NUWC-NPT Technical Report 12,313
12 February 2020

Quantifying Acoustic Impacts on Marine Species: Methods and Analytical Approach for Activities at the Point Mugu Sea Range

Peter H. Hulton
Jessica B. Desrochers
Joseph O. Fayton
Kevin N. Nelson
Laura M. Sparks
Jessica A. Greene
Monica L. DeAngelis
NUWC Division Newport

Naval Undersea Warfare Center Division Newport, Rhode Island

PREFACE

This report was funded by the Naval Air Systems Command (NAVAIR) Ranges Sustainability Office (NAVAIR 52F00ME), "Marine Species Acoustic Effects Modeling within the Point Mugu Sea Range Environmental Impact Statement/Overseas Environmental Impact Statement Study Area." The sponsoring activity is the Naval Air Warfare Command, Weapons Division (NAWCWD), (Code EB2ROOM) program manager, Cory L. Scott, NAWCWD Range Sustainability Office.

The technical reviewer for this report was Peter H. Hulton (Code 709).

Reviewed and Approved: 12 February 2020

Dennis Tierney
Head, Infrastructure Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (*DD-MM-YYYY*) 12-02-2020	**2. REPORT TYPE** Technical Report	**3. DATES COVERED (*From – To*)** April 2020 to April 2030

4. TITLE AND SUBTITLE **Quantifying Acoustic Impacts on Marine Species: Methods and Analytical Approach for Activities at the Point Mugu Sea Range**	**5a. CONTRACT NUMBER**
	5b. GRANT NUMBER N/A
	5c. PROGRAM ELEMENT NUMBER N/A
6. AUTHOR(S) Peter H. Hulton, Jessica B. Desrochers, Joseph O. Fayton, Kevin N. Nelson, Laura M. Sparks Jessica A. Greene, and Monica L. DeAngelis	**5.d PROJECT NUMBER** N/A
	5e. TASK NUMBER N/A
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Undersea Warfare Center Division 1176 Howell Street Newport, RI 02841-1708	**8. PERFORMING ORGANIZATION REPORT NUMBER** TR 12,313
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Commander NAWCWD Code Ji6000D ! Administration Circle STOP 1011 China Lake, CA 93555-6100	**10. SPONSORING/MONITOR'S ACRONYM** NAVAIR
	11. SPONSORING/MONITORING REPORT NUMBER

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT. The United States Department of the Navy is required to assess impacts of Navy-generated sound in the water on protected marine species in compliance with applicable laws and regulations. This report applies to the Point Mugu Sea Range (PMSR) Environmental Impact Statement/Overseas Environmental Impact Statement and describes the methods and analytical approach to quantifying the number of potential effects to marine species as a result of training and testing at the PMSR. Stock and guild breakouts are also discussed to present a comprehensive overview of the methods to quantify acoustic impacts on marine mammals. The Navy Acoustics Effect Model (NAEMO) serves as the primary data entry point for Navy activity information and as a repository for modeling output and estimated effects. The Navy used specific information about environmental conditions, best available marine species data, and projected Navy activities within the PMSR as inputs into NAEMO.

15. SUBJECT TERMS
Navy Acoustics Effect Model (NAEMO), Acoustic modeling, Marine Species

16. SECURITY CLASSIFICATION OF: U			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Monica L. DeAngelis
a. REPORT **U**	**b. ABSTRACT** **U**	**c. THIS PAGE** **U**	SAR	119	**19b. TELEPHONE NUMBER** *(Include area code)* (401) 832-6378

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-1

This page left intentionally blank.

TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS (Cont'd)

Section **Page**

List of Illustrations

Figure **Page**

List of Illustrations (Cont'd)

Figure **Page**

List of Tables

List of Abbreviations and Acronyms

Acronym	Definition
ALT1	Alternative 1
ALT2	Alternative 2
BIA	Biologically Important Area
CASS	Comprehensive Acoustic Simulation System
CCE	California Current Ecosystem
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
ENP	Eastern North Pacific
ESA	Endangered Species Act
GRAB	Gaussian Ray Bundle
HSTT	Hawaii-Southern California Training and Testing
HYCOM	Hybrid Acoustic Coordinate Ocean Model
MEM	Military Expended Materials
MSMT	Marine Species Modeling Team
NAA	No Action Alternative
NAEMO	Navy Acoustic Effects Model
NAVAIR	Naval Air Systems Command
NEW	Net Explosive Weight
NMFS	National Marine Fisheries Service
NMSDD	Navy Marine Species Density Database
NUWC	Naval Undersea Warfare Center
OAML	Ocean and Atmospheric Master Library
PMSR	Point Mugu Sea Range
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SOCAL	Southern California
SPL	Sound Pressure Level
SWFSC	Southwest Fisheries and Science Center
TTS	Temporary Threshold Shift
U.S.	United States

1 INTRODUCTION

The Naval Undersea Warfare Center (NUWC) Division Newport Marine Species Modeling Team (MSMT) was contracted by the Naval Air Systems Command (NAVAIR) Ranges Sustainability Office (NAVAIR 52F00ME) to conduct a series of quantitative acoustic effects analyses to determine the level of behavioral disturbances and physiological effects for individual marine mammals and sea turtles resulting from a series of surface detonations taking place at the Point Mugu Sea Range (PMSR). Detonations occurring at or near the surface are the result of testing and training activities occurring at PMSR and involve the deployment of various ordnance within the range. Each deployment of ordnance will be evaluated individually, taking into account the Net Explosive Weight (NEW), number of ordnance expended, and geographic location within the range.

This page left intentionally blank.

2 MODELING APPROACH

All of the acoustic effects modeling will be conducted using the Navy Acoustic Effects Model (NAEMO). NAEMO is the standard Navy model used to collate, analyze, and report potential effects of training and testing activities on marine mammals and sea turtles. Inputs to NAEMO include the definitions of one or more scenarios, which describe the details of each activity. Each scenario describes the number and type of platforms and sound or explosive sources being used, platform speed and depth, and duration of each scenario. Locations and number of times each scenario will occur annually are also recorded.

Source characteristics are combined with environmental data (bathymetry, sound speed, bottom characterization, and wind speed) and analyzed using the Comprehensive Acoustic System Simulation/Gaussian Ray Bundle (CASS/GRAB) or the Navy's Standard Parabolic Equation sound propagation codes to determine the three-dimensional sound field for each source. Marine species density information is then processed to develop a series of species distribution files for each species present in the study area. Each distribution file varies the abundance and placement of the animats, or representative animals, based on uncertainty defined in the density data and published group size data (Department of the Navy 2017). Scenario details, three-dimensional sound field data, and marine species distributions are then combined in NAEMO to build virtual three-dimensional representations of each scenario and environment. This information is then processed by NAEMO to determine the number of marine species exposed in each scenario. The NAEMO simulation process is run multiple times for each season to provide an average of potential effects on marine species. Each iteration includes variations in marine species distributions along with the initial position and direction of each platform or deployment location of ordnance. Navy marine species acoustic effects criteria and thresholds are then applied in the NAEMO Post-Processor to quantify the number of marine mammals and sea turtle effects. Results from each iteration are averaged to provide the number of marine species effects for a given period. A complete description of the NAEMO model and modeling approach used for this analysis can be found in the Navy's Phase III Quantitative Analysis Technical Report (Department of the Navy 2018).

This page left intentionally blank.

3 DATA INPUTS

Individual scenarios for each source were developed. These scenarios include the counts and clusters of ordnance deployed during each testing or training activity. Counts refer to the numbers of ordnance deployed relatively far apart in time, typically more than a few minutes. Clusters refer to ordnance deployed within a short duration, typically within a few minutes. For modeling purposes, counts are modeled as independent sources spaced out in time while clusters are modeled as a group of sources detonating at the same time. Scenarios can have both counts and clusters defined to simulate multiple groups of ordnance being deployed (i.e., multiple gun bursts). Scenarios also define the depth of each source being modeled. The sources modeled have been determined by NAVAIR PMSR personnel to detonate at or near (<10 meters) the surface. For modeling purposes, all ordnance analyzed are assumed to detonate at 0.1 meters below the surface.

This page left intentionally blank.

4 SOURCE CHARACTERISTICS

The ordnance analyzed includes a variety of air-to-surface or surface-to-surface missiles, rockets, bombs, and gunfire expended on range. For modeling purposes each ordnance was assigned to a specific impulsive bin and corresponding net explosive weight based on the Navy's Phase III comprehensive environmental compliance and sustainment process. Parameters used for the NAEMO analysis are shown in Table 4-1.

Table 4-1. System Source Characteristics

Impulsive Bin	*Net Explosive Weight*
E1	0.1-0.25 lbs.
E3	0.5-2.5 lbs.
E5	5-10 lbs.
E6	10-20 lbs.
E7	20-60 lbs.
E8	60-100 lbs.
E9	100-250 lbs.
E10	250-500 lbs.

This page left intentionally blank.

5 AREAS OF OPERATION

Each scenario was modeled in each location (Figure 5-1) and identified in Table 5-1. The alternative numbers (No Action Alternative (NAA), Alternative 1 (ALT1), and Alternative 2 (ALT2) in Table 5-1 define the number of ordnances used over a one year timeframe. The event multipliers were created by dividing the alternative numbers by the amount of ordnances used during a single event. The ordnance amount of a single event was calculated by multiplying the count and cluster numbers defined for each source. The event multipliers were applied to the results from each modeled event to obtain a set of annual results for each location. Results from each location were then summed to produce the total annual effects for each set of event multipliers.

Table 5-1. Source Counts and Modeling Locations for Modeled Sources Only

Modeled Bin	*Number in a Cluster*	*Counts per day*	*Modeled Areas*
Bombs			
E7	8	1	W289S, W532 N/E/S
E9	2	1	W289S
Guns			
E1	60	16.67	W289S
E1	50	20	W289S, W532 N/E/S
E1	50	40	W289S
E3	60	8.33	W289S, W532 N/E/S
E3	40	12.5	W289S, W532 N/E/S
E5	20	6	W289S
Missiles			
E3	1	2	W289S
E6	1	2	W289S
E6	5	2	W289S, W532 N/E/S
E6	8	2	W289S

Table 5-1. Source Counts and Modeling Locations for Modeled Sources Only (Cont'd)

Modeled Bin	*Number in a Cluster*	*Counts per day*	*Modeled Areas*
Missiles			
E7	2	1	W289S, W532 N/E/S
E8	4	2	W289S
E8	4	2.5	PMSR
E8	1	2	W289S, W532 N/E/S
E8	8	1	W289S
E8	1	2	W289S
E9	4	1	W289S
E9	1	2	W289S, SNI
E9	1	2	W289S, W532 N/E/S
E9	1	1	W289S
E10	2	1	W289S
Rockets			
E5	1	5	W289S, W532 N/E/S

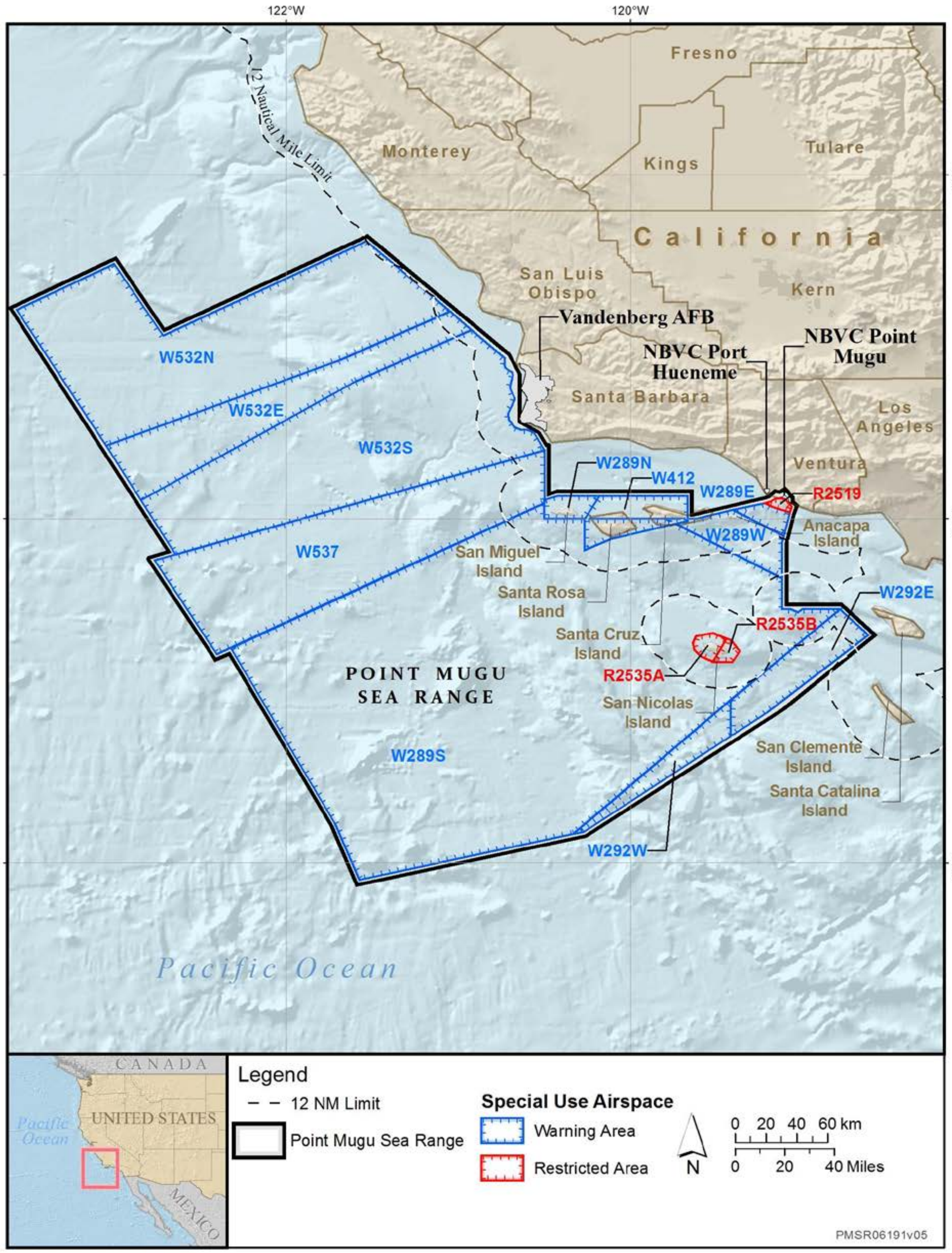

Figure 5-1. Point Mugu Sea Range Study Area

This page left intentionally blank.

6 ENVIRONMENTAL DATA

The Ocean and Atmospheric Master Library (OAML) (Table 6-1) and the Hybrid Coordinate Ocean Model (HYCOM) databases were utilized for the NAEMO analyses. OAML is maintained by the Naval Oceanographic Operations Command and provides a baseline set of Navy standard core models, databases, and algorithms. OAML databases include bathymetric data, bottom sediment properties, and wind speed data required for conducting underwater sound propagation analyses. HYCOM is a multi-depth ocean model developed by the National Oceanic and Atmospheric Administration and was used for salinity and temperature data.

Data for four environmental characteristics (bathymetry, sound speed profile, sediment type, and wind speed) were obtained or derived for January (winter) and July (summer). Bathymetry data were obtained from the Digital Bathymetric Database Variable-Resolution. Salinity and temperature data from the HYCOM database were used to derive sound speed profiles. The wind speed was extracted from the Surface Marine Gridded Climatology database.

The databases used for each environmental parameter is shown in Table 6-1. More detail of the environmental data used in the NAEMO model can be found in the Navy's Phase III Quantitative Analysis Technical Report (Department of the Navy 2018).

Table 6-1. Oceanographic and Atmospheric Master Library Environmental Databases

Parameter	***Database***
Bathymetry	Digital Bathymetric Database Variable-Resolution Version 6.2 (Level 0)
Sound Speed Profile	Hybrid Acoustic Coordinate Ocean Model (HYCOM) Version 2.2
Wind Speed	Surface Marine Gridded Climatology Version 2.0
Geo-Acoustic Parameters	Re-Packed Bottom Sediment Type Version 2.0 (includes High-Frequency Environmental Acoustics Version 1.0)
	Low-Frequency Bottom Loss Version 11.1*
	High-Frequency Bottom Loss Version 2.2*
*Low-frequency and high-frequency bottom loss databases are used to capture the variability of bottom sediment to absorb or reflect energy from high-frequency and low-frequency sound sources.	

Sound propagation is calculated at representative points throughout each modeling area using CASS/GRAB. When a simulation is run, each source in the scenario is randomly placed within the modeling area and within 0.5 nmi of each other. It is assumed that sound propagation at each modeled source location follows the same propagation as the closest propagation analysis point.

This page left intentionally blank.

7 MARINE SPECIES DENSITY AND DISTRIBUTION DATA

Animats were distributed in NAEMO across the entire study area based on density data obtained from the Navy Marine Species Density Database (NMSDD) (Department of the Navy 2017).

The finest temporal resolution for the NMSDD data for the Hawaii-Southern California Training and Testing (HSTT) Study Area is seasonal. The four seasons are defined as:

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

However, density data are rarely available at this temporal resolution. For each area and season, the Navy's goal is to identify the best available density estimate; different data sources may be utilized to attain this goal. To select marine species density estimates, the Navy established a data hierarchy based on available data (Department of the Navy 2017). Seasonal density estimates for the PMSR Study Area are described in detail for each species below. There was only one species, the harbor porpoise, where there was no density within the PMSR Study Area (Department of the Navy 2017), so a new density layer was developed. See Section 7.2.6.

For most marine megafauna, abundance is estimated using line-transect surveys or mark-recapture studies (Barlow 2010; Barlow and 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. Exclusive Economic Zone (EEZ) off California, Oregon, and Washington (referred to herein as a "uniform" density estimate). In some cases, the survey area is broken up into several strata and density estimates are derived for each stratum (a "stratified" density estimate). More recently, a newer method called spatial habitat modeling has been used to estimate cetacean densities that address some of these shortcomings (Barlow et al. 2009; Becker et al. 2012a; Becker et al. 2010; Becker et al. 2016; Becker et al. 2014; Becker et al. 2017; Boyd et al. 2017; Ferguson et al. 2006; Forney et al. 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 vary with, and are predicted at the scale of, the underlying environmental covariates.

Density information is provided in Table 7-1 for individual marine mammal species grouped under *mysticetes, odontocetes*, and *pinnipeds* that are expected in the PMSR. Although several sea turtle species have the potential to occur in PMSR, density information is provided below for only the leatherback sea turtle (*Dermochelys coriacea*). Loggerhead and green turtles are found in California waters, but generally further south than PMSR.

Species considered in the analysis are listed in Table 7-1.

Table 7-1. Marine Species That May Occur Near the PMSR

Common Name	***Scientific Name***	***Stock or DPS***
Mysticetes		
Blue whale	*Balaenoptera musculus*	Eastern North Pacific Stock
Bryde's whale	*Balaenoptera edeni*	Eastern Tropical Pacific Stock
Fin whale	*Balaenoptera physalus*	California/Oregon/Washington Stock
Gray whale	*Eschrichtius robustus*	Eastern North Pacific and Segment Distinct Population Segment
		Western North Pacific Distinct Population Segment
Humpback whale	*Megaptera novaeangliae*	Central America Distinct Population Segment
		Mexico Distinct Population Segment
Minke whale	*Balaenoptera acutorostrata*	California/Oregon/Washington Stock
Sei whale	*Balaenoptera borealis*	Eastern North Pacific Stock
Odontocetes		
Baird's beaked whale	*Berardius bairdii*	California/Oregon/Washington Stock
Bottlenose dolphin	*Tursiops truncatus*	California Coastal Stock
		California/Oregon/Washington Offshore Stock
Cuvier's beaked whale[1]	*Ziphius cavirostris*	California/Oregon/Washington Stock
Dall's porpoise	*Phocoenoides dalli*	California/Oregon/Washington Stock
Dwarf sperm whale	*Kogia sima*	California/Oregon/Washington Stock
Harbor porpoise	*Phocoena*	Morro Bay Stock
Killer whale	*Orcinus orca*	East Pacific Offshore Stock
		West Coast Transient Stock
Long-beaked common dolphin	*Delphinus capensis*	California Stock
Mesoplodont beaked whales[1,2]	*Mesoplodon spp.*	California/Oregon/Washington Stock
Northern right whale dolphin	*Lissodelphis borealis*	California/Oregon/Washington Stock
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	California/Oregon/Washington Stock
Pygmy killer whale	*Feresa attenuata*	Hawaii Stock
Pygmy sperm whale	*Kogia breviceps*	California/Oregon/Washington Stock
Risso's dolphin	*Grampus griseus*	California/Oregon/Washington Stock

[1]Study area density estimates are represented by a small beaked whale guild (includes Cuvier's and beaked whales of the genus *Mesoplodon*).
[2] The six Mesoplodont beaked whale species off California are *M. densirostris, M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, and M. stejnegeri.*

Table 7-1. Marine Species That May Occur Near the PMSR (Cont'd)

Common Name	*Scientific Name*	*Stock or DPS*
Odontocetes		
Short-beaked common dolphin	*Delphinus delphis*	California/Oregon/Washington Stock
Short-finned pilot whale	*Globicephala macrorhynchus*	California/Oregon/Washington Stock
Sperm whale	*Physeter macrocephalus*	California/Oregon/Washington Stock
Striped dolphin	*Stenella coeruleoalba*	California/Oregon/Washington Stock
Pinnipeds		
California sea lion	*Zalophus californianus*	U.S. Stock
Guadalupe fur seal[2]	*Arctocephalus townsendi*	Mexico Stock
Harbor seal	*Phoca vitulina*	California Stock
Northern elephant seal	*Mirounga angustirostris*	California Breeding Stock
Northern fur seal	*Callorhinus ursinus*	California Stock
Sea Turtles		
Leatherback sea turtle	*Dermochelys coriacea*	Western Pacific

[1] Study area density estimates are represented by a small beaked whale guild (includes Cuvier's and beaked whales of the genus *Mesoplodon*).
[2] The six Mesoplodont beaked whale species off California are *M. densirostris, M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, and M. stejnegeri.*

7.1 Mysticetes

7.1.1 Blue Whales, *Balaenoptera musculus*

There are four subspecies of blue whale, but only one is found in the North Pacific. The National Marine Fisheries Service (NMFS) recognizes two stocks of this subspecies: an Eastern North Pacific (ENP) stock and a Central North Pacific stock (Carretta et al. 2019) . The Central North Pacific stock is not expected to overlap in the PMSR. The ENP stock includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2019). The U.S. West Coast is one of the most important feeding areas for this species in summer and fall, but, increasingly, blue whales from the ENP stock have been found feeding to the North and South of this area during this time (Carretta et al. 2019). Nine 'biologically important areas' (BIAs) for blue whale feeding are identified off the California coast by Calambokidis et al. (2015). Most of the ENP stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome. Density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in PMSR are from the ENP stock.

While blue whale distribution would be expected to shift relative to their prey, a habitat-based density model was applied to the PMSR for summer/fall (Figure 7-1) in the absence of better information (Becker et al. in prep). However, blue whales are likely farther offshore or not present during the winter/spring season in PMSR when compared to the summer/fall (Becker et al. 2018; Campbell et al. 2015; Lewis and Širović 2018; Redfern et al. 2013). Campbell et al.'s (2015) uniform density estimate covered only to Morro Bay, CA; however, since this was the best available estimate for the PMSR Study Area for the winter/spring, the Campbell et al.'s (2015) density estimate was extrapolated to cover the entire PMSR Study Area for those seasons (Figure 7-2). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

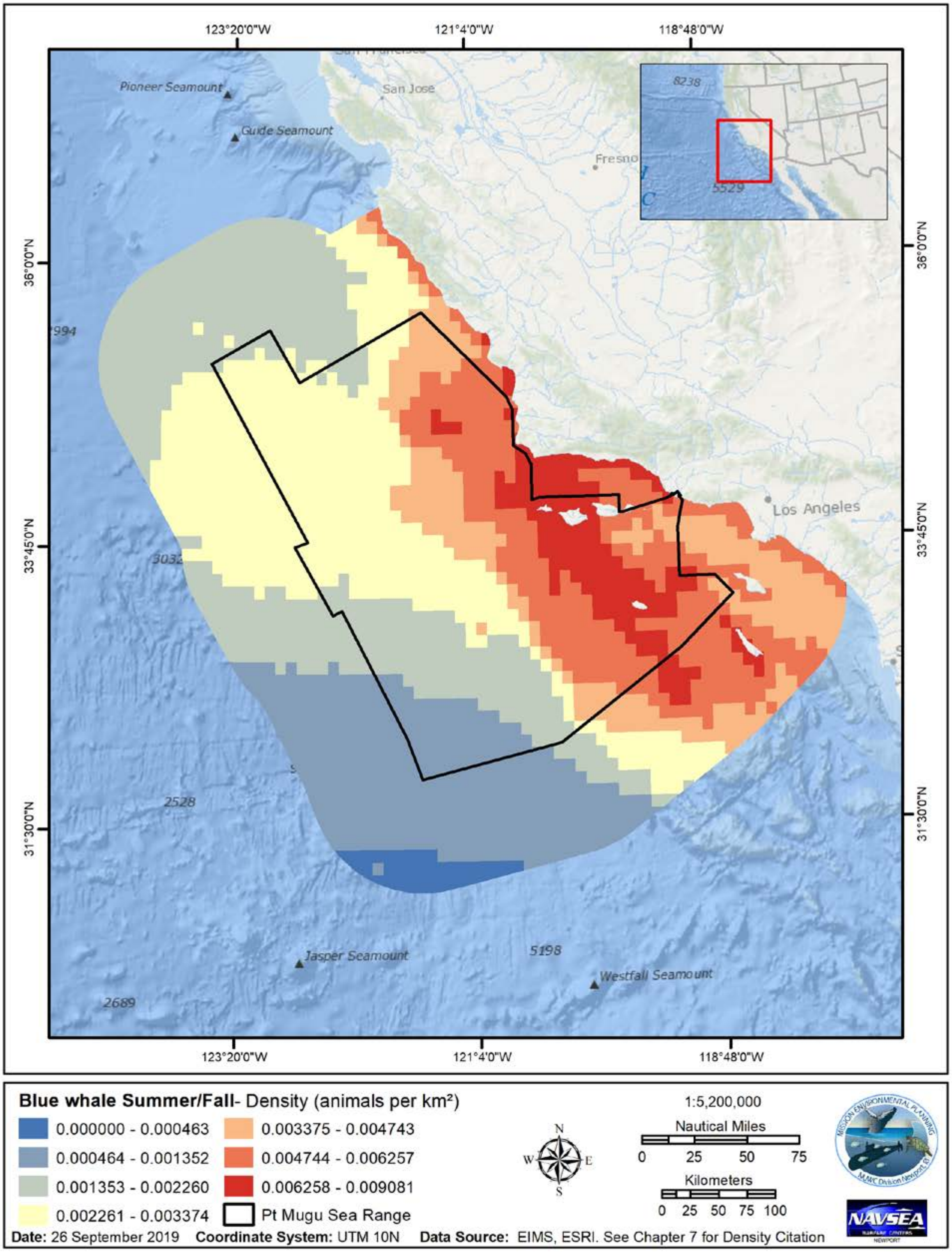

Figure 7-1. Blue Whale Summer/Fall Density in the PMSR

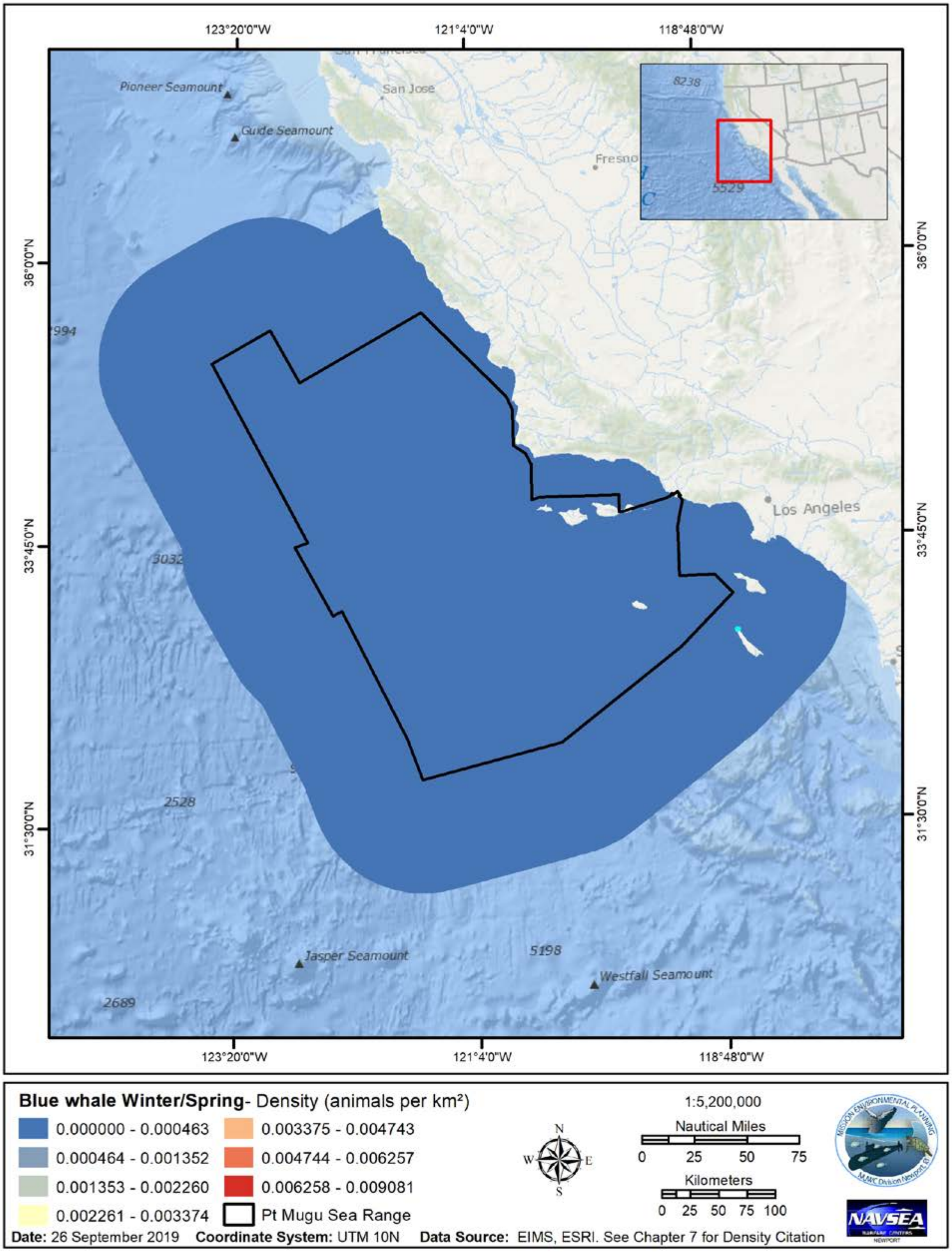

Figure 7-2. Blue Whale Spring/Winter Density in the PMSR

7.1.2 Bryde's Whale, *Balaenoptera edeni*

Bryde's whale sightings and acoustic detections off Southern California have increased over the last 10 years (Debich et al. 2015; Jefferson et al. 2014; Kerosky et al. 2012; Rice et al. 2018; Smultea et al. 2012), indicating a potential northern shift in distribution (Kerosky et al. 2012). Bryde's whales have been sighted and acoustically detected in Southern California waters in all seasons, although they are most common in summer and fall (Barlow 2016; Barlow and Forney 2007; Debich et al. 2015; Kerosky et al. 2012; Smultea et al. 2012). The recognizes two stocks of Bryde's whales in the U.S. Pacific, the Eastern Tropical Pacific stock (the only stock found in PMSR) and the Hawaii stock (Carretta et al. 2019). Density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in PMSR are from the Eastern Tropical Pacific stock.

Bryde's whale occurrence is likely driven by prey availability within the California Current ecosystem, which is affected by seasonal and inter-annual changes in climate and oceanographic conditions (Kerosky et al. 2012). Bryde's whales were observed in the Southern California Bight from summer to early winter, indicating seasonal poleward range expansion. However, very little is known about their presence in the PMSR. While applying the uniform annual density may overestimate Bryde's whale occurrence in the entire PMSR (Figure 7-3), this value is considered the best available science due to a paucity of any other data. The Navy considers this uniform annual density to be the most conservative.

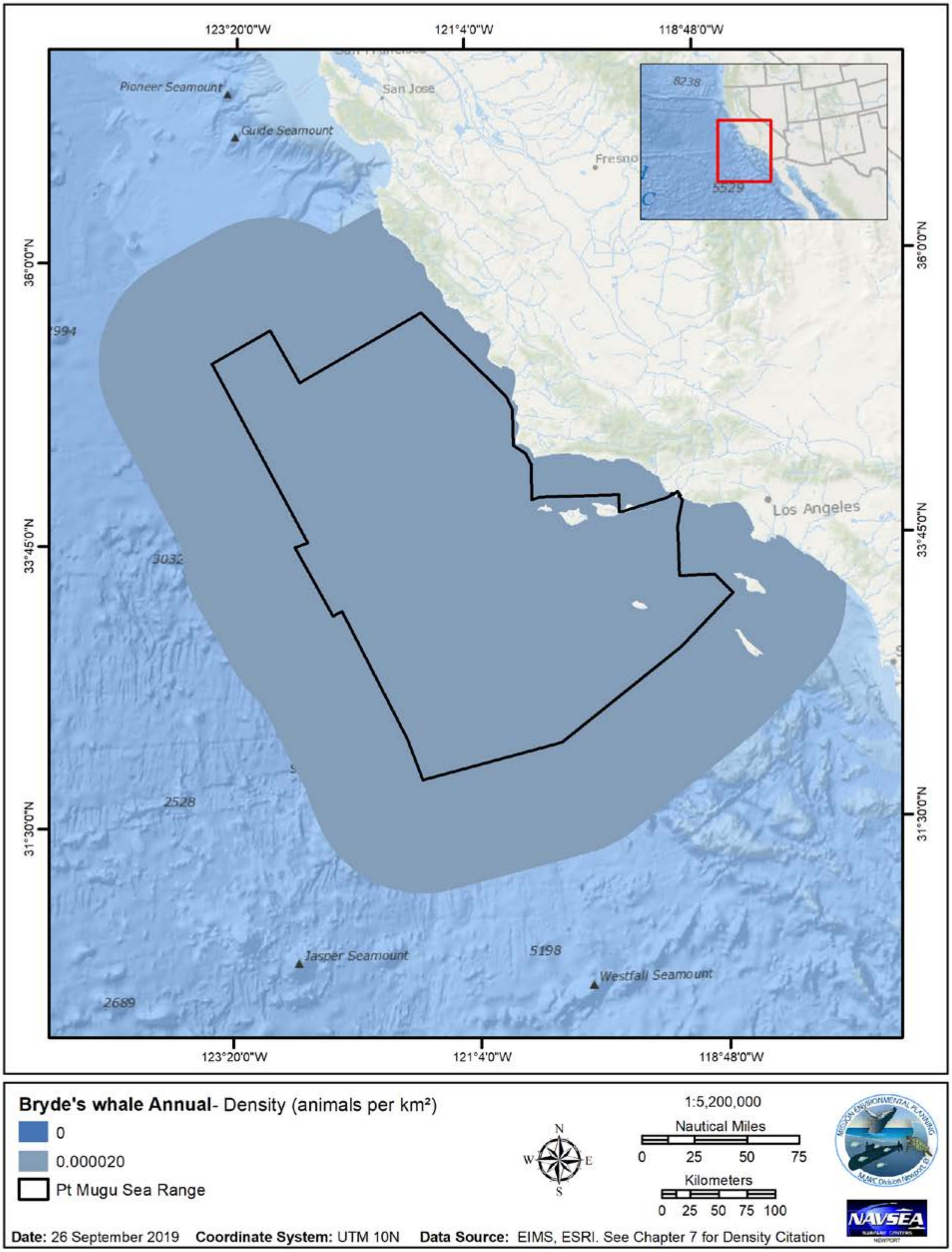

Figure 7-3. Bryde's Whale Annual Density in the PMSR

7.1.3 Fin Whale, *Balaenoptera physalus*

The NMFS recognizes three stocks of fin whales in U.S. Pacific waters: the Northeast Pacific stock, the California/Oregon/Washington (CA/OR/WA) stock, and the Hawaii stock (Carretta et al. 2019). The range of the Alaska stock does not overlap with the HSTT Study Area or PMSR. (Archer et al. 2013) presented evidence for geographic separation of fin whale stocks based on mitochondrial DNA clades near Point Conception, California (an area within the PMSR). However, density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in the PMSR are from the CA/OR/WA stock

NMSDD included a habitat-based density model for fin whales across the entire PMSR during the summer/fall season (Figure 7-4), but only included uniform density for a portion of the PMSR during the winter and spring seasons based on (Campbell et al. 2015). Therefore, in the absence of other density estimates applicable to the entire PMSR in winter and spring, the (Campbell et al. 2015) density for winter/spring (Figure 7-5) were extrapolated to cover the entire PMSR Study Area for these seasons. Fin whale habitat generally occurs in waters further offshore, characterized by cold surface temperatures, intermediate mixed-layer depths, and intermediate concentrations of surface chlorophyll (Redfern et al. 2013) which varies seasonally and interannually. However, fin whales are likely farther offshore during the winter/spring season (Redfern et al. 2013). Although these density estimates, particularly those for the winter/spring, may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions; they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

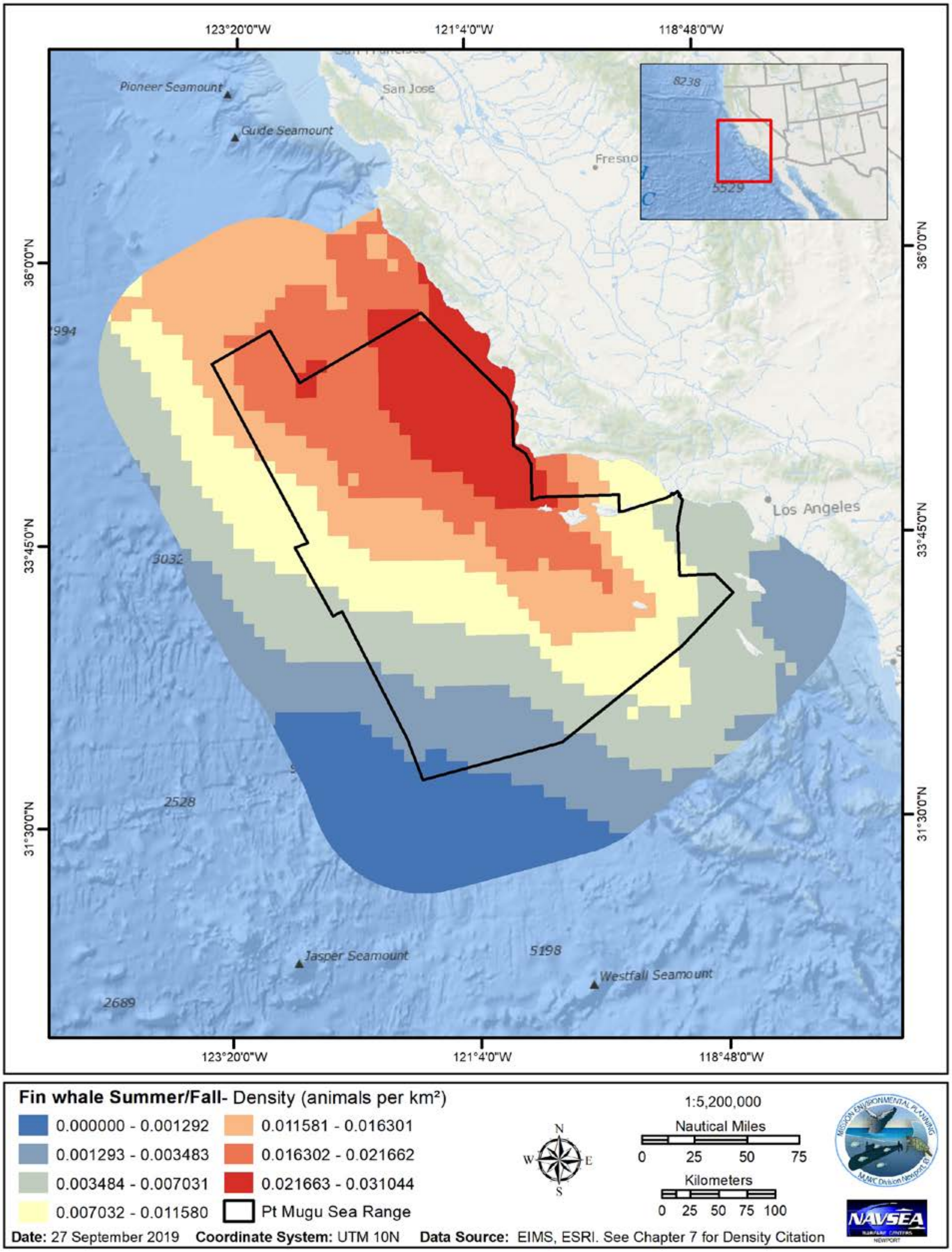

Figure 7-4. Fin Whale Summer/Fall Density in the PMSR

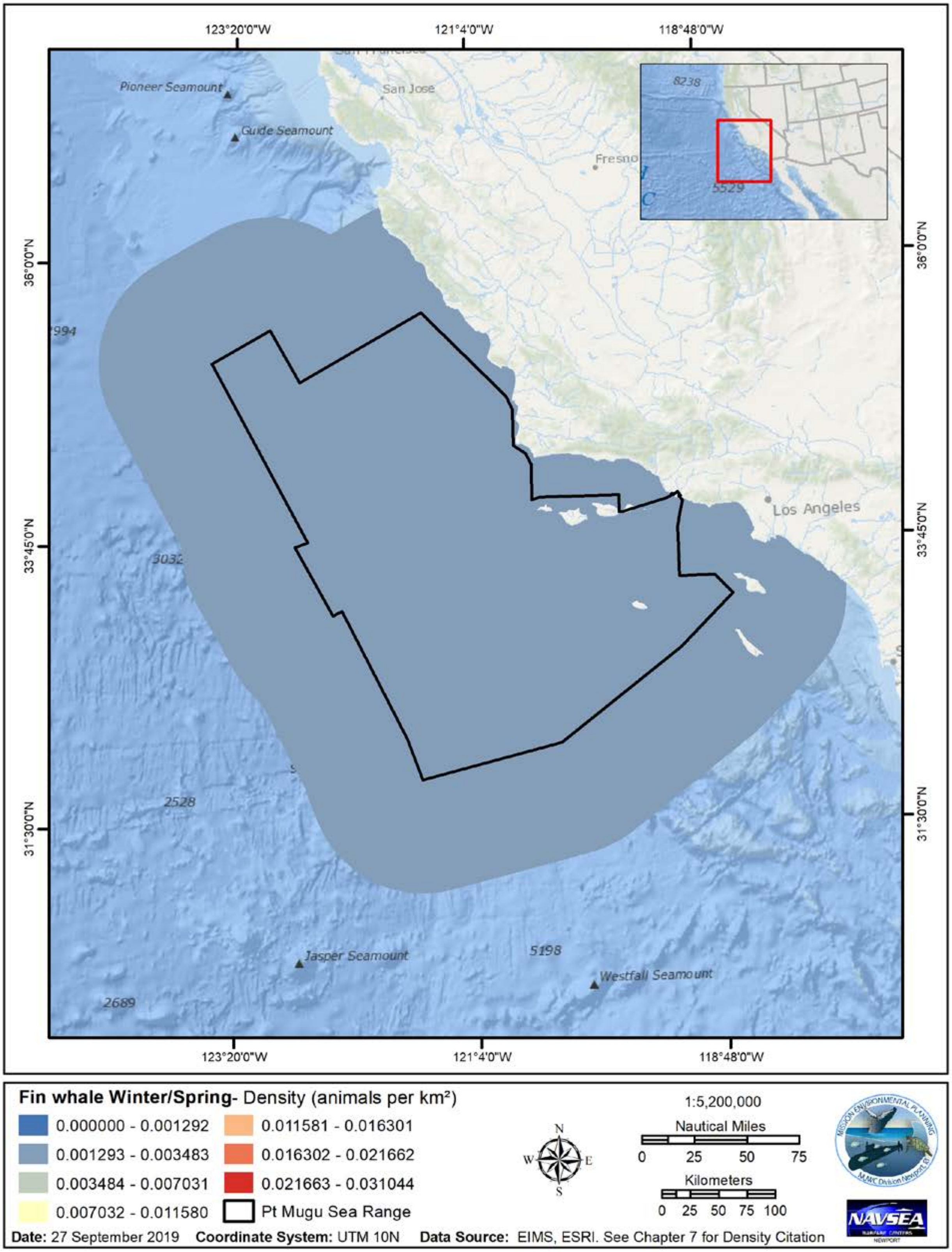

Figure 7-5. Fin Whale Winter/Spring Density in the PMSR

7.1.4 Gray Whale, *Eschrichtius robustus*

The NMFS recognizes two stocks of Gray whales in the North Pacific: the larger ENP stock and the highly endangered Western North Pacific stock (Carretta et al. 2019). 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. 2011; Mate et al. 2015). While it is possible that sightings of western population animals might be included in the data used to estimate Gray whale density in the ENP, 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 available and all animals are assumed to belong to the ENP stock of Gray whales (Department of the Navy 2017). Shelden and Laake (2002) estimated that, along the coast, 95.24 percent of Gray whales were within 2.24 nmi of the coast during migration and 4.76 percent were between 2.25 and 20 nmi from the coast. In order to generate spatially accurate density estimates, the Navy identified regions for Gray whales consistent with the literature where density values could be assigned. An inshore region was designated that extended across the Southern California Bight (i.e., from Point Conception to just south of the United States-Mexico border (Dailey et al. 1993) to approximately 5 nmi west of the Channel Islands. An offshore region was designated that extended an additional 20 nmi to the west (i.e., 25 nmi west of the Channel Islands).

Seasonal Gray whale densities and geographic boundaries for the PMSR are provided in Figures 7-6 through 7-12. These densities and geographic boundaries are based on the migratory corridor Gray whales use during their southbound and northbound migration and are appropriate for the entire U.S. West Coast. Therefore, the densities available in NMSDD are applicable to the entire PMSR.

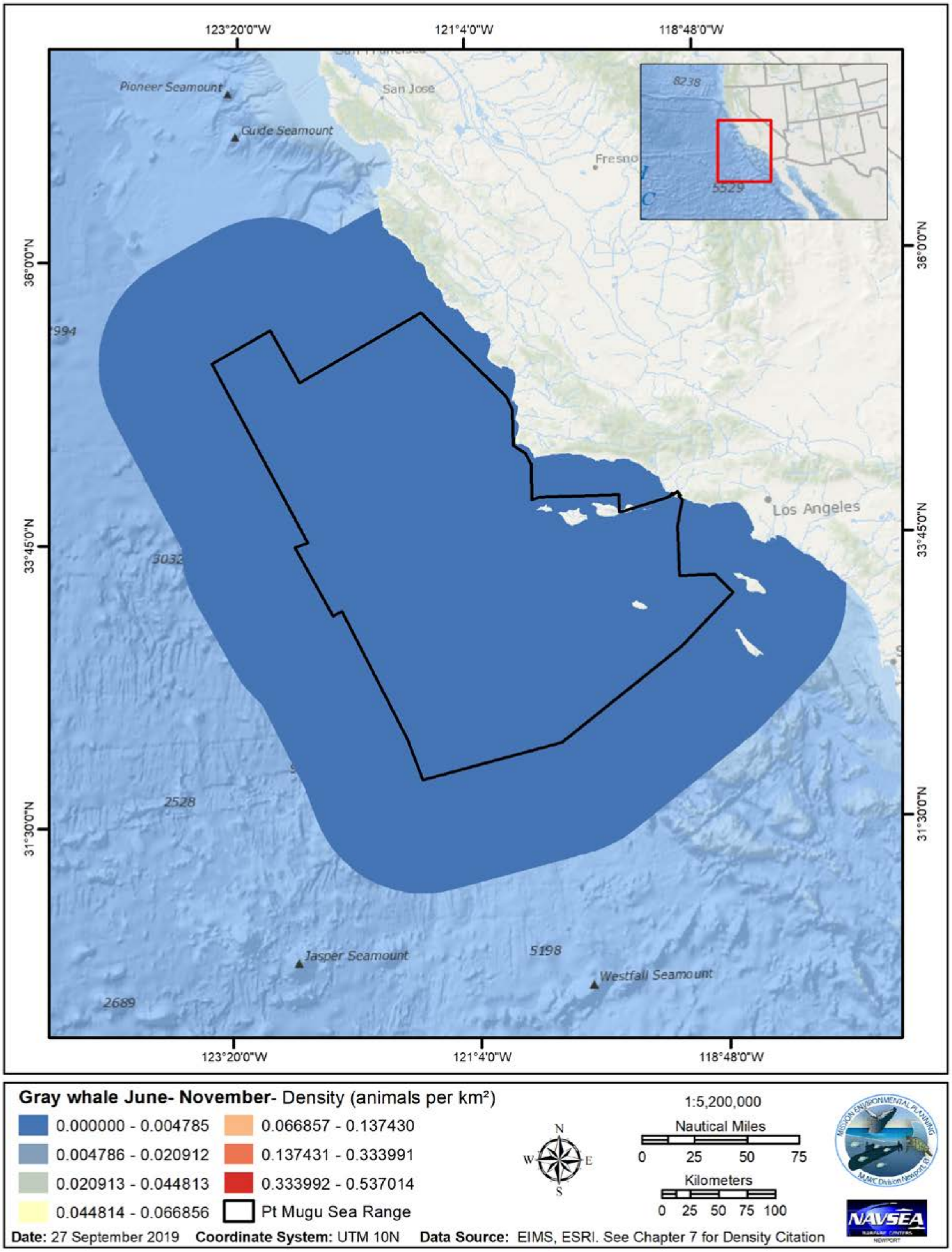

Figure 7-6. Gray Whale June to November Density in the PMSR

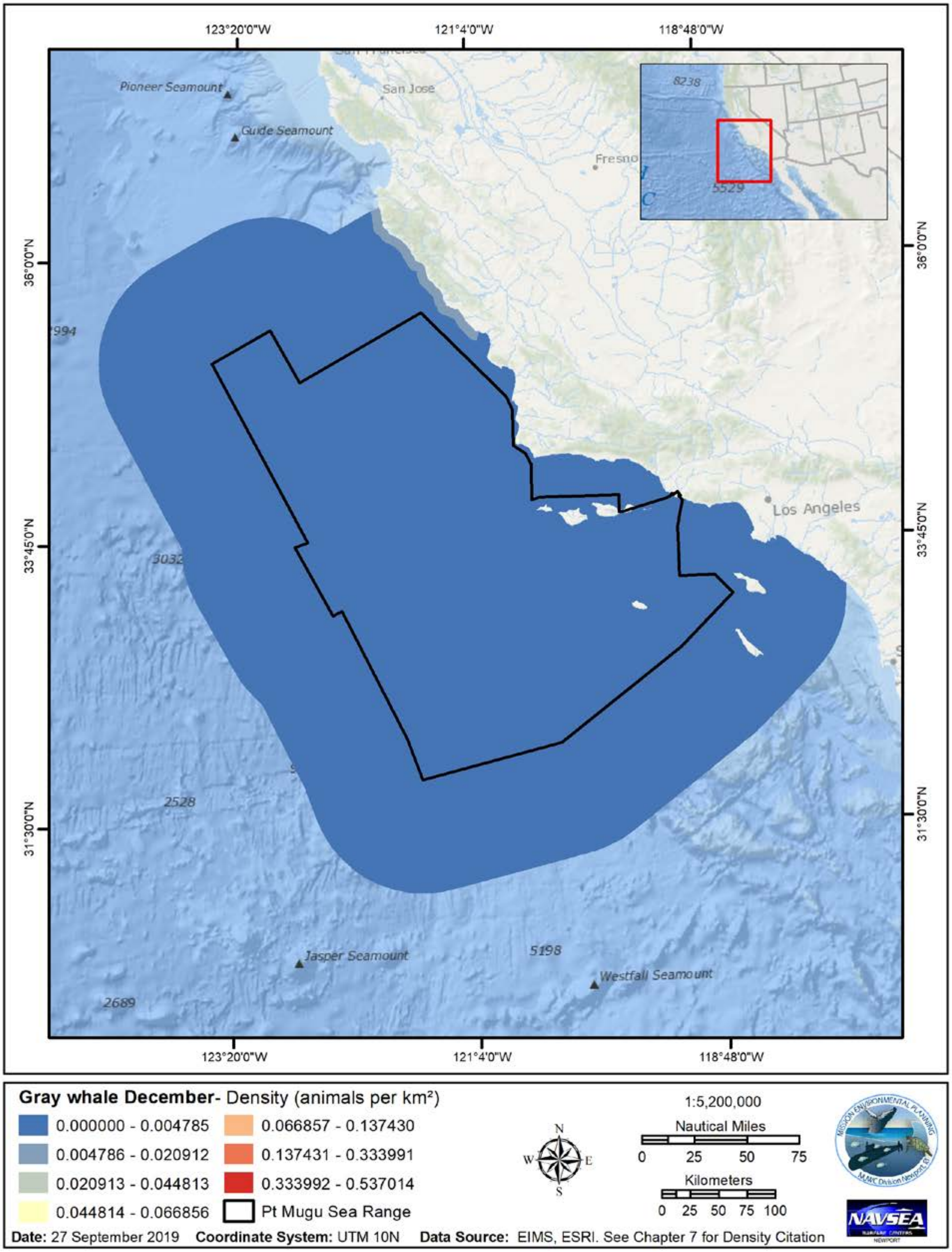

Figure 7-7. Gray Whale December Density in the PMSR

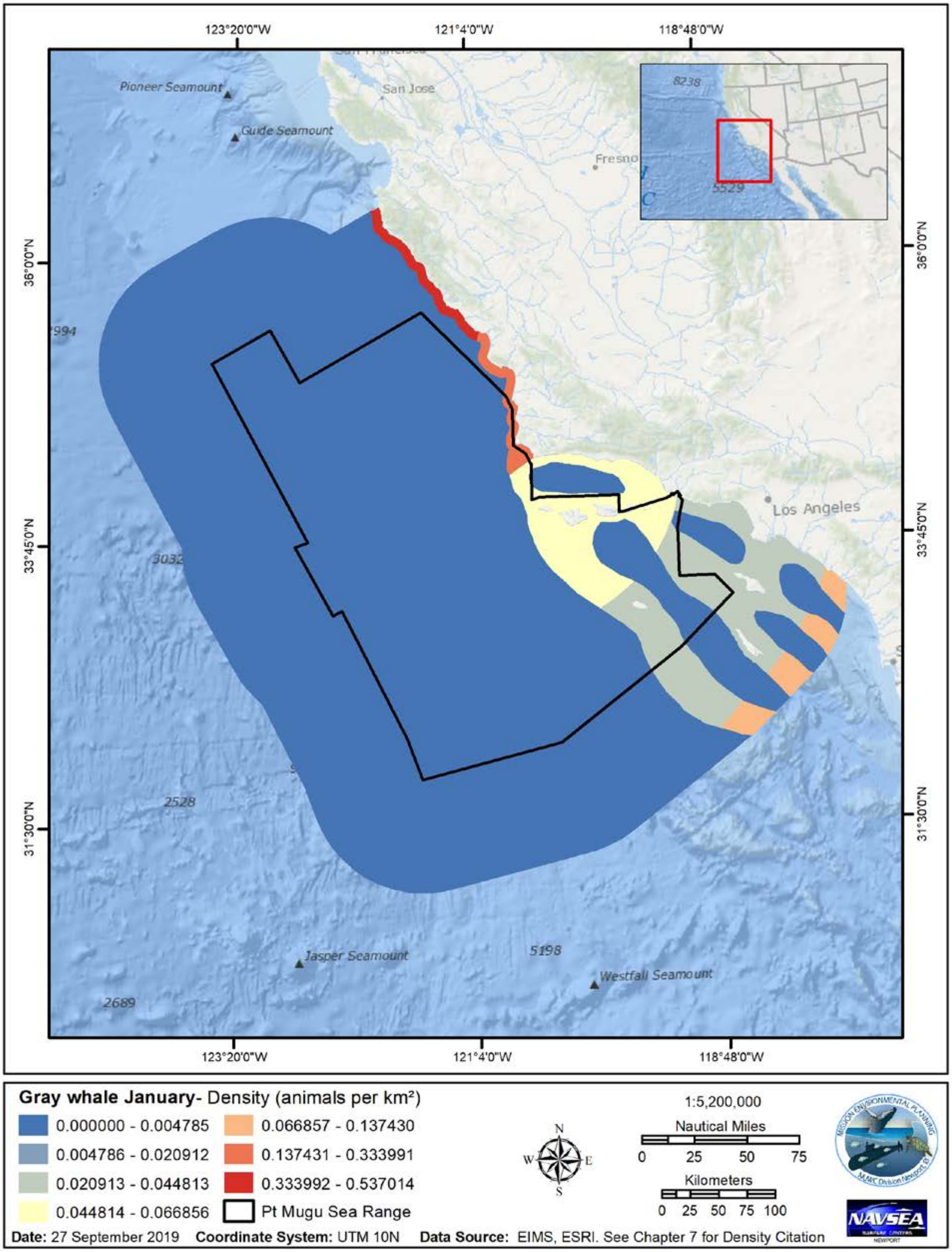

Figure 7-8. Gray Whale January Density in the PMSR

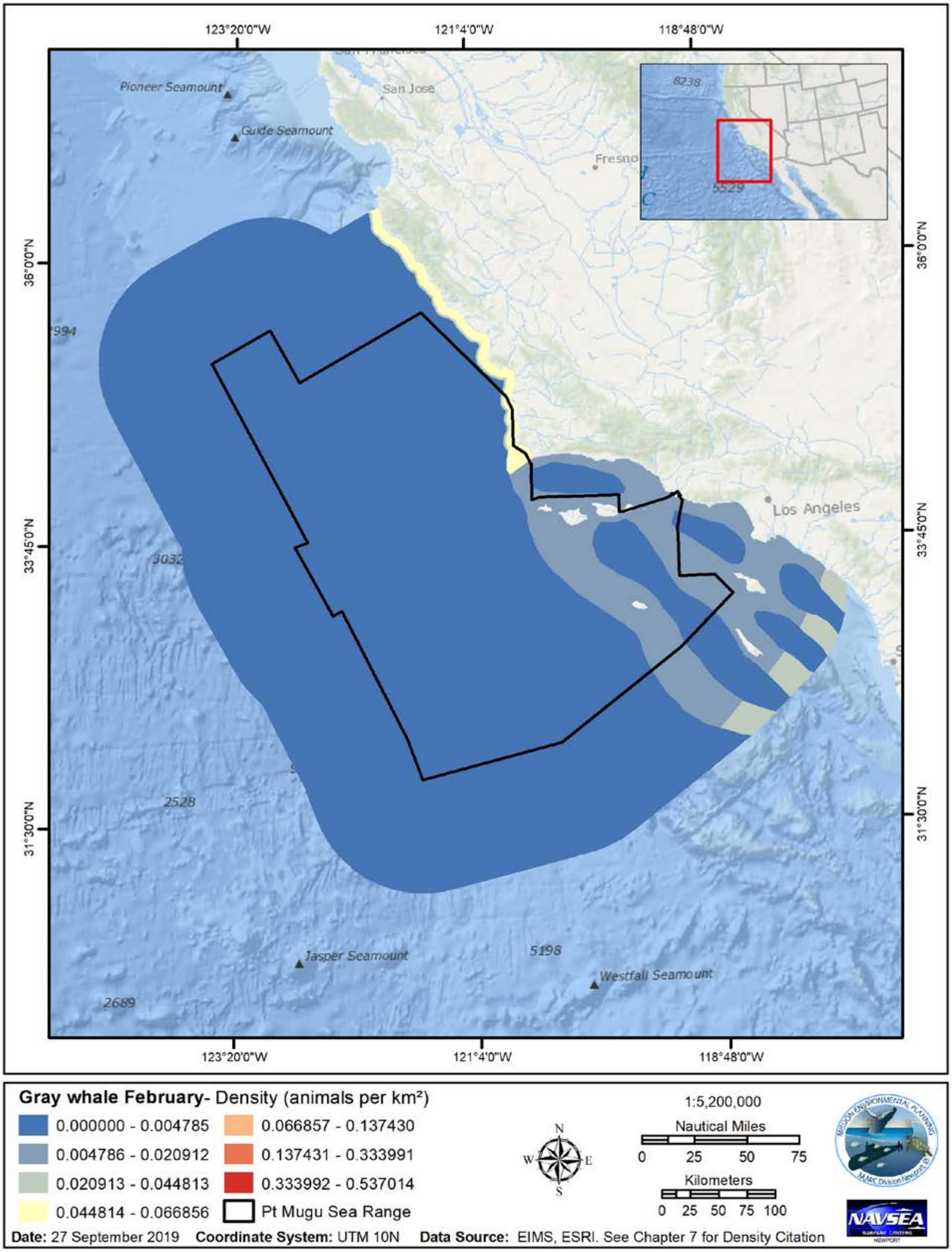

Figure 7-9. Gray Whale February Density in the PMSR

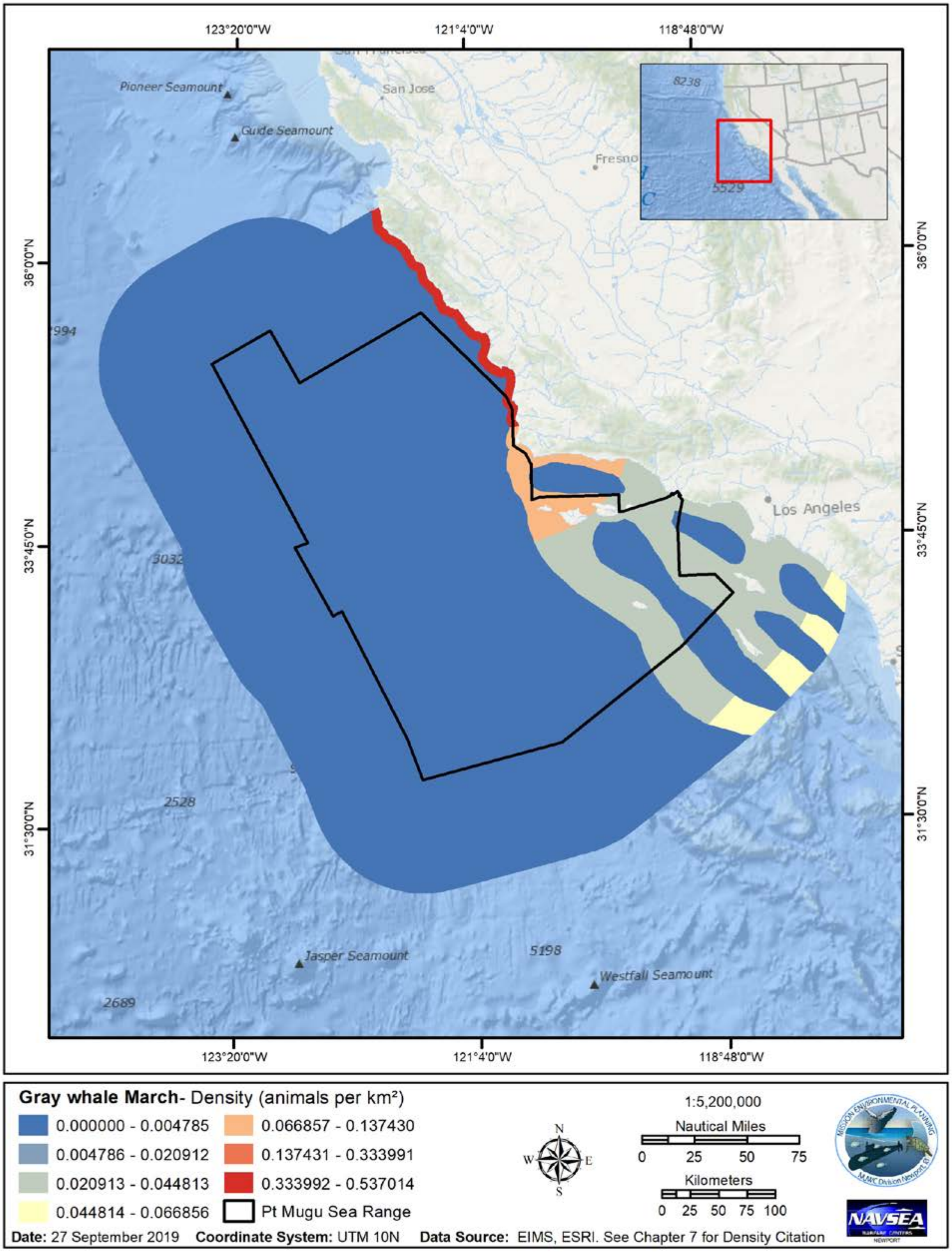

Figure 7-10. Gray Whale March Density in the PMSR

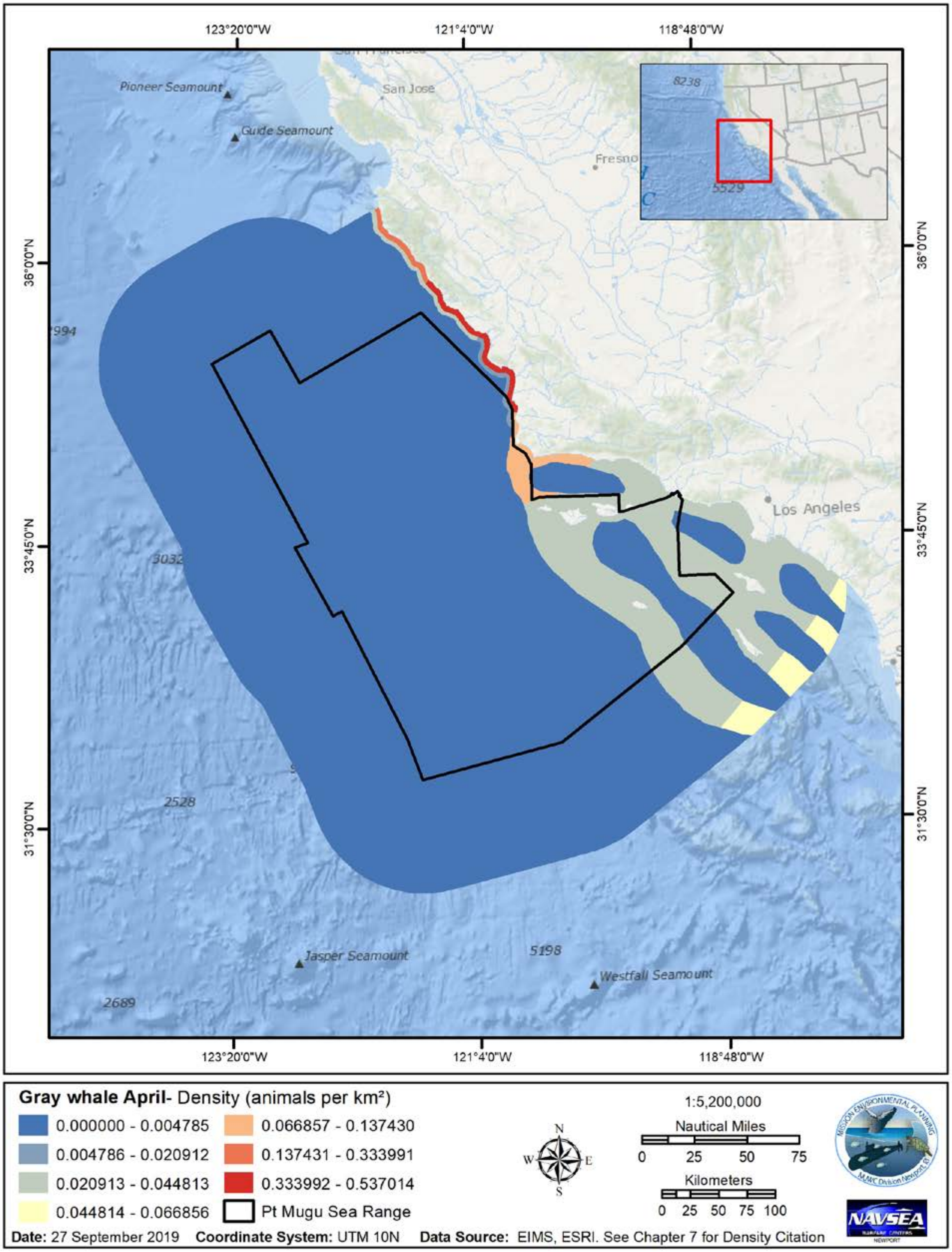

Figure 7-11. Gray Whale April Density in the PMSR

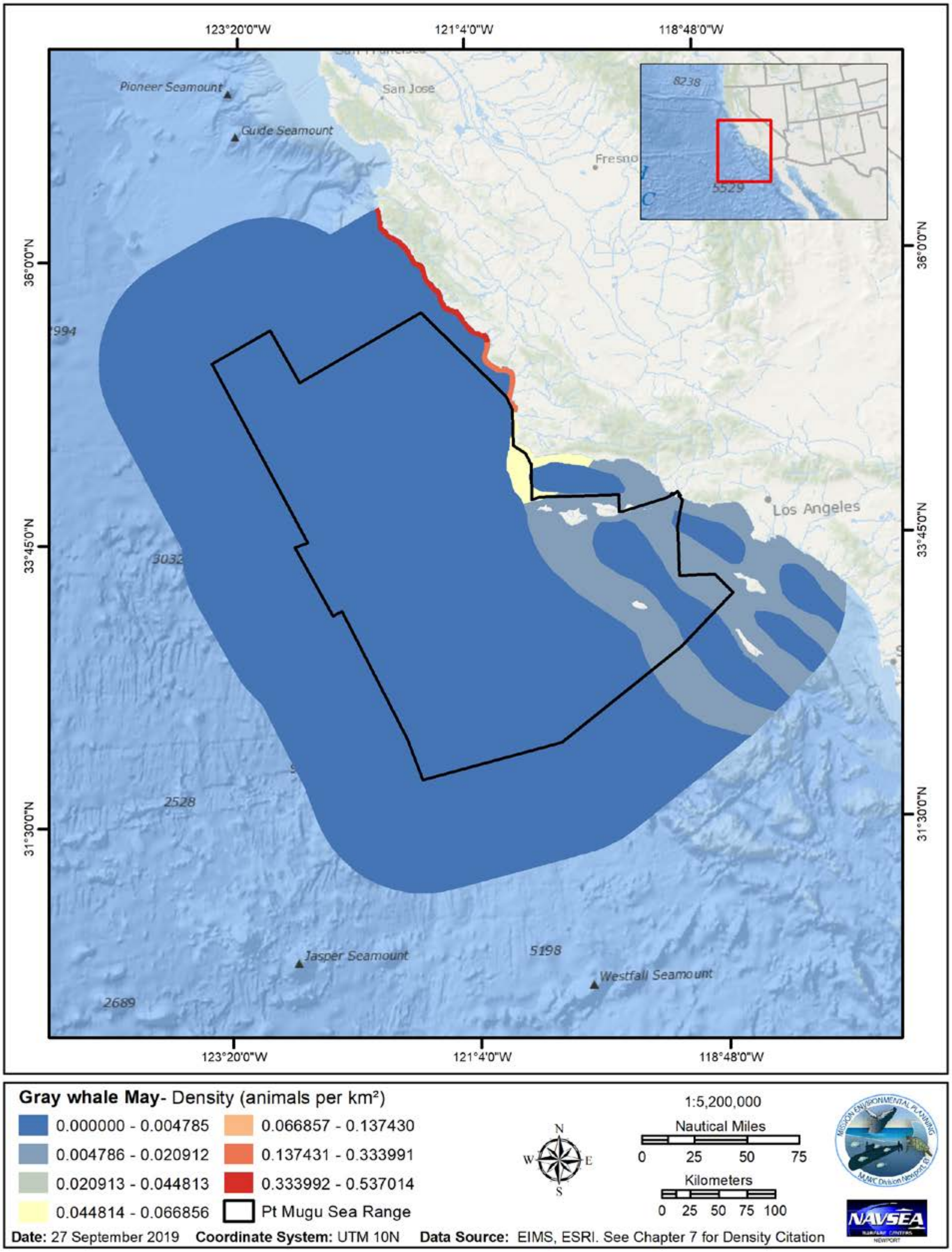

Figure 7-12. Gray Whale May Density in the PMSR

7.1.5 Humpback Whale, *Megaptera novaeangliae*

In the Pacific, the NMFS previously divided humpback whales into four stocks. On 11 October 2016, the NMFS's Final Rule was published (81 Federal Register [FR] 62259) to divide the species into 14 Distinct Population Segments (DPSs) worldwide, four of which occur in the North Pacific: (1) Western North Pacific, (2) Hawaii, (3) Mexico, and (4) Central America. The NMFS is evaluating the stock structure of humpback whales under the Marine Mammal Protection Act, but no changes to current stock structure are presented at this time. Along the U.S. West Coast, one stock, the CA/OR/WA stock, is currently recognized which includes two separate feeding groups. Only the California and Oregon feeding group of whales that belong to the Central American and Mexican DPSs defined under the Endangered Species Act (ESA) (81 FR 62259) is expected to overlap with the PMSR. The CA/OR/WA stock of humpback whales is present in the PMSR as they migrate northward from their winter breeding grounds in Mexico and Central America and then again when migrating southward in their return from feeding areas along the U.S West Coast, British Columbia, and Alaska (Carretta et al. 2018; Carretta et al. 2019).

The NMSDD included a habitat-based density model for humpback whales across the entire PMSR during the summer/fall season (Figure 7-13), and winter/spring (Figure 7-14). Humpback whale habitat occurs in productive coastal waters characterized by cold temperatures, low salinities, and high chlorophyll concentrations (Redfern et al. 2013) which varies seasonally and interannually. Humpback whale distribution may shift year to year and between seasons (Becker et al. 2017; Redfern et al. 2013). While applying the habitat-based density model may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

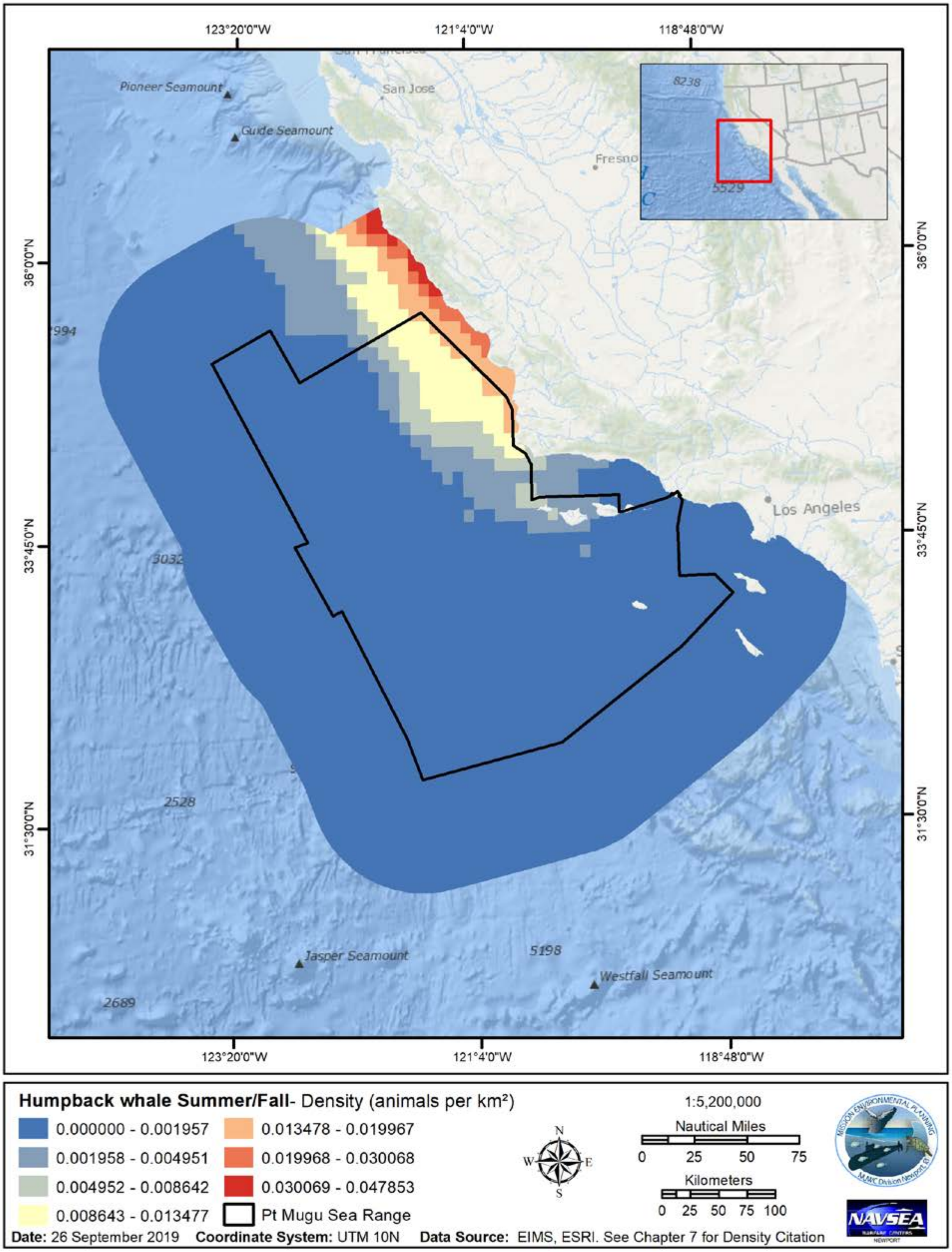

Figure 7-13. Humpback Whale Summer/Fall Density in the PMSR

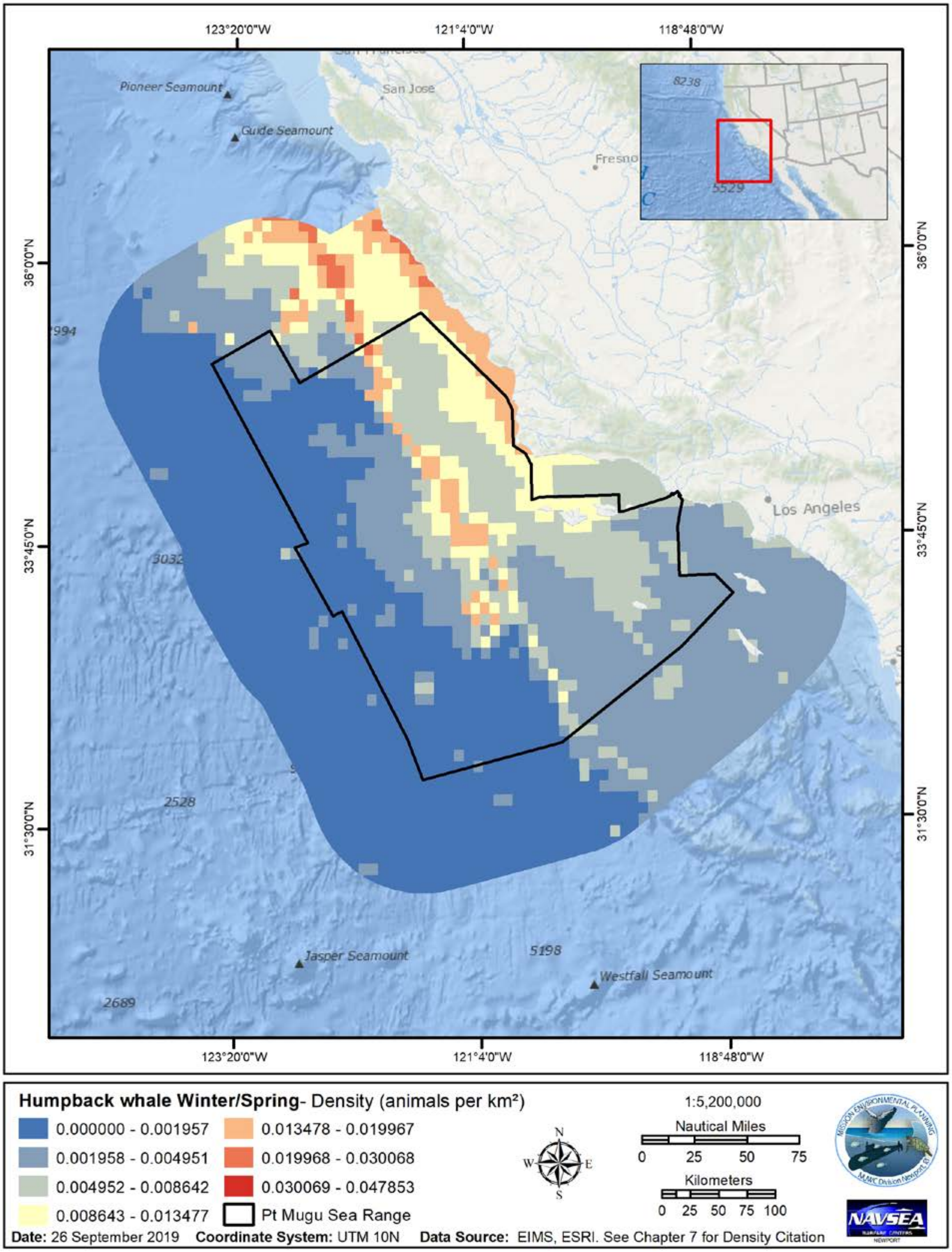

Figure 7-14. Humpback Whale Winter/Spring Density in the PMSR

7.1.6 Minke Whale, *Balaenoptera acutorostrata*

The NMFS has designated three stocks of minke whale in the North Pacific: (1) the Hawaii stock, (2) the CA/OR/WA stock, and (3) the Alaska stock (Carretta et al. 2019). Minke whales occur year-round in California (Barlow 1997; Dohl et al. 1983; Forney et al. 1995) and in the Gulf of California (Tershy et al. 1990). Minke whales are present at least in summer/fall along the Pacific coast of Baja California (Wade and Gerrodette 1993). Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales further north, minke whales in coastal waters of California, Oregon, and Washington (including Puget Sound) are considered as a separate stock. However, density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in PMSR are from the CA/OR/WA stock.

The NMSDD included uniform density for minke whales for all seasons (Figure 7-15); however, based on what is known about minke whale distribution their occurrence likely varies seasonally in the PMSR. Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

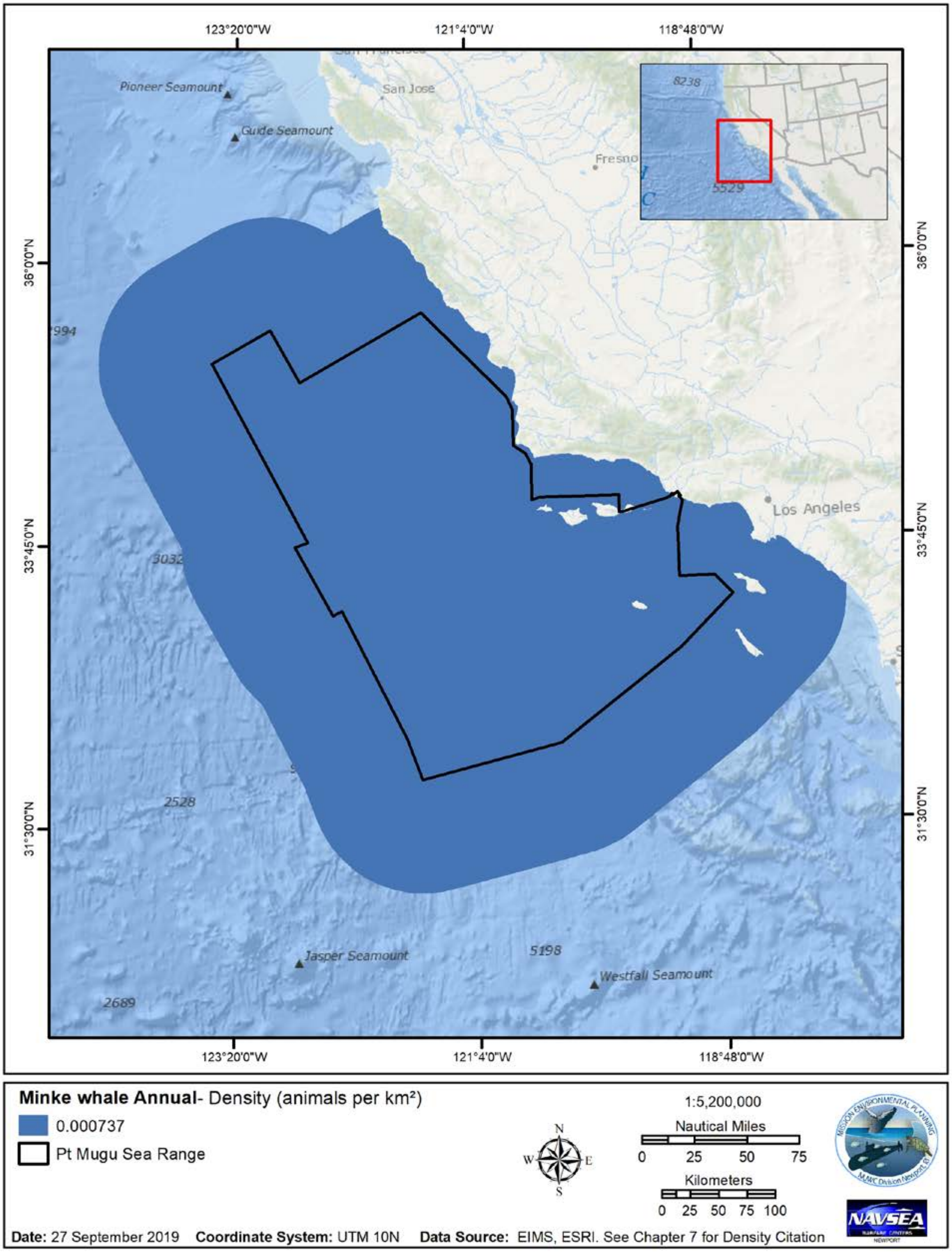

Figure 7-15. Minke Whale Annual Density in the PMSR

7.1.7 Sei Whale, *Balaenoptera borealis*

The NMFS recognizes two stocks of Sei whales in the U.S. Pacific, the ENP stock and the Hawaii stock (Carretta et al. 2019). Only the ENP stock is expected in the PMSR. However, density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling.

NMSDD included an annual Sei whale density (Figure 7-16), though Sei whale occurrence is likely driven by seasonal and inter-annual changes in climate and oceanographic conditions. Although Sei whales prefer deep waters, tend to stay farther offshore, and are considered rare in Southern California, they have been observed in the Southern California Bight in summer/fall as they typically travel to lower latitudes in the winter. Very little is known about their presence in the PMSR. Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers this uniform annual density to be the most conservative.

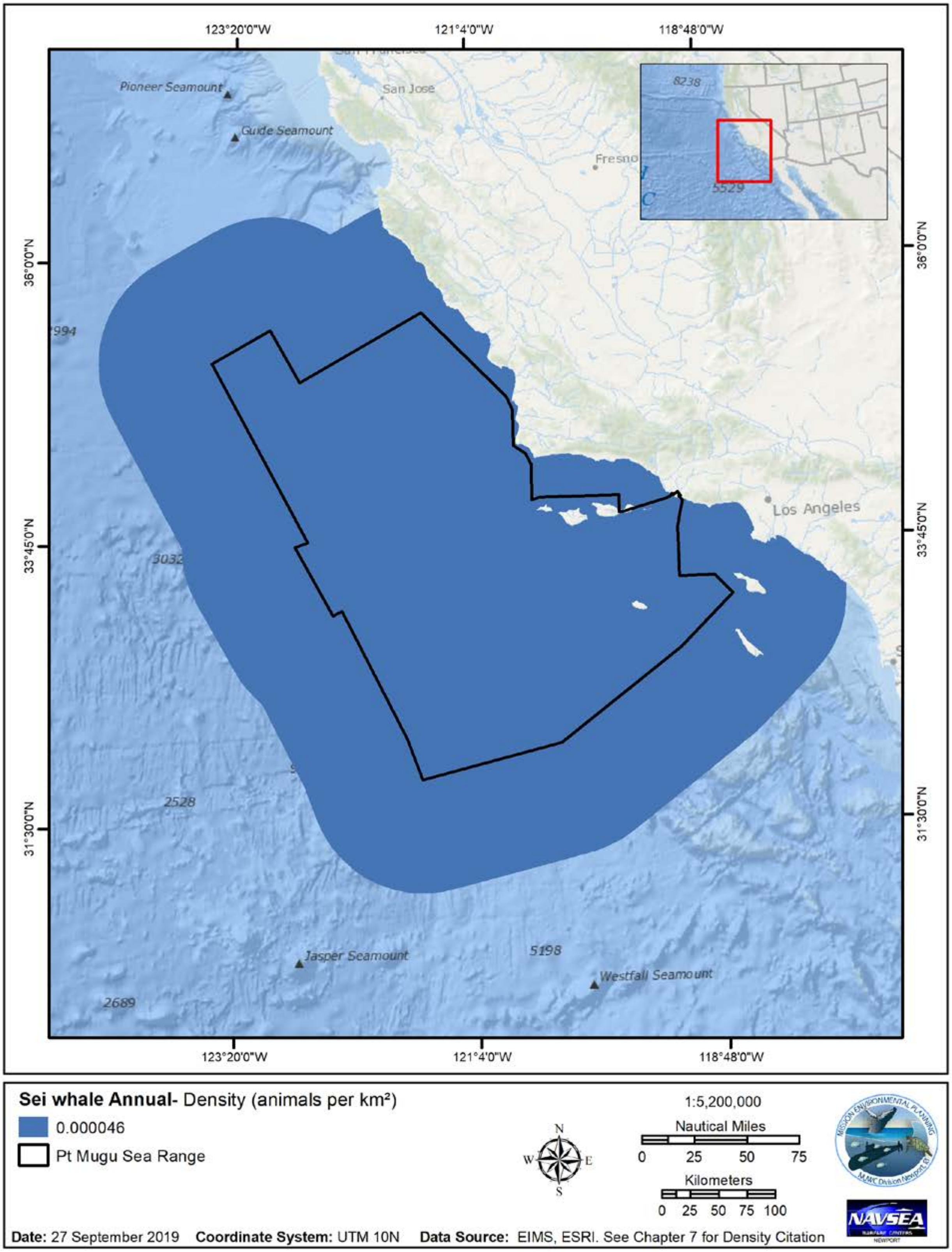

Figure 7-16. Sei Whale Annual Density in the PMSR

7.2 Odontocetes

7.2.1 Beaked Whale Species

The Beaked whale is problematic in terms of establishing values for the marine species density database because of their relative scarcity and the difficulty of distinguishing species at sea. Researchers have addressed these problems primarily by pooling the data into groups by either family or size. 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 having density data for some species until sufficient data exist because the Navy needs to be able to quantify its interactions with all species of concern in its operation areas.

There are a myriad of Beaked whales 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 the NMFS to represent seven species of beaked whale that are seen or successfully identified very rarely in the California Current Ecosystem (CCE). This guild is used to represent density for the PMSR Study Area.

7.2.1.1 Baird's Beaked Whale, *Berardius bairdii*

Two stocks of Baird's Beaked whale are recognized by the NMFS, an Alaska stock, which covers a large part of the North Pacific, and a CA/OR/OR stock that is found primarily in the CCE (Carretta et al. 2019). The latter stock is the only one expected to occur within the PMSR. However, very little is known about their presence in the PMSR. Baird's Beaked whales may prefer continental shelf and sea mount habitat (Jefferson et al. 2015). However, density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in PMSR are from the CA/OR/WA stock.

NMSDD included a habitat-based annual density for Baird's Beaked whale (Department of the Navy 2017) across the PMSR for all seasons (Figure 7-17). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers this annual density to be the most conservative.

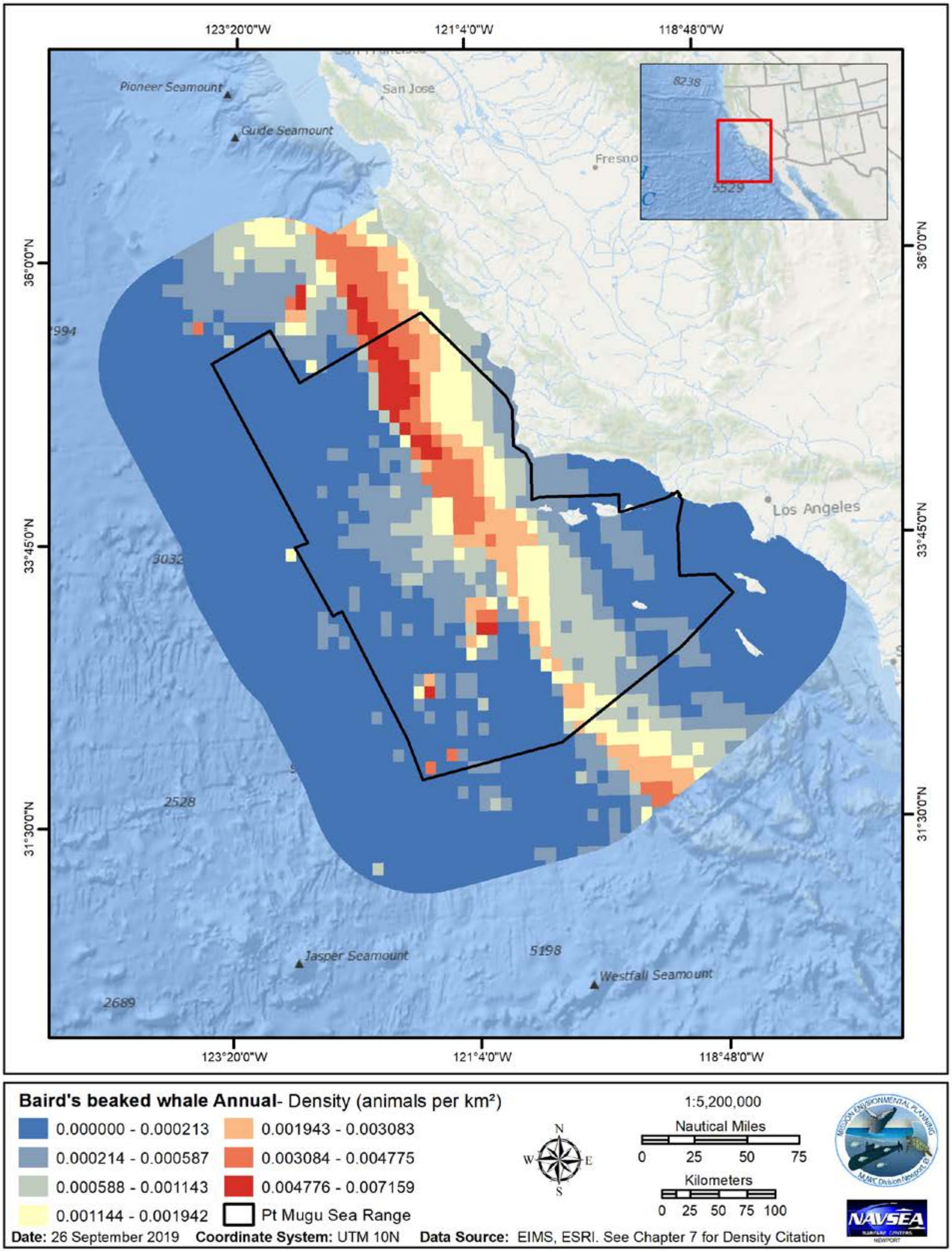

Figure 7-17. Baird's Beaked Whale Annual Density in the PMSR

7.2.1.2 Small Beaked Whale Guild

There are numerous Beaked whale species known or suspected to be present off the U.S. West Coast, but they are often rarely seen and difficult to identify. To increase sample sizes for modeling, the NMFS 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 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 (*Mesoplodon peruvianus*), Stejneger's Beaked whale (*Mesoplodon stejnegeri*), and Cuvier's Beaked whale. This guild was used to represent the annual, habitat-based density model (Figure 7-18) for the PMSR Study Area (Department of the Navy 2017). This value is considered the best available science due to a paucity of any other data. The Navy considers this annual density to be the most conservative.

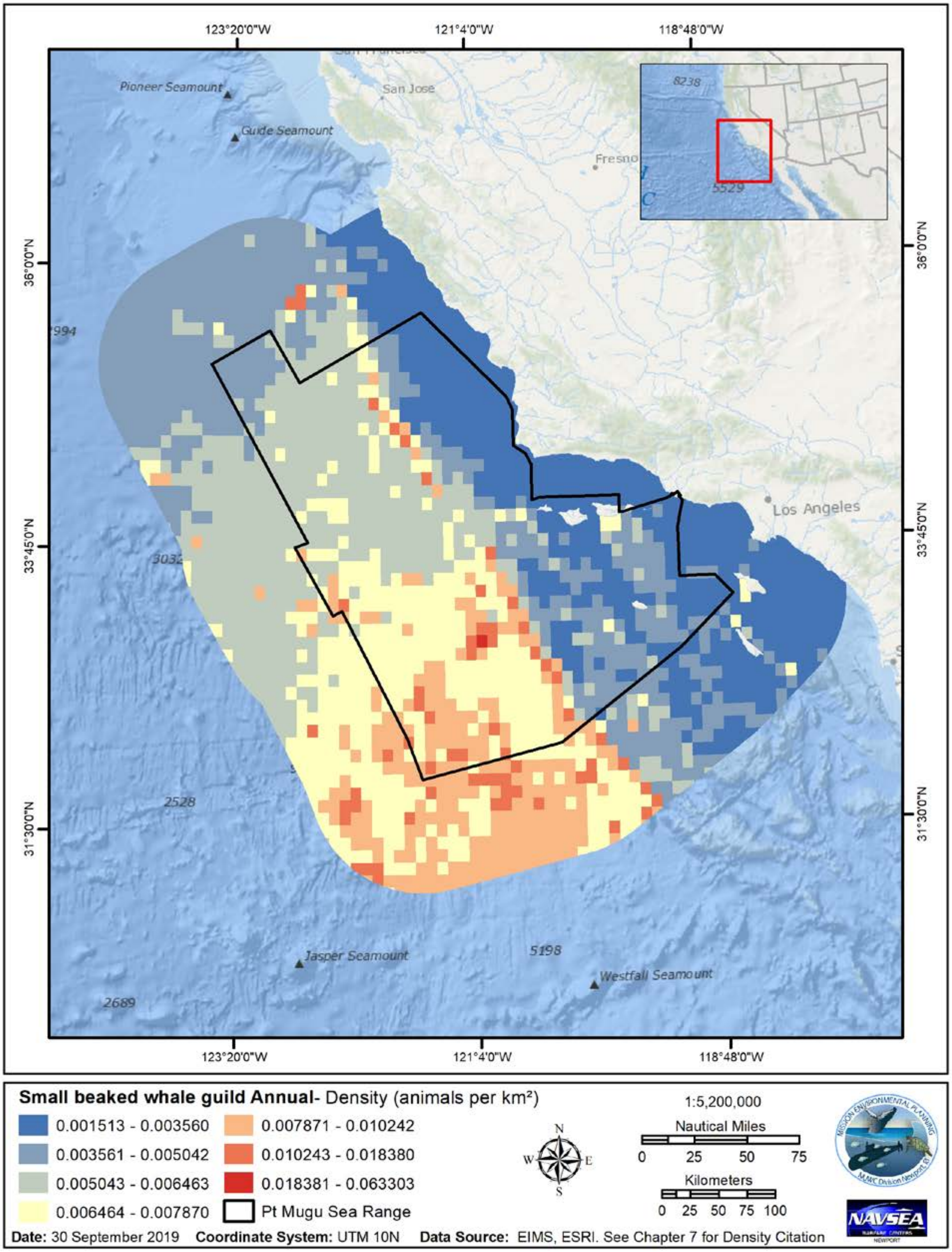

Figure 7-18. Small Beaked Whale Guild Annual Density in the PMSR

7.2.2 Bottlenose Dolphin (Coastal Stock), *Tursiops truncatus*

The basic division in bottlenose dolphin populations is often between offshore and coastal forms (Baird et al. 1993; Wells and Scott 1999). The NMFS recognizes two stocks and one stock complex of bottlenose dolphins in Pacific U.S. waters: a Hawaiian Island Stock Complex, a CA/WA/OR Offshore stock, and a California Coastal stock (Carretta et al. 2019). The California coastal stock of bottlenose dolphins is distinct from the offshore stock, based on significant differences in genetics and cranial morphology (Lowther-Thieleking et al. 2015; Perrin et al. 2011). California coastal bottlenose dolphins are found within about one kilometer of shore (Carretta et al. 1998; Defran et al. 1999; Hansen 1990) from central California South into Mexican waters, at least as far South as San Quintin, Mexico.

For the PMSR, density values are separated out by the coastal and offshore (see section 9.2.4) stocks. The NMSDD included annual uniform density for coastal bottlenose dolphin (Becker et al. 2016) and are separated into a southern (Figure 7-19) and northern portion (Figure 7-20) of the PMSR for visibility purposes. Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers this annual density to be the most conservative.

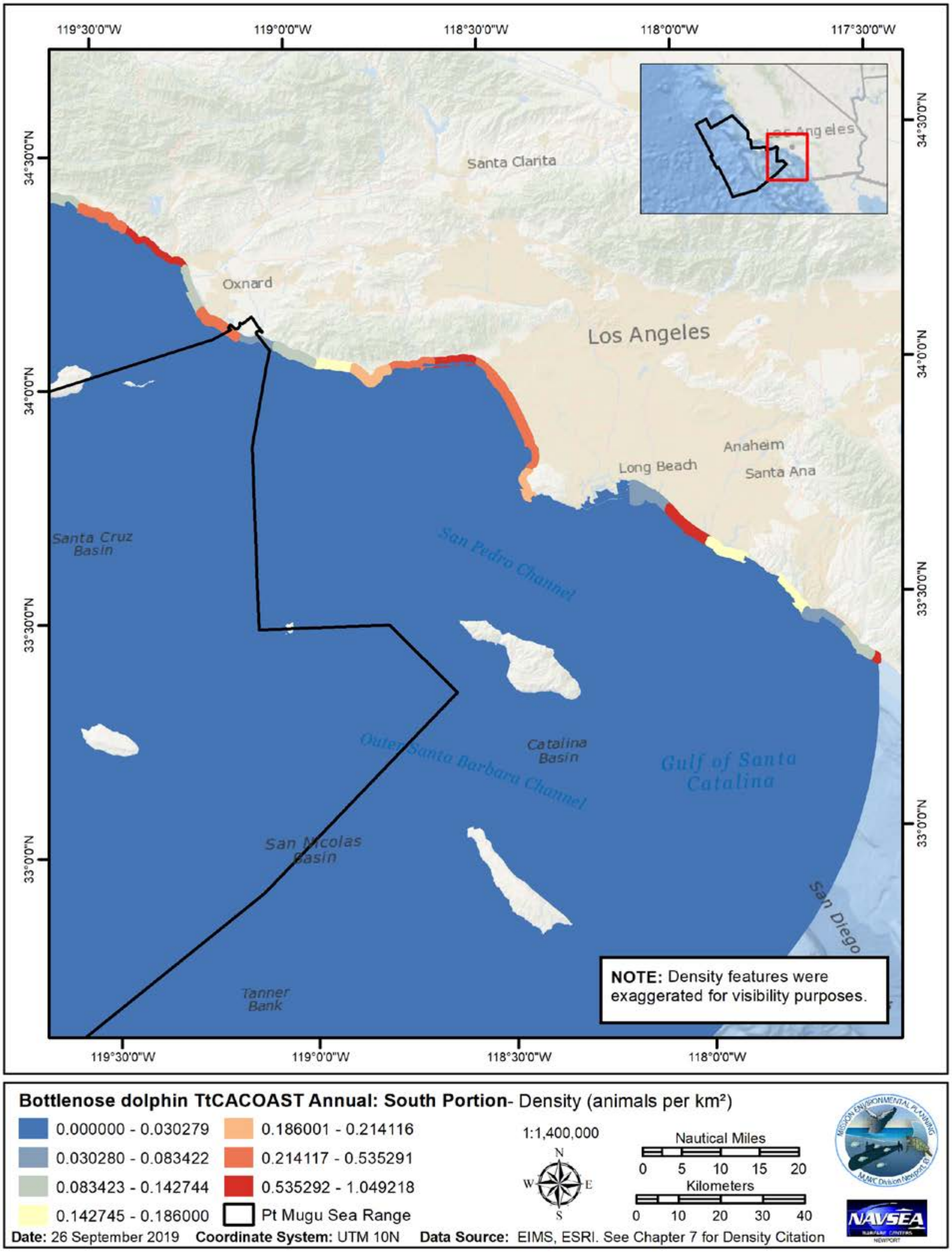

Figure 7-19. Coastal Bottlenose Dolphin Annual Density (Southern Portion) in the PMSR

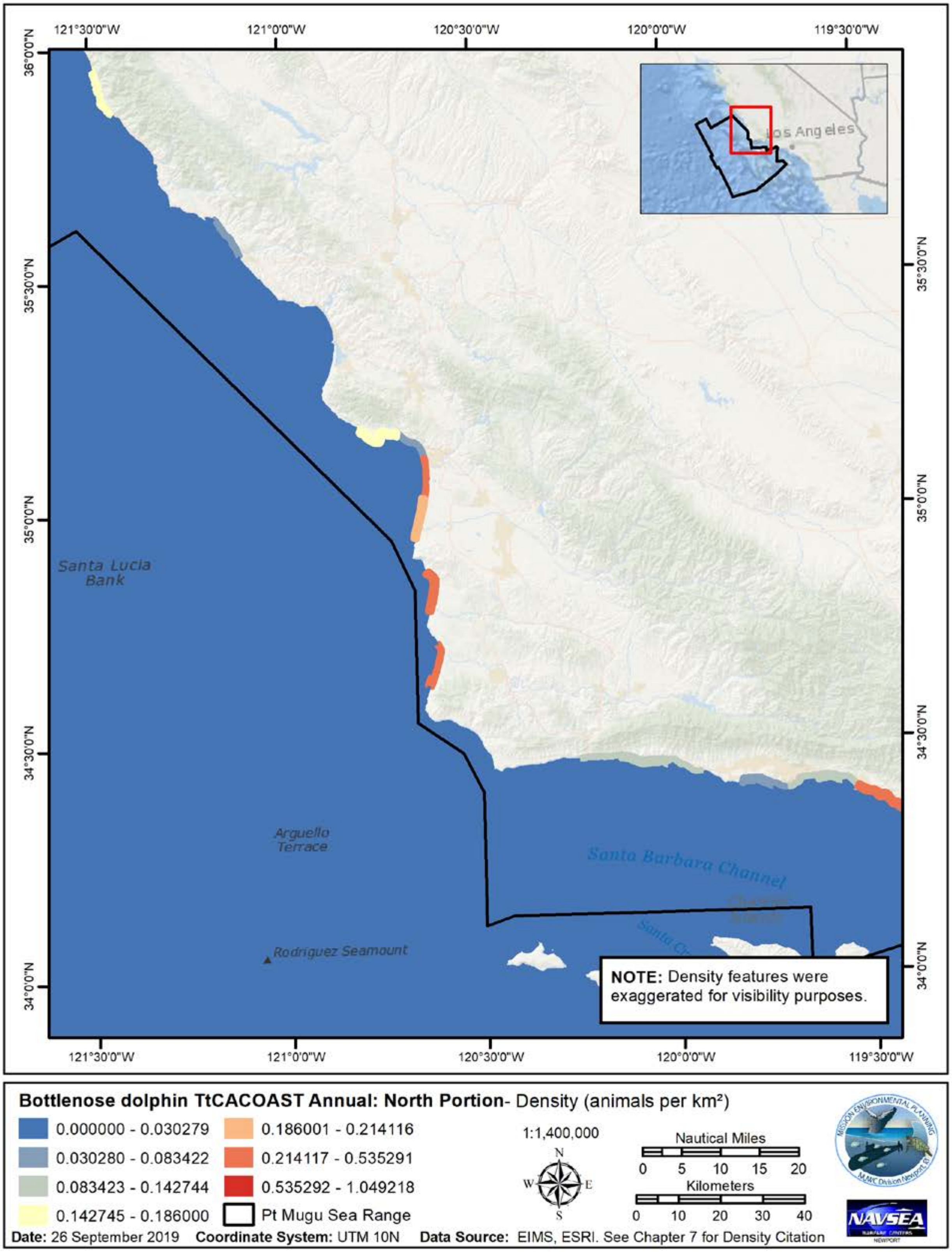

Figure 7-20. Coastal Bottlenose Dolphin Annual Density (Northern Portion) in the PMSR

7.2.3 Bottlenose Dolphin (CA/OR/WA Offshore Stock), *Tursiops truncatus*

The basic division in populations is often between offshore and coastal forms (Baird et al. 1993; Wells and Scott 1999). The NMFS recognizes two stocks and one stock complex of bottlenose dolphins in Pacific U.S. waters: a Hawaiian Island Stock Complex, a CA/OR/WA Offshore stock, and a California Coastal stock (Carretta et al. 2019). On surveys conducted off California, offshore bottlenose dolphins have been found at distances greater than a few kilometers from the mainland and throughout the Southern California Bight. They have also been documented in offshore waters as far North as about 41°N, and they may range into Oregon and Washington waters during warm-water periods. Sighting records off California and Baja California (Lee 1993; Mangels and Gerrodette 1994) suggest that offshore bottlenose dolphins have a continuous distribution in these two regions.

For the PMSR, density values are separated out by the coastal (see Section 7.2.3) and offshore stocks. The NMSDD included a habitat-based density model for CA/OR/WA offshore bottlenose dolphin (Becker et al. 2016) across the entire PMSR for all seasons (Figure 7-21). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers this uniform density to be the most conservative.

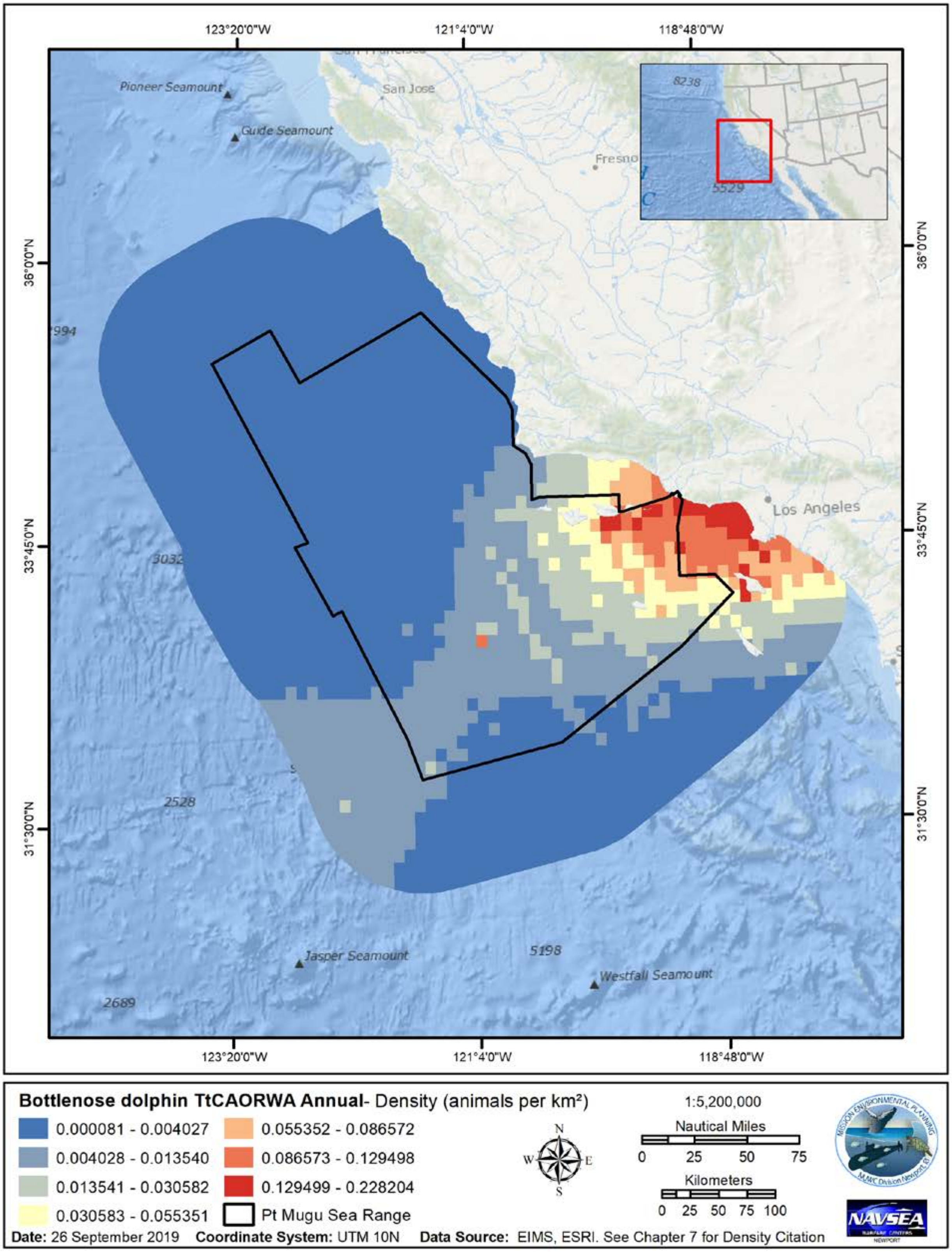

Figure 7-21. CA/OR/WA Bottlenose Dolphin Annual Density in the PMSR

7.2.4 Dall's Porpoise, *Phocoenoides dalli*

The NMFS defines two stocks for Dall's porpoise, an Alaska stock and a CA/OR/WA stock (Carretta et al. 2019). The CA/OR/WA stock is the only stock that is expected in the PMSR. Off the U.S. West Coast, they are commonly seen in shelf, slope, and offshore waters (Morejohn 1979). The southern end of this population's range is not well documented, but they are commonly seen off Southern California in winter, and during cold water periods they probably range into Mexican waters off northern Baja California.

The NMSDD included a habitat-based density model for Dall's porpoise (Becker et al. 2016) across the entire PMSR during the summer/fall season (Figure 7-22) and the winter/spring (Figure 7-23). Dall's porpoise presence in California is dynamic; their distribution shifts South into Southern California when the water temperatures are cool; therefore, their presence is not constant, but dependent on oceanic conditions (Becker et al. 2016; Becker et al. 2014; Forney 2000). While Dall's porpoise distribution would be expected to shift interannually, the density model from the summer/fall was applied to the entire PMSR Study Area. Dall's porpoise distribution in the winter and spring season may also vary (Becker et al. 2017; Fleming et al. 2018). While applying the habitat-based density model may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

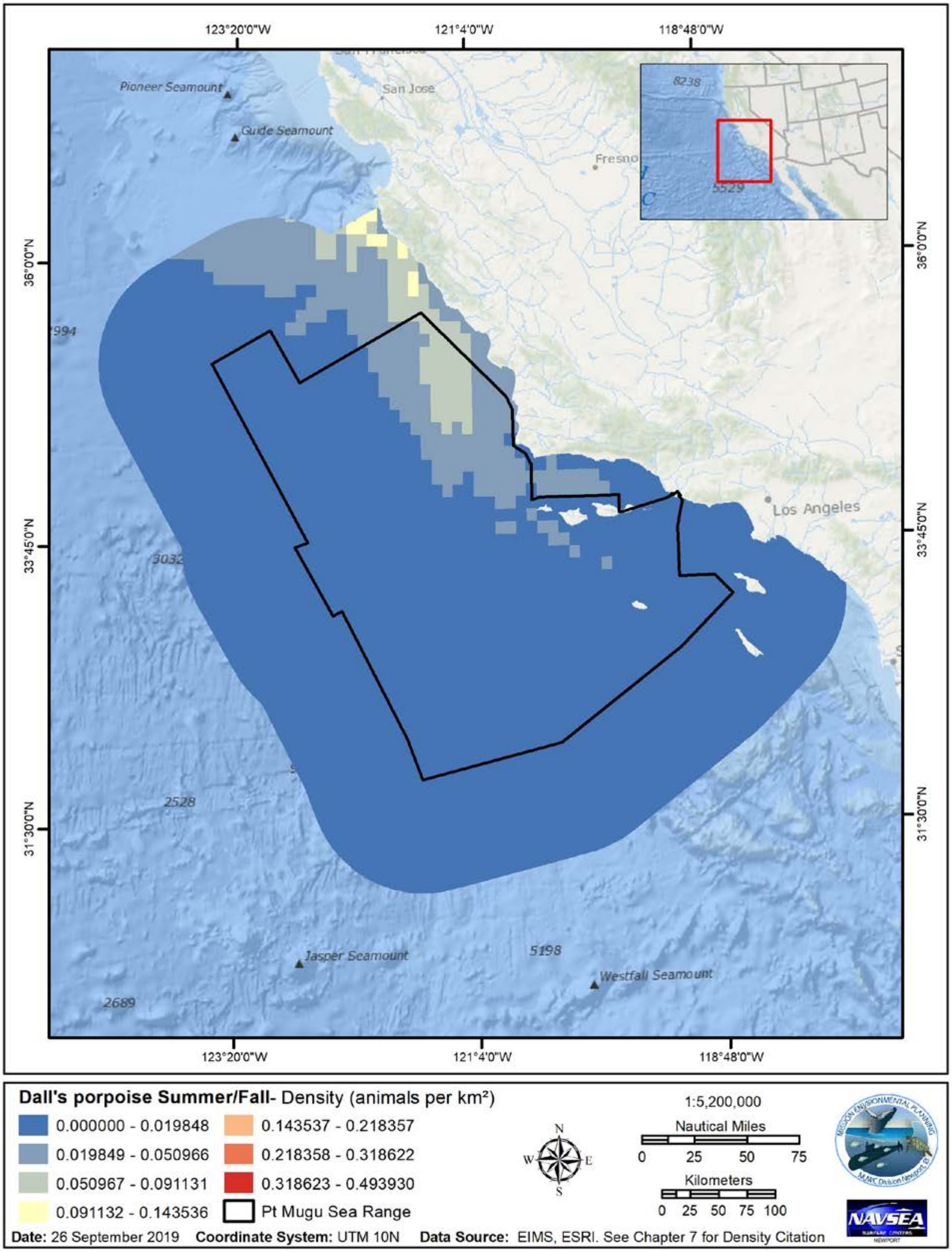

Figure 7-22. Dall's Porpoise Summer/Fall Density in the PMSR

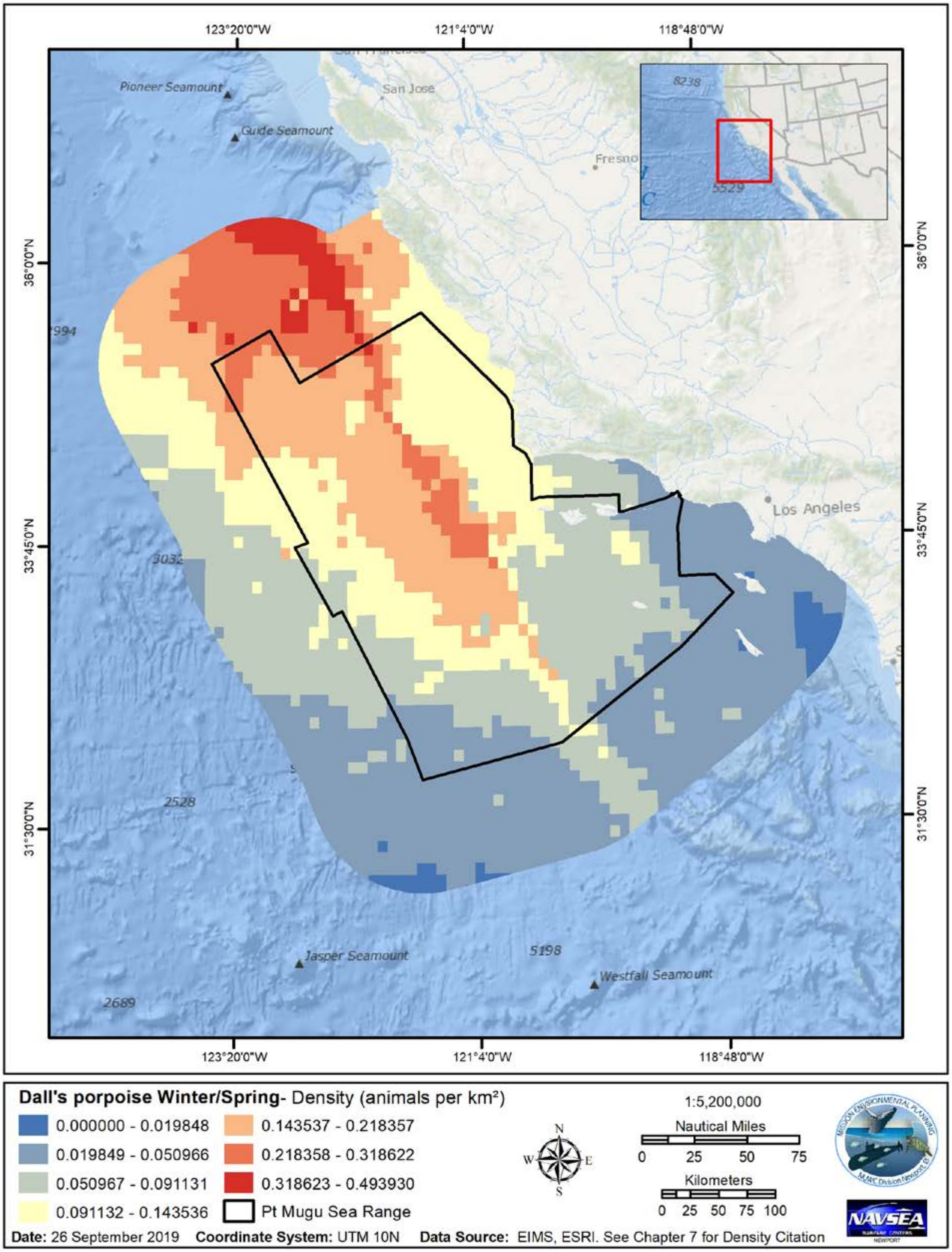

Figure 7-23. Dall's Porpoise Winter/Spring Density in the PMSR

7.2.5 Dwarf Sperm Whale, *Kogia sima*

In U.S. Pacific waters, Dwarf Sperm whales are divided into two stocks by the NMFS: the CA/OR/WA stock and the Hawaii stock (Carretta et al. 2019). The two stocks are considered to be discrete from each other and only the CA/OR/WA stocks of Dwarf Sperm whales would be expected in the PMSR. Few live sightings have occurred off the U.S. West Coast and not enough is known about their seasonal patterns. Therefore, density values for the PMSR Study Area from the summer and fall also provide the best estimate for the winter and spring seasons (Barlow and Forney 2007; Ferguson et al. 2003) and represent an annual density estimate (Figure 7-24). While applying the uniform annual density estimate for all seasons may overestimate Dwarf Sperm whale occurrence in the PMSR, these values are considered the best available science due to a paucity of any other data. The Navy considers these density estimates to be the most conservative.

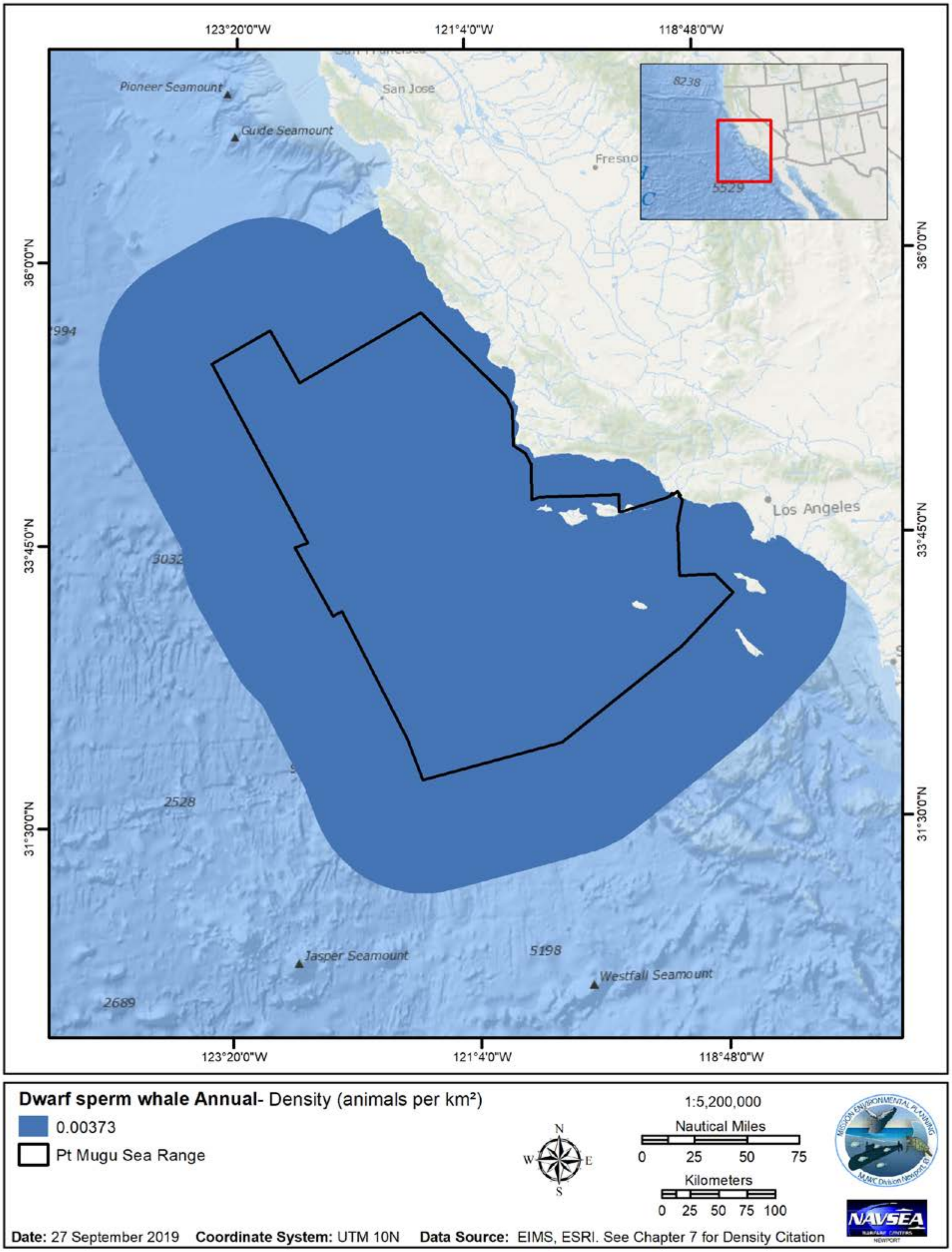

Figure 7-24. Dwarf Sperm Whale Annual Density in the PMSR

7.2.6 Harbor Porpoise, *Phocoena phocoena*

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. The NMFS has defined eight harbor porpoise stocks in California, Oregon, Washington, and Alaska. Only the Morro Bay stock, whose range extends from Point Conception to Big Sur, California, overlaps with the PMSR. The NMSDD did not include density estimates for harbor porpoise. Forney et al. (2014) provided uniform density for harbor porpoise for the species as a whole in California (Figure 7-25). Although these density estimates may not be accurate for PMSR based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

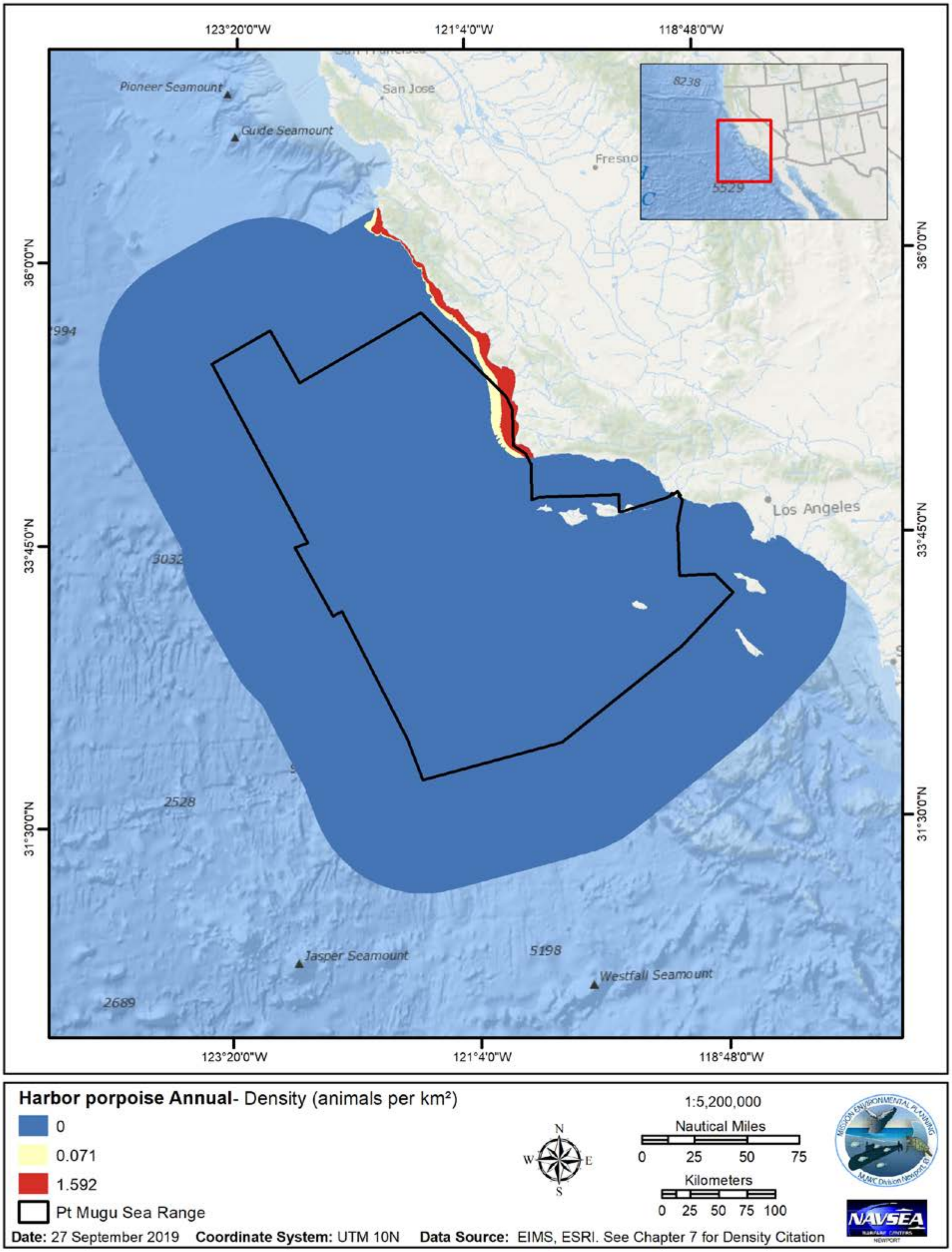

Figure 7-25. Harbor Porpoise Annual Density in the PMSR

7.2.7 Killer Whale, *Orcinus orca*

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 2009; 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). Eight killer whale stocks are recognized within the Pacific U.S. EEZ, including the West Coast Transient stock (Alaska through California); the Offshore stock (Southeast Alaska through California); and the Southern Resident stock (mainly within the inland waters of Washington State and Southern British Columbia, but also in coastal waters from British Columbia through California) (Carretta et al. 2019; Muto 2019). Only two stocks observed in California are expected in the PMSR, the offshore and West Coast Transient stocks.

Annual uniform density values for killer whales are available in the PMSR Study Area for all seasons (Figure 7-26) from the Southwest Fisheries and Science Center (SWFSC) reports, memoranda, and scientific literature (Department of the Navy 2017). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers the annual density estimate to be the most conservative. However, density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in PMSR are from the offshore and West Coast Transient stocks.

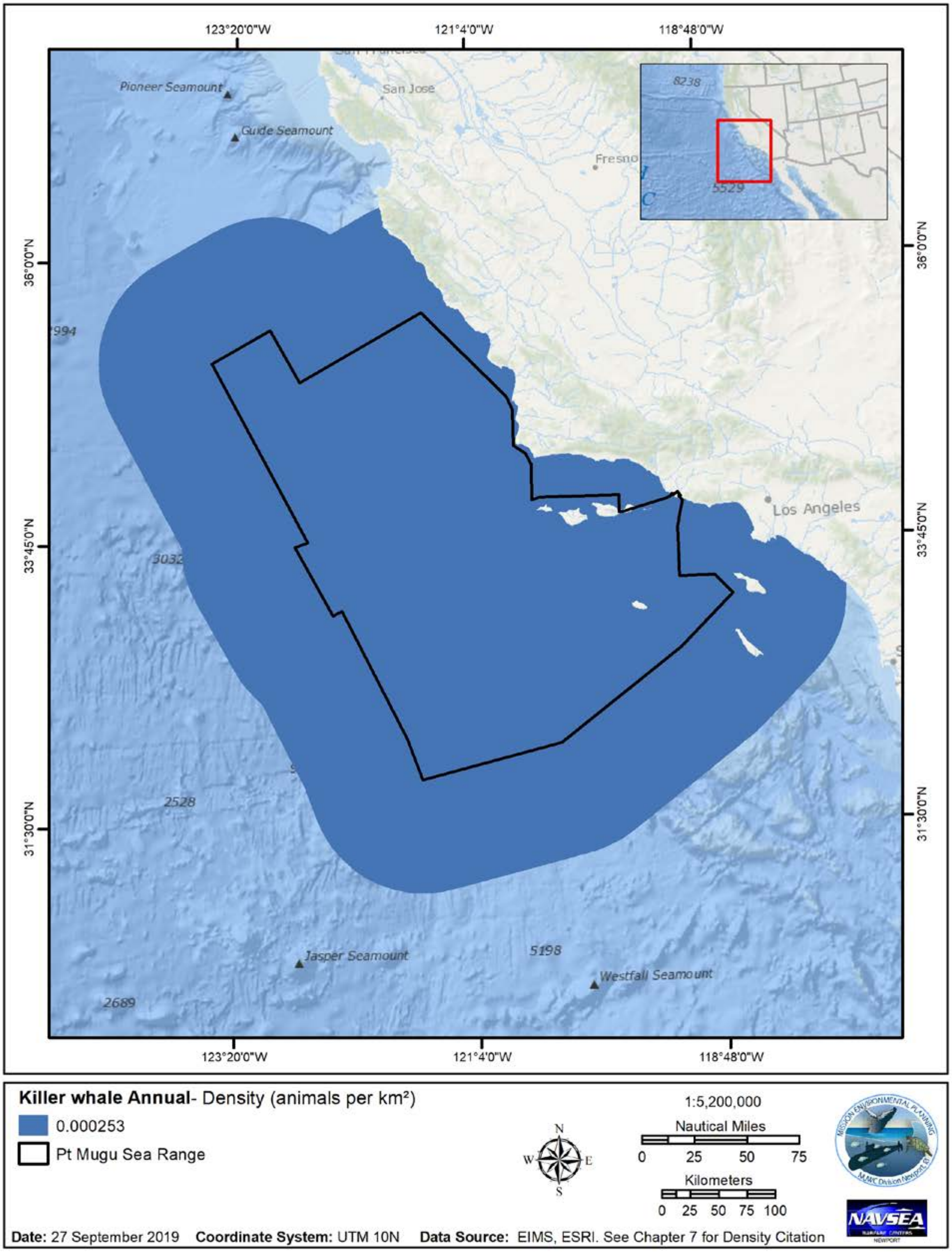

Figure 7-26. Killer Whale Annual Density in the PMSR

7.2.8 Long-Beaked Common Dolphin, *Delphinus delphis bairdii*

The long-beaked common dolphin is known to exhibit seasonal shifts in abundance (mainly North/South) throughout its range off California and Baja, Mexico (Carretta et al. 2019; Heyning and Perrin 1994). The NMFS recognizes a single stock (California stock) of long-beaked common dolphins (Carretta et al. 2019). All of the long-beaked common dolphins in the PMSR are presumed to be from this stock. However, recently the Society for Marine Mammalogy's Committee on Taxonomy grouped all common dolphins into a single species, *Delphinus delphis*, but they are still recognized as a separate subspecies, *Delphinus delphis bairdii*.

Becker et al. (in prep) developed a habitat-based density model for long-beaked common dolphin based on survey data collected off the U.S. West Coast, including the PMSR Study Area. The model provided spatially-explicit density estimates off the U.S. West Coast for summer and fall; however, these density estimates are considered appropriate for all seasons for the PMSR Study Area (Department of the Navy 2017). As such, these same density estimates were applied to the PMSR and represent an annual density estimate (Figure 7-27). The Navy considers these values to be the best available science and conservative density estimates.

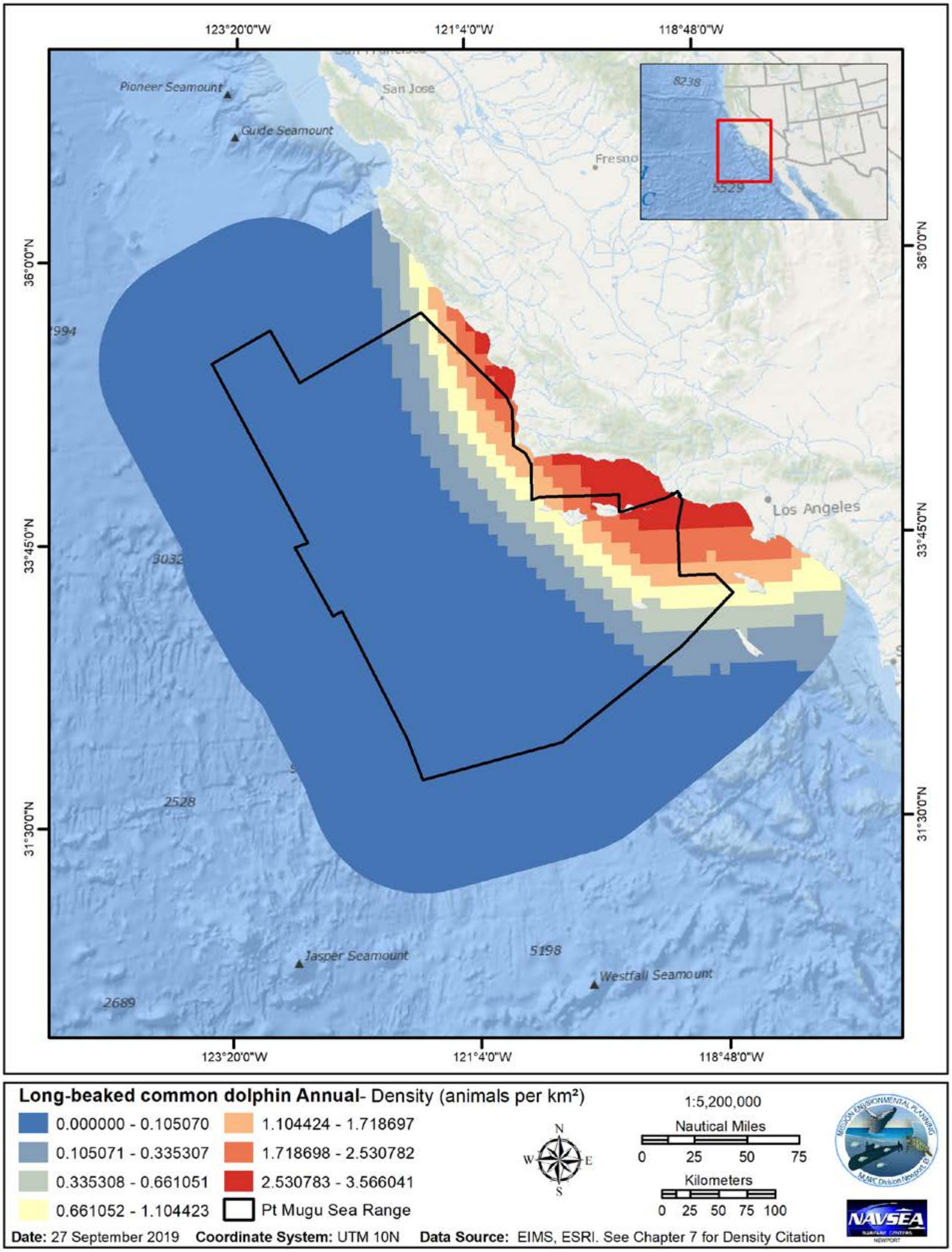

Figure 7-27. Long-Beaked Common Dolphin Annual Density in the PMSR

7.2.9 Northern Right Whale Dolphin, *Lissodelphis borealis*

The northern right whale dolphin is a temperate species found across the Pacific (Lipsky and Brownell Jr. 2009). Off the U.S. West Coast, they have been seen primarily in shelf and slope waters, with seasonal movements into the Southern California Bight (Dohl et al. 1983; Dohl et al. 1981; Leatherwood and Walker 1979). It appears more in Southern California in the cool months (Soldevilla et al. 2006) and is not seen frequently in Canadian waters (Baird and Stacey 1991). Only the CA/OR/WA stock of northern right whale dolphin is expected in the PMSR.

The habitat-based density model from for the northern right whale dolphin (Becker et al. in prep) was applied to PMSR for all seasons and represents an annual density estimate (Figure 7-28). Although the annual density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

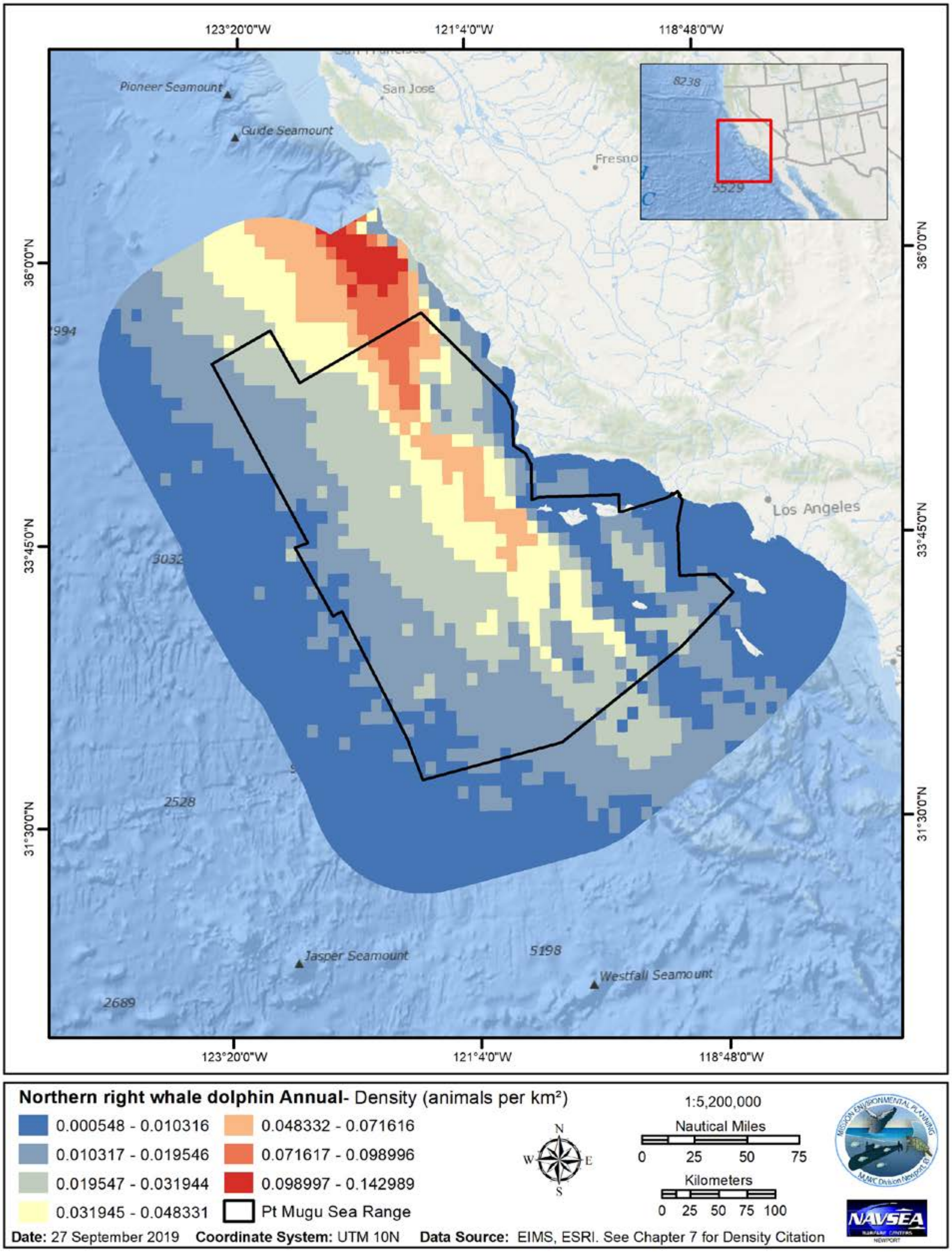

Figure 7-28. Northern Right Whale Dolphin Annual Density in the PMSR

7.2.10 Pacific White-Sided Dolphin, *Lagenorhynchus obliquidens*

Pacific white-sided dolphins are endemic to temperate waters of the North Pacific Ocean, and common both on the high seas and along the continental margins (Brownell Jr. et al. 1998). Off the U.S. West Coast, Pacific white-sided dolphins occur primarily in shelf and slope waters. Two stocks of Pacific white-sided dolphin are recognized by the NMFS (Carretta et al. 2019). One is a complex of units (the CA/OR/WA, Northern and Southern stocks) that contains two forms of the species, which should be separate stocks. The area between 33°N and 36°N seems to be the overlap area of the two forms, which is near the Southern California Bight and Northern Baja California; this area overlaps directly with the HSTT Study Area and the PMSR. Until the difference between the two forms can be recognized in the field, the two stocks will be managed as a single unit. Therefore, density values for the PMSR are presented for the species as a whole, not separated by stock or geographic separation as subspecies identification is impractical during most surveys. Species are assigned to stocks after NAEMO modeling. However, it is assumed that all individuals in PMSR are from the CA/OR/WA stocks.

The habitat-based density model from Becker et al. (in prep) was applied to the entire PMSR for summer/fall (Figure 7-29). Campbell et al. (2015) provide the most recent winter/spring (Figure 7-30) density estimate for Pacific white-sided dolphins in Southern California waters which was extrapolated to the entire PMSR Study Area. Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

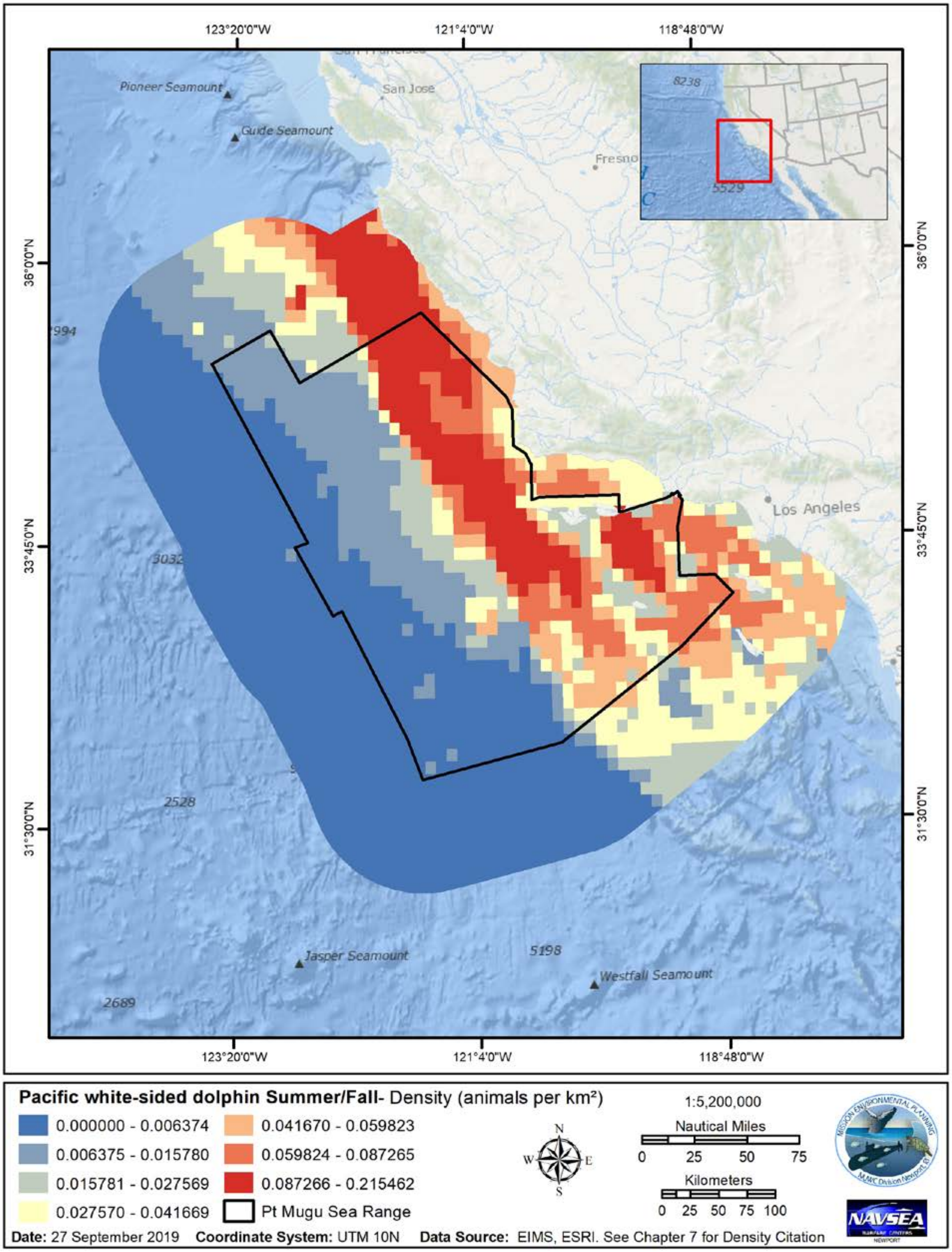

Figure 7-29. Pacific White-Sided Dolphin Summer/Fall Density in the PMSR

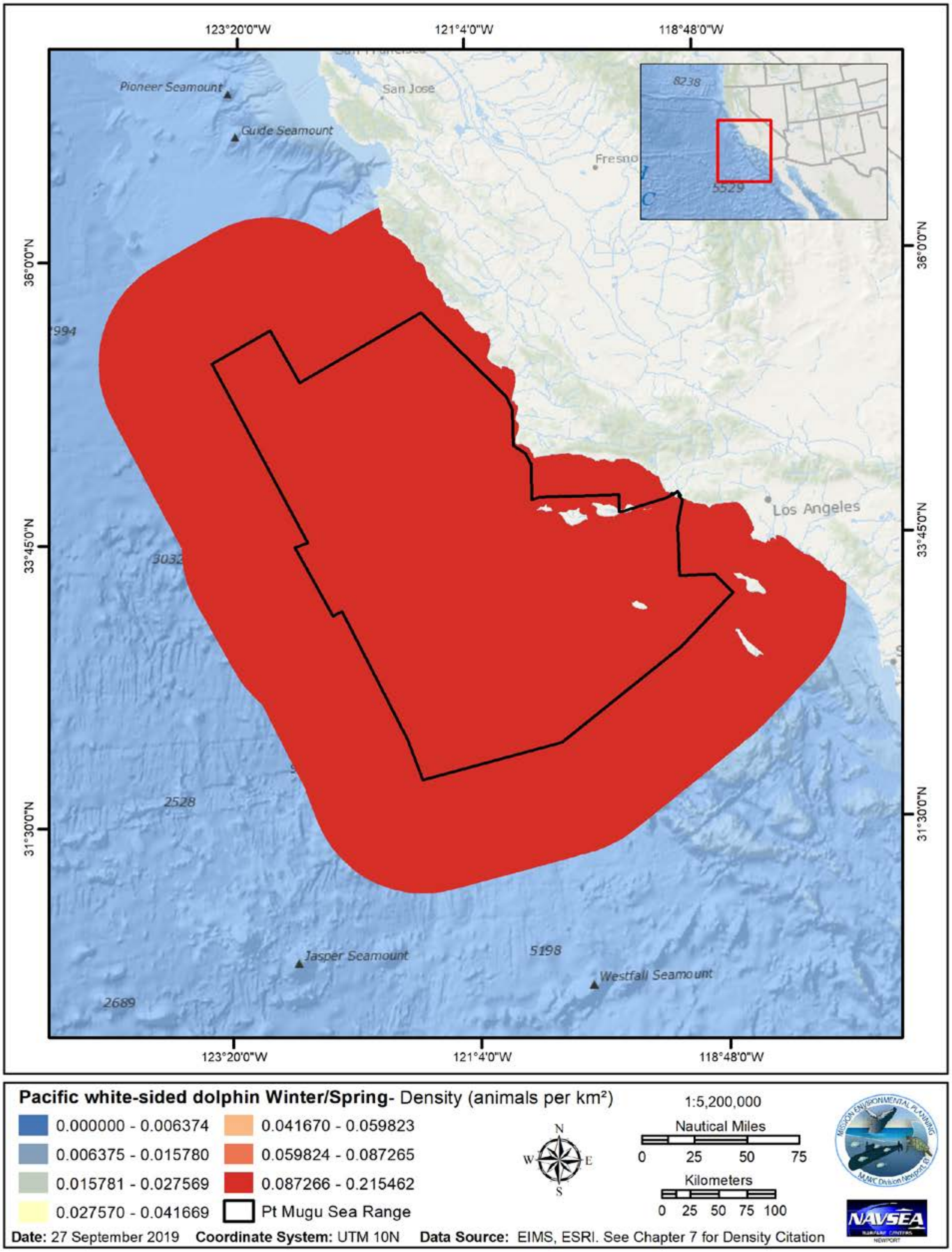

Figure 7-30. Pacific White-Sided Dolphin Winter/Spring Density in the PMSR

7.2.11 Pygmy Killer Whale, *Feresa attenuata*

This tropical species is not typically observed in California, but one group of 27 animals was seen off Southern California during a SWFSC survey in 2014, most likely due to the unusually warm oceanographic conditions during the survey (Barlow 2016). Records also show that the species has been observed in pelagic zones of the Eastern Tropical Pacific (Hamilton et al. 2009). The NMFS recognizes a single Hawaiian stock of pygmy killer whales (Carretta et al. 2019) and it is assumed the animals sighted were from this this stock.

While pygmy killer whale distribution would be expected to shift based on what is known about their habitat preferences, the geographically and temporally stratified summer/fall density from Barlow (2015) was applied to the entire PMSR (Figure 7-31). This likely overestimates pygmy killer whale occurrence in the PMSR during the summer/fall as they are considered rare, but these values are considered the best available science due to a paucity of any other data. The only available density estimate for the winter/spring season are from the Kaschner et al. (2006) relative environmental suitability or RES model and shown for the winter/spring seasons (Figure 7-32). Although the density is zero, this species was still modeled in NAEMO. The Navy considers these density estimates to be the most conservative.

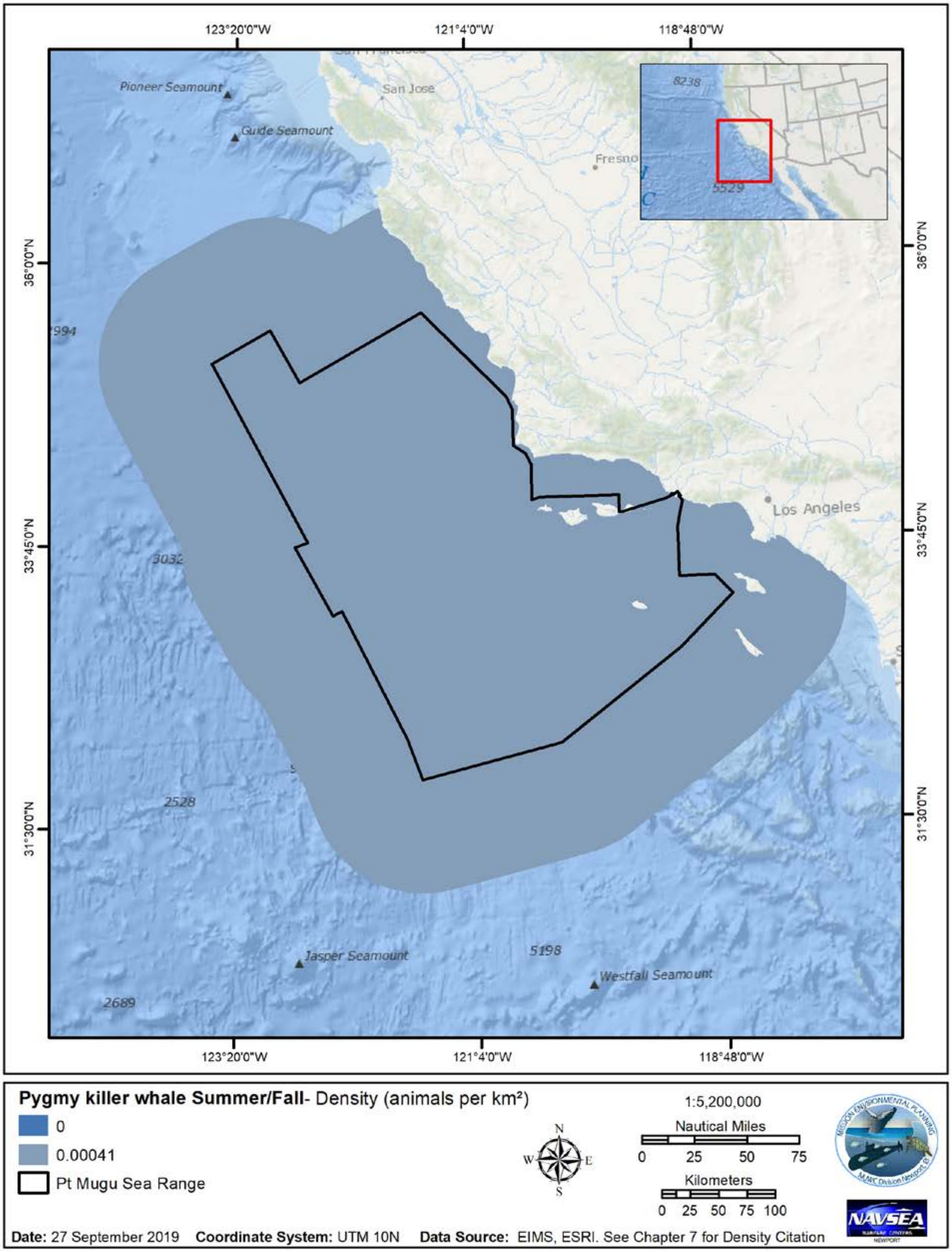

Figure 7-31. Pygmy Killer Whale Summer/Fall Density in the PMSR

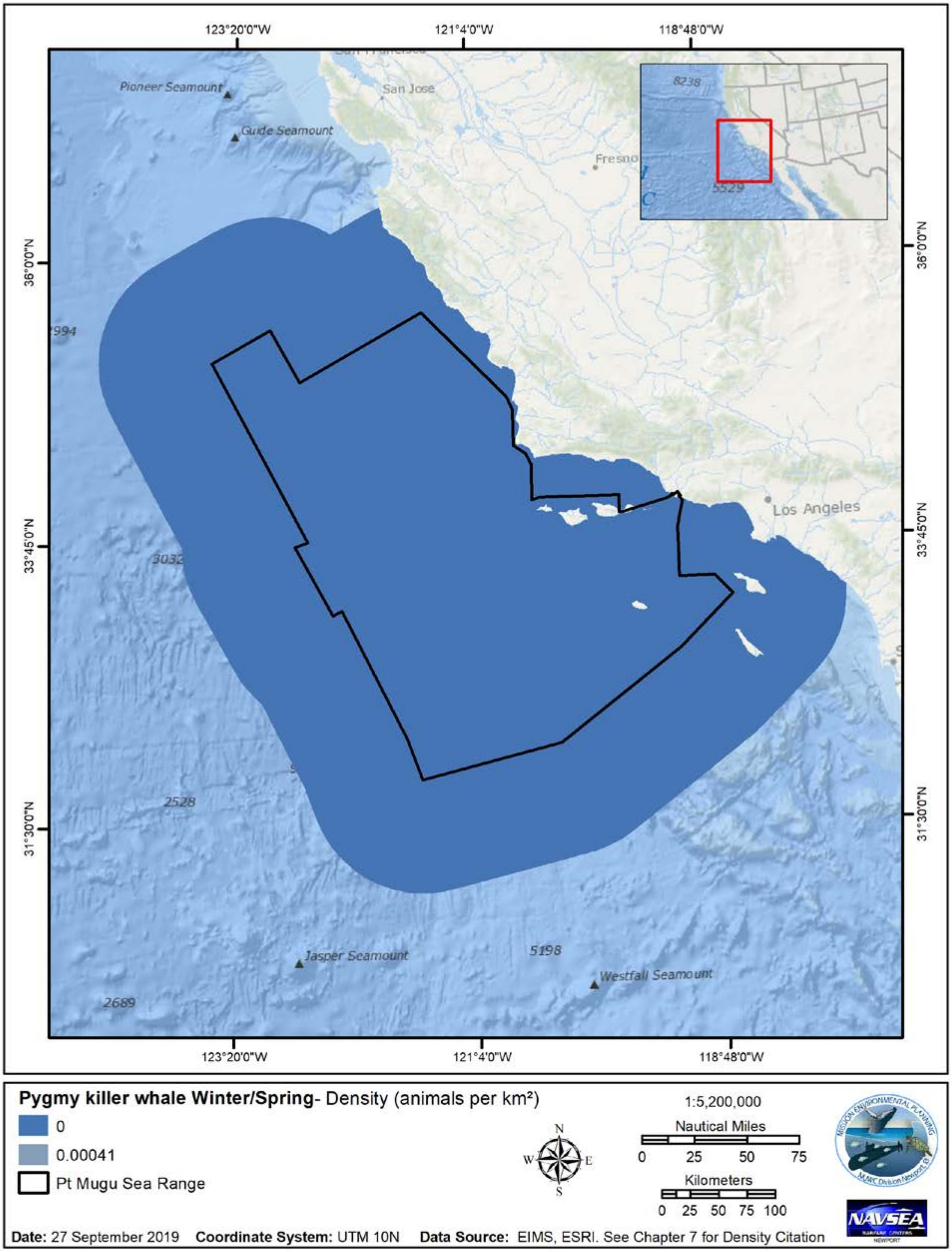

Figure 7-32. Pygmy Killer Whale Winter/Spring Density in the PMSR

7.2.12 Pygmy Sperm Whale, *Kogia breviceps*

In U.S. Pacific waters, pygmy sperm whales are divided into two stocks by the NMFS: the CA/OR/WA stock and the Hawaii stock (Carretta et al. 2019). The two stocks are considered to be discrete from each other and only the CA/OR/WA stocks of pygmy sperm whales would be expected in the PMSR. Few live sightings have occurred off the U.S. West Coast and not enough is known about their seasonal patterns. Therefore, density values for the PMSR Study Area from the summer and fall also provide the best estimate for the winter and spring seasons (Barlow and Forney 2007; Ferguson et al. 2003) and represent an annual density estimate (Figure 7-33). While applying the uniform annual density estimate for all seasons may overestimate pygmy sperm whale occurrence in the PMSR, these values are considered the best available science due to a paucity of any other data. The Navy considers these density estimates to be the most conservative.

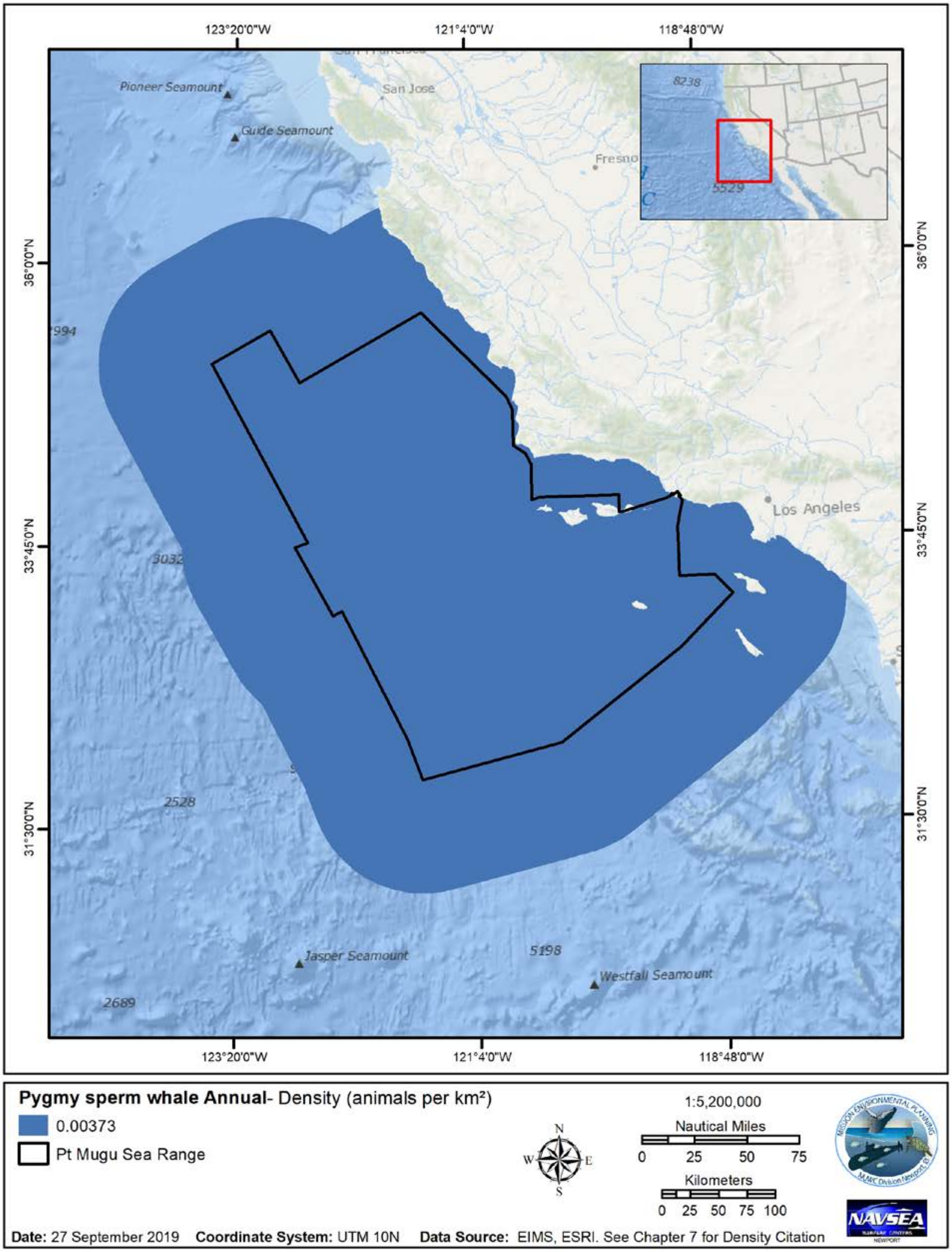

Figure 7-33. Pygmy Sperm Whale Annual Density in the PMSR

7.2.13 Risso’s Dolphin, *Grampus griseus*

Off the U.S. West Coast, Risso's dolphins are commonly seen on the shelf in the Southern California Bight and in slope and offshore waters of California, Oregon and Washington. Animals found off California during the colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer (Green et al. 1992; Green et al. 1993). The southern end of this population's range is not well documented, but previous surveys have shown a conspicuous 500 nmi distributional gap between these animals and Risso's dolphins sighted South of Baja California and in the Gulf of California (Mangels and Gerrodette 1994). The NMFS defines two stocks of Risso’s dolphins in the Pacific, a Hawaiian stock, and a CA/OR/WA stock (Carretta et al. 2019). Only the CA/OR/WA stock of Risso’s dolphin is expected in the PMSR.

The habitat-based density model from Becker et al. (in prep) for the Risso’s dolphin represents the best available density estimate for the PMSR Study Area for all seasons and represents the annual density estimate applied to the PMSR (Figure 7-34). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

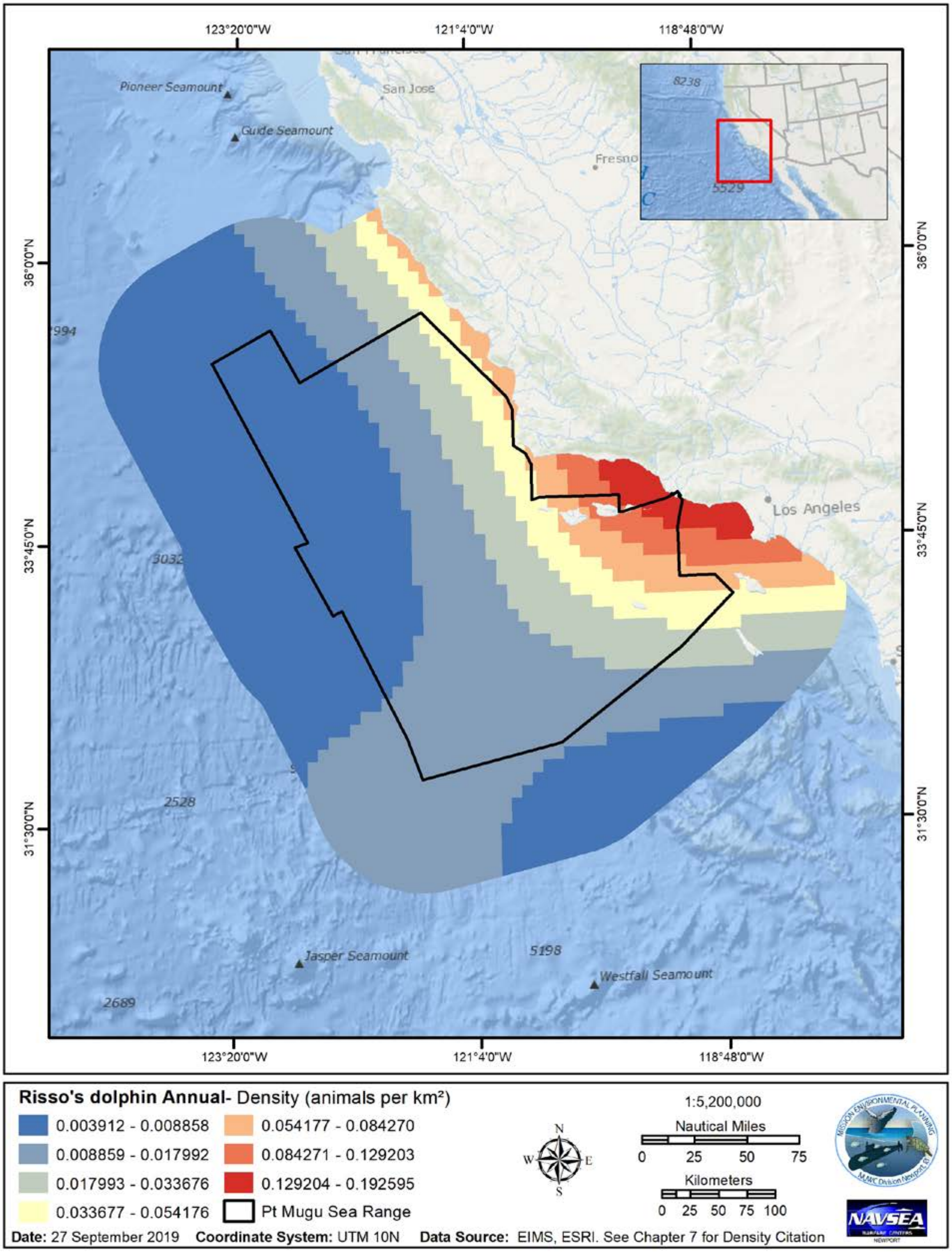

Figure 7-34. Risso's Dolphin Annual Density in the PMSR

7.2.14 Short-Beaked Common Dolphin, *Delphinus delphis*

Short-beaked common dolphins are the most abundant cetacean off California and are widely distributed between the coast and at least 300 nmi distance from shore. The abundance of this species off California has been shown to change on both seasonal and inter-annual time scales (Barlow 2016; Dohl et al. 1986; Forney and Barlow 1998). The distribution of short-beaked common dolphins is continuous southward into Mexican waters to about 13°N (Mangels and Gerrodette 1994; Perrin et al. 1985; Wade and Gerrodette 1993). The NMFS recognizes a CA/OR/WA stock of short-beaked common dolphins in the U.S. EEZ (Carretta et al. 2019). In the PMSR, this stock is the one that is observed.

The habitat-based density model from Becker et al. (in prep) was applied to the entire PMSR for summer/fall (Figure 7-35). Becker et al. (2017) provide the most recent winter/spring (Figure 7-36) density estimate for Pacific white-sided dolphins in Southern California waters, which was extrapolated to the entire PMSR Study Area. Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

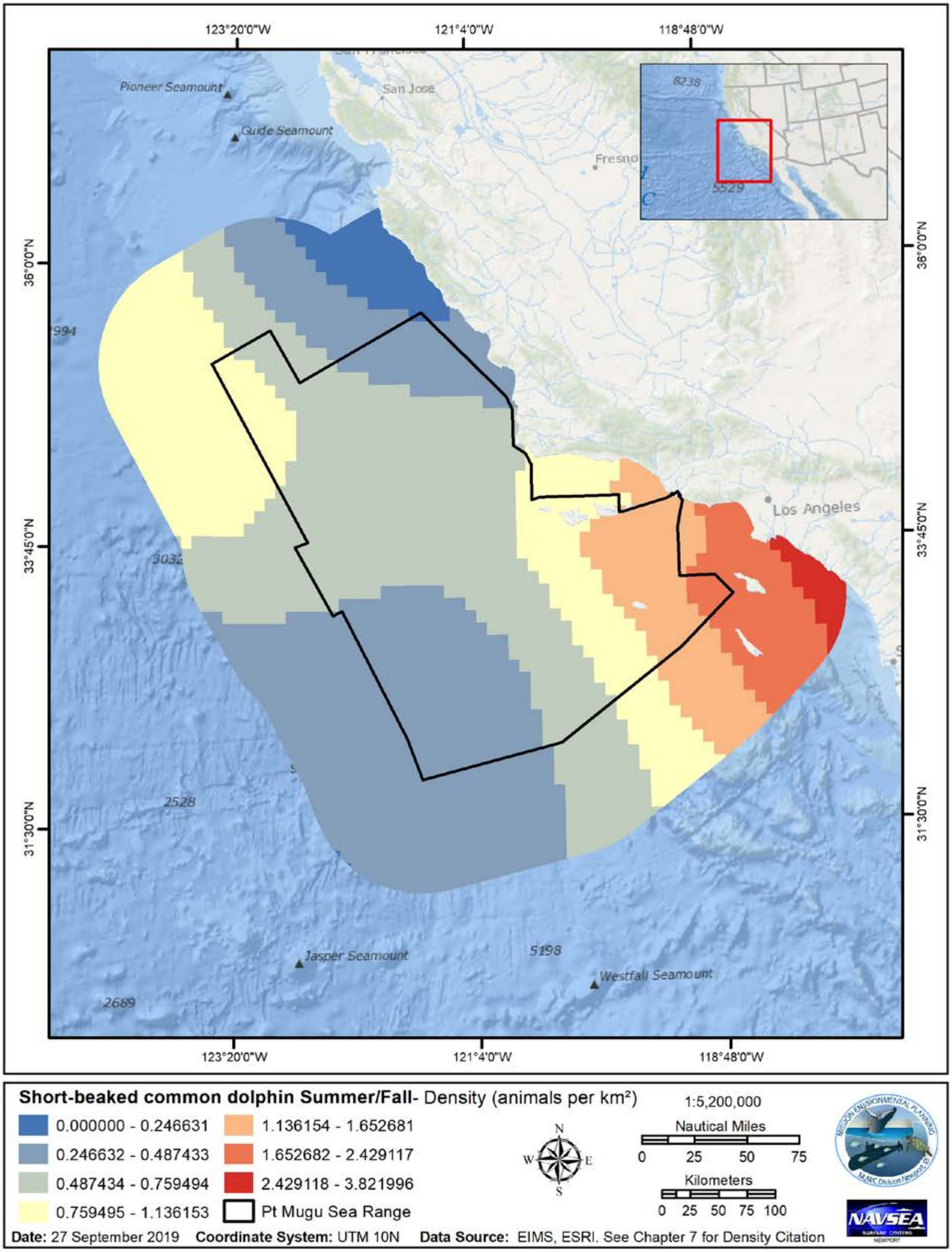

Figure 7-35. Short-Beaked Common Dolphin Summer/Fall Density in the PMSR

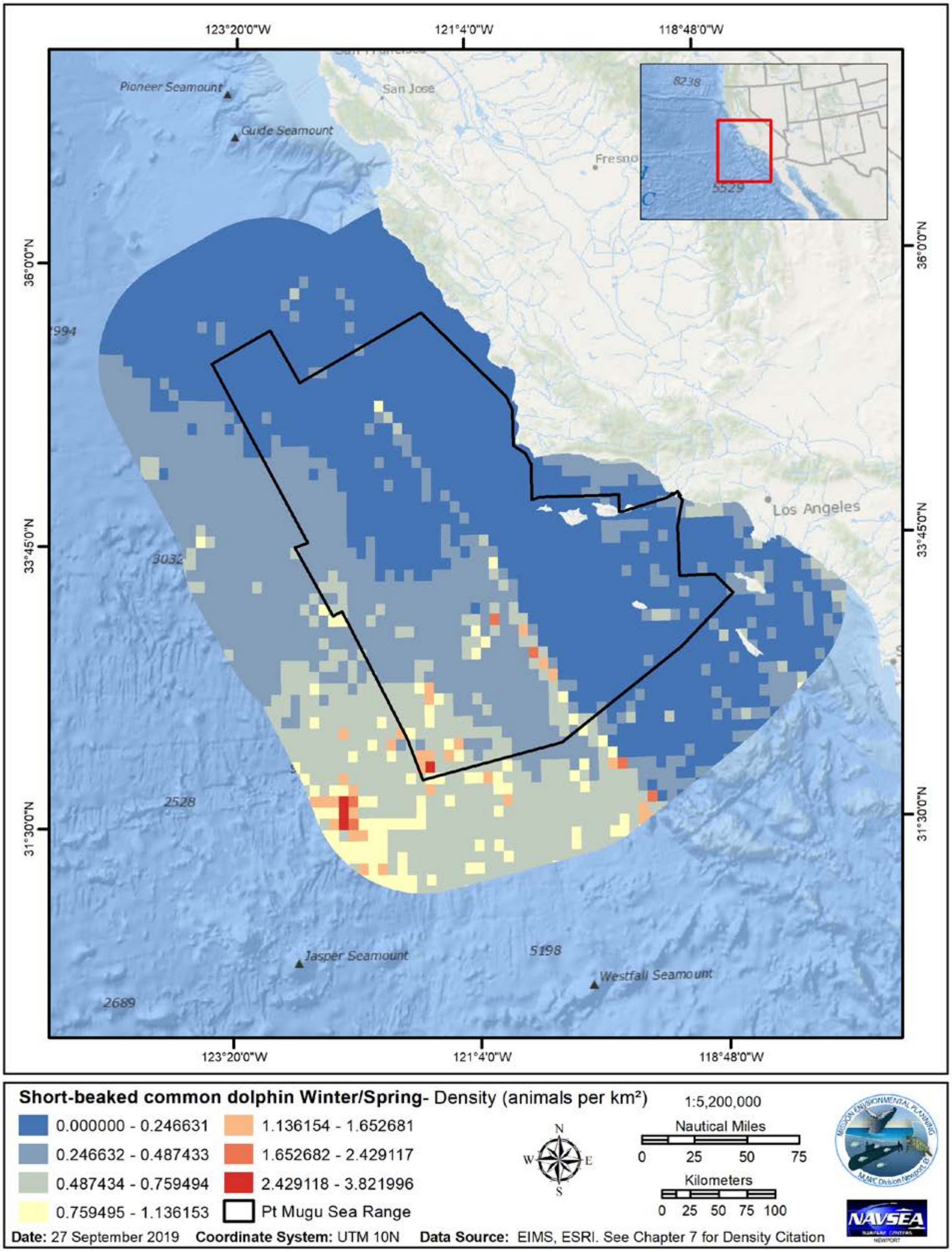

Figure 7-36. Short-Beaked Common Dolphin Winter/Spring Density in the PMSR

7.2.15 Short-Finned Pilot Whale, *Globicephala macrorhyncus*

Short-finned pilot whales were once common off Southern California, with an apparently resident population around Santa Catalina Island, as well as seasonal migrants (Dohl et al. 1981). After a strong El Niño event in 1982–83, short-finned pilot whales virtually disappeared from this region, and despite an increased survey effort along the entire U.S. West Coast, sightings and fishery takes are rare and have primarily occurred during warm-water years (Barlow 2016; Caretta et al. 2004; Julian and Beeson 1998). The NMFS defines two stocks of short-finned pilot whales in the Pacific, a Hawaiian stock, and a CA/OR/WA stock (Carretta et al. 2019). Animals in the PMSR are expected to be from the CA/OR/WA stock only.

While short-finned pilot whale distribution would be expected to shift based on what is known about their habitat preferences, the geographically and temporally stratified summer/fall density from Barlow (2016) was used to represent an annual density estimate for the PMSR (Figure 7-37). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

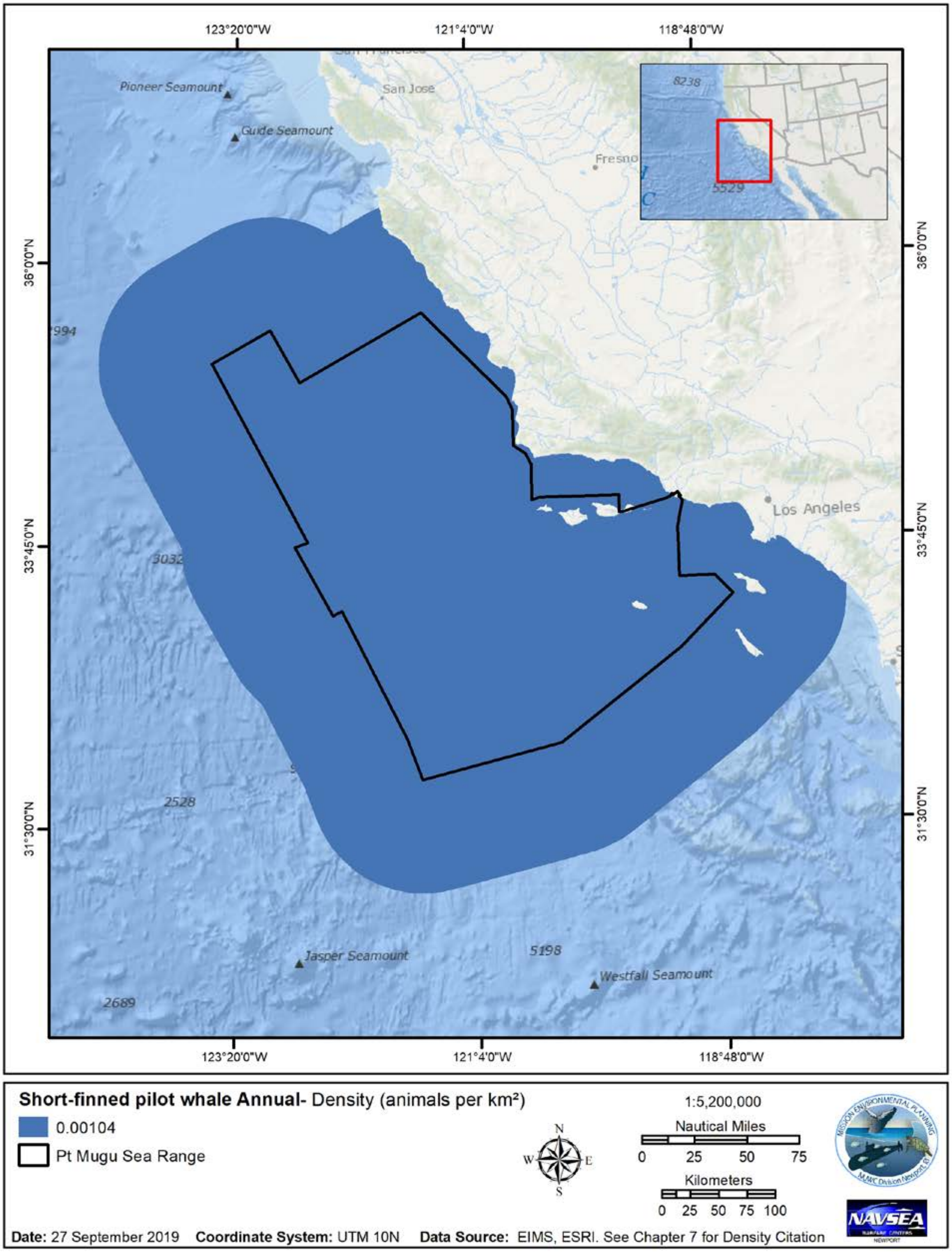

Figure 7-37. Short-Finned Pilot Whale Annual Density in the PMSR

7.2.16 Sperm Whale, *Physeter macrocephalus*

Sperm whales are one of the most-widely distributed species of marine mammal (Whitehead 2009). Sperm whales are found year-round in California waters (Barlow 1995; Dohl et al. 1983; Forney et al. 1995), but they reach peak abundance from April through mid-June and from the end of August through mid-November (Rice 1974). The NMFS has divided sperm whales in the North Pacific into three stocks: the CA/OR/WA stock, the Hawaii stock, and the North Pacific stock (Carretta et al. 2019). Animals in the PMSR are expected to be from the CA/OR/WA stock only.

While sperm whale distribution would be expected to shift based on what is known about their habitat preferences, the habitat based summer/fall density estimate from Becker et al. (in prep) was used to represent an annual density estimate for the PMSR (Figure 7-38). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

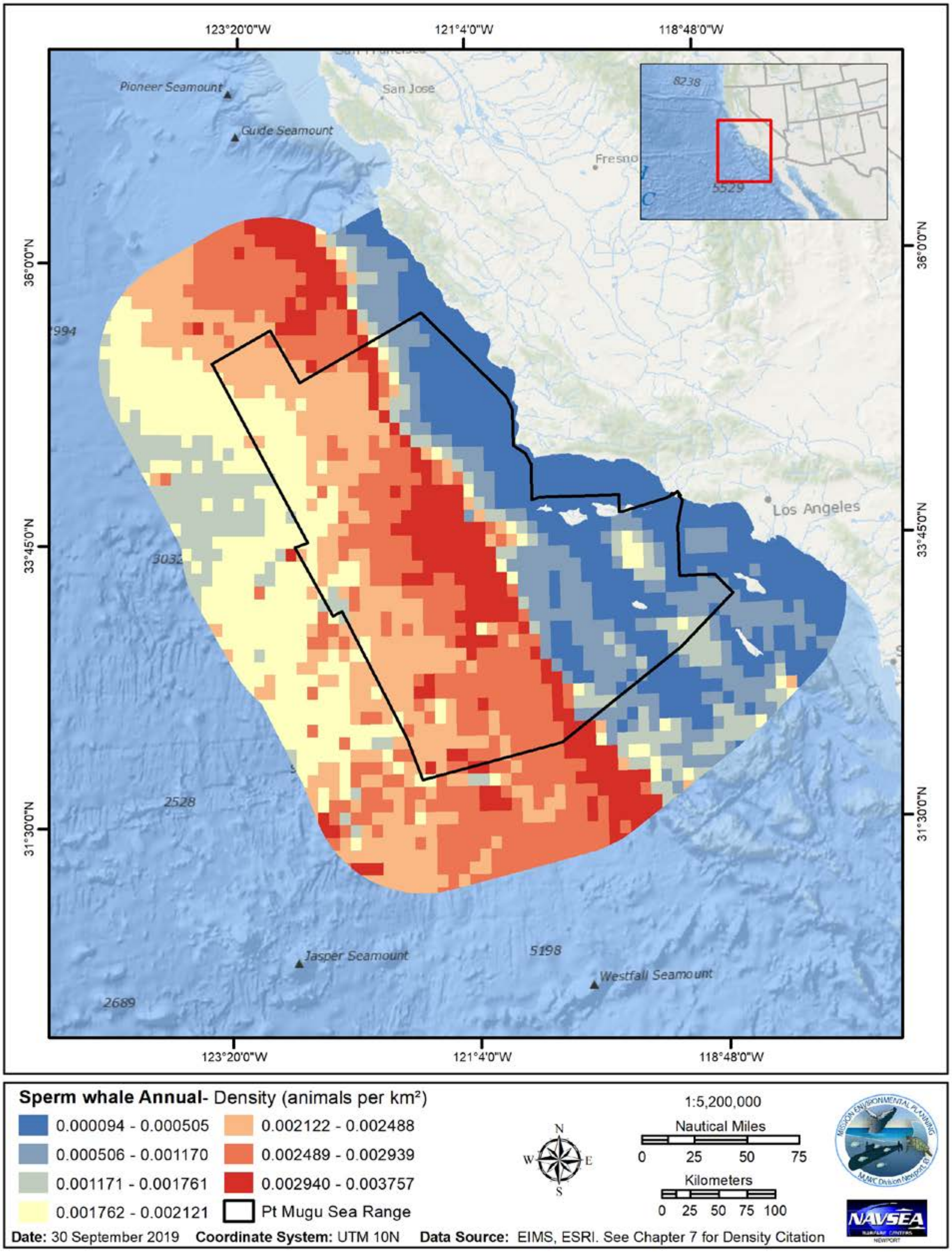

Figure 7-38. Sperm Whale Annual Density in the PMSR

7.2.17 Striped Dolphin, *Stenella coeruleoalba*

Striped dolphins are commonly encountered in warm offshore waters of California (Barlow 2016), are primarily pelagic, and are typically found past the continental shelf (Archer 2009). Based on sighting records off California and Mexico, striped dolphins appear to have a continuous distribution in offshore waters of these two regions (Mangels and Gerrodette 1994; Perrin et al. 1985). No information on possible seasonality in distribution is available, because the California surveys that extended 300 nmi offshore were conducted only during the summer/fall period. The NMFS recognizes two stocks in the North Pacific, a Hawaiian stock and a CA/OR/WA stock (Carretta et al. 2019). Animals in the PMSR are expected to be from the CA/OR/WA stock only.

While striped dolphin distribution would be expected to shift based on what is known about their habitat preferences, the habitat based summer/fall density estimate from Becker et al. (in prep) was used to represent an annual density estimate for the PMSR (Figure 7-39). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

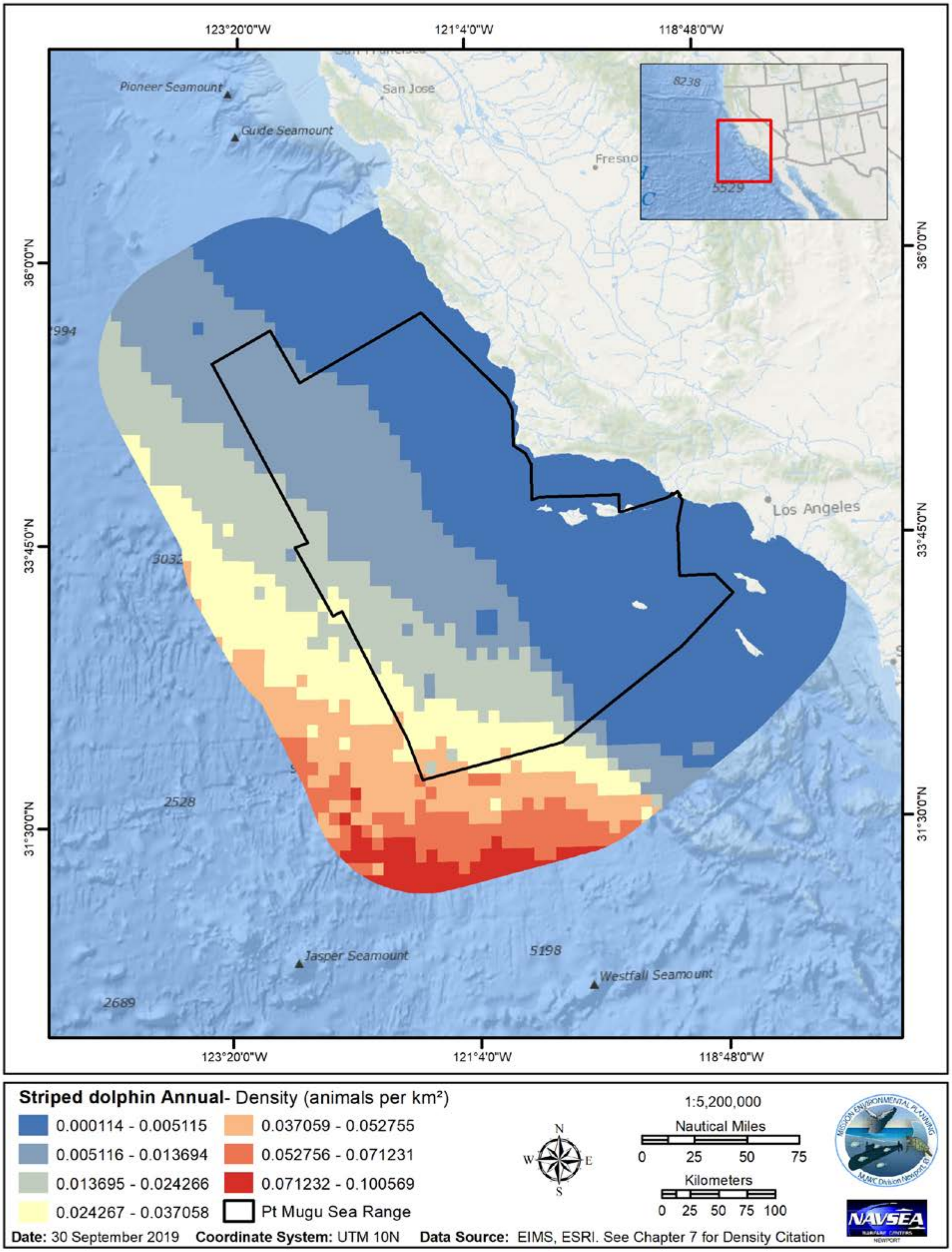

Figure 7-39. Striped Dolphin Annual Density in the PMSR

7.3 Pinnipeds

7.3.1 California Sea Lion, *Zalophus californianus*

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). The NMFS recognizes one stock of California sea lion, the U.S. stock (Carretta et al. 2019).

Throughout the year, adult female California sea lions alternate between nursing their pup on shore and foraging at sea and generally move North from breeding and haul-out sites when foraging (Kuhn and Costa 2014; Melin and DeLong 2000). The pupping season begins in March and extends through the following May with most pups leaving the pupping sites by the next pupping season. 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 up to the Gulf of Alaska (Kuhn 2006; Kuhn and Costa 2014; Lowry and Forney 2005; Maniscalco et al. 2004; Melin et al. 2008; Melin et al. 2012; National Oceanic and Atmospheric Administration 2016; Testa 2012).

The two largest rookeries, composing approximately 67 to 69 percent of all California sea lions, are on San Nicolas Island, located South of the most southerly extent of the PMSR, and San Miguel Island, located within the extent of the PMSR (Lowry et al. 2017). Therefore, it is reasonable to conclude that the majority of the California sea lion population would overlap with the PMSR to forage. However, adult female sea lions tracked from rookeries on San Clemente Island, located outside of the PMSR, mostly remain in Southern California waters (Lowry and Forney 2005). Seasonal uniform density estimates for California sea lions across the PMSR during summer (Figure 7-40), fall (Figure 7-41), winter (Figure 7-42), and spring (Figure 7-43) are distributed by geographic distance from shore (0–40km, 40–70km, and 70–450km). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

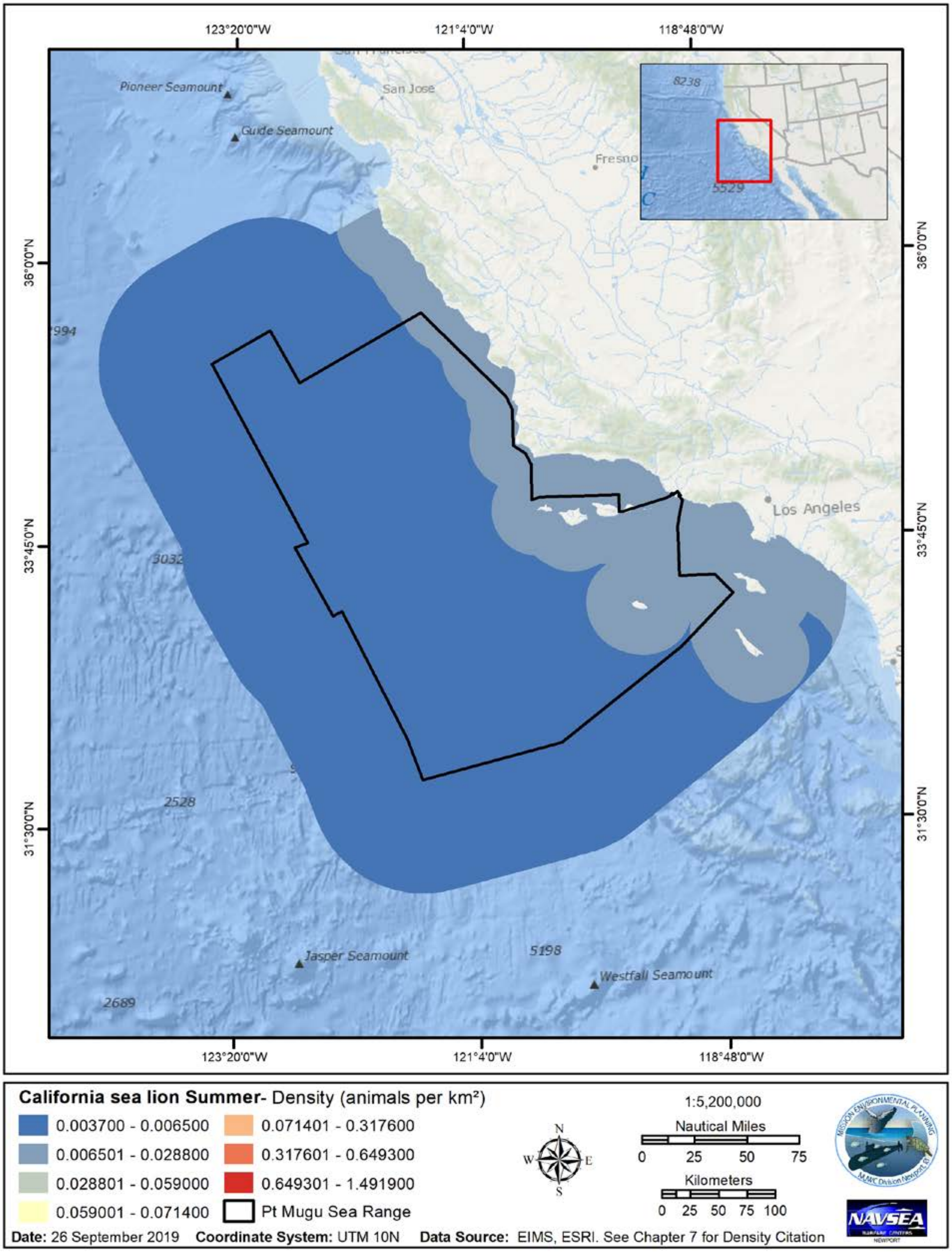

Figure 7-40. California Sea Lion Summer Density in the PMSR

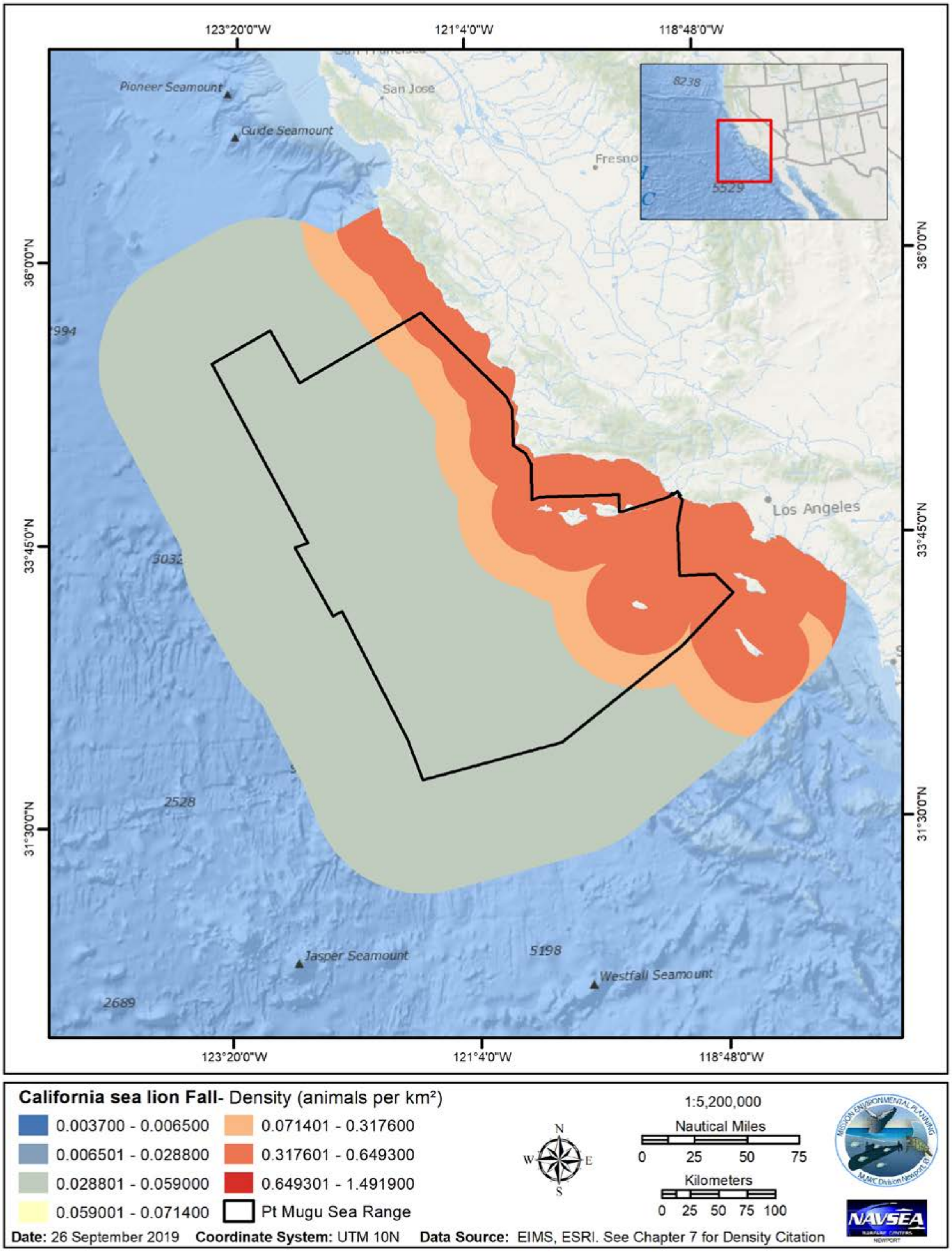

Figure 7-41. California Sea Lion Fall Density in the PMSR

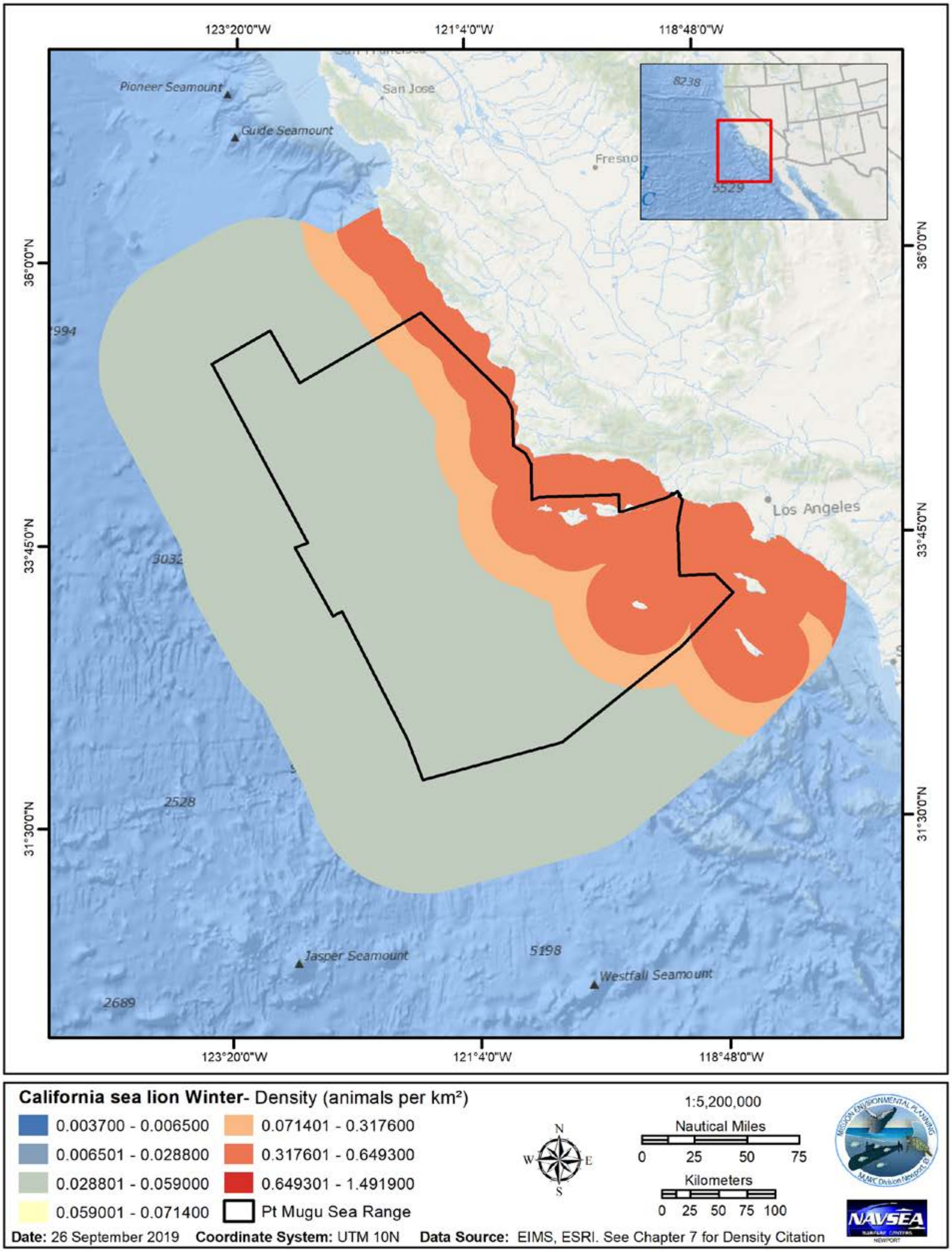

Figure 7-42. California Sea Lion Winter Density in the PMSR

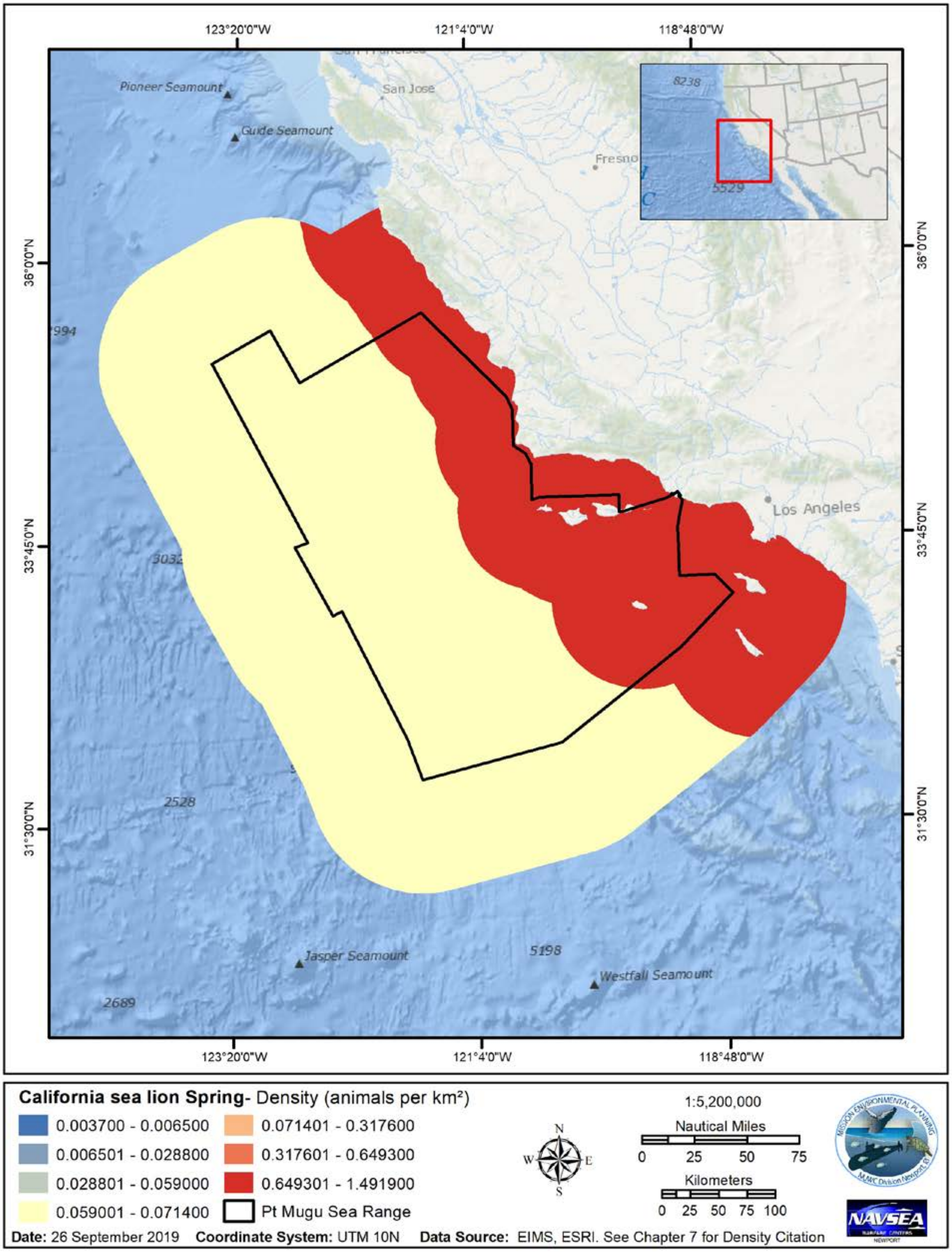

Figure 7-43. California Sea Lion Spring Density in the PMSR

7.3.2 Guadalupe Fur Seal, *Arctocephalus townsendi*

Guadalupe fur seals 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 California Bight starting in the 1960s (Stewart et al. 1993), and, in 1997, a female and pup were observed on San Miguel Island (Melin and Delong 1999). Since then, a small group has persisted in that area (Aurioles-Gamboa et al. 2010). Other than their occurrence at San Miguel Island, Guadalupe fur seals were not observed at any of the other Channel Islands in the NMFS aerial surveys between 2011 and 2015 (Lowry et al. 2017). Although the population has been growing, the species is listed as threatened under the ESA. The 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. 2019; Carretta et al. 2017; Pablo-Rodríguez et al. 2016). From June through July, adult males come to shore for the breeding season and then most move North to forage. From June through April, adult females with dependent pups make regular foraging trips from rookeries. Pups are weaned in spring (Gallo-Reynoso et al. 2008; Yochem et al. 1987). Along the U.S. West Coast, strandings occur almost annually in California waters and animals are increasingly observed in Oregon and Washington waters. Guadalupe fur seals can be expected to occur in both deeper waters of the open ocean and coastal waters within the PMSR Study Area (Hanni et al. 1997; Jefferson et al. 2015; Norris 2017, 2019).

For Guadalupe fur seals, the cool season is defined as September–May, and the warm water season is defined as June–August. This is slightly different from other pinniped species. The PMSR Study Area included seasonal uniform density estimates for Guadalupe Fur seals offshore (> 3,000 m isobaths) and inshore PMSR during summer/fall (Figure 7-44) and winter/spring (Figure 7-45). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

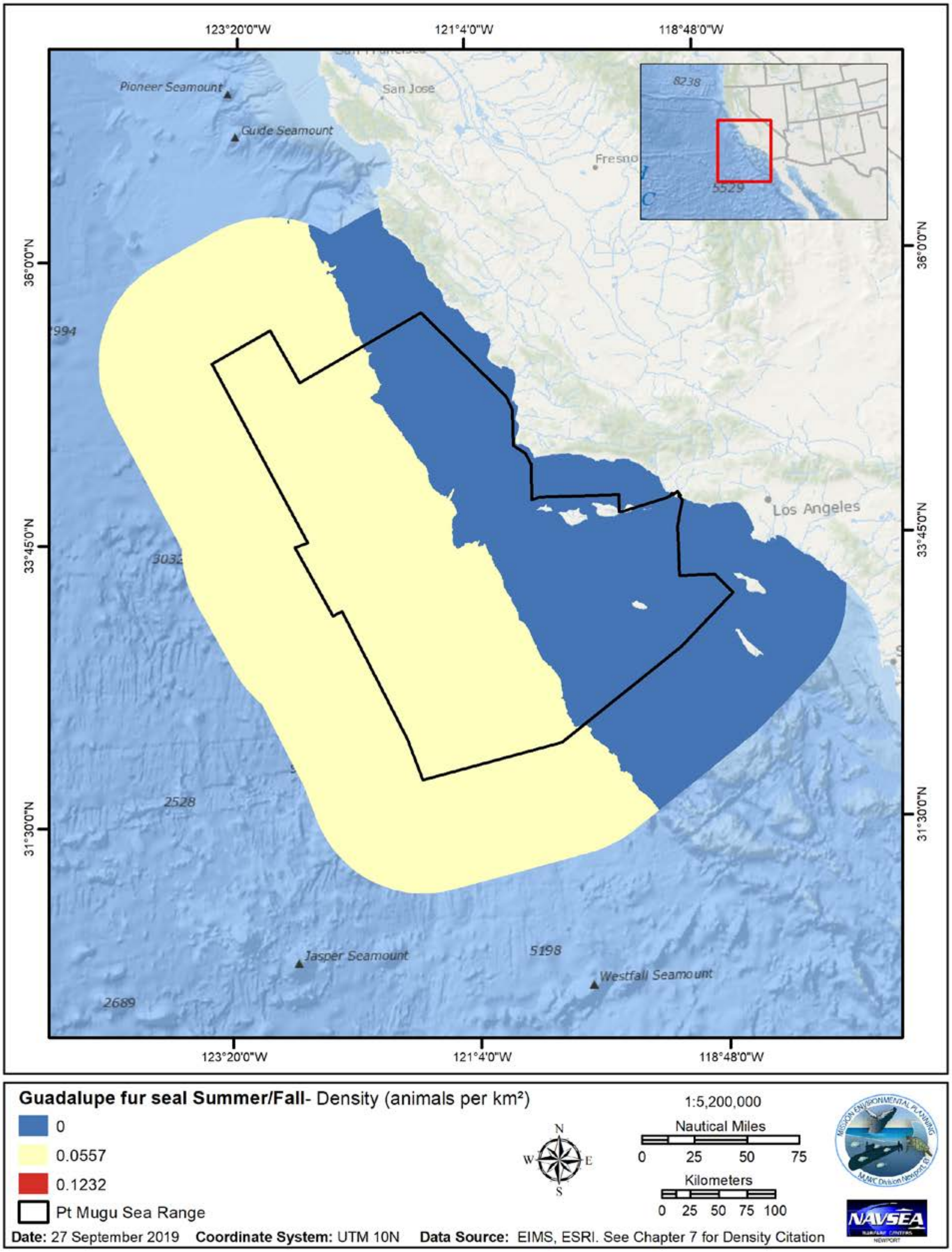

Figure 7-44. Guadalupe Fur Seal Summer/Fall Density in the PMSR

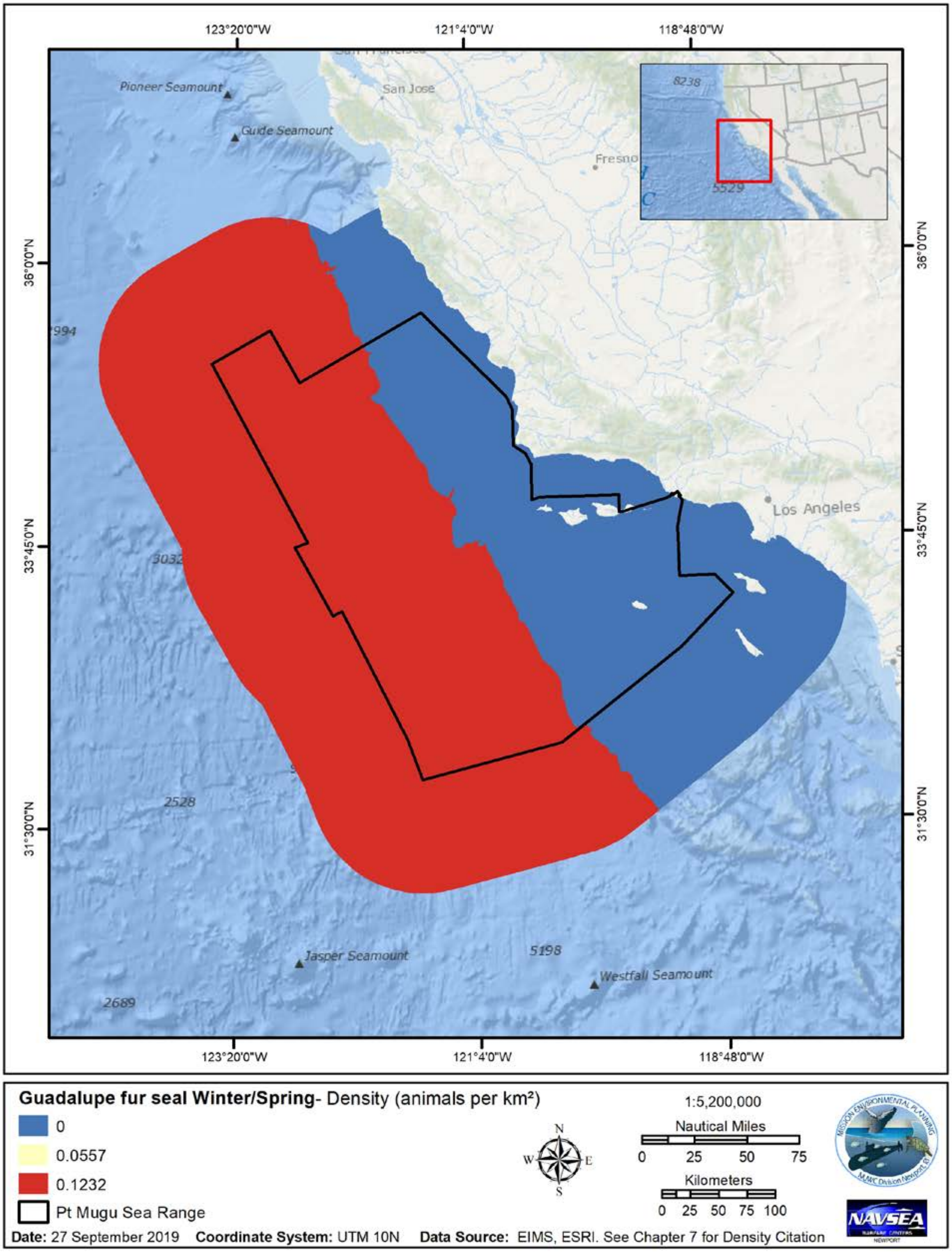

Figure 7-45. Guadalupe Fur Seal Winter/Spring Density in the PMSR

7.3.3 Harbor Seal, *Phoca vitulina richardii*

The harbor seal (*Phoca vitulina*) is a small seal that is found in the near shore environment of much of the Northern Hemisphere (Jefferson et al. 2015). Harbor seals do not make extensive pelagic migrations, but do travel 300–500 km to find food or suitable breeding areas (Harvey and Goley 2011; Herder 1986). *Phoca vitulina richardii* is the Eastern Pacific subspecies that would be encountered in the PMSR. The NMFS recognizes 17 harbor seal stocks along the U.S. Pacific Coast (Carretta et al. 2019; Muto 2019). There are 12 stocks present in Alaska waters and 5 stocks occurring in Washington, Oregon, and California waters. Species from only the California stock would be expected in PMSR (Carretta et al. 2019).

From January to May, dependent harbor seal pups are present at haul-out locations, but many have left by May. The range of pupping dates varies with location, with more northerly locations having later pupping dates. From May to June, juveniles and adults spend more time on shore to molt. Since harbor seals generally occur within 50 miles of their haul-out sites, the Navy applied a uniform annual density estimate from the coast offshore (Figure 7-46) including a 50 mile buffer around all known haul-out sites from islands within the acoustic modeling study areas (Bailey et al. 2014; Lowry et al. 2005; Menza et al. 2016). Zero density was assigned to waters outside this buffer. Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

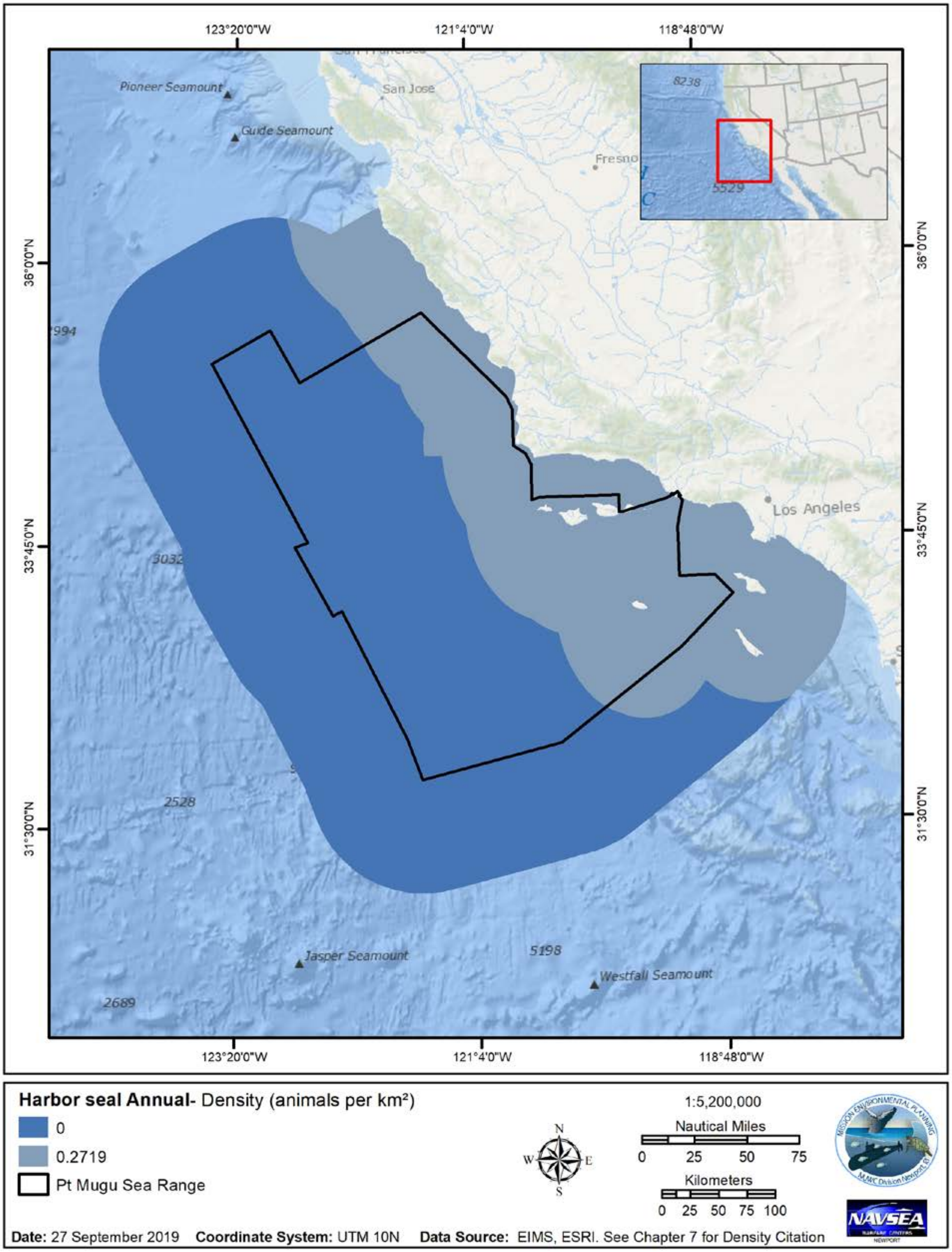

Figure 7-46. Harbor Seal Annual Density in the PMSR

7.3.4 Northern Elephant Seal, *Mirounga angustirostris*

This highly sexually dimorphic seal is found only in the Eastern North Pacific (Jefferson et al. 2015). Northern Elephant seals breed and give birth in California (U.S.) and Baja California (Mexico) from December to March (García-Aguilar et al. 2018; Stewart and Huber 1993). Small colonies of Northern Elephant seals haul out and breed on Santa Barbara Island and San Clemente Island, while large colonies are found on San Nicolas, Santa, Rosa, and San Miguel Islands (Lowry et al. 2014; Lowry et al. 2017; Stewart et al. 1993; Stewart et al. 1994) peak abundance in California is during the January–February breeding season (Lowry et al. 2017). Adult females spend about 28 days on shore for breeding and nursing their pups; adult and sub-adult males spend the entire three months on shore for breeding. Juveniles forage at sea and generally move northward with the exception of seals originating from Guadalupe Island. From March through June, adult females and juveniles return to shore to molt, and adult and sub-adult males forage in the North Pacific around the Gulf of Alaska (Le Boeuf et al. 2000). Weaned pups leave for their first trip to sea in April and May. From July through August, males move onshore to molt, adult females and juveniles forage at sea, and from September through November, juveniles haul out for about 30 days. NMFS considers Northern Elephant seals in the Study Area to be from the California Breeding Stock, although Elephant seals from Baja Mexico frequently migrate north through the PMSR Study Area (Aurioles-Gamboa and Camacho-Ríos 2007; Carretta et al. 2019).

The in-water density estimate included in the PMSR Study Area assumes that the 21,563 Elephant seals considered to represent the California stock would remain in the PMSR, and thus, represents a conservative value. Seasonal estimates of the population of Northern Elephant seals potentially at sea during the warm season (75 percent) and cool season (50 percent) were derived from published literature (Le Boeuf and Laws 1994; Worthy et al. 1992). Density estimates for the summer/fall (Figure 7-47) and winter/spring (Figure 7-48) seasons were calculated by taking the California stock population estimate (21,563) and adding an estimate of the population from Mexico (15,083) to arrive at a total abundance of 36,646 seals (Department of the Navy 2017). While applying these seasonal uniform densities may overestimate northern elephant seal occurrence in the PMSR based on what is known about their seasonal movement, these values are considered the best available science due to a paucity of any other data. The Navy considers these density estimates to be the most conservative.

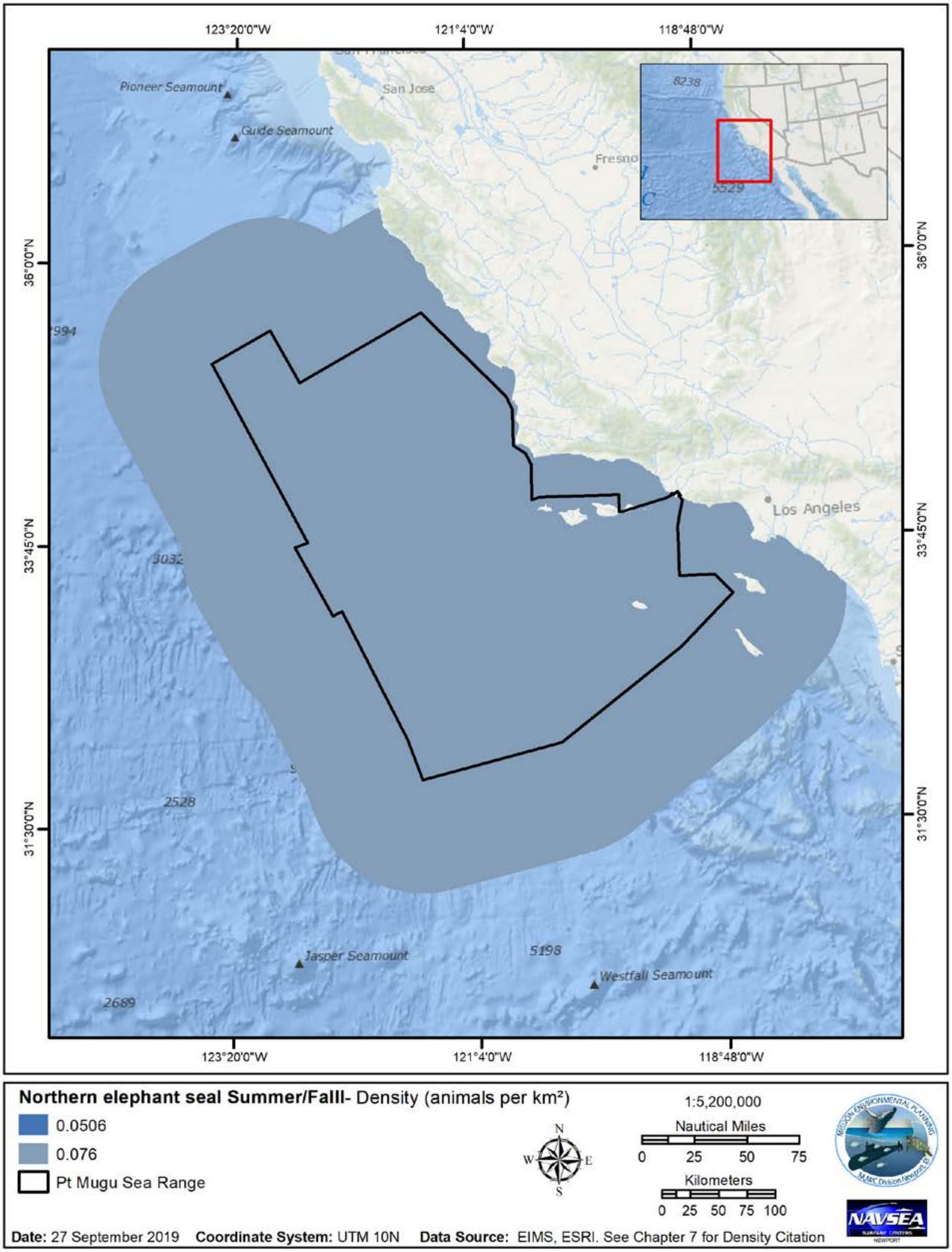

Figure 7-47. Northern Elephant Seal Summer/Fall Density in the PMSR

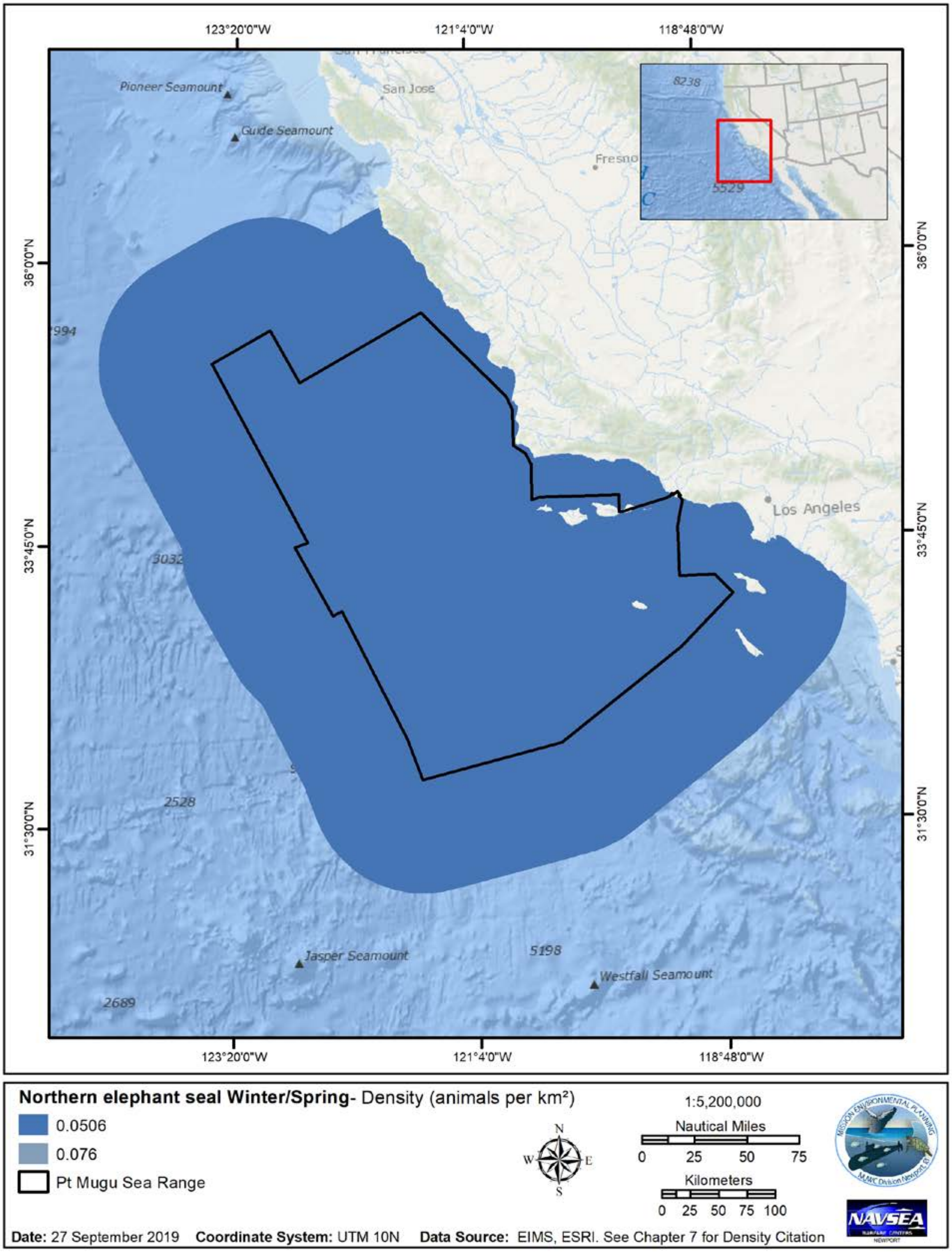

Figure 7-48. Northern Elephant Seal Winter/Spring Density in the PMSR

7.3.5 Northern Fur Seal, *Callorhinus ursinus*

Northern Fur seals occur from Southern California north to the Bering Sea and West to Japan (Carretta et al. 2019). The population of northern fur seals occurring in U.S. waters is comprised of two main stocks recognized by the NMFS: the California stock, which includes seals from San Miguel Island and the Farallon Islands, and the Eastern Pacific stock, which occurs primarily in Alaskan waters (Carretta et al. 2019). Species from the California stock only would be expected in PMSR (Carretta et al. 2019). A small breeding population, less than 1 percent of the total population, is found on San Miguel Island off Southern California and the Farallon Islands off central California.

The Navy's estimate for the PMSR used a similar method described in the Department of the Navy (2017) using the NMFS' San Miguel Island population estimate of 13,384 Northern Fur seals. This is a highly conservative assumption that most of the population would remain in the PMSR. Seasonal estimates of the percentage of Northern Fur seals potentially at sea during summer/fall (15 percent) and winter/spring (50 percent) seasons were derived from published literature (Antonelis et al. 1990; Ream et al. 2005; Roppel 1984). The summer/fall (Figure 7-49) and winter/spring (Figure 7-50) density estimates were calculated by taking the population estimate multiplied by the percentage of the population at sea for each season and dividing by the area of the NMFS Southern California Stratum (Department of the Navy 2017). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

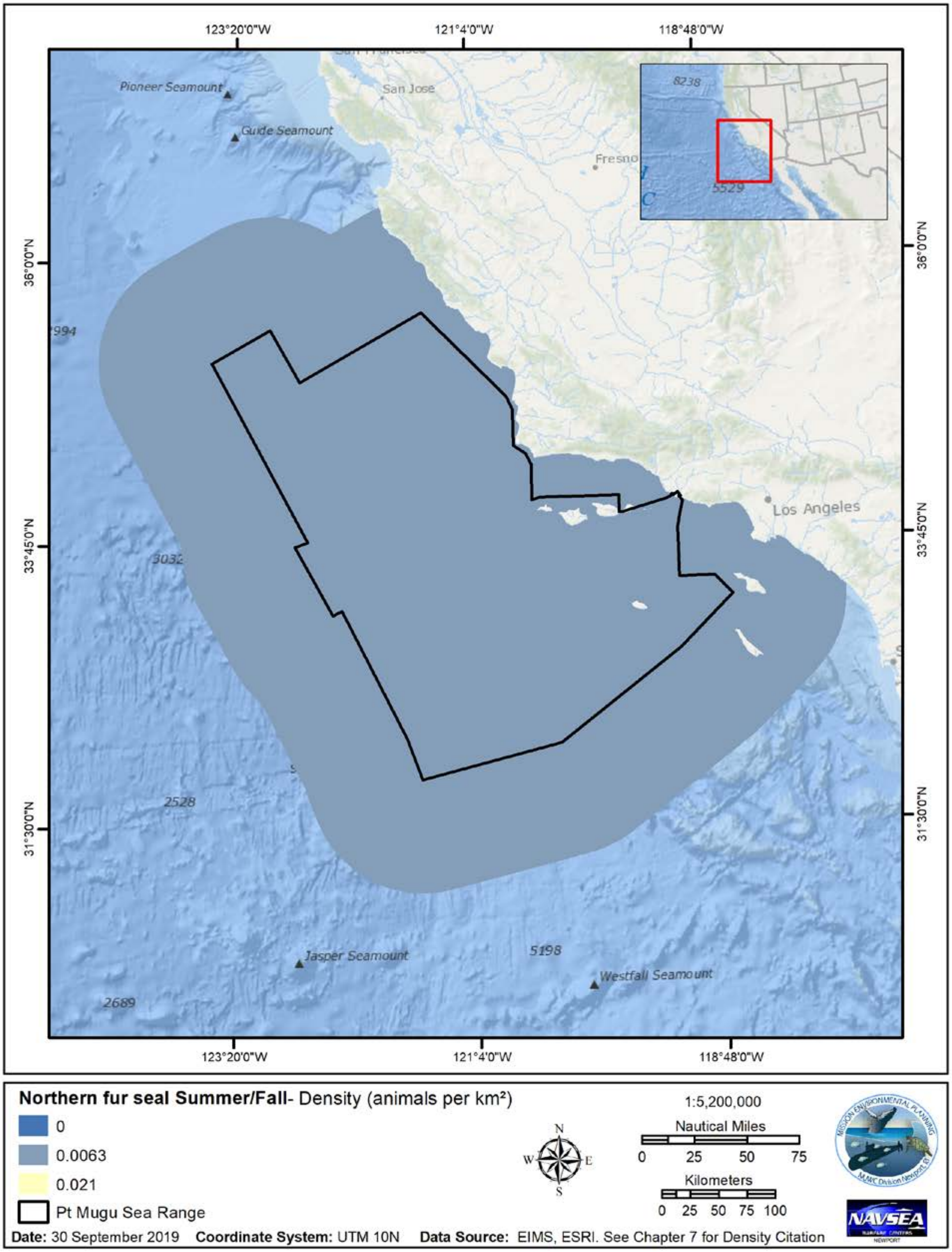

Figure 7-49. Northern Fur Seal Summer/Fall Density in the PMSR

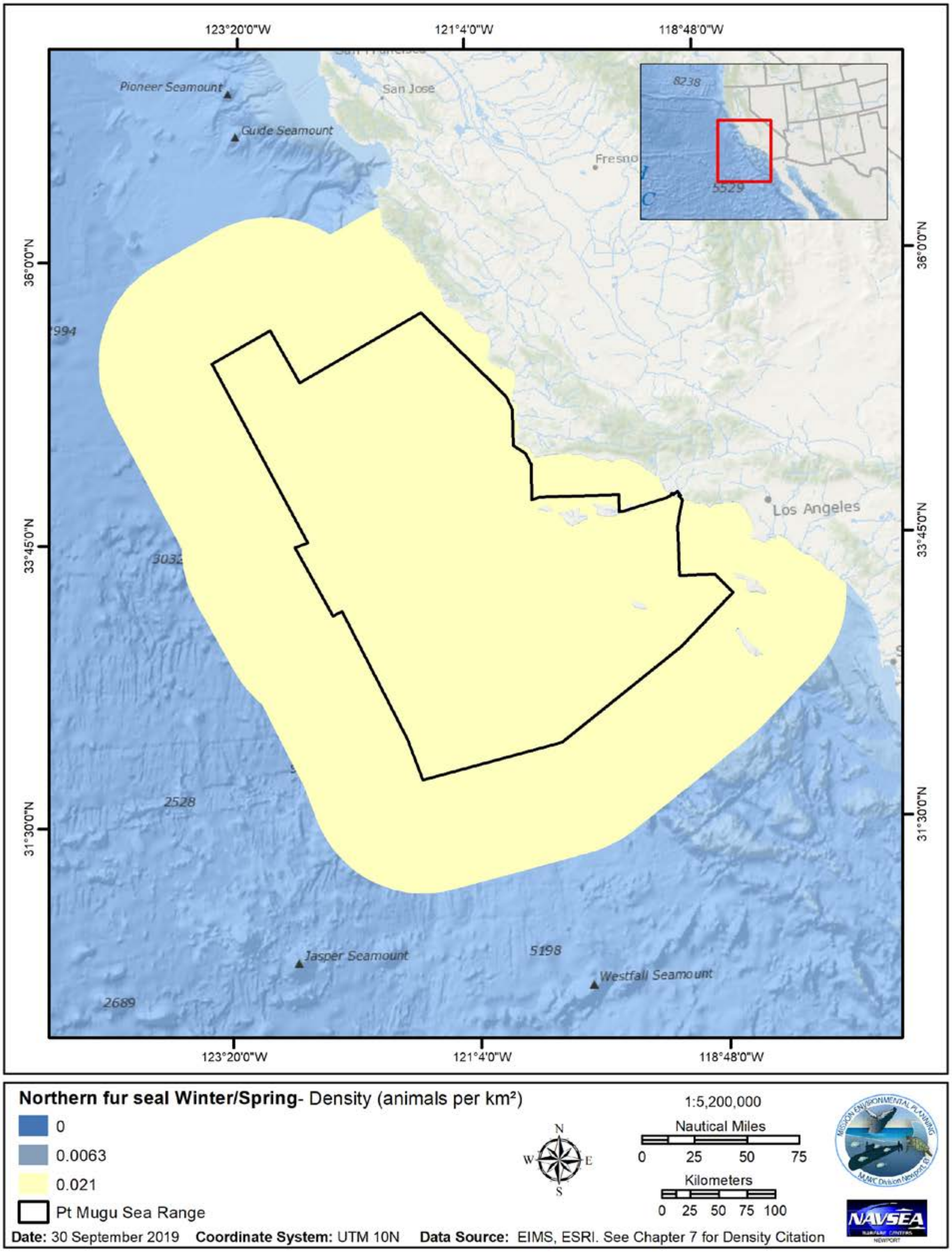

Figure 7-50. Northern Fur Seal Winter/Spring Density in the PMSR

7.4 Sea Turtles

7.4.1 Leatherback Sea Turtle, *Dermochelys coriacea*

The leatherback turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans, from 71°N to 47°S (Eckert 1995), and nests on tropical and occasionally subtropical beaches (Myers and Hays 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). In a study analyzing the movements of 135 leatherbacks fitted with satellite tracking tags, the turtles were found to inhabit waters with sea surface temperatures ranging from 11.3 to 31.7 degrees C (mean of 24.7 degrees C) (Bailey et al. 2012). Adult leatherback turtles forage in temperate and subpolar regions in all oceans, and migrate to tropical nesting beaches located between 30°N and 20°S. Leatherbacks migrate from western Pacific Ocean nesting beaches to forage in the CCE of the U.S. Pacific (Benson et al. 2007; Kobayashi et al. 2008).

There is a tremendous paucity of in-water occurrence data for sea turtles. Although tagging studies of individual leatherback sea turtles have been performed (Shillinger et al. 2008), there is little assessment of the general presence of turtles in an area beyond their use of beaches. Many studies assess turtle numbers by counting nesting individuals or number of eggs (Hitipeuw et al. 2007; Patino-Martinez et al. 2008) or recording by catch (Bartol and Ketten 2006; Donoso and Dutton 2010). In-water densities cannot be estimated realistically from data collected on the beach. In many cases, the Navy has had to rely on datasets obtained by Navy biologists during monitoring activities. While leatherback sea turtle distribution would be expected to shift based on what is known about their habitat preferences, an annual uniform density estimate was applied for the PMSR Study Area (Figure 7-51). Although these density estimates may not be accurate based on interannual variability, fluctuations in population size, or may not exactly reflect spatial distributions, they represent the best available science due to the paucity of other data. The Navy considers these density estimates to be the most conservative.

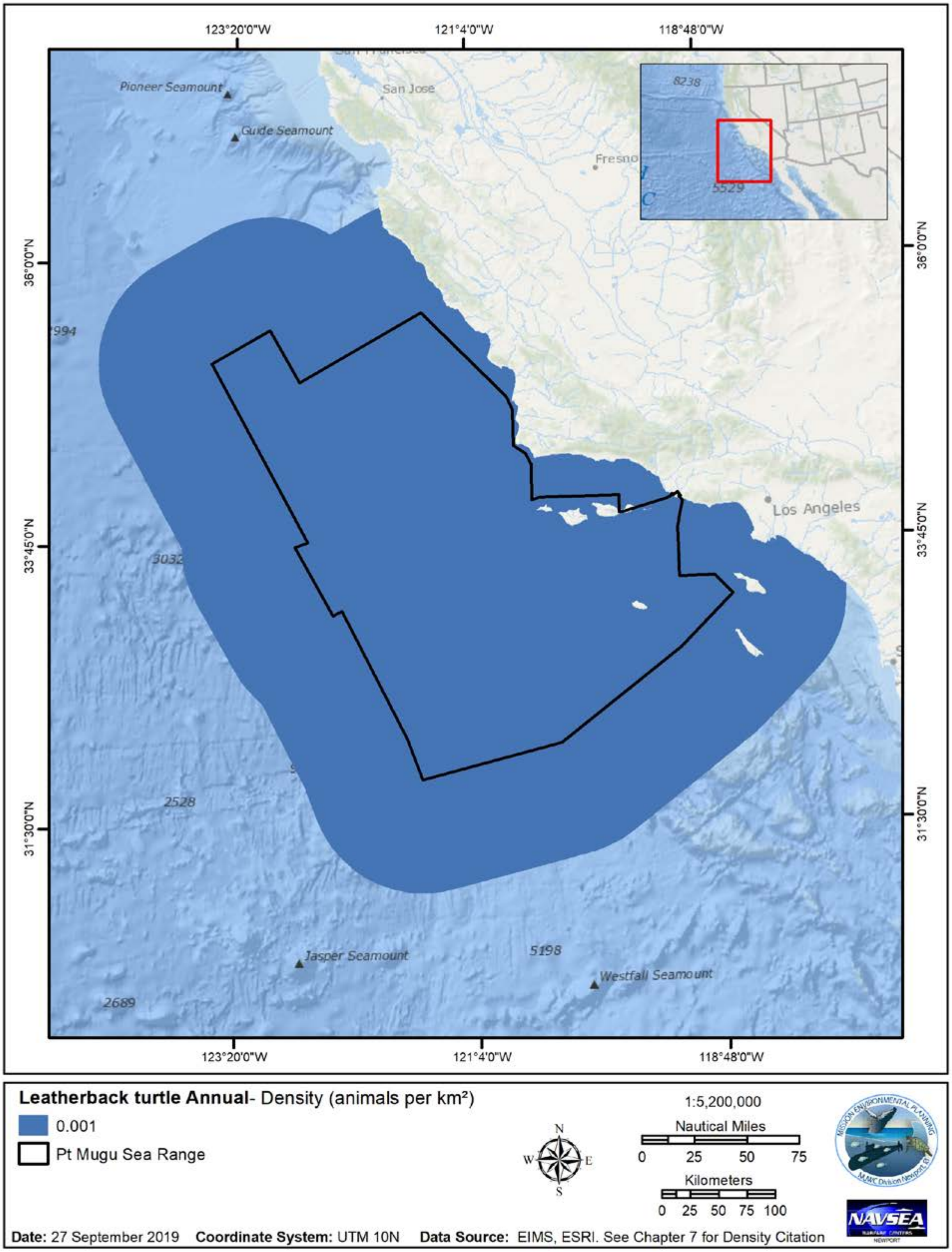

Figure 7-51. Leatherback Sea Turtle Annual Density in the PMSR

This page left intentionally blank.

8 MARINE MAMMAL CRITERIA AND THRESHOLDS

The Navy's Phase III marine mammal criteria and thresholds (Department of the Navy 2017) were utilized for this analysis. The criteria provide specific threshold levels for acoustic and impulsive sources that can be used to determine potential auditory effects (Permanent Threshold Shift (PTS)/Temporary Threshold Shift (TTS)), behavioral responses to underwater anthropogenic sound, and non-auditory physiological impacts.

All received impulse, Sound Exposure Level (SEL) and Sound Pressure Level (SPL), are recorded for each mammal in the defined area that received an SPL level of at least 100 dB. These values are then compared against all thresholds defined in Table 8-1 to calculate exposure numbers. As a reminder, sea turtles are assessed qualitatively because of a lack of appropriate density data.

Table 8-1. Effects, Criteria, and Thresholds for Impulsive Sources

Group	*Species*	*Behavioral Criteria*	*Physiological Criteria*		
			Onset TTS	*Onset PTS*	*Onset GI (Gastrointestinal) Tract Injury (SPL) 50%*
Low-Frequency Cetaceans	All mysticetes	163 dB SEL	168 dB SEL 213 dB SPL	183 dB SEL 219 dB SPL	243 dB re 1 µPa peak
Mid-Frequency Cetaceans	Most delphinids, beaked whales, medium and large toothed whales	165 dB SEL	170 dB SEL 224 dB SPL	185 dB SEL 230 dB SPL	243 dB re 1 µPa peak
High-Frequency Cetaceans	Porpoises, River dolphins, *Cephalorynchus* spp., *Kogia* spp.	135 dB SEL	140 dB SEL 196 dB SPL	155 dB SEL 202 dB SPL	243 dB re 1 µPa peak
Otariidae Odobenidae (in water)	California sea lion, Guadalupe Fur seal, Northern Fur seal	183 dB SEL	188 dB SEL 226 dB SPL	203 dB SEL 232 dB SPL	243 dB re 1 µPa peak
Phocinae (in water)	Harbor seal	165 dB SEL	170 dB SEL 212 dB SPL	185 dB SEL 218 dB SPL	243 dB re 1 µPa peak
Monochinae (in water)	Northern Elephant seal	165 dB SEL	170 dB SEL 212 dB SPL	185 dB SEL 218 dB SPL	243 dB re 1 µPa peak

Mortality and slight lung injury thresholds are calculated using the mass and depth of the mammal. An adult mass and a calf mass are defined for each species based on the literature.

Mortality (50% risk of extensive lung injury):

$$Mortality\ Impulse\ Threshold = 144M^{1/3}(1 + \frac{D}{10.1})^{1/6}\ Pa - s$$

Injury (50% risk of slight lung injury):

$$Slight\ Lung\ Injury\ Impulse\ Threshold = 65.8M^{1/3}(1 + \frac{D}{10.1})^{1/6}\ Pa - s$$

Where *D* is depth (meters) and *M* is mass (kg).

9 REFERENCES

Antonelis, G. A., Stewart, B. S., and Perryman, W. F. (1990). Foraging characteristics of female northern fur seals (Callorhinus ursinus) and California sea lions (Zalophus californianus). *Canadian Journal of Zoology, 68*(1), 150–158.

Archer, F. I. (2009). Striped Dolphin: Stenella coeruleoalba. In *Encyclopedia of marine mammals* (1127–1129): Elsevier.

Archer, F. I., Morin, P. A., Hancock-Hanser, B. L., Robertson, K. M., Leslie, M. S., Bérubé, M., Panigada, S., and Taylor, B. L. (2013). Mitogenomic phylogenetics of fin whales (Balaenoptera physalus spp.): genetic evidence for revision of subspecies. *PLoS One, 8*(5), e63396.

Aurioles-Gamboa, D., and Camacho-Ríos, F. J. (2007). Diet and feeding overlap of two otariids, Zalophus californianus and Arctocephalus townsendi: Implications to survive environmental uncertainty. *Aquatic Mammals, 33*(3), 315.

Aurioles-Gamboa, D., Elorriaga-Verplancken, F., and Hernández-Camacho, C. J. (2010). The current population status of Guadalupe fur seal (Arctocephalus townsendi) on the San Benito Islands, Mexico. *Marine Mammal Science, 26*(2), 402-408.

Bailey, H., Benson, S. R., Shillinger, G. L., Bograd, S. J., Dutton, P. H., Eckert, S. A., Morreale, S. J., Paladino, F. V., Eguchi, T., and Foley, D. G. (2012). Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. *Ecological Applications, 22*(3), 735–747.

Bailey, H., Hammond, P. S., and Thompson, P. M. (2014). Modelling harbour seal habitat by combining data from multiple tracking systems. *Journal of Experimental Marine Biology and Ecology, 450*, 30–39.

Baird, R. W. (2000). The killer whale. *Cetacean societies: Field studies of dolphins and whales*, 127–153.

Baird, R. W. and Stacey, P. J. (1991). Status of Risso's dolphin, Grampus griseus, in Canada. *Canadian field-naturalist. Ottawa ON, 105*(2), 233–242.

Baird, R. W., Walters, E. L., and Stacey, P. J. (1993). Status of the bottlenose dolphin, Tursiops truncatus, with special reference to Canada. *Canadian Field -Naturalist, 107*(4), 466–480.

Barlow, J. (1995). The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. *Oceanographic Literature Review, 9*(42), 784.

Barlow, J. (1997). *Preliminary estimates of cetacean abundance off California, Oregon, and Washington based on a 1996 ship survey and comparisons of passing and closing modes*: Southwest Fisheries Science Center.

Barlow, J. (2010). Cetacean abundance in the California Current estimated from a 2008 ship-based line-transect survey.

Barlow, J. (2015). Inferring trackline detection probabilities, g (0), for cetaceans from apparent densities in different survey conditions. *Marine Mammal Science, 31*(3), 923–943.

Barlow, J. (2016). Cetacean abundance in the California Current estimated from ship-based line-transect surveys in 1991–2014. *Administrative report lJ-12-01. Southwest Fisheries Science Center, National Marine Fisheries Service, la Jolla, California, USA*.

Barlow, J., Ferguson, M. C., Becker, E. A., Redfern, J. V., Forney, K. A., Vilchis, I. L., Fiedler, P. C., Gerrodette, T., and Ballance, L. T. (2009). Predictive modeling of cetacean densities in the eastern Pacific Ocean.

Barlow, J. and Forney, K. A. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *Fishery Bulletin, 105*(4), 509–526.

Barlow, J. and Hanan, D. (1995). An assessment of the status of harbour porpoise in central California (SC/42/SM6). *REPORTS-INTERNATIONAL WHALING COMMISSION SPECIAL ISSUES, 16*, 123–140.

Barrett-Lennard, L. G., Ford, J. K., and Heise, K. A. (1996). The mixed blessing of echolocation: differences in sonar use by fish-eating and mammal-eating killer whales. *Animal Behaviour, 51*(3), 553–565.

Bartol, S. and Ketten, D. (2006). Turtle and Tuna Hearing (Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries: NOAA Technical Memorandum NMFS-PIFSC-7). *Honolulu, HI: Pacific Islands Fisheries Science Center*.

Becker, E., Foley, D., Forney, K., Barlow, J., Redfern, J., and Gentemann, C. (2012a). Forecasting cetacean abundance patterns to enhance management decisions. *Endangered Species Research, 16*(2), 97–112.

Becker, E. A., Forney, K. A., Ferguson, M. C., Barlow, J., and Redfern, J. V. (2012b). Predictive modeling of cetacean densities in the California current ecosystem based on summer/fall ship surveys in 1991-2008. *NOAA Technical Memorandum, NMFS-SWFSC, 499*, 1–45.

Becker, E. A., Forney, K. A., Ferguson, M. C., Foley, D. G., Smith, R. C., Barlow, J., and Redfern, J. V. (2010). Comparing California Current cetacean–habitat models developed using in situ and remotely sensed sea surface temperature data. *Marine Ecology Progress Series, 413*, 163–183. doi: 10.3354/meps08696.

Becker, E. A., Forney, K. A., Fiedler, P. C., Barlow, J., Chivers, S. J., Edwards, C. A., Moore, A. M., and Redfern, J. V. (2016). Moving Towards Dynamic Ocean Management: How Well Do Modeled Ocean Products Predict Species Distributions? *Remote Sensing, 8*(2), 149. doi: 10.3390/rs8020149.

Becker, E. A., Forney, K. A., Foley, D. G., Smith, R. C., Moore, T. J., and Barlow, J. (2014). Predicting seasonal density patterns of California cetaceans based on habitat models. *Endangered Species Research, 23*(1), 1–22.

Becker, E. A., Forney, K. A., Redfern, J. V., Barlow, J., Jacox, M. G., Roberts, J. J., and Palacios, D. M. (2018). Predicting cetacean abundance and distribution in a changing climate. *Diversity and Distributions, 25*(4), 626–643.

Becker, E. A., Forney, K. A., Thayre, B. J., Debich, A. J., Campbell, G. S., Whitaker, K., Douglas, A. B., Gilles, A., Hoopes, R., and Hildebrand, J. A. (2017). Habitat-based density models for three cetacean species off Southern California illustrate pronounced seasonal differences. *Frontiers in Marine Science, 4*, 121.

Benson, S. R., Forney, K. A., Harvey, J. T., Carretta, J. V., and Dutton, P. H. (2007). Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990−2003. *Fishery Bulletin, 105*(3), 337–347.

Boyd, C., Barlow, J., Becker, E. A., Forney, K. A., Gerrodette, T., Moore, J. E., and Punt, A. E. (2017). Estimation of population size and trends for highly mobile species with dynamic spatial distributions. *Diversity and Distributions, 24*(1), 1–12.

Brownell Jr, R. L., Walker, W. A., and Forney, K. A. (1998). Pacific white-sided dolphin Lagenorhynchus obliquidens (Gill, 1865). *Handbook of marine mammals, 6*, 57–84.

Calambokidis, J., Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, P. J., Ford, J. K. B., Gabriele, C. M., LeDuc, R., Mattila, D., Rojas-Bracho, L., Straley, J. M., Taylor, B. L., Urban Ramirez, J., Weller, D., Witteveen, B. H., Yamaguchi, M., Bendlin, A., Camacho, D., Flynn, K., Havron, A., Huggins, J., and Maloney, N. (2008). *SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific*. Cascadia Research for the U.S. Department of Commerce.

Calambokidis, J., Steiger, G. H., Curtice, C., Harrison, J., Ferguson, M. C., Becker, E., DeAngelis, M., and Parijs, S. M. V. (2015). 4. Biologically Important Areas for selected cetaceans within U.S. waters – West Coast region. *Aquatic Mammals, 41*(1), 39-53. doi: 10.1578/am.41.1.2015.39.

Campbell, G. S., Thomas, L., Whitaker, K., Douglas, A. B., Calambokidis, J., and Hildebrand, J. A. (2015). Inter-annual and seasonal trends in cetacean distribution, density, and abundance off southern California. *Deep-Sea Research Part II: Tropical Studies in Oceanography, 112*, 143–157.

Caretta, J. V., Price, T., Petersen, D., and Read, R. (2004). Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996–2002. *Marine Fisheries Review, 66*(2), 21–30.

Carretta, J., Forney, K., and Laake, J. (1998). Abundance of southern California coastal bottlenose dolphins estimated from tandem aerial surveys. *Marine Mammal Science, 14*(4), 655–675.

Carretta, J. V., Forney, K. A., Oleson, E. M., Weller, D. W., Lang, A. R., Baker, J., Muto, M. M., Hanson, B., Orr, A. J., Huber, H., Lowry, M. S., Barlow, J., Moore, J. E., Lynch, D., Carswell, L., and Brownell, J., Robert L. (2018). *U.S. Pacific Marine Mammal Stock Assessments: 2017*. U.S. Department of Commerce.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell Jr. and R. L. B. (2019). *U.S. Pacific Marine Mammal Stock Assessments: 2018*. La Jolla, CA: U.S. Department of Commerce.

Carretta, J. V., Oleson, E., Forney, K. A., Lang, A. R., and Weller, D. W. (2017). *U.S. Pacific marine mammal stock assessements, 2016*. Southwest Fisheries Science Center.

Dailey, M. D., Reish, D. J., and Anderson, J. W. (1993). *Ecology of the Southern California Bight: a synthesis and interpretation*: Univ of California Press.

Debich, A. J., Baumann-Pickering, S., Širović, A., Hildebrand, J. A., Alldredge, A. L., Gottlieb, R. S., Herbert, S. T., Johnson, S. C., Rice, A. C., and Roche, L. K. (2015). Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training Area Dec 2012–Jan 2014. *Scripps Institution of Oceanography, Marine Physical Laboratory, La Jolla, CA*.

Defran, R., Weller, D. W., Kelly, D. L., and Espinosa, M. A. (1999). Range characteristics of Pacific coast bottlenose dolphins (Tursiops truncatus) in the Southern California Bight. *Marine Mammal Science, 15*(2), 381–393.

Department of the Navy. (2015). *U.S. Navy Marine Species Density Database for the Pacific Ocean (NAVFAC Pacific Technical Report)*. Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

Department of the Navy. (2017). *U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area*. Pearl Harbor, HI: Naval Facilities Engineering Command Pacific. p. 274.

Department of the Navy. (2018). *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Technical Report prepared by NUWC Division, Newport, Space and Naval Warfare Systems Center Pacific, G2 Software Systems, and the National Marine Mammal Foundation). Newport, RI: Naval Undersea Warfare Center.

Dohl, T., Bonnell, M., and Ford, R. G. (1986). Distribution and Abundance of Common Dolphin, Delphinus delphis, in the Southern California Bight: A Quantitative Assessment Based Upon Aerial Transect Data. *Fishery Bulletin, 84*(2), 333–343.

Dohl, T., Guess, R., Dunman, M., and Helm, R. (1983). Cetaceans of central and northern California, 1980–83; status, abundance, and distribution: Santa Cruz. *University of California, Minerals Management Service Contract Report*, 14–12.

Dohl, T., Norris, K., Guess, R., Bryant, J., and Honig, M. (1981). Cetacea of the Southern California Bight. Part II of Investigator's Reports, Summary of Marine Mammal and Seabird Surveys of the Southern California Bight Area, 1975–1978. Final Report prepared by the University of California, Santa Cruz, for the Bureau of Land Management. *Contract No. AA550-CT7–36. SpringfieldVirgi-Virginia: National Technical Information Service*.

Donoso, M. and Dutton, P. H. (2010). Sea turtle bycatch in the Chilean pelagic longline fishery in the southeastern Pacific: Opportunities for conservation. *Biological Conservation, 143*(11), 2672–2684.

Eckert, K. L. (1995). Anthropogenic threats to sea turtles. *Biology and conservation of sea turtles, 611*.

Ferguson, M., Barlow, J., and Shores, L. (2003). Addendum: Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986–96. *NOAA Administrative Report LJ-01-04 (Addendum), 99*.

Ferguson, M. C., Barlow, J., Fiedler, P., Reilly, S. B., and Gerrodette, T. (2006). Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. *Ecological Modelling, 193*(3-4), 645–662.

Fleming, A. H., Yack, T., Redfern, J. V., Becker, E. A., Moore, T. J., and Barlow, J. (2018). Combining acoustic and visual detections in habitat models of Dall's porpoise. *Ecological modelling, 384*, 198–208.

Ford, J. K. (2009). Killer whale: Orcinus orca. In *Encyclopedia of marine mammals* (650–657): Elsevier.

Forney, K., Barlow, J., and Carretta, J. (1995). The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. *Oceanographic Literature Review, 9*(42), 784–785.

Forney, K. A. (2000). Environmental models of cetacean abundance: reducing uncertainty in population trends. *Conservation Biology, 14*(5), 1271–1286.

Forney, K. A. and Barlow, J. (1998). Seasonal patterns in the abundance and distribution of California cetaceans, 1991–1992. *Marine Mammal Science, 14*(3), 460–489.

Forney, K. A., Becker, E. A., Foley, D. G., Barlow, J., and Oleson, E. M. (2015). Habitat-based models of cetacean density and distribution in the central North Pacific. *Endangered Species Research, 27*(1), 1–20.

Forney, K. A., Ferguson, M. C., Becker, E. A., Fiedler, P. C., Redfern, J. V., Barlow, J., Vilchis, I. L., and Ballance, L. T. (2012). Habitat-based spatial models of cetacean density in the eastern Pacific Ocean. *Endangered Species Research, 16*(2), 113–133. doi: 10.3354/esr00393.

Gallo-Reynoso, J. P., Figueroa-Carranza, A.-L., and Le Boeuf, B. (2008). Foraging behavior of lactating Guadalupe fur seal females. *Avances en el Estudio de los Mamíferos de México, C. Lorenzo, E. Espinoza and J. Ortega (eds.). Publicaciones Especiales, 2*, 595–614.

García-Aguilar, M. C., Turrent, C., Elorriaga-Verplancken, F. R., Arias-Del-Razo, A., and Schramm, Y. (2018). Climate change and the northern elephant seal (Mirounga angustirostris) population in Baja California, Mexico. *PloS one, 13*(2), e0193211.

Gaskin, D. (1984). The harbour porpoise *Phocoena phocoena* (L.): regional populations, status and information on direct and indirect catches. *Report of International Whaling Commission, 34*, 569–586.

Green, G., Brueggeman, J., Grotefendt, R., Bowlby, C., Bonnell, M., and Balcomb III, K. (1992). Cetacean distribution and abundance off Oregon and Washington, 1989–1990.

Green, G., Grotefendt, R., Smultea, M., Bowlby, C., and Rowlett, R. (1993). Delphinid aerial surveys in Oregon and Washington waters. *Final Report prepared for NMFS, National Marine Mammal Laboratory, 7600*.

Hamilton, T. A., Redfern, J. V., Barlow, J., Ballance, L. T., Gerrodette, T., Holt, R. S., Forney, K. A., and Taylor, B. L. (2009). Atlas of cetacean sightings for Southwest Fisheries Science Center cetacean and ecosystem surveys, 1986–2005.

Hanni, K. D., Long, D. J., Jones, R. E., Pyle, P., and Morgan, L. E. (1997). Sightings and strandings of Guadalupe fur seals in central and northern California, 1988–1995. *Journal of Mammalogy, 78*(2), 684–690.

Hansen, L. J. (1990). California coastal bottlenose dolphin. In. Reeves, S. L. a. R. R. (Ed.), *The Bottlenose Dolphin* (403–420). San Diego: Academic Press.

Harvey, J. T. and Goley, D. (2011). Determining a correction factor for aerial surveys of harbor seals in California. *Marine Mammal Science, 27*(4), 719–735.

Herder, M. (1986). *Seasonal movements and hauling site fidelity of harbor seals, Phoca vitulina richardsi, tagged at the Russian River, California.* MS Thesis. Humbolt State Univ.

Heyning, J. E. and Perrin, W. F. (1994). Evidence for two species of common dolphins (genus Delphinus) from the eastern North Pacific. *Contributions in Science, Natural History Museum of Los Angels County, 442*, 1–35.

Hitipeuw, C., Dutton, P. H., Benson, S., Thebu, J., and Bakarbessy, J. (2007). Population status and internesting movement of leatherback turtles, Dermochelys coriacea, nesting on the northwest coast of Papua, Indonesia. *Chelonian Conservation and Biology, 6*(1), 28–36.

Jefferson, T. A., Smultea, M. A., and Bacon, C. E. (2014). Southern California Bight marine mammal density and abundance from aerial surveys, 2008–2013. *J. Mar. Anim. Their Ecol, 7*, 14–30.

Jefferson, T. A., Webber, M. A., and Pitman, R. L. (2015). *Marine mammals of the world: a comprehensive guide to their identification* (2nd ed.): Academic Press.

Julian, F. and Beeson, M. (1998). Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990–1995. *Fishery Bulletin, 96*, 271–284.

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

Kerosky, S. M., Širović, A., Roche, L. K., Baumann-Pickering, S., Wiggins, S. M., and Hildebrand, J. A. (2012). Bryde's whale seasonal range expansion and increasing presence in the Southern California Bight from 2000 to 2010. *Deep Sea Research Part I: Oceanographic Research Papers, 65*, 125–132.

Kobayashi, D. R., Polovina, J. J., Parker, D. M., Kamezaki, N., Cheng, I.-J., Uchida, I., Dutton, P. H., and Balazs, G. H. (2008). Pelagic habitat characterization of loggerhead sea turtles, Caretta caretta, in the North Pacific Ocean (1997–2006): insights from satellite tag tracking and remotely sensed data. *Journal of Experimental Marine Biology and Ecology, 356*(1-2), 96–114.

Kuhn, C. E. (2006). Measuring at sea feeding to understand the foraging behavior of pinnipeds.

Kuhn, C. E. and Costa, D. P. (2014). Interannual variation in the at-sea behavior of California sea lions (*Zalophus californianus*). *Marine Mammal Science, 30*(4), 1297–1319.

Le Boeuf, B., Crocker, D. E., Costa, D. P., Blackwell, S. B., Webb, P. M., and Houser, D. S. (2000). Foraging ecology of northern elephant seals. *Ecological monographs, 70*(3), 353–382.

Le Boeuf, B. J. and Laws, R. M. (1994). *Elephant seals: an introduction to the genus*: University of California Press: Berkeley/Los Angeles, CA.

Leatherwood, S. and Walker, W. A. (1979). The northern right whale dolphin Lissodelphis borealis Peale in the eastern North Pacific. In *Behavior of marine animals* (85–141): Springer.

Lee, T. (1993). *Summary of cetacean survey data collected between the years of 1974 and 1985. NOAA Tech. Mem*. NOAA-TM-NMFSSWFSC-181. 184.

Lewis, L. A. and Širović, A. (2018). Variability in blue whale acoustic behavior off southern California. *Marine Mammal Science, 34*(2), 311–329.

Lipsky, J. D. and Brownell Jr, R. L. (2009). Right Whale Dolphins Lissodelphis borealis and L. peronii: Lissodelphis borealis and L. peronii. In *Encyclopedia of Marine Mammals* (813–817): Elsevier.

Lowry, M. S., Carretta, J. V., and Forney, K. A. (2005). Pacific harbor seal, Phoca vitulina richardsi, census in California during May–July 2004.

Lowry, M. S., Condit, R., Hatfield, B., Allen, S. G., Berger, R., Morris, P. A., Le Boeuf, B. J., and Reiter, J. (2014). Abundance, Distribution, and Population Growth of the Northern Elephant Seal (Mirounga angustirostris) in the United States from 1991 to 2010. *Aquatic Mammals, 40*(1).

Lowry, M. S. and Forney, K. A. (2005). Abundance and distribution of California sea lions (Zalophus californianus) in central and northern California during 1998 and summer 1999. *Fishery Bulletin, 103*(2), 331–343.

Lowry, M. S., Nehasil, S. E., and Jaime, E. M. (2017). Distribution of California sea lions, northern elephant seals, pacific harbor seals, and Steller sea lions at the Channel Islands during July 2011–2015.

Lowther-Thieleking, J. L., Archer, F. I., Lang, A. R., and Weller, D. W. (2015). Genetic differentiation among coastal and offshore common bottlenose dolphins, Tursiops truncatus, in the eastern North Pacific Ocean. *Marine Mammal Science, 31*(1), 1–20.

Mangels, K. F. and Gerrodette, T. (1994). *Report of cetacean sightings during a marine mammal survey in the eastern Pacific Ocean and the Gulf of California aboard the NOAA ships McArthur and David Starr Jordan, July 28–November 6, 1993*. NMFS. p. 88.

Maniscalco, J. M., Wynne, K., Pitcher, K. W., Hanson, M. B., Melin, S. R., and Atkinson, S. (2004). The occurrence of California sea lions (Zalophus californianus) in Alaska. *Aquatic Mammals, 30*(3), 427–433.

Mate, B., Bradford, A., Tsidulko, G., Vertyankin, V., and Ilyashenko, V. (2011). Late-feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the Eastern North Pacific. *International Whaling Commission-Scientific Committee, Tromso, Norway*.

Mate, B. R., Ilyashenko, V. Y., Bradford, A. L., Vertyankin, V. V., Tsidulko, G. A., Rozhnov, V. V., and Irvine, L. M. (2015). Critically endangered western gray whales migrate to the eastern North Pacific. *Biology letters, 11*(4), 20150071.

Melin, S., DeLong, R., and Siniff, D. (2008). The effects of El Niño on the foraging behavior of lactating California sea lions (Zalophus californianus californianus) during the nonbreeding season. *Canadian Journal of Zoology, 86*(3), 192–206.

Melin, S. R. and Delong, R. L. (1999). Observations of a Guadalupe fur seal (Arctocephalus townsendi) female and pup at San Miguel Island, California. *Marine Mammal Science, 15*(3), 885–888.

Melin, S. R. and DeLong, R. L. (2000). *At-sea distribution and diving behavior of California sea lion females from San Miguel Island, California.* Paper presented at the Proceedings of the Fifth California Islands Symposium. United States Department of the Interior, Minerals Management Service, MMS.

Melin, S. R., Sterling, J. T., Ream, R. R., Towell, R., Zeppelin, T., Orr, A. J., Dickerson, B., Pelland, N., and Kuhn, C. (2012). A tale of two stocks: Studies of northern fur seals breeding at the northern and southern extent of the range. *Alaska Fisheries Science Center Quarterly Report, Seattle, Washington*.

Menza, C. W., Leirness, J., White, T. P., Winship, A. J., Kinlan, B. P., Kracker, L. M., Zamon, J. E., Ballance, L. T., Becker, E. A., and Forney, K. A. (2016). Predictive mapping of seabirds, pinnipeds and cetaceans off the pacific coast of Washington.

Morejohn, G. V. (1979). The natural history of Dall's porpoise in the North Pacific Ocean. In *Behavior of marine animals* (45–83): Springer.

Morin, P. A., Archer, F. I., Foote, A. D., Vilstrup, J., Allen, E. E., Wade, P., Durban, J., Parsons, K., Pitman, R., and Li, L. (2010). Complete mitochondrial genome phylogeographic analysis of killer whales (Orcinus orca) indicates multiple species. *Genome research, 20*(7), 908–916.

Muto, M. M., V. T. Helker, R. P. Angliss, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. (2019). *Alaska Marine Mammal Stock Assessment: 2018*. Seattle, WA: U.S. Department of Commerce.

Myers, A. E. and Hays, G. C. (2006). Do leatherback turtles Dermochelys coriacea forage during the breeding season? A combination of data-logging devices provide new insights. *Marine Ecology Progress Series, 322*, 259–267.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998). *Recovery Plan for US Pacific Populations of the Leatherback Turtle (Dermochelys coriacea)*.

National Oceanic and Atmospheric Administration. (2016). 2013–2016 California Sea Lion Unusual Mortality Event in California. Retrieved from http://www.nmfs.noaa.gov/pr/health/mmume/californiasealions2013.htm as accessed on 2019.

Norris, T. (2017). *Personal communication via email between Tenaya Norris (The Marine Mammal Center) and Conrad Erkelens (Mantech International Corporation) on Guadalupe fur seal abundance and distribution*. Personal communication via to Erkelens, C. L.

Norris, T. (2019). *Guadalupe Fur Seal Population Census and Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean*. Sausalito, CA: The Marine Mammal Center.

Pablo-Rodríguez, N., Aurioles-Gamboa, D., and Montero-Muñoz, J. L. (2016). Niche overlap and habitat use at distinct temporal scales among the California sea lions (Zalophus californianus) and Guadalupe fur seals (Arctocephalus philippii townsendi). *Marine Mammal Science, 32*(2), 466–489.

Patino-Martinez, J., Marco, A., Quiñones, L., and Godley, B. (2008). Globally significant nesting of the leatherback turtle (Dermochelys coriacea) on the Caribbean coast of Colombia and Panama. *Biological Conservation, 141*(8), 1982–1988.

Perrin, W. F., Scott, M. D., Walker, G. J., and Cass-Dudley, V. L. (1985). Review of geographical stocks of tropical dolphins (Stenella spp. and Delphinus delphis) in the eastern Pacific.

Perrin, W. F., Thieleking, J. L., Walker, W. A., Archer, F. I., and Robertson, K. M. (2011). Common bottlenose dolphins (*Tursiops truncatus*) in California waters: Cranial differentiation of coastal and offshore ecotypes. *Marine Mammal Science, 27*(4), 769–792.

Ream, R. R., Sterling, J. T., and Loughlin, T. R. (2005). Oceanographic features related to northern fur seal migratory movements. *Deep Sea Research Part II: Topical Studies in Oceanography, 52*(5-6), 823–843.

Redfern, J., Ferguson, M., Becker, E., Hyrenbach, K., Good, C., Barlow, J., Kaschner, K., Baumgartner, M. F., Forney, K., and Ballance, L. (2006). Techniques for cetacean–habitat modeling. *Marine Ecology Progress Series, 310*, 271–295.

Redfern, J. V., McKenna, M. F., Moore, T. J., Calambokidis, J., DeAngelis, M., Becker, E. A., Barlow, J., Forney, K. A., Fiedler, P. C., and Chivers, S. J. (2013). Assessing the risk of ships striking large whales in marine spatial planning. *Conservation Biology, 27*(2), 292–302.

Rice, A. C., Baumann-Pickering, S., Širović, A., Hildebrand, J. A., Rafter, M., Thayre, B. J., Trickey, J. S., and Wiggins, S. M. (2018). Passive Acoustic Monitoring for Marine Mammals in the SOCAL Range Complex April 2016–June 2017. *Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, MPL Technical Memorandum, 618*, 45.

Rice, D. W. (1974). Whales and whale research in the eastern North Pacific. *The whale problem: A status report. Harvard Press, Cambridge, MA*, 170–195.

Roppel, A. Y. (1984). Management of northern fur seals on the Pribilof Islands, Alaska, 1786–1981.

Shelden, K. and Laake, I. (2002). Comparison of the offshore distribution of southbound migrating gray whales from aerial survey data collected off Granite Canyon, California, 1979-96. *Journal of Cetacean Research and Management, 4*(1), 53–56.

Shillinger, G. L., Palacios, D. M., Bailey, H., Bograd, S. J., Swithenbank, A. M., Gaspar, P., Wallace, B. P., Spotila, J. R., Paladino, F. V., and Piedra, R. (2008). Persistent leatherback turtle migrations present opportunities for conservation. *PLoS biology, 6*(7), e171.

Smultea, M. A., Douglas, A. B., Bacon, C. E., Jefferson, T. A., and Mazzuca, L. (2012). Bryde's whale (*Balaenoptera brydei/edeni*) sightings in the Southern California Bight. *Aquatic Mammals, 38*(1), 92.

Soldevilla, M., Wiggins, S., Calambokidis, J., Douglas, A., Oleson, E., and Hildebrand, J. A. (2006). Marine mammal monitoring and habitat investigations during CalCOFI surveys.

Stewart, B. and Huber, H. (1993). Mammalian species: (*Mirounga angustirostris*). *American Society of Mammalogists, 449*, 1–10.

Stewart, B. S., Yochem, P. K., DeLong, R. L., and Antonelis, G. A. (1993). *Trends in abundance and status of pinnipeds on the southern California Channel Islands.* Paper presented at the Third California Islands symposium: Recent advances in research on the California Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Stewart, B. S., Yochem, P. K., Huber, H. R., DeLong, R. L., Jameson, R. J., Sydeman, W. J., Allen, S. G., and Le Boeuf, B. (1994). History and present status of the northern elephant seal population. *Elephant seals: Population Ecology, Behavior and Physiology* (BJ Le Boeuf and RM Laws, eds). University of California Press, Los Angeles, 29–48.

Tershy, B. R., Breese, D., and Strong, C. S. (1990). Abundance, seasonal distribution and population composition of balaenopterid whales in the Canal de Ballenas, Gulf of California, Mexico. *Rept. Int. Whal. Commn., Special*(12), 369–375.

Testa, J. W. (2012). Fur seal investigations, 2010–2011.

Wade, P. R. and Gerrodette, T. (1993). Estimates of cetacean abundance and distribution in the eastern tropical Pacific. *Report of the International Whaling Commission, 43*(477-493).

Wells, R. S. and Scott, M. D. (1999). Bottlenose dolphin *tursiops truncatus* (montagu, 1821). *Handbook of marine mammals: the second book of dolphins and porpoises, 6*, 137–182.

Whitehead, H. (2009). Sperm whale: (*Physeter macrocephalus)*. In *Encyclopedia of marine mammals* (919–925): Elsevier.

Worthy, G., Morris, P., Costa, D., and Boeuf, B. L. (1992). Moult energetics of the northern elephant seal (*Mirounga angustirostris*). *Journal of Zoology, 227*(2), 257–265.

Yochem, P. K., Stewart, B. S., DeLong, R. L., and DeMaster, D. P. (1987). Diel haul-out patterns and site fidelity of harbor seals (Phoca vitulina richardsi) on San Miguel Island, California, in autumn. *Marine Mammal Science, 3*(4), 323–332.

NUWC-NPT Technical Report 12,313

DISTRIBUTION LIST

External
Defense Technical Information Center

Internal
Codes: 1033 (Corporate Research and Information Center)

Total: 2