile females, juvenile males could be present in the Study Area year round.

Females in the Study Area = 28,987 + 9,831 = 38,819 (adult and juvenile females)

Juvenile Males = (38,819 / 0.95) x 0.05 = 2,043 (juvenile males)

It is noteworthy that neither satellite tagging nor the pelagic collections indicate that pups of the Eastern Pacific Stock enter the Study Area. However, pups tagged in the Pribilofs have historically stranded on the Washington coast in the month of January (DeLong, 2018b). Therefore, to account for the unlikely but potential occurrence of pups in the Study Area, the analysis assumes that 5 percent of pups enter the Study Area during their first year. Based on the 2014 pup count of 138,829 and a 51 percent mortality rate, an estimate of 3,401 pups would occur in the Study Area in January.

Pups = (138,829 x 0.51) x 0.05 = 3,401 pups/yearlings

10.1.2.2 California Stock

The proportion of time that adult females and pups of both sexes from the California Stock spend in the Study Area was estimated based upon population counts and the proportion of time that satellite tagged animals from San Miguel Island spent in the Study Area. Population size was estimated based on the 2013 pup count from San Miguel Island and the 2014 pup count on the Farallon Islands. On San Miguel Island, 3,346 pups were born (Carretta et al., 2018) and 656 pups were born on the Farallon Islands (Berger et al., In review) for a total of 4,002 pups. After adjusting for an 80 percent natality rate (i.e., multiply by 1.2) the total number of adult females in the California Stock is estimate to be 4,802.

Of 37 tracked adult females, 35 percent entered the Study Area in December; however many of the tags failed shortly after deployment. Ten of 21 females (48 percent) whose tags lasted until 1 January (after being tagged in November) entered the Study Area. Applying this percentage to the number of adult females in the population results in an estimate of 2,305 adult females entering the Study Area (i.e., 4,802 x 0.48 = 2,305). Based on the locations of tagged animals, adult females are assumed to have spent 46 percent of their time in the Study Area. Therefore, the abundance of adult females from the California Stock found in the Study Area in December is 1,060 (i.e., 2,305 x 0.46 = 1,060). From January through March, tagged adult females spent only 9 percent of their time in the Study Area. Applying this percentage to the number of adult females in the population that entered the Study Area results in an abundance of 207 (i.e., 2,305 x 0.09 = 207) adult females for January through March. No tagged adult female northern fur seals entered the Study Area from April through November. From mid-June through late November most adult females would be on route to or at breeding rookeries located south of the Study Area.

Twenty-three tagged northern fur seal pups (13 females and 10 males) were tracked from San Miguel Island north towards Study Area. Six of the females and seven of the males spent time in the Study Area. Of the six female pups whose tags lasted until 1 January, 83 percent entered the Study Area and spent 34 percent of their time within the Study Area in December. If half of the 4,002 pups born on San Miguel Island and the Farallon Islands were female, then there are an estimated 2,001 female pups in the population. Applying the percentages derived from the tagged pups, an abundance of 565 female pups is estimated to be in the Study Area on any given day in December.

Abundance = (2,001 female pups x 0.83 entered Study Area) x 0.34 (time in Study Area) = 565 female pups

Two pups whose tags lasted until June spent 16 percent of their time in the Study Area from January through March and 27 percent of their time in the Study Area from April through June. Applying these percentages to the number of female pups entering the Study Area yields an abundance of 266 female pups from January through March and 448 female pups from April through June.

January – March = 1,661 x 0.16 = 266 female pups

April – June = 1,661 x 0.27 = 448 female pups.

Seven of ten male pups whose tags lasted into January entered the Study Area and spent 11 percent of their time in the Study Area in December and January. Applying these percentages to the number of male pups who entered the Study Area results in an abundance estimate of 154 male pups for December and January.

Abundance = (2,001 male pups x 0.70 entered Study Area) x 0.11 (time in Study Area) = 154 male pups

There are no tagging data on male pups entering the Study Area during any other time of the year.

There are no data on the in-water distribution of juvenile northern fur seals from the California Stock. It is likely that they move northward from rookery islands towards the Study Area, as other age classes do, and that some proportion would be found in the Study Area during part of the year. However, the currently available data do not allow for an estimate of the number that would enter the Study Area and how long they would remain in the Study Area.

Nevertheless, to avoid underestimating the number of northern fur seals that enter the Study Area, and consequently underestimating potential impacts, the Navy is assuming that 20 percent of juvenile fur seals in the California Stock spend 35 percent of their time in the Study Area. The ratio of age class abundance estimates presented in Loughlin et al. (1994) for the Eastern Pacific Stock of northern fur seals indicates that juveniles (ages 1 to 3) make up 37 percent of the overall abundance. Applying this percentage to the 14,050 northern fur seals in the California Stock results in an estimate of 5,199 juvenile fur seals (both males and females) in the California Stock. As noted above, juvenile females in the Eastern Pacific Stock spent 35 percent of the time in the Study Area. This same percentage was applied to all juveniles (males and females) in the California Stock, to be conservative, rather than applying the separate, indirect approximations for males used for the Eastern Pacific Stock. Based on these estimates, 364 juvenile northern fur seals could be expected to be in the Study Area throughout the year.

Juveniles = (14,050 x 0.37 juveniles) x 0.20 (enter Study Area) x 0.35 (time in Study Area) = 364 juvenile fur seals

The abundances calculated by the methods described above include estimates for age and sex classes in both stocks. The total abundance for each month is the value used in the density calculations. As noted above, the abundance data for the California Stock are incomplete. Given that the stock is much smaller than the Eastern Pacific Stock, the lack of data does not meaningfully affect the density estimates.

Table 10.1-2: Monthly Abundance of Northern Fur Seal in the Offshore Area

	Eastern Pacific Stock Abundance				**California Stock Abundance**				
Month	Adult females	Juvenile females	Juvenile males	Pups	Adult females	Adult Males[1]	Juveniles[2]	Pups[3]	**Total Abundance**
January	28,987	9,831	2,043	3,401	207		364	420	45,254
February	28,987	9,831	2,043	0	207		364	266	41,699
March	28,987	9,831	2,043	0	207		364	266	41,699
April	28,987	9,831	2,043	0	0		364	448	41,674
May	28,987	9,831	2,043	0	0		364	448	41,674
June	0	9,831	2,043	0	0	0	364	448	12,687
July	0	9,831	2,043	0	0	0	364	No data	12,238
August	0	9,831	2,043	0	0	0	364	No data	12,238
September	0	9,831	2,043	0	0	0	364	No data	12,238
October	0	9,831	2,043	0	0		364	No data	12,238
November	0	9,831	2,043	0	0		364	No data	12,238

Table 10-2: Monthly Abundance of Northern Fur Seal in the Offshore Area (continued)

Month	Eastern Pacific Stock Abundance				California Stock Abundance				Total Abundance
	Adult females	Juvenile females	Juvenile males	Pups	Adult females	Adult Males[1]	Juveniles[2]	Pups[3]	
December	0	9,831	2,043	0	1,060		364	719	14,017

[1]Adult males are occasionally seen hauled out along the Washington coast and are assumed to be at breeding sites in summer (June – September).

[2]No data are available. Abundance is based on an assumption that 20 percent of the CA Stock enters the NWTT Study Area.

[3]Pups includes both male and female pups which were calculated separately for the California Stock, as described above.

10.1.2.3 Distribution

The distribution of northern fur seals in the Offshore area is largely driven by the occurrence of their prey which often correlates with transient oceanographic features, such as changes in sea surface temperature and the locations of upwelling zones (Olesiuk, 2012; Ream et al., 2005). The spatial area and location of these features is often unpredictable and varies spatially and seasonally. Olesiuk (2012) mapped data from sealing logbooks from 1882-1911, North Pacific Fur Seal Commission research collections and sightings from 1958-1974, the National Marine Mammals Lab platform of opportunity sighting database from 1957-2007, and published reports on satellite tags deployed since 1991, to describe the distribution and migration patterns of northern fur seals in the eastern North Pacific.

Based on the depicted distributions, three strata were created to estimate the occurrence of northern fur seals in the Offshore area: 1) Study Area boundary (22 km) to 70 km from shore, 2) >70 to 130 km from shore, and 3) >130 to Study Area boundary (463 km from shore). The majority of fur seals (estimated at 70 percent in this analysis) are expected to occur over the outer continental shelf and slope between 70 and 130 km from shore (Kajimura, 1984). Northern fur seals are less likely to occur in large numbers in the shallower waters over the continental shelf, therefore 5 percent of the population is allocated to the nearshore stratum (Kenyon & Wilke, 1953; Oleson et al., 2009). The data compiled by Olesiuk (2012) and sealing data reported by Kajimura (1984) supported a third stratum extending out to the western boundary of the Study Area for this analysis and recognizing that northern fur seals are known to occur beyond that distance particularly during migrations. Twenty-five percent of the population was allocated to this stratum.

Table 10.1-3: Strata Used to Calculate Densities for Northern Fur Seal in the Offshore Area

Stratum	Delineation (km)	Area (km^2)
1	22 to 70	54,238
2	>70 to 130	63,866
3	>130 to 463	296,945

The equation provided below illustrates how densities for northern fur seal were calculated. The January density for stratum 2 (>70 to 130 km from shore) was calculated as:

Density = (45,254 x 0.70) / 63,866km^2= 0.4960 northern fur seals/km^2

All density estimates for northern fur seal were calculated using the same equation but with the appropriate abundance estimates and spatial area values.

Table 10.1-4: Summary of Density Values for Northern Fur Seal in the Offshore Area

Month	Density Stratum 1 (animals/km^2)	Density Stratum 2 (animals/km^2)	Density Stratum 3 (animals/km^2)
January	0.0417	0.4960	0.0381
February	0.0384	0.4570	0.0351
March	0.0384	0.4570	0.0351
April	0.0384	0.4568	0.0351
May	0.0384	0.4568	0.0351
June	0.0117	0.1391	0.0107
July	0.0113	0.1341	0.0103
August	0.0113	0.1341	0.0103
September	0.0113	0.1341	0.0103
October	0.0113	0.1341	0.0103
November	0.0113	0.1341	0.0103
December	0.0129	0.1536	0.0118

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

In spring, female fur seals are likely to occur in Behm Canal during times when herring are spawning. The herring fishery is closed in Behm Canal, but fur seals are likely there during the spawning season, which extends from February to April (DeLong & Jeffries, 2017). Kenyon and Wilke (1953) document "several thousand" female northern fur seals entering deep inland waters to feed. Based on this approximation, 3,000 northern fur seals were used to estimate the density in Western Behm Canal and the surrounding region in spring. No growth rate was applied for this population, because the estimate is an approximation from 1953, not an abundance.

The density calculation for northern fur seals in Behm Canal during the spring season is:

Density = 3,000/10,857 km^2= 0.27633 fur seals/km^2

Table 10.1-5: Summary of Density Values for Northern Fur Seal in the Inland Waters and Western Behm Canal

Location	Spring	Summer	Fall	Winter
Inland Waters	0	0	0	0
Western Behm Canal	0.27633	0	0	0

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

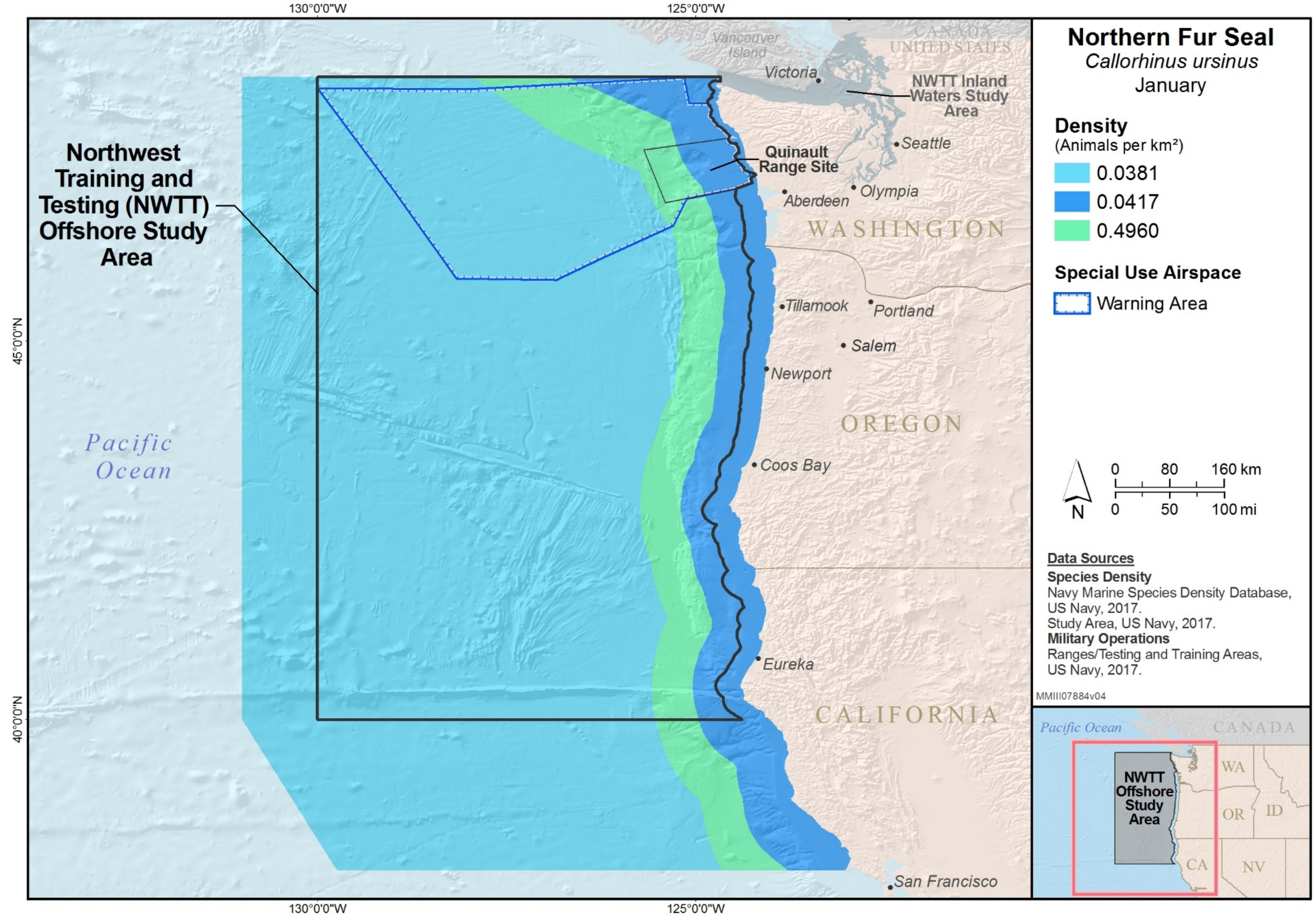

Figure 10.1-4: Offshore January Distribution of Northern Fur Seal

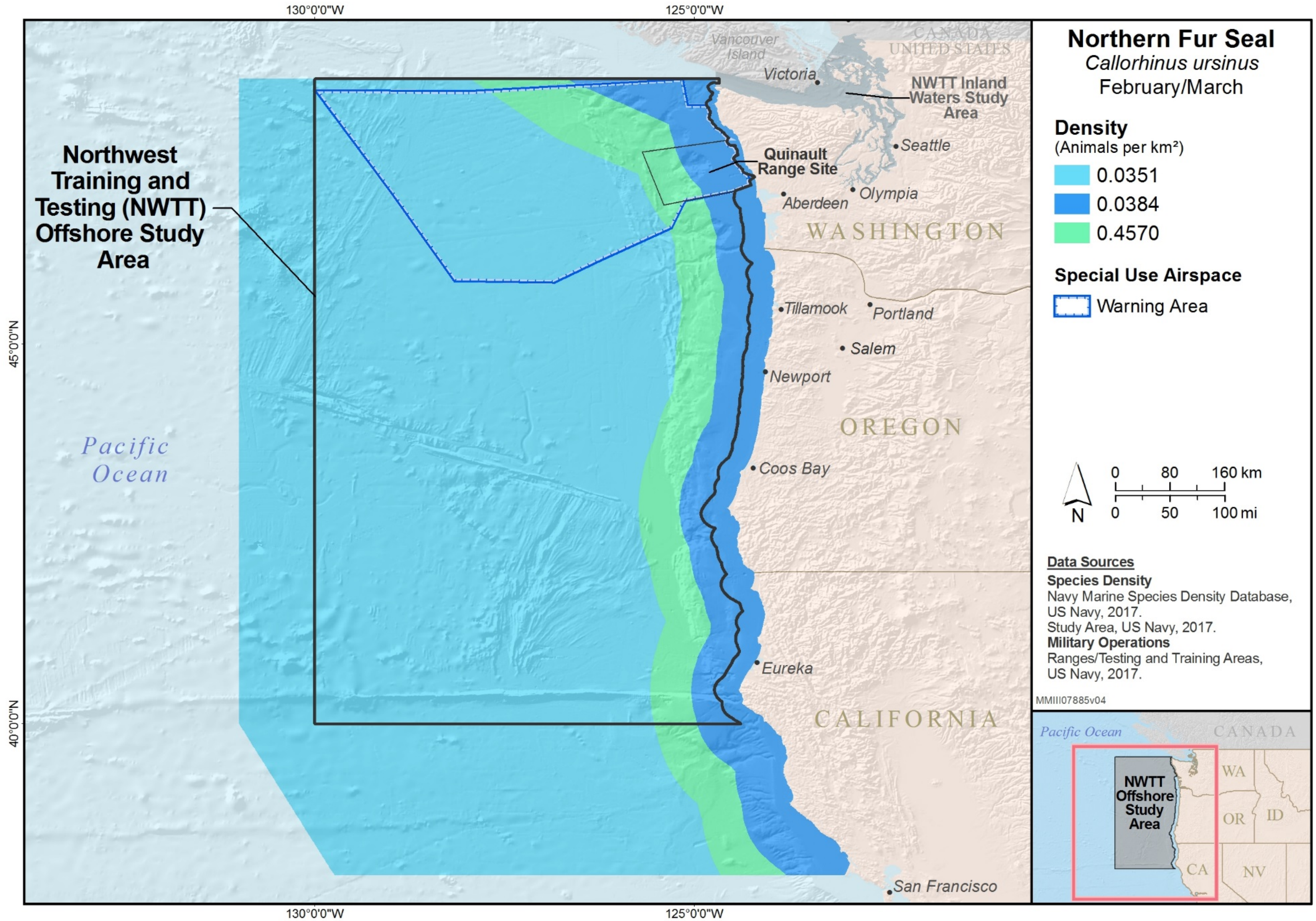

Figure 10.1-5: Offshore February/March Distribution of Northern Fur Seal

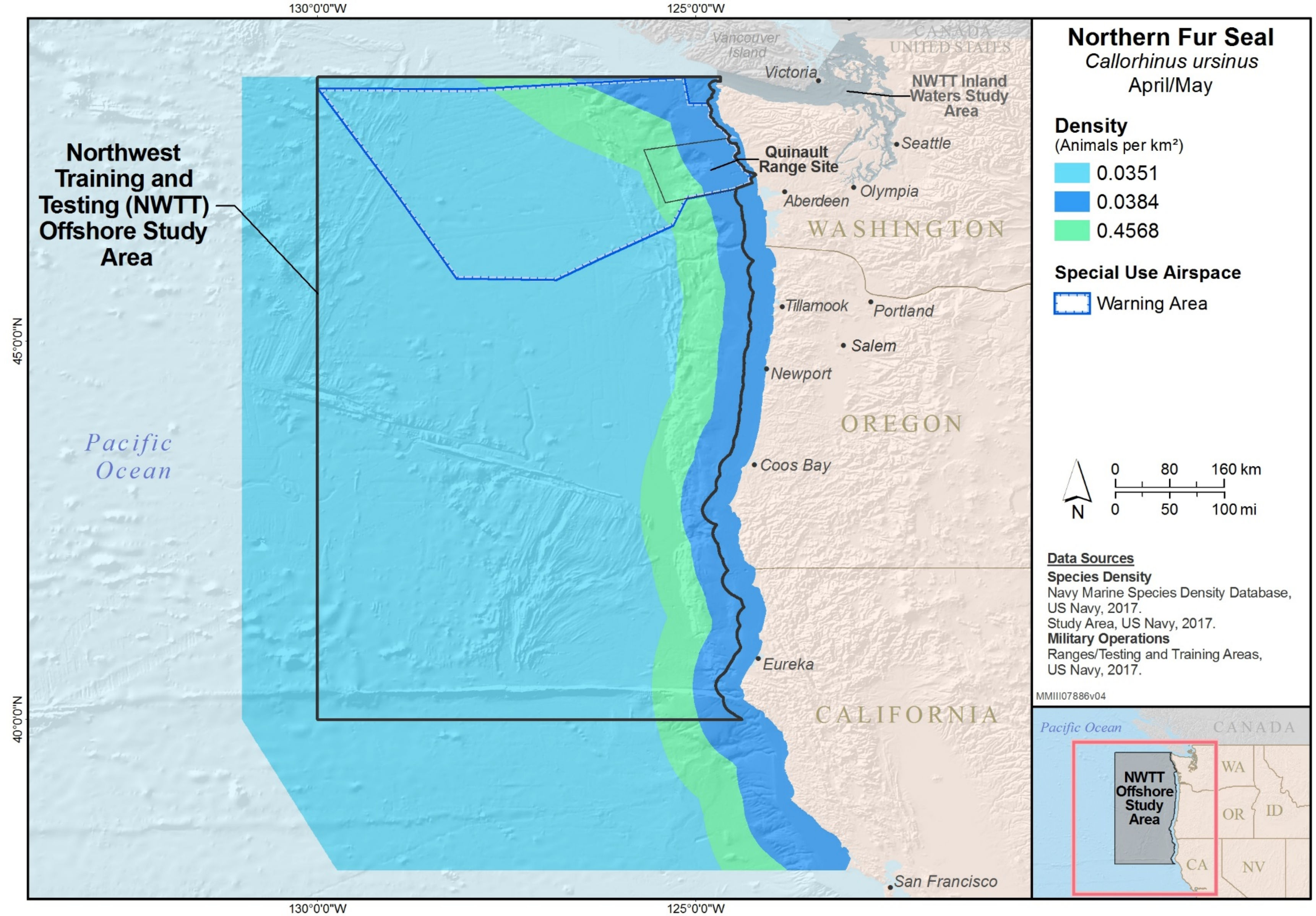

Figure 10.1-6: Offshore April/May Distribution of Northern Fur Seal

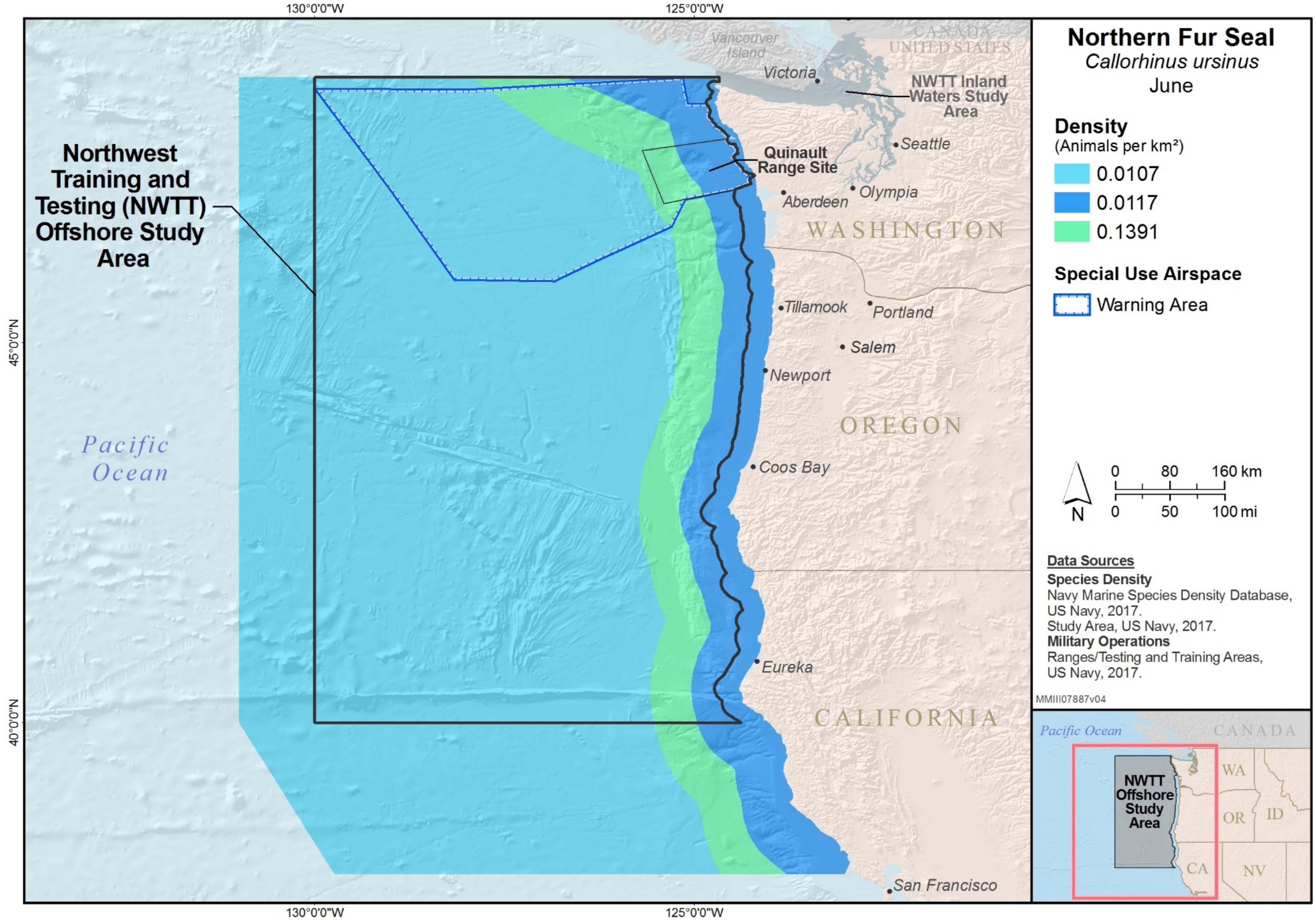

Figure 10.1-7: Offshore June Distribution of Northern Fur Seal

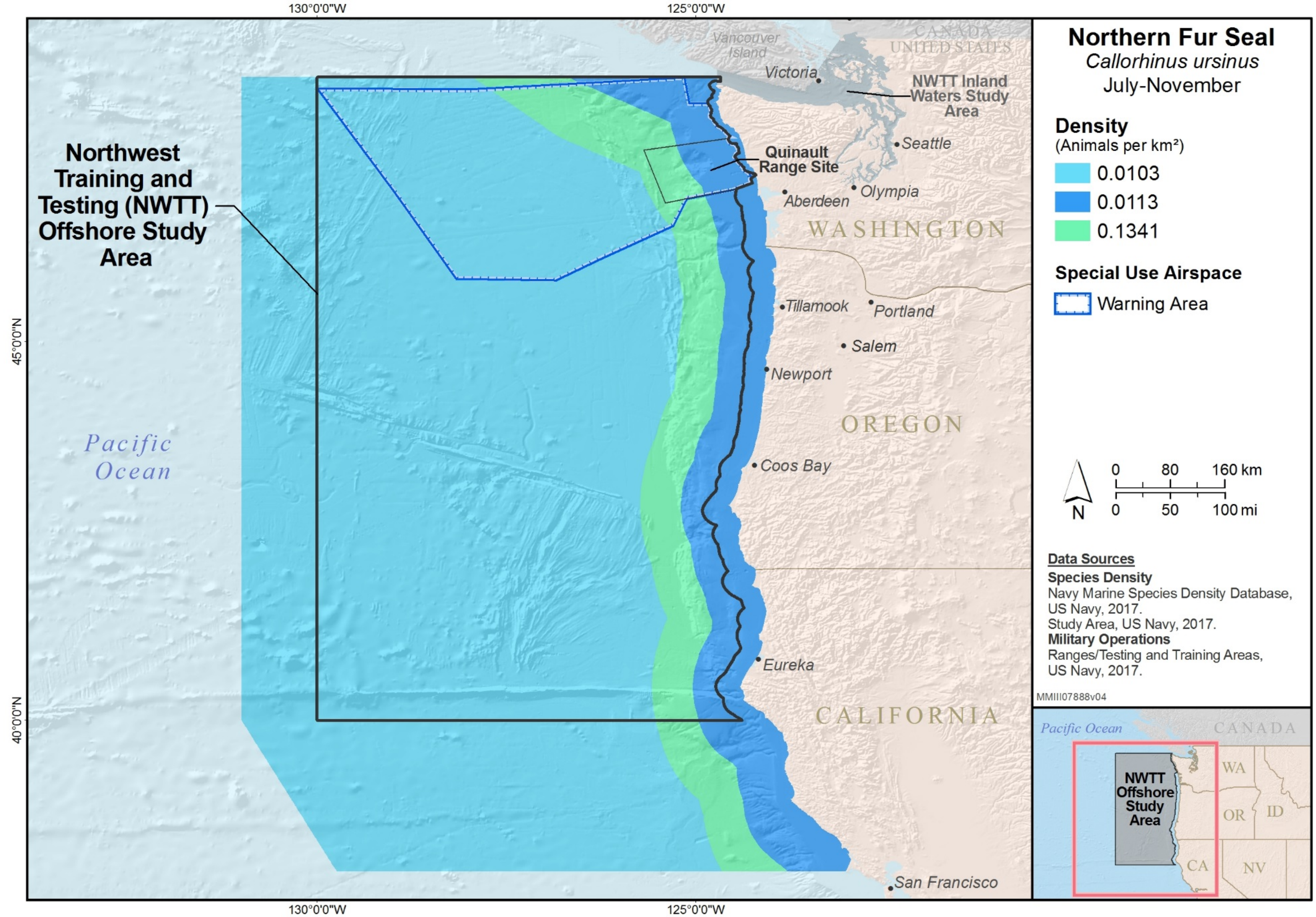

Figure 10.1-8: Offshore July through November Distribution of Northern Fur Seal

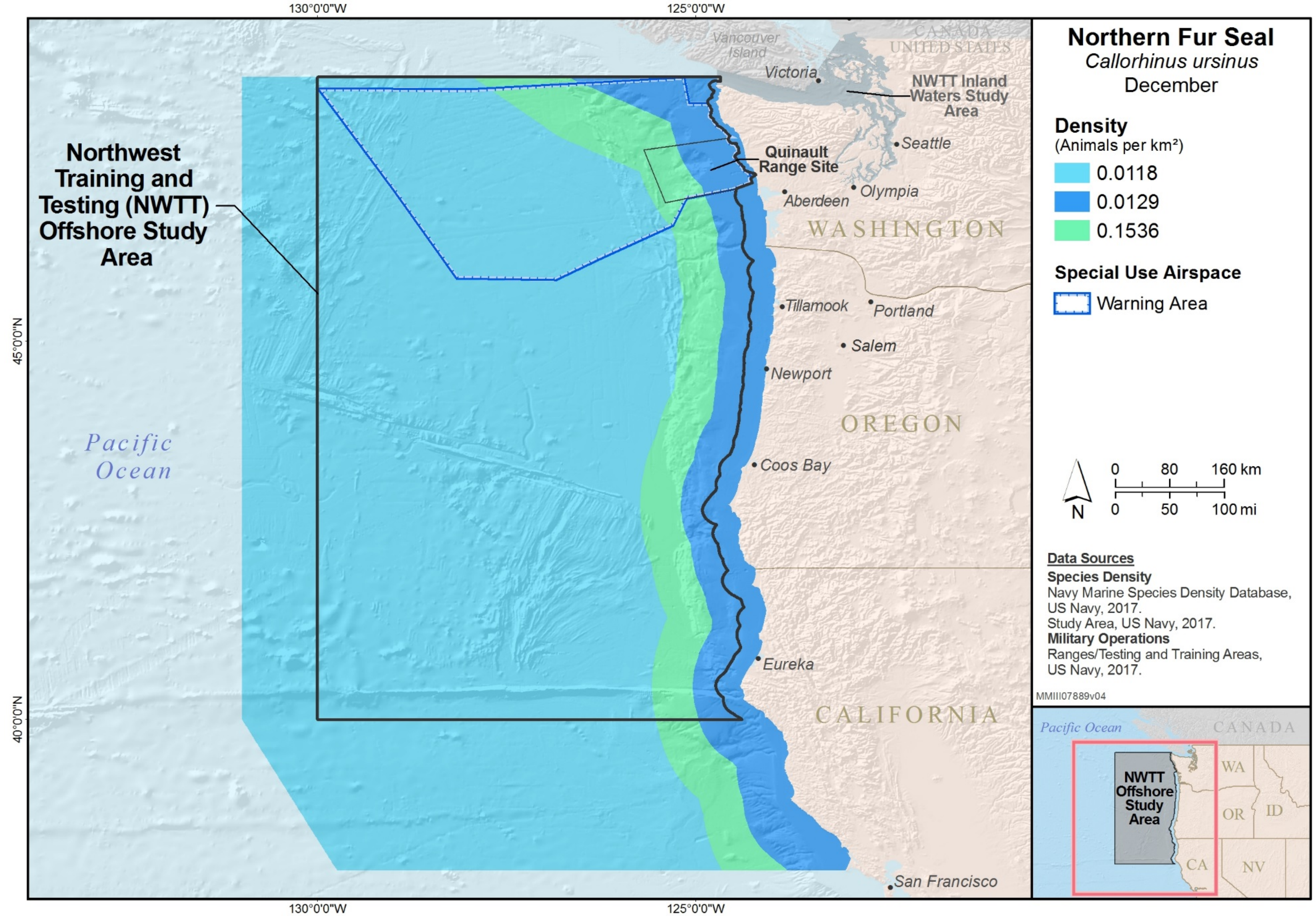

Figure 10.1-9: Offshore December Distribution of Northern Fur Seal

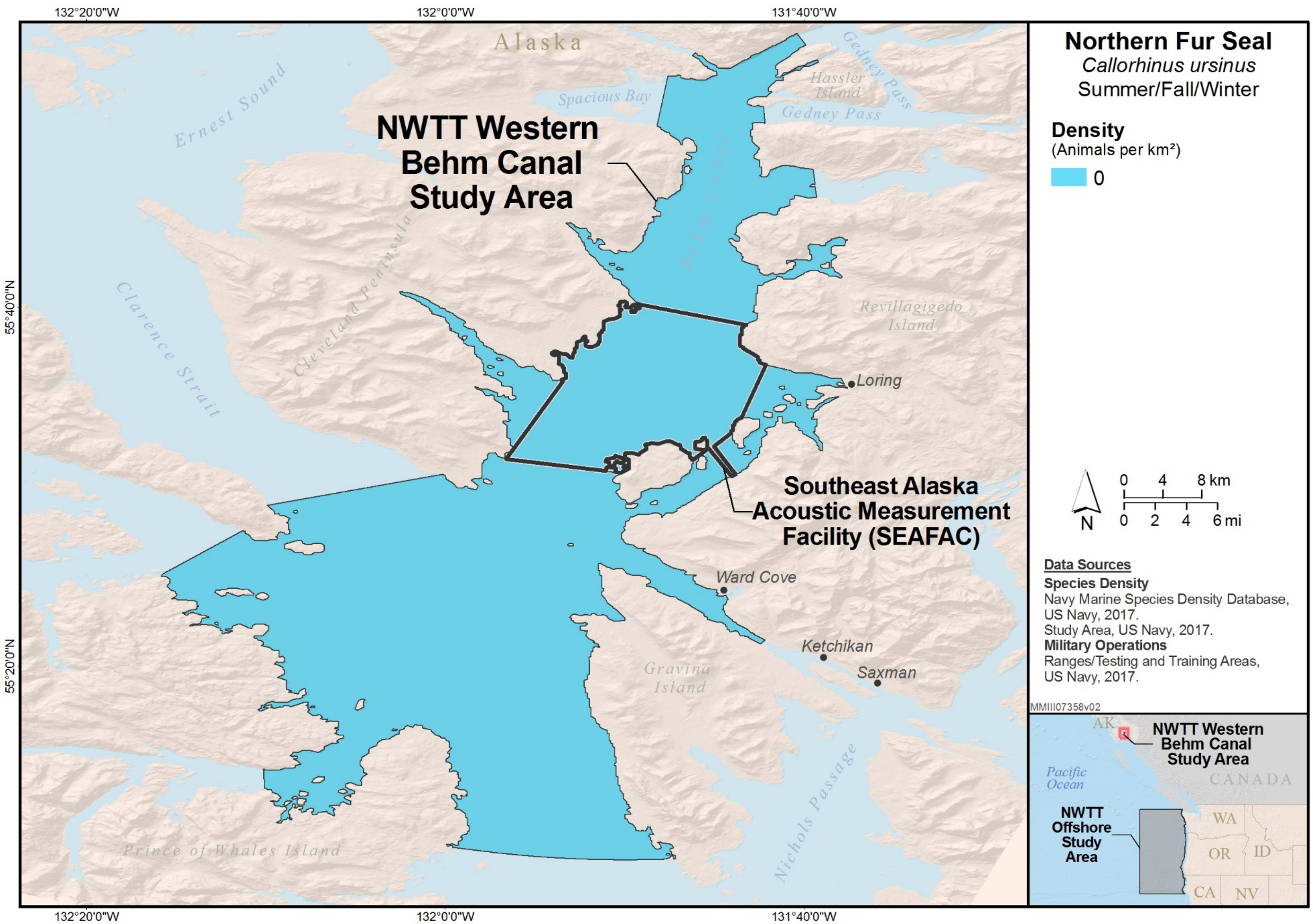

Figure 10.1-10: Western Behm Canal Summer/Fall/Winter Distribution of Northern Fur Seal

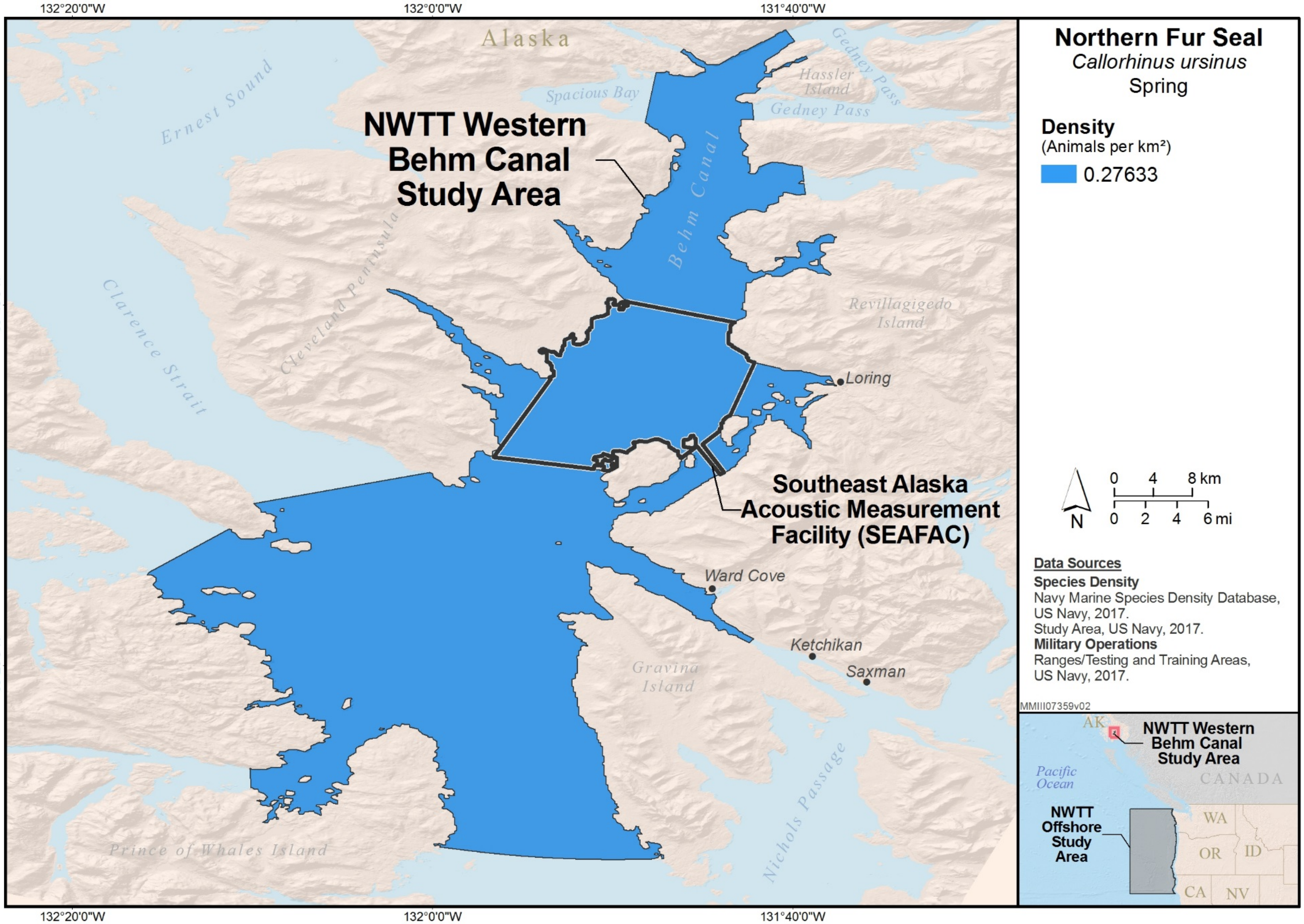

Figure 10.1-11: Western Behm Canal Spring Distribution of Northern Fur Seal

10.1.3 *EUMETOPIAS JUBATUS*, STELLER SEA LION

NMFS has designated two Steller sea lion stocks in the North Pacific corresponding to two DPSs (Muto et al., 2017). The Eastern U.S. Stock (or DPS) is defined as the population occurring east of 144°W longitude and the Western U.S. Stock (or DPS) consists of sea lions occurring west of 144°W longitude. Although the distribution of individuals from the two stocks overlaps outside of the breeding season (DeLong, 2018c; Fritz et al., 2016; Jemison et al., 2013; Raum-Suryan et al., 2004), only sea lions from the Eastern U.S. Stock, defined as those living in southeast Alaska, British Columbia, Washington, California, and Oregon, are expected in the Study Area (National Marine Fisheries Service, 2016b).

Offshore. The Eastern U.S. Stock of Steller sea lions has established rookeries and breeding sites along the coasts of California, Oregon, British Columbia, and southeast Alaska. A new rookery was recently discovered along the coast of Washington at the Carroll Island and Sea Lion Rock complex, where more than 100 pups were born in 2015 (Muto et al., 2017; Wiles, 2015). The NMFS 2016 Stock Assessment Report did not factor in pups born at sites along the Washington coast (Muto et al., 2017). Considering that pups have been observed at multiple breeding sites since 2013, specifically at the Carroll Island and Sea Lion Rock complex (Wiles, 2015), the Stock Assessment Report abundance of 1,407 Steller sea lions (non-pups only) for Washington underestimates the total population. Wiles (2015) estimates that up to 2,500 Steller sea lions are present along the Washington coast, which is the abundance estimate used to calculate densities in this analysis. Approximately 30,000 Steller sea lions occur along the coast of British Columbia, but these animals are not included in the abundance of sea lions occurring in U.S. waters.

Applying the annual growth rate associated with each population, reported in Muto et al. (2017), results in a projected 2017 abundance of 42,730 Steller sea lions in U.S. waters.

Table 10.1-6: Abundance of Eastern U.S. Stock of Steller Sea Lions in 2015 and Projected 2017 Abundance

Region	Growth Rate (%)	2015 Abundance (non-pups + pups)	2017 Projected Abundance
California	1.95	4,056	4,216
Oregon	2.39	7,480	7,947
Washington	8.77	2,500	2,958
Southeast Alaska	2.33	28,594	29,942
Total Eastern U.S. Stock		**42,730**	**45,063**

Sources: (Muto et al., 2017; Wiles, 2015)

Steller sea lions from northern California and southern Oregon rookeries migrate north in September following the breeding season and winter in northern Oregon, Washington, and British Columbia waters. They disperse widely following the breeding season, which extends from May through July, likely in search of different types of prey, which may be concentrated in areas where oceanic fronts and eddies persist (Fritz et al., 2016; Jemison et al., 2013; Lander et al., 2010; Muto et al., 2017; National Marine Fisheries Service, 2013; Raum-Suryan et al., 2004; Sigler et al., 2017). Adults depart rookeries in August. Females with pups remain within 500 km of their rookery during the non-breeding season and juveniles of both sexes and adult males disperse more widely but remain primarily over the continental shelf (Wiles, 2015).

Based on 11 sightings along the Washington coast, Steller sea lions were observed at an average distance of 13 km from shore and 35 km from the shelf break (defined as the 200 m isobath) (Oleson et al., 2009). The mean water depth in the area of occurrence was 42 m, and surveys were conducted out to approximately 60 km from shore. Wiles (2015) estimated that Steller sea lions off the Washington coast primarily occurred within 60 km of shore, favoring habitat over the continental shelf. However, a few individuals may travel several hundred kilometers offshore (Merrick & Loughlin, 1997; Wiles, 2015). Surveys conducted off the coasts of Washington, Oregon, and northern California in winter, summer, and fall from 2011 to 2012 recorded 4 sightings of 10 individuals (Adams et al., 2014). All sightings occurred over the continental shelf (< 200 m water depth).

Based on these occurrence and distribution data, two strata were used to estimate densities for Steller sea lions. The spatial area extending from shore to the 200 m isobath (i.e., over the continental shelf) was defined as one stratum, and the second stratum extended from the 200 m isobath to 300 km from shore to account for reports of Steller sea lions occurring several hundred kilometers offshore. Ninety-five percent of the population of Steller sea lions occurring in the Study Area were distributed over the continental shelf stratum and the remaining 5 percent were assumed to occur between the 200 m isobath and 300 km from shore.

The percentage of time Steller sea lions spend hauled-out varies by season, life stage, and geographic location. Kucey (2005) reported that sea lions were in the water an average of 49 percent of the time at multiple sites along the British Columbia coast. Call et al. (2007) reported juveniles spending 44 percent of their time in the water, but with large variability in age, region, and season. In southeast Alaska, juveniles spent 81 of the time at sea in summer but just 13 percent in winter (Call et al., 2007). Trites and Porter (2002) observed that lactating females spend 76 to 78 percent of time foraging at sea and pups and yearlings were at sea 55 and 60 of the time, respectively.

To calculate densities in the Study Area, the 2017 projected abundances were adjusted to account for time spent hauled-out. In spring and winter, sea lions were estimated to be in the water 64 percent of the time. In summer, when sea lions are more likely to be in the water, the percent of animals estimated to be in the water was increased to 76 percent, and in fall sea lions were anticipated to be in the water 53 percent of the time. The density for Steller sea lions over the continental shelf in the Washington region in fall is calculated as:

Density = (2,958 sea lions x 0.53) x 0.95 / 10,716 km^2= 0.1390 sea lions/km^2 (0 to 200 m Stratum)

The density from the continental shelf to 300 km from shore for the same season and region is:

Density = (2,958 sea lions x 0.53) x 0.05 / 73,658 km^2= 0.0011 sea lions/km^2 (200 m to 300 km Stratum)

Calculations were made for both strata in each region and season using the same process.

Inland Waters. Steller sea lions occur mainly along the Washington coast from the Columbia River to Cape Flattery (Jeffries et al., 2000; Wiles, 2015); however, smaller numbers use the Strait of Juan de Fuca, San Juan Islands, and Puget Sound south to the mouth of the Nisqually River in Thurston and Pierce counties (Wiles, 2015). A total of 22 haulouts used by Steller sea lions (and other pinnipeds) are located in Washington inland waters, and an additional 6 sites are located on the Canadian side of the Strait of Juan de Fuca and southern Strait of Georgia (Jeffries, 2014; Wiles, 2015).

While Steller sea lions are occasionally observed in the Strait of Juan de Fuca, they are seasonally present in Puget Sound. An estimate of several dozen to a few hundred Steller sea lions (mostly males) are present in Puget Sound at any given time with peak abundance in fall and winter (Smultea et al., 2017). No Steller sea lions were sighted from May through July during aerial surveys of Puget Sound from 2014 through 2016 (Smultea et al., 2017). A number of haulout sites have been identified in Puget Sound, including at naval facilities in Hood Canal (Naval Base Kitsap Bangor) and at Naval Station Everett and Naval Base Kitsap Bremerton in Puget Sound (Jeffries, 2014; Jeffries et al., 2000). Jeffries (2014) identified five winter haulout sites in Puget Sound used by Steller sea lions, ranging from immediately south of Port Townsend (near Admiralty Inlet) to Olympia in southern Puget Sound. Numbers of animals observed at these sites ranged from a few animals to just under 100. During the summer breeding season, very few, if any, Steller sea lions would be expected in the Inland Waters portion of the Study Area (Jeffries, 2014; Smultea et al., 2017).

Densities were calculated for three areas within in the Inland Waters Area: (1) Hood Canal, (2) Puget Sound, and (3) Strait of Juan de Fuca and San Juan Islands. Smultea et al. (2017) documented six sightings in Hood Canal but were not able to survey the area around Naval Base Kitsap Bangor, which is a known haulout site for Steller sea lions. To account for sea lions potentially missed during the survey, the six sightings were assumed to represent 30 percent of the population in Hood Canal. Therefore, to calculate a density for Hood Canal, 18 Steller sea lions were estimated to occur in the canal. As a conservative measure, the annual growth rate of 8.77 percent for the Washington region was applied (over 2 years) resulting in a projected 2017 abundance of 21 sea lions. The highest occurrence of Steller sea lions in inland waters is expected to be in fall and winter (Jeffries, 2014; Wiles, 2015), therefore, no seasonal reduction in abundance was applied for those seasons. No haulout correction was needed, because 96 percent of Steller sea lion groups encountered during the surveys conducted by Smultea et al. (2017) were in the water. Adult Steller sea lions are not expected to be in Hood Canal in summer or spring during the breeding season; however, to account for the potential occurrence of juveniles and non-breeding adults in Hood Canal, 2 percent of the population was assumed to remain in spring and summer. The density for Steller sea lions in Hood Canal in fall and winter is calculated as:

$$\text{Density} = (21 \text{ sea lions} \times 1.00) / 335 \text{ km}^2 = 0.0636 \text{ sea lions/km}^2$$

The density for Steller sea lions in Hood Canal in spring and summer is:

$$\text{Density} = (21 \text{ sea lions} \times 0.02) / 335 \text{ km}^2 = 0.0013 \text{ sea lions/km}^2$$

Aerial surveys conducted of haulouts in Puget Sound recorded the highest counts of Steller sea lions in November with 44 animals counted on 6 November and 50 animals counted on 8 November 2013

(Jeffries, 2014; Smultea et al., 2017). Smultea et al. (2017) documented 68 Steller sea lions during aerial surveys in September 2014, which included the 6 in Hood Canal (noted above) and an additional 6 in the Strait of Juan de Fuca. No Steller sea lions were observed during surveys in September 2013, indicating a variable occurrence in Puget Sound. Based on the sightings data, 80 Steller sea lions were estimated to occur in Puget Sound. The 8.77 percent annual growth range for Steller sea lions in the Washington region was applied to calculate a projected 2017 abundance of 95 sea lions. All sea lions are assumed to be in Puget Sound in fall and winter and just 2 percent are expected to occur in spring and summer.

The density for Steller sea lions in Puget Sound in fall and winter is calculated as:

Density = (95 sea lions x 1.00) / 1,981 km^2= 0.0478 sea lions/km^2

The density for Steller sea lions in Puget Sound in spring and summer is:

Density = (95 sea lions x 0.02) / 1,981 km^2= 0.0010 sea lions/km^2

To calculate a density for the Strait of Juan de Fuca and the San Juan Islands, it was assumed that the all Steller sea lions in Puget Sound and Hood Canal would transit through the strait at some time in winter and fall. Sea lions haulout at sites in the Strait of Juan de Fuca, such as Waadah Island where approximately 10 Steller sea lions have been observed annually; however, for the purpose of calculating a density, it is assumed that in-water occurrence in the strait would be brief. Sea lions also routinely haul out on the Canadian side of the strait at well-established sites, including Race Rocks, a winter haulout site used by hundreds of Steller sea lions as they enter inland waters to feed on herring (Committee on the Status of Endangered Wildlife in Canada, 2013; Edgell & Demarchi, 2012). To account for Steller sea lions from Canadian waters occurring in the strait, an additional 20 sea lions were added to the total abundance estimate for Hood Canal and Puget Sound for a total abundance of 118 sea lions. Of the 118 sea lions, only 10 percent are expected to be in the water at any given time in fall and winter, based on the assumption that sea lions are briefly transiting through the strait or are hauled-out at sites along the strait. In spring and summer, when few sea lions are expected to be in inland waters, 1 percent of sea lions are estimated to be in the water.

The density for Steller sea lions in the Strait of Juan de Fuca in fall and winter is calculated as:

Density = (118 sea lions x 0.1) / 4,399 km^2= 0.0027 sea lions/km^2

The density for Steller sea lions in Puget Sound in spring and summer is:

Density = (118 sea lions x 0.01) / 4,399 km^2= 0.0003 sea lions/km^2

Western Behm Canal. Over 65 percent of Steller sea lions in the U.S. Eastern Stock (Washington, Oregon, California, and southeast Alaska) occur in southeast Alaska. An abundance of 28,594 sea lions (pups and non-pups) was estimated to occur in the southeast Alaska region based on surveys from 2015 (Muto et al., 2017). A 2017 abundance was estimated by applying an annual growth rate of 2.33 percent, resulting in a projected abundance of 29,942 sea lions. The majority of rookeries and haulout sites in southeast Alaska are located north of the Behm Canal area (Jemison et al., 2013). There are no haulout sites in Behm Canal (Fritz et al., 2016).

The spatial area used to calculate densities for Steller sea lions in southeast Alaska was based on the regional delineations by Muto et al. (2017) and the preference of Steller sea lions for continental shelf habitat (i.e., from shore to the 200 m isobath) (National Marine Fisheries Service, 2016b; Pitcher et al., 2007; Wiles, 2015). As noted in the discussion on density estimates in the Offshore area, Steller sea lion haulout behavior varies by season, life stage, and region (Call et al., 2007; Kucey, 2005; Merrick & Loughlin, 1997). Sea lions were estimated to be in the water an average of 53 percent of the time in fall, 64 percent in spring and winter, and 76 percent in summer.

The density for Steller sea lions in the Behm Canal area in spring and winter is calculated as:

Density = 29,942 (sea lions) x 0.64 / 71,975 km^2= 0.26624 sea lions/km^2

The density for Steller sea lions in the Behm Canal area in fall is calculated as:

Density = 29,942 (sea lions) x 0.53 / 71,975 km^2= 0.22048 sea lions/km^2

The density for Steller sea lions in the Behm Canal area in summer is calculated as:

Density = 29,942 (sea lions) x 0.76 / 71,975 km^2= 0.31616 sea lions/km^2

Table 10.1-7: Summary of Density Values for Steller Sea Lion

Location	Spring	Summer	Fall	Winter
Offshore (0 to 200 m isobath) Washington	0.1678	0.1993	0.1390	0.1678
Offshore (0 to 200 m isobath) Oregon	0.2824	0.3354	0.2339	0.2824
Offshore (0 to 200 m isobath) California	0.1524	0.1810	0.1262	0.1524
Offshore (200 m isobath to 300 km from shore) Washington	0.0013	0.0015	0.0011	0.0013
Offshore (200 m isobath to 300 km from shore) Oregon	0.0019	0.0023	0.0016	0.0019
Offshore (200 m isobath to 300 km from shore) California	0.0003	0.0004	0.0003	0.0003
Inland Waters (Hood Canal)	0.0013	0.0013	0.0636	0.0636
Inland Waters (Puget Sound)	0.0010	0.0010	0.0478	0.0478
Inland Waters (Strait of Juan de Fuca and San Juan Islands area)	0.0003	0.0003	0.0027	0.0027
Western Behm Canal	0.26624	0.31616	0.22048	0.26624

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

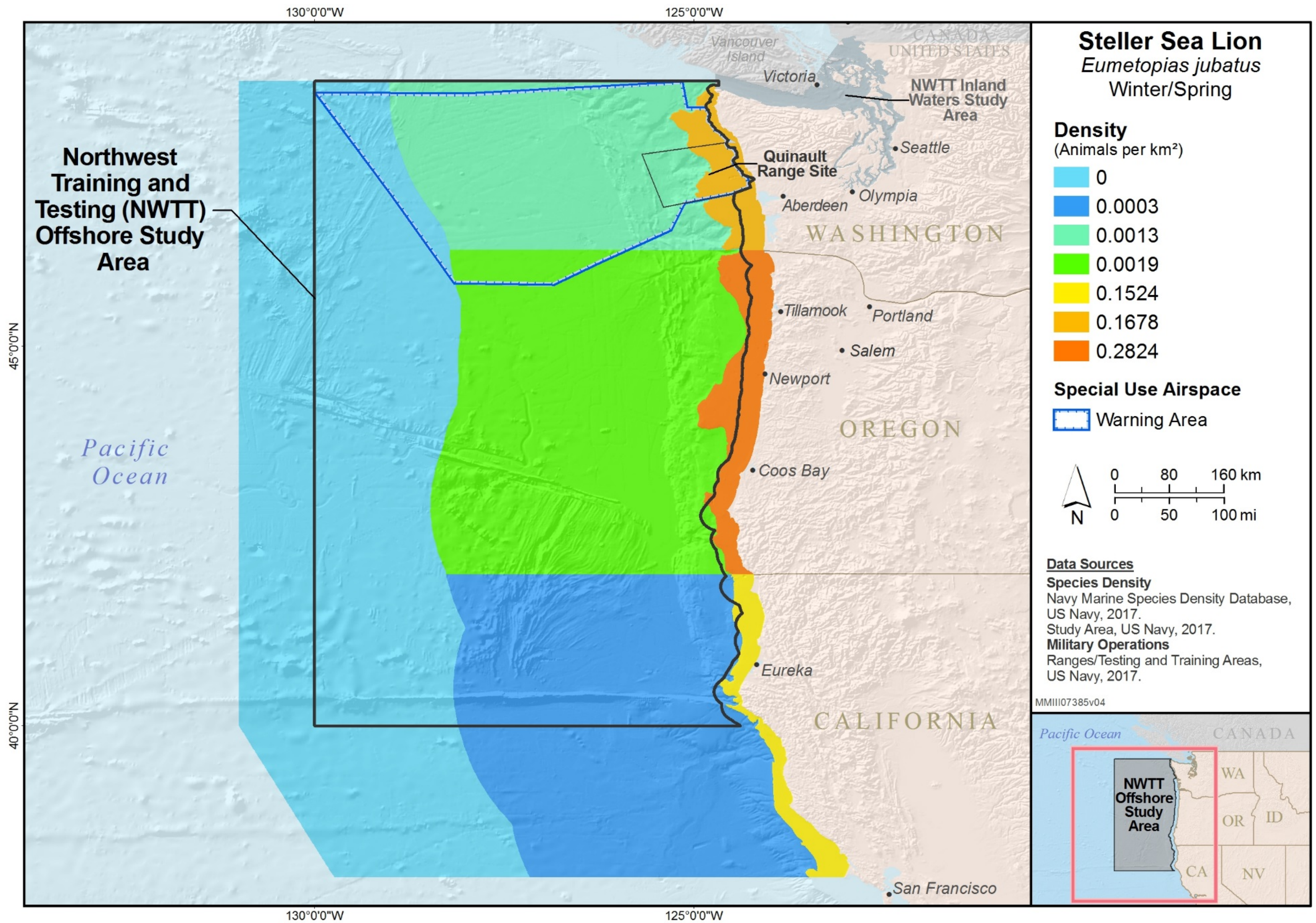

Figure 10.1-12: Offshore Winter/Spring Distribution of Steller Sea Lion

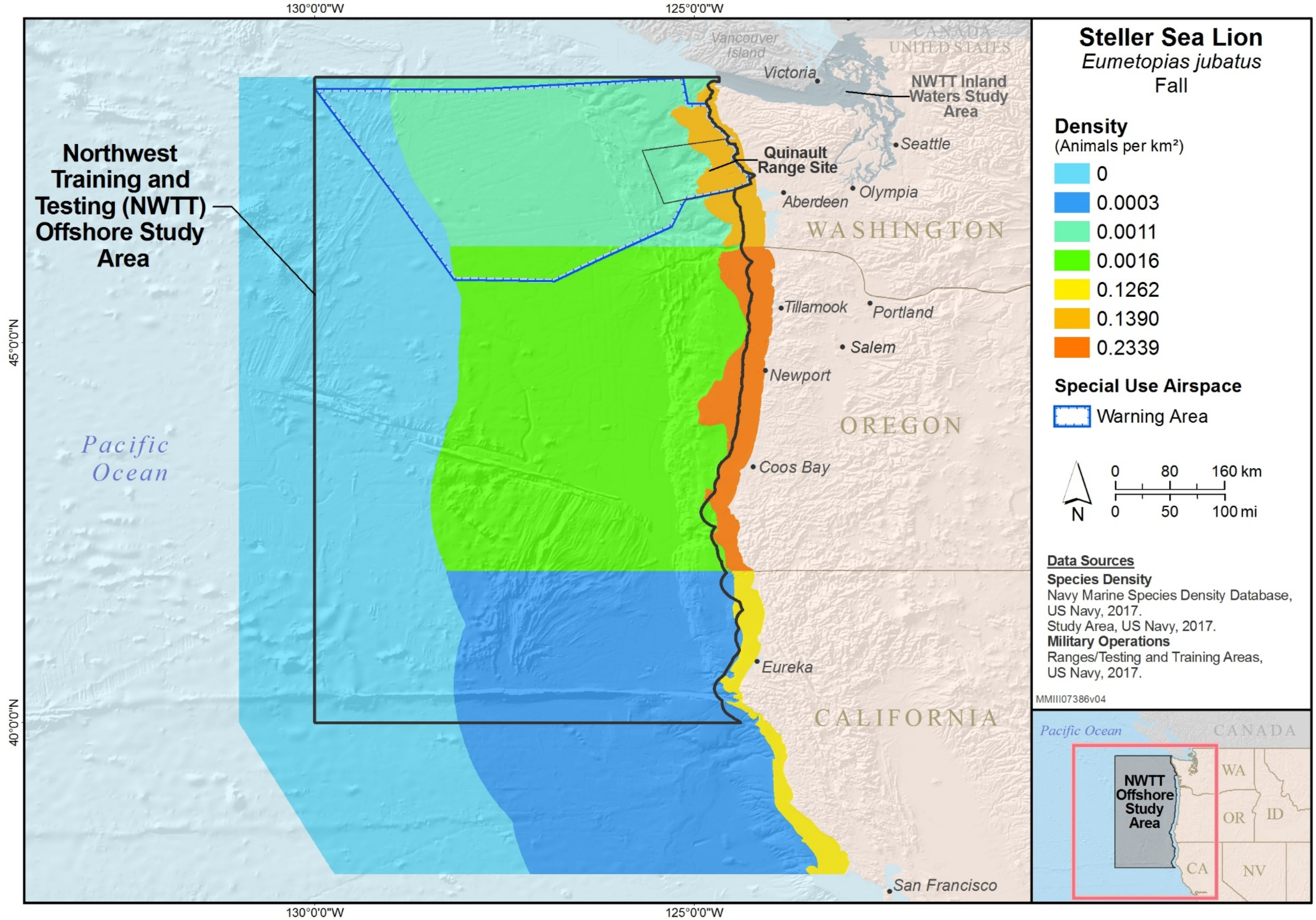

Figure 10.1-13: Offshore Fall Distribution of Steller Sea Lion

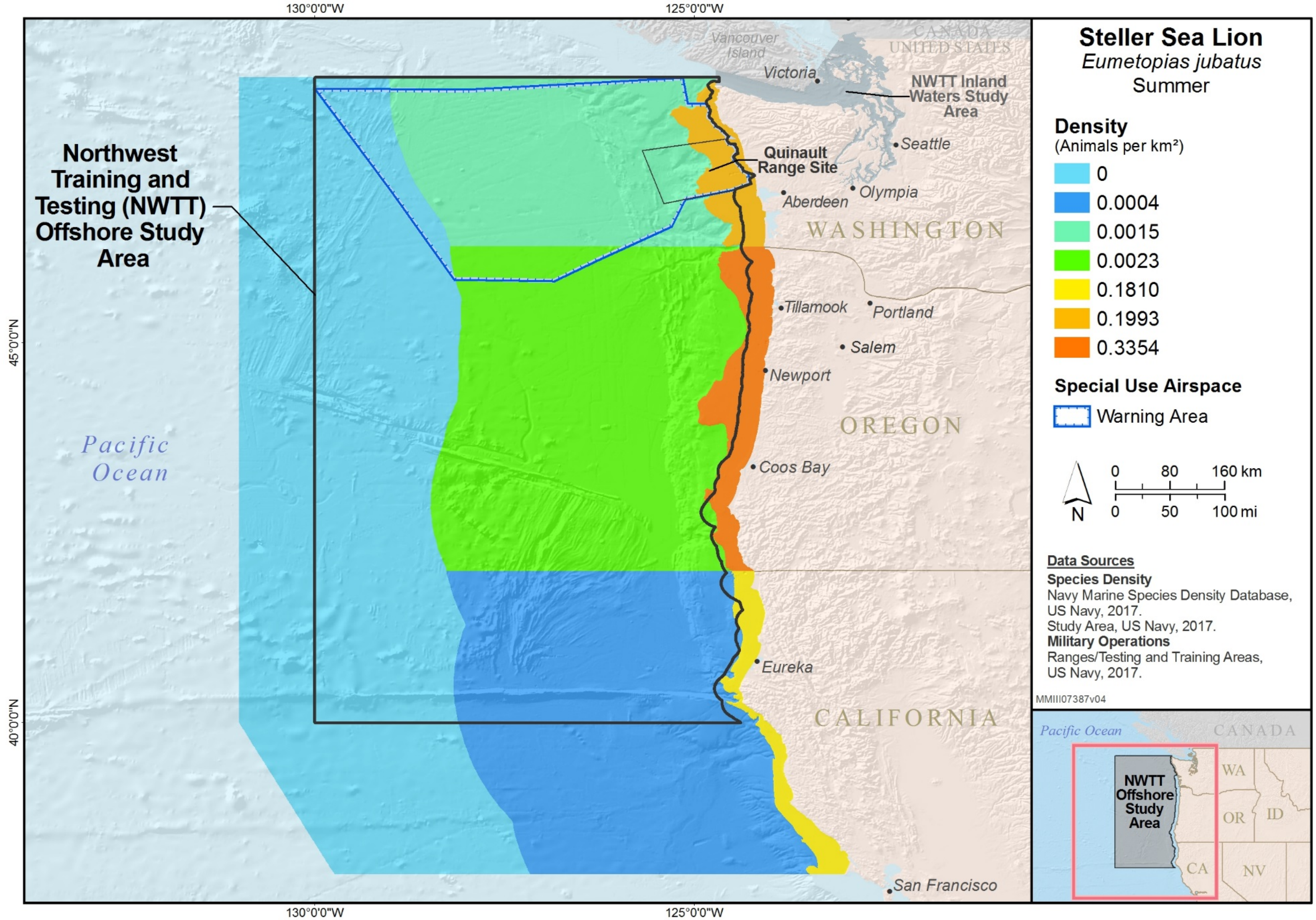

Figure 10.1-14: Offshore Summer Distribution of Steller Sea Lion

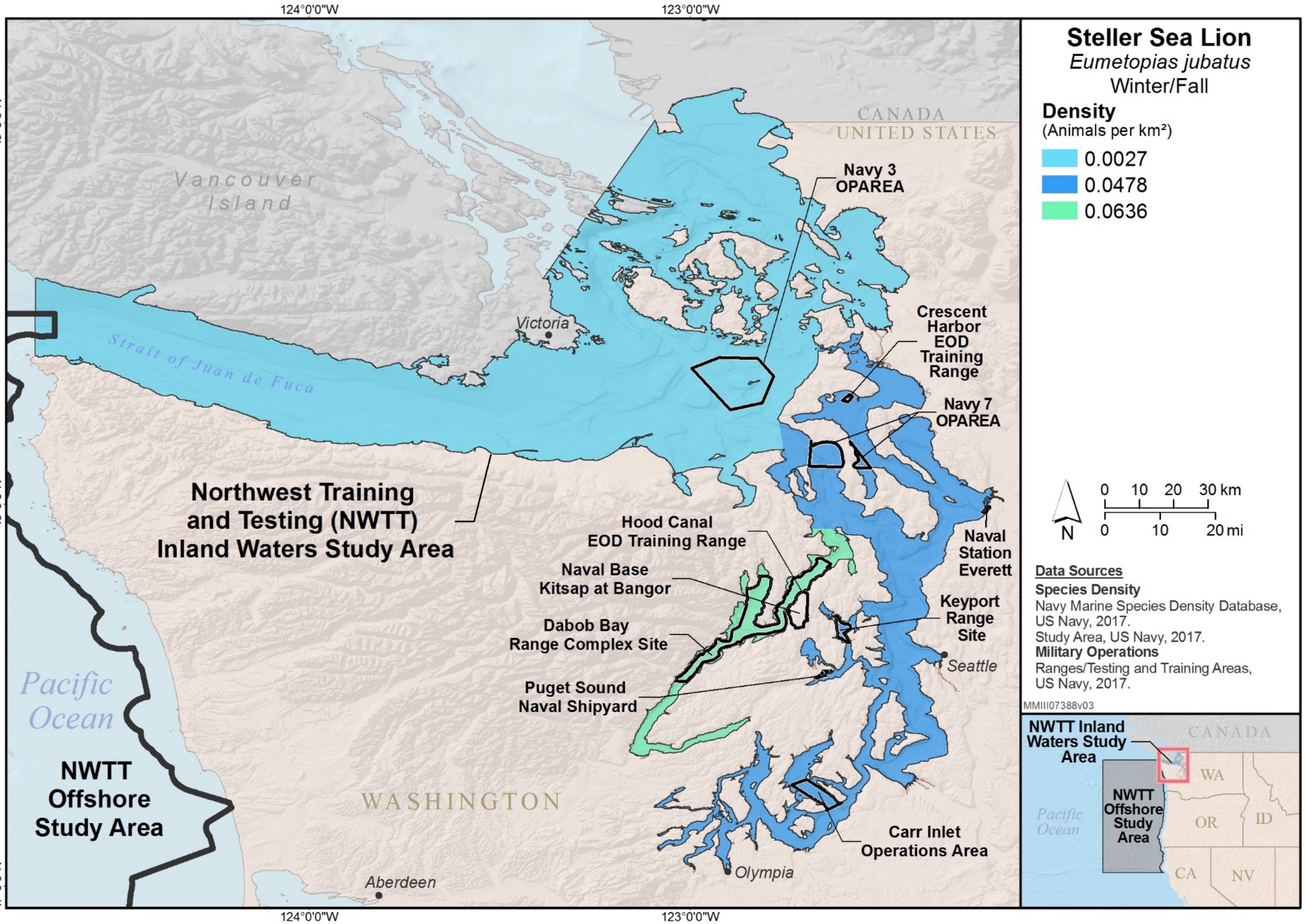

Figure 10.1-15: Inland Waters Winter/Fall Distribution of Steller Sea Lion

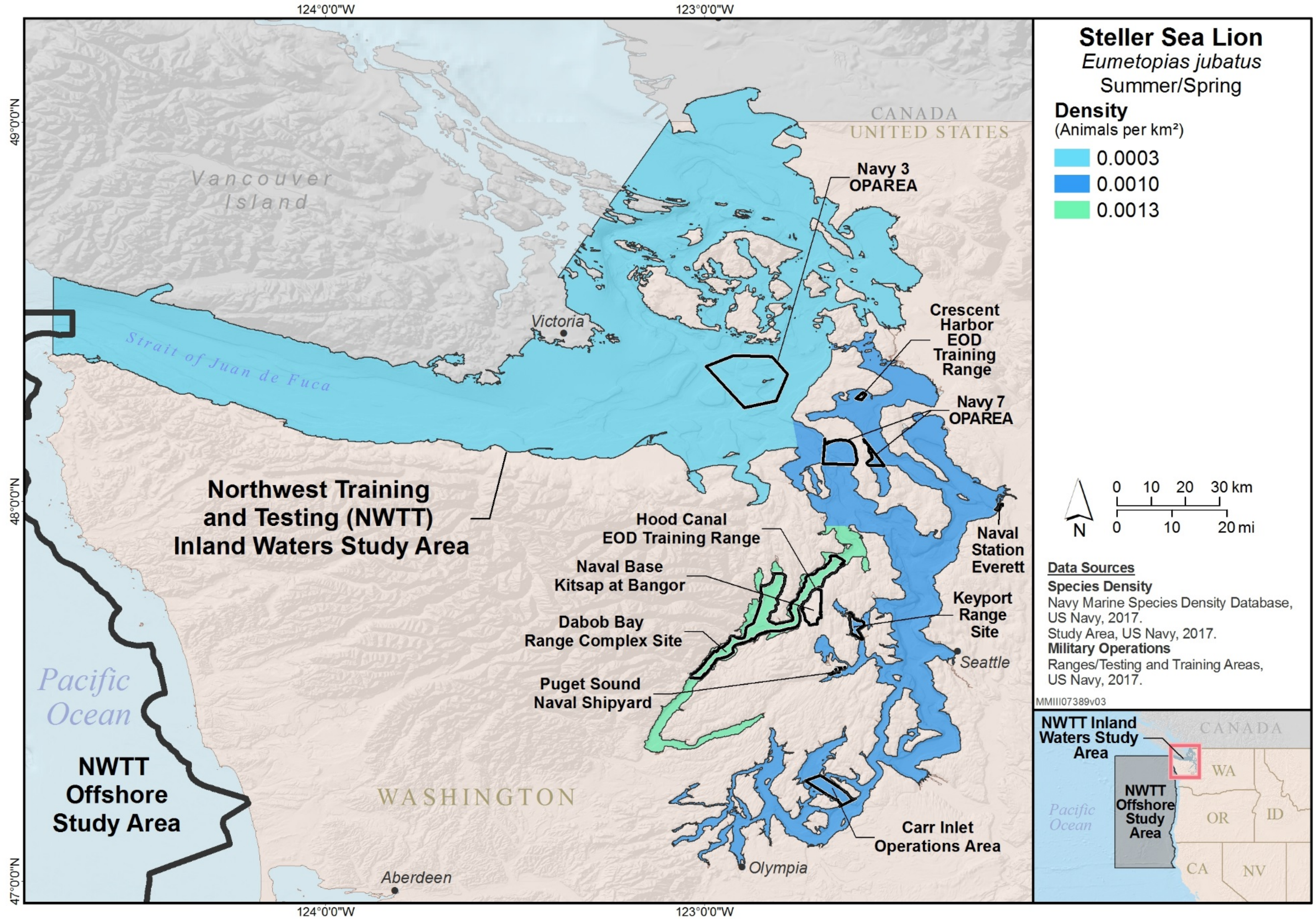

Figure 10.1-16: Inland Waters Summer/Spring Distribution of Steller Sea Lion

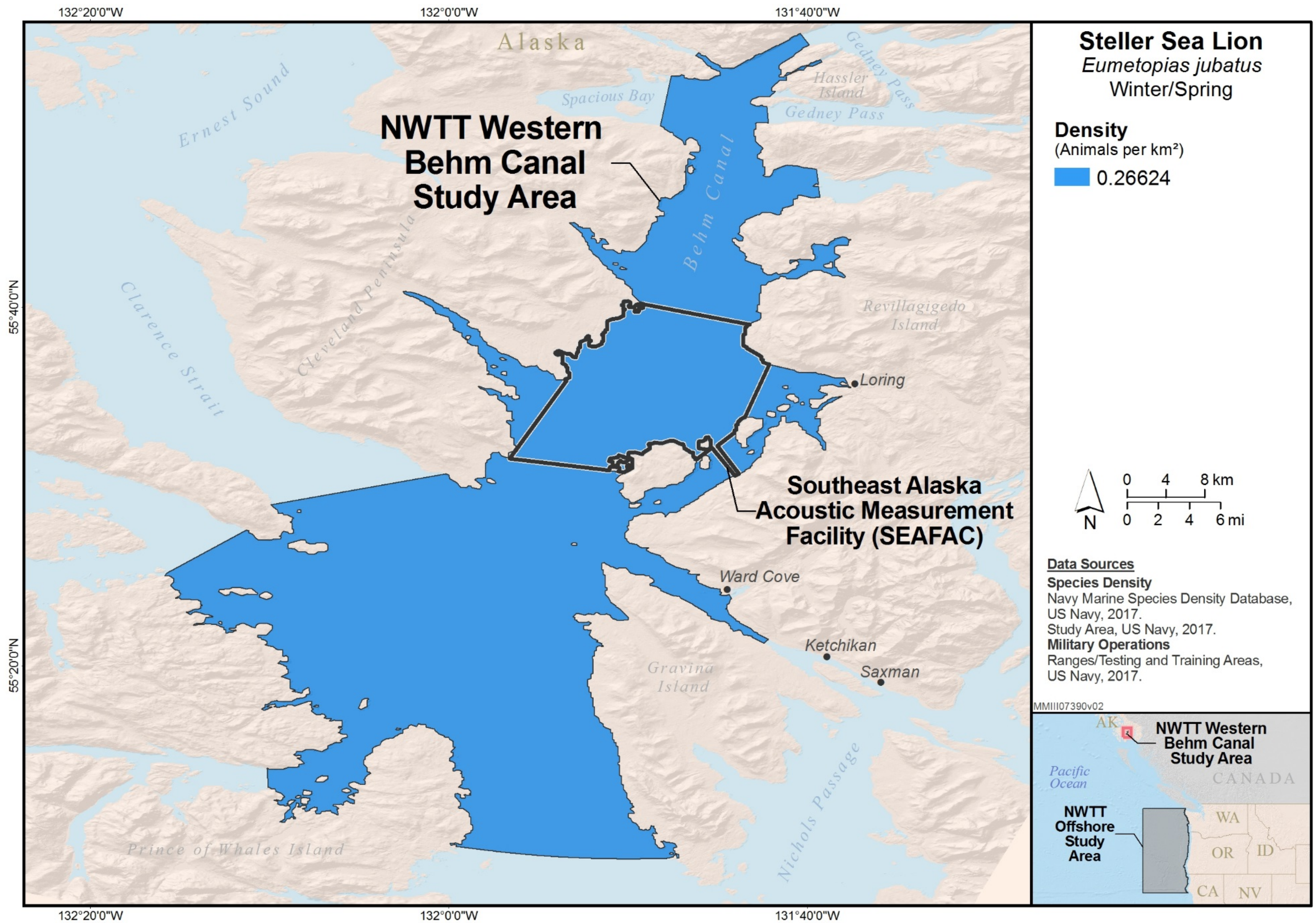

Figure 10.1-17: Western Behm Canal Winter/Spring Distribution of Steller Sea Lion

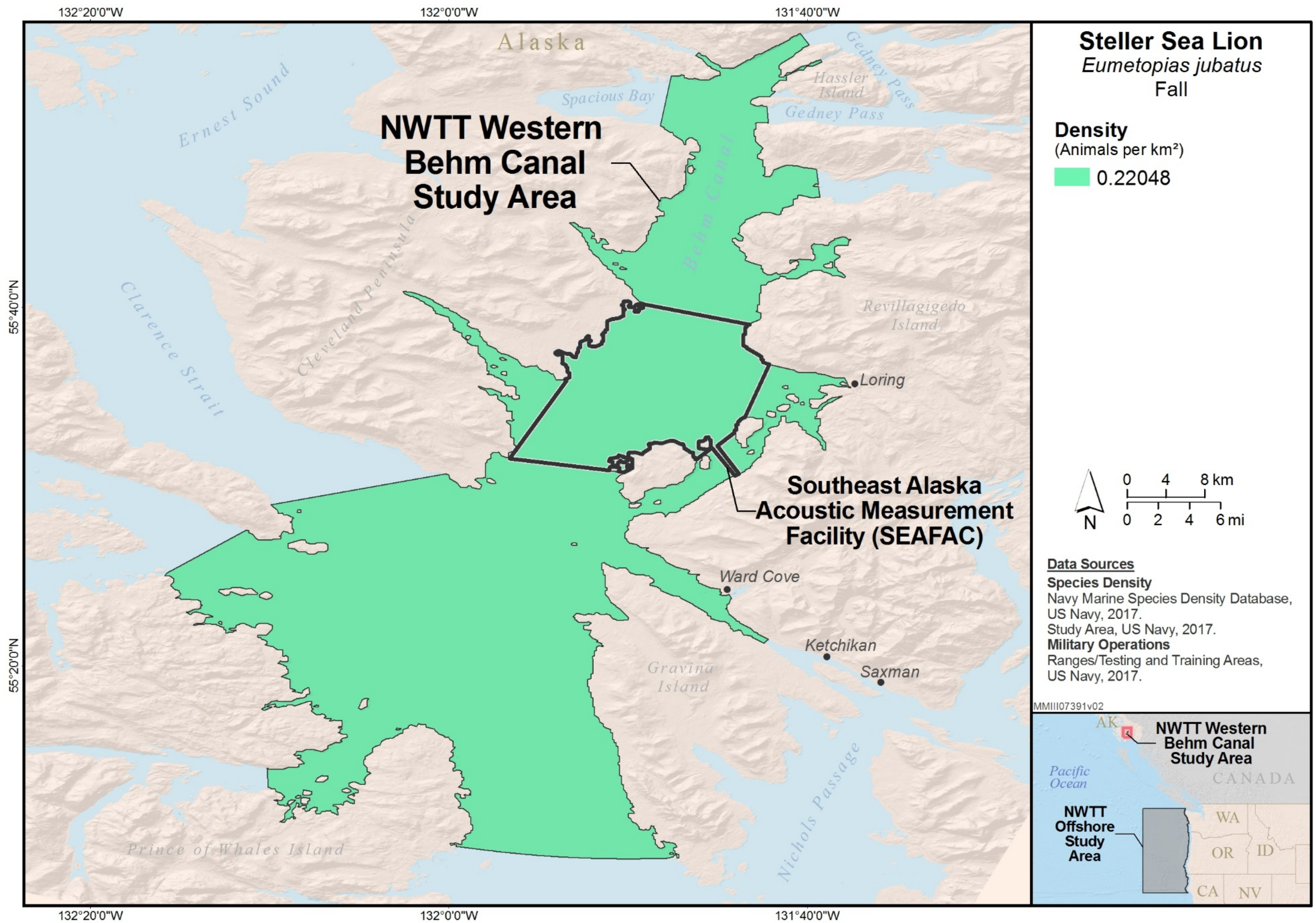

Figure 10.1-18: Western Behm Canal Fall Distribution of Steller Sea Lion

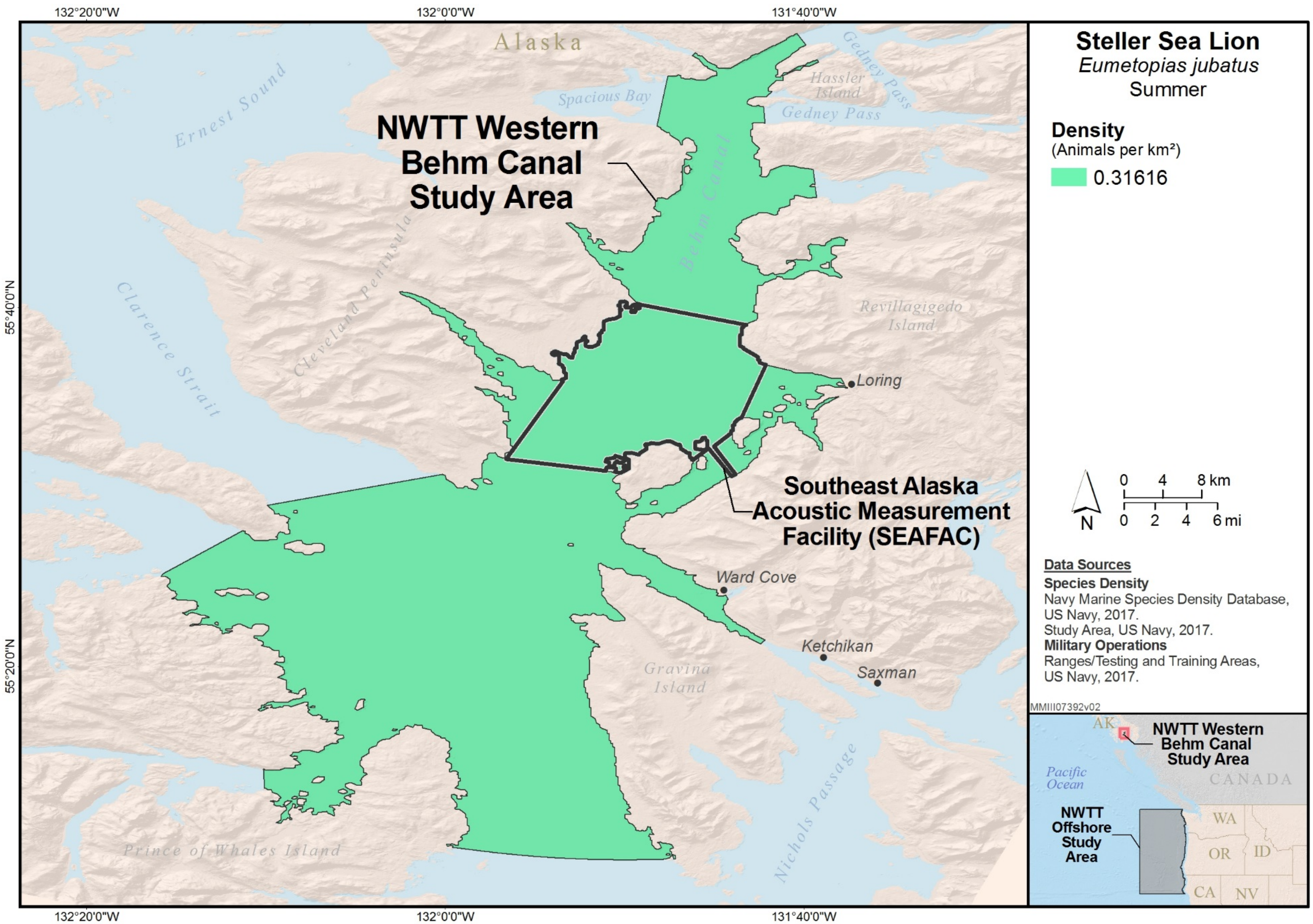

Figure 10.1-19: Western Behm Canal Summer Distribution of Steller Sea Lion

10.1.4 *MIROUNGA ANGUSTIROSTRIS*, NORTHERN ELEPHANT SEAL

Northern elephant seals have made a remarkable recovery from overharvesting in the 1800s (Hoelzel et al., 2002; Stewart et al., 1993; Sydeman & Allen, 1999). One stock of northern elephant seals, the California Breeding Stock, is recognized by NMFS in U.S. waters. Stock abundance is estimated to be 179,000 seals (Carretta et al., 2017b). A separate breeding population in Baja California, Mexico is considered to be demographically isolated from the California Breeding Stock (Carretta et al., 2017b; Mesnick et al., 1998). Density values calculated in this report are based only on the California Breeding Stock abundance of 179,000 northern elephant seals.

The most recent surveys supporting the abundance estimate were conducted in 2010 (Carretta et al., 2017b). By applying the average growth rate of 3.8 percent per year for the California Breeding Stock over the 7 years from 2010 to 2017, a projected 2017 abundance estimate of 232,399 elephant seals was calculated (Carretta et al., 2017b; Lowry et al., 2014).

Offshore. During the December–March breeding season, northern elephant seals are on islands offshore of central and southern California, south of the Study Area (Le Boeuf et al., 2000; Lowry et al., 2014; Robinson et al., 2012). Adult females spend about 30 days on shore for breeding and nursing their pups and return to sea in late winter, dispersing into offshore pelagic waters of the eastern North Pacific. Females remain at sea from February into April before returning south to molt (Robinson et al., 2012). Molting females are on shore for approximately one month before returning to sea and migrating north to forage. Females spend about 10 months at sea and 2 months ashore annually (83 percent of their time at sea).

Robinson et al. (2012) tracked 297 adult female northern elephant seals during post-breeding and post-molting migrations from a central California and a Baja California, Mexico rookery to foraging areas in the Eastern North Pacific. The data showed that female elephant seal foraging areas strongly correlated with the location of the stable boundary separating the sub-arctic and sub-tropical gyres. The boundary fluctuates seasonally, but remains between 40˚ and 50˚ N latitude and is typically at or slightly north of 45 ˚N latitude as it approaches the Study Area.

Adult and sub-adult males spend three months on shore during the breeding season. Post breeding, adult males migrate north and forage on benthic prey over the continental shelf from California to southeast Alaska (Le Boeuf et al., 2000; Stewart & DeLong, 1995). Males remain at sea for approximately four months before returning south to molt in summer (July – August) (Le Boeuf et al., 2000; Stewart & DeLong, 1995). Juvenile males are likely to remain north of California breeding sites and may be more abundant in the Study Area than adult males (Thorson, 2018). Adult males are at sea for approximately 8 months (66 percent) of the year. Males migrating through the Offshore area between foraging areas (off Alaska) and breeding and molting sites (off southern California) would be expected to transit through the NWTT Study Area in about 30 days (Le Boeuf et al., 2000). Males would not be expected to occur in the Offshore area in large numbers during other times.

Male and female distributions at sea differ both seasonally and spatially. Pup counts reported by Lowry et al. (2014) and life tables compiled by Condit et al. (2014) were used to estimate the proportion of males and females in the overall population, which was estimated to be 56 percent female and 44 percent male. Females are assumed to be at sea 100 percent of the time within their seasonal distribution area in fall and summer, as depicted by (Robinson et al., 2012). Females disperse widely after the breeding season and after molting, and do not haul out (Robinson et al., 2012). They come to shore in winter to breed, but are onshore for the entire winter breeding season, which extends from December to early March; therefore, females are estimated to be at sea 33 percent of the winter season. Females come to shore for about 30 days in spring to molt; therefore, they are distributed at sea for approximately 66 percent of the spring season. Males are estimated to be at sea in fall and spring about 90 percent of the time; they are more likely to be closer to shore than females and may occasionally haul out, which is accounted for with a 10 percent adjustment for time spent out of the water. Males come to shore for almost all of the winter breeding season (estimate 10 percent at sea to account for juveniles that may remain north of the Channel Islands) and spend about one month onshore in summer to molt.

Applying a growth rate of 3.80 percent per year to the 2010 abundance of 179,000 elephant seals results in a 2017 abundance of 232,399 elephant seals. The calculation for the fall abundance is provided as an example:

Fall Abundance = (129,592 females x 1.00) + (102,808 males x 0.90) = 222,118 elephant seals

Table 10.1-8: Seasonal Abundance Estimates for Northern Elephant Seal

Location	Spring	Summer	Fall	Winter
Offshore	178,057	197,445	222,118	53,046
Inland Waters (Strait of Juan de Fuca)	10	11	12	3
Western Behm Canal	7,893	0	7,893	0

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

Monthly distribution maps produced by Robinson et al. (2012) and showing the extent of foraging areas used by satellite tagged female elephant seals were used to estimate the spatial areas used in the density calculations for this species. Although the distributions were based only on tagged female seals, Le Boeuf et al. (2000) and Simmons et al. (2007) reported similar tracks by males over broad spatial scales. The spatial areas representing each monthly distribution were calculated using a GIS and then averaged to produce seasonally variable spatial areas.

The equation below illustrates how the density of northern elephant seal was calculated in the four seasons:

Fall Density = 222,118 / 6,182,769 km^2= 0.0359 elephant seals/km^2

Spring Density = 178,057 / 5,604,726 km^2= 0.0318 elephant seals/km^2

Summer Density = 197,445 / 6,388,177 km^2= 0.0309 elephant seals/km^2

Winter Density = 53,046 / 3,521,181 km^2= 0.0151 elephant seals/km^2

All density estimates for northern elephant seal were calculated using the same equations but with the relevant abundance and spatial area estimates.

Inland Waters. Jeffries (2014) recorded 1 to 3 juvenile elephant seals during surveys at haulout sites at the eastern end of the Strait of Juan de Fuca from April to November 2013. The juvenile elephant seals were hauled out with harbor seals, and sightings were distributed evenly over the time period (maximum = 3, minimum = 1). Haulouts were located on offshore islands or islands and spits in the Strait of Juan de Fuca (Jeffries et al., 2000). For the purposes of estimating a density in the Strait of Juan de Fuca, the maximum number (maximum = 3) observed during the survey period was used as an abundance estimate for the Strait Juan de Fuca portion of the Inland Waters area. Since data on northern elephant seal occurrence in the Canadian portion of the Strait are unknown, an additional 10 elephant seals were added to the estimate for a total abundance of 13 seals. To calculate seasonal abundances, it was assumed that 6 of the 13 were females and the remaining 7 were males. The same seasonal estimates of in-water occurrence derived for the Offshore area were applied, resulting in the seasonal abundances. Solitary individuals may occasionally be seen farther inland, but substantial numbers of northern elephant seals are not expected to occur in Hood Canal or Puget Sound.

Western Behm Canal. DeLong and Jeffries (2017) indicated that a small number of male northern elephant seals could occur in the Behm Canal area, because water depth (> 600 m) is suitable habitat for the seals. However, elephant seals would not be expected to haul out in the canal. Occurrence in Behm Canal was estimated by extrapolating data from Le Boeuf et al. (2000), which showed that 2 out of 20 (or 10 percent) of tagged male elephant seals used inland waters in southeast Alaska and Puget Sound. Lowry et al. (2014) estimated that 40,684 pups were born in 2010. To calculate an abundance, it was assumed that 50 percent of the pups were males. Applying a multiplication factor of 3.88 (males only) resulted in a population of 78,926 male elephant seals. Assuming 10 percent of the male population use inland waters, resulted in an estimate of 7,893 elephant seals in Behm Canal. Based on migratory behavior, male elephant seals would only be expected in Behm Canal in fall and spring (DeLong & Jeffries, 2017). The spatial area used in the density calculation encompassed Behm Canal and nearby inland waters and was 10,857 km^2.

All density estimates for northern elephant seal were calculated using the same density calculation but with the appropriate abundance estimates and spatial area values.

Table 10.1-9: Summary of Density Values for Northern Elephant Seal

Location	Spring	Summer	Fall	Winter
Offshore	0.0318	0.0309	0.0359	0.0151
Inland Waters (Strait of Juan de Fuca)	0.0024	0.0025	0.0029	0.0006
Western Behm Canal	0.72699	0	0.72699	0

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

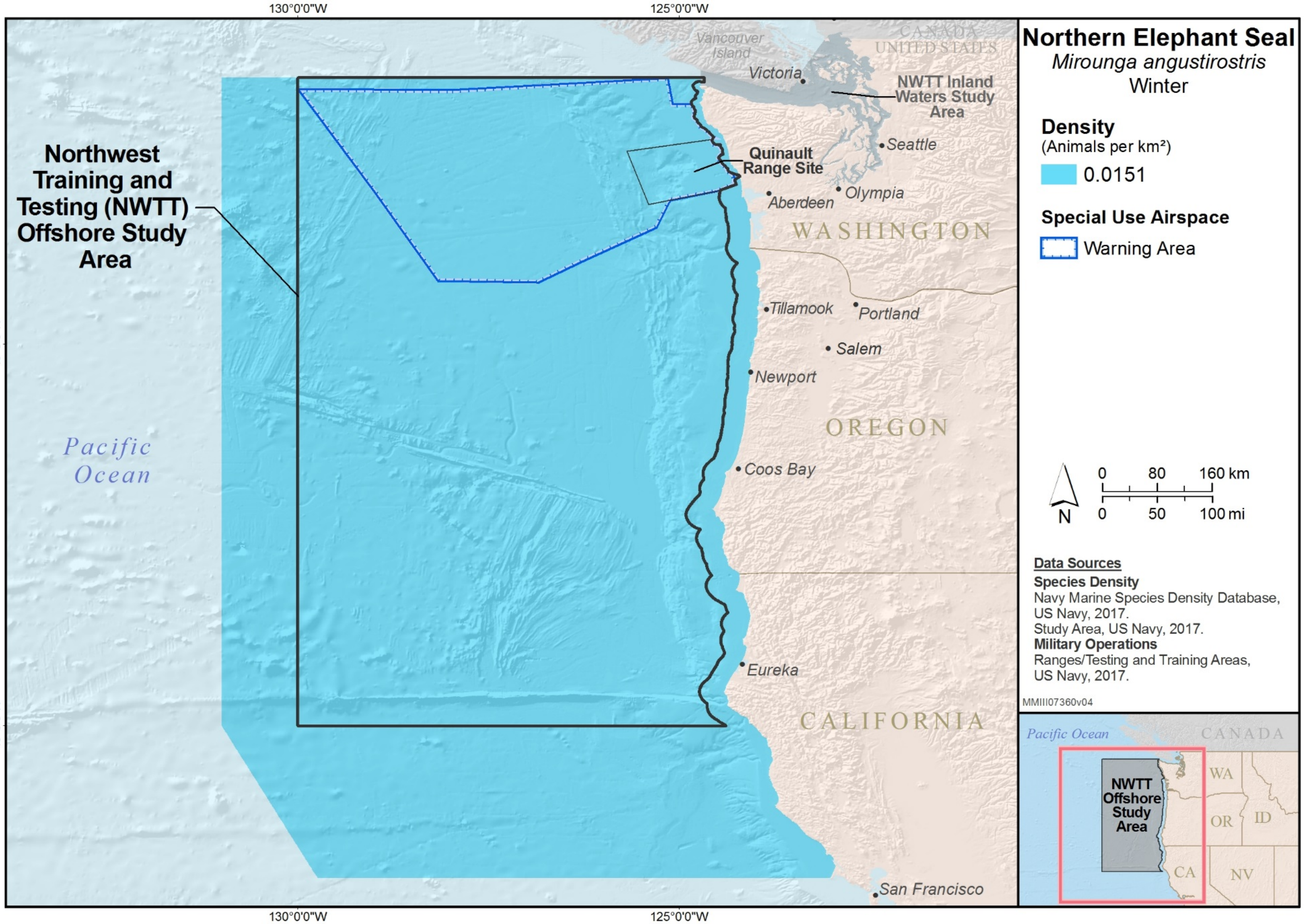

Figure 10.1-20: Offshore Winter Distribution of Northern Elephant Seal

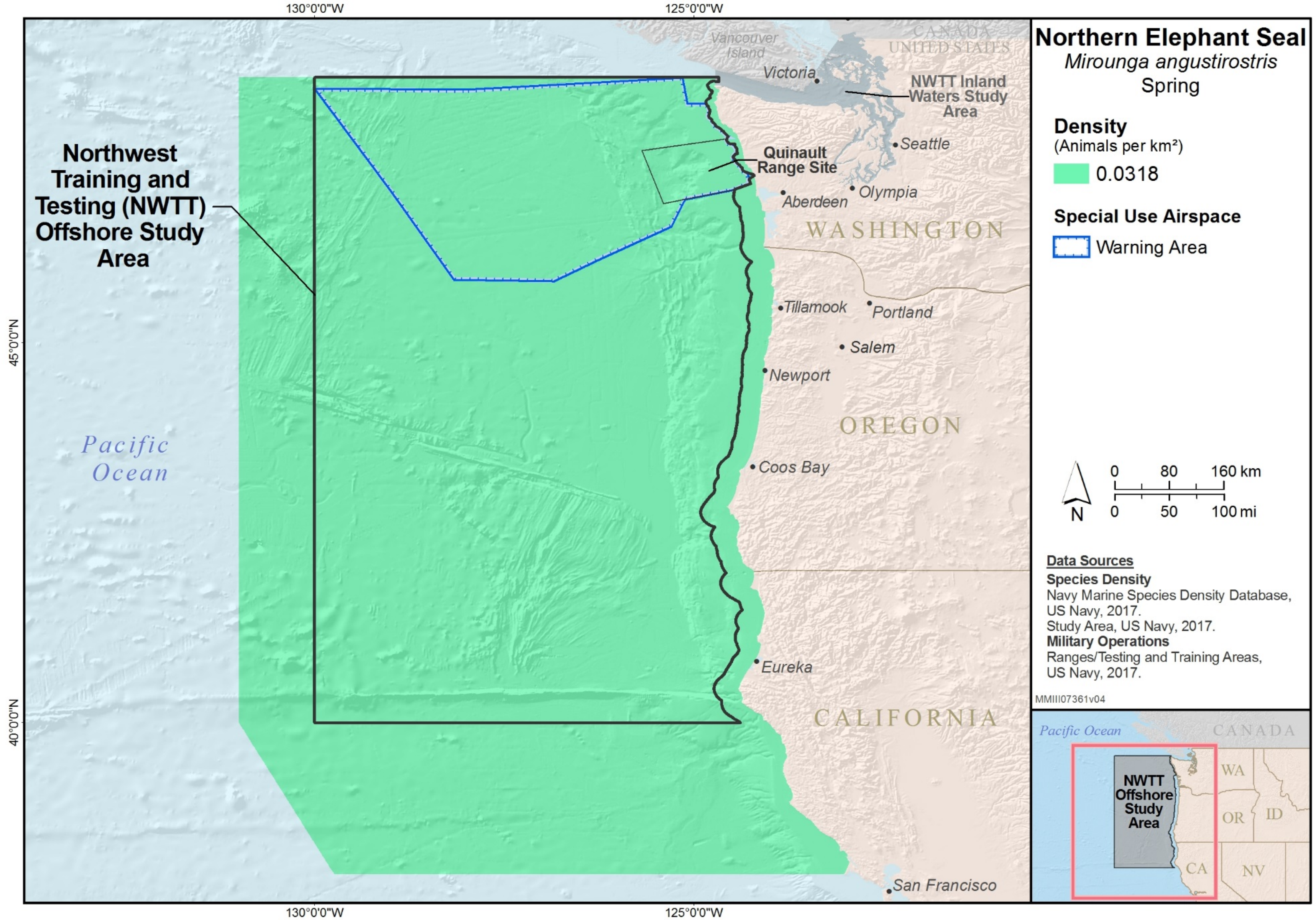

Figure 10.1-21: Offshore Spring Distribution of Northern Elephant Seal

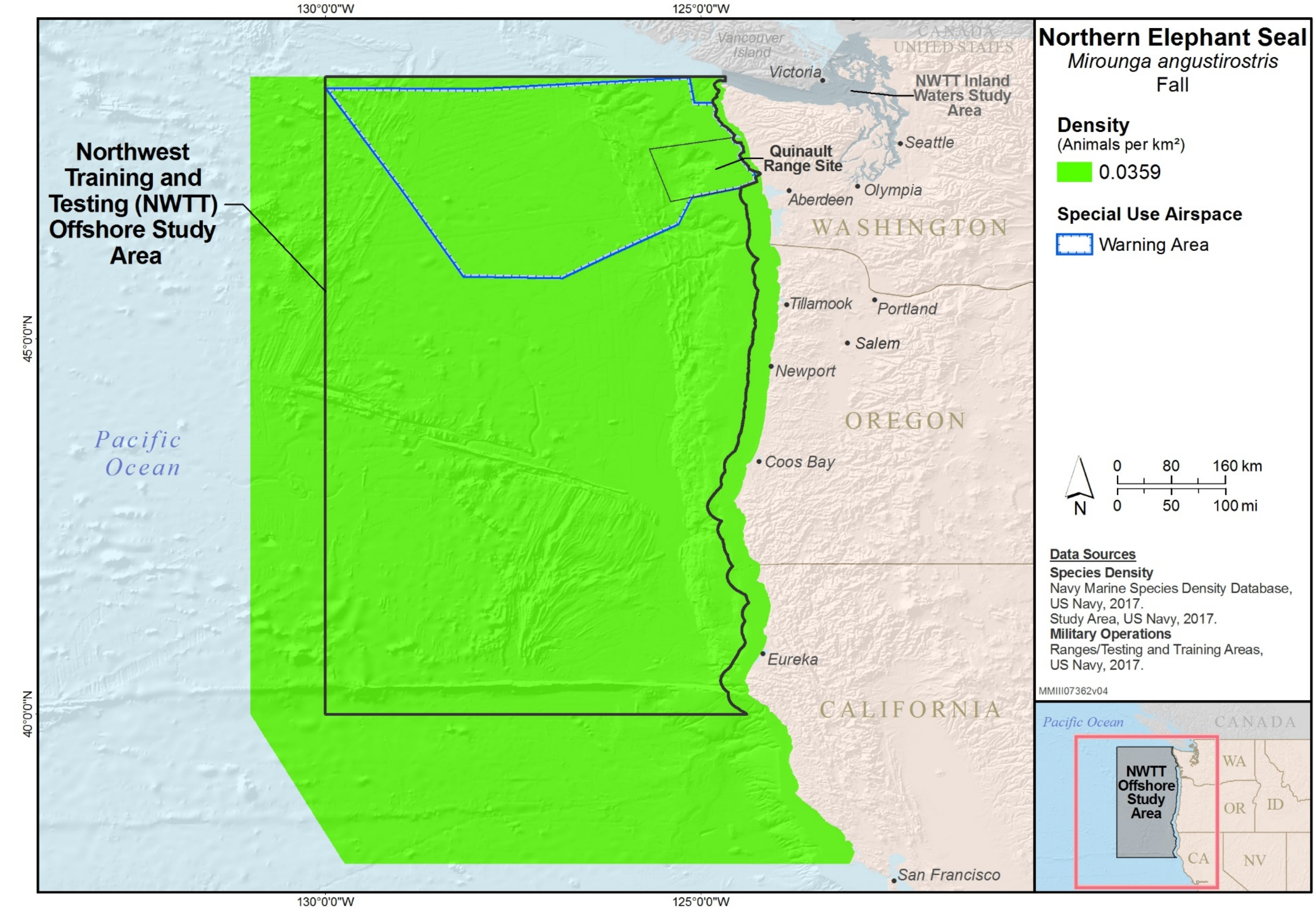

Figure 10.1-22: Offshore Fall Distribution of Northern Elephant Seal

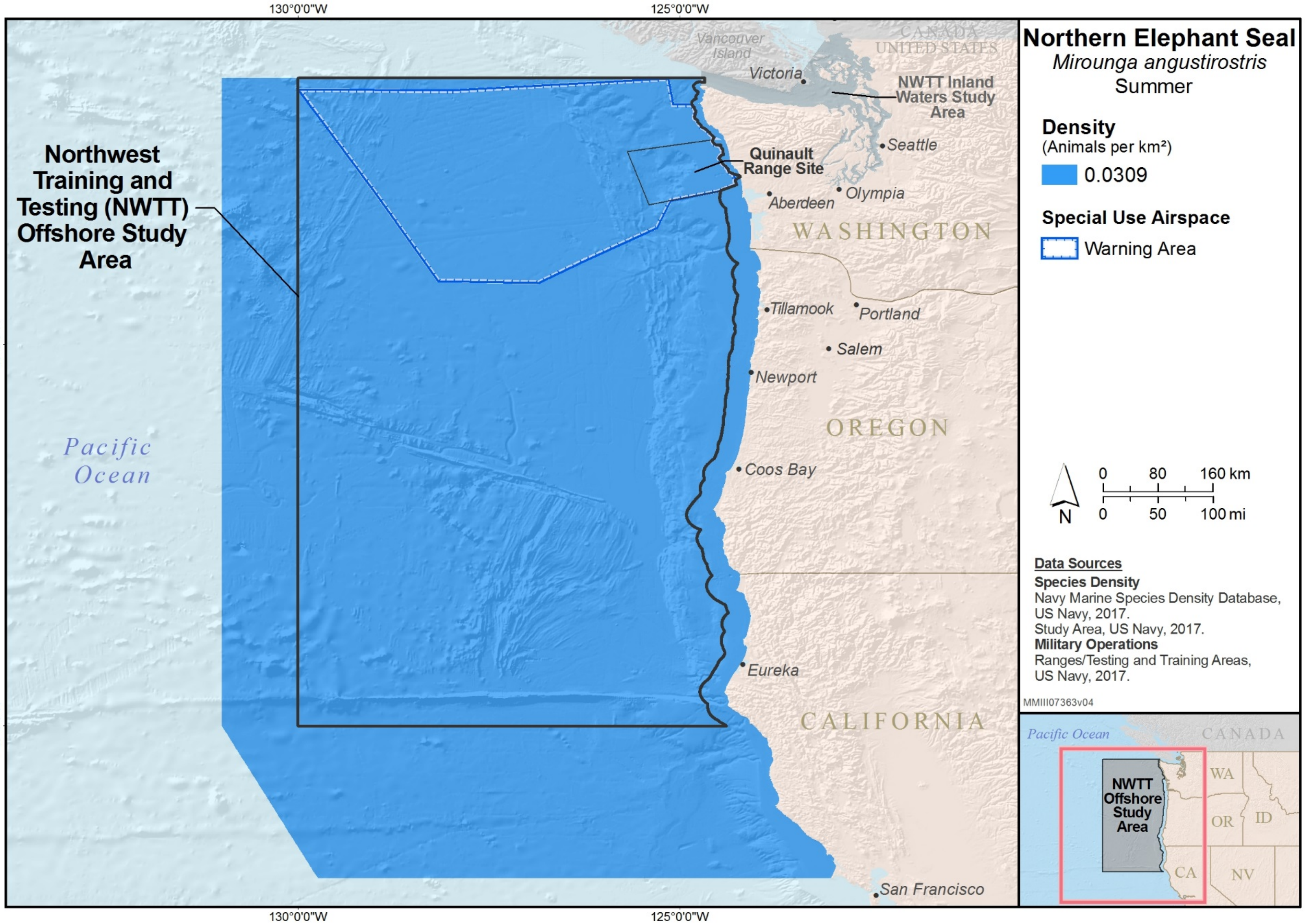

Figure 10.1-23: Offshore Summer Distribution of Northern Elephant Seal

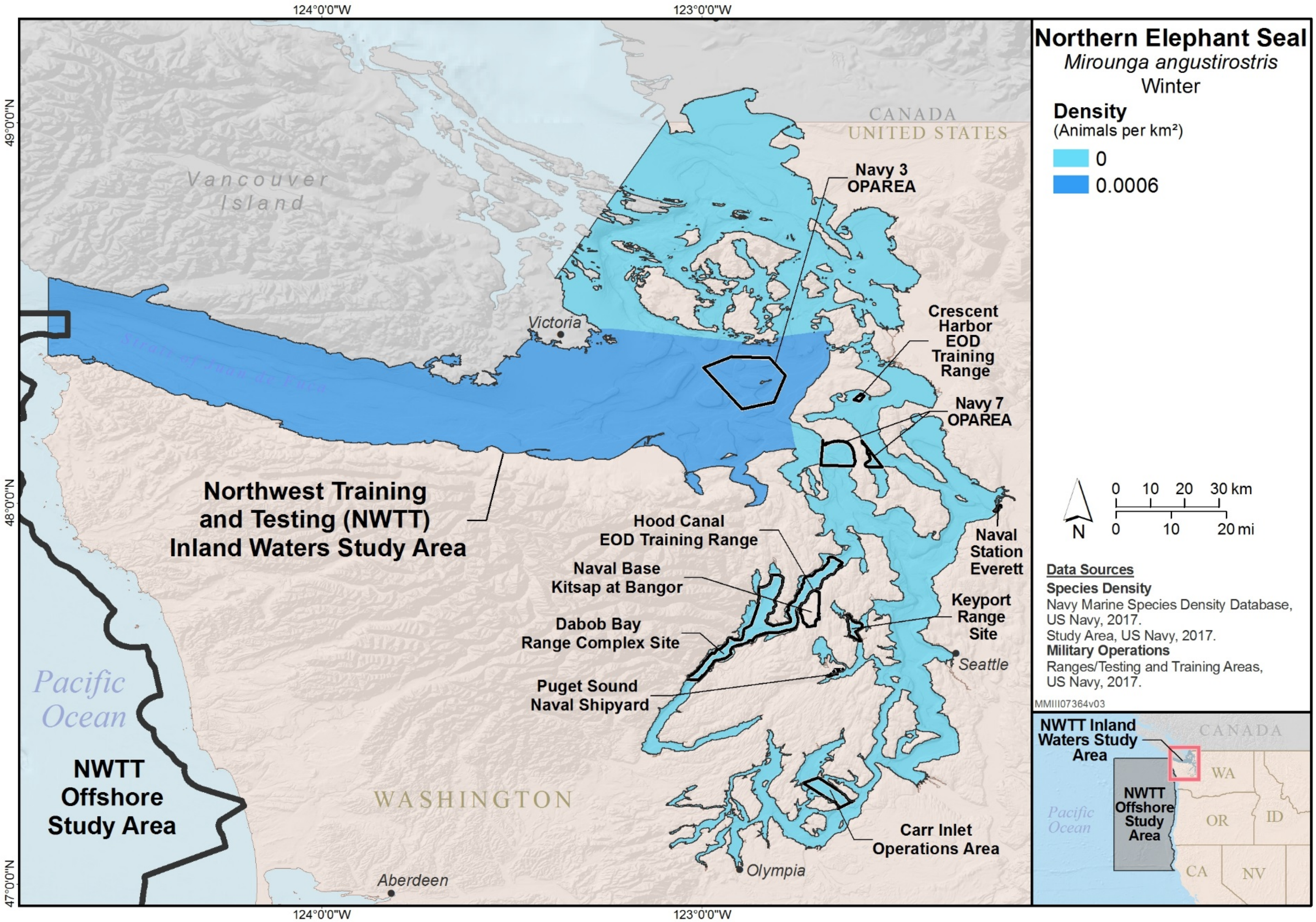

Figure 10.1-24: Inland Waters Winter Distribution of Northern Elephant Seal

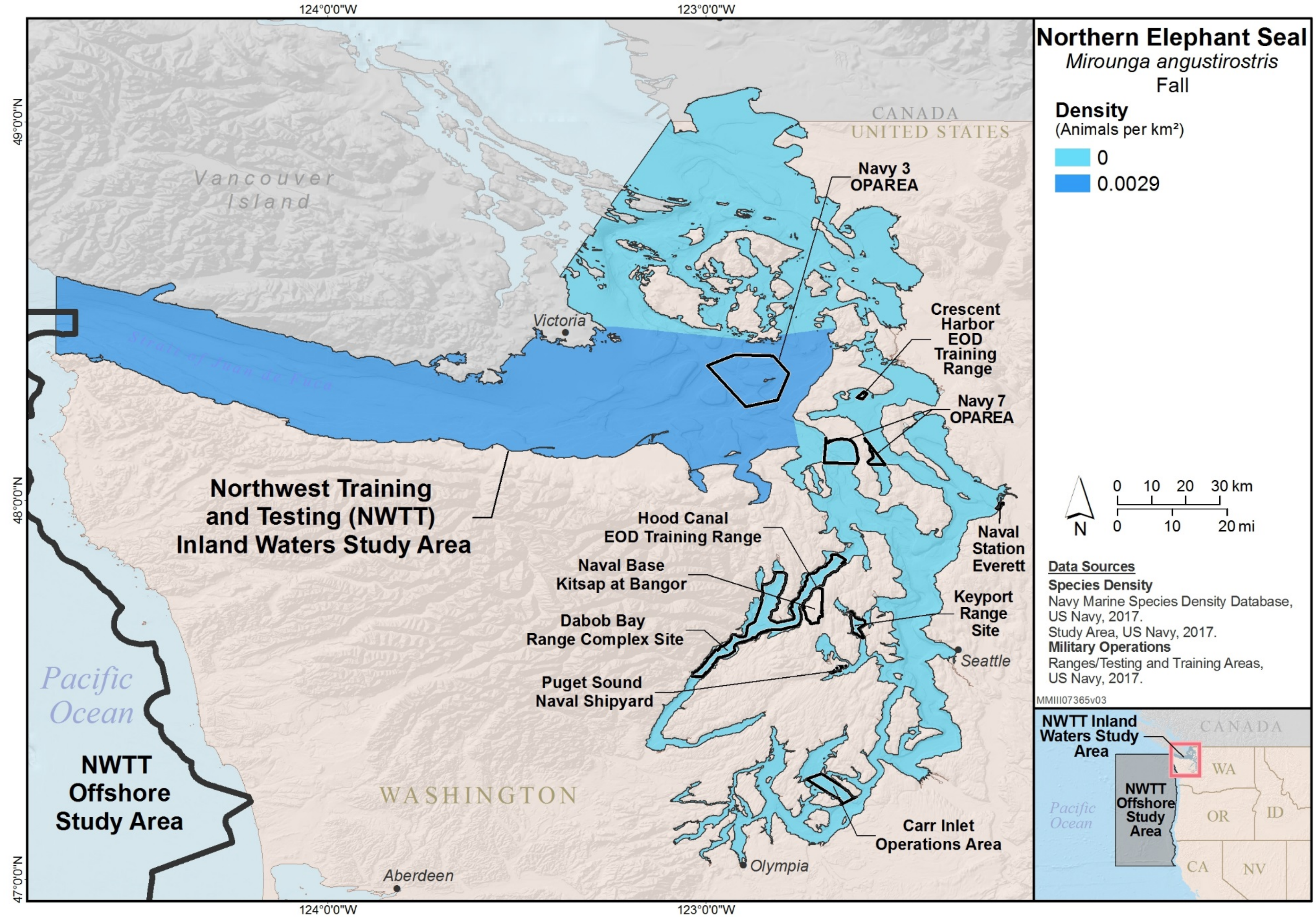

Figure 10.1-25: Inland Waters Fall Distribution of Northern Elephant Seal

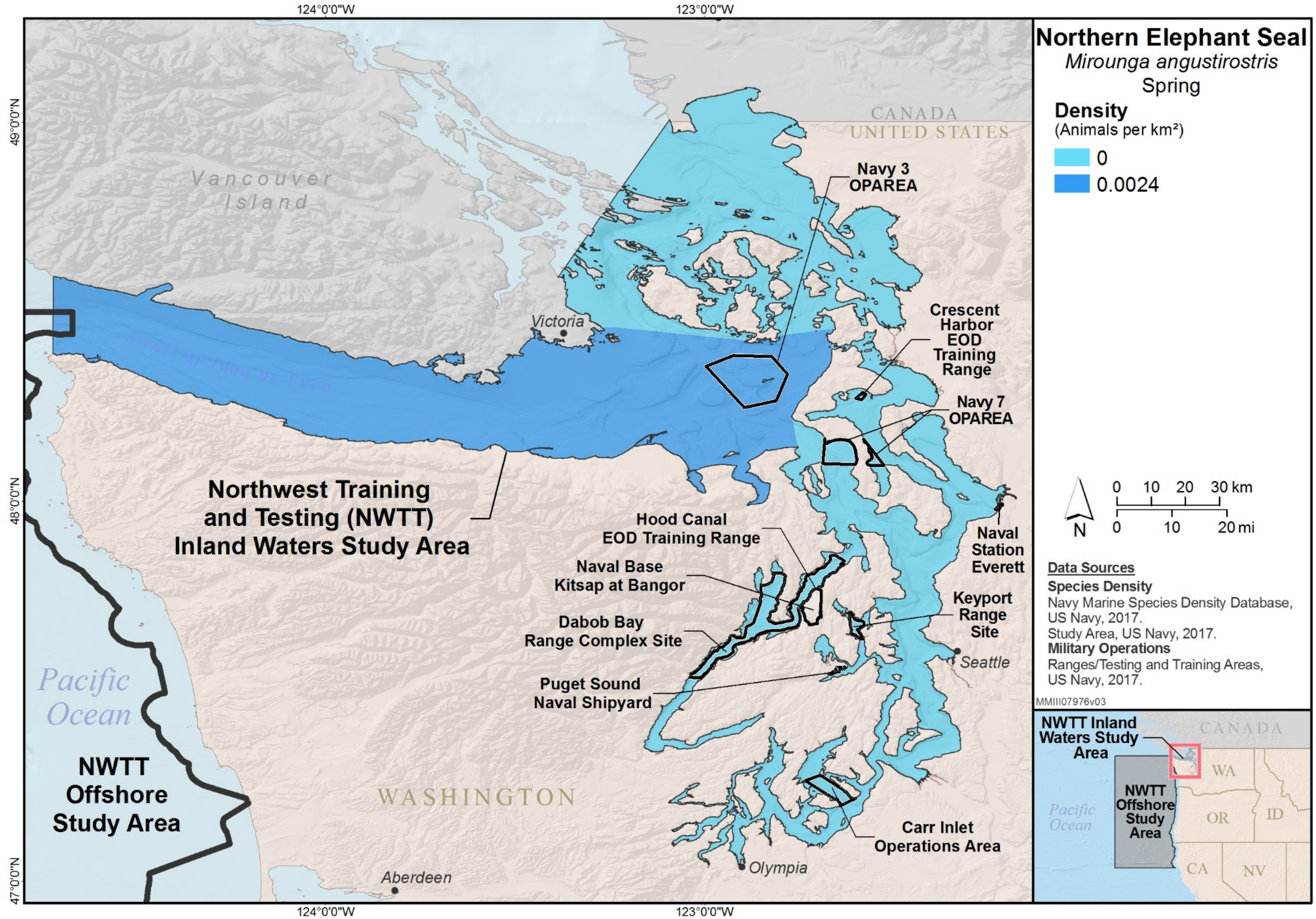

Figure 10.1-26: Inland Waters Spring Distribution of Northern Elephant Seal

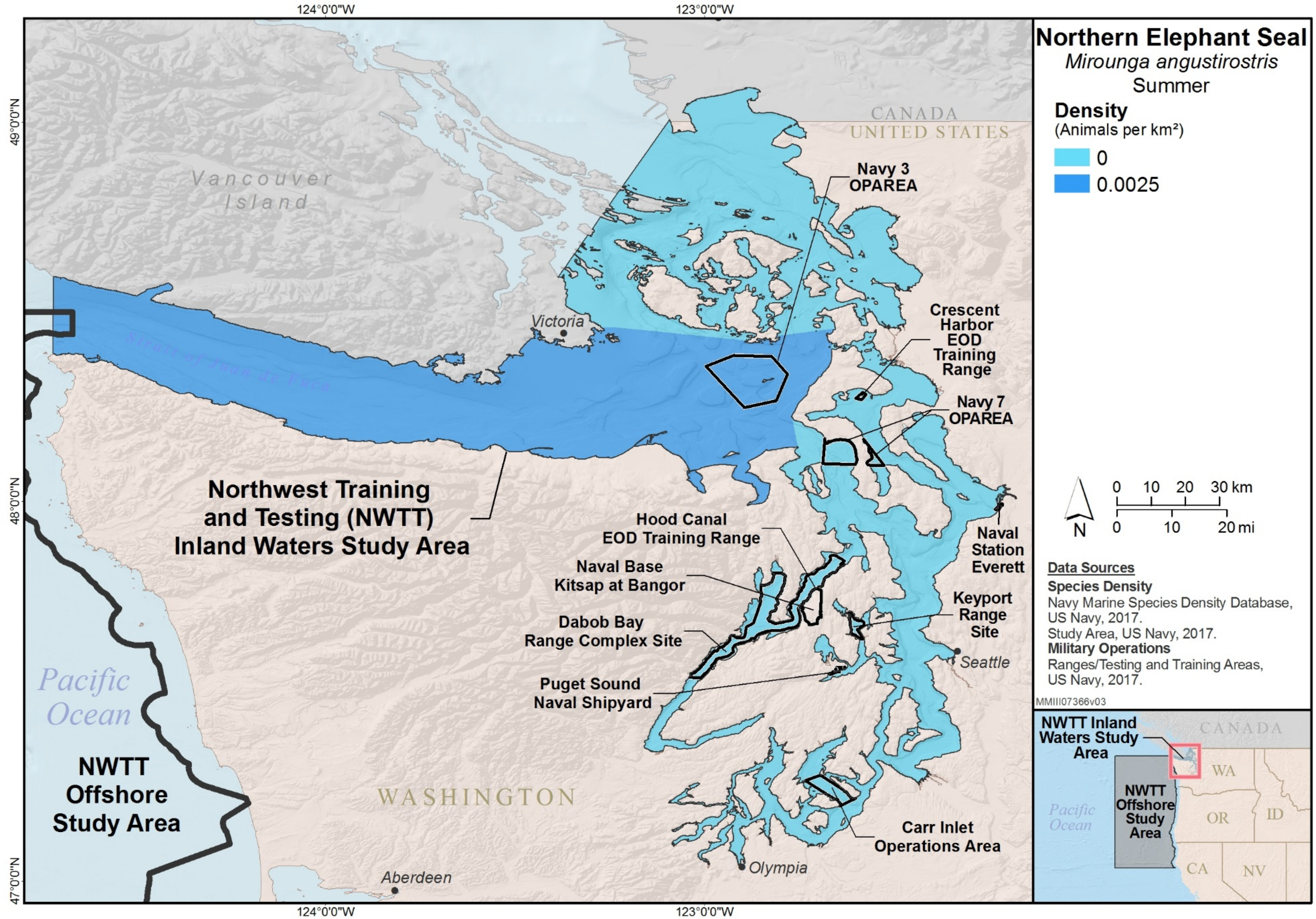

Figure 10.1-27: Inland Waters Summer Distribution of Northern Elephant Seal

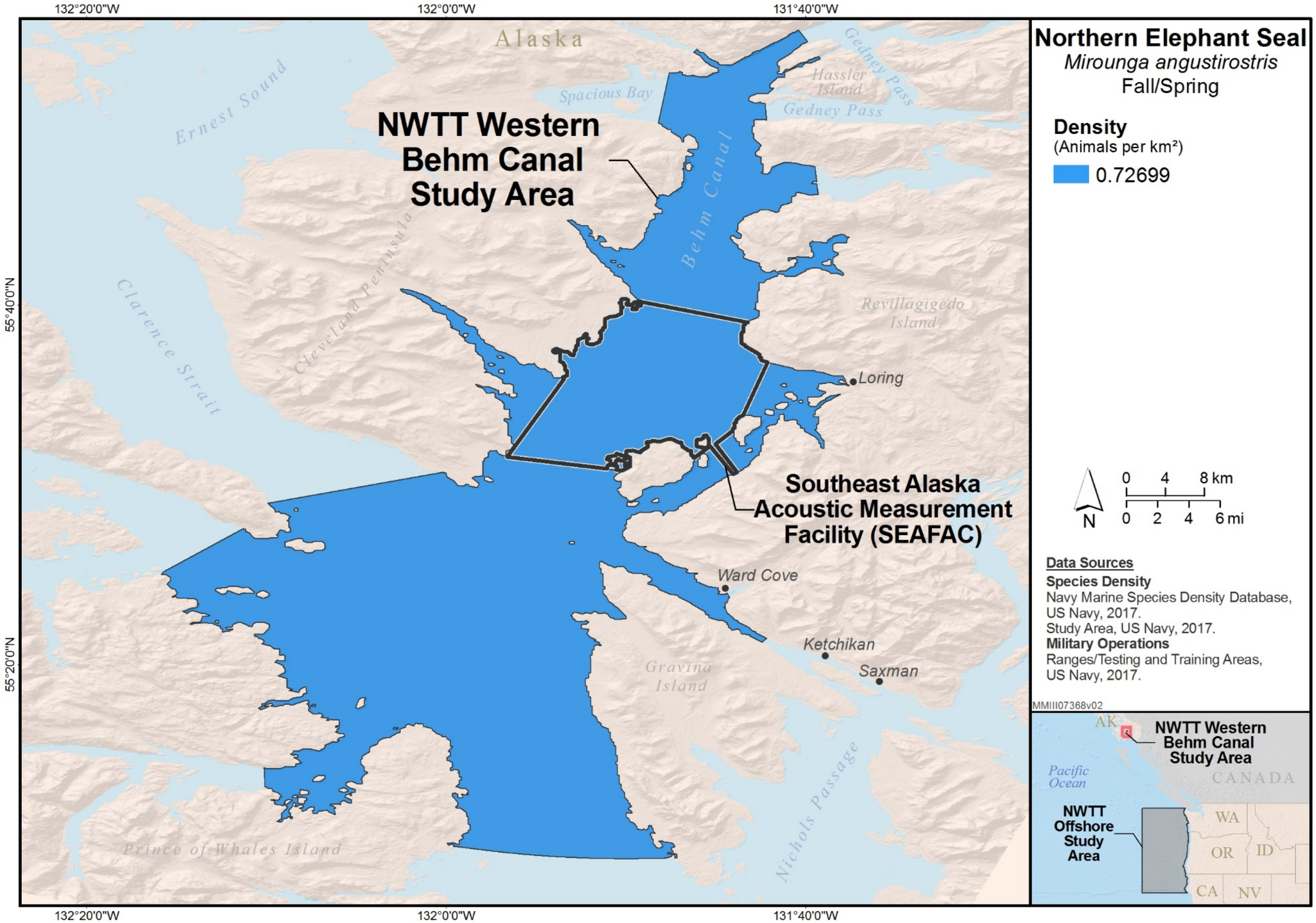

Figure 10.1-28: Western Behm Canal Fall/Spring Distribution of Northern Elephant Seal

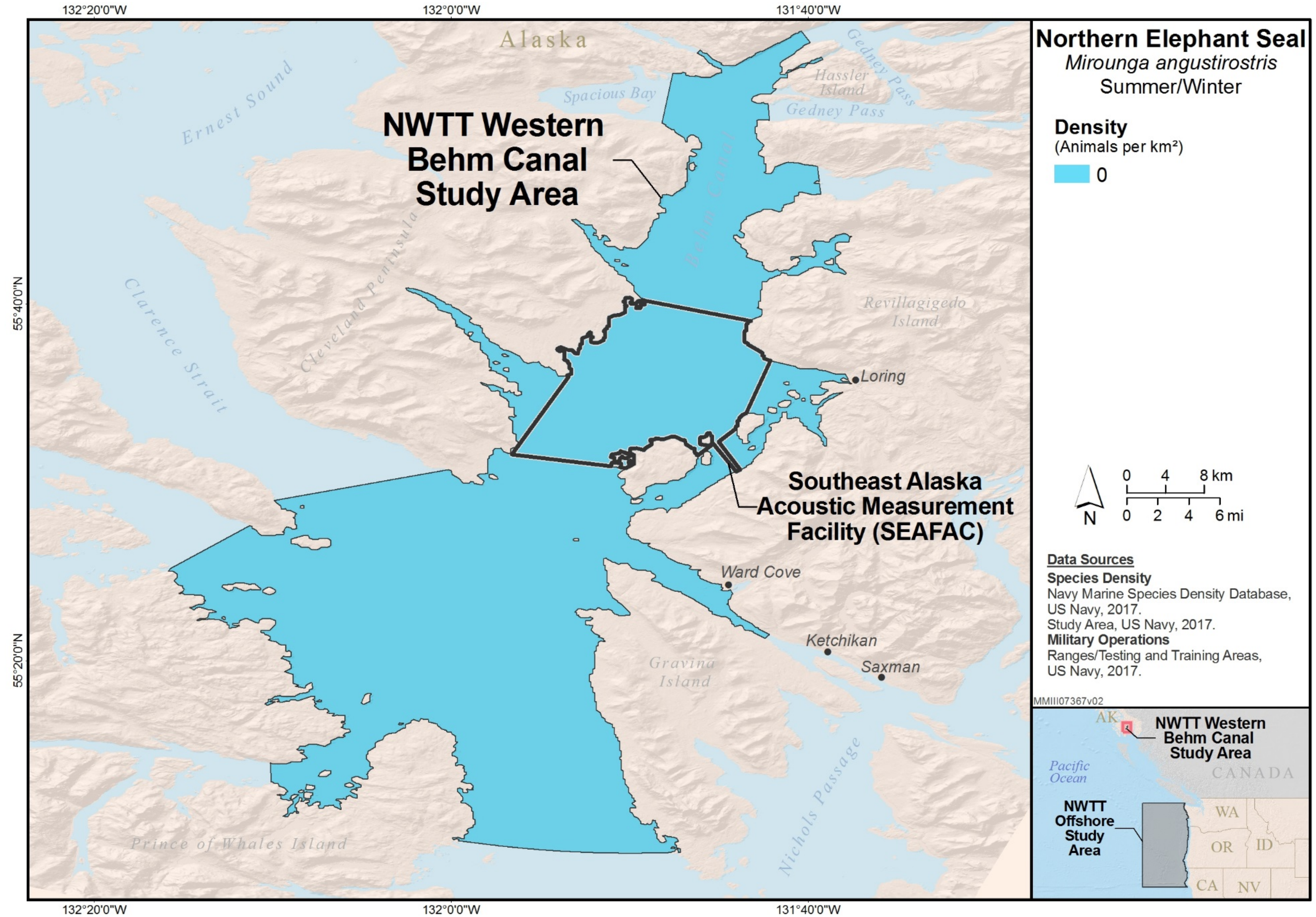

Figure 10.1-29: Western Behm Canal Summer/Winter Distribution of Northern Elephant Seal

10.1.5 *PHOCA VITULINA*, PACIFIC HARBOR SEAL

The harbor seal is a small seal that is found in the nearshore environment of much of the Northern Hemisphere (Jefferson et al., 2015). It is one of the most adaptable seals and can haul out in a variety of terrestrial environments (Riedman & Estes, 1990); in some locations, such as Alaska, it can even occupy freshwater lakes. *Phoca vitulina richardsi* is the eastern Pacific subspecies (Riedman & Estes, 1990) that would be encountered in the Pacific Northwest and southeast Alaska. The NMFS recognizes 17 harbor seal stocks along the U.S. Pacific coast including Alaska (Carretta et al., 2017b; Muto et al., 2017). There are 12 stocks present in Alaska waters and 5 stocks occurring in Washington, Oregon, and California waters. Species from six of those 17 stocks would be expected in Study Area: Clarence Strait (Alaska), Northern Washington Inland Waters, Hood Canal, Southern Puget Sound, Washington and Oregon Coast, and California (Carretta et al., 2017b; Muto et al., 2018a). Harbor seals occur in the Study Area year-round.

Offshore. Only harbor seals from the Washington and Oregon Coast stock and the California stock would be expected to occur in the Offshore area. Abundance for the Washington and Oregon Coast is estimated to be 24,732 harbor seals (Carretta et al., 2017b). Survey data supporting this abundance estimate are from 1999, which exceeds the eight-year limit beyond which NMFS will not confirm abundance in a stock assessment report (Carretta et al., 2017b). However, based on logistic growth curves for the Washington and Oregon Coast stock that leveled off in the early 1990s (Carretta et al., 2017b) and unpublished data from the Washington Department of Fish and Wildlife (DeLong & Jeffries, 2017), an annual growth rate of 0 percent (i.e., the population has remained stable) was applied such that the 2017 abundance estimate for the stock was still 24,732 harbor seals. A haulout factor of 33 percent was used to account for hauled-out seals (i.e., seals are estimated to be in the water 33 percent of the time) (Huber et al., 2001). A single stratum extending from shore to 30 km offshore was used to define the spatial area used for calculating densities (Bailey et al., 2014; Oleson et al., 2009).

Density = (24,732 x 1.00) x 0.33 / 23,838 km^2= 0.3424 seals/km^2

Average relative density estimates for the Washington coast predicted by (Menza et al., 2016) were lower (peaking above 0.15 animals/km^2), but generally of the same order of magnitude.

The same assumptions used to estimate abundance and density for the Washington and Oregon Coast stock were used to calculate the densities for the California stock. An estimate of 30,968 harbor seals make up the California stock (Carretta et al., 2017b). As with the Washington and Oregon Coast stock, growth is assumed to be flat (Carretta et al., 2017b; DeLong & Jeffries, 2017). Based on surveys in 2002 and 2004, (Lowry et al., 2008) estimate that 37.8 percent of harbor seals in the California stock are in northern California, defined as the area from Point Reyes to the California/Oregon border (i.e. the coastline from 38.00 N to 42.000°N). Harbor seals in northern California are expected to be in the water 36 percent of the time (Harvey & Goley, 2011), and a single stratum extending 30 km from shore between 38.00 N to 42.000°N along the California coastline was used to define the spatial area.

Density = (30,968 x 0.378) x 0.36 / 15,496 km^2= 0.2719 seals/km^2

Inland Waters. In-water abundance and density estimates were taken directly from Jefferson et al. (2017). The estimates were based on Navy-funded line-transect aerial surveys of Puget Sound, including Hood Canal, from 2013 to 2016 (Smultea et al., 2017). Both conventional and multiple covariate line-transect approaches were applied. An abundance of 2,009 harbor seals was estimated for the Hood Canal stock. The seasonal density estimates provided for six pre-defined sub-regions of Hood Canal were used for the Navy's acoustic effects analysis instead of the pooled seasonal data also reported by Jefferson et al. (2017). Densities for sub-regions 1 and 2 were pooled in the seasonal data because of low sighting numbers in those regions. Additionally, the density for sub-region 1 was extrapolated into the adjacent area north of sub-region 1 (north of the Hood Canal Bridge), which was not part of the survey area analyzed by Jefferson et al. (2017).

Densities used in the Navy's analysis for the Northern Washington Inland Waters stock and the Southern Puget Sound stock were derived from abundance estimates provided in Smultea et al. (2017). The spatial area used to represent the Southern Puget Sound stock is composed of four smaller sub-regions identified in the report as Vashon, Bainbridge, Seattle, and Southern Puget Sound. Similarly, the spatial area used to represent the Northern Washington Inland Waters stock is composed of three sub-regions: Admiralty Inlet, East Whidbey, and South Whidbey (Smultea et al., 2017). An annual density estimate was calculated for each of the two larger spatial areas (i.e., Southern Puget Sound and Northern Washington Inland Waters) by summing the abundance estimates for each sub-region and dividing by the total combined spatial area of the sub-regions.

Density = 3,116 seals / 1,102 km^2= 2.83 seals/km^2 (Northern Washington Inland Waters)

Density = 4,042 seals / 1,033 km^2= 3.91 seals/km^2 (Southern Puget Sound)

No correction factor for hauled-out seals was needed because abundance estimates by Jefferson et al. (2017) and Smultea et al. (2017) only counted seals that were in the water. Refer to Table 18 in Smultea et al. (2017) for the abundances and spatial areas used to calculation densities.

The surveys reported by Smultea et al. (2017) did not encompass the Strait of Juan de Fuca or the San Juan Islands area. For those areas, counts at multiple haulout sites provided by Jeffries (2017) were used to calculate an abundance and a density. All counts were made in July and August of 2013 and 2014. A total abundance for each of the four months was calculated using the region-specific correction factor of 37 percent, which estimates that 37 percent of seals are in the water (Huber et al., 2001). Using the peak estimate if 13,775 harbor seals from July 2013, the number of seals in the water was 5,097. The combined spatial area of the San Juan Islands area and the Strait of Juan de Fuca is approximately 6,707 km^2, and the resulting density for harbor seals in these two areas is 0.76 seals/km^2.

Density = 5,097 / 6,707 km^2= 0.76 seals/km^2 (Strait of Juan de Fuca and San Juan Islands area)

Although counts were only made in summer, harbor seals remain in the area year round and the density estimate is used for all seasons.

Western Behm Canal. Muto et al. (2018a) provided an abundance estimate for the Clarence Strait stock of 31,634 harbor seals. The estimate is based on survey data from 2007 to 2011. A growth rate of 2.91 percent per year, derived from Muto et al. (2018a), was applied and resulted in a 2017 estimated abundance of 44,632 harbor seals. During the summer molting season, harbor seals are estimated to be hauled out between 81 and 86 percent of the time (i.e., in the water between 19 and 14 percent of the time) (National Marine Fisheries Service, 2015; Simpkins et al., 2003). For summer, a haulout factor of 19 percent was applied to estimate an in-water abundance. For the remainder of the year (fall, spring, and winter), a haulout factor of 42 percent was applied (Withrow et al., 1999). The spatial area used to calculate densities was based on the distribution map provided by Muto et al. (2018a).

Density = 44,632 / 18,745 km^2= 1.7267 seals/km^2 (Western Behm Canal)

Table 10.1-10: Summary of Density Values for Harbor Seal

Location	Spring	Summer	Fall	Winter
Offshore (WA/OR)	0.3424	0.3424	0.3424	0.3424
Offshore (CA)	0.2719	0.2719	0.2719	0.2719
Inland Waters (Hood Canal Sub-region 1 & 2 pooled)	1.64	1.25	0.82	0.73
Inland Waters (Hood Canal Sub-region 3)	8.38	7.39	4.22	3.74
Inland Waters (Hood Canal Sub-region 4)	12.39	10.93	6.24	5.53
Inland Waters (Hood Canal Sub-region 5)	7.70	6.79	3.88	3.43
Inland Waters (Hood Canal Sub-region 6)	7.60	6.70	3.83	3.39
Inland Waters (Northern Washington Inland Waters)	2.83	2.83	2.83	2.83
Inland Waters (Southern Puget Sound)	3.91	3.91	3.91	3.91
Inland Waters (Strait of Juan de Fuca and San Juan Islands)	0.76	0.76	0.76	0.76
Western Behm Canal	1.7267	0.7811	1.7267	1.7267

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

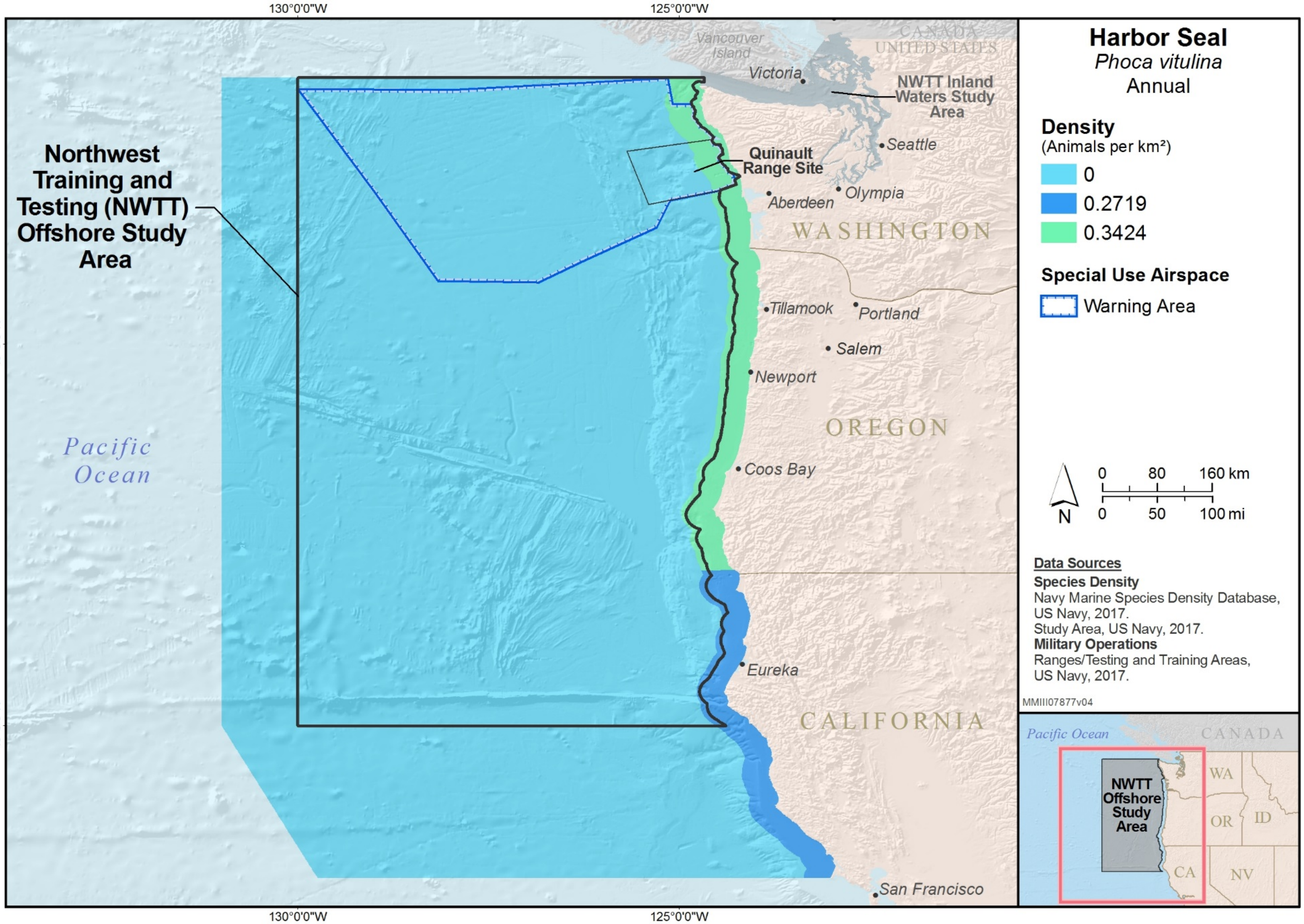

Figure 10.1-30: Offshore Annual Distribution of Harbor Seal

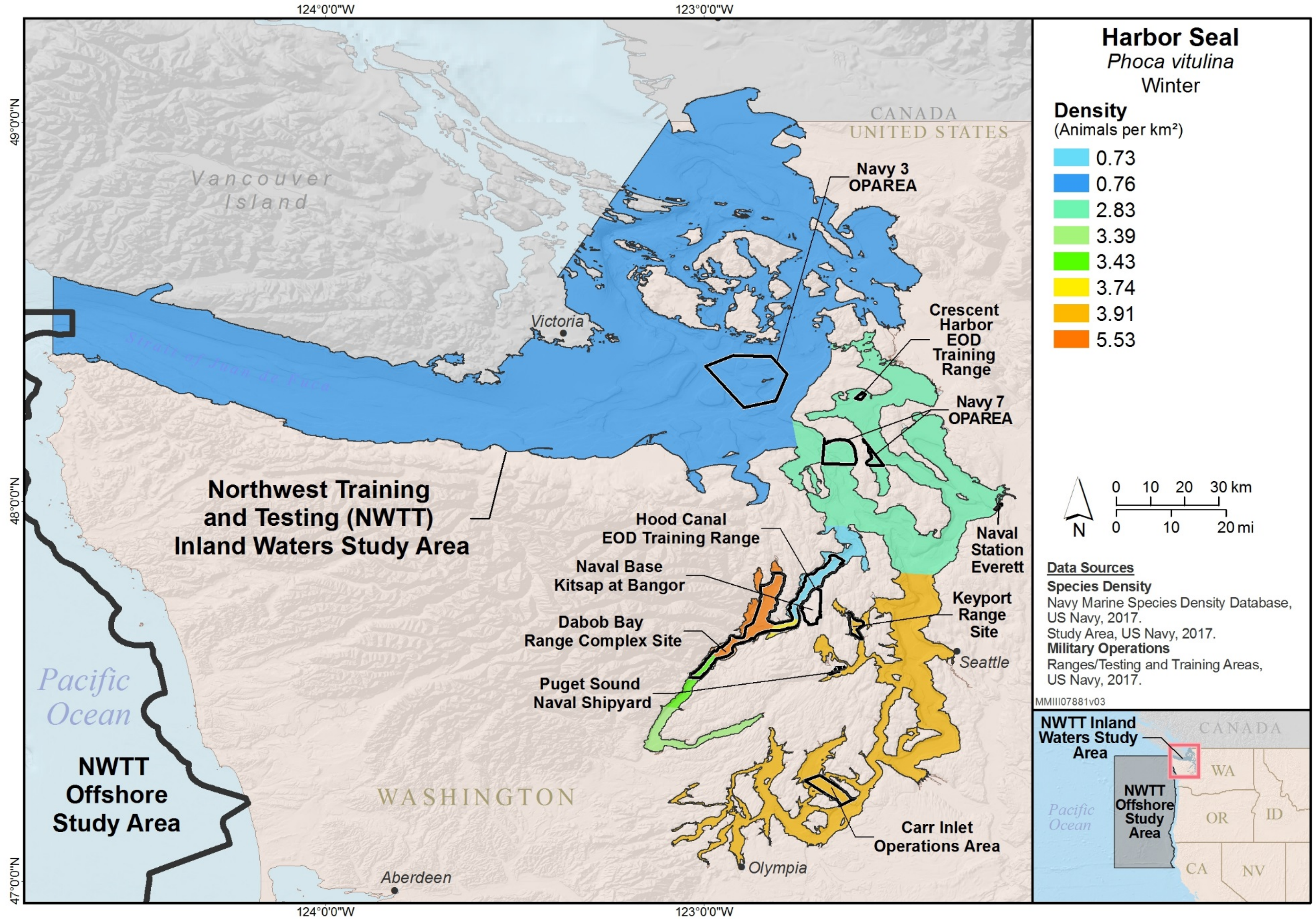

Figure 10.1-31: Inland Waters Winter Distribution of Harbor Seal

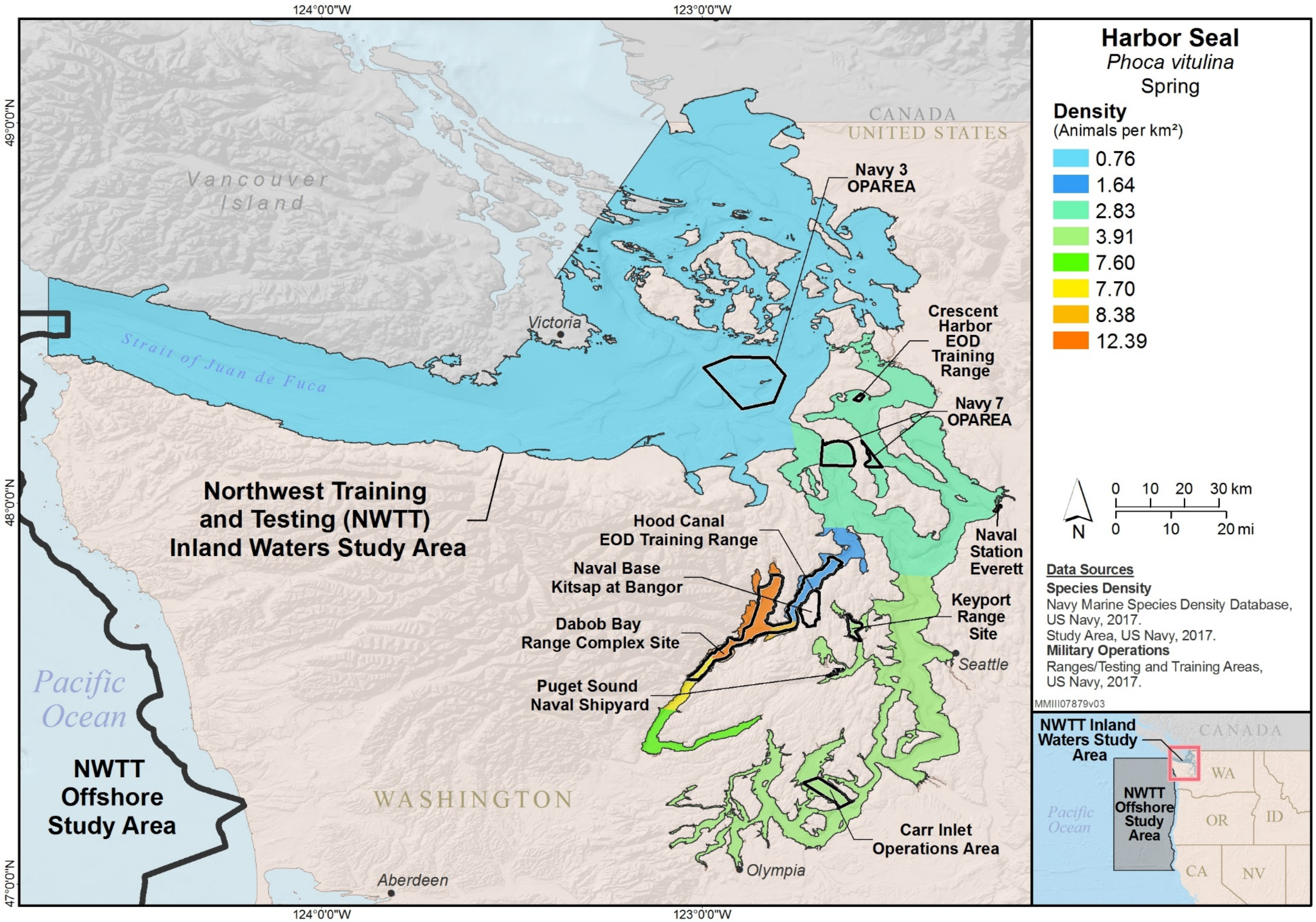

Figure 10.1-32: Inland Waters Spring Distribution of Harbor Seal

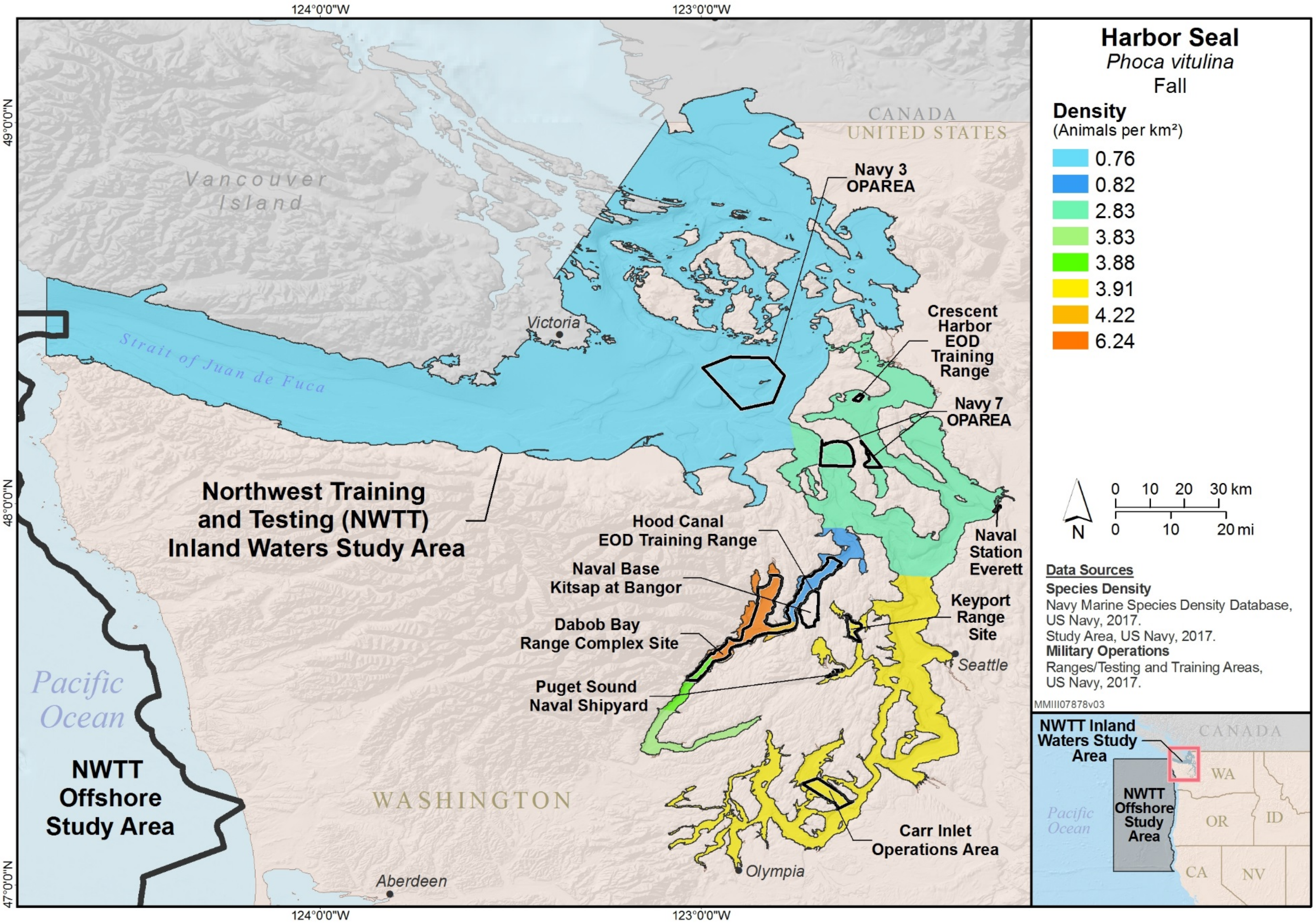

Figure 10.1-33: Inland Waters Fall Distribution of Harbor Seal

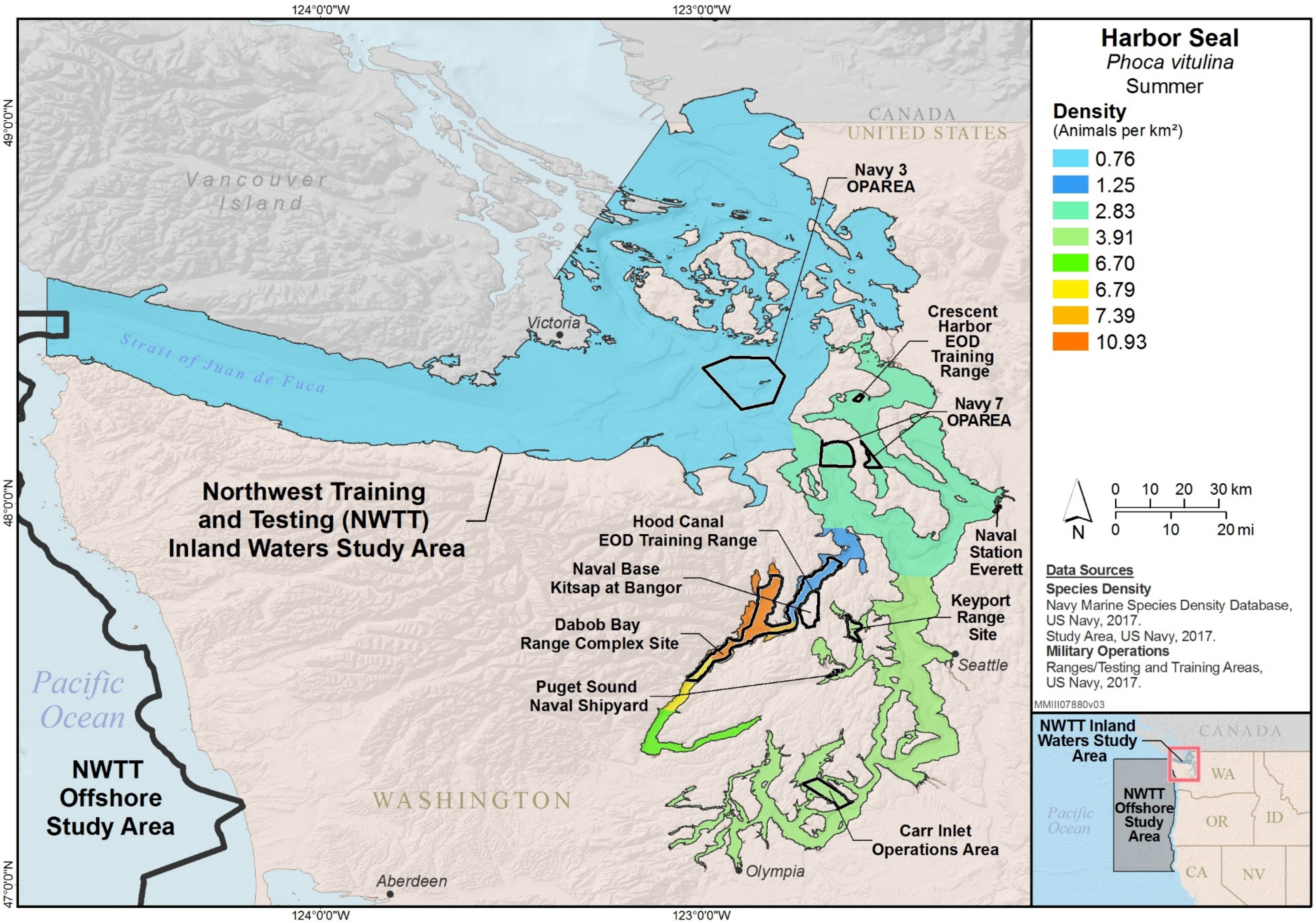

Figure 10.1-34: Inland Waters Summer Distribution of Harbor Seal

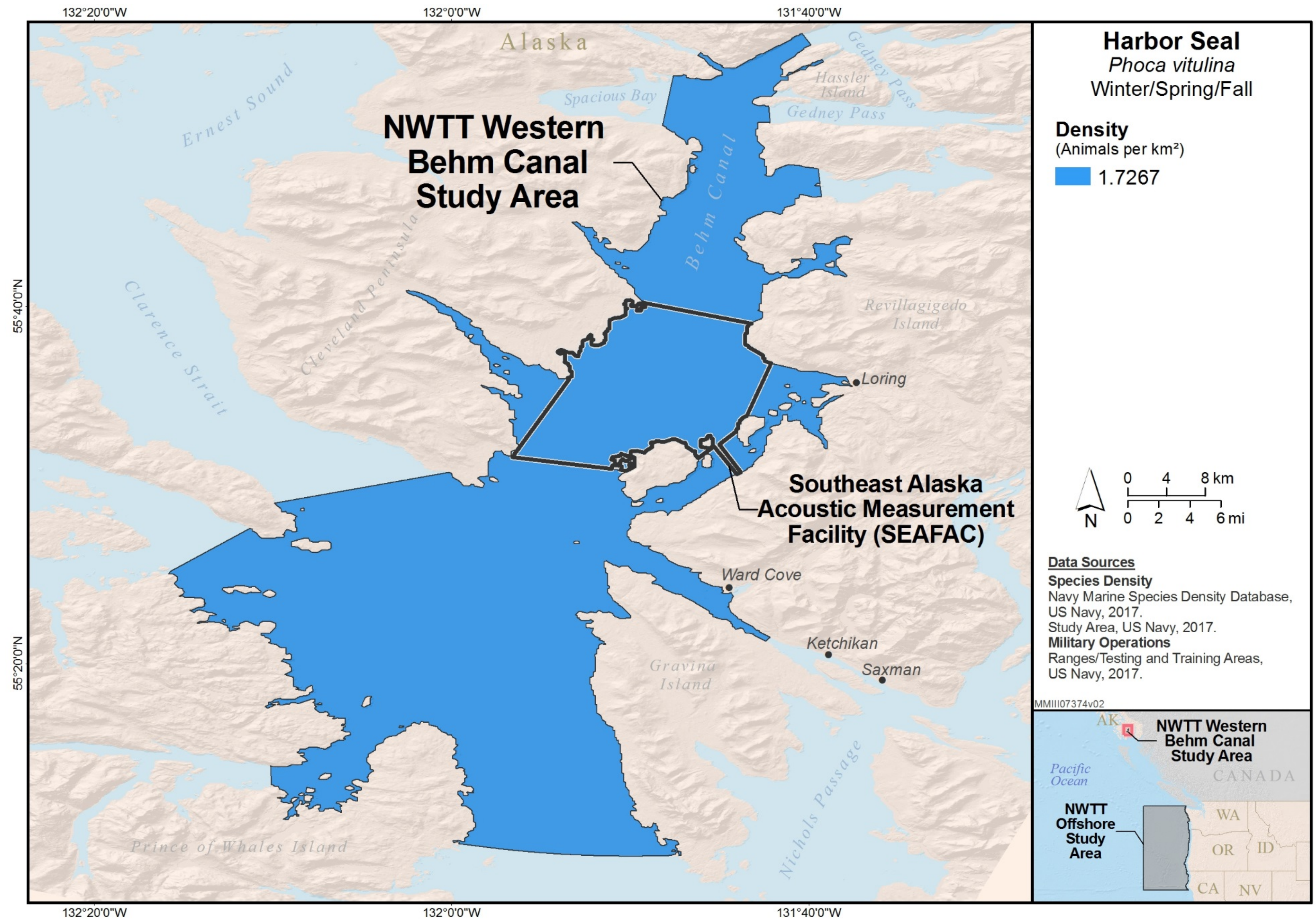

Figure 10.1-35: Western Behm Canal Winter/Spring/Fall Distribution of Harbor Seal

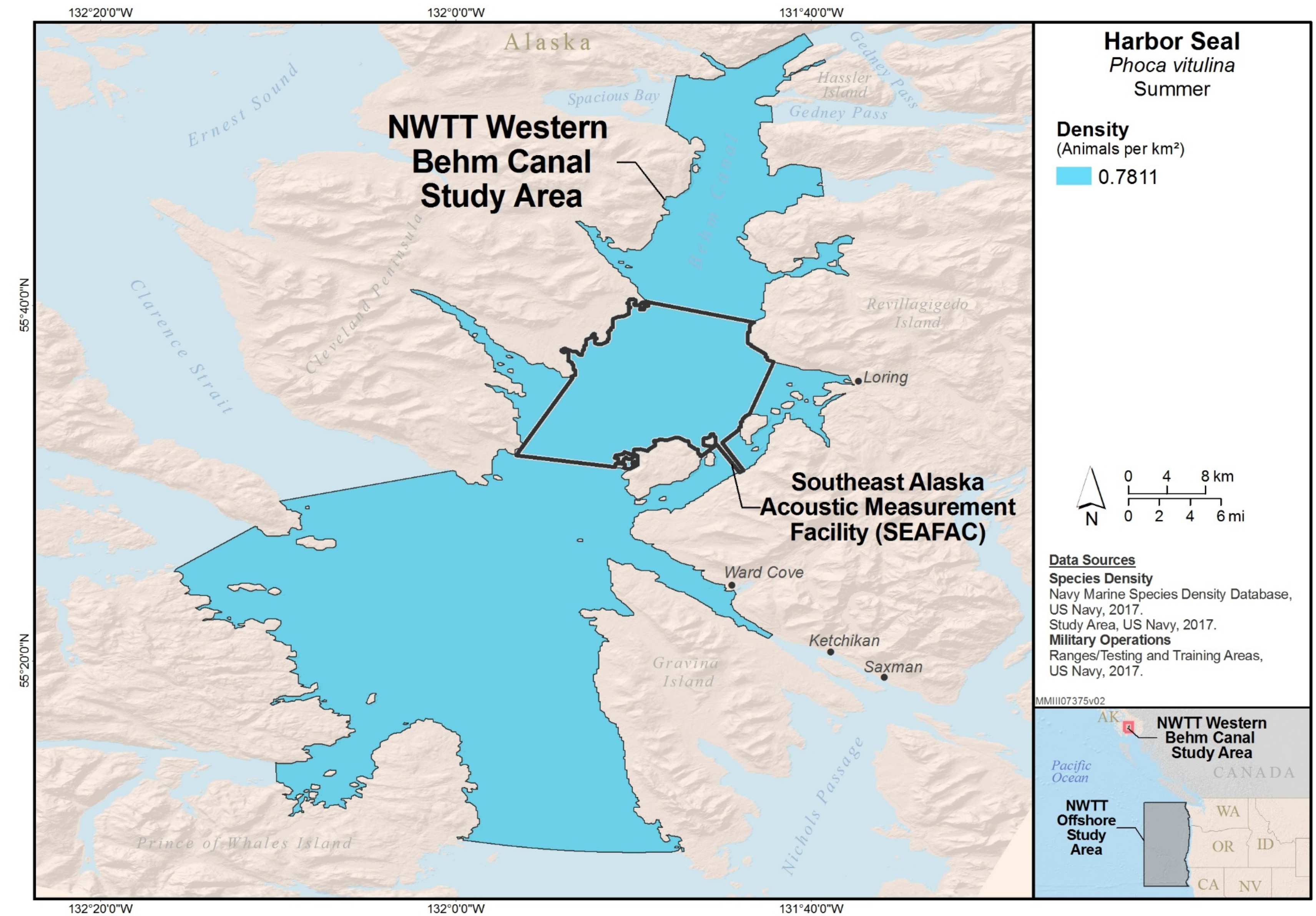

Figure 10.1-36: Western Behm Canal Summer Distribution of Harbor Seal

10.1.6 *ZALOPHUS CALIFORNIANUS*, CALIFORNIA SEA LION

The California sea lion is an abundant pinniped found along the Pacific coast of North America from the Gulf of Alaska to southern Mexico (Jefferson et al., 2015). NMFS's stock assessment report provides an abundance estimate of 296,750 animals in the single U.S. stock (Carretta et al., 2017b).

Males are on shore during the summer breeding season (May through July) and then most move north of the Channel Islands to forage off central and northern California and as far north as the Gulf of Alaska (Lowry & Forney, 2005; Maniscalco et al., 2004). Only adult and sub-adult males would be expected to migrate into the Study Area from California breeding sites (Jeffries et al., 2000; Lowry & Forney, 2005).

Offshore. Seasonal at-sea abundance is estimated from strip transect survey data collected offshore along the California coastline (Lowry & Forney, 2005). The survey area was divided into 7 strata, labeled A through G. Abundance estimates from the two northern most strata (A and B) were used to estimate the abundance of California sea lions occurring in the Study Area. While the northern most stratum (A) only partially overlaps with the Study Area, this approach conservatively assumes that all sea lions from the two strata would continue north into the Study Area.

The majority of male sea lions would be expected in the Study Area from August to mid-June (Wright et al., 2010). In summer, males are expected to be at breeding sites off of Southern California. In-water abundance estimates of adult and sub adult males in strata A and B were extrapolated to estimate seasonal densities in the Study Area. In-water surveys conducted by Lowry and Forney (2005) in May, September, and December of 1998 and in July of 1999 were used to estimate seasonal abundance for the purpose of calculating densities in this report. Jefferies et al. (2000) estimated that there are between 3,000 and 5,000 California sea lions in "northwest waters (Washington and British Columbia)," which corroborates estimates based on data from Lowry and Forney (2005).

Approximately 3,000 male sea lions are known to pass through the Offshore Area in August as they migrate northward to the Washington coast and inland waters (DeLong, 2018a; Wright et al., 2010). However, Lowry and Forney (2005) did not sight any sea lions during the July 1999 survey in strata A and B, which was not unexpected, because, nearly all male sea lions are expected to be on or near breeding sites off California in July (DeLong et al., 2017; Wright et al., 2010). The abundance estimates used in this report based on Lowry and Forney (2005) were: 2,822 sea lions in fall, 3,977 in spring, and 3,288 in winter. An estimate of 3,000 male sea lions is used for the month of August. Projected 2017 seasonal abundance estimates were derived by applying an annual growth rate of 5.4 percent (Carretta et al., 2017b) between 1999 and 2017 to the abundance estimates from Lowry and Forney (2005). No correction for hauled-out sea lions was needed because counts were of sea lions in the water (Lowry & Forney, 2005).

The strata used to calculate densities were based on distribution data from Wright et al. (2010) and Lowry and Forney (2005) indicating that approximately 90 percent of California sea lions occurred within 40 km of shore and 100 percent of sea lions were within 70 km of shore. The offshore distribution is consistent with survey data reported by Oleson et al. (2009) and migration patterns observed by Gearin et al. (2017), which showed that males remained within the 1,000 m isobath as they migrated between

Puget Sound and the Channel Islands. Sea lions tagged in Puget Sound and tracked as they traveled along the U.S. West Coast were within a mean distance of 14 nautical miles (26 km) from shore (DeLong et al., 2017). A third stratum was added that extends from shore to 450 km offshore to account for anomalous conditions, such as changes in sea surface temperature and upwelling associated with El Niño, during which California sea lions have been encountered farther from shore, presumable seeking prey (DeLong & Jeffries, 2017; Weise et al., 2010). Sample density calculations are provided below.

Fall Density = (7,273 sea lions x 0.90) / 11,744 km^2= 0.5573 sea lions/km^2 (0 to 40 km Stratum)

Spring Density = (10,249 sea lions x 0.10) / 791 km^2= 1.2951 sea lions/km^2 (40 to 70 km Stratum)

Winter Density = (8,473 sea lions x 1.00) / 143,518 km^2= 0.0590 sea lions/km^2 (0 to 450 km Stratum)

August Density = 3,000 sea lions / 93,747 km^2 = 0.0288 sea lions/km^2 (0 to 40 km Stratum)

Inland Waters Area. Densities were calculated for three areas within in the Inland Waters Area: (1) Hood Canal, (2) Strait of Juan de Fuca and San Juan Islands, and (3) Puget Sound. DeLong et al. (2017) conducted weekly counts of adult male California sea lions to estimate the number of sea lions that use Navy facilities in Puget Sound and to describe their foraging and diving behavior in inland and coastal waters. Weekly counts were made at four Navy facilities: Naval Base Kitsap-Bangor, Naval Base Kitsap-Bremerton, Naval Station Everett, and Naval Base Kitsap-Manchester to estimate abundance, and satellite dive recorders were deployed on sea lions to obtain haulout times, distributions, and diving behavior.

Monthly abundance estimates derived from counts at Bangor were used to estimate a density for Hood Canal, and abundance estimates derived from counts at the three other Navy facilities were summed and combined with abundance estimates from Commencement Bay and the South Sound (Carr Inlet and Case Inlet) to estimate abundance for Puget Sound (DeLong et al., 2017). The data were consolidated into four seasons by averaging the monthly abundances according to the following convention: Spring (March–May), summer (June–August), fall (September–November), and winter (December – February).

Table 10.1-11: Seasonal Abundances for Hood Canal and Puget Sound Used in Density Calculations for California Sea Lion

Season	Hood Canal	Puget Sound					
	Bangor	Bremerton	Everett	Manchester	Commencement Bay	South Sound	Total
Winter	75	73	76	113	140	200	**601**
Spring	79	20	136	85	80	150	**471**
Summer	6	8	20	5	10	15	**58**

Table 10-11: Seasonal Abundances for Hood Canal and Puget Sound Used in Density Calculations for California Sea Lion (continued)

Season	Hood Canal	Puget Sound					
	Bangor	Bremerton	Everett	Manchester	Commencement Bay	South Sound	Total
Fall	122	191	225	88	140	200	**843**
Total	**282**						**1,974**

Note: Seasonal abundance estimates are based on monthly abundances at Navy facilities reported by DeLong et al. (2017).

Nearly all male California sea lions are expected to migrate from inland waters in Puget Sound and Hood Canal to breeding colonies off Southern California in spring and then return in fall after the summer breeding season (Gearin et al., 2017; Jeffries et al., 2000; Lowry & Forney, 2005). Migrating California sea lions would transit through the Strait of Juan de Fuca at some point in spring and late summer therefore, a density for the strait was estimated based on the length and time of migration (Gearin et al., 2017) and abundance estimates by (DeLong et al., 2017). The southbound migrations of 8 tagged California sea lions took an average of 25 days and the single northbound migration that was recorded lasted 30 days (Gearin et al., 2017). The transit times included two to three stops at haulout sites along the route. The rapid migrations suggest that when in the water the sea lions move directly toward their destination and do not linger while en route (Gearin et al., 2017). An individual sea lion transiting through the Strait of Juan de Fuca in spring and fall would likely take no more than a day or two pass through the strait, and the majority of migrating sea lions are likely to be through the strait in less than one month (late May to early June and late August to early September) (Gearin et al., 2017). Sea lions fitted with satellite tags in the Seattle area in the spring of 1995, 1996, and 2000 departed on average on 28 May and arrived at San Miguel Island, California on average on 23 June. Similar departure dates for California sea lions off the coast of Oregon were reported by Wright et al. (2010).

There are an estimated 2,256 California sea lions in Puget Sound and Hood Canal combined that would transit through the Strait of Juan de Fuca in approximately September and May/June (DeLong et al., 2017; Gearin et al., 2017; Jeffries, 2018). California sea lions are hauled-out 44 percent of the time (56 percent in-water) (DeLong et al., 2017). The spatial area identified as Juan de Fuca is approximately 4,200 km^2 and was used to estimate densities in the Strait of Juan de Fuca. Based on these estimates, the density for California sea lion in the Strait of Juan de Fuca in September is calculated as:

$$\text{Density} = 2{,}256 \text{ (total abundance)} \times 0.56 \text{ (haul-out)} / 4{,}200 \text{ km}^2 = 0.3008 \text{ sea lions/km}^2$$

The density for California sea lion in the Strait of Juan de Fuca in May/June (distributed over two months) is calculated as:

$$\text{Density} = (2{,}256 \text{ (total abundance)} \times 0.50 \text{ (over two months)} \times 0.56 \text{ (haul-out)} / 4{,}200\text{km}^2 = 0.1504 \text{ sea lions/km}^2$$

Jeffries (2014) reported on the occurrence of a small number of sea lions year-round in the Strait of Juan de Fuca, including during the summer breeding season. DeLong et al. (2017) reported that 8 of 30 California sea lions fitted with satellite tags moved north to the Strait of Georgia and west of Vancouver Island, British Columbia, Canada necessitating passage either through the Strait of Juan de Fuca or the San Juan Islands. For the purposes of estimating seasonal abundances in the strait and in the San Juan Islands, it was assumed that 50 percent of sea lions transited through the strait and 50 percent moved north through the San Juan Islands. To account for the presence of sea lions in these locations during the non-migratory period, 13 percent (4 out of 30) of the seasonal abundance of sea lions in Puget Sound were assumed to occur in either the strait or the San Juan Islands. The density calculation for California sea lions in the Strait of Juan de Fuca in March/April is:

Density = 471 sea lions (spring abundance) x 0.13 (estimated percentage in the strait) x 0.56 (haul-out) / 4,200 km^2= 0.0084 sea lions/km^2

Density estimates for California sea lion in the Strait of Juan de Fuca for the remainder of the non-migratory period (i.e., excluding September and May/June) were calculated using the same process. As noted above, the abundance estimates for the San Juan Islands were identical, therefore the only difference in the density calculations for the San Juan Islands was the spatial area used in the calculation, which was 2,507 km^2.

The spatial area used for Hood Canal was the sum of the areas used for harbor seal density estimates (Jefferson et al., 2017) and an adjacent area of approximately 19 km^2 to the north; the total spatial area used to represent Hood Canal was approximately 380 km^2. The spatial area for the Puget Sound stratum used to calculate densities for California sea lion were the sum of the areas identified as Puget Sound and Southern Puget Sound. The total area was 2,136 km^2. The density for California sea lions in Hood Canal in fall is calculated as:

Density = 122 (fall abundance) x 0.56 / 380 km^2= 0.1798 sea lions/km^2

The density for California sea lions in Puget Sound in winter is calculated as:

Density = 337 (winter abundance) x 0.56 / 2,136 km^2= 0.1577 sea lions/km^2

Seasonal density estimates for California sea lions in Hood Canal and Puget Sound were calculated using the same process.

Western Behm Canal. This species is not expected to occur in the Western Behm Canal portion of the NWTT Study Area.

Table 10.1-12: Summary of Density Values for California Sea Lion

Location	Spring	Summer	Fall	Winter
Offshore (0 to 40 km from shore)	1.4919	0.0288 (August) 0 (June/July)	0.5573	0.6493
Offshore (40 to70 km from shore)	1.2951	0.0037 (August) 0 (June/July)	0.2726	0.3176
Offshore (0 to 450 km from shore)	0.0714	0.0065 (August) 0 (June/July)	0.0507	0.0590
Inland Waters (Hood Canal)	0.1169	0.0088	0.1798	0.1100
Inland Waters (Puget Sound)	0.1235	0.0152	0.2211	0.1577
Inland Waters (Strait of Juan de Fuca)	0.1504 (May) 0.0084 (March/April)	0.1504 (June) 0.0010 (July/August)	0.3008 (September) 0.0105 (October/November)*	0.0107 (Dec–Feb)
Inland Waters (San Juan Islands)	0.0140	0.0017	0.0251	0.0179
Western Behm Canal	0	0	0	0

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

*A density of 0.0105 was mistakenly used in the Navy's model (instead of the correct density of 0.0150) to model California sea lion exposures in the Strait of Juan de Fuca in October/November. A brief investigation was conducted to determine by how much the number of predicted exposures would increase if the density value were increased to 0.0150. While there is a 43 percent difference between the two density values, the densities are relatively low, and there are only seven behavioral exposures of California sea lions in the strait during the warm season (June–November). No other exposures (e.g., TTS or PTS) are predicted in the strait. Increasing exposures by 43 percent would result in 3 additional behavioral exposures (for a total of 10). However, the months of September and June are also part of the warm season. Densities for those two months are 0.3008 and 0.1504, respectively, which are more than 10 times greater than 0.0150. Based on the much greater densities, it is likely that most if not all of the seven exposures in the warm season occur in those two months and not in October/November. Therefore, increasing the density to 0.0150 in October/November is unlikely to increase exposures by any measurable amount. To put these values into perspective, there are approximately 31,000 behavioral exposures predicted for California sea lion in the Study Area. Any increase in the number of exposures in the Strait of Juan de Fuca would be negligible by comparison.

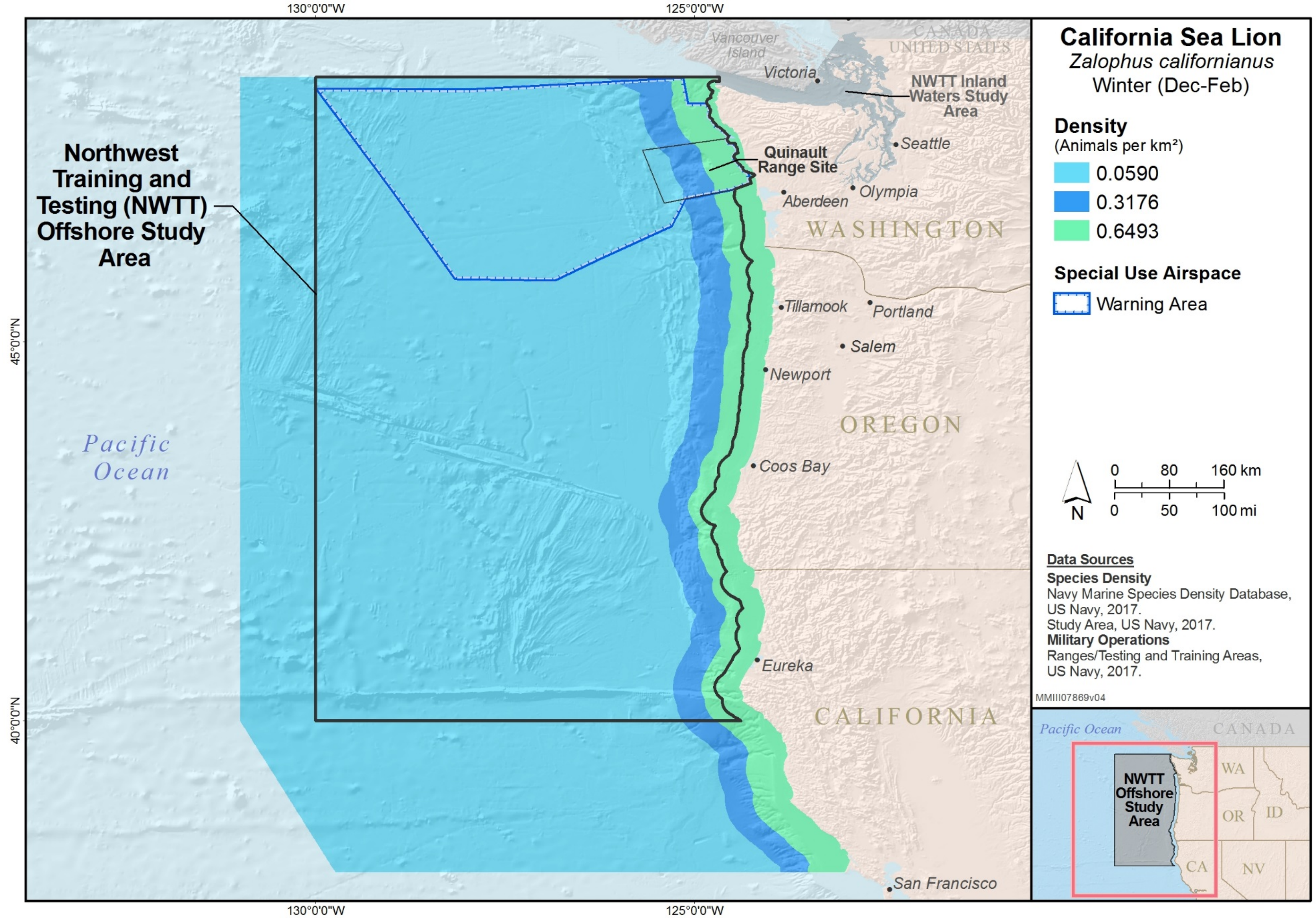

Figure 10.1-37: Offshore Winter Distribution of California Sea Lion

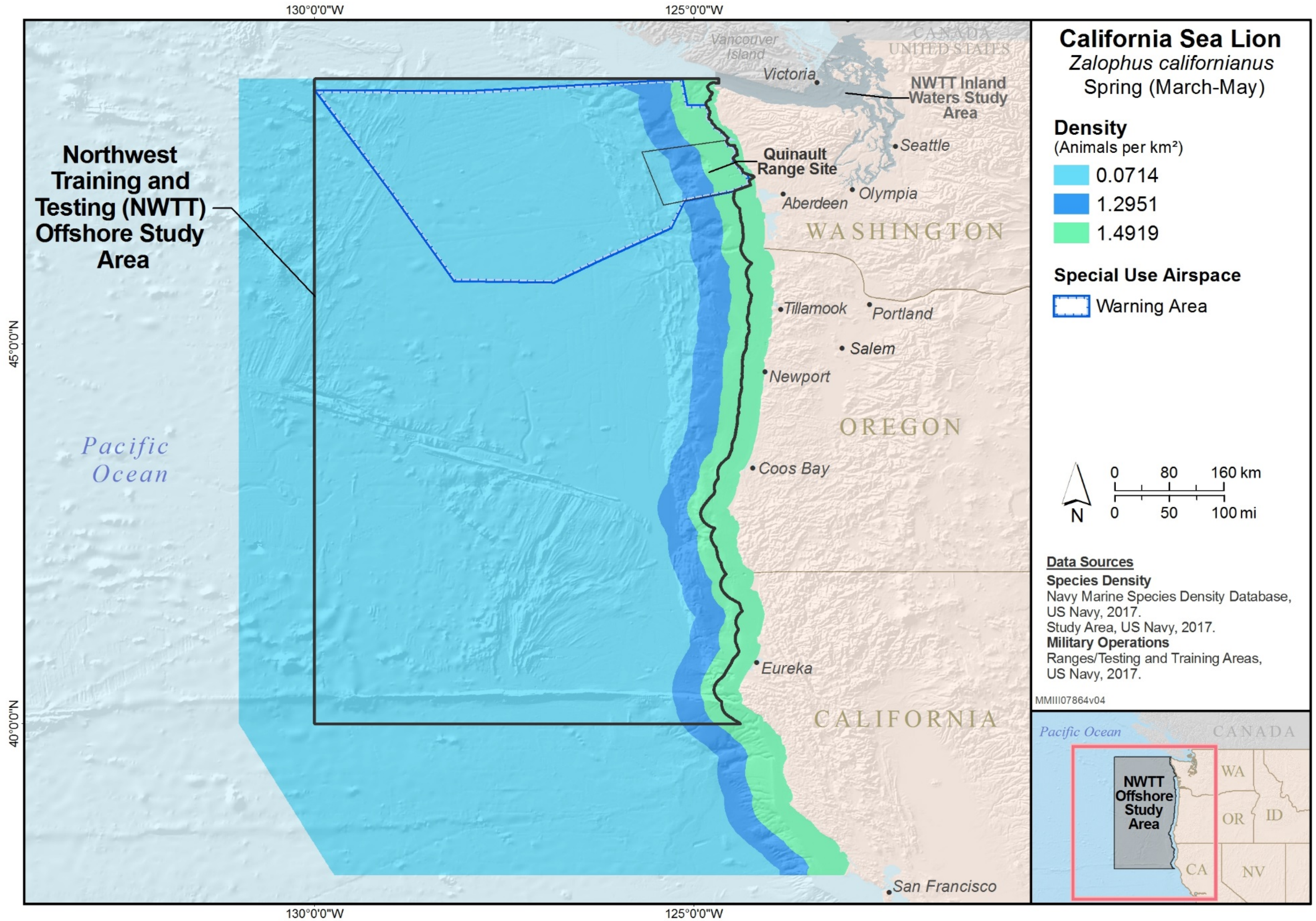

Figure 10.1-38: Offshore Spring Distribution of California Sea Lion

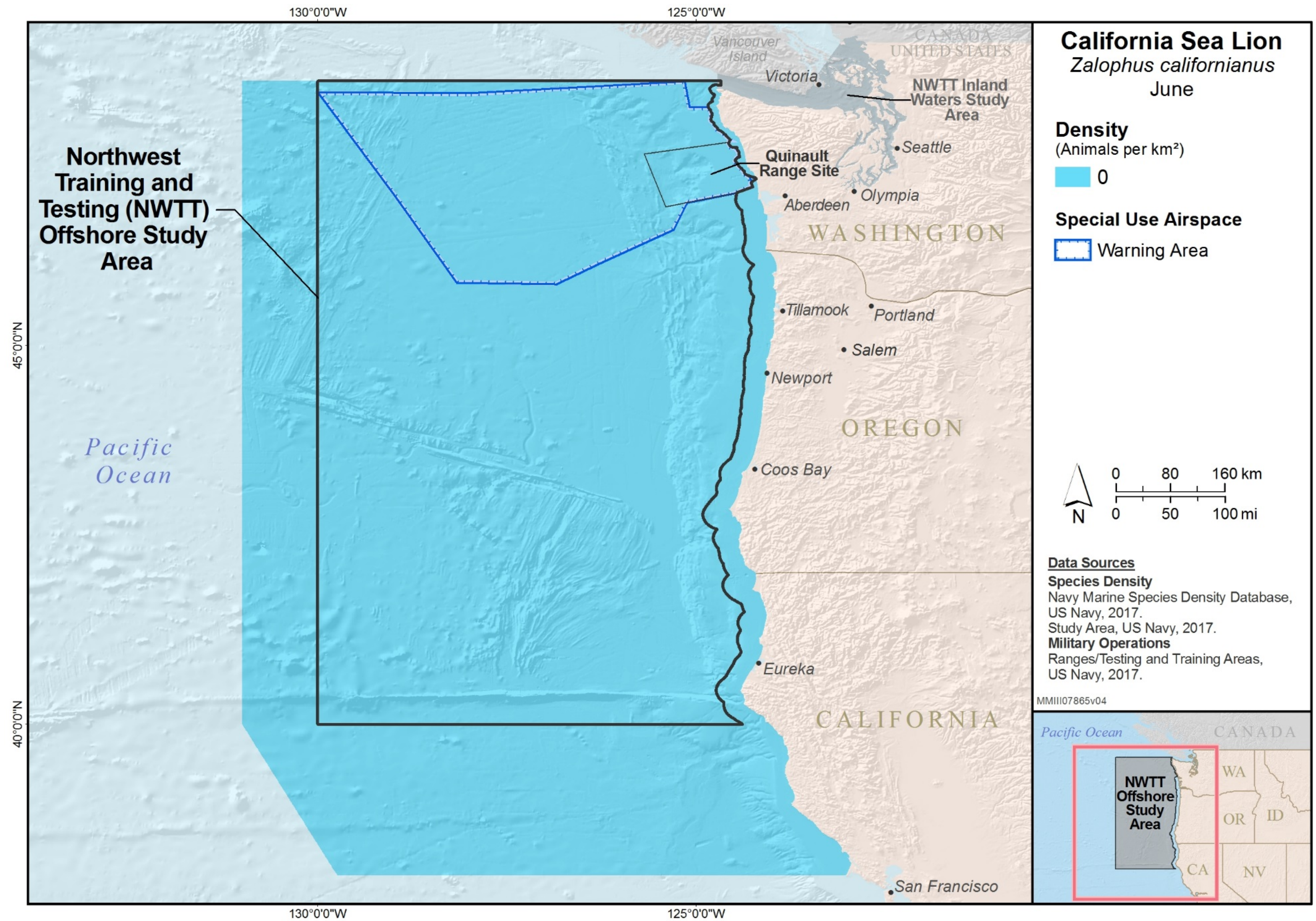

Figure 10.1-39: Offshore June Distribution of California Sea Lion

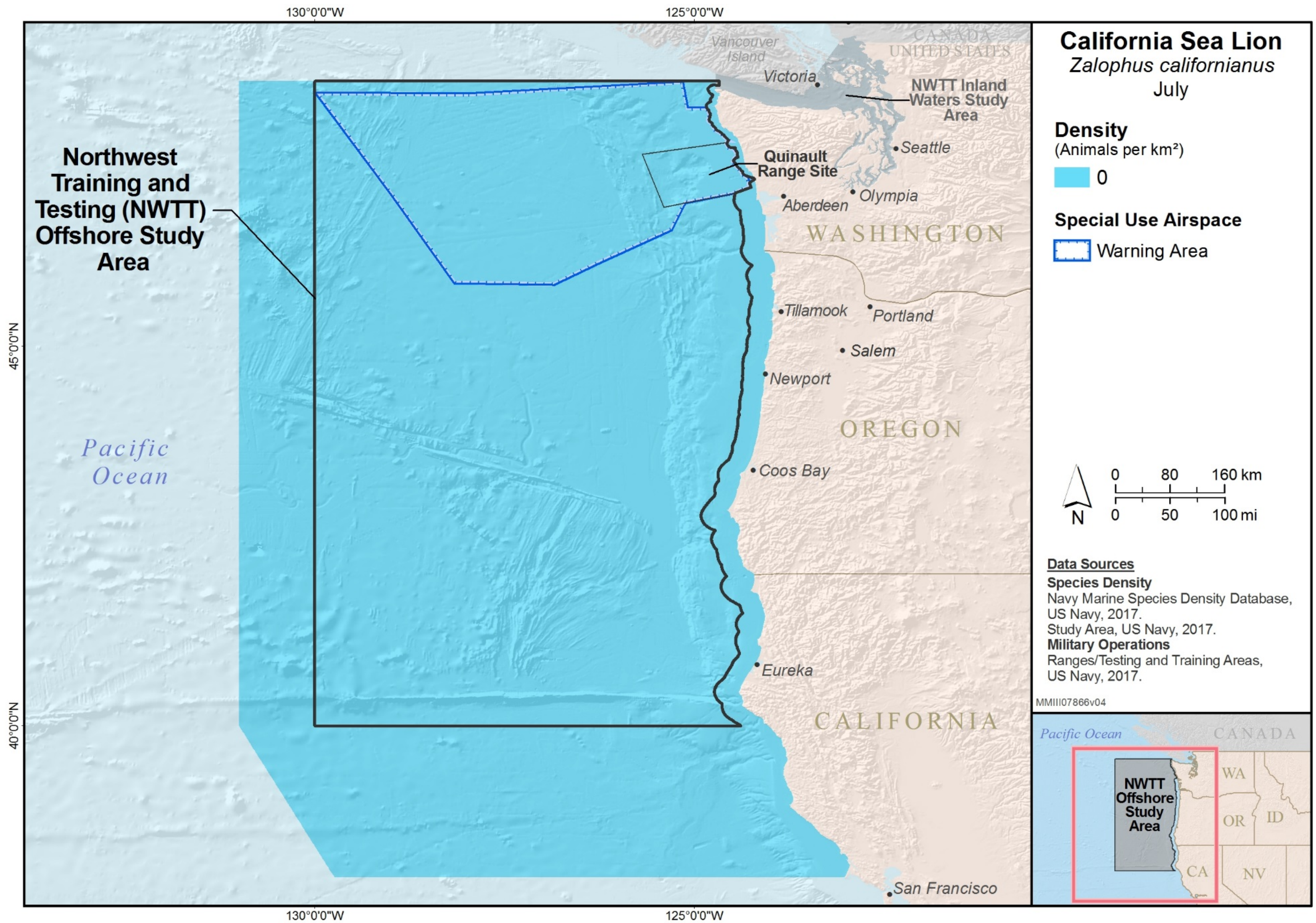

Figure 10.1-40: Offshore July Distribution of California Sea Lion

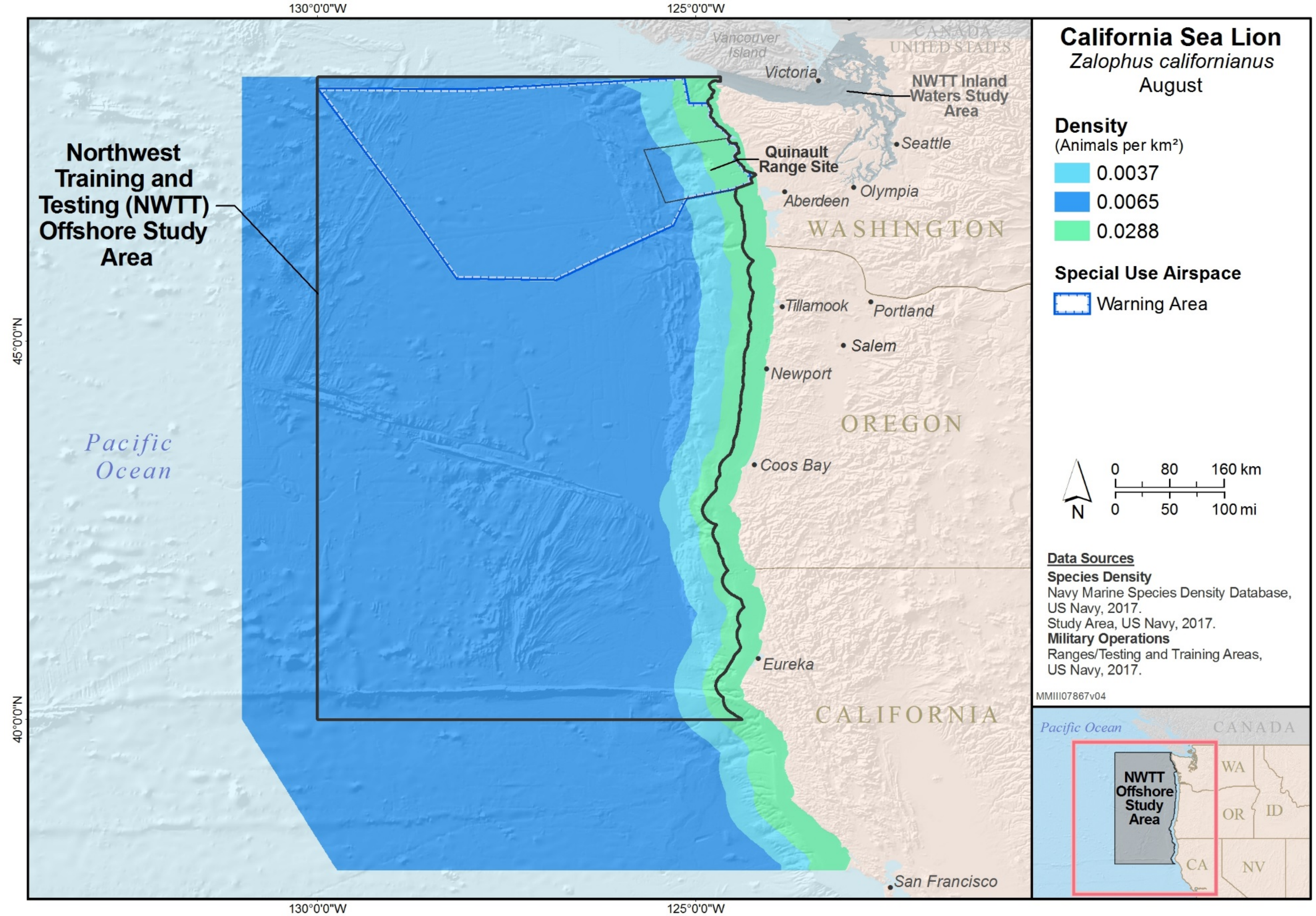

Figure 10.1-41: Offshore August Distribution of California Sea Lion

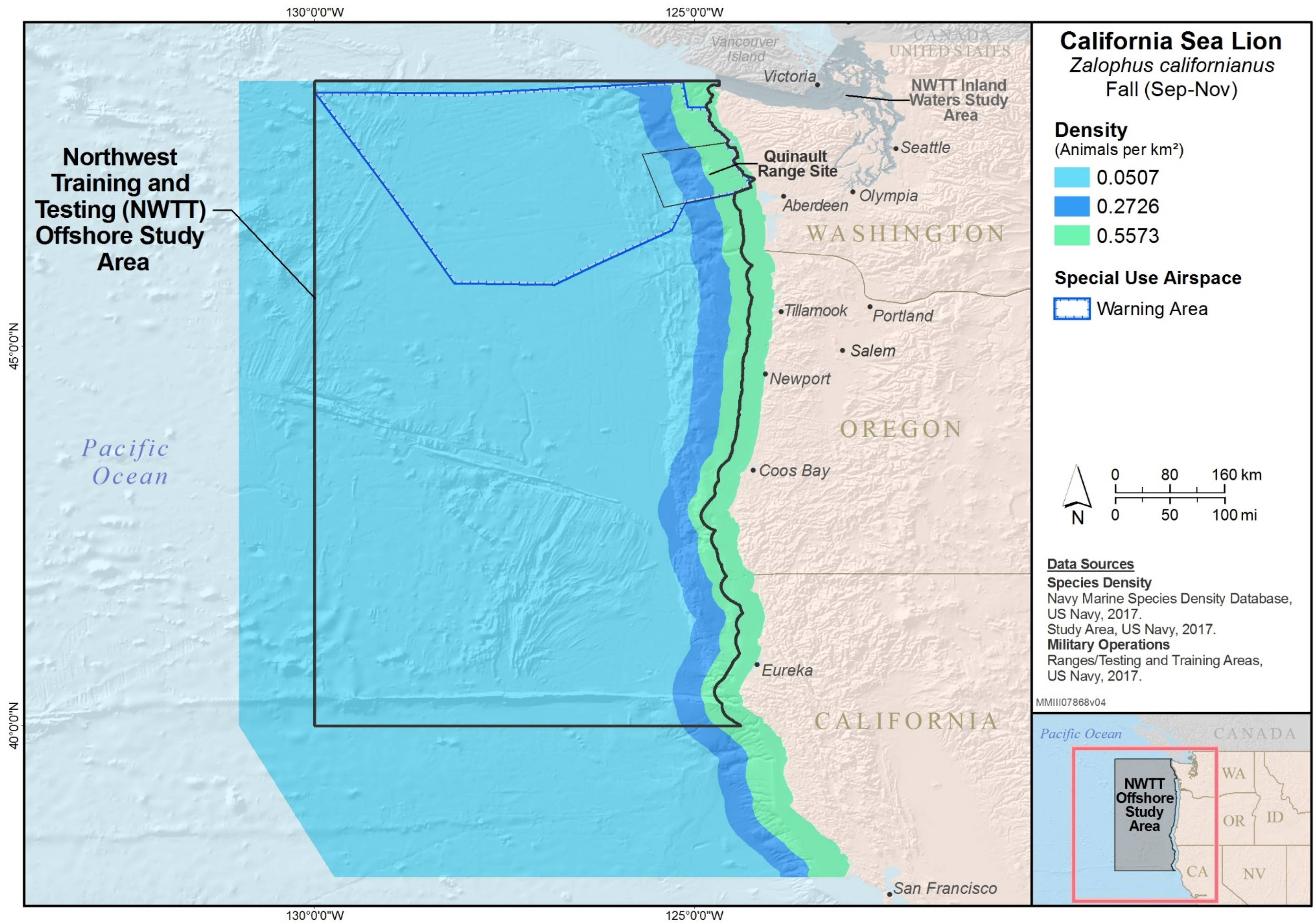

Figure 10.1-42: Offshore Fall Distribution of California Sea Lion

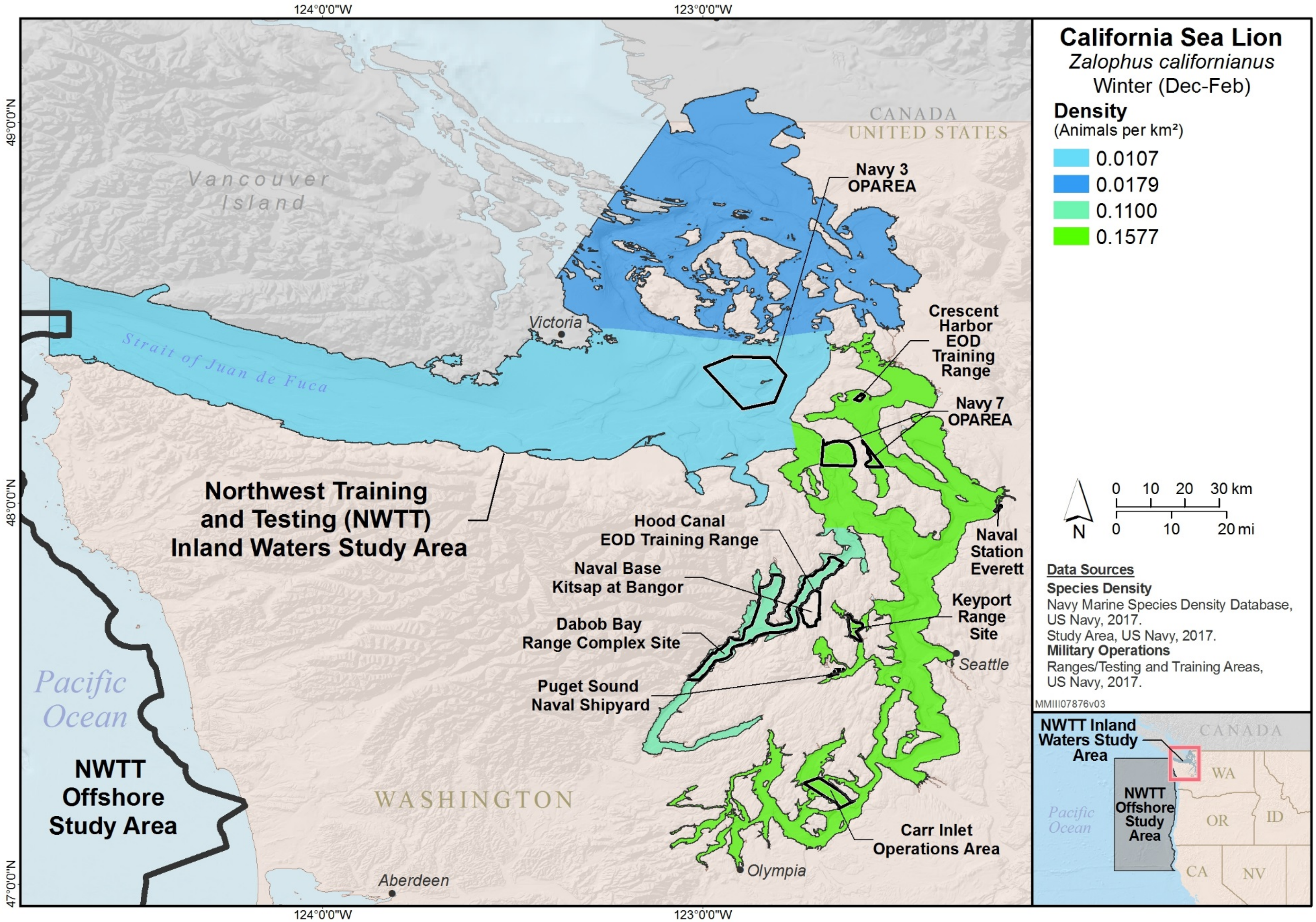

Figure 10.1-43: Inland Waters Winter Distribution of California Sea Lion

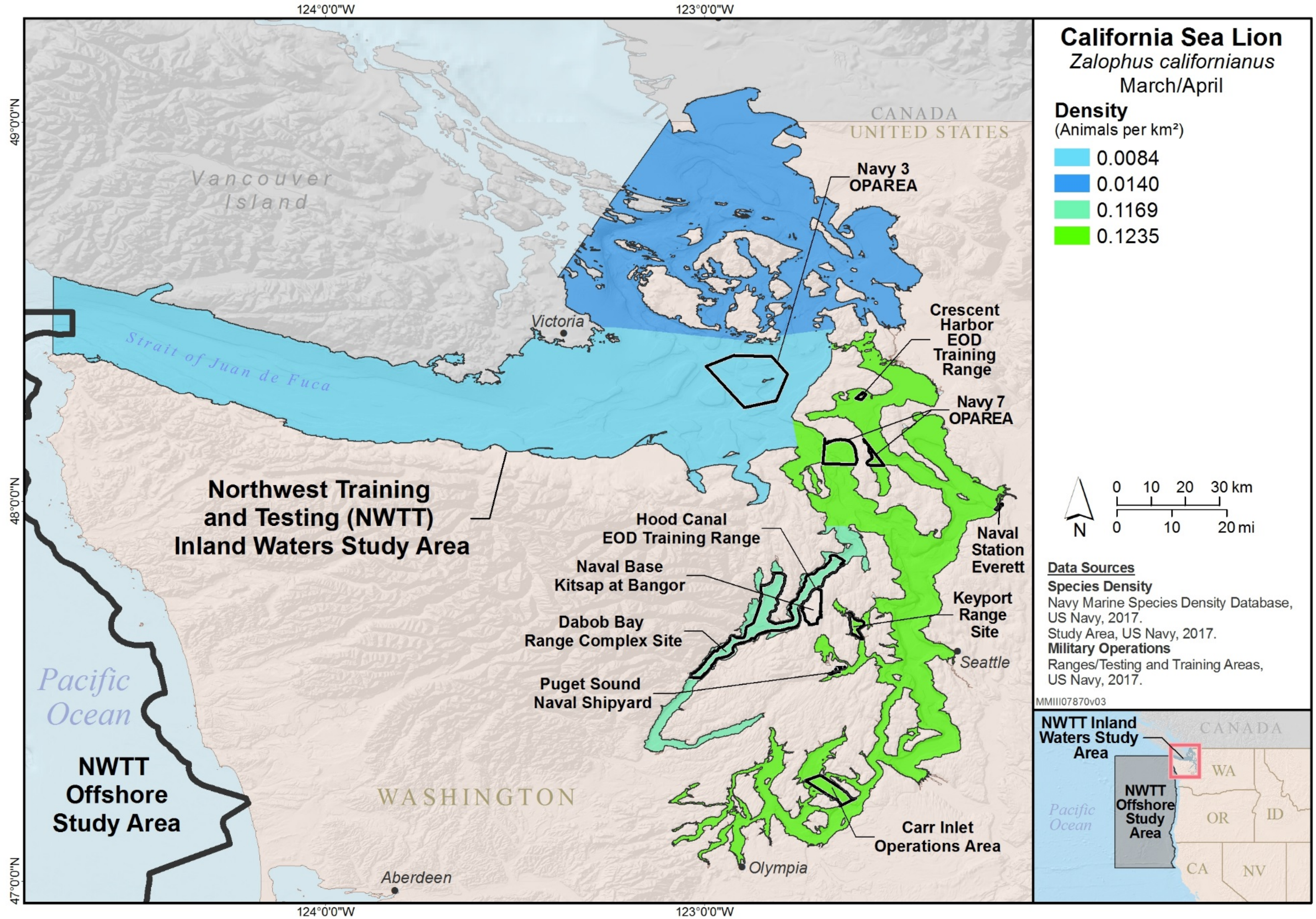

Figure 10.1-44: Inland Waters March/April Distribution of California Sea Lion

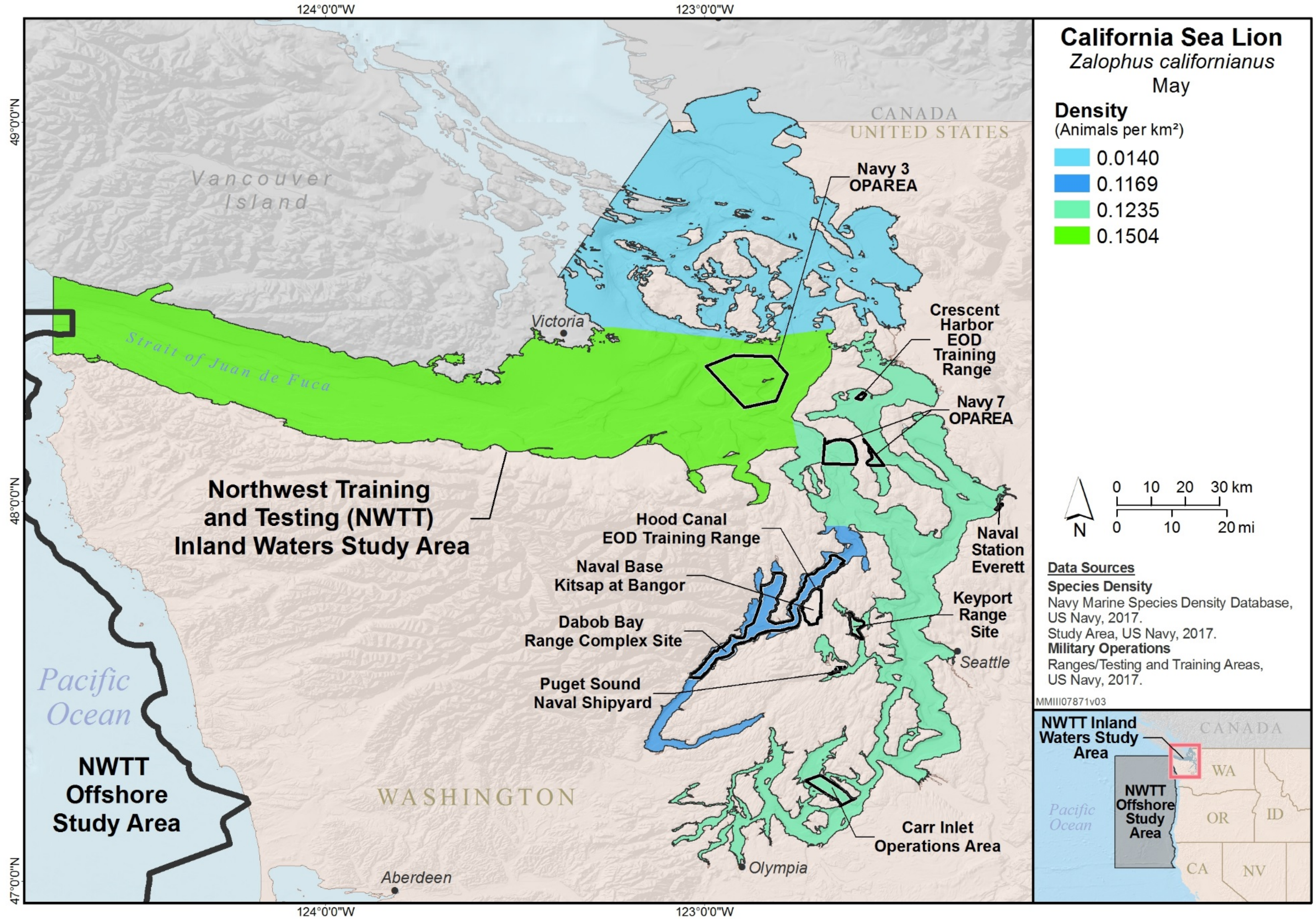

Figure 10.1-45: Inland Waters May Distribution of California Sea Lion

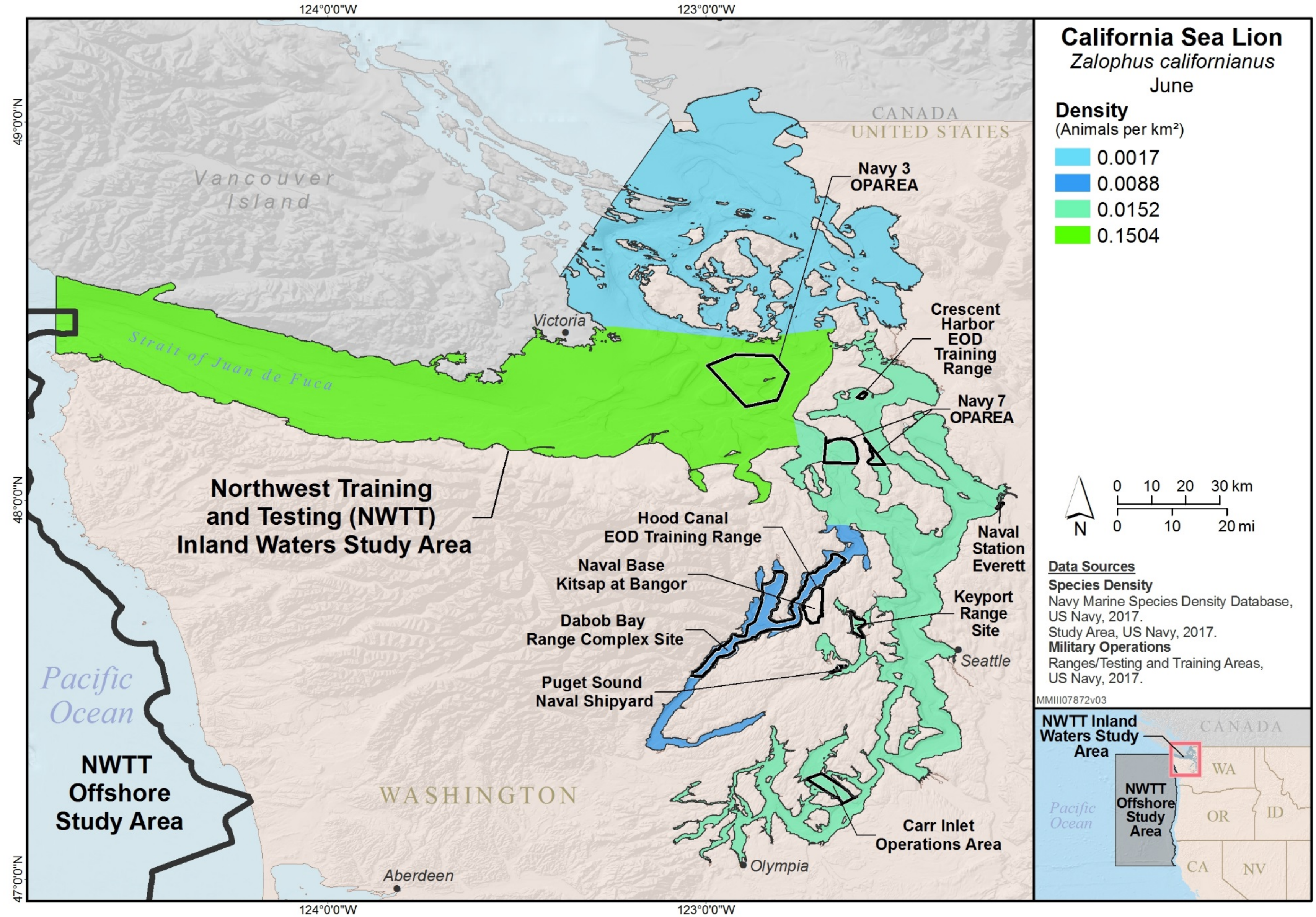

Figure 10.1-46: Inland Waters June Distribution of California Sea Lion

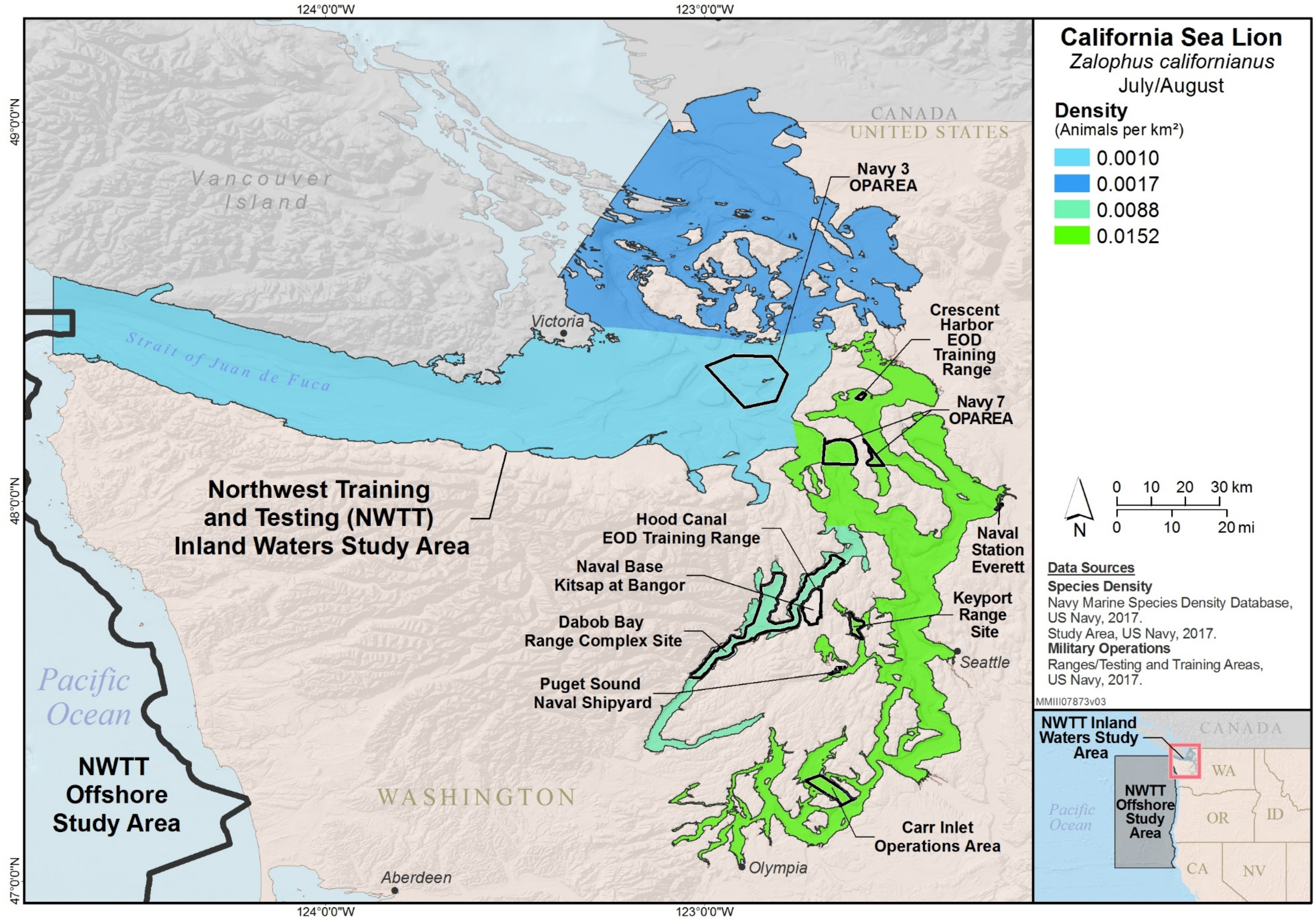

Figure 10.1-47: Inland Waters July/August Distribution of California Sea Lion

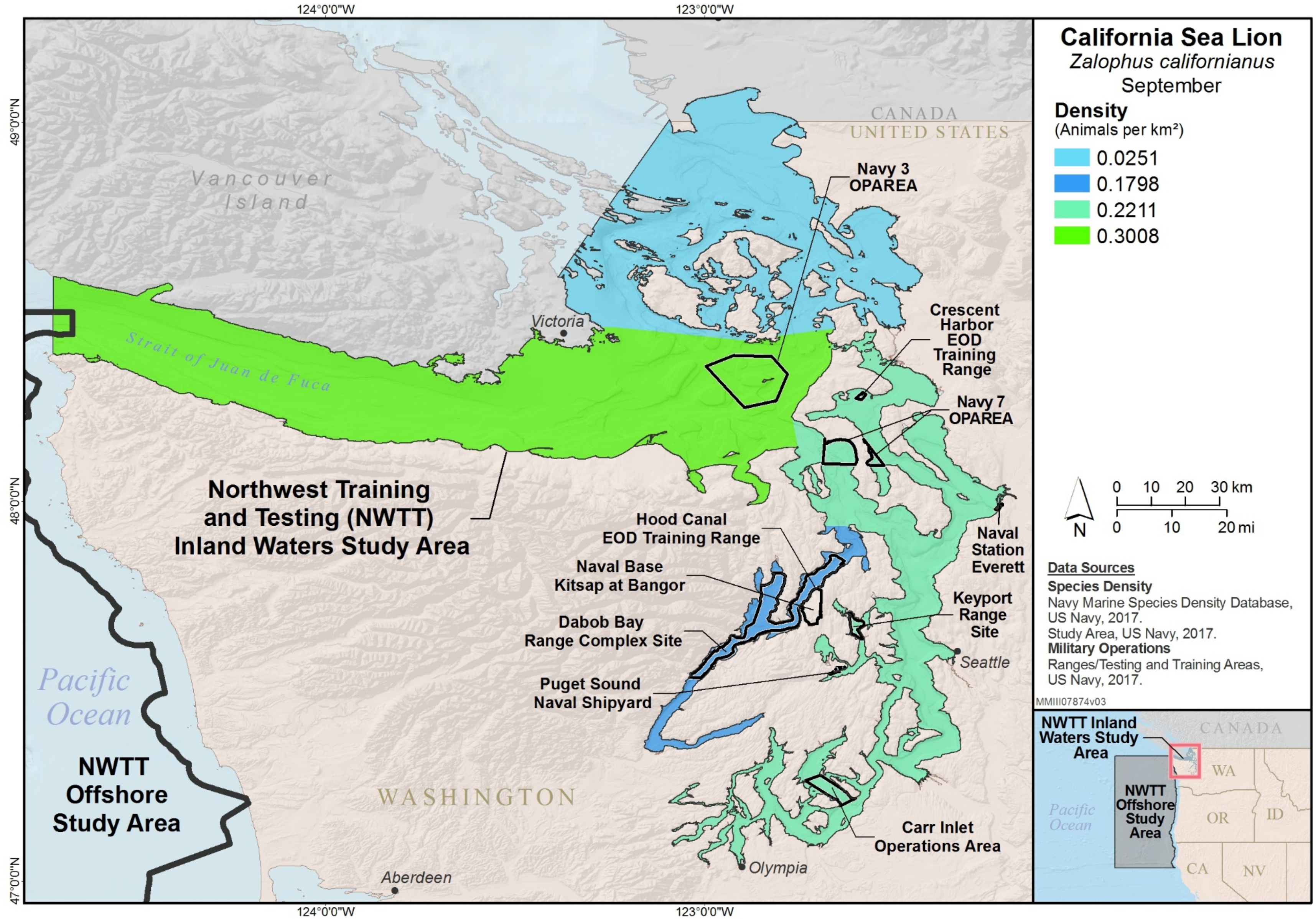

Figure 10.1-48: Inland Waters September Distribution of California Sea Lion

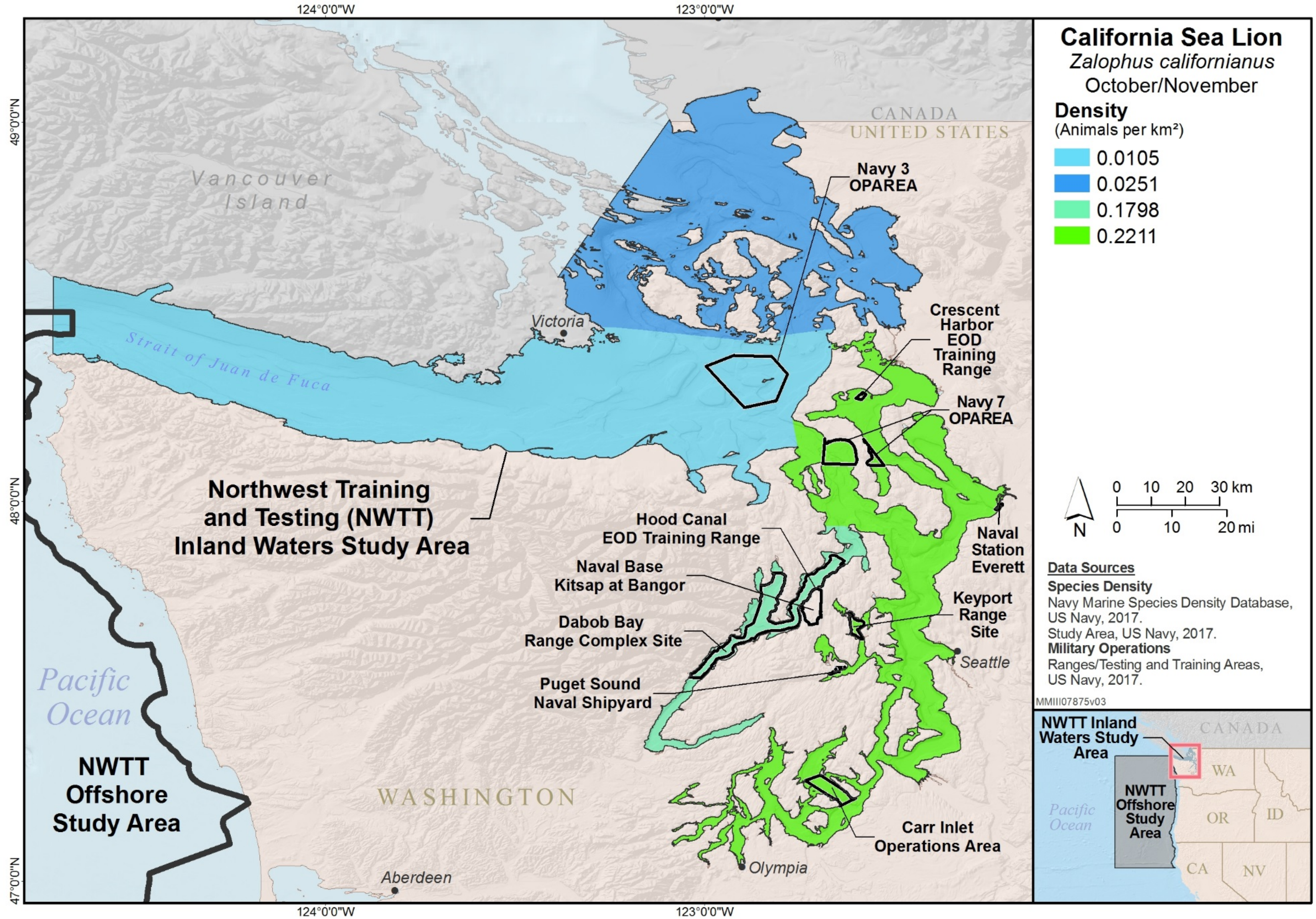

Figure 10.1-49: Inland Waters October/November Distribution of California Sea Lion

11 OTTERS

11.1 OTTER SPECIES PROFILES

The USFWS recognizes five northern sea otter stocks in U.S. waters under MMPA guidelines. There is a single stock in Washington waters (the northern sea otter [*Enhydra lutris kenyoni*]); and a single stock in California (the southern sea otter [*Enhydra lutris nereis*]). Only the Washington stock of sea otter occurs in the Study Area (Carretta et al., 2017b; U.S. Fish and Wildlife Service, 2018). There are three sea otter stocks in Alaska that are designated Southeast, Southcentral, and Southwest stocks (Muto et al., 2019). The boundaries of the Southcentral and the Southwest stocks are far from the Study Area and the Southeast Alaska stock is not known to be present in the western Behm Canal portion of the Study Area since they routinely only inhabit the Pacific Coast in southeast Alaska (Muto et al., 2018a; Muto et al., 2018b; Muto et al., 2019) and were not observed during the most recent surveys of the area (Tinker et al., 2019).

Sea otters that occur along the coast of Washington are the result of reintroduction efforts of the northern sea otter (*Enhydra lutris kenyoni*) from Amchitka Island, Alaska in 1969 and 1970 (Lance et al., 2004; Sato, 2018). These sea otters are not listed as threatened or endangered under the ESA (Carretta et al., 2017b; U.S. Fish and Wildlife Service, 2018). The Washington stock is not classified as strategic because the population is growing and is not listed as depleted under the MMPA. The State of Washington developed a recovery plan to address the northern sea otter population in its waters (Lance et al., 2004; Sato, 2018).

11.1.1 *ENHYDRA LUTRIS KENYONI*, NORTHERN SEA OTTER

The northern sea otter in the Pacific Northwest generally occupies coastal habitat exposed to the open ocean along rocky shorelines with clusters of small islets, reefs, and relatively shallow water depths (Fisheries and Oceans Canada, 2015; Hale et al., 2019; Jeffries et al., 2019; Laidre et al., 2009; Nichol et al., 2015; Walker et al., 2008). Sea otters seldom range more than 2 km from shore, because they are benthic foragers and limited in their ability to dive to the seafloor in deeper waters generally located farther from shore. Although some individuals, particularly juvenile males, are known to travel farther offshore, at a population level, sea otters predominantly occur in shallow, nearshore waters (Bodkin, 2015; Bodkin et al., 2004; Calambokidis et al., 1987; Hale et al., 2019; Laidre et al., 2009; Muto et al., 2017; Pearson, 2019; Riedman & Estes, 1990).

Offshore. An underwater density estimate was calculated for sea otters in the Offshore Area based on observations and measurements of sea otter occurrence and dive behavior. The time sea otters spend foraging was used to estimate the portion of time they would be underwater and potentially exposed to acoustic stressors. The analysis assumes that sea otters would not be exposed to underwater acoustics when resting or consuming prey (feeding) at the surface with their heads out of the water. To calculate an underwater abundance, time spent foraging underwater was used as a correction factor on the total abundance reported by Jeffries et al. (2019). This correction factor is based on the following research and studies:

- Walker et al. (2008) reported that sea otters in Olympic Coast National Marine Sanctuary found between the 0 – 20 m isobaths "primarily spent their daylight hours resting (62.3 percent), grooming (19.7 percent), and feeding (7.6 percent)."
- U.S. Fish and Wildlife Service and U.S. Department of the Navy (2020) reported that sea otters off Washington spend 40 – 50 percent of their time underwater.
- Laidre et al. (2009) reported that on average sea otters spend 41 percent of the time foraging and 45 percent of the time resting;
- Hale et al. (2019) reported that the longest dive durations (at Koitlah Point) showed sea otters spent 63 percent of their time submerged (dive duration 83.49 sec; surface 48.59 sec), while the average for all other sites showed sea otters were underwater 55 percent of the time (dive 47.55 sec; surface – 38.23 sec);
- Comparative data from studies in Alaska demonstrated that sea otters (at or near equilibrium density) foraged 51 to 58 percent of the time at Amchitka Island, while at Attu Island (below equilibrium density) sea otters invested only 16 to 18 percent of their time foraging (Estes et al., 1982);
- In California where resources were abundant, sea otters spent less than 40 percent of their time foraging (Thometz et al., 2016). Mean dive intervals and post-dive intervals indicated time spent underwater ranged from 31 to 64 percent in resource abundant habitats off California.
- A reported growth rate exceeding 9 percent for sea otters off Washington (Jeffries et al., 2019) suggests a resource abundant habitat in the Offshore Area

Based on the information summarized above on foraging behavior, and discussed further below, the Navy determined a correction factor of 50 percent of the total abundance was appropriate for calculating an underwater abundance for sea otters in support of estimating an underwater density.

While the ability to forage successfully is a primary driver of sea otter distribution, the Navy acknowledges that sea otters also move seasonally to areas where prey is available or where sheltered waters offer protection from storms and rough seas (Laidre et al., 2009; Lance et al., 2004; Riedman & Estes, 1990; Sato, 2018). Nevertheless, the density estimate presented below is necessarily based on the fixed physical environmental features of depth and distance from shore as these are known and quantifiable.

<u>Time Underwater</u>: The study by Estes et al. (1982) comparing data from Amchitka and Attu Islands in Alaska reported varying foraging times based on the density of sea otters at each location. The sea otter population at or near equilibrium density on Amchitka Island foraged from 51.0 to 58.0 percent of the time, while on Attu Island where the population was below equilibrium density, sea otters invested only 16.0 to 18.0 percent of their time foraging. The population density off the Washington coast is assumed to be more similar to the population off Amchitka Island (Jeffries et al., 2019). Laidre et al. (2009) found time spent foraging was minimal beyond 40 m depth in Washington waters, and Walker et al. (2008) estimated that when sea otters were in waters between 0 and 20 m depth that they spent the majority (62.3 percent) of daylight hours resting and just 7.6 percent of their time foraging.

Fine-scale female and male distributions greater than a depth of 30 m are based on tracking data from Laidre et al. (2009) and observations reported by Hale et al. (2019). Laidre et al. (2009) noted adult females spent 76 percent of their resting time and 60 percent of their foraging time in the shallowest habitat (0 – 10 m). Since their presence is “negligible” beyond 30 m (Hale et al., 2019; Laidre et al., 2009), a reasonable assumption is that females spend the remaining 40 percent of their foraging time in depths ranging from 10 – 30 m. Adult males spent about 22 percent of their time foraging in 0 – 10 m and 32 – 34 percent of their time foraging at depths between 10 and 30 m (Bodkin et al., 2012; Hale et al., 2019; Laidre et al., 2009). Therefore, it is reasonable to conclude that males spend approximately 55 percent (22 + 33 percent) of their time foraging in depths of 30 m or less. Foraging time beyond 40 m for all age and sex classes off Washington was minimal; however, to account for sea otters (presumed to be adult and juvenile males) occurring beyond 40 m, 5 percent of males were estimated to occur between 40 and 100 m depths.

While the waters off Washington differ in many aspects from other otter habitats, these depth distributions are consistent with findings provided by time-depth-recorder tags on sea otters off California, where a mean dive depth of approximately 8 m was recorded for males and females (Thometz et al., 2016), and with similar data from southeast Alaska indicating that 84 percent of foraging time occurs between 2 and 30 m depths (Bodkin et al., 2012; Bodkin et al., 2004). The recordings from Alaska showed that females dove to depths of 20 m or less 85 percent of the time. Hale et al. (2019) concluded that the dive behavior of sea otter populations from different locations appears to be similar.

<u>Coastal Range</u>: Density strata were also defined by variations in occurrence along the coastline between Washington and northern California. Results from 75 radio-tagged sea otters off Washington indicated adult males had the largest home ranges along the coastline (50 ± 9 km), adult females had significantly smaller home ranges (38 ± 10 km), and subadult females had the smallest home ranges (24 ± 9 km). In Washington waters, otters ranged year round along approximately 130 km of coastline extending northward from Point Grenville to Pillar Point on the Strait of Juan de Fuca (Jeffries et al., 2016; Laidre et al., 2009; Lance et al., 2004; Sato, 2018), with approximately 75 percent of the population found south of La Push (Hale et al., 2019; Jeffries et al., 2016; Sato, 2018). Between depths of 0 and 40 m, approximately 80.29 percent of the population is located from La Push to Grays Harbor and 19.71 percent is located from Cape Flattery to La Push (Jeffries et al., 2019; U.S. Fish and Wildlife Service & U.S. Department of the Navy, 2020).

<u>Depth Range</u>: The distribution of sea otters with water depth is distinctly different for males and females, with females tending to remain in shallower water closer to shore and only males likely to occur in depths greater than 40 m. To incorporate this distinction into the density, 59 percent of the population was estimated to be female with 41 percent male based on the population structure reported by Bodkin et al. (2000). Other factors such as age and the presence of dependent pups likely also affect distribution with depth or distance from shore, however, those distinctions are less definitive and a simpler distribution based on sex is deemed adequate for this density calculation.

Off the coast of Washington, observations have indicated female sea otters were most frequently found resting and foraging in shallow waters between 0 and 10 m in depth, whereas males rested and foraged farther offshore where water depths were between 10 and 40 m (Hale et al., 2019; Laidre et al., 2009; Walker et al., 2008).

The abundance estimated by Jeffries et al. (2019) is the latest estimate for the sea otter population off the Washington coast and was the basis for the density calculation. However, the survey area used by Jeffries et al. (2019) did not extend beyond the 40 m isobath. A survey of sea otters in southeast Alaska by Tinker et al. (2019) estimated that 95 percent of sea otters would be found between 0 and 40 m depths, and an estimated 5 percent of males could occur between the 40 m and 100 m depths to account for reported sightings beyond a depth of 40 m (U.S. Fish and Wildlife Service & U.S. Department of the Navy, 2020). Sea otters foraging off the Washington coast spend minimal time beyond the 40m isobath (Hale et al., 2019; Laidre et al., 2009), so for the purpose of calculating this density estimate the population is not distributed beyond (seaward of) the 100 m isobath; although, no survey has been conducted beyond the 40 m isobath in the Offshore Area that would confirm this. The depth distribution is consistent with findings from Alaska and California and is a reasonable extrapolation for the Offshore Area given sea otters are concentrated in waters less than 50 m deep in Alaska and California (Bodkin et al., 2012; Thometz et al., 2016; Tinker et al., 2019).

Density Calculations: The abundance of sea otters in the Offshore Area within the 40 m isobath was estimated to be 2,785 individuals (Jeffries et al., 2019). The estimate is based on a census of sea otters along the coastline and does not account for undetected individuals (Bodkin, 2015). Densities are calculated by dividing an abundance by an area to estimate the number of sea otters per square kilometer (sea otters / km^2). As discussed above, the distribution of males and females varies with depth. Therefore, to estimate a more representative density, the number of males and females in the population was calculated and each group was distributed over the appropriate depth ranges.

Abundance (0 to 40 m) = 2,785 (Jeffries et al., 2019)

However, an estimated 5 percent of the population occurs in waters between 40 and 100 m in depth in Alaska (Tinker et al., 2019; U.S. Fish and Wildlife Service & U.S. Department of the Navy, 2020), and is assumed to be the case in the Offshore Area as well.

2,785 x 0.05 = 139 sea otters (between 40 and 100 m)

Total abundance (0 to 100 m) = 2,785 + 139 = 2,924

Therefore, from shore to a depth of 40 m there are 2,785 sea otters. Approximately 59 percent of this population is female and 41 percent are male, resulting in 1,643 females and 1,142 males, based on Jeffries et al. (2019) abundance estimate of sea otters within the 40 m isobath. Beyond the 40 m isobath, an estimated 5 percent of the population (139 sea otters) are added to account for the potential occurrence of males in deeper waters, where Jeffries et al. (2019) did not survey, but Tinker et al. (2019) and Laidre et al. (2009) estimated a small number of males would occur.

Females were distributed with water depth by estimating that 60 percent (986 sea otters) occurred from shore to 10 m, and 40 percent (657 sea otters) occurred from 10 to 30 m, as discussed above. No female sea otters were distributed beyond 40 m. Male sea otters were distributed by estimating that 22 percent (251 sea otters) occurred from shore to 10 m, 33 percent (377 sea otters) from 10 to 30 m, and 5 percent (139 sea otters) from 40 to 100 m. The remaining stratum from 30 to 40 m was calculated to be 514 sea otters (1,281 – 251 – 377 – 139 = 514), which is equivalent to 28 percent of the male population. After distributing male and female abundance estimates over the depth ranges, the abundances were multiplied by 50 percent to estimate underwater abundances in support of calculating stratified underwater densities.

The distribution of sea otters also varies along the coast. As discussed above, 19.71 percent of sea otters were estimated to occur from Cape Flattery to La Push and 80.29 percent to occur from La Push to Grays Harbor. To account for the possible occurrence of sea otters south of Grays Harbor, three sea otters were distributed from Grays Harbor to the California-Oregon border. The stratified (with depth and along the coast) underwater abundances are shown in Table 11.1-1. Underwater density estimates are calculated by dividing the stratified abundances by the spatial areas of each stratum (Table 11.1-1). The resulting underwater densities in the Offshore Area are shown in Table 11.1-2 and depicted in Figure 11.1-1.

Inland Waters. This species is not expected to occur in the Inland Waters portion of the NWTT Study Area as any reported sighting in the Inland Waters (Strait of Juan de Fuca, San Juan Islands, and southern Puget Sound) is considered extralimital by the Washington Department of Fish and Wildlife (Jeffries et al., 2019).

Western Behm Canal. This species is not expected to occur in the Western Behm Canal portion of the NWTT Study Area.

Table 11.1-1: Underwater Abundance Estimates by Depth and Distribution Along the Coast

Coastal Strata	Abundance			Area (km^2)
Offshore Cape Flattery to La Push	Female	Male	Total	
Total abundance in Stratum	162	126	288	
Shore to 10 m	97	28	125	58
10 to 30 m	65	42	106	144
30 to 40 m	NA	51	51	259
40 to 100 m	NA	14	14	489
Offshore La Push to Grays Harbor	Female	Male	Total	Area (km^2)
Total abundance in Stratum	660	514	1,174	
Shore to 10 m	396	101	497	224
10 m to 30 m	264	151	415	796
30 m to 40 m	NA	206	206	456
40 m to 100 m	NA	56	56	2,063

Table 11.1-1: Underwater Abundance Estimates by Depth and Distribution Along the Coast (continued)

Coastal Strata	Abundance			Area (km^2)
Offshore Grays Harbor to California	Female	Male	Total	Area (km^2)
Total abundance in Stratum	1.7700	1.2300	3	
Shore to 10 m	1.0620	0.2706	1.3326	689
10 m to 30 m	0.7080	0.4059	1.1139	1,348
30 m to 40 m	NA	0.4034	0.4034	739
40 m to 100 m	NA	0.1501	0.1501	7,077

NA = Not Applicable.

Table 11.1-2: Summary of Underwater Density Values for Northern Sea Otter

Location	Spring	Summer	Fall	Winter
Offshore Cape Flattery to La Push				
Shore to 10 m	2.1538	2.1538	2.1538	2.1538
10 m to 30 m	0.7388	0.7388	0.7388	0.7388
30 m to 40 m	0.1955	0.1955	0.1955	0.1955
40 m to 100 m	0.0281	0.0281	0.0281	0.0281
Offshore La Push to Grays Harbor				
Shore to 10 m	2.2188	2.2188	2.2188	2.2188
10 m to 30 m	0.5214	0.5214	0.5214	0.5214
30 m to 40 m	0.4523	0.4523	0.4523	0.4523
40 m to 100 m	0.0271	0.0271	0.0271	0.0271
Offshore Grays Harbor to California				
Shore to 10 m	0.0019	0.0019	0.0019	0.0019
10 m to 30 m	0.0008	0.0008	0.0008	0.0008
30 m to 40 m	0.0005	0.0005	0.0005	0.0005
40 m to 100 m	0.00002	0.00002	0.00002	0.00002
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

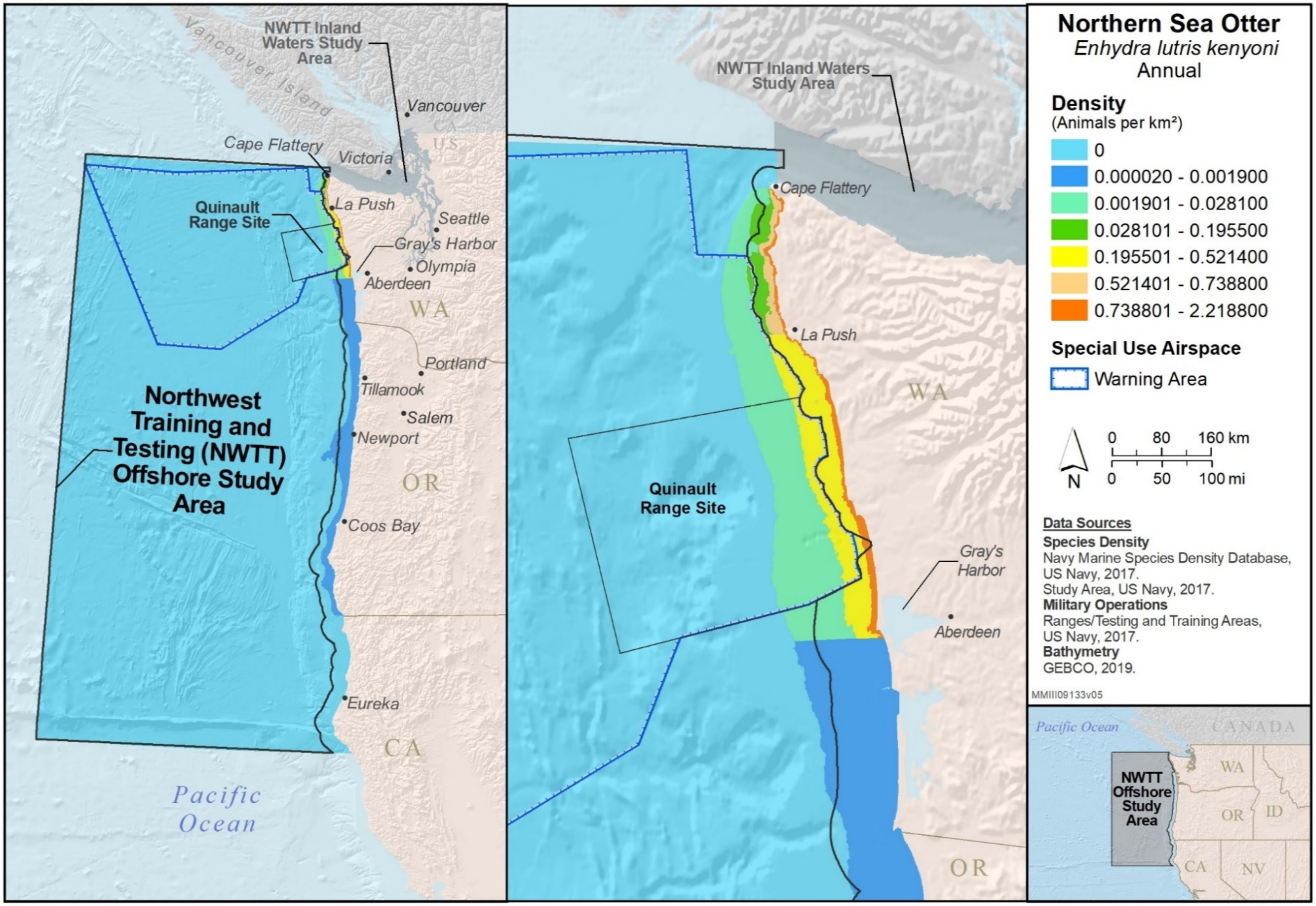

Figure 11.1-1: Annual Density for Northern Sea Otter

12 SEA TURTLES

12.1 SEA TURTLE SPECIES PROFILES

Sea turtles are a group of marine reptiles whose species are either threatened or endangered (Lutz & Musick, 1997; Spotila, 2004). There is a tremendous paucity of in-water occurrence data for sea turtles. Although tagging studies involving leatherback turtles have been performed (Benson et al., 2011; Benson et al., 2007; Shillinger et al., 2008), there is little assessment of the general presence of sea turtles in a specific area beyond their use of beaches. Many studies assess turtle numbers by counting nesting individuals or numbers of eggs (Hitipeuw et al., 2007; Patino-Martinez et al., 2008) or by recording bycatch (Bartol & Ketten, 2006; Donoso & Dutton, 2010). However, accurate in-water densities cannot be estimated based solely on data collected on nesting beaches, many of which, in the case of leatherbacks, are located along western coast of the Pacific Ocean. In many cases, the Navy has had to rely on data sets obtained by Navy biologists during monitoring activities (Aschettino et al., 2013; Smultea et al., 2008).

Only the leatherback sea turtle is expected to occur in the Study Area in substantial numbers (Benson et al., 2011). The hard-shell turtles of the Cheloniidae family (loggerhead, olive ridley, and green) with the potential to occur in the Study Area are considered tropical, subtropical, and warm temperate species that rarely stray into colder waters (Eckert, 1993; Hodge & Wing, 2000). Hard-shell turtles encountered in the Study Area are usually stranded dead or cold stunned (National Marine Fisheries Service, 2017). In contrast to leatherback sea turtles, most hard-shell turtles seek optimal seawater temperatures near 65 °F and become cold-stressed when water temperatures are below 50°Fahrenheit.

12.1.1 *DERMOCHELYS CORIACEA*, LEATHERBACK SEA TURTLE

The leatherback turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans, and nests on tropical and occasionally subtropical beaches (Hebshi et al., 2008; Myers & Hays, 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1992). Found from 71°N to 47°S, it has the most extensive adult range of any turtle (Eckert, 1995). Leatherbacks are also the most migratory sea turtles 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°Celsius (or 52 to 89° Fahrenheit) (mean of 24.7°Celsius) (Bailey et al., 2012). The study also found that oceanographic features such as mesoscale eddies, convergence zones, and areas of upwelling attracted foraging leatherbacks because these features are often associated with aggregations of prey. Hebshi et al. (2008) 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 CCE (Benson et al., 2007; Hebshi et al., 2008; Kobayashi et al., 2008).

Offshore. No density estimate for leatherback sea turtles in the Study Area is currently available due to a lack systematic survey data north of the CCE (Benson, 2017). To estimate an abundance, data from the CCE were extrapolated into the Study Area. A projected 2017 abundance of 130 sea turtles occurring in the CCE was derived by applying a 6 percent annual growth rate to a 2014 abundance estimate of 109 leatherback sea turtles (Curtis et al., 2015). Seasonal distribution data reported by Benson et al. (2011), indicate that leatherback sea turtles may not migrate annually and would likely remain in the CCE year round; therefore, the same density is used for all seasons. The spatial area used to estimate density is the CCE as depicted by (Curtis et al., 2015).

Density = 130 sea turtles / 1,140,913km^2= 0.000114 sea turtles/km^2

Inland Waters. This species is not expected to occur in the Inland Waters portion of the NWTT Study Area.

Western Behm Canal. This species is not expected to occur in the Western Behm Canal portion of the NWTT Study Area.

Table 12.1-1: Summary of Density Values for Leatherback Sea Turtle

Location	Spring	Summer	Fall	Winter
Offshore	0.000114	0.000114	0.000114	0.000114
Inland Waters	0	0	0	0
Western Behm Canal	0	0	0	0

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

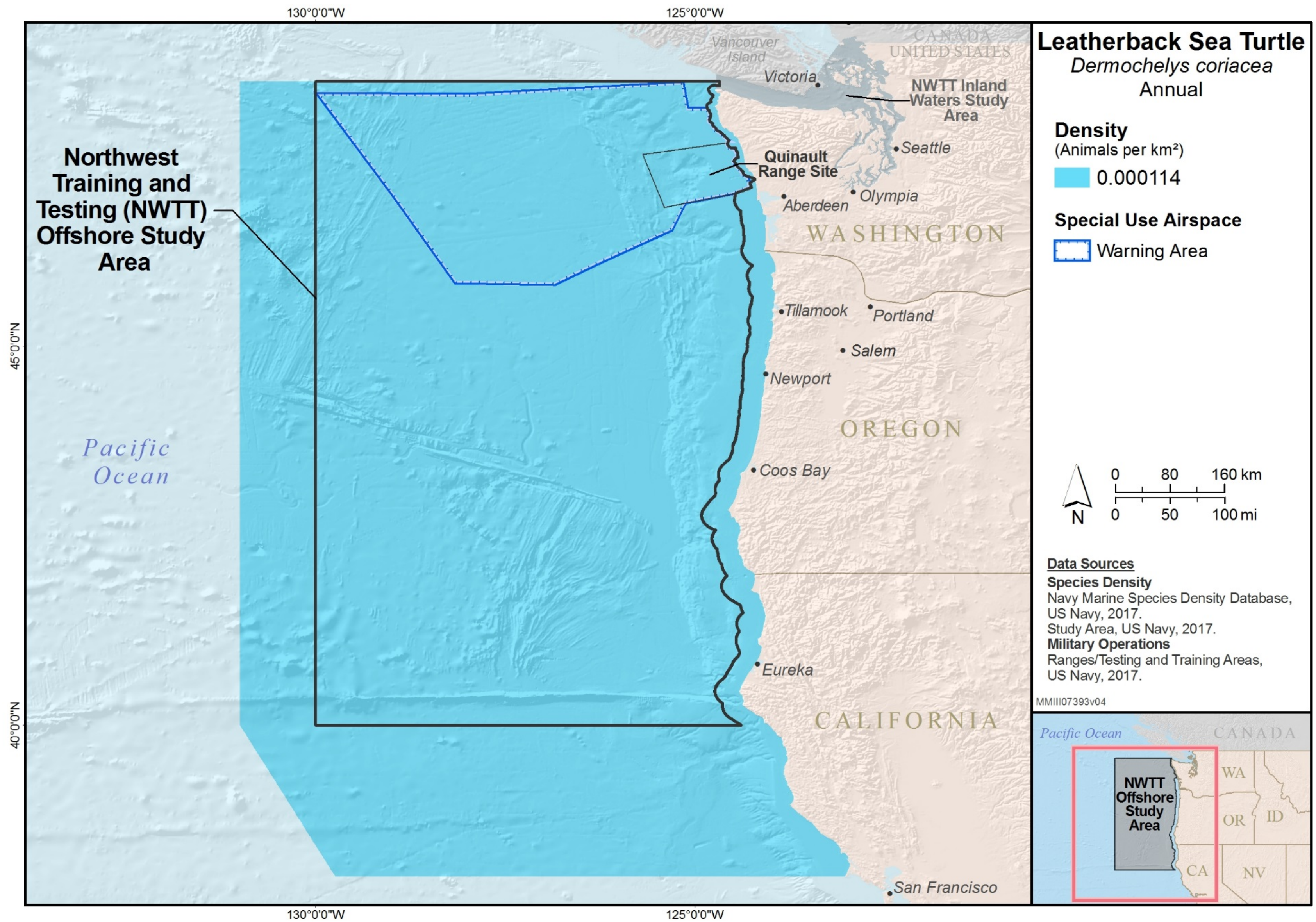

Figure 12.1-1: Offshore Annual Distribution of Leatherback Sea Turtle

13 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), but still represent a snapshot in time, so that as science progresses and better estimates become available, the NMSDD will be updated for use in future Navy modeling efforts. Scientists from NMFS and the Navy have already identified many new methods and projects that will improve and expand the data in the NMSDD for the next time it is called upon as a data source. The ultimate goal is to arrive at accurate density estimates for every species. As suggested in the species descriptions, this may be very difficult to achieve for some species, and techniques other than line-transect sampling may be required. Even when estimates are achieved, they will need to be maintained through regular monitoring, because the size of marine species populations changes over time and their distributions change with the large-scale dynamics in the world's oceans. 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 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.

California Current Ecosystem (CCE) Study Area: A study area defined by National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS), Southwest Fisheries Science Center (SWFSC) that encompasses waters off the United States (U.S.) West Coast between the shore and approximately 300 nautical miles offshore.

California Current Ecosystem Models: CCE habitat-based density models developed by SWFSC. The CCE 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.

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.

Fundamental niche: All of the environments in which a species can theoretically survive, absent competition from other species.

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 or sea lions 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 CCE Models and 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.

Pacific Coast Feeding Group: A group of a few hundred gray whales that feed along the Pacific coast between southeast Alaska and Southern California during the summer and fall. At present, these animals are not treated as distinct from the Eastern North Pacific population.

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).

Realized niche: The portion of the fundamental niche in which species live. Due to factors such as interspecific and intraspecific dynamics, and lack of resources, the realized niche is typically smaller than the fundamental niche.

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

Southern California Bight: Geographic region defined as the coastal and offshore area between Point Conception and a point just south of the United States-Mexico border. The California Channel Islands are included within the Southern California Bight. Due to the major bend in the coast (the "bight") in this area, the coast curves from northwest to southeast.

Southwest Fisheries Science Center: One of the six science centers under the purview of National Oceanic and Atmospheric Administration, 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 SWFSC Habitat-Based Density 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).

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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)
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: <u>Create 4 layers</u>, one for each season, Spring, Summer, Fall, or Winter
    - Populate the SEASON field as, Spring, Summer, Fall, or Winter
    - Duplicate seasonal density data were necessary to accommodate the Cold and Warm classification
    - Duplicate seasonal density data were necessary to accommodate multiple seasons (i.e., Spring, Summer, Fall, and not Winter)
- Species with annual distribution: <u>Create 4 layers</u>, one for each season, Spring, Summer, Fall, or Winter

  - Duplicate the annual layer for each of the four seasons so there are 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 Southern California the NGA 75k coastline was used with manual removal of bays and inlets by the Naval Undersea Warfare Center).

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